FORAGES

The Science of Grassland Agriculture
"Take not too much of a land, weare not out all the fatnesse, but leave it in some heart."

—By Pliny the Elder, A.D. 23–79, from his *Historiae Naturalis*, in 37 volumes
This Volume Is Respectfully Dedicated

To the Memory of Those gone on before, who, envisioning the needs of the future and the possibility of better things, lived purposefully, giving of themselves.

In Recognition of Those of our own day, who, endowed with leadership ability in research and education, continue to stimulate us to more productive effort.

For the Inspiration of Those who today follow on, but who tomorrow, building upon established foundations, will be charged with the responsibility of solving the new problems with which those of their day will be confronted.
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Preface

The most important thing about this book is its authorship. Its title page says "... 52 contributing authors selected for their recognized leadership in the field of Grassland Agriculture." Many of the different chapters are authored by the one person generally recognized as the very best authority on a particular subject. Other chapters, however, perhaps could have been written equally well by any one of three or four other different persons.

Each chapter is written by a person standing at the forefront in forage knowledge. Interest in forage production and utilization is not confined to agronomists and soil conservationists. The economist and farm manager, the agricultural engineer, animal and dairy husbandry specialists, and many others are as much concerned. The material included is the information of the greatest concern and value to the largest number.

In the 60 chapters under which the material is presented, more subjects are included than probably can be covered adequately in most organized classes. Some chapters will be of more interest and value for use in a given part of the country than in others. Equal care has been given to the selection of data and other kinds of information of interest and concern to those in the Northeast, in the Deep South, and in the Southwest and West, as to those in the Corn Belt and in the Eastern Great Plains. The coverage is sufficiently broad to permit considerable selection in order to emphasize production factors most applicable to a given environment.

It sometimes will be desirable to give more attention to certain subjects than has been possible within the limits of this volume. In this connection, the reader will appreciate and find most helpful the extensive citations to the best literature giving further details and results.

One of the responsibilities the editors have felt most important has been the elimination of any undesirable repetition between the different chapters and authors. The editors believe, however, that each subject unit (chapter) should give a complete picture within itself. Only
such limited and casual repetition in coverage as is definitely desirable has been retained. The editors also have unified the style of organization and presentation in the different chapters, while at the same time preserving the individuality of expression of the respective authors.

FORAGES—The Science of Grassland Agriculture, has been prepared especially for use by organized groups, but also will have great value as a ready reference for farm managers and operators, soil conservation personnel, research workers and many others in related fields.

H. D. Hughes
Maurice E. Heath
Darrel S. Metcalfe

April, 1951
PART I

Forages and a Productive Agriculture
The Only Kettle She's Got!
Forages in Our Advancing Civilization

Early recognition of the high value of grass is indicated by a writer in the Book of Psalms some thousands of years back—"He causeth the grass to grow for the cattle." Moses promised the Children of Israel, as their reward if they accepted the commandments of God, that they would have "Grass in their fields for their cattle." Again, "In the habitation of dragons shall be grass," and again, "The Lord shall give to everyone grass in the fields." The want of grass was recognized as the symbol of desolation—"The hay is withered away, the grass faileth." The theme of grazing runs all through the Books of Genesis and Exodus.¹

"But grazing lands were vital to primitive man long before cattle were domesticated. Man's first attempts to control his fate, to provide for future need instead of remaining the victim of droughts or other untoward circumstances, which were the beginnings of civilization, must have been in grasslands, where the young calves, lambs, and kids he caught and tamed could find forage. It was on grasslands, too, that primitive man, after he had reached the food-producing as distinguished from the food-gathering stage, developed more rapidly. . . ."

It is generally believed that in the dim ages of the past, as man struggled with his environment for better living, a pastoral type of husbandry followed the hunting stage. This in turn was followed by the growing of cereal grains. The extensive cultivation of forage-producing crops came still later in the evolutionary process.

GRASS PLAYS AN IMPORTANT ROLE

Making hay from harvested forage undoubtedly is a very ancient agricultural practice. But the conversion of green forage into cured hay, capable of being stored and used through a considerable period of time, is believed to have had a more important part in the development of civilization than most of us realize. It is associated with a stabilized type of agriculture.

It has been pointed out that in the agricultural development of America the pioneers depended to a considerable degree on game as a source of food and income. This was soon supplemented by the returns from a limited number of

¹ Smithsonian Scientific Ser. 11. Old and New Plant Lore. 1931.
livestock, grazing the open prairies and woods. As transportation facilities developed—and with the demand in congested areas for such concentrated food products as wheat—grain farming became an important enterprise. This in turn gave way in many areas to a type of general farming, in which a considerable part of the cash grain crops was replaced by forage for livestock.

With a steadily increasing demand for food products, both cereal and animal, and in view of the greater acre production obtained from harvested crops than from pasture, an increasing acreage of pasture land was plowed up to grow harvested crops. However, the superiority of a system of farming which utilizes forage in the production of livestock, as compared with specialized cash grain production or other specialized crops, is coming to be more generally recognized. Such a system of farming tends not only to maintain soil productivity but also contributes to economic stability.

**UNIVERSAL BENEFICENCE OF GRASS**

From the pen of John James Ingalls there appeared in the *Kansas Magazine* in 1872 certain inspired words and thoughts under the title of "Bluegrass." In the portion most often used Senator Ingalls pictures grass at its best—its persistence, its aggressiveness, its sod-forming characteristics, and the true worth of these characteristics to world civilization and advancement.

Here is the picture with which Senator Ingalls beguiles us and leads us out and away:

Attracted by the bland softness of an afternoon in my primeval winter in Kansas, I rode southward through the dense forest that then covered the bluffs of the North Fork of Wildcat. The ground was sodden with the ooze of melting snow. . . . A tropical atmosphere brooded upon an arctic scene, creating the strange spectacle of summer in winter. June in January, peculiar to Kansas, which unseen cannot be imagined, but once seen can never be forgotten. A sudden descent into the sheltered valley revealed an unexpected crescent of dazzling verdure. . . . It was Bluegrass, unknown in Eden, the final triumph of nature, reserved to compensate her favorite offspring, in the new Paradise of Kansas, for the loss of the old upon the banks of the Tigris and Euphrates.

Next in importance to the Divine profusion of water, light, and air—these three great physical facts which render existence possible—may be reckoned the universal beneficence of grass.

Grass is the most widely distributed of all vegetable beings, and is at once the type of our life and the emblem of our mortality. Lying in the sunshine among the buttercups and dandelions of May, scarcely higher in intelligence than the minute tenants of that mimic wilderness, our earliest recollections of are of grass; and when the fitful fever is ended, and the foolish wrangle of the market and forum is closed, grass heals over the scar which our descent into the bosom of the earth has made, and the carpet of the infant becomes the blanket of the dead.

. . . Grass is the Forgiveness of Nature—her constant benefaction. Fields trampled with battle, saturated with blood, torn with the ruts of cannon, grow green again with grass, and carnage is forgotten. Streets abandoned by traffic become grass grown, like rural lanes, and are obliterated. Forests decay, harvests perish, flowers vanish, but grass is immortal. Beleaguered by the sullen hosts of winter, it withdraws into the impregnable fortress of its subterranean vitality, and emerges upon the first solicitation of spring. Sown by the winds, by wandering birds, propagated by the subtle horticulture of the elements, which are its ministers and servants, it softens the rude outline of the world. Its tenacious fibers hold the earth in its place, and prevent its soluble components from washing into the wasting sea. It invades the solitude of deserts, climbs the inaccessible slopes and forbidding pinnacles of mountains, modifies climates, and determines the history, character and destiny of nations.

**Should Its Harvest Fail**

Unobtrusive and patient, it has immortal vigor and aggression. Banished from the thoroughfare and the field, it bides its time to return and when vigilance is relaxed, or the dynasty has perished, it silently resumes the throne from which it has been expelled, but which it never abdicates. It bears no
blazomy of bloom to charm the sense with fragrance or splendor, but its homely hue is more enchanting than the lily or the rose. It yields no fruit in earth or air, and yet, should its harvest fail for a single year, famine would depopulate the world. . . .

OUR HISTORICAL GRASS COVER PICTURE

Originally the land surface of our large prairie areas was covered with a great variety of native grasses, a few legumes, and other flowering plants. Most of the prairie east of the Missouri was covered with so-called “tall-grass” species and that to the west with “short-grass” species. Along the sloughs the tall, coarse prairie cordgrass and bluejoint reedgrass were often found, practically in pure stands. On the better drained soils, big bluestem and yellow Indiangrass held forth, in growth so tall and with stands so dense that the cattle of the early settlers could be found only by the tinkling of the cowbells or the waving of the grasses. Where moisture conditions were less favorable, the shorter grasses dominated—little bluestem, sideoats grama, blue grama, and other similar grasses. So thick and tough were the roots of these prairie grasses that some farmers preferred not to break the sod until after the stand had been weakened by grazing and repeated mowing.

Studies have indicated that 65 per cent of the prairie grasses extended their roots to a depth of five feet or more. It is believed that the bulk of the prairie was below and not above the soil surface. When the farmer mowed the prai-

prairie in the fall, with yields of two or three tons of dry hay per acre, he left a still larger amount of living plant material in the soil.

The prairie cover broke the force of the beating rains, even torrential downpours. Runoff water from these prairie soils is known to have been slight, and that which did run away was clear. Thus, the soil surface was protected by litter and leafy growth, with the soil particles held firmly in place by dense, deep root growth.

In general, our more fertile, deep soils were formed under the vegetative cover of the prairie. The growth and decay of these native grasses through thousands of years resulted in deep, rich black soils. These soils will continue to be highly productive provided sufficient quantities of sod-forming grass-legume combinations are grown—the very foundation of a permanent, highly productive agriculture.4

The Picture Changes

But what of the present in relation to that ideal picture? As our pioneer farmers pushed steadily westward those of the advance guard always had more grass than they could use. First, there was

So thick and tough were the roots of these native grasses that some farmers preferred not to break the sod until after the stand had been weakened by grazing and repeated mowing. (See p. 5.)
more of the unimproved prairie grass cover than was required to balance the grain crops that could be produced. Later, the aggressive, free-seeding, dense, sod-forming newcomer—Kentucky bluegrass—provided pasturage without any effort on the farmer's part. Areas in pasture were little appreciated and utterly neglected. The result was that with the passing of the years many of these areas gradually deteriorated.

As our agriculture developed, with less and less land in grass, the time came when continuous close grazing from early spring to late in the growing season, with no opportunity for the accumulation of root reserves, resulted in thin, weak sods. Weedy, unpalatable grasses and other plants with little or no feed value easily penetrated these sods. Plant nutrients were removed annually in the form of milk, beet, and mutton, with no thought of replenishment. Much of the land in pasture came gradually to give smaller and smaller returns.

Throughout most of the eastern Wheat Belt and the Corn Belt, land had been under the plow for upwards of three quarters of a century before any particular attention was given to methods by which the returns from permanent pasture lands might be increased. A somewhat similar condition developed in other areas. It is believed that the historic background of our pioneer love-bears is a factor in the difficulty experienced in getting any great number of farmers to take the steps necessary for the improvement of pastures.

The picture is much the same for rotation lands. Fields were intensively cultivated, encouraging the rapid breakdown of organic matter and the liberation and removal from the soil, both in crops and by leaching, of the essential soil nutrients.

The increased frequency of dust storms and decreasing crop yields, with more and deeper gullies in evidence, has brought an increasing number of land owners in the twentieth century to a realization of the fact that a radical change in the cropping pattern is imperative.

THREE THOUSAND GULLIES. In a single Corn Belt county some three thousand gullies 10 feet or more in depth have been recorded, most of them out of control except by the expenditure of thousands of dollars of public funds. The presence of these gullies proves that the farm practices of the past under which this critical condition developed were wrong—the result of a grassless agriculture. Too large a portion of the land planted to row crops through a period of years creates a serious soil conservation problem.

Growers in this area, and in many other heavily cropped areas, are finding to their dismay that many grass-legume seedings fail to result in stands. The soils have been cropped to such an extent, the topsoil has so eroded, the water holding organic matter of the soil so broken down and used and lost, the run-off of rainfall from the surface so rapid, that comparatively little water enters the soil and is held. Such soil dries out quickly with the result that grass seedlings fail generally. When we have no sod-forming crops in our rotations the productivity of our soils decreases rapidly.5

Cornerstones in Conservation

That adapted grasses and legumes are the chief tools in soil building, improvement, and conservation is now generally recognized. Fundamental research on

The improvement and production of the grasses and legumes, together with studies on the soil factors relating to their most successful growth and on the effect of such crops upon the soil itself, has provided the foundation upon which our better land use program is built.

Widespread interest has developed in the value and utilization of sod crops; also some appreciation of the problems to be solved in order that these grasses and legumes shall contribute most to abundant production, through soil improvement and conservation. The inclusion and right use of these sod crops in the cropping picture apparently is basic to the health and well-being of both animal and man in a permanently productive agriculture.

The direct benefit from the inclusion of sod crops in the rotation, as this affects the yield of crops which follow, has been recognized and evaluated under a great variety of environmental conditions and through a long period of years. This represents a very real credit to the sod crops.

Much evidence has been accumulated on the extent to which sod crops in rotation increase the permeability and the water-holding capacity of a given soil. We have been learning much of the effect of grass roots on the granulation of the soil particles and the relation of this characteristic to the resistance of a given soil to destructive erosion.

Progress has been made in finding strains and varieties and species of grasses and legumes better suited to a given environment and use than previously were known. It is recognized, however, that a mere beginning has been made in this field. Perhaps no better examples can be cited than the southern type strains of smooth bromegrass, Ladino clover, birdsfoot trefoil, the Ranger and Buffalo alfalfas, and the improved...
strains from several native grasses. In like manner the acre production and nutritive value of pastures and hay crops have been increased by better soil management and cultural practices.7

All of these efforts have been important as they bear upon the extent to which an increasing number of farmers may come to see the way to the more generous use of sod crops in their cropping plans. With the relatively low return which farmers have come to expect from acres in pasture, and even to a degree from hay crops, a vigorous program to maximize the returns from land in sod crops is essential.

It appears difficult for many farmers to make an adequate expenditure of labor and cash to increase materially the returns from pasture and hay lands. Even those who have been convinced of the necessity of increasing their acreage in sod crops in order to save their soils from ruin are confronted with a problem of marketing their pasture and hay after it is available. We not only have the problem of increasing the acre production of pasture and hay acreages, but also the problem of satisfactory utilization and marketing of this product.

FORAGE AND OTHER FEED RESOURCES

Of the estimated 367 million acres from which crops were harvested in 1947 in the United States, approximately 37 per cent were used to produce feed for livestock. In the broad sense all feed consumed by livestock is classed as forage. In the more restricted sense usually used, however, we think of forage as the roughages, mostly hay and pasture. We exclude the cereal grains and other concentrates.

The foods produced in the United States which are used directly for human consumption are produced on about two-tenths of the harvested crop area. The remaining one-tenth is devoted in the main to fiber crops such as cotton, and to specialized crops such as stimulants, sugar, etc.

In addition to the acres from which crops are harvested, there are some 230 million within the humid area which are used for pasture. Also, there is an area of some 800 million acres of semi-arid grazing land and forest and cut-over pasture land.

Livestock consume about three-fourths of the production from improved land, either in pasture or harvested crops, plus also the pasturage provided by our less productive acres.8 More than one-third of the feed for livestock comes from pasture and range land. When hay is included, more than one-half of the feed is from grassland.9

Pasture and range constitute the largest acreage of land use—55 per cent of the land area.10

But the land use picture is very different as we move from one part of the country to another. There is a direct relationship between the extent to which an area is used for the production of forage and the climatic and soil conditions which prevail.11

In the eastern half of the United States, about one-fourth of the area is devoted to corn for grain, one-fourth to product roughages such as silage, fodder, and hay, with approximately 5 per cent devoted to other feed crops. This area also has produced more than one-half of the cotton of the world in earlier years.

Hay crops occupy about one-third of the crop land in the dairy and hay area in the North and East, with corn fodder and silage harvested from between 5 and 10 per cent.

In the corn and winter wheat region, lying to the south and west of the dairy and hay region, nearly three-fourths of the crop land is used to produce forage for livestock, and most of the remaining one-fourth to produce human food. In the Corn Belt proper, adjoining on the north and west, about 85 per cent produces feed for farm animals, with only about 15 per cent food for man.

In the Cotton Belt, a little more than a half of the crop land has been used to produce feed for livestock, with something less than one-third of the acreage in cotton, tobacco, and other specialized crops not used directly as feed or food. This changed rapidly toward mid-century, with more feed and less cotton.

On the whole, the western half of the United States is largely arid or semi-arid and consequently is used mostly for pasture or range. Wheat, mostly used for food, occupies nearly one-third of the harvested crop land in this area, being one of the best semi-arid crops.

MAXIMIZING THE USE OF FORAGES

A frequent query by farmers who are trying to keep their soil at home and improve its productivity is how far they can go in maximizing the use of grass
and hay in the production of market livestock and livestock products. That is a problem to which agricultural economists have been giving much thought as well as those especially concerned with the conservation of our soil (see Chapters 3 and 4).

The relation of soil topography, seasonal rainfall, transportation, market demand, and many other factors must have consideration. The extent and kind of forage that can be utilized profitably is related to the type of livestock. Of the total feed consumed in the United States by livestock, pastures provided 35 per cent and hay land approximately 16 per cent, or slightly more than half the total. As heavy users of forage, sheep and goats have ranked first, with 12 and 80 per cent of their feed consisting of hay and pasture, respectively. Beef cattle ranked second, with 13 and 60 per cent; dairy cattle third with 26 and 38 per cent; and horses and mules with 31 and 32 per cent.

In livestock use of total forage production, dairy cattle have been consuming 53 per cent of the hay and 34 per cent of the pasture; beef cattle 16 per cent of the hay and 33 per cent of the pasture; horses and mules 24 per cent of the hay and 11 per cent of the pasture; with sheep and goats 7 per cent of the hay and 20 per cent of the pasture.12

In looking to an increased use of sod crops in livestock production programs in the Corn Belt of great significance are the acres of hay and pasture used by different livestock to balance one acre of corn. Data reported in 1934 from 600 Illinois farms 13 for a two-year period shows that breeding sheep used 13.5 acres of hay and pasture for each acre of corn; beef cattle used 4.6 acres; dairy cattle, 3.8; feeder lambs, 1.5; feeder cattle, .6 and hogs, .2 of one acre of hay and pasture for each acre of corn consumed.

Any large shift from row crops to sod crops tends to upset the established economy, so that prices that previously prevailed may not hold under the new order. Hay values and pasture rentals, for example, may decrease rather quickly and sharply with an increase in the acreage devoted to these crops. Also, significant increases in the proportion of forages used in relation to grain crops in feeding livestock may affect the quality of the finished product. The quality of dairy products usually is improved by the extensive use of high quality pasture, grass-legume silage, and the like. It is recognized, however, that beef cattle which go to market directly from pasture do not reach the high finish attained by grain-fed animals. Even beef cattle fed grain on pasture usually sell at a price somewhat below that of animals fed in the dry lot. This is in spite of the fact that no valid reason can be found for such differences, except perhaps public prejudice to the yellow tinge in the fat of cattle produced on pasture.

Both sheep and lambs frequently are finished for market without the use of grain. Early spring lambs finished on pasture with little or no grain frequently top the June market.

It is believed true that regardless of the class or kind of livestock fed, the lowest cost nutrients consumed come from effectively utilized pastures, and the next lowest from hay crops. But general recognition of that fact alone is not sufficient. In most parts of the country the acres devoted to use as pasture must tie into a well balanced program with harvested crops.

Not a Single Simple Problem

No one problem is complete within itself. Many of our agricultural problems are so complex that to consider one phase without at the same time considering several others is likely to lead to false conclusions. In the economics of a grassland agriculture, it is recognized that in addition to the feed value of the grasses and legumes, there are other potentials of perhaps as great importance.

Forage problems relate directly to the research of the soil physicist and the soil chemist; to the investigations in soil management and soil fertility; to the results obtained by those who deal with the problems of soil conservation through erosion control; also to the cash grain farmer, and to the livestock producer with his summer grazing procedures and winter feeding management problems.

They go even farther, in fact, and must be given high priority in the thinking of the agricultural economist. They influence to a significant degree not only short time procedures but also the long time national economy. It is believed that the factual material contained in the chapters which follow will prove of value in the solution of some of these problems.

Time Required for Changes

Some years back William Newton Clark, writing about the time required for the introduction of new ideas said:

First the idea must be seen in enthusiastic vision by someone, and enunciated for the world to hear. It must get abroad among men, and be somewhat widely considered. It must come to be deemed important. Then it must be ignored, recognized, restated, ridiculed, refuted, denied, doubted, admitted, discussed, affirmed, believed, accepted, taught to adults, taught to children, wrought into literature, put into practice, tested by its fruits, allowed to modify other ideas, embodied in institutions; and in the course of some generations it will sink in among the certainties that are assured and acted upon without question and without thought. For this process two hundred years is but a short period.

But that statement was made before the day of high-pressure sales programs, before the air waves were crowded with commercially sponsored news, informational, and educational programs; before we had county agricultural agents in practically every county; before state colleges had their agricultural extension divisions with their corps of specialists and their well organized information bureaus, with radio stations at their command. That was before profusely illustrated informational booklets came into every home; before the day of the technicolor motion picture; before the day of the Farm Security Administration, the Soil Conservation Service, and other similar action agencies; before the organization of watershed areas, with funds, equipment, and trained personnel available to demonstrate the value of proved conservation practices; and finally, before the day of Soil Conservation Districts, organized in nearly every county in large parts of many states, with farm planners available to work with every individual farmer willing to co-operate.

We are not willing today to accept the idea that two hundred years is but a short period in which to expect new ideas to “sink in among the certainties that are assured, to be acted upon without question and without thought.”

Progress toward a Grassland Agriculture has been made; this progress will be more apparent and rapid in the years ahead.

A PROPOSED GRASSLAND PHILOSOPHY

Dr. P. V. Cardon, formerly in charge of the Division of Forage Crops and Dis-
in rotation with other crops because they appreciate its intrinsic value. Then soil conservation, in all its aspects, will follow as a natural consequence.

Farmers will accord grass its proper place in American agriculture when they become convinced that grass culture is economically feasible not only as a dependable source of food for livestock, but as a soil improving crop to be reflected in the returns from other crops and as an otherwise legitimate component of cropping enterprises.

To this end, all research, educational, and action agencies could well afford to align their forces. In such alignment these forces could view grass culture broadly and with respect to its place in farm practice within wide areas. They will give full consideration to the economy of grass in current use, as well as to its value in preserving soil for future generations of society.

** **

THE LAST OF THE VIRGIN SOD

We broke today on the homestead
The last of the virgin sod,
And a haunting feeling oppressed me
That we'd marred a work of God.

A fragrance rose from the furrow,
A fragrance both fresh and old;
It was fresh with the dew of morning,
Yet aged with time untold.

The creak of leather and clevis,
The rip of the coulter blade,
And we wreck what God with the labor
Of a million years had made.

I thought, while laying the last land,
Of the tropical sun and rains,
Of the jungles, glaciers and oceans
Which had helped to make these plains.

Of monsters, horrid and fearful,
Which reigned in the land we plow,
And it seemed to me so presumptuous
Of man to claim it now.

So when, today on the homestead,
We finished the virgin sod,
Is it strange I almost regretted
To have marred that work of God.

RUDOLF RUSEK
GRASS—HAY—PASTURE
From Genesis to Revelation

**Genesis 1-12:**
And the earth brought forth GRASS . . . whose seed was in itself, after its kind: and God saw that it was good.

**Genesis 47-1:**
They said moreover unto Pharaoh, for to sojourn in the land are we come; for thy servants have no PASTURE for their flocks; for the famine is sore in the land of Canaan . . .

**Deuteronomy 11-15:**
And I will seed GRASS in thy fields for the cattle, that thou mayest eat and be full.

**1 Kings 4-23:**
Ten fat oxen and twenty oxen out of the PASTURES, and an hundred sheep. beside harts, and roebucks, and fallow deer, and fatted fowl . . .

**1 Kings 18-5:**
And Ahab said to Obadiah, Go into the land, unto all fountains of water, and unto all brooks; peradventure we may find GRASS to save the horses and the mules alive, that we lose not all the beasts.

**Psalms 65-13:**
The PASTURES are clothed with flocks; the valleys also are covered over with corn; they shout for joy, they also sing.

**Psalms 104-14:**
He causeth the GRASS to grow for the cattle, and herb for the service of man; that he may bring forth food out of the earth.

**Proverbs 19-12:**
The king's wrath is as the roaring of a lion: but his favor is as dew upon the GRASS.

**Isaiah 15-6:**
For the waters of Nimir shall be desolate: for the HAY is withered away, the GRASS faileth, there is no green thing.

**Isaiah 40-8:**
The GRASS withereth, the flower fadeth: but the word of the Lord shall stand forever.

**Joel 1-18:**
How do the beasts groan, the herds of cattle are perplexed, because they have no PASTURE: yea the flocks of sheep are made desolate.

**Joel 1-20:**
The beasts of the field cry unto thee: for the rivers of waters are dried up and the fire hath devoured the PASTURES of the wilderness.

**Matthew 14-19:**
And he commanded the multitude to sit down on the GRASS, and he took the five loaves and the two fishes, and looking up to heaven, he blessed and brake, and gave the loaves to his disciples, and the disciples to the multitude.

**Revelation 9-4:**
And it was commanded that they should not hurt the GRASS of the earth, neither any green thing . . .

—After E. W. Hamilton
Milwaukee, Wisconsin
Chapter 2

What Is Grassland Farming?

When row-crop and livestock production are built around the grassland acres on individual farms and ranches—that is grassland farming. The grassland acres include land devoted to the culture of forage grasses and legumes grown alone or in combination. The grassland farmer takes into account soils, plants, animals and their inter-relationships. Adequate acreages of adapted grass-legume combinations are provided, depending on soil needs. High quality forages are emphasized in livestock production, with grains supplementing rather than dominating the feeding practices.

Grassland farmers are often craftsmen in the culture and use of grass. When grassland farming is practiced intensively, organic matter is renewed, soil erosion prevented, gully formation arrested, and soil tillage improved. Soil conservation is the inevitable result of grassland farming. It results in more bushels of corn and other grains from fewer acres. Less labor and machine costs per unit of production are required.

As Myers points out:

Forage crops are still the orphan children on the majority of farms in the United States. In the earlier days, of course, forage crops were relegated to the poorest areas of the farm. The pasture land was considered to be that land that was not useful for the growing of other crops... The farmer used the very best land he had for the production of corn and wheat and other cultivated crops and used whatever land remained for the production of grasses and legumes.

A GRASSLAND PHILOSOPHY

A sound national grassland philosophy must be developed before grassland farming will be generally practiced on individual farms. When so practiced it will result in a permanent, highly productive agriculture. To accomplish this will require the best thinking and efforts of farmers as well as of all leaders and workers in the applied phases of agriculture.

It has been pointed out by Graber that, "Grassland farming" is not a catch phrase, it is a trend whereby farmers are emphasizing the use and value of their grass-legume crops in their over-all operations. The soil and climate, together with those factors that govern the production and utilization of grasses and legumes, will determine the intensity of grassland farming in different parts of the coun-

FORAGES
The Science of Grassland Agriculture

UNDER THE EDITORIAL AUTHORSHIP OF
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With 52 additional contributing authors,
selected for their recognized leadership
in the field of Grassland Agriculture

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Fig. 2.1 “Grassland farmers are craftsmen. . . . organic matter is renewed, soil erosion prevented, gully formation arrested, and soil tillth improved. . . . It results in more bushels of corn and other grains from fewer acres. Less labor and machine costs per unit of production are required.” (See p. 16.)

A Grassland Philosophy

try. Although the forage plants in the range country may be quite different from those of the humid south or north, the principles to be followed are similar regardless of location. These principles have to do with the productivity of the soil as measured by response to management when the sod crops are made the foundation of the farm and ranch operation. The Wisconsin College of Agriculture Grassland Committee believes:

Grassland agriculture is a long-time program directed towards increased production from improved grasslands and more efficient use of high quality forage, rich in protein, minerals, and protective vitamins.

Shifts from a cash crop system, such as cotton in the South, and grain in the North and West, to one emphasizing forage production and utilization with livestock, require additional skills and a much higher type of management by the farm operator. The ultimate in grassland farming requires the highest type of farm management. It will result in the greatest return possible over a long period of years. It is balancing the physical factors of production at a high level and at the same time giving us an adequate diet.

The Bureau of Agricultural Economics of the U.S.D.A. states that if we raised our per capita consumption 8 per cent above that of 1946 to supply an adequate diet, our 1955 population would require 10 per cent more dairy products; 8 per cent more meat, poultry, and fish; 9 per cent more fats and oils, including butter, bacon, and fat cuts; and 29 per cent less grain products. The grassland farming trend will provide for the neces-

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sary shifts to the kinds of foods needed.
Stapledon, after many years of research and observation on grasslands, concluded:

Grass (... grass and clover) properly used insures soil fertility, grass marries the soil to the animal and the solid foundation of agriculture is the marriage of animal and soil. That spells humus. ... Grass properly employed counteracts the devastating influence of erosion.

The outstanding feature of grassland is its complexity. ... Soil, climate, grazing animal. Which of these three is the most important factor? Most emphatically the grazing animal: Manure right, sow right, and manage the grazing animal wrong and you are nowhere. Without the grazing animal there would be no grassland worthy of the name anywhere in the world. Management is therefore the key to the solution of the whole grassland problem.

Cardon observed that grassland farming is not necessarily an extensive farm operation. In some places it is very intensive—as much so as vegetable culture.

Inseparably linked with livestock production, grassland agriculture under good management may equal or increase the production of digestible nutrients to the acre and reduce materially the labor needed to grow and utilize a given amount of those nutrients. It may also lower significantly the cost of supplying the protein—often bought as a concentrate—required for high levels of animal nutrition. Grassland agriculture envisions the use of grasses and legumes alone or in combination or rotation according to systems of management best suited to land use under various environments, with ample provisions for root crops, leafy vegetables, fruits, fibers, forests, and specialty crops as needed.

Thus grassland agriculture differs from other types of farming chiefly with respect to the emphasis placed on grasses and legumes. They are dominant in a flexible pattern designed to conserve the land and its productivity but at the same time keep it adjustable to emergency needs.

Cardon also stated:

America today is definitely grass-minded, but America still lacks the profound grass-consciousness which prompts Europeans to take advantage of favorable physical conditions, to grow more and better grass, and to utilize it to better advantage.

Grass-consciousness differs from grass-mindedness. The one may be and probably is an outgrowth of the other, but grass-consciousness is the more profound. Grass-mindedness inspires grass culture for specific purposes, as, for example, a corrective of soil erosion. Grass-consciousness, on the other hand, regards such specific uses of grass as incidental to its primary uses. It is grass itself that is important—Grass is a farm crop which is worthy of as good land and as intelligent culture as any other crop. Grass is a crop around which to build profitable farm enterprises; it conserves the land, it benefits other crops grown in rotation with it, it is the basis of a type of farming in which the control of erosion, the protection of water sheds, and the improvement of pastures and ranges follow as matters of course. Thus, grass-consciousness recognizes and utilizes the intrinsic greater value of grass without discounting, but automatically providing for the full play of its incidental values. The culture of other crops fits into this grassland background and grassland agriculture emerges. ...

Grassland agriculture represents a definite advance towards stabilized agriculture. It is not a reversion to pastoral practices. It cuts across all phases of agricultural production and therefore commands a high degree of managerial ability. It calls for all of the skill usually required in crop production plus the application of that and other skills in the production of crops in rotation with grass. The successful establishment and maintenance of good grass cover requires skillful application of the best agronomic information available, and there is much still to be learned about the breaking and preparation of sodland for succeeding crops in rotation of which grass is a part. Moreover, the utilization of grass, if it is to be made profitable, requires knowledge of a high order pertaining to animal production. A successful grassland farmer, in other words, must be a very good all-round farmer. ...

Complementary Benefits From Forages

In grassland farming the complementary benefits of the sod crop are many.

FEED FOR LIVESTOCK. One of the most important benefits of high quality, productive forages is the fact that they
Climatic and soil conditions determine where forages can be grown. They also affect the yield obtained. But it is economic considerations which finally decide where, when and how much forages should be grown. Economic considerations determine whether forage, grain, fiber, or other crops should be grown under a given condition.¹

**FORAGE AMOUNT A FARM MANAGEMENT PROBLEM**

Each individual farmer must consider forage crops from the standpoint of how they fit into the pattern of his farm. Farmers ordinarily have limited resources to work with. So they must decide how they can use their labor, capital, and land most profitably. To maximize profits it is necessary that the farmer use each unit of limited resources where it will bring him the greatest return. He must decide whether to invest scarce capital in legume seed, fertilizer, brood sows, machinery or some other investment alternative. He must decide whether a day of labor or an acre of land will bring in greater returns if used to grow alfalfa, corn, peanuts, cotton, wheat, or some other crop. He must make similar choices between crops and livestock enterprises, also between different kinds of livestock. For example, he should use labor to produce pork instead of forage only under one condition—if the dollar return from a day’s work spent on hogs is greater than the return from the same amount of labor spent on alfalfa, clover, or some other hay crop. Finally, he must decide whether, or consider how, the different enterprises fit into a pattern for his farm as a whole.

Some farm enterprises are in direct competition with each other. Other crop and livestock enterprises go together, hand-in-hand. The best livestock enterprise for any one farm depends partly on the crops which can be grown and on the yield of these crops. At the same time, however, the livestock program which is most profitable under a given condition helps determine which crops should be grown. For example, a farmer living in a certain milk shed may have conditions which would make high yields of corn and wheat possible. A high price for whole milk and the returns from

¹ Heady, Earl O. The economics of rotations with farm and production applications. *Jour. Farm Econ.* 33:441-457, 1951.
dairying, however, may lead him to produce only hay and pasture on his own land. He does this to support as large a number of dairy animals as possible. He can buy concentrate feeds.

The questions of the most desirable rotation or of the most profitable ration to be fed a given class of livestock are not distinct and separate problems. They are problems that must be considered together if maximum farm profits are to result.

Some Questions To Be Answered

When forages are to be produced in the farm program some of the questions that must be answered are: (a) How many acres should be grown? (b) What type and variety? (c) What level of acre yield should be attained through varying the rates of applying fertilizer, seed, and other cultural practices? (d) Should the forage be harvested as pasture, hay or silage? (e) If harvested as hay, should a baler, chopper or hay loader be used?

Agronomy provides basic yield data while engineering provides information on machine performance in answering these questions. Price and cost information must be added to these data in arriving at the final dollars and cents answer. Each farmer must take the responsibility for making the best use of the soil resources, capital, labor, and managerial ability at his command. There is no "fixed recipe" which will tell all farmers exactly the amount of forage to produce. The amounts, kinds, and yields of forages and the methods of harvesting and utilizing them must be solved. It is a problem peculiar to each individual farm.

There are certain economic principles which apply. These determine the conditions under which the production of additional kinds and amounts of forages will increase farm profits. They cannot be developed in this one short chapter. Only the broader and more general economic aspects of forage production will be considered.

COMPARATIVE ADVANTAGE

The average amount of forage produced per farm varies greatly between different localities. In some areas nearly all the land area is devoted to grasses and legumes. Some regions grow very little of these crops. In other areas a near-even balance exists between forage and grain or fiber crops. The areas which can produce the highest acre yields of grasses or legumes do not always specialize to the greatest extent in these crops.

The principle of comparative advantage is the economic law which helps explain this regional specialization. In general, this principle or law indicates that crops should not always be grown where absolute yields and income per acre are greatest. Rather they should be produced where relative or comparative yield and return are greatest.

For example, the yield per acre of both forage and grain crops is greater in the Corn Belt than in most of the Great Plains area. Certain sections of the Corn Belt, however, grow a greater acreage of grain than of grasses and legumes. At the same time in parts of the Great Plains practically all the land is devoted to grasses and livestock grazing. Here the Corn Belt has an absolute advantage in both forage and grain crops. Yet the
Great Plains grazing area has a "comparative or relative advantage" for grasses. The reason—its yield disadvantage for grass is less than for grain crops.

In the same vein, the Corn Belt has a comparative advantage for grain, since its actual advantage for corn, oats and soybeans is greater than for the forage crops.

To illustrate: Suppose that in region $A$ an acre of land along with the necessary capital and labor will yield either 2.5 tons of hay or 60 bushels of corn. In region $B$ the yields for hay and corn are 1.5 tons and 30 bushels, respectively. Region $B$ has a comparative advantage in hay because the yield is 60 per cent as great as in region $A$ while the corn yield is only 50 per cent as great. Conversely, $A$ has the comparative advantage in corn.

Here is another illustration of this principle. Business executives, or professional workers such as lawyers and doctors, often are more adept at bookkeeping than their secretaries. Or, they can dust office equipment at a more rapid pace than the charwomen who perform these duties. Yet the business executive or medical specialist can make a greater return by devoting his efforts to professional duties, where he has an even greater advantage.

It must be borne in mind, also, that consumers of commodities and services help establish the comparative advantage and the amount of specialization in any one crop or enterprise. The prices consumers are willing to pay tend to push each region into producing the product for which it has the greatest relative advantage. Market prices reflect the consumers' desires for different products. Aside from geographical variations this is the same for all farmers. In effect, the consumer thus indicates that the farmer with the lowest relative costs (not always the lowest absolute costs) should produce a given crop.

Historically, broad regions with varying degrees of specialization in grasses and legumes have become established. Some regions produce forages because the topography and climate make it impossible to produce any other crop. But mainly, forages are produced in areas where they have a comparative advantage over other crops. There are important possibilities for the substitution of forage for grain crops in many of our agricultural regions. This is a Dallis-Bermuda-carpetgrass-clover mixed lowland pasture in Georgia. U.S.D.A. photo.
Economic Aspects of Forage Production

forage for grain crops in many of our agricultural regions.

Changes in comparative advantage are brought about especially by: (a) changes in consumers' tastes for different things, and hence the prices which they are willing to pay for them as compared to others; and (b) changes in the acre yield or costs of one crop as compared to that of other crops.

The American diet is fairly stable. Therefore, the greatest opportunity for increasing the comparative advantage of forage crops relative to grain and fiber crops is through increasing the relative acre return as compared with that of other crops.

Best Combination With Other Crops

Very few farming regions in the United States have such a distinct advantage in grain, fiber, fruit, or other crops that they cannot afford to devote any of their land to forage production. Generally, the problem is to get the best combination of forages with other crops.

The proper combination from a national economic standpoint is one which gives both a maximum satisfaction to consumers and a maximum profit to farm operators. Once this balance has been struck, any major shift away from it is to the disadvantage of both farmers and consumers.

ROLE FOR THE INDIVIDUAL FARM

Any farm manager has the problem of deciding on the most profitable combination of crop and livestock enterprises. The manner in which enterprises should be combined depends partly on the relationships which they bear to each other. Farm enterprises fall into three categories depending on their relationship to one another. They are either competitive, complementary or independent.4

The competitive and complementary classifications best explain the economic role of forage crops in the organization of a farm in order to maximize profits. These two general relationships help explain not only which farms should grow grasses or legumes but also help determine how many acres of forage should be grown on any one farm.

Complementary Relationships

Enterprises are complementary with each other when the production of one increases the quantity of the other from given resources. The complementary nature of grasses and legumes is perhaps the most important reason explaining their place in the farm organization.

Forage crops are complementary with grain crops when an increased acreage and production of these forage crops also increases the total production of grain from a given farm or area of land.

The reasons why forage crops may serve in a complementary relationship to grain crops are outlined in other chapters. They are mainly these:

1. Legumes add nitrogen to the soil. This becomes a direct source of plant food for later grain crops.

2. Grasses and legumes add organic matter to the soil. Thus they have a beneficial effect on soil structure and tilth. This may increase the per acre yield of crops which follow in the rotation. The better soil drainage brought about permits more timely planting and cultivation of the crop. Or grasses and legumes may have direct yield effects through the chemical and physical processes of the soil.

3. Forage crops grown in rotation

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4 See the following books for a complete discussion of these relationships: Hopkins, Loc. cit.* Chapter 3. Black, Loc. cit.* Chapters 16, 17, 18. Forester, Loc. cit.* Chapter 3.
Forages Reduce Runoff and Erosion

Wind erosion is estimated to be active in some degree over more than 200 million acres of farm and grazing land in the Great Plains area from Texas to North Dakota and in other parts of the West.

**FORAGES REDUCE RUNOFF AND EROSION**

The United States Department of Agriculture in cooperation with various state stations has reported the results of studies on factors affecting erosion and methods of control for important soil and climatic areas throughout the United States.

A summary emphasizing the role of forage in reducing runoff and erosion is shown in Table 4.1. It is evident that runoff and erosion vary widely for different soils and with the degree of slope. The most outstanding differences, however, are between the runoff and erosion from row crops and from sod crops. For example, Muskingum silt loam in Ohio had a soil loss of 99.3 tons per acre from corn and .02 from a bluegrass sod. From row crops 40.3 per cent of the total rainfall was lost as runoff whereas only 4.8 per cent was lost from bluegrass sod. Approximately 7500 years would be required to erode one inch of soil under bluegrass. In contrast, the loss of 99.3 tons per acre under continuous corn would require 1.5 years to remove an inch of soil by erosion.

The data in Table 4.1 are average annual losses that include all types of rain. But the real value of forages in control-
TABLE 4.1

EFFECT OF ROW AND SOD CROPS ON RUNOFF AND EROSION ON DIFFERENT SOILS

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Location</th>
<th>Slope %</th>
<th>Soil loss T/A</th>
<th>Runoff %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marshall silt loam</td>
<td>Iowa</td>
<td>9.0</td>
<td>38.3</td>
<td>.03</td>
</tr>
<tr>
<td>Shelby loam</td>
<td>Mo.</td>
<td>8.0</td>
<td>50.9</td>
<td>.16</td>
</tr>
<tr>
<td>Muskingum silt loam</td>
<td>Ohio</td>
<td>12.0</td>
<td>99.3</td>
<td>.02</td>
</tr>
<tr>
<td>Stephenville fine sand loam</td>
<td>Okla.</td>
<td>7.7</td>
<td>18.9</td>
<td>.02</td>
</tr>
<tr>
<td>Cecil clay loam</td>
<td>N. C.</td>
<td>10.0</td>
<td>31.2</td>
<td>.31</td>
</tr>
<tr>
<td>Kervin fine sandy loam</td>
<td>Texas</td>
<td>8.7</td>
<td>24.0</td>
<td>.08</td>
</tr>
<tr>
<td>Kervin fine sandy loam</td>
<td>Texas</td>
<td>16.5</td>
<td>61.1</td>
<td>.005</td>
</tr>
<tr>
<td>Nacogdoches sandy loam</td>
<td>Texas</td>
<td>10.0</td>
<td>6.5</td>
<td>.005</td>
</tr>
<tr>
<td>Austin clay</td>
<td>Texas</td>
<td>4.0</td>
<td>20.6</td>
<td>.02</td>
</tr>
<tr>
<td>Austin black clay</td>
<td>Texas</td>
<td>2.0</td>
<td>7.8</td>
<td>.08</td>
</tr>
<tr>
<td>Fayette silt loam</td>
<td>Wis.</td>
<td>16.0</td>
<td>111.7</td>
<td>.10</td>
</tr>
</tbody>
</table>

Row crop was continuous corn on Marshall, Shelby, Muskingum, Fayette, and Austin soils. Cotton was grown on the Stephenville, Cecil, Kervin, and Nacogdoches soils. The sod crop was either Bluegrass or Bermudagrass.

The effect of vegetative soil cover on soil loss by erosion between corn harvest, September 29, and seedbed preparation time the following May 9. Missouri Soil Conservation Experiment Farm, McCredie (Mo. Agr. Exp. Sta. Bul. 518).

**CANOPY INTERCEPTION**

Anyone who has walked through a field of grass, hay or corn after a rain realizes that a considerable portion of the precipitation clings to the leaves and must later either pass down the stalks of the plant to the soil or be lost by evaporation. Horton's comprehensive review of early investigations on rainfall

TABLE 4.2
RUNOFF AND EROSION FROM CORN AND SOD DURING A SINGLE INTENSE RAIN ON MARSHALL AND SHELBY SOILS

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Location</th>
<th>Rainfall in.</th>
<th>Soil loss T/A Corn</th>
<th>Soil loss T/A Sod</th>
<th>Runoff % Corn</th>
<th>Runoff % Sod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shelby loam</td>
<td>Mo.</td>
<td>3.76</td>
<td>46.0</td>
<td>.05</td>
<td>68.0</td>
<td>39.0</td>
</tr>
<tr>
<td>Marshall silt loam</td>
<td>Iowa</td>
<td></td>
<td>37.0</td>
<td></td>
<td>70.0</td>
<td>2.3</td>
</tr>
</tbody>
</table>

interception shows wide variation in the percentage of rainfall intercepted by different types of vegetation. Haynes found that 35.8 per cent of the 10.8 inches of rain that fell between April 27 and September 15 was intercepted by alfalfa. Similar studies with corn for the period May 27 to September 15 show that 15.5 per cent of the 7.1 inches of rain that fell in 27 storms was intercepted by corn. Oats intercepted 6.9 per cent of the 6.8 inches of rain that fell in 35 storms from April 15 to June 30. His general conclusions are that interception of rainfall increases directly with the increase of vegetative cover. Forages with their dense covering of leaves and stems afford maximum canopy interception of rainfall.

In 1874 Wollny observed that rye, peas, and vetch protected the soil from the raindrops to such an extent that the non-capillary porosity of a shaded, humus containing, calcareous sandy soil was from 34 per cent to 53 per cent higher than adjacent unprotected soil. He attributed these differences to the protection of the soil from the dispersive action of raindrops which destroyed the surface structure. In unprotected soil the percolating water which contained the finer soil particles decreased the porosity. Later work confirms the findings of Wollny.

Although forages intercept an appreciable amount of rainfall their greatest benefit is in controlling erosion by protecting the surface of the soil from the beating action of raindrops.

**Type and Amount of Vegetation Influence Runoff and Erosion**

Numerous studies are available that show the effect of protecting the soil surface with vegetation or mulch in reducing runoff and erosion. Duley and Kelley described and photographed the formation of a compact surface layer which greatly reduced the infiltration rate and showed the effect of mulch in preventing its formation.

The effect of forages on runoff and erosion has been shown to be directly related to the type and amount of growth. Alderfer and Robinson found a rate of runoff in inches per hour of

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Fig. 4.4 The increased efforts being made to save and improve our soils center on the use of hay and pasture crops. This use is supported by contour and strip planting, with well planned and maintained grass waterways. The new cropping pattern for rolling and erosive soils is well illustrated here by the area which surrounds one of the 12 "Great American Churches" featured in 1950 by *The Christian Century and Life* magazines—the Washington Prairie church in the Decorah, Iowa, area. Photo by William R. Wilson.
1.3 from a poor pasture sod heavily grazed. On an adjacent site of poor sod, not as heavily grazed but clipped, the rate of runoff was about .8 inches per hour. On a good sod heavily grazed the rate of runoff was about .5 inches per hour. On an excellent sod heavily manured, lightly grazed but clipped, less than .1 inch per hour of rainfall was lost as runoff. On the excellent sod no runoff was observed until 30 minutes after the rain started, whereas on the other sites runoff started within a few minutes. Heavy grazing not only reduced vegetative cover but decreased the non-capillary porosity and also decreased the volume of the 0 to 1 inch layer of soil. This is important. On most of our soils the condition of the immediate surface influences to a large extent the rate of water penetration and, indirectly, the rate of runoff and erosion. A direct relationship was found between the rate of runoff and compaction of the 0 to 1 inch layer of soil. This emphasizes the importance of careful management of pasture areas to prevent trampling and puddling of the immediate surface soil by livestock during periods when the soil contains excessive moisture.

Duley and Kelley\textsuperscript{10} found that grassland permanently in sod had an effect similar to that of a heavy mulch in allowing a high rate of intake of water. When the grass and debris were removed from the surface the rate of intake decreased rapidly.

Pasture management practices, including the intensity of grazing and the use of fertilizer practices such as a combination of fertilizer and lime to stimulate the amount and density of cover growing, are important factors influencing runoff and erosion. Gard et al.\textsuperscript{11} found a soil loss of 3544 pounds per acre from a treated and severely-grazed pasture. This is in contrast to 389 pounds from a treated and moderately grazed pasture. The total percentage of rainfall loss as runoff was 17.3 for the severely grazed and 9.4 for the moderately grazed pastures. These data are from four years of study at the Dixon Springs Soil and Water Conservation Experiment Station in southern Illinois. The amount of runoff from a rain of 4.02 inches on July 3 and 4, 1941, is an excellent example of what may be expected during drought periods. On the treated severely-grazed plot, 3/4 of the rainfall, or 1.45 inches, was lost as runoff. Only about 1/24, or 0.17 inches, was lost from the treated moderately-grazed area. These studies also showed that the additional moisture available for the moderately-grazed areas was effective in stimulating growth for greater forage production.

Browning and Sudds\textsuperscript{12} found the rate of water penetration in undisturbed orchard sods to be approximately five times that from adjacent areas that had been cultivated with little vegetation present and subject to disturbance and some compaction by spray rigs and farm machinery. The unusually high infiltration rate of about five inches per hour found on the sodded areas may be explained by the unusually loose and friable condition that developed over a period of years from vegetation that was allowed to grow undisturbed and return to the surface. Worm holes, insect burrows, and channels left by decayed roots also were factors in the development of the unusually high infiltration rate.

**Crop Residues Reduce Runoff and Erosion**

In addition to their direct beneficial effect in controlling runoff and erosion,
Forages also are effectively used as surface mulches to reduce runoff and erosion. The formation of a semipervious layer at the immediate soil surface, often only a few millimeters thick, can be largely prevented with a cover of residue or by a growing forage crop.

Duley and Kelley \(^\text{13}\) found the average infiltration rate for six widely different soils to be .74 inches per hour on the bare cultivated area. In contrast, adjacent areas covered with mulch had an infiltration rate of .24 inches.

Borst and Woodburn \(^\text{14}\) concluded that the beneficial effect of mulch on the surface in eliminating the raindrop impact, with its destructive effect on the soil surface, rather than the reduction of overland flow velocity was the major contribution of the mulch in reducing soil loss.

\(^{13}\) Duley, F. L., and Kelley, L. L. Loc. cit.\(^8\)


**FORAGES FOR GRASS WATERWAYS**

A mat of grass and grass roots has no equal in holding soil. Severe erosion and gullies develop where natural drainage ways are not maintained in sod. The success of contouring, strip cropping, and terracing depends on the safe disposal of excess rainfall by the use of grass waterways. Grass waterways may well be considered the foundation of such erosion control practices as effective rotation, strip cropping, contour farming, terracing, gully control, and intelligent farming in general.

The plant cover protects the waterway channel surface from the erosive action of flowing water and hinders the movement of soil particles from the channel bed. This protective action varies with the kind of vegetation and with the uniformity of cover. On individual kinds of vegetation it varies according to the age and condition of the plants, whether the vegetation is cut short or left long, and the season of the year. The type and
amount of vegetation in the waterway have a marked effect on the capacity and stability of these channels. Ree and Palmer have developed graphs for determining the maximum conditions under which different types of vegetation are effective in resisting the erosive action of runoff water in grass waterways. A number of authors outline the steps in the preparation and seeding of a grass waterway. They call attention particularly to the size of the area to be drained, the width of the waterway, preparation of seedbed, manure and fertilizer treatments, grass mixtures, seeding rates, and maintenance.

17 Leffler, Allan T. Contouring and grass waterways made easy. Iowa Agr. Ext. Ser. 63 (Revised), 1945.

**STRIP CROPPING**

Strip cropping is the arrangement in alternate strips of erosive intertilled crops and small grain crops with conserving grasses and legumes, at right angles to the natural slope of the land. This has been shown to be effective in reducing runoff and erosion. Close-growing forage crops are the key to successful strip cropping. The strip of meadow serves as a buffer to slow down and disperse the rate of runoff from the intertilled area. The velocity of the silt-laden water is reduced as it enters the sod strip, causing the deposition of much of the silt in the sod strip. It also prevents concentration of water in low areas which, if allowed to flow uncontrolled from the field, would in time develop gullies. Studies at the several soil erosion experiment stations have shown that, on the average, strip-cropped fields lose only
about one-fourth as much soil as comparable fields not strip cropped.\textsuperscript{16} The different types of strip cropping, factors to consider in developing a strip-cropping plan and its effect on general farm operation have been discussed by a number of workers.\textsuperscript{20, 21, 22}

**FORAGES AS COVER CROPS**

The planting of cover crops is an important part of a good cropping system. Such crops are planted in, or following, erosive intertilled crops to help prevent erosion and the leaching of plant nutrients. This is particularly true in those sections where mild winters leave farm land unprotected from the ravages of erosion during the high-intensity rains that frequently occur in those areas. Studies by Copley et al. in North Carolina\textsuperscript{23} show the value of cover crops in controlling runoff and erosion.

Soil and water losses from a desurfaced Cecil Clay soil, cropped continuously to cotton without a cover crop, were compared with losses from a corn-cotton rotation in which rye and vetch were seeded as the cover crop in the corn, with cowpeas as the cover crop in the cotton. It has been found that approximately the same amount of erosion occurs under corn and cotton. In the cropping system without a cover crop, 32.2 tons per acre of soil and 11 per cent of the total rainfall were lost. In the system with cover crops, 18.2 tons per acre of soil and 7.2 per cent of the rainfall were lost.


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**Forages in the Rotation**

On a Dunmore silt loam soil in Virginia the use of a rye and vetch cover crop materially reduced the amount of water lost as percolate and the loss of plant nutrients.\textsuperscript{19} On fallow land, 22.9 per cent of the rainfall was lost as percolate. When a rye and vetch cover crop was used, only 16.2 per cent of the rainfall was lost as percolate, or a reduction of 29 per cent as the result of the cover crop. The percolate from the fallow areas contained 37 per cent more magnesium and calcium carbonate, 77 per cent more potassium, and 126 per cent more nitrate nitrogen than adjacent areas on which cover crops were used.

The effects of cover on erosion after corn harvest at the McCreedy (Missouri) Soil Conservation Experiment Farm are shown in Figure I.3.\textsuperscript{25}

**FORAGES IN THE ROTATION**

If farmers could devote all of their land to forest trees and properly managed pastures there would be virtually no erosion. But the average farm in this country will not support a family if the entire area is used for either timber growing or for grazing. Food and fiber requirements for our civilization necessitate the production of intertilled crops. This can be done and the productivity of the land maintained providing the right combination of depleting row crop and conserving forages is supplemented with supporting practices, such as contouring, strip cropping, and terraces, adapted to the needs of the land.

Hays and Clark\textsuperscript{25} developed a series of rotations for Fayette soils in Wisconsin that will minimize soil losses under
different land conditions. Similar recommendations also have been developed for Missouri \(^27\) and Iowa. \(^28\)

**FORAGES AFFECT SOIL TEMPERATURE**

Some of the highest rates of runoff occur in early spring when the ground is frozen. Erosion also can be serious at this time unless the land is protected with vegetation. Numerous investigators have shown the effect of vegetation on soil temperature. In addition to protecting the surface from erosion a good cover of forages may keep the soil from freezing and thus allow greater percolation of water. The effect of snow cover and vegetation on Michigan soil temperature at a three-inch depth is shown in Table 4.4. \(^29\) Under Michigan conditions, minimum January temperature three inches below the surface for bare land was 7.5°F, for land covered with snow 27.0°F, and for vegetative cover with snow 32.0°F.

Bouyoucos \(^30\) concludes from four years study that in exceptionally cold weather soil protected by vegetation and a layer of snow may have 25°F higher temperature than bare soil at a three-inch depth, and that the soil temperature fluctuates less under sod than where the soil is bare.

Snow depth and frost penetration studies were made during the winter of 1935–36 on the Big Creek watershed in North Central Missouri (Table 4.4). \(^31\) Average frost penetration was 25 inches on bare land, 12 inches with vegetative cover not over 5 inches tall, and 5 inches where the vegetative cover was over 5 inches tall. Average snow accumulation was in reverse order. On bare land the average snow depth ranged from 0–4 inches, whereas snow accumulated to depths of from 10–24 inches where the

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\(^{27}\) Smith, Dwight D. et al. Loc. cit. 27


\(^{31}\) Anonymous. Loc. cit. 30
\begin{table}
\centering
\caption{Effect of Snow Cover on Soil Temperature at 3-Inch Depth, January, 1915}
\begin{tabular}{lccc}
\hline
Temperature determined & Temperature of & Soil temperature at depth of 3 inches & \\
& the air & Bare & Snow bare & Snow uncompacted, vegetation \\
\hline
Maximum & $+41$ & 32.3 & 32.3 & 35.7 \\
Minimum & $-13$ & 7.5 & 27.0 & 32.0 \\
Average maximum & $+27.96$ & 38.79 & 31.51 & 34.82 \\
Average minimum & $-13.80$ & 24.95 & 31.11 & 34.55 \\
\hline
\end{tabular}
\end{table}

\begin{table}
\centering
\caption{Determinations of Snow Depth and Frost Penetration in Big Creek Watershed, MO, Under Different Cover Conditions}
\begin{tabular}{lccc}
\hline
Cover condition & Av. snow depth & Av. frost penetration & Estimated absorption during thaw \\
\hline
Barren & 0 to 4 & 25 & 0 to 50 \\
Vegetative cover (not over 5 inches tall) & 4 to 10 & 12 & 50 to 90 \\
Vegetative cover (over 5 inches tall) & 10 to 24 & 5 & 90 to 100 \\
\hline
\end{tabular}
\end{table}

vegetative cover was over 5 inches tall. It is apparent from these data that a cover of vegetation and snow has an important effect on soil temperature and absorption of water.

\section*{Forages and Soil Tilth}

The main value of crop rotation from the standpoint of erosion control lies in the sod crop and the reduction in soil cultivation or soil tillage. It has been pointed out by Bradfield\footnote{Bradfield, Richard. Soil conservation from the standpoint of soil physics. \textit{Jour. Amer. Soc. Agron.} 29:83–92, 1937.} that sod crop, and grass in particular, produce an excellent physical soil condition and that this is essential in erosion control. Crop rotation alone will not control erosion, but it is fundamental to erosion control and a permanent agriculture. It has been seriously neglected and now must be given its place. The introduction on the farms of this country of crop rotations adequate for erosion control when supplemented by supporting practices, fertilizer and manure use, and good farm management will aid materially in stabilizing crop production and in developing a sound and permanent agriculture.

Crop rotations with adequate sod crops are the key to good soil tilth. Soils that contain a high percentage of large, stable granules, as a result of sod crops in the rotation, are more resistant to the erosive action of raindrops than soils depleted of organic matter through intensive cropping to intertill crops and which contain few large, stable soil granules. Studies at erosion experiment stations show that, on the average, erosion from corn following a sod crop is only about one-half that from corn which follows a clean-tilled crop in the rotation.

The effect on soil aggregation of crops grown on Marshall silt loam for an
eleven year period is shown in Figure 4.8. Clover turned down before corn in the corn, oats, and clover rotation increases the aggregates 27 per cent as compared with continuous corn. This, in addition to the smaller plant growth available to protect the surface from the beating action of raindrops when continuous corn is followed, explains the 38.3 ton per acre soil loss under continuous corn. And this is in contrast to an 18.3 ton soil loss from corn that fol-

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Plant Roots Form Channels

The effect on soil loss and runoff of different crops, and different degrees and lengths of slope, has been determined for different soils in different parts of the country. The runoff water and soil from these plots are caught and accurate determinations of loss are made. *Iowa S.C.S. photo.*

In all cases sod crops have almost doubled the amount of stable aggregates present, in contrast to the situation under continuous corn. The increased aggregation that results from close-growing vegetation emphasizes the importance of including sod crops regularly in the rotation. This maintains a stable structure that resists the action of tillage implements and the beating action of raindrops during the period when the land is in intertilled crops.

Crops are known to differ materially in the type and amount of residue they leave in the soil. The chemical composition and amount of residue has also been shown to have an important influence on the amount and stability of the aggregates. Materials which decompose rapidly, such as legumes, bring about aggregation in a relatively short period of time—two or three weeks under field conditions—but lose their effectiveness within two or three months. On the other hand, the more carbonaceous materials require a longer period of time to affect aggregation but have a more lasting effect on soil structure.

PLANT ROOTS FORM CHANNELS

Channels left by decayed roots also perform an important function in water infiltration, storage of water, and soil and water conservation. These roots spread out through the soil in an amazingly complicated network, the density of the roots depending on the type and amount of the vegetation. This net-

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work is particularly dense close to the surface. Below two feet it is somewhat less so. While the roots are alive their growing tips force their way into minute cracks in the soil granules, expand and enlarge the opening, or break the granules into still finer particles. When the roots die, as happens annually with one-third or more of the roots, they soon decay, leaving channels through which water may penetrate into the soil. The beneficial effects of roots of grass and of such crop plants as alfalfa and sweetclover are much greater than most tilled crops. This is because of the extent of their root system and the size of the channels resulting from their decay.

FORAGES AND SEDIMENTATION

It is recognized that silt accumulating in natural and artificial reservoirs is rapidly decreasing their storage capacity and leaves the water unsuited for recreational purposes.

The seriousness of the reservoir-silting problem, particularly from an economic and engineering standpoint, deserves special consideration. There are more than 8,400 dams and reservoirs in the United States. A conservative estimate would place the initial investment in these at more than two billion dollars. The usefulness of at least one-fifth of them, representing probably three-quarters of the total investment, is in

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Fig. 4.10 The camera lens and film of the Navy Research Laboratory, much faster than the human eye, catch and hold the image of a raindrop (top) as it is about to strike the surface of a saturated soil. In sequence, the other photos show the action a moment later as the drop strikes the wet soil surface, dispersing surface materials much as a small explosion would do. The value and need of forage cover as a preventive of such action is coming increasingly to be recognized. U.S.D.A. photos.
water storage alone. When storage is gone as a result of silting their value will largely have disappeared.

Of 56 reservoirs examined by the Soil Conservation Service in the southern Piedmont region in 1934, 13 major reservoirs with dams averaging 29.8 feet in height were found to have been completely filled by eroded material within an average period of 29.4 years.

Numerous examples could be cited showing the damage by siltation to reservoirs where the watershed was not adequately protected by forages and other conservation measures. The story of Lake Decatur is typical. This story, in a well-illustrated publication, shows how the citizens of Decatur, Ill., more than twenty-five years ago built a 2,800 acre lake at a cost of two million dollars to provide a water supply and recreational facilities for the community. In twenty-five years this lake lost more than a fourth of its capacity by silting of precious topsoil from the fertile prairie soil in the watershed. Damage to the reservoir as well as to the farmland of the area would not have occurred if wise land use and conservation measures had been adopted on the entire watershed.

**QUESTIONS**

1. How many acres of land in the United States have been damaged by erosion?
2. What is canopy interception, and how is it related to soil conservation?
3. What is the relative effectiveness of clean-tilled row crops and forages in controlling runoff and erosion?
4. What forages, if any, are used for cover crops, and how do they influence soil conservation?
5. Under what conditions is strip cropping recommended? How effective is it as a conservation measure? What determines its effectiveness?
6. Under what conditions would forages be used as surface mulches, and what effect do mulches have on runoff and erosion?
7. What is soil tilth? What relation do crop rotations have to it?
8. Discuss crop rotations in relation to soil conservation.
9. How does the type and amount of vegetative cover affect soil conservation?
10. What effect does vegetative cover have on soil temperature, and how does this relate to soil conservation?

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SOIL FERTILITY

The term soil fertility in its usual sense refers to the broad combination of factors affecting fertility. Such factors as exchange capacity, per cent base saturation, aggregation, type of colloid, presence of toxic elements, organic matter content and level of essential elements are all components of soil fertility. It is not possible, with present information, to evaluate all of these factors as they are related to the nutritive value of forages. However, the nutrient level factor has been studied rather extensively, is fundamental to the growth of nutritive forage, and probably is the one that can be most readily improved in farm practice. Consequently, this discussion is confined largely to the nutrient level aspects of soil fertility as they relate to the nutritive value of forage.

NUTRITIVE VALUE

Nutritive value must be considered here in a restricted sense, i.e., chemical composition of plants in terms of the known requirements of animals for plant constituents. The biological analysis of plants has not progressed far enough at this stage to provide much data bearing directly upon the soil fertility problem. However, the approximate minimum requirements and desired amounts of protein, total digestible nutrients, and minerals are known for the various classes of livestock. These are presented in Table 5.4 as a basis for evaluating nutritive value. An increase in any constituent beyond the level considered adequate in the animal diet has not been proven to have nutritive value. There is, however, some evidence to indicate that nutrient levels may affect the nutritive value of plants in a manner not readily detected by chemical methods now in use. An article from the U. S. Plant, Soil and Nutrition Laboratory states: 1

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TABLE 5.1

AVERAGE PERCENTAGE OF NITROGEN, PHOSPHORUS, AND CALCIUM IN ALFALFA AND SMOOTH BROME IN 1948 AND 1949 WHEN GROWN AT 2 OR 3 FERTILITY LEVELS, ON 2 OR 3 SOIL TYPES, AND HARVESTED AT AN INTERMEDIATE STAGE OF GROWTH *

<table>
<thead>
<tr>
<th>Location</th>
<th>Soil Type</th>
<th>N</th>
<th>P</th>
<th>Ca</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALFALFA:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Madison</td>
<td>Miami silt loam</td>
<td>3.46</td>
<td>.342</td>
<td>1.61</td>
</tr>
<tr>
<td>Marshfield</td>
<td>Spencer silt loam</td>
<td>3.12</td>
<td>.278</td>
<td>1.25</td>
</tr>
<tr>
<td>Hancock</td>
<td>Plainfield silt loam</td>
<td>2.61</td>
<td>.248</td>
<td>1.18</td>
</tr>
<tr>
<td>SMOOTH BROME:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Madison</td>
<td>Miami silt loam</td>
<td>2.18</td>
<td>.321</td>
<td>.47</td>
</tr>
<tr>
<td>Marshfield</td>
<td>Spencer silt loam</td>
<td>1.87</td>
<td>.248</td>
<td>.36</td>
</tr>
</tbody>
</table>

* Differences for alfalfa are in most cases significant, but the comparisons for smooth brome do not differ significantly.

Fertilization of forages with superphosphate and lime produced crops of superior nutritive value as measured by growth of lambs and rabbits fed the forages, even though the superiority of such fertilized forages was not reflected in their chemical composition.

Burger studied the effect of soil type and fertilization on the total nitrogen, calcium, and phosphorus content of forages and of their nutritional value when fed to guinea pigs. Alfalfa and Ladino clover fertilized with 180 pounds of $P_2O_5$ and 180 pounds of $K_2O$ per acre produced significantly greater gains in weight when fed to guinea pigs than comparable unfertilized forage. Fertilization of smooth brome failed to improve its nutritional value. The effect that soil differences may have on the composition of legumes and grasses is suggested by Burger's data in Table 5.1.

It seems evident from this and other work that in some cases, at least, increased soil fertility may enhance the nutritive value of forage which is already adequate by present nutritional standards. No generally accepted explanation of the mechanisms involved in this improvement in "quality" of forage has been advanced. Certainly no method other than that of feeding trial has as yet been devised to determine relative value. Consequently, it seems advisable to restrict our consideration largely to those constituents known to have nutritional significance, and to be readily determinable by chemical methods.

Most experiments comparing nutrient levels have depended upon the application of nutrients to establish the different levels. This is to be expected, since this usually is the most convenient and positive way to assure valid comparisons. Consequently, most of the data on which we have drawn are from experiments of this nature.

FACTORS OTHER THAN SOIL FERTILITY

It should be kept in mind that in addition to soil fertility there are many other factors that are of importance in determining plant composition and nutritive value.

STAGE OF MATURITY. As plants approach maturity they almost always decrease in percentage composition of protein and minerals and increase in fiber, thereby becoming less desirable

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from a nutritive standpoint. Fertility level may affect the nutritive value of plants by influencing maturity. In fact, it is quite likely that many of the differences in nutritive value credited to fertilizer application, actually are due to differences in maturity. These changes may be either up or down, since nutrient level and balance may either speed up or slow down maturity, depending upon the circumstances. Deficiency of phosphorus frequently delays maturity, as does an excess of nitrogen. An adequate, balanced, soil fertility level usually hastens maturity of plants having a determinate type of growth. On the other hand, such plants as Ladino clover probably can be kept in the vegetative stage of growth much longer under high fertility conditions than where a deficiency of one or more nutrients exists.

**CLIMATE**. Climate or weather variations may have a direct as well as indirect effect upon plant composition. Daniel and Harper \(^4\) have shown that phosphorus content is increased and calcium decreased under wet conditions, with the reverse true during dry seasons.

**DIRECT INFLUENCE OF SOIL FERTILITY**

Soil fertility controls, to a large degree, the nutritive value of the forages generally grown in the humid regions. This comes about through its control over the type of plants that can be grown with greatest success on a given soil. Legumes such as alfalfa and Ladino clover thrive only on soils well supplied (naturally or artificially) with phosphorus, calcium, magnesium, and potassium. In the absence of adequate supplies of these elements legumes having lower requirements must be substituted. These plants almost invariably are lower in nutritive value, or production, or both. Furthermore, continued production of these without replenishment of the mineral supply will sooner or later bring about further reduction in both yield and quality. Similarly, grasses such as smooth brome, timothy, and orchardgrass grow well only in the presence of a large nitrogen supply. At lower nitrogen levels various high fiber-low protein grasses may thrive but the nutritive value of the forage suffers.

Soil fertility usually is overshadowed by moisture as a controlling factor in arid regions. However, the importance of soil fertility in this respect throughout the humid regions can scarcely be overemphasized.

**NUTRIENT LEVELS**

Nutrient level in the soil usually, though not always, affects the nutrient level in the individual species. Macy, \(^5\) in 1936, classified nutrient levels in plants into the following three groups:

1. **Minimum percentage**—yield increased as the supply of the element in question is increased, but the nutrient concentration in the plant remains static.
2. **Poverty adjustment**—both yield and nutrient concentration increase as the nutrient supply increases.
3. **Luxury consumption**—nutrient concentration increases but yield remains static as nutrient supply increases.

Actually, there is a fourth stage at which increasing nutrient supply fails to increase either nutrient concentration or yield. Sometimes excessive application may directly or indirectly depress

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Direct Effect of Major Nutrients

As long as the nutrient supply remains below the poverty adjustment, or above the luxury consumption levels, no change in nutrient composition can be expected.

It is difficult to find data from field experiments that appear to fit this classification. Some of the reasons for this are fairly obvious from an examination of Figure 5.1. Most experiments have not covered the entire range, and where they have approached it the points determined have been entirely too far apart to reveal the exact shape of the curves. The data on which Figure 5.1 is based would appear to fit this classification rather well, if a sufficient number of points were available near the lower ends of both curves. At any rate, it helps to explain the frequent failure of fertilization to affect the chemical composition of the plant.

Conditions within the soil itself also may prevent nutrient level changes in the plant. Such nutrients as phosphorus under some conditions may become so rapidly and securely fixed as to have little effect upon the nutrient supply. Iron may be so firmly fixed by some soils that this element must be applied to the foliage if the plant is to get an adequate supply.

NUTRIENT BALANCE

Nutrient balance also may play an important part in this process. For example, Bear & Prince have shown that if the Ca & Mg ratio in alfalfa exceeds 3.5, growth is limited. Yet below this ratio normal growth is attained, with these three cations being, to a considerable extent, interchangeable. Thus, an increase in nutrient supply may be made ineffective through an unbalance of nutrients. In a similar manner an increase in the level of one nutrient may reduce the uptake of another. The uptake of several of the so-called "minor" elements, particularly cobalt, manganese, zinc, and iron may be sharply curtailed by excessive liming. Manganese deficiency is thought to occur in most cases only under conditions of overliming. Thus, while an increase in the lime level of a soil frequently leaves the protein, calcium and phosphorus contents of the resulting forages unchanged, deficiencies in some of the micronutrients may be developed or accentuated.

DIRECT EFFECT OF MAJOR NUTRIENTS

Kobe lespedeza and carpetgrass are examples of plants that can exist under quite low fertility levels. Data in Table 5.2 serve to illustrate the effect of increasing nutrient level upon plant composition under low fertility conditions. Comparison of these analyses with the standards in Tables 5.4 and 5.5 reveals that in several cases the phosphorus and protein contents of the herbage were well below standard. Even under the best treatment shown some values remained on the low side. Protein in carpetgrass remains unchanged, perhaps indicating that this may be the maximum
58  5. Soil Fertility and the Nutritive Value of Forages

TABLE 5.2

<table>
<thead>
<tr>
<th>Treatment and crop</th>
<th>Percentage</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P</td>
<td>Ca</td>
</tr>
<tr>
<td>Kobe lespedeza *—Leon fine sand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No treatment</td>
<td>0.12</td>
<td>0.57</td>
</tr>
<tr>
<td>81 lbs. P₂O₅ + 37 lbs. K₂O</td>
<td>0.15</td>
<td>0.93</td>
</tr>
<tr>
<td>81 lbs. P₂O₅ + 1500 lbs. limestone</td>
<td>0.20</td>
<td>0.89</td>
</tr>
<tr>
<td>Kobe lespedeza †—Cecil gr. L.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No treatment</td>
<td>0.08</td>
<td>0.56</td>
</tr>
<tr>
<td>60 lbs. P₂O₅</td>
<td>0.12</td>
<td>0.90</td>
</tr>
<tr>
<td>4,000 lbs. limestone</td>
<td>0.09</td>
<td>0.85</td>
</tr>
<tr>
<td>60 lbs. P₂O₅ + 4,000 lbs. limestone</td>
<td>0.13</td>
<td>0.90</td>
</tr>
<tr>
<td>Carpetgrass †—Bladen fine sand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No treatment</td>
<td>0.13</td>
<td>0.35</td>
</tr>
<tr>
<td>72 lbs. N</td>
<td>0.10</td>
<td>0.29</td>
</tr>
<tr>
<td>NPKL—72 N, 144 P₂O₅, 100 K₂O, 2,000 limestone</td>
<td>0.23</td>
<td>0.57</td>
</tr>
</tbody>
</table>


for this species under the condition of this study.

The data in Table 5.2 represent rather extreme conditions. However, the literature, as shown by Beeson, contains numerous analyses of forages that approach the danger zone from the nutritional point of view. (See “Animal Requirements” p. 62.)

In contrast to the situation described above it is unusual to find the phosphorus, calcium, or protein content of the plants having high nutrient requirements low enough to make their forage value doubtful. This is due to the simple fact that soil conditions for their normal growth will insure automatically a reasonable level of nutrient content. An example of the operation of this factor may be seen in Figure 5.1. This Ladino clover was grown on a soil extremely low in phosphorus (trace by .002 NH₄SO₄).

Even without treatment the phosphorus content was fairly adequate for the more tolerant classes of animals. With the application of sufficient phosphorus to permit normal growth the content of this element was readily adjusted upward, bringing it well within the satisfactory nutritional zone. In other words, if the more nutritious forages grow well on a given soil, there is likely to be little doubt as to their nutritional quality.

Micronutrients

The group of mineral elements required by animals in relatively minute quantities, including manganese, copper, zinc, cobalt, iodine, and iron, are often called the “minor,” trace, or micronutrient elements. Deficiencies of these occur in certain soils in various parts of the world. In most cases their concentration in plant tissue is quite low but may be increased by applying them to the soil. As has been previously mentioned, the availability of several of them is materially influenced by liming. In some cases it is necessary to by-pass the soil and apply the element directly to the
foliage in order to increase the content in the plant. The addition of several of these to the salt mixtures supplied to animals is frequently resorted to in order to assure an adequate supply.

It is true that plants growing on fertile soils are likely to contain adequate amounts of these micronutrient elements. However, the effects of soil fertility levels on the plant content of some of them have been studied only in a limited way. Consequently, general rules of behavior cannot be outlined at present.

**Vitamins**

The effect of the soil upon the vitamin content of plants has been of interest to investigators for some time. It is known that the vitamin content of forages is quite variable. However, at least at present, the vitamin content of plants seems to depend upon such environmental factors as light and temperature and upon heredity, rather than the soil. There is no proof at present of a direct effect of soil fertility level upon vitamin content. Of course, since species, varieties, and strains may differ in their content of vitamins, soil fertility may have an important indirect effect through a change in the proportion of different plants produced on a given area.

In brief, the inherent characteristics of the plant plus the changes taking place in processing and storage are the important factors in determining the vitamin content.

**FLEXIBILITY OF PLANT COMPOSITION**

Some constituents of plants seem to be more readily influenced by fertility level than others. This may be due to limitations imposed by the physiology of the plants themselves, or in some cases by their environment. At any rate, present knowledge in this field suggests that certain useful generalizations can be made.

**NITROGEN.** The total nitrogen (or crude protein) content of forages is rather readily influenced by fertility level. The addition of nitrogen to nitrogen deficient soils almost always results in an appreciable increase in the level of this constituent in grasses. Such treatment may or may not affect the nitrogen content of legumes. The application of lime to lime deficient soils, on the other hand, usually improves the protein content of the legumes growing on such soils. This is generally believed to be due to a more favorable environment for the nitrogen-fixing bacteria.

**PHOSPHORUS.** The phosphorus content for a given forage frequently appears to be almost unchangeable. As previously mentioned, this often may be due to the position on the phosphorus response curve of the particular soil under consideration. On phosphorus deficient soils, however, the phosphorus content of the plant usually is quite readily increased by an increase in the phosphorus level of the soil. The range of values usually encountered in alfalfa, for example, is from about 0.15 to 0.3 per cent phosphorus, with normal plants seldom falling below 0.20 per cent. Plants containing more than 0.40 per cent are rare. Liming may, at times, either increase or decrease the phosphorus content of the herbage.

**CALCIUM.** A given plant species tends to maintain a relatively stable content of calcium, although changes in the calcium content of certain legumes through an increase in calcium level of the soil are fairly common. Alfalfa usually varies between a low of slightly
less than 1 per cent to as high as 2.5 per cent calcium, with more of the variation due to seasonal conditions than to soil treatment. The general level of calcium in the grasses is much lower—less than 1 per cent—and less variable. The addition of relatively large quantities of calcium to the soil, and even fairly large increases in exchangeable soil calcium, may leave the calcium content of grasses and many of the more tolerant legumes unaffected.

The calcium content of some legumes is quite readily affected by the potassium supply. The calcium content of alfalfa and Ladino clover often is appreciably depressed by large increases in the potassium level.

**Potassium.** The content of some forage plants is fairly flexible and readily changed by applications of potassium. This element probably is the prize example of “luxury consumption.” A level of around 1.2 per cent potassium in alfalfa or Ladino plants represents a soil nutrient supply ample for normal growth, yet liberal applications of this element will frequently increase the content in these plants to above 3 per cent and occasionally above 4 per cent. The requirement of animals for this element is quite low and since excessive concentration of it in the plant may repress the uptake of other cations, such as calcium, this luxury consumption of potassium may be undesirable, and from more than one viewpoint. In the case of potassium, grasses frequently contain higher concentrations than that of the legumes growing in association with them, and appear to be equally variable.

**INDIRECT EFFECT OF SOIL FERTILITY**

The direct effect of soil fertility upon the nutritive value of forages can be quite marked and at times may be vital. On the other hand, the indirect effects are in evidence on every farm and consequently may have more over-all significance from the nutritional point of view than the direct effect. Soil fertility exerts an influence, indirectly, upon nutritive value in several different ways. Only two of the major ones will be considered here.

**Botanical Composition**

Soil fertility is a significant factor in determining the botanical composition of sods. Legumes, generally speaking, are benefited by high levels of phosphorus, potassium, calcium, and magnesium, while grasses respond principally to the nitrogen level. Any shift between nutrient levels may change the proportion of grass and legume.

In pasture renovation, soils depleted of their fertility are limed and fertilized with phosphate and potash—treatments conducive to legume development. As a result, the weeds are reduced and legumes increased. The grass-legume stand therefore is brought into balance with the available nitrogen. As the nitrogen level is increased through the legume the grass increases at the expense of the legume, until we have a type of vegetation in which grass predominates. As the available nitrogen is exhausted by the grass the shift in plant population is back toward the legume.8

The rapidity with which the shift occurs is governed by the various environmental factors, the competitive ability of the individual species, management, and the presence of diseases. Any environmental factor, whether it be plant nutrients, moisture, light or temperature, that is more favorable to one group of plants than another will aid in their

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An attempt is made here to bring together certain data of interest to the student of forages which are not available in other chapters. These will serve as a ready reference.

The trend is toward an increased use of forage crop seed. The acreage seeded to forage crops is being stepped up. There is an increased appreciation of forages to prevent erosion and maintain crop production.

**SEED PRODUCTION AREAS**

Table 6.1 gives the leading states in the production of the more important grass and legume seed. The acreages and

<table>
<thead>
<tr>
<th>State</th>
<th>Acreage harvested</th>
<th>Bus. yield per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>RED CLOVER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ill.</td>
<td>309,200</td>
<td>250,000</td>
</tr>
<tr>
<td>Ind.</td>
<td>258,900</td>
<td>232,000</td>
</tr>
<tr>
<td>Iowa</td>
<td>243,400</td>
<td>141,000</td>
</tr>
<tr>
<td>Ohio</td>
<td>229,400</td>
<td>250,000</td>
</tr>
<tr>
<td>Wis.</td>
<td>176,400</td>
<td>158,000</td>
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<tr>
<td>Mich</td>
<td>148,000</td>
<td>210,000</td>
</tr>
<tr>
<td>Mo.</td>
<td>131,900</td>
<td>170,000</td>
</tr>
<tr>
<td>Minn</td>
<td>69,700</td>
<td>118,000</td>
</tr>
<tr>
<td>Idaho</td>
<td>32,450</td>
<td>30,000</td>
</tr>
<tr>
<td>Pa.</td>
<td>28,800</td>
<td>31,000</td>
</tr>
<tr>
<td>U.S.</td>
<td>1,754,440</td>
<td>1,789,500</td>
</tr>
<tr>
<td>ALFALFA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kan.</td>
<td>154,700</td>
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</tr>
<tr>
<td>Neb.</td>
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<tr>
<td>Minn.</td>
<td>75,400</td>
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</tr>
<tr>
<td>Mich.</td>
<td>74,100</td>
<td>44,000</td>
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## 6. Forage Statistics

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<th>Bus. yield per acre</th>
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<tr>
<td></td>
<td><strong>Av. 1938-47</strong></td>
<td><strong>1948</strong></td>
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<tr>
<td>Mont.</td>
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<td>62,000</td>
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<tr>
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<td>40,000</td>
</tr>
<tr>
<td>Utah.</td>
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<td>45,000</td>
</tr>
<tr>
<td>Idaho.</td>
<td>33,400</td>
<td>20,000</td>
</tr>
<tr>
<td>N. D.</td>
<td>27,400</td>
<td>21,000</td>
</tr>
<tr>
<td>U. S.</td>
<td>892,760</td>
<td>635,400</td>
</tr>
</tbody>
</table>

### Lespedeza

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<th>Bus. yield per acre</th>
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</thead>
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<tr>
<td>Tenn.</td>
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<td>Kan.</td>
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<td>72,000</td>
</tr>
<tr>
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<td>42,000</td>
</tr>
<tr>
<td>Ga.</td>
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<td>73,000</td>
</tr>
<tr>
<td>Va.</td>
<td>25,400</td>
<td>27,000</td>
</tr>
<tr>
<td>Ind.</td>
<td>23,280</td>
<td>19,000</td>
</tr>
<tr>
<td>Ark.</td>
<td>20,930</td>
<td>43,000</td>
</tr>
<tr>
<td>U. S.</td>
<td>825,080</td>
<td>982,300</td>
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### Sweetclover

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</tr>
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<tbody>
<tr>
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</tr>
<tr>
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<td>97,800</td>
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<tr>
<td>Ill.</td>
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<td>9,000</td>
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<tr>
<td>N. D.</td>
<td>25,650</td>
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<tr>
<td>Iowa.</td>
<td>22,330</td>
<td>4,500</td>
</tr>
<tr>
<td>U. S.</td>
<td>315,790</td>
<td>193,700</td>
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### Alsike Clover

<table>
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<td><strong>Av. 1943-47</strong></td>
<td><strong>1948</strong></td>
</tr>
<tr>
<td>Minn.</td>
<td>30,500</td>
<td>29,000</td>
</tr>
<tr>
<td>Ohio.</td>
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<td>25,000</td>
</tr>
<tr>
<td>Ore.</td>
<td>16,600</td>
<td>18,000</td>
</tr>
<tr>
<td>Wis.</td>
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<td>20,000</td>
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<tr>
<td>Ill.</td>
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<td>8,500</td>
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<tr>
<td>Mich.</td>
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<td>12,000</td>
</tr>
<tr>
<td>Idaho.</td>
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<tr>
<td>Ind.</td>
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<td>3,000</td>
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<tr>
<td>Iowa.</td>
<td>5,320</td>
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</tr>
<tr>
<td>Calif.</td>
<td>1,933 †</td>
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<tr>
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### Crimson Clover

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<tr>
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<td>34,000</td>
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<tr>
<td>Ga.</td>
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<td>13,000</td>
</tr>
<tr>
<td>State</td>
<td>Acreage harvested</td>
<td>Lbs. yield per acre</td>
</tr>
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<td>-------------</td>
<td>-------------------</td>
<td>---------------------</td>
</tr>
<tr>
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<tr>
<td>Ore...</td>
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<tr>
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<td>980</td>
<td></td>
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<td>62,100</td>
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<td>WHITE CLOVER</td>
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<td>5,800</td>
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<td>3,100</td>
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<tr>
<td>Ky...</td>
<td>†</td>
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<td>U. S...</td>
<td>25,620</td>
<td>32,800</td>
</tr>
<tr>
<td>LADINO CLOVER</td>
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<td>Calif...</td>
<td>6,600</td>
<td>13,000</td>
</tr>
<tr>
<td>Ore...</td>
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<td>5,500</td>
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<tr>
<td>Idaho...</td>
<td>600</td>
<td>1,500</td>
</tr>
<tr>
<td>U. S...</td>
<td>12,220</td>
<td>20,000</td>
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<td>Ga...</td>
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<td>23,000</td>
</tr>
<tr>
<td>Fla...</td>
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<tr>
<td>Ala...</td>
<td>5,840</td>
<td>5,000</td>
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<tr>
<td>S. C...</td>
<td>$</td>
<td>1,000</td>
</tr>
<tr>
<td>U. S...</td>
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<td>39,000</td>
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<td>TIMOTHY</td>
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</tr>
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<tr>
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<td>4,600</td>
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<td>Ind...</td>
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<td>5,000</td>
</tr>
<tr>
<td>Pa...</td>
<td>5,680</td>
<td>5,100</td>
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<tr>
<td>U. S...</td>
<td>406,430</td>
<td>128,700</td>
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<td>REDTOP</td>
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<td>Ill...</td>
<td>183,000</td>
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</tr>
<tr>
<td>Mo...</td>
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<td>U. S...</td>
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<td>N. M...</td>
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</tr>
<tr>
<td>Colo...</td>
<td>15,770</td>
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<tr>
<td>Kan...</td>
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<td>Neb...</td>
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<td>3,800</td>
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<tr>
<td>Calif...</td>
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<td>Okla...</td>
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</tr>
<tr>
<td>Ore...</td>
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<td>1,300</td>
</tr>
<tr>
<td>U. S...</td>
<td>126,116</td>
<td>55,100</td>
</tr>
</tbody>
</table>
acre yields of forage seed crops vary greatly from year to year. However, data for a number of years indicate those areas leading in the seed production of any specific crop. See also Figure 6.1.

**EXPORTS AND IMPORTS**

Exports and imports of forage crop seed fluctuate greatly from year to year depending on the available supply in this country and in other countries. Exports and imports also are restricted by trade barriers, tariffs, staining regulations, and other seed control legislation.

Table 6.2 gives the imports and exports of forage seed for the 6-year period, 1945 to 1950, inclusive. The movement of seed during the period of years immediately preceding was not representative of normal trade, affected as it was by war influences.

**FUTURE SEED NEEDS**

A survey on predicted forage seed use, made by the Production and Marketing Administration in 1949, indicates an increasing need for forage seed—an increase in use by 1955 of 140 per cent above 1950 and by 1960 of 160 per cent. Of particular interest is the indicated demand for the different types of forage. In some cases no increase in use is anticipated while in others the expected use is 10 and 20 times as much in 1960 as in 1950. See Table 6.3.

**SEED OF RANGE AND PASTURE SPECIES**

The need for more information on the seed production of a number of grasses
Fig. 6.1 States leading (among first 10) in the production of seed of some of the more important legumes and grasses. See pp. 65-68 for listing of states in order of average number of acres harvested.
### TABLE 6.2
United States Exports and Imports of Forage Crops Seed in Thousands of Pounds, 1945–1950, Inclusive *

<table>
<thead>
<tr>
<th>Item</th>
<th>1945</th>
<th>1946</th>
<th>1947</th>
<th>1948</th>
<th>1949</th>
<th>1950</th>
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<tr>
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<td>277</td>
<td>876</td>
<td>1,303</td>
<td>836</td>
<td>1,698</td>
<td>1,071</td>
</tr>
<tr>
<td>Red</td>
<td>1,082</td>
<td>1,129</td>
<td>5,630</td>
<td>355</td>
<td>348</td>
<td>62</td>
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<tr>
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<td>11</td>
<td>751</td>
<td>2,359</td>
<td>1,947</td>
<td>1,619</td>
<td>118</td>
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<td>Other</td>
<td>722</td>
<td>2,373</td>
<td>1,498</td>
<td>1,002</td>
<td>2,918</td>
<td>370</td>
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<td>8,477</td>
<td>10,678</td>
<td>11,616</td>
<td>10,034</td>
<td>4,588</td>
<td>2,410</td>
</tr>
<tr>
<td>Kentucky bluegrass</td>
<td>743</td>
<td>892</td>
<td>1,462</td>
<td>999</td>
<td>2,559</td>
<td>1,114</td>
</tr>
<tr>
<td>Redtop</td>
<td>1,220</td>
<td>2,873</td>
<td>1,603</td>
<td>594</td>
<td>596</td>
<td>167</td>
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<tr>
<td>Orchardgrass</td>
<td>800</td>
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<td>370</td>
<td>1,209</td>
<td>1,468</td>
<td>78</td>
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<td>Fescue</td>
<td>477</td>
<td>1,275</td>
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<td>229</td>
<td>718</td>
<td>121</td>
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<td>Other grass seed</td>
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<td>17,407</td>
<td>4,535</td>
<td>2,095</td>
<td>4,139</td>
<td>1,988</td>
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<td>37,647</td>
<td>7,692</td>
<td>16,004</td>
<td>5,482</td>
<td>3,435</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alfalfa</td>
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<td>4,141</td>
<td>17,040</td>
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<td>Red</td>
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<td>42</td>
<td>80</td>
<td>4,116</td>
<td>2,863</td>
<td>2,641</td>
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<td>663</td>
<td>1,128</td>
<td>1,594</td>
<td>762</td>
<td>880</td>
<td>880</td>
</tr>
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<td>9,907</td>
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<td>8,235</td>
<td>8,235</td>
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<td>850</td>
<td>1,995</td>
<td>1,272</td>
<td>1,728</td>
<td>1,728</td>
</tr>
<tr>
<td>Other</td>
<td>306</td>
<td>11,810</td>
<td>25,494</td>
<td>2,396</td>
<td>940</td>
<td>940</td>
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<tr>
<td><strong>Vetch</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Hairy</td>
<td>0</td>
<td>59</td>
<td>315</td>
<td>158</td>
<td>49</td>
<td>9</td>
</tr>
<tr>
<td>Other</td>
<td>149</td>
<td>248</td>
<td>128</td>
<td>82</td>
<td>93</td>
<td>93</td>
</tr>
<tr>
<td><strong>Bentgrass</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada bluegrass</td>
<td>43</td>
<td>100</td>
<td>107</td>
<td>281</td>
<td>28</td>
<td>37</td>
</tr>
<tr>
<td>Kentucky bluegrass</td>
<td>13</td>
<td>15</td>
<td>1</td>
<td>300</td>
<td>1,077</td>
<td>1,077</td>
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<tr>
<td>Ryegrass</td>
<td>194</td>
<td>38</td>
<td>5</td>
<td>41</td>
<td>660</td>
<td>660</td>
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<tr>
<td>Orchardgrass</td>
<td>1,176</td>
<td>522</td>
<td>78</td>
<td>15</td>
<td>863</td>
<td>973</td>
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<tr>
<td>Millet</td>
<td>112</td>
<td>220</td>
<td>487</td>
<td>1,124</td>
<td>217</td>
<td>217</td>
</tr>
<tr>
<td>Timothy</td>
<td>7</td>
<td>73</td>
<td>1</td>
<td>1</td>
<td>235</td>
<td>235</td>
</tr>
<tr>
<td>Bromegrass</td>
<td>689</td>
<td>164</td>
<td>162</td>
<td>3</td>
<td>3190</td>
<td>3190</td>
</tr>
<tr>
<td>Wheatgrass</td>
<td>7,630</td>
<td>4,583</td>
<td>6,216</td>
<td>3,190</td>
<td>3,190</td>
<td>3,190</td>
</tr>
<tr>
<td>Tall oatgrass</td>
<td>877</td>
<td>11,476</td>
<td>2,092</td>
<td>8,977</td>
<td>3,127</td>
<td>2,172</td>
</tr>
</tbody>
</table>

* Compiled from reports of the Bureau of Agricultural Economics, Division of Statistical and Historical Research, U.S.D.A.

† January–September only.
‡ If any, included with "other grass and field seed."
§ If any, included with "other clover seed."
¶ If any, included with Hairy vetch.
‖ If any, included with "other grass seed."

and legumes, which are recognized for their value in range and pasture seedings, led to a special survey covering the years 1949 and 1950. Included were 20 native and introduced grasses and 4 legumes. For 16 of these, production estimates had not previously been available. The more complete coverage for the remaining 8 justifies the revision of previous seed production estimates. The purpose of this survey was "... to aid in balancing seed production with the anticipated requirements of a permanent grassland agricultural program..." (See Table 6.4.)

### SEED INFORMATION

Tables 6.5 and 6.6 give the number of seed per pound, weight per bushel, and
### TABLE 6.3
Estimated Thousands of Pounds of Seed of the More Important Legumes and Grasses * That Farmers in the United States Might Be Expected to Use for Seeding in the Years 1950, 1955, and 1960. †

<table>
<thead>
<tr>
<th>Common name</th>
<th>Region of adaptation or use</th>
<th>1950</th>
<th>1955</th>
<th>1960</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ANNUAL LEGUMES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alyceclover</td>
<td>S. ½ of Cotton Belt</td>
<td>1,443</td>
<td>1,583</td>
<td>1,650</td>
</tr>
<tr>
<td>Bean—Mung</td>
<td>Corn and Soybean Belt</td>
<td>93</td>
<td>134</td>
<td>135</td>
</tr>
<tr>
<td>Beggarweed (Tall Tick Clover)</td>
<td>S. ½ of Cotton Belt</td>
<td>400</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>Black Medick</td>
<td>S. U.S. &amp; Pacific N.W.</td>
<td>193</td>
<td>1,643</td>
<td>1,421</td>
</tr>
<tr>
<td>Bur Clover—California</td>
<td>S. ½ Cotton Belt &amp; S. Pacific Coast</td>
<td>29</td>
<td>292</td>
<td>337</td>
</tr>
<tr>
<td>Bur Clover—Spotised</td>
<td>Cotton Belt &amp; S. Pacific Coast</td>
<td>2,529</td>
<td>8,714</td>
<td>15,768</td>
</tr>
<tr>
<td>Button Clover</td>
<td>S.E. &amp; S.W. U.S.</td>
<td>76</td>
<td>128</td>
<td>163</td>
</tr>
<tr>
<td>Clover—Crimson</td>
<td>S. &amp; S.E. U.S. &amp; Pacific N.W.</td>
<td>24,355</td>
<td>31,038</td>
<td>37,315</td>
</tr>
<tr>
<td>Clover—Field Hop</td>
<td>N. U.S.</td>
<td>884</td>
<td>4,697</td>
<td>7,912</td>
</tr>
<tr>
<td>Clover—Large Hop</td>
<td>S. U.S. &amp; Pacific Coast</td>
<td>54</td>
<td>120</td>
<td>158</td>
</tr>
<tr>
<td>Clover—Persian</td>
<td>S.E. U.S. &amp; S.W. Irrigated</td>
<td>284</td>
<td>1,544</td>
<td>2,534</td>
</tr>
<tr>
<td>Clover—Small Hop</td>
<td>S. &amp; S.E. U.S. &amp; Pacific Coast</td>
<td>153</td>
<td>752</td>
<td>1,658</td>
</tr>
<tr>
<td>Clover—Sub.</td>
<td>S.E. U.S. &amp; Pacific Coast</td>
<td>268</td>
<td>230</td>
<td>249</td>
</tr>
<tr>
<td>Cowpea</td>
<td>S. ½ U.S. &amp; S. Pacific states</td>
<td>55,269</td>
<td>73,085</td>
<td>74,608</td>
</tr>
<tr>
<td>Crotalaria—Lanceleaf</td>
<td>S.E. U.S.</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Crotalaria—Showy</td>
<td>S.E. U.S.</td>
<td>2,204</td>
<td>3,098</td>
<td>3,439</td>
</tr>
<tr>
<td>Crotalaria—Slenderleaf</td>
<td>S.E. U.S.</td>
<td>250</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>Crotalaria—Striped</td>
<td>S.E. U.S.</td>
<td>880</td>
<td>1,060</td>
<td>1,325</td>
</tr>
<tr>
<td>Lespedeza—Common</td>
<td>S.E. U.S.</td>
<td>3,745</td>
<td>16,011</td>
<td>28,415</td>
</tr>
<tr>
<td>Lespedeza—Kobe</td>
<td>S.E. U.S.</td>
<td>57,504</td>
<td>83,420</td>
<td>162,160</td>
</tr>
<tr>
<td>Lespedeza—Korean</td>
<td>Corn Belt &amp; N. Cotton Belt</td>
<td>138,890</td>
<td>172,615</td>
<td>192,993</td>
</tr>
<tr>
<td>Lespedeza—Tenn. 76</td>
<td>S.E. U.S.</td>
<td>2,712</td>
<td>15,675</td>
<td>22,581</td>
</tr>
<tr>
<td>Lupine—Blue</td>
<td>S. ½ of S.E. Cotton Belt</td>
<td>57,055</td>
<td>67,357</td>
<td>78,370</td>
</tr>
<tr>
<td>Lupine—Sweet Yellow</td>
<td>S. ½ of S.E. Cotton Belt</td>
<td>112</td>
<td>302</td>
<td>452</td>
</tr>
<tr>
<td>Peas—Field</td>
<td>General U.S.</td>
<td>72,731</td>
<td>99,836</td>
<td>104,400</td>
</tr>
<tr>
<td>Peas—Rough</td>
<td>S.E. U.S. &amp; Pacific N.W.</td>
<td>12,132</td>
<td>21,447</td>
<td>26,216</td>
</tr>
<tr>
<td>Sesbania or Hemp Sesbania</td>
<td>S. U.S.</td>
<td>895</td>
<td>1,110</td>
<td>1,120</td>
</tr>
<tr>
<td>Sweetclover—Hubam</td>
<td>Tex., Pacific N.W., Cotton &amp; Corn Belt</td>
<td>10,434</td>
<td>31,673</td>
<td>36,812</td>
</tr>
<tr>
<td>Sweetclover—Sour</td>
<td>S. &amp; S.W. U.S.</td>
<td>4,233</td>
<td>6,791</td>
<td>9,576</td>
</tr>
<tr>
<td>Velvet Bean</td>
<td>S. ½ of Cotton Belt</td>
<td>28,990</td>
<td>31,481</td>
<td>31,181</td>
</tr>
<tr>
<td>Vetch—Common</td>
<td>Pacific Coast &amp; S.E. U.S.</td>
<td>37,643</td>
<td>44,997</td>
<td>44,993</td>
</tr>
<tr>
<td>Vetch—Hairy</td>
<td>General U.S.</td>
<td>49,094</td>
<td>77,915</td>
<td>85,158</td>
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<tr>
<td>Vetch—Horsebean</td>
<td>S. Pacific Coast &amp; S.E. U.S.</td>
<td>150</td>
<td>180</td>
<td>180</td>
</tr>
<tr>
<td>Vetch—Hungarian</td>
<td>Pacific Coast &amp; S.E. U.S.</td>
<td>113</td>
<td>118</td>
<td>121</td>
</tr>
<tr>
<td>Vetch—Purple</td>
<td>Pacific Coast &amp; S.E. U.S.</td>
<td>9,172</td>
<td>11,422</td>
<td>13,672</td>
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<tr>
<td><strong>BIENNIAL LEGUMES</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Clover—Mammoth</td>
<td>General U.S.</td>
<td>7,243</td>
<td>8,022</td>
<td>8,362</td>
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<tr>
<td>Clover—Red</td>
<td>General U.S.</td>
<td>120,337</td>
<td>145,271</td>
<td>149,389</td>
</tr>
<tr>
<td>Sweetclover—White</td>
<td>General U.S.</td>
<td>60,793</td>
<td>87,736</td>
<td>93,876</td>
</tr>
<tr>
<td>Sweetclover—Yellow</td>
<td>General U.S.</td>
<td>38,049</td>
<td>61,380</td>
<td>58,069</td>
</tr>
<tr>
<td><strong>PERENNIAL LEGUMES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alfalfa</td>
<td>General U.S.</td>
<td>102,368</td>
<td>123,758</td>
<td>130,091</td>
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<tr>
<td>Clover—Alsike</td>
<td>N. U.S.</td>
<td>13,616</td>
<td>14,260</td>
<td>14,205</td>
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<tr>
<td>Clover—Ladino</td>
<td>General U.S.</td>
<td>9,012</td>
<td>12,384</td>
<td>14,855</td>
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<tr>
<td>Clover—White</td>
<td>General U.S.</td>
<td>3,931</td>
<td>7,951</td>
<td>12,405</td>
</tr>
<tr>
<td>Indigo-Hairy</td>
<td>Coastal Plains Fla. to Tex.</td>
<td>57</td>
<td>225</td>
<td>430</td>
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<tr>
<td>Kudzu-Thunberg</td>
<td>S.E. U.S.</td>
<td>25,368</td>
<td>44,586</td>
<td>85,148</td>
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<tr>
<td>Lespedeza—Sericea</td>
<td>S.E. U.S.</td>
<td>8,007</td>
<td>9,978</td>
<td>16,684</td>
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<tr>
<td>Trefol—Big</td>
<td>Orc., Wash., Calif. &amp; S.E. Coast</td>
<td>17</td>
<td>81</td>
<td>127</td>
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<tr>
<td>Trefol—Broadleaf Birdsfoot</td>
<td>N.E. states, Corn Belt &amp; Pacific Coast</td>
<td>246</td>
<td>629</td>
<td>911</td>
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<tr>
<td>Trefol—Narrowleaf Birdsfoot</td>
<td>Orc., Wash., Calif., N.Y.</td>
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<td>83</td>
<td>106</td>
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<td><strong>ANNUAL GRASSES</strong></td>
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<td></td>
<td></td>
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<td>Ryegrass—Italian or common</td>
<td>Pacific Coast—E. U.S.</td>
<td>36,606</td>
<td>55,116</td>
<td>66,702</td>
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<td>Sudangrass</td>
<td>General U.S.</td>
<td>37,302</td>
<td>49,792</td>
<td>58,816</td>
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</table>
**Forage Statistics**

<table>
<thead>
<tr>
<th>Common name</th>
<th>Region of adaptation or use</th>
<th>1950</th>
<th>1955</th>
<th>1960</th>
</tr>
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<td><strong>PERENNIAL GRASSES</strong></td>
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<tr>
<td>Bermudagrass</td>
<td>Cotton Belt</td>
<td>700</td>
<td>5,359</td>
<td>11,319</td>
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<tr>
<td>Bluegrass</td>
<td>N. Great Plains &amp; Pacific N.W.</td>
<td>243</td>
<td>243</td>
<td>259</td>
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<tr>
<td>Bluegrass</td>
<td>N. 3/4 Humid U. S.</td>
<td>7,293</td>
<td>8,105</td>
<td>8,653</td>
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<tr>
<td>Bluegrass</td>
<td>E. Great Plains</td>
<td>256</td>
<td>369</td>
<td>350</td>
</tr>
<tr>
<td>Bluegrass</td>
<td>E. Great Plains</td>
<td>342</td>
<td>1,165</td>
<td>2,363</td>
</tr>
<tr>
<td>Bluegrass</td>
<td>E. Great Plains</td>
<td>188</td>
<td>279</td>
<td>280</td>
</tr>
<tr>
<td>Bluegrass</td>
<td>S. Great Plains</td>
<td>128</td>
<td>775</td>
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<td>Brome</td>
<td>California-Mountain</td>
<td>622</td>
<td>943</td>
<td>1,085</td>
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<td>80</td>
<td>120</td>
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<td>N.W. U. S.</td>
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<td>4,298</td>
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<td>Brome</td>
<td>S. Great Plains</td>
<td>101</td>
<td>1,291</td>
<td>3,001</td>
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<tr>
<td>Brome</td>
<td>E. Great Plains</td>
<td>42</td>
<td>100</td>
<td>102</td>
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<tr>
<td>Brome</td>
<td>S. Great Plains</td>
<td>108</td>
<td>143</td>
<td>175</td>
</tr>
<tr>
<td>Brome</td>
<td>N. Great Plains</td>
<td>19</td>
<td>338</td>
<td>270</td>
</tr>
<tr>
<td>Brome</td>
<td>Central &amp; S. Great Plains</td>
<td>303</td>
<td>413</td>
<td>477</td>
</tr>
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<td>Brome</td>
<td>S. U. S.</td>
<td>195</td>
<td>352</td>
<td>500</td>
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<tr>
<td>Brome</td>
<td>S. U. S.</td>
<td>106</td>
<td>141</td>
<td>176</td>
</tr>
<tr>
<td>Brome</td>
<td>N. Great Plains</td>
<td>10,346</td>
<td>12,017</td>
<td>12,760</td>
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<tr>
<td>Brome</td>
<td>N. Great Plains</td>
<td>1,089</td>
<td>2,245</td>
<td>2,718</td>
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<tr>
<td>Brome</td>
<td>N. Great Plains</td>
<td>716</td>
<td>1,579</td>
<td>1,549</td>
</tr>
<tr>
<td>Brome</td>
<td>N. Great Plains</td>
<td>149</td>
<td>231</td>
<td>217</td>
</tr>
<tr>
<td>Brome</td>
<td>N. Great Plains</td>
<td>199</td>
<td>202</td>
<td>83</td>
</tr>
</tbody>
</table>

*Species with less than 100,000 pounds estimate omitted.
†These figures are based on the assumption that reasonably priced seed would be available and that educational programs would be continued on the same pattern as 1949. This report was submitted to the Agricultural Conservation Programs Branch by State P.M.A. Committees in 1949.

Seeding rate in pounds per acre of some of the more important grasses and legumes. Since seed vary greatly in size from lot to lot, depending on seasonal and other environmental conditions, these figures vary greatly.

**CHANGES IN HAY PRODUCTION**

Although the acreage of all tame hay harvested in the United States as a whole has undergone only moderate changes, there have been some significant changes in different parts of the country, both in the kinds of tame hays produced and in their quantity and quality. In 1920, nearly sixty per cent of the tame hay acreage was clover and timothy, including stands of timothy, of clover, and of mixtures of the two. Now clover and timothy represent but a third of the

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Measurement of Hay in Stack and Mow

### Table 6.7

<table>
<thead>
<tr>
<th>Kind of seed</th>
<th>Acres harvested</th>
<th>Yield in lbs. per acre</th>
<th>Production in lbs., 000 omitted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1940</td>
<td>1950</td>
<td>1940</td>
</tr>
<tr>
<td>Bluegum mixtures...</td>
<td>18,200</td>
<td>34,300</td>
<td>55</td>
</tr>
<tr>
<td>Bluegum, King Ranch</td>
<td>2,800</td>
<td>10,500</td>
<td>75</td>
</tr>
<tr>
<td>Bromegrass, Mountain</td>
<td>850</td>
<td>1,000</td>
<td>341</td>
</tr>
<tr>
<td>Bromegrass, Smooth</td>
<td>74,200</td>
<td>143,950</td>
<td>158</td>
</tr>
<tr>
<td>Buffalograss</td>
<td>3,930</td>
<td>2,320</td>
<td>35</td>
</tr>
<tr>
<td>Dallisgrass</td>
<td>6,000</td>
<td>8,300</td>
<td>90</td>
</tr>
<tr>
<td>Fescue, Chewings</td>
<td>12,500</td>
<td>13,600</td>
<td>202</td>
</tr>
<tr>
<td>Fescue, Red</td>
<td>7,500</td>
<td>7,150</td>
<td>126</td>
</tr>
<tr>
<td>Fescue, Tall (Alta and Ky. 31 or Stute's grass)</td>
<td>42,410</td>
<td>71,730</td>
<td>267</td>
</tr>
<tr>
<td>Grama, Blue</td>
<td>2,200</td>
<td>11,000</td>
<td>25</td>
</tr>
<tr>
<td>Grama, Side-Oats</td>
<td>4,100</td>
<td>7,600</td>
<td>58</td>
</tr>
<tr>
<td>Lovegrass, Sand</td>
<td>6,100</td>
<td>12,300</td>
<td>58</td>
</tr>
<tr>
<td>Lovegrass, Weeping</td>
<td>1,200</td>
<td>700</td>
<td>100</td>
</tr>
<tr>
<td>Wheatgrass, Creasted</td>
<td>51,300</td>
<td>67,300</td>
<td>107</td>
</tr>
<tr>
<td>Wheatgrass, Intermediate</td>
<td>1,740</td>
<td>2,630</td>
<td>103</td>
</tr>
<tr>
<td>Wheatgrass, Slender</td>
<td>160</td>
<td>600</td>
<td>275</td>
</tr>
<tr>
<td>Wheatgrass, Tail</td>
<td>320</td>
<td>600</td>
<td>132</td>
</tr>
<tr>
<td>Wheatgrass, Western</td>
<td>750</td>
<td>1,250</td>
<td>80</td>
</tr>
<tr>
<td>Wildrye, Canada</td>
<td>2,800</td>
<td>500</td>
<td>63</td>
</tr>
<tr>
<td>Wildrye, Russian</td>
<td>200</td>
<td>200</td>
<td>150</td>
</tr>
<tr>
<td>Clover, Crimson</td>
<td>90,950</td>
<td>119,110</td>
<td>209</td>
</tr>
<tr>
<td>Clover, Ladino</td>
<td>26,620</td>
<td>59,840</td>
<td>140</td>
</tr>
<tr>
<td>Clover, White</td>
<td>29,900</td>
<td>40,100</td>
<td>77</td>
</tr>
<tr>
<td>Trefall, Birdfoot</td>
<td>3,600</td>
<td>7,000</td>
<td>30</td>
</tr>
</tbody>
</table>


Measurement of Hay in Stack and Mow

The volume of a rectangular stack is equal to its length (L) multiplied by the area of the cross section. The length can easily be measured but the exact area of the cross section is not so readily determined. A formula is necessary to compute the area from the two measurements width (W) and over (O). Width is the width of the stack at the ground; length is the average length of the stack; and over is the distance from the ground on one side over the stack to the ground on the other side. Stacks are divided into three types, based on shape. Factors have been developed for use in determining the volume of each type of stack.

1. Low, round-topped stacks (Great Plains States):

\[0.52 \times O - (0.14 \times W) \times WL = \text{Volume}\]

2. High, round-topped stacks (Intermountain States):

\[0.52 \times O - (0.16 \times W) \times WL = \text{Volume}\]

3. Square, flat-topped stacks (Sacramento & San Joaquin valleys of California):

\[0.56 \times O - (0.55 \times W) \times WL = \text{Volume}\]

Another method of determining the volumes of oblong or rectangular stacks is the F-O-W-L method. In this method a factor F is used which takes into account the varying shapes of stacks, and it varies from 0.25 to 0.37. The factor F is multiplied by the overthrow (O), by the width (W), and this product by the length (L). With picks of different shapes.
<table>
<thead>
<tr>
<th>Scientific and common name</th>
<th>No. seed per lb</th>
<th>Seeding rate, lbs. per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agropyron cristatum, crested wheatgrass</td>
<td>175,000</td>
<td>6-12</td>
</tr>
<tr>
<td>Agropyron dasystachyum, thickspike wheatgrass</td>
<td>154,000</td>
<td>6-12</td>
</tr>
<tr>
<td>Agropyron desertorum, desert wheatgrass</td>
<td>175,000</td>
<td>6-12</td>
</tr>
<tr>
<td>Agropyron elongatum, tall wheatgrass</td>
<td>79,000</td>
<td>8-12</td>
</tr>
<tr>
<td>Agropyron inermes, beardless wheatgrass</td>
<td>150,000</td>
<td>6-12</td>
</tr>
<tr>
<td>Agropyron intermedium, intermediate wheatgrass</td>
<td>88,000</td>
<td>8-12</td>
</tr>
<tr>
<td>Agropyron microstachyum, thiekspike wheatgrass</td>
<td>162,000</td>
<td>6-12</td>
</tr>
<tr>
<td>Agropyron repens, quickgrass (w)</td>
<td>110,000</td>
<td>6-12</td>
</tr>
<tr>
<td>Agropyron riparium, streambank wheatgrass</td>
<td>156,000</td>
<td>6-12</td>
</tr>
<tr>
<td>Agropyron semicostatum, drooping wheatgrass</td>
<td>59,000</td>
<td>6-12</td>
</tr>
<tr>
<td>Agropyron stibium, Siberian wheatgrass</td>
<td>170,000</td>
<td>6-12</td>
</tr>
<tr>
<td>Agropyron smithii, western wheatgrass</td>
<td>110,000</td>
<td>5-15</td>
</tr>
<tr>
<td>Agropyron spicatum, bluebunch wheatgrass</td>
<td>95,000</td>
<td>6-12</td>
</tr>
<tr>
<td>Agropyron subsecundum, bearded wheatgrass</td>
<td>117,000</td>
<td>6-12</td>
</tr>
<tr>
<td>Agropyron trachycaulum, slender wheatgrass</td>
<td>159,000</td>
<td>6-12</td>
</tr>
<tr>
<td>Agropyron trichophorum, stiffhair wheatgrass</td>
<td>100,000</td>
<td>8-12</td>
</tr>
<tr>
<td>Agrostis alba, redtop</td>
<td>4,990,000</td>
<td>5-10</td>
</tr>
<tr>
<td>Agrostis canina, velvet bent</td>
<td>10,800,000</td>
<td>40-60</td>
</tr>
<tr>
<td>Agrostis palustris, creeping bent</td>
<td>7,800,000</td>
<td>40-60</td>
</tr>
<tr>
<td>Agrostis tenuis, colonial bent</td>
<td>8,723,000</td>
<td>40-60</td>
</tr>
<tr>
<td>Alopecurus pratensis, meadow foxtail</td>
<td>576,000</td>
<td>15-25</td>
</tr>
<tr>
<td>Aneura arenaria, European beachgrass</td>
<td>114,000</td>
<td>Vegetative</td>
</tr>
<tr>
<td>Aneura brevistipula, American beachgrass</td>
<td>165,000</td>
<td>Vegetative</td>
</tr>
<tr>
<td>Andropogon fucatus, big bluestem</td>
<td>115,000</td>
<td>10-15</td>
</tr>
<tr>
<td>Andropogon halii, sand bluestem</td>
<td>113,000</td>
<td>10-20</td>
</tr>
<tr>
<td>Andropogon intermedius var. caucasicus, Caucaian bluestem</td>
<td>1,072,000</td>
<td>10-15</td>
</tr>
<tr>
<td>Andropogon ischaemum, yellow bluestem</td>
<td>1,409,000</td>
<td>10-15</td>
</tr>
<tr>
<td>Andropogon scoparius, little bluestem</td>
<td>260,000</td>
<td>10-15</td>
</tr>
<tr>
<td>Andropogon virginicus, broomedge</td>
<td>726,000</td>
<td>15-25</td>
</tr>
<tr>
<td>Anthoxanthum odoratum, sweet vernalgrass</td>
<td>576,000</td>
<td>15-25</td>
</tr>
<tr>
<td>Aristida longiseta, red three-awn</td>
<td>150,000</td>
<td>40-50</td>
</tr>
<tr>
<td>Aristidales mayetis, tall outgrass</td>
<td>82,000</td>
<td></td>
</tr>
<tr>
<td>Avena sativa, oats</td>
<td>13,000</td>
<td>60-90</td>
</tr>
<tr>
<td>Avena sativa, oats</td>
<td>1,222,000</td>
<td>5-12</td>
</tr>
<tr>
<td>Bouteloua curtipendula, side-oats grama</td>
<td>191,000</td>
<td>10-15</td>
</tr>
<tr>
<td>Bouteloua crispatula, black grama</td>
<td>1,355,000</td>
<td>10-15</td>
</tr>
<tr>
<td>Bouteloua johnsonii, slender grama</td>
<td>1,428,000</td>
<td>10-15</td>
</tr>
<tr>
<td>Bouteloua gracilis, blue grama</td>
<td>825,000</td>
<td>10-15</td>
</tr>
<tr>
<td>Bouteloua hirsuta, hairy grama</td>
<td>980,000</td>
<td>10-15</td>
</tr>
<tr>
<td>Bouteloua rossii, Rothrock grama</td>
<td>4,095,000</td>
<td>10-15</td>
</tr>
<tr>
<td>Briza maxima, big quakinggrass (o)</td>
<td>280,000</td>
<td>15-30</td>
</tr>
<tr>
<td>Bromus arvensis, field brome</td>
<td>62,000</td>
<td>15-25</td>
</tr>
<tr>
<td>Bromus caltharius, reseegrass</td>
<td>71,000</td>
<td>10-20</td>
</tr>
<tr>
<td>Bromus erectus, meadow brome</td>
<td>136,000</td>
<td>10-20</td>
</tr>
<tr>
<td>Bromus inermis, smooth brome</td>
<td>71,000</td>
<td>10-20</td>
</tr>
<tr>
<td>Bromus jecutus, meadow brome</td>
<td>208,000</td>
<td>4-8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scientific and common name</th>
<th>No. seed per lb</th>
<th>Seeding rate, lbs. per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calamagrostis canadensis, bluejoint reedgrass</td>
<td>88,000</td>
<td>8-12</td>
</tr>
<tr>
<td>Calamagrostis gigantea, big sandreed</td>
<td>273,760</td>
<td>8-12</td>
</tr>
<tr>
<td>Calamagrostis longifolia, prairie sandreed</td>
<td>1,770,000</td>
<td>8-15</td>
</tr>
<tr>
<td>Gynodon dactylon, Bermuda grass</td>
<td>1,797,000</td>
<td>6-8</td>
</tr>
<tr>
<td>Cynurus cristatus, crested dogtail</td>
<td>722,600</td>
<td>15-25</td>
</tr>
<tr>
<td>Dactylis glomerata, orchardgrass</td>
<td>664,000</td>
<td>6-15</td>
</tr>
<tr>
<td>Digitaria decumbens, hairy crabgrass (w)</td>
<td>825,000</td>
<td>Vegetative</td>
</tr>
<tr>
<td>Distichlis stricta, inland saltgrass</td>
<td>1,555,000</td>
<td>8-10</td>
</tr>
<tr>
<td>Echinochloa crusgalli var. frumentacea, Japanese millet</td>
<td>155,000</td>
<td>20-25</td>
</tr>
<tr>
<td>Elymus canadensis, Canada wildrye</td>
<td>115,000</td>
<td>10-15</td>
</tr>
<tr>
<td>Elymus condensatus, giant wildrye</td>
<td>166,000</td>
<td>10-15</td>
</tr>
<tr>
<td>Elymus giganteus, Siberian wildrye</td>
<td>100,000</td>
<td>10-15</td>
</tr>
<tr>
<td>Elymus glaucus, blue wildrye</td>
<td>137,000</td>
<td>10-15</td>
</tr>
<tr>
<td>Elymus juneus, Russian wildrye</td>
<td>175,000</td>
<td>8-10</td>
</tr>
<tr>
<td>Elymus triticeodes, creeping wildrye</td>
<td>51,000</td>
<td>5-15</td>
</tr>
<tr>
<td>Elymus virginicus, Virginia wildrye</td>
<td>73,000</td>
<td>10-15</td>
</tr>
<tr>
<td>Eragrostis chloromelas, Boer lovegrass</td>
<td>2,922,000</td>
<td>1-3</td>
</tr>
<tr>
<td>Eragrostis curvula, weeping lovegrass</td>
<td>1,463,000</td>
<td>1-3</td>
</tr>
<tr>
<td>Erhagrostis lehmaniana, Lehmann lovegrass</td>
<td>4,245,000</td>
<td>1-3</td>
</tr>
<tr>
<td>Eragrostis trichodes, sand lovegrass</td>
<td>1,300,000</td>
<td>1-3</td>
</tr>
<tr>
<td>Eremochloa ophiuroides, centipedegrass</td>
<td>408,000</td>
<td>15-25</td>
</tr>
<tr>
<td>Echinochloa miliacea, Italian ryegrass</td>
<td>965,000</td>
<td>15-25</td>
</tr>
<tr>
<td>Festuca arundinacea, tall fescue</td>
<td>227,000</td>
<td>10-25</td>
</tr>
<tr>
<td>Festuca idahoensis, Idaho fescue</td>
<td>412,000</td>
<td></td>
</tr>
<tr>
<td>Festuca niyars, rattail fescue (w)</td>
<td>680,000</td>
<td>15-25</td>
</tr>
<tr>
<td>Festuca octoflora, sixweeks fescue (w)</td>
<td>615,000</td>
<td>15-40</td>
</tr>
<tr>
<td>Festuca ovina, sheep fescue</td>
<td>615,000</td>
<td>15-40</td>
</tr>
<tr>
<td>Hilaria rigida, big galleta</td>
<td>33,000</td>
<td></td>
</tr>
<tr>
<td>Hordeum bulbosum, bulbous barley</td>
<td>1,524,000</td>
<td>10-25</td>
</tr>
<tr>
<td>Hordeum jubatum, foxtail barley (w)</td>
<td>50,000</td>
<td>8-12</td>
</tr>
<tr>
<td>Hordeum nelsoni, meadow barley (w)</td>
<td>14,000</td>
<td>60-70</td>
</tr>
<tr>
<td>Hyparrhenia kirta</td>
<td>614,000</td>
<td>5-10</td>
</tr>
<tr>
<td>Hyparrhenia rufa, jaragua</td>
<td>707,000</td>
<td>5-10</td>
</tr>
<tr>
<td>Imperata cylindrica, cogongrass</td>
<td>269,000</td>
<td>4-8</td>
</tr>
<tr>
<td>Koeleria cristata, junegrass</td>
<td>159,000</td>
<td>4-8</td>
</tr>
<tr>
<td>Lolium multiflorum, Italian ryegrass</td>
<td>25,000</td>
<td>25-35</td>
</tr>
<tr>
<td>Lolium perenne, perennial ryegrass</td>
<td>28,000</td>
<td>25-35</td>
</tr>
<tr>
<td>Muhlenbergia porteri, bush muhly</td>
<td>2,424,000</td>
<td>8-10</td>
</tr>
<tr>
<td>Oryzopsis hymenoides, Indian ricegrass</td>
<td>141,000</td>
<td></td>
</tr>
<tr>
<td>Oryzopsis miliacea, smilo grass</td>
<td>884,000</td>
<td></td>
</tr>
<tr>
<td>Panicum antidotale, blue panic</td>
<td>657,000</td>
<td>2-6</td>
</tr>
<tr>
<td>Panicum maximum, Guinea-grass</td>
<td>1,066,000</td>
<td>Vegetative</td>
</tr>
<tr>
<td>Panicum milicentum, proso</td>
<td>82,000</td>
<td>15-25</td>
</tr>
<tr>
<td>Panicum obtusum, vine-mesquite</td>
<td>143,000</td>
<td>5-10</td>
</tr>
<tr>
<td>Panicum purpurascens, Paragras</td>
<td>0 = ornamentals.</td>
<td>Vegetative</td>
</tr>
</tbody>
</table>

* = in burs or unhulled.  
**w** = weedy in character.  
*o* = ornamentals.
### 6. Forage Statistics

<table>
<thead>
<tr>
<th>Scientific and common name</th>
<th>No. seed per lb.</th>
<th>Seeding rate, lbs. per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Panicum repens,</em> torpedograss</td>
<td>510,000</td>
<td>Vegetative</td>
</tr>
<tr>
<td><em>Panicum virgatum,</em> switchgrass</td>
<td>389,000</td>
<td>5-8</td>
</tr>
<tr>
<td><em>Paspalum dilatatum,</em> Dallisgrass</td>
<td>220,000</td>
<td>8-20</td>
</tr>
<tr>
<td><em>Paspalum lateral,</em> fiedl paspalum (w)</td>
<td>156,000</td>
<td>10-20</td>
</tr>
<tr>
<td><em>Paspalum notatum,</em> Bahiagrass</td>
<td>1,059,000</td>
<td>10-15</td>
</tr>
<tr>
<td><em>Paspalum phricatum,</em> browneed paspalum</td>
<td>317,000</td>
<td>10-15</td>
</tr>
<tr>
<td><em>Paspalum striatum,</em> sand paspalum</td>
<td>258,000</td>
<td>5-10</td>
</tr>
<tr>
<td><em>Paspalum ureilae,</em> Vaseygrass</td>
<td>440,000</td>
<td>10-20</td>
</tr>
<tr>
<td><em>Pennisetum glaucum,</em> pearlmillet</td>
<td>88,000</td>
<td>20-30</td>
</tr>
<tr>
<td><em>Pennisetum purpureum,</em> Napiergrass</td>
<td>1,402,000</td>
<td>6-12</td>
</tr>
<tr>
<td><em>Phalaris arundinacea,</em> reed canarygrass</td>
<td>533,000</td>
<td>5-10</td>
</tr>
<tr>
<td><em>Phalaris canariensis,</em> canarygrass</td>
<td>68,000</td>
<td>25-30</td>
</tr>
<tr>
<td><em>Phalaris culrus,</em> Carolina canarygrass</td>
<td>429,000</td>
<td>10-15</td>
</tr>
<tr>
<td><em>Phalaris tuberosa var. stenoptera,</em> Hardina grass</td>
<td>355,000</td>
<td>25-30</td>
</tr>
<tr>
<td><em>Phleum pratense,</em> timothy</td>
<td>1,230,000</td>
<td>6-10</td>
</tr>
<tr>
<td><em>Poa annua,</em> annual bluegrass</td>
<td>882,000</td>
<td>15-25</td>
</tr>
<tr>
<td><em>Poa arachnifera,</em> Texas bluegrass</td>
<td>1,186,000</td>
<td>4-6</td>
</tr>
<tr>
<td><em>Poa bulbosa,</em> bulbous bluegrass</td>
<td>1,874,000</td>
<td>20-25</td>
</tr>
<tr>
<td><em>Poa compressa,</em> Canada bluegrass</td>
<td>2,495,000</td>
<td>15-25</td>
</tr>
<tr>
<td><em>Poa nevadensis,</em> Nevada bluegrass</td>
<td>1,082,000</td>
<td>6-10</td>
</tr>
<tr>
<td><em>Poa pratensis,</em> Kentucky bluegrass</td>
<td>2,177,000</td>
<td>15-25</td>
</tr>
<tr>
<td><em>Poa secunda,</em> Sandberg bluegrass</td>
<td>925,000</td>
<td>6-10</td>
</tr>
<tr>
<td><em>Poa trivialis,</em> rough bluegrass</td>
<td>2,540,000</td>
<td>15-25</td>
</tr>
<tr>
<td><em>Puccinellia Psittali,</em> Nuttall alkali-grass</td>
<td>2,108,000</td>
<td>6-10</td>
</tr>
<tr>
<td><em>Redflea grama,</em> blowoutgrass</td>
<td>263,000</td>
<td>Vegetative</td>
</tr>
<tr>
<td><em>Saccharum officinarum,</em> sugarcane</td>
<td>429,000</td>
<td>Vegetative</td>
</tr>
<tr>
<td><em>Secale cereale,</em> rye</td>
<td>18,000</td>
<td>90-160</td>
</tr>
<tr>
<td>*Sesleria foxtail millet</td>
<td>220,000</td>
<td>20-30</td>
</tr>
<tr>
<td><em>Sesleria macrostachya,</em> plains bristlegrass</td>
<td>305,000</td>
<td>4-6</td>
</tr>
<tr>
<td><em>Sorghastrum nutans,</em> yellow Indian grass</td>
<td>175,000</td>
<td>10-15</td>
</tr>
<tr>
<td><em>Sorghum halapense,</em> Johnsonsgrass</td>
<td>118,000</td>
<td>10-25</td>
</tr>
<tr>
<td><em>Sorghum vulgare,</em> sorghum</td>
<td>28,000</td>
<td>15-75</td>
</tr>
<tr>
<td><em>Sorghum vulgare var. sudanense,</em> Sudan grass</td>
<td>55,000</td>
<td>20-25</td>
</tr>
<tr>
<td><em>Sporobolus airoides,</em> alkali sacaton</td>
<td>1,758,000</td>
<td>4-6</td>
</tr>
<tr>
<td><em>Sporobolus asper,</em> tall dropseed</td>
<td>503,000</td>
<td>4-6</td>
</tr>
<tr>
<td><em>Sporobolus asper var. hookeri,</em> meadow dropseed</td>
<td>823,000</td>
<td>4-6</td>
</tr>
<tr>
<td><em>Sporobolus cryptandrum,</em> sand dropseed</td>
<td>5,298,000</td>
<td>2-4</td>
</tr>
<tr>
<td><em>Sporobolus giganteus,</em> giant dropseed</td>
<td>1,723,000</td>
<td>2-4</td>
</tr>
<tr>
<td><em>Sporobolus wrightii,</em> sacaton</td>
<td>1,965,000</td>
<td>2-4</td>
</tr>
<tr>
<td><em>Stipa capensis,</em> St. Augustinegrass</td>
<td>115,000</td>
<td>Vegetative</td>
</tr>
<tr>
<td><em>Stipa comata,</em> needle-and-thread</td>
<td>118,000</td>
<td>8-12</td>
</tr>
<tr>
<td><em>Stipa pachycaulis,</em> California needlegrass</td>
<td>181,000</td>
<td>Vegetative</td>
</tr>
<tr>
<td><em>Stipa viridula,</em> green needlegrass</td>
<td>105,000</td>
<td>8-12</td>
</tr>
<tr>
<td><em>Triodia californica,</em> Arizona cottontop</td>
<td>718,000</td>
<td>4-8</td>
</tr>
<tr>
<td><em>Triodia repens,</em> Natal grass</td>
<td>501,000</td>
<td>4-8</td>
</tr>
<tr>
<td><em>Triticeae flava,</em> purpletop</td>
<td>465,000</td>
<td>4-6</td>
</tr>
<tr>
<td><em>Tripsacum dactyloides,</em> eastern gramagrass</td>
<td>7,280</td>
<td>Vegetative</td>
</tr>
<tr>
<td><em>Trisetum flavescens,</em> yellow triestem</td>
<td>389,000</td>
<td>Vegetative</td>
</tr>
<tr>
<td><em>Triticum aestivum,</em> wheat</td>
<td>510,000</td>
<td>60-150</td>
</tr>
<tr>
<td><em>Urochloa latifolia,</em> broadleaf uniola (o)</td>
<td>94,000</td>
<td>Vegetative</td>
</tr>
<tr>
<td><em>Urochloa paniculata,</em> sea-oats (o)</td>
<td>1,118</td>
<td>6-10</td>
</tr>
<tr>
<td><em>Zea mays,</em> corn</td>
<td>11,340</td>
<td>50-100</td>
</tr>
<tr>
<td><em>Zizania aquatica,</em> annual wildrice</td>
<td>1,300,000</td>
<td>Vegetative</td>
</tr>
<tr>
<td><em>Zizania natricola,</em> Manilagrass</td>
<td>681,000</td>
<td>Vegetative</td>
</tr>
</tbody>
</table>

* = in burs or unhusked.  
w = weedy in character.  
o = ornamentals.
### TABLE 6.6
SEED PER POUND, WEIGHT PER BUSHEL AND RATE OF SEEDING OF SOME OF THE MORE IMPORTANT LEGUMES, ARRANGED ALPHABETICALLY BY SCIENTIFIC NAME

<table>
<thead>
<tr>
<th>Scientific and common name</th>
<th>No. seed per lb</th>
<th>Weight per bushel, lbs</th>
<th>Seeding rate, lbs. per acre (broadcast)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almoscarpus rugoscis, alyceclover</td>
<td>360,000</td>
<td>60</td>
<td>10–12</td>
</tr>
<tr>
<td>Anthyllis vulneraria, kidneyvetch</td>
<td>180,000</td>
<td>60</td>
<td>15–20</td>
</tr>
<tr>
<td>Arachis hypogaea, peanut</td>
<td>1,000</td>
<td>22 *</td>
<td>30 *</td>
</tr>
<tr>
<td>Aragagalus cicer, cicer milkvetch</td>
<td>130,000</td>
<td>60</td>
<td>20–25</td>
</tr>
<tr>
<td>Aragagalus falcatus, sicklepod milkvetch</td>
<td>130,000</td>
<td>60</td>
<td>20–25</td>
</tr>
<tr>
<td>Aragagalus rubi, Ruby milkvetch</td>
<td>240,000</td>
<td>60</td>
<td>10–12</td>
</tr>
<tr>
<td>Cajanus indicus, pigeonpea</td>
<td>8,000</td>
<td>60</td>
<td>8–10 †</td>
</tr>
<tr>
<td>Canna tiera, sickle senna</td>
<td>22,000</td>
<td>60</td>
<td>40–45</td>
</tr>
<tr>
<td>Chamaecrista fasciculata, showy partridge-pea</td>
<td>64,000</td>
<td>57</td>
<td>20–30</td>
</tr>
<tr>
<td>Cicer aritinum, garbanzo</td>
<td>1,000</td>
<td>54</td>
<td>20–30 †</td>
</tr>
<tr>
<td>Corolla varia, varia crownvetch</td>
<td>110,000</td>
<td>55</td>
<td>15–20</td>
</tr>
<tr>
<td>Crotalaria incana, chak crotalaria</td>
<td>85,000</td>
<td>60</td>
<td>15–18</td>
</tr>
<tr>
<td>Crotalaria intermedia, slenderleaf crotalaria</td>
<td>100,000</td>
<td>60</td>
<td>10–15</td>
</tr>
<tr>
<td>Crotalaria juncea, sunn crotalaria</td>
<td>15,000</td>
<td>35–40</td>
<td></td>
</tr>
<tr>
<td>Crotalaria lanceolata, lance crotalaria</td>
<td>170,000</td>
<td>60</td>
<td>7–10</td>
</tr>
<tr>
<td>Crotalaria mucronata, striped crotalaria</td>
<td>75,000</td>
<td>60</td>
<td>10–15</td>
</tr>
<tr>
<td>Crotalaria spectabilis, showy crotalaria</td>
<td>30,000</td>
<td>60</td>
<td>25–30</td>
</tr>
<tr>
<td>Cyamopsis tetragonoloba, guar</td>
<td>20,000</td>
<td>60</td>
<td>30–40</td>
</tr>
<tr>
<td>Dalea alpicoiroides, foxtail dalea</td>
<td>150,000</td>
<td>60</td>
<td>10–15</td>
</tr>
<tr>
<td>Desmodium purpureum, tall tickclover</td>
<td>200,000</td>
<td>60</td>
<td>8–10</td>
</tr>
<tr>
<td>Dolichos lablab, hyacinth-bean</td>
<td>1,400</td>
<td>60</td>
<td>20–25 †</td>
</tr>
<tr>
<td>Gloridium viridarium, bagpod</td>
<td>1,500</td>
<td>56</td>
<td>20–30 †</td>
</tr>
<tr>
<td>Glycine soja, soybean</td>
<td>5,000</td>
<td>60</td>
<td>45–60</td>
</tr>
<tr>
<td>Hedysarum coronarium, sulla</td>
<td>100,000</td>
<td>60</td>
<td>20–25</td>
</tr>
<tr>
<td>Indigofera hirsuta, hairy indigo</td>
<td>200,000</td>
<td>55</td>
<td>8–10</td>
</tr>
<tr>
<td>Lathyris cicer, flatpod peavine</td>
<td>8,000</td>
<td>60</td>
<td>60–70</td>
</tr>
<tr>
<td>Lathyris hirsuta, roughpea</td>
<td>15,000</td>
<td>55</td>
<td>50–60</td>
</tr>
<tr>
<td>Lathyris sativus, grasspea</td>
<td>5,000</td>
<td>60</td>
<td>70–80</td>
</tr>
<tr>
<td>Lathyris sylvestris, flatpea</td>
<td>8,000</td>
<td>60</td>
<td>60–70</td>
</tr>
<tr>
<td>Lathyris tinguiorum, Tangier-pea</td>
<td>5,000</td>
<td>60</td>
<td>70–80</td>
</tr>
<tr>
<td>Lens esculenta, lentil</td>
<td>9,000</td>
<td>60</td>
<td>12–15 †</td>
</tr>
<tr>
<td>Lenspeza bicolor, bicolor lespedeza</td>
<td>82,000</td>
<td>60</td>
<td>1–2 †</td>
</tr>
<tr>
<td>Lenspeza cuneata, sericea lespedeza</td>
<td>350,000</td>
<td>60</td>
<td>10–15</td>
</tr>
<tr>
<td>Lenspeza cyrtobotrya, bush lespedeza</td>
<td>65,000</td>
<td>60</td>
<td>1–2 †</td>
</tr>
<tr>
<td>Lenspeza hedysonoides, rush lespedeza</td>
<td>500,000</td>
<td>60</td>
<td>10–15</td>
</tr>
<tr>
<td>Lenspeza latissima, decumbent lespedeza</td>
<td>300,000</td>
<td>60</td>
<td>10–15</td>
</tr>
<tr>
<td>Lenspeza stipulacea, Korean lespedeza</td>
<td>225,000 *</td>
<td>40 *</td>
<td>10–15 *</td>
</tr>
<tr>
<td>Lenspeza stratiata, common lespedeza var. Koebe</td>
<td>190,000 *</td>
<td>25 *</td>
<td>10–15 *</td>
</tr>
<tr>
<td>Lenspeza stratiata, common lespedeza var. Tennessee #76</td>
<td>310,000 *</td>
<td>25 *</td>
<td>8–10 *</td>
</tr>
<tr>
<td>Lotus corniculatus, broadleaf birdsfoot trefoil</td>
<td>375,000</td>
<td>60</td>
<td>5–8</td>
</tr>
<tr>
<td>Lotus tenuis, narrowleaf birdsfoot trefoil</td>
<td>400,000</td>
<td>60</td>
<td>5–8</td>
</tr>
<tr>
<td>Lotus uliginosus, big trefoil</td>
<td>1,000,000</td>
<td>60</td>
<td>3–5</td>
</tr>
<tr>
<td>Lupinus albus, white lupine</td>
<td>1,500</td>
<td>60</td>
<td>100–120</td>
</tr>
<tr>
<td>Lupinus angustifolius, blue lupine</td>
<td>2,500</td>
<td>60</td>
<td>70–100</td>
</tr>
<tr>
<td>Lupinus luteus, yellow lupine</td>
<td>4,000</td>
<td>60</td>
<td>50–80</td>
</tr>
<tr>
<td>Lupinus subcarnosus, bluebonnet</td>
<td>14,000</td>
<td>60</td>
<td>40–45</td>
</tr>
<tr>
<td>Medicago arabica, spotted bur-clover</td>
<td>210,000</td>
<td>10 *</td>
<td>100 *</td>
</tr>
<tr>
<td>Medicago falcata, yellow alfalfa</td>
<td>208,000</td>
<td>60</td>
<td>15–20</td>
</tr>
<tr>
<td>Medicago hispida, California bur-clover</td>
<td>140,000</td>
<td>60</td>
<td>20–25</td>
</tr>
<tr>
<td>Medicago lupulina, black mede</td>
<td>300,000</td>
<td>60</td>
<td>10–15</td>
</tr>
</tbody>
</table>

* Unhulled.
† Planted in rows 3 to 4 feet apart.
### Scientific and common name

<table>
<thead>
<tr>
<th>Scientific and common name</th>
<th>No. seed per lb</th>
<th>Weight per bushel, lbs.</th>
<th>Seeding rate, lbs. per acre (broadcast)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Medicago minima</em>, little bur-clover.</td>
<td>400,000</td>
<td>10</td>
<td>60</td>
</tr>
<tr>
<td><em>Medicago orbicularis</em>, button clover.</td>
<td>150,000</td>
<td>60</td>
<td>15-20</td>
</tr>
<tr>
<td><em>Medicago sativa</em>, purple alfalfa.</td>
<td>200,000</td>
<td>60</td>
<td>15-20</td>
</tr>
<tr>
<td><em>Medicago satellitae</em>, small medic.</td>
<td>43,000</td>
<td>15</td>
<td>100</td>
</tr>
<tr>
<td><em>Melilotus alba</em>, white sweet clover.</td>
<td>260,000</td>
<td>60</td>
<td>10-15</td>
</tr>
<tr>
<td><em>Melilotus indica</em>, sour clover.</td>
<td>275,000</td>
<td>60</td>
<td>10-15</td>
</tr>
<tr>
<td><em>Melilotus officinalis</em>, yellow sweet clover.</td>
<td>260,000</td>
<td>60</td>
<td>10-15</td>
</tr>
<tr>
<td><em>Melilotus scabrella</em>, snail medic.</td>
<td>250,000</td>
<td>60</td>
<td>10-15</td>
</tr>
<tr>
<td><em>Melilotus albus</em>, purple alfalfa.</td>
<td>30,000</td>
<td>55</td>
<td>30-35</td>
</tr>
<tr>
<td><em>Medicago sativa</em>, little bur-dover.</td>
<td>160,000</td>
<td>36</td>
<td>15-20</td>
</tr>
<tr>
<td><em>Phaseolus acutifolius</em>, mat bean.</td>
<td>28,000</td>
<td>60</td>
<td>35-40</td>
</tr>
<tr>
<td><em>Phaseolus exilis</em>, Texas bean.</td>
<td>25,000</td>
<td>60</td>
<td>25-30</td>
</tr>
<tr>
<td><em>Phaseolus angularis</em>, aduki bean.</td>
<td>4,000</td>
<td>60</td>
<td>20-25†</td>
</tr>
<tr>
<td><em>Phaseolus aureus</em>, mung bean.</td>
<td>10,000</td>
<td>60</td>
<td>60-70†</td>
</tr>
<tr>
<td><em>Phaseolus coccineus</em>, rice bean.</td>
<td>10,000</td>
<td>60</td>
<td>70-80†</td>
</tr>
<tr>
<td><em>Pisum arvense</em>, field pea.</td>
<td>3,000</td>
<td>60</td>
<td>70-90†</td>
</tr>
<tr>
<td><em>Pueraria phaseoloides</em>, tropical kudzu.</td>
<td>37,000</td>
<td>54</td>
<td>10-15†</td>
</tr>
<tr>
<td><em>Pueraria thunbergiata</em>, Thunberg kudzu.</td>
<td>40,000</td>
<td>54</td>
<td>6-10†</td>
</tr>
<tr>
<td><em>Sesbania exaltata</em>, hemp sesbania.</td>
<td>40,000</td>
<td>60</td>
<td>20-25†</td>
</tr>
<tr>
<td><em>Stizolobium durringhamianum</em>, Deering velvet bean.</td>
<td>1,000</td>
<td>60</td>
<td>30-40†</td>
</tr>
<tr>
<td><em>Stylosias helvolus</em>, trailing wild bean.</td>
<td>9,000</td>
<td>50</td>
<td>50-60†</td>
</tr>
<tr>
<td><em>Trifolium agrarium</em>, hop clover.</td>
<td>1,000,000</td>
<td>60</td>
<td>4-5†</td>
</tr>
<tr>
<td><em>Trifolium alexandrinum</em>, berseem.</td>
<td>200,000</td>
<td>60</td>
<td>15-20†</td>
</tr>
<tr>
<td><em>Trifolium dubium</em>, small hop clover.</td>
<td>1,000,000</td>
<td>60</td>
<td>4-5†</td>
</tr>
<tr>
<td><em>Trifolium fragiferum</em>, strawberry clover.</td>
<td>300,000</td>
<td>60</td>
<td>6-10†</td>
</tr>
<tr>
<td><em>Trifolium glutinatum</em>, cluster clover.</td>
<td>1,000,000</td>
<td>60</td>
<td>3-4†</td>
</tr>
<tr>
<td><em>Trifolium hirtum</em>, rose clover.</td>
<td>140,000</td>
<td>60</td>
<td>15-20†</td>
</tr>
<tr>
<td><em>Trifolium hybridum</em>, alake clover.</td>
<td>700,000</td>
<td>60</td>
<td>6-8†</td>
</tr>
<tr>
<td><em>Trifolium incarnatum</em>, crimson clover.</td>
<td>140,000</td>
<td>60</td>
<td>15-20†</td>
</tr>
<tr>
<td><em>Trifolium lapponicum</em>, lappa clover.</td>
<td>680,000</td>
<td>60</td>
<td>4-5†</td>
</tr>
<tr>
<td><em>Trifolium nigrescens</em>, ball clover.</td>
<td>1,000,000</td>
<td>60</td>
<td>2-4</td>
</tr>
<tr>
<td><em>Trifolium pratense</em>, red clover.</td>
<td>275,000</td>
<td>60</td>
<td>8-12†</td>
</tr>
<tr>
<td><em>Trifolium procumbens</em>, large hop clover.</td>
<td>2,000,000</td>
<td>60</td>
<td>3-4†</td>
</tr>
<tr>
<td><em>Trifolium repens</em>, white clover.</td>
<td>800,000</td>
<td>60</td>
<td>1-4†</td>
</tr>
<tr>
<td><em>Trifolium resupinatum</em>, Persian clover.</td>
<td>675,000</td>
<td>60</td>
<td>4-6†</td>
</tr>
<tr>
<td><em>Trifolium striatum</em>, knotted clover.</td>
<td>231,000</td>
<td>60</td>
<td>8-12†</td>
</tr>
<tr>
<td><em>Trifolium subterraneum</em>, sub clover.</td>
<td>65,000</td>
<td>60</td>
<td>20-25†</td>
</tr>
<tr>
<td><em>Trigonella foemina-gracilis</em>, fenugreek.</td>
<td>23,000</td>
<td>60</td>
<td>25-35†</td>
</tr>
<tr>
<td><em>Vicia angustifolia</em>, narrowleaf vetch.</td>
<td>30,000</td>
<td>60</td>
<td>30-40†</td>
</tr>
<tr>
<td><em>Vicia arborescens</em>, one-flower (monantha) vetch.</td>
<td>12,000</td>
<td>60</td>
<td>50-60†</td>
</tr>
<tr>
<td><em>Vicia atropurpurea</em>, purple vetch.</td>
<td>10,000</td>
<td>60</td>
<td>50-60†</td>
</tr>
<tr>
<td><em>Vicia cracca</em>, bird vetch.</td>
<td>40,000</td>
<td>60</td>
<td>30-35†</td>
</tr>
<tr>
<td><em>Vicia dasyacarpia</em>, woollypod vetch.</td>
<td>10,000</td>
<td>60</td>
<td>50-60†</td>
</tr>
<tr>
<td><em>Vicia faba</em>, major, broad bean.</td>
<td>500</td>
<td>60</td>
<td>70-80†</td>
</tr>
<tr>
<td><em>Vicia faba</em>, horsebean.</td>
<td>3,000</td>
<td>60</td>
<td>80-100†</td>
</tr>
<tr>
<td><em>Vicia grandiflora</em>, bigflower vetch.</td>
<td>32,000</td>
<td>60</td>
<td>35-40†</td>
</tr>
<tr>
<td><em>Vicia pannonica</em>, Hungarian vetch.</td>
<td>10,000</td>
<td>60</td>
<td>70-80†</td>
</tr>
<tr>
<td><em>Vicia sativa</em>, common vetch.</td>
<td>7,000</td>
<td>60</td>
<td>70-80†</td>
</tr>
<tr>
<td><em>Vicia villosa</em>, hairy vetch.</td>
<td>20,000</td>
<td>60</td>
<td>40-45†</td>
</tr>
<tr>
<td><em>Vigna sinensis</em>, cowpea.</td>
<td>3,000</td>
<td>60</td>
<td>20-30†</td>
</tr>
</tbody>
</table>

* Unhulled.
† Planted in rows 3 to 4 feet apart.
TABLE 6.7
AVERAGE PRODUCTION IN THOUSANDS OF TONS OF ALL HAY IN THE U. S. AND RELATIVE IMPORTANCE OF DIFFERENT KINDS BY 5-YEAR PERIODS, 1920–44

<table>
<thead>
<tr>
<th>5-year average</th>
<th>All hay</th>
<th>% of all hay</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Legumes and clover</td>
</tr>
<tr>
<td></td>
<td></td>
<td>reported separately</td>
</tr>
<tr>
<td>1920–1924</td>
<td>90,503</td>
<td>25</td>
</tr>
<tr>
<td>1925–1929</td>
<td>85,077</td>
<td>33</td>
</tr>
<tr>
<td>1930–1934</td>
<td>73,801</td>
<td>40</td>
</tr>
<tr>
<td>1935–1939</td>
<td>84,247</td>
<td>46</td>
</tr>
<tr>
<td>1940–1944</td>
<td>96,430</td>
<td>48 ‡</td>
</tr>
</tbody>
</table>

* Alfalfa, clover, and timothy hay.
† Grains cut green for hay and production reported as miscellaneous tame hay.
‡ The legume percentage would be increasingly greater in recent years and the “clover and timothy” percentage considerably smaller if statistics on clover hays (grown alone) were available and included.

by the formula: Volume = 0.08 × height × circumference at the base × circumference at the shoulder. The volume of the upper portion of the stack is found by the formula: Volume = 0.04 × height × circumference at the base of the top portion squared. These formulas give the volume of hay in the stack.

In order to find the number of tons it is necessary to divide the volume of the rectangular or round stacks by the estimated number of cubic feet per ton.

CUBIC FEET PER TON. Many factors affect the density of hay and therefore the number of cubic feet required per ton of hay. The factor that causes the greatest variation probably is the amount of moisture in the hay at the time of stacking or placing in the mow. Tough or slightly uncured hay will settle and become more compact than very dry or overcured hay. Other factors like texture and foreign material may affect the density also, but probably not to the same extent as moisture. For these reasons there often is a considerable difference in the number of cubic feet required per ton in different stacks and


### Table 6.8

**Estimated Silo Capacity in Tons of Settled Corn Silage**

<table>
<thead>
<tr>
<th>Silage depth in ft.</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>14</th>
<th>16</th>
<th>18</th>
<th>20</th>
<th>22</th>
<th>24</th>
<th>26</th>
<th>28</th>
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<td>184</td>
<td>215</td>
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</table>

For immature corn add 10 to 15 per cent to the capacity given. If corn is unusually dry when ensiled, deduct 10 to 15 per cent. If corn is rich in grain add 5 to 10 per cent. If very little grain is present, deduct 10 per cent.

### Table 6.9

**Average Weight per Cubic Foot of Settled Unwilted Alfalfa Silage and Capacities of Silos of Various Diameters**

<table>
<thead>
<tr>
<th>Depth of settled silage in ft</th>
<th>12</th>
<th>14</th>
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<th>18</th>
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<tbody>
<tr>
<td>2</td>
<td>16.9</td>
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<td></td>
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<tr>
<td>4</td>
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<td>6</td>
<td>27.3</td>
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<td>8</td>
<td>31.1</td>
<td></td>
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<td>34.1</td>
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</tr>
<tr>
<td>12</td>
<td>36.7</td>
<td></td>
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<tr>
<td>14</td>
<td>38.8</td>
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<tr>
<td>16</td>
<td>40.5</td>
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<td>18</td>
<td>42.1</td>
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<td>36</td>
<td>51.5</td>
<td></td>
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</table>

*Measured from the surface of the settled silage before any is removed from the silo.*

### Kind of Hay

<table>
<thead>
<tr>
<th>Kind of Hay</th>
<th>Length of time in stack</th>
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<tr>
<td></td>
<td>30 to 90 days</td>
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<tr>
<td>Alfalfa</td>
<td>435 cu. ft./ton</td>
</tr>
<tr>
<td>Timothy and</td>
<td>640 cu. ft./ton</td>
</tr>
<tr>
<td>timothy mixed Wild</td>
<td>600 cu. ft./ton</td>
</tr>
</tbody>
</table>

Figures used for estimating the tonnage of hay in the stack may be used for estimating the tonnage of hay in the mow. However, for hay stored in the mow a volume for estimating tonnage is a block $8 \times 8 \times 8$ feet, or 512 cu. ft., as equal to a ton of hay. For extremely well-settled tame hay (i.e., in the bottom of large mows) 343 cubic feet has been used in some cases.

### Baled and Chopped Hay

A ton of baled hay occupies from about 100 to 250 cubic feet, or 15 to 50 per cent of...
the space occupied by loose hay. Bales vary in size. The smaller bales, 50 to 60 pounds, are easily handled but commercial hay is preferred in 70 to 80 pound bales. As a general rule for baled hay, reduce the volume to one-fourth and for chopped hay to one-half that required for loose hay. (See Chapter 48 for variations from this rule.)

**Measurement of Silage in Silo**

**CORN SILAGE.** To determine the amount of silage, the volume of the silo is divided by the number of cubic feet per ton, the average being about 44 for silage settled 30 days or more. The density is influenced by several factors including silage depth, diameter of silo, per cent moisture, et al. Silo capacities for corn silage are shown in Table 6.8.

**ALFALFA SILAGE.** Table 6.9 gives silage density and silo capacities for unwilted alfalfa.

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PART II

Forage Grasses and Legumes
The Botany of Grasses and Legumes

Our principal forages are largely in the two botanical families, the grasses, Gramineae, and the legumes, Leguminosae.

THE GRASSES

The grasses are grouped into about 600 genera, with close to 5,000 species. Of these, about 150 genera and 1,500 species are found growing in the United States. They have a wider range than any other family of flowering plants. The grass family includes about 75 per cent of the cultivated forage crops and all the cereal crops.

Economic Value of Grasses

The grasses excel all other seed-bearing plants in their use by man and animals. They furnish the principal breadstuffs of the world and the bulk of the feed of animals. Over one-half of the farm income of the United States comes from the grasses, including corn, wheat, and other cereals. In addition to the foods derived from their seed and fruits, as in the case of cereals, and the forage from their vegetative structures the grasses are of value to man in many other ways.

General Description of Grasses

Grasses are either annuals, winter annuals, or perennials. Almost all are herbaceous (non-woody) plants. The grasses are monocotyledons, as distinguished from legumes which are dicotyledons. This distinction between the two groups is based on the structure of the embryo; the major root stem axis of the embryo carries lateral members known as cotyledons or seed leaves; monocotyledons have only one cotyledon while dicotyledons have two.

In size, the grasses range from a few inches to seventy feet or more in height, the greatest sizes being attained by the bamboo. Corn, sugar cane, and sorghum are representative of the larger species of grasses. The organs of the grasses are the stems, roots, leaves, inflorescences, and fruits.

Morphology of Grasses

The organs of grasses undergo many modifications from the usual or typical structure. However, they have certain common characteristics.

LEAVES. The leaves are borne on the stem, alternately in two rows, one at each node. The leaf consists of sheath, blade, and ligule (Fig. 7.1 G,J.). The sheath surrounds the stem above the

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The Grasses

Many grasses have, in addition to the vertical flowering stems or culms, horizontal stems, called rhizomes, which are characteristic of quackgrass, Johnsongrass, bluegrass and many others (Fig. 7.1I). The rhizome is, in most cases, the over-wintering part of perennial grasses.

Creeping stems above ground are called stolons (Fig. 7.1H). The stolons resemble rhizomes in that they have definite nodes and internodes, nodal meristems from which secondary structures arise, and leaves. They are more “stem-like” than rhizomes in that they lie above ground and their leaves develop and function normally. Two of the best known stoloniferous grasses are buffalo grass and Bermudagrass. Certain grasses have thickened lower internodes in which food accumulates and from which new shoots arise, thus serving to perpetuate the plants through the winter or dormant season. These food storage internodes usually are known as corms. The timothy structure differs somewhat and is called the haplocorm.

Stems. The jointed stem of a grass is distinctly divided into nodes and internodes. The internode may be either hollow, pithy, or solid. The node or joint is always solid. The leaves have their vascular connections with the stem at the node. Lateral buds arise in the axils of the leaves. These lateral buds may become vegetative (sucker) branches of the stem or flower shoots. Brace roots arise from the nodal meristem (keimerring), a zone just above the node, except that at the second node the branches arise just below the node. The cells of the nodal meristem remain meristematic until the stem has progressed well toward maturity. It is because of the differential growth on the lower side of a lodged stem that lodged stems are able to turn upward and again attain a partially erect position.

Roots. Grasses have fibrous root systems.

The primary grass root may persist for only a short time after germination, as in corn. An extensive system of secondary roots soon arises at the lower nodes of the young stem and comprises the major part of the permanent root system. Secondary roots sometimes form at nodes above the ground, as in the case of corn (prop roots), or at the nodes of creeping stems (rhizome or stolon).

Fig. 7.1 Illustrations of characteristic growth of grass plants. (A) Flowers arranged as several spikelets on a central axis, enclosed in two empty glumes or bracts. (B) The different parts of a grass flower. (C) The developed fruit or seed, a caryopsis. The caryopsis is shown successively enclosed in the outer glumes, with the lemma and palea both closely adhering and free. (D) Spikelets arranged in a terminal spike. (E) Spikelets arranged in a panicle. (F) Spikelets arranged in a raceme. (G) The ligule, at the junction of the leaf blade and leaf sheath. (H, I, J) Means of propagating or spreading: stolon, rhizome, and bulb, respectively. U.S.D.A. Yearbook photo. 1948.
INFLORESCENCE. The unit of the grass inflorescence is the spikelet. The spikelets usually are in groups or clusters, which constitute the inflorescence (Fig. 7.1A). There are several types of inflorescence. The simplest is the raceme, in which case the spikelets are borne along an unbranched axis (Fig. 7.1F). A typical raceme in grasses is rare. The spike differs from the raceme in having sessile spikelets (Fig. 7.1D). Wheat and barley have spikes. The panicle is the most common type of grass inflorescence. In a panicle the spikelets are pedicelled in a branched inflorescence (Fig. 7.1E). The panicle may be either open, diffuse, or contracted. The flower clusters of bromegrass, Kentucky bluegrass, and redtop are panicles.

It is in the spikelet that specialization usually takes place. The spikelet has a variable number of flowers, ranging from one to many, depending on the species. The axis of the spikelet is the rachilla. At the base of the spikelet two glumes are attached, on opposite sides of the rachilla. They enclose the florets of the spikelet.

FLOWERS. The grasses usually have perfect flowers which are small, with rudimentary perianth (Fig. 7.1B). The flowers are arranged in spikelets which consist of a shortened axis, the rachilla, and two to many two-ranked bracts, the lowest two being empty. The one or more bracts above the empty glumes are the lemmas. In the axils of the lemmas are the flowers. Between each flower and the rachilla is a two-nerved bract called the palea. Stamens vary from one to many, but three is the usual number. There is one pistil, and the pistil has a one-celled ovary with one ovule. Commonly two styles are present, each with a feathery (plumose) stigma. The perianth consists of two or sometimes three minute blisters, called lodicules, located inside the lemma at the base of the flower. These lodicules help to force open the lemma and palea at the time of anthesis and thus aid in pollination. The slender filaments bear two-celled anthers. Most grasses flower every year. However, some perennials that spread by rhizomes may cover extensive areas without flowering regularly. Typically, the grasses are adapted to cross pollination by wind but many species are cleistogamous (self-pollinating in the bud), as wheat, oats and barley.

FRUIT OR CARYOPSIS. The fruit of the grasses usually is a caryopsis or kernel (Fig. 7.1C). The single seed is grown fast to the ovary wall, forming a seed-like grain. The pericarp is the modified ovary wall while the seed is the developed ovule. The caryopsis may be free from the lemma and palea, as in wheat, or it may be permanently inclosed, as in oats. The caryopsis may enlarge during ripening and greatly exceed the glumes, lemma and palea, as in corn. The pericarp closely adheres to the seed and thus resembles a seed coat. A seed coat (testa), however, is an ovular structure while the pericarp is the modified ovary wall. The pericarp protects the seed against the loss of moisture, the attacks of organisms, and injuries from fungicides and insecticides. The embryo (germ) lies on the side of the caryopsis next to the lemma and can easily be seen as an oval depression. The part of the caryopsis not occupied by the embryo is the endosperm in which food is stored. The embryo consists of a plumule, radicle, and scutellum. Following germination, the plumule develops into the above ground portion of the plant. The radicle develops into the primary root system, which anchors the...
seedling and absorbs water. During germination, the scutellum or cotyledon of the germ secretes from its outer layer of cells certain enzymes which dissolve the stored food in the endosperm. This makes possible the movement of food materials into the plumule and radicle.

**THE LEGUMES**

There are nearly 500 genera and some 11,000 species of legumes, with almost 4,000 species in America.

**Economic Value of Legumes**

The legumes are well known as soil building plants. Among them are many of value for hay, pasture, green manure, nectar, and for the food value of their seed and fruit. It is estimated that of the acres of all legumes in the United States 40 million are cut for hay, 15 million cut for seed, 5 million are used for cover crop, and 40 million acres for pasture. It is estimated that the nitrogen added to the soil by growing legume crops is greater than the amount added by the use of commercial fertilizers. The total nitrogen from this source would approximate 2 million tons.

**General Description of Legumes**

The legume family name, **Leguminosae**, is derived from the term "legume," which is the name of the type of fruit (pod) characteristic of the plants of this family. A legume is a mono-carpellary fruit, that contains only a single row of seed and dehisces along both sutures or ribs.

As the legume plant grows the symbiotic bacteria responsible for the formation of the nodules on the roots are able to use the nitrogen in the air and to multiply in the nodules. The nitrogen in turn becomes available to the legume plant and aids in its nourishment and growth.

Legumes are dicotyledons. They may be annuals, biennials, or perennials.

**Morphology of Legumes**

The legumes have characteristics that differ in many ways from those of grasses. Although there are rather distinct morphological differences between genera and between some species, there is much uniformity in the characteristic growth of the cultivated legumes.

**LEAVES.** The leaves of the legumes are arranged alternately and have characteristically large stipules. The leaves usually are either pinnately or palmately compound (Fig. 7.2).
The Botany of Grasses and Legumes

Fig. 7.3 The white clovers spread by means of stolons, with roots at each node. Leaves and flower heads are borne on long unbranched stalks, rising directly from the nodes of the stolons. (Adapted from Isely, Iowa State College Journal of Science, Vol. 25, No. 3.)

Stems. The stems of legumes vary greatly in the different species in length, size, amount of branching, and woodiness.

Roots. Most of the legumes, especially the herbaceous ones, have tap roots. Most important, they nearly all have associated with their roots the nitrogen-fixing bacteria which replenish the nitrate supply in soil, appropriating for their own use, and later that of other plants, the free nitrogen of the atmosphere.

Inflorescence. The flowers usually are arranged either in racemes as in the pea, in heads as in the clover, or in a spike-like raceme as in alfalfa.

Flowers. The flowers of naturally cross-pollinated species of legumes have corollas characteristically papilionaceous, or "butterfly-like" (Fig. 7.4). These irregular flowers consist of five petals—a standard, two wings, and a keel that consists of two petals that are more or less united. The calyx normally is four or five toothed. The keel, so named for its boat-like shape, incloses the stigma and the stamens. There are usually ten stamens, nine of which usually have their filaments joined, forming an envelope that incloses the long slender style. The stigma is not quite capitate, or terminal, but is somewhat oblique, that is extending slightly down the side. The corolla tube formed by the partial joining of the five petals varies in length in the different species. In red clover the corolla tube, sometimes twelve or more millimeters in length, is relatively long for the size of the flower. In alsike, white clover, sweetclover, and alfalfa the tube is much shorter than that of red clover.

Since the nectar is secreted at the bottom of the corolla tube, the length of the corolla is a determining factor in the ability of bees and other insects to reach the nectar and thus is a factor in the pollination of the flower. Some legumes, for
FIG. 7.5 Different types of legume seed and seed pods: (1) yellow sweetclover, (2) alfalfa, (3) red clover, (4) vetch, (5) common lespedeza, (6) Korean lespedeza, (7) field pea, (8) cowpea.

example many of the beans and peas, are ordinarily autogamous (self-pollinating) and rather completely self-compatible. They pollinate their own stigmas and need no tripping to get the pollen on the stigma, the pollen contacting the stigma as it rolls out of the opening anthers. In many legumes, of which the clovers and alfalfa are good examples, the anthers are too far below the stigma for the pollen to contact it when the anthers dehisc. These flowers must be tripped, that is the keel must be pressed down until the anthers and stigma spring out of the keel and the pollen is flipped into the air and thus given an opportunity to fall back on the stigma. Other legumes, of which red clover is a good example, are self-sterile, therefore the stigma must be fertilized with pollen from another plant or no seed will be formed. In such legumes as sweetclover and alfalfa, which are at least in part self-sterile, the flower as a rule must be tripped in order for the pollen to reach the stigma.

FRUIT. The fruit is a pod containing one to several seed (Fig. 7.5). The seed usually are without an endosperm at maturity. In legume seed the reserve food is stored in the two cotyledons. The hilum is the scar where the seed has been detached from the pod. Near one end and between the edges of the cotyledons is the embryo axis, which consists of the plumule and the radicle. Each seed is enclosed in the testa or seedcoat. When germination starts the radicle pushes out and down, developing into the root system. In this case the radicle gives rise to the major part of the permanent root system. The plumule develops into the above ground portion of the plant.

COMMON AND BOTANICAL NAMES

The accompanying list * shows the common and scientific names of all the grasses, legumes, and certain other plants mentioned in this volume, as well as those of a few others which the authors believed would be of interest to the reader. Since many forage crop plants are known by different names in different sections of the United States, this list is included here for the reader's convenience.

The approved common names, listed

7. The Botany of Grasses and Legumes

alphabetically, are written with the first letter of the name capitalized, for example, Alfalfa; other forms in use but not approved are in italics: *Beardgrass* (Bluestem).

In the list of scientific names, the genus is in capital letters (MEDICAGO): species and varieties listed under each genus are in lower-case letters (sativa var. media).*

† The scientific name of any plant consists of two words. The first or "genus" name is always capitalized. The second or "species" name is written with a lowercase initial letter. The genus name corresponds roughly in our last name, and the species to our first name, as *Zea* mays would to Brown, John. The scientific name may be followed by the abbreviation of the name of the person who first named the species. Thus, *Zea* mays L. means that this species was named by the great Swedish botanist Linnaeus.

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<th>COMMON NAMES</th>
<th>SCIENTIFIC NAMES</th>
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<tbody>
<tr>
<td><em>Alfalfa</em></td>
<td>MEDICAGO sativa</td>
</tr>
<tr>
<td><em>Alfalfa, variegated</em></td>
<td>MEDICAGO sativa var. media</td>
</tr>
<tr>
<td><em>Alfalfa, yellow</em></td>
<td>MEDICAGO falcata</td>
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<tr>
<td><em>Alkali-grass, Nuttall</em></td>
<td>PUCCINELLIA nuttalliana</td>
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<td><em>Alyceclover</em></td>
<td>ALYSICARPUS vaginalis</td>
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<td><em>Blowoutgrass</em></td>
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<td><em>Bluebonnet; Texas Lupine</em></td>
<td>POA</td>
</tr>
<tr>
<td><em>Bluegrass</em></td>
<td>annua</td>
</tr>
<tr>
<td><em>Annual</em></td>
<td>ampla</td>
</tr>
<tr>
<td><em>Big</em></td>
<td>bulbosa</td>
</tr>
<tr>
<td><em>Bulbous (winter)</em></td>
<td>compressa</td>
</tr>
<tr>
<td><em>Canada</em></td>
<td>pratensis</td>
</tr>
<tr>
<td><em>Kentucky</em></td>
<td>fendlerianna</td>
</tr>
<tr>
<td><em>Mutton</em></td>
<td>nevdensis</td>
</tr>
<tr>
<td><em>Nevada</em></td>
<td>trivialis</td>
</tr>
<tr>
<td><em>Rough; Roughstalk</em></td>
<td>secunda (P. sandbergii)</td>
</tr>
</tbody>
</table>
Forage Crop Breeding

The recent widespread recognition of the value of grasses and legumes has resulted in the initiation of research to improve forage crops in much the same way that the cereals had been improved. In certain countries where forage crops occupy a more prominent place in agriculture than has been true in this country, breeding programs have been in progress for some time. The favorable results from these studies provide the necessary background and pattern for similar work here.

From a genetic point of view, the improvement of forage crops and grain crops is based on the same biological principles. But the grain and forage crops differ in many important respects. An appreciation of the significance of these differences is necessary to fully evaluate the problem and to determine the most effective procedures for improvement. The major differences between the forage and grain crops which have a bearing on a breeding program are:

1. The majority of forage crops are naturally cross pollinated, while the grain crops, except corn and rye, and sorghums to a limited extent, are naturally self-pollinated.

2. Many forage species exhibit varying degrees of self-sterility which may limit the opportunity for controlled inbreeding. Effective ways to utilize self-sterility will be discussed in a subsequent section.

3. Most forage species are grown in mixtures of two or more components which adds complexity in evaluation and in breeding for mutual compatibility.

4. Perennial forage species require a long period of time for development and evaluation of new varieties or strains, thus delaying progress in improvement.

5. Stand establishment of breeding nurseries usually must be with transplants. This added cost tends to reduce the size of populations that can be grown.

6. The bases for the evaluation of breeding material often are not clear-cut and definite.

7. Basic breeding procedures have not been well established, either from

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114 9. Forage Crop Breeding

Fig. 9.1. "Although from a genetic point of view the improvement of forage crops and grain crops is based upon the same biological principle, the two groups of crops differ in many important respects. An appreciation of the significance of these differences is necessary to evaluate fully the problem and to determine the most effective procedures to follow..." (See p. 113.) A bromegrass spikelet within one minute after anthesis, with the anthers, or pollen sacks, dangling at the end of the long filaments, and the feathery stigmas strikingly in evidence. Iowa State College photo.

long-time experience or research data.
8. In some species controlled hybridization is difficult because of the small size of floral organs.

Obviously, certain of these particular features of forage species may be advantageous in the breeding program. Some of the more important of these characteristics and their implications for forage breeding will be discussed.

MODE OF POLLINATION IN FORAGE SPECIES

Plants may be cross pollinated either by wind blown pollen or by the transfer of pollen by insects. Some plants may be naturally cross pollinated, but may
Self-Sterility

Extensive research has been conducted on the nature and extent of self-sterility in forage species. The mechanisms involved may be grouped into the following general categories.

Irregularities in Chromosome Behavior

Many species of forage crops appear to have had a complex origin. The data on chromosome numbers in Table 9.1 show differences among plants within a single species. A wide range in chromosome numbers exists among different species within the same genus, in such genera as Agropyron, Bromus, Festuca, Panicum, Stipa, and many others. It is quite possible that interspecific crosses may have played a major role in the evolutionary development of existing species. In annual species propagated by seed, plants with irregularities in pairing of chromosomes would tend to be eliminated if these plants produced less seed than those with normal chromosome pairing. In perennial plants, however, survival is not dependent alone upon seed production, and irregular chromo-

set seed freely when selfed. Other species may have perfect flowers but exhibit varying degrees of self-sterility. Certain species, such as buffalograss, may be dioecious, in which case cross pollination is essential to seed production. In some species, such as bluegrass, seed may be produced without gametic union, in a process called apomixis. Pollination may be necessary in such cases to stimulate seed development even though fertilization does not take place.

FIG. 9.2 "... cross pollination is one of the distinguishing features among many forage species... increases the variability within a given population... Variable populations may have been subjected to sufficiently diverse selection pressures through a long enough period of years to permit the establishment of ecotypes of particular adaptive value, to best meet the specific conditions under which they were grown." (See p. 118.) Indigenous strains of side-oats grama grown under comparable conditions at Ames, Iowa, showing marked differences in earliness of maturity and leafiness: (1) North Dakota; (2) Nebraska; (3) Oklahoma. Iowa S.C.S. photo.

FIG. 9.3 "Plants may be cross pollinated either by wind blown pollen or by the transfer of pollen by insects... For those species in which the degree of self incompatibility does not limit inbreeding, it may be desirable to produce inbred lines for evaluation and subsequent use in improved strains." (See p. 111.) Orchardgrass plants with panicles supported and enclosed in parchment bags for controlled self pollination. Iowa State College photo.
some behavior could thus persist for a long period of time.

Studies by Elliott with perennial species in the Bromopsis section of the genus *Bromus* have given important information on the extent of variability in chromosome behavior. In *B. inermis* (smooth brome) and *B. pumellellianus* (pumelly brome) chromosome pairing was found to be very irregular. A highly significant relationship was found between open-pollinated seed setting and percentage of irregularities in chromosome pairing. In an attempt to determine the extent of relationship between the different species in this section, Elliott made crosses between smooth bromegrass and other species having 7, 14, 21, 28, and 35 pairs of chromosomes. Successful crosses were obtained between smooth bromegrass and pumelly bromegrass, and between each of these two 28-chromosome species and the 35-chromosome pair species, *B. riparius*. Successful crosses could not be made between *B. inermis* and other species. Between some species that have the same chromosome numbers crosses can be made easily. In other species crosses are difficult to make and the resulting progenies may be extremely low in fertility. An example of the latter type of relationship was found in sweetclover species (*Melilotus*) by Webster. Although the self-fertility of the F₁ generation was low, some plants in the F₂ generation were as fertile as their parents, while others were almost completely sterile.

In some species the original chromosomes apparently have been reduplicated, giving rise to four sets of each, instead of two. These species are called autotetraploids. Chromosome pairing as a consequence of doubling may not be normal. Among cultivated forages, orchardgrass probably was derived in this manner. Extensive cytological studies have been made on this species. Myers and Hill have shown that the per cent seed set by selfing in orchardgrass is related to the extent of irregularities at reduction division.

To gain further insight on the effects of chromosome doubling many experimental autotetraploids have been made and studied to determine their fertility and possible agronomic value. Almost without exception the experimental autotetraploids are low in fertility. Selection for higher levels of fertility have been effective in sweetclover, and in alsike clover.

Although abnormal chromosome behavior may have a marked effect on fertility, this factor alone cannot explain the widespread occurrence of low fertility in forage species. In many cases self-fertility may be low when chromosome pairing is normal. Other causes of self-sterility are discussed below.

**Result of Action of Specific Gene**

An extensive review of the literature on the mechanisms of self-sterility in plants has been presented by Stout. Only a few illustrations will be presented here. Studies by East and Mangelsdorf on

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with Nicotiana showed that a multiple series of genes, designated S_1, S_2, S_3, \ldots, S_n, were responsible for self-sterility through the failure of pollen tube growth in the stylar tissue only when either of the genes in the stylar tissue were the same as the gene in pollen tube of the male gamete.

A similar genetic mechanism has been used to explain self-sterility and cross-fertility in red clover, white clover, and yellow sweetclover. In addition to the genes for self-sterility found in the above species, a dominant factor for self-fertility also exists. The number of different self-sterility factors in red clover and white clover apparently is quite large and therefore intercrossing is not restricted.

Although one type of genetic explanation has been shown to affect self-sterility in at least three legume species, different genetic systems undoubtedly are operative in others. In studies with narrow-leaf birdsfoot trefoil, Elliott could not explain sterility on the same basis as for red clover. Apparently more than one system may be present within a single species, as shown by Gutierrez in studies with plants of yellow sweetclover that were intermediate to relatively high in self-fertility.

Variation in seed set by selfing has been found to be quite large among individual plants in alfalfa, smooth brome, orchardgrass and many other self-sterile species. From the data available and from the experiences of forage breeders, it seems quite likely that in these species a complex genetic system for self-sterility exists and that its expression may be greatly modified by the level of inbreeding and by the environmental conditions under which the plants are grown. In many self-sterile species it is possible to obtain some selfed seed, making possible the evaluation of individual plants by their inbred progenies and the establishment of inbred lines.

Result of Developmental Competition

In the development of the embryo after fertilization, competition for nutrition may occur between the embryo tissue, the endosperm, and the nucellus. Studies by Brink and Cooper have shown this factor to be the major reason for low seed set following selfing of alfalfa. This mechanism of self-sterility has been called "somatoplastic sterility." A higher frequency of ovules collapsing following selfing, in comparison with the frequency when crossed, was clearly demonstrated in these studies. It was shown that the rate of growth of the endosperm was much slower in selfed seed than in crossed seed. Apparently the endosperm prevents unfavorable competition between the nucellar tissue and the developing embryo. The wide difference in self-fertility among alfalfa plants may possibly be due to genetic systems conditioning the extent of physiologic competition for nutrients in the development of the seed.

The above explanations of types of self-sterility are by no means the sole causes of low seed production from self-pollination. They serve to illustrate the fact that many causes may be present. To the above should be added such factors as unfavorable positional relationships.
of the stigma and anthers, differential development of the pistillate and staminate portion of the flower, and the presence of stigmatic films that must be ruptured to release stigmatic fluid necessary for pollen germination. Because of the widespread occurrence of self-sterility among forage species, it is desirable for the breeder to determine the extent and range of self-fertility within the species under investigation. It will be shown in a later section that the specific breeding method used may be directly related to the degree of self-sterility, and that self-sterility may become an important asset rather than a handicap to the program.

**Results of Cross Pollination**

The widespread occurrence of cross pollination is one of the distinguishing features among many forage species. This characteristic adds some complexity to the problem of forage breeding. Cross pollination increases variability within a given population, thus providing the breeder with a wide range of types. Variable populations may have been subjected to sufficiently diverse environments through a long enough period of years to permit the establishment of strains of particular adaptive value to best meet the specific conditions under which they were grown. It should be recognized, however, that changes by natural selection for any set of genetic factors are relatively slow in perennial species—particularly for those in which individual plant replacements by seedling progenies are not likely to occur. In annual or biennial cross-pollinated species, or perennials frequently propagated from seed, changes under different environments may produce marked differences in adaptation. This gives the breeder an opportunity to utilize the environment as a tool for selection.

Cross pollination also serves as a useful natural mechanism to preserve recessive traits that may have little value under a particular natural environment but may be useful when the species is grown under different conditions, or when grown as a cultivated crop. For example, natural selection for longevity, or for survival during periods of drought (often associated with the non-leafy plant type), may be a disadvantage when the species is used in short rotation systems under more humid conditions.

A high degree of cross pollination may be desirable when selected individuals are utilized in the production of synthetic varieties (see page 124). This also would be favorable when crossbred progenies are desired to test the general combining ability of selected individuals. By and large, the advantages of cross pollination outweigh those of self-pollination.

In naturally self-pollinated and apomictic species, the well established methods of pure line selection are used to isolate strains. The breeding of these species therefore is relatively less complex, both to obtain distinct varieties and to maintain their purity.

The mode of pollination has been determined for several economic forage species. The summary given in Table 9.1 of some of the more common species is taken largely from the 1948 U. S. Yearbook of Agriculture (page 313), from the studies reported by D. C. Smith, and from results of actual breeding experience and research.

**EVALUATION OF BREEDING MATERIALS**

Selection of superior plants, either for direct utilization, as in the case of naturally self-pollinated plants, or for use in some type of recombination with other desirable plants in the cross-pollinated species, represents a major problem in forage breeding. For those crops

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usually grown alone, the difficulties are not as great as for those commonly grown in two or more component mixtures. Annual species can be evaluated more readily than perennials. In the perennial group determination of longevity requires a period of years, and hence delays the attainment of the ultimate objectives.

For most forage crops the characters desired in new strains, such as winter hardiness, drought tolerance, disease resistance, leafiness, and nutritive value appear to be inherited in a complex manner. Character expression also may be strongly influenced by the environment under which the breeding materials are grown.

The selection of desirable non-inbred individuals may be based on one of several types of tests, including:

1. Evaluation by growing clonally propagated plants in rows or tiller beds, either alone or in association with other species. This method is applicable largely to perennials that may be propagated by sod pieces or by stem cuttings.

2. Evaluation based on performance of inbred progenies. In naturally self-pollinated species this would be the normal procedure to find desirable pure lines. In cross-pollinated species the original plants likely would be heterozygous and hence their inbred progenies would show segregation for the heterozygous factor pairs. In self-sterile cross-pollinated species it may not be possible to obtain inbred progenies by the conventional method of self-pollination. In this case sib mating may need to be employed.

3. Evaluation based on the performance of top-cross, polycross, or open-pollinated progenies. This procedure is widely used in corn improvement to determine how a given line will perform on the average with other lines. The effective use of the top-cross in breeding cross-pollinated forages depends a great deal on the extent of natural cross pollination. In most cases, when working with forages, unlike with corn, it is difficult to produce top-crossed seed by hand pollination. The breeder generally must rely upon natural crosses and use open-pollinated seed for testing. In highly self-sterile species open-pollinated seed would largely be the result of cross pollination.

4. Evaluation based on performance of single crosses. Specific combining ability may be tested either with non-inbred plants or established inbred lines. This is of particular value, as will be shown later, as a basis for selecting plants or lines for recombination into synthetic varieties. Single-cross seed may be produced by placing the inflorescences of the two parents to be crossed in a single bag, by planting the two in an isolated crossing plot, or by hand crossing when only limited quantities of seed are needed. The extent of cross pollination becomes an important factor in making crosses by natural pollination techniques.

Some investigations have been reported on these several methods of evaluation, although the data are by no means as extensive as with corn. Tysdal and Crandall found a highly significant positive association of wilt resistance and leaf hopper resistance of non-inbred alfalfa clones when correlated with the same characters in their polycross. Positive associations also were found between polycross performance of non-

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### TABLE 9.1
**Mode of Pollination and Chromosome Numbers of Some of the Common Species of Grasses and Legumes**

<table>
<thead>
<tr>
<th>Genus and species</th>
<th>Common name</th>
<th>Chromosome numbers *</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGROPYRON</td>
<td>Crested wheatgrass</td>
<td>14, 28, 42</td>
</tr>
<tr>
<td>cristatum</td>
<td>Tall wheatgrass</td>
<td>14, 56, 70</td>
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<tr>
<td>elongatum</td>
<td>Intermediate wheatgrass</td>
<td>28, 42</td>
</tr>
<tr>
<td>intermedium</td>
<td>Quackgrass</td>
<td>28, 42</td>
</tr>
<tr>
<td>repens</td>
<td>Bluestem wheatgrass</td>
<td>42, 56</td>
</tr>
<tr>
<td>smithii</td>
<td>Stiffhair wheatgrass</td>
<td>42</td>
</tr>
<tr>
<td>trichophorum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AGROSTIS</td>
<td>Redtop</td>
<td>28, 42</td>
</tr>
<tr>
<td>alba</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ANDROPOGON</td>
<td>Big bluestem</td>
<td>40, 60, 70</td>
</tr>
<tr>
<td>furcatus</td>
<td>Little bluestem</td>
<td>40</td>
</tr>
<tr>
<td>scoparius</td>
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<td></td>
</tr>
<tr>
<td>ARRHENATHERUM</td>
<td>Tall oatgrass</td>
<td>28</td>
</tr>
<tr>
<td>elatius</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BOUTELOUA</td>
<td>Side oats grama</td>
<td>40, 42, 45, 56, 70, 98</td>
</tr>
<tr>
<td>curtipendula †</td>
<td>Blue grama</td>
<td>21, 28, 35, 40, 42, 61, 77</td>
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<tr>
<td>graecilis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BROMUS</td>
<td>Meadow brome</td>
<td>42, 56</td>
</tr>
<tr>
<td>erectus</td>
<td>Smooth brome</td>
<td>42, 56</td>
</tr>
<tr>
<td>inermis</td>
<td>Pumelly brome</td>
<td>42, 56</td>
</tr>
<tr>
<td>pumelliannus</td>
<td>Bermudagrass</td>
<td>30, 36</td>
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<td>Orchardgrass</td>
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</tr>
<tr>
<td>dactylon</td>
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<tr>
<td>DACTYLIS</td>
<td>Russian wildrye</td>
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<tr>
<td>glomerata</td>
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</tr>
<tr>
<td>ELYMUS</td>
<td>Meadow fescue</td>
<td>14, 28, 42, 70</td>
</tr>
<tr>
<td>junceus</td>
<td>Red fescue</td>
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<td>FESTUCA</td>
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<td>elatior</td>
<td>Birdsfoot trefoil</td>
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<tr>
<td>rubra</td>
<td>Wetland trefoil</td>
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</tr>
<tr>
<td>LOTUS</td>
<td>Purple alfalfa</td>
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</tr>
<tr>
<td>corniculatus</td>
<td>Yellow alfalfa</td>
<td>16, 32</td>
</tr>
<tr>
<td>uliginosis</td>
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<tr>
<td>MEDICAGO</td>
<td>White sweetclover</td>
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</tr>
<tr>
<td>sativa</td>
<td>Yellow sweetclover</td>
<td>16</td>
</tr>
<tr>
<td>falcata</td>
<td>Daghestan sweetclover</td>
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</tr>
<tr>
<td>MELILOTUS</td>
<td>Switchgrass</td>
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<tr>
<td>alba</td>
<td>Bahiagrass</td>
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<tr>
<td>sativa</td>
<td>Pearlmillet</td>
<td>14</td>
</tr>
<tr>
<td>MELILOTUS</td>
<td>Reed canarygrass</td>
<td>14, 28</td>
</tr>
<tr>
<td>falcata</td>
<td>Timothy</td>
<td>14, 42</td>
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<tr>
<td>PHLEUM</td>
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<td></td>
</tr>
<tr>
<td>pratense</td>
<td>Alsike clover</td>
<td>16</td>
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<tr>
<td>PHILALIS</td>
<td>Crimson clover</td>
<td>14, 16</td>
</tr>
<tr>
<td>arundinacea</td>
<td>Red clover</td>
<td>14</td>
</tr>
<tr>
<td>PHILALIS</td>
<td>White clover</td>
<td>32</td>
</tr>
<tr>
<td>pratense</td>
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<td></td>
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<tr>
<td>PRIMULUM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pratense</td>
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</tr>
<tr>
<td>TRIFOLIUM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>hybridum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>incarnatum</td>
<td></td>
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</tr>
<tr>
<td>pratense</td>
<td></td>
<td></td>
</tr>
<tr>
<td>repens</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AGROPYRON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>paniciflorum</td>
<td></td>
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<tr>
<td>BROMUS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>carinatus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>catharticus</td>
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<td></td>
</tr>
</tbody>
</table>

*Normally cross-pollinated*

† Largely Self-Pollinated
The yellow flowered alfalfa, *M. falcata*, has already been mentioned. It has a sickle-shaped pod in contrast to the curled pod of common alfalfa, *M. sativa*. It is hardy, native to Siberia, and has persisted in Alaska. It crosses readily with *M. sativa*, and the variegated group of varieties are considered to have originated from this cross. Sometimes the varieties of this group are classified as *M. media* or *M. sativa media*. All of these have 32 chromosomes.

Several other species, including *M. arborea*, *M. gaetulca*, *M. glutinosa*, *M. platycarpa*, and *M. hemicycla* might be useful in breeding. All these have 32 chromosomes except *M. platycarpa*, which has 16. They are not being grown commercially.

**QUESTIONS**

1. How do you account for the steady increase in alfalfa acreage of the United States?
2. Why is alfalfa rated a superior forage crop?
3. List the advantages and disadvantages of using alfalfa for pasture.
4. Why is alfalfa-bromegrass a superior combination for pasture?
5. List the alfalfa varieties you would recommend in your locality and tell why in each case.
6. Why are selected strains of the Common Group and varieties of the Nonhardy Group recommended over the variegated varieties for southwestern United States?
7. Why are Buffalo and Ranger superior varieties? How were they developed?
8. Which varieties would you recommend for a short rotation on your farm? Why?
9. You are to seed twenty acres of alfalfa on your farm. Discuss choice of field, soil fertilization, time of seeding, choice of companion crop, seed inoculation, rate of seeding, and method of seeding.
10. What are the problems in producing alfalfa seed in your area? How would you best handle these problems?
11. How would you manage an alfalfa field for hay to insure high-quality forage and to maintain a strong, vigorous stand?
Red Clover and Alsike Clover

Red clover, *Trifolium pratense*, is the most widely grown of all the true clovers. Grown alone and together with timothy it constitutes the most important legume hay crop in the northeastern quarter of the United States.

The original home of red clover probably was in southwestern Asia in the region of Media and south to the Caspian Sea. It was domesticated more recently than alfalfa. In the thirteenth century, red clover was mentioned by Albertus Magnus as a feed for cows. By 1600 it was cultivated in Italy, Flanders and France. The crop was introduced into England in 1645. It probably was brought to America by English colonists shortly after that date. Jared Eliot wrote of its use in Massachusetts in 1747.

The introduction of red clover into European agriculture was a step of great importance because it marked the beginning of the development of regular crop rotation and the decline of the bare fallow system.

**DISTRIBUTION AND ADAPTATION**

Red clover is widely distributed throughout the world. It is now naturalized in most of Europe, northern Africa, Asia Minor, Turkestan and the Himalayan region. At the present time it is an important forage crop in northern and western Europe, west central Asia, the United States, Canada, New Zealand and Australia.

According to Hunter and Leake, all red clovers may be grouped into three divisions, (1) early flowering, (2) late flowering, and (3) wild red. In North America wild red clover, as it is found in England, is unknown. Most American varieties are of the early flowering type and are known collectively as Medium Red clover. This type is characterized by producing two hay crops per year and having a biennial or short-lived perennial growth habit. In any large population, many plants may be found that live over the second winter, behaving as short-lived perennials.

American Mammoth red clover is the principal late flowering type grown in this country. In Canada, an additional variety, Altaswede, is grown to some extent. Under favorable conditions the late flowering, or single-cut type, is a perennial, producing one crop plus an aftermath. Occasionally, under exceedingly favorable moisture conditions and with

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Objectives in breeding have been greater winter hardiness, disease resist­ance, and a more perennial growth habit. Since 1905 the Tennessee Station has been interested in the selection of red clover resistant to southern anthracnose, caused by *Colletotrichum trifolii.* Much work also has been done on this problem in Kentucky. In the northern states, Wisconsin has led in the development of improved varieties. Work has been directed toward the development of a variety resistant to powdery mildew caused by *Erysiphaceae polygoni.* Efforts are being made also to combine resistance to northern anthracnose, *C. c section*, with mildew resistance.

Cumberland has some resistance to southern anthracnose and is adapted to the southern part of the red clover belt. It originated in 1937 as a composite of Kentucky 215, Tennessee Anthracnose Resistant, and Sanford (Virginia).

Midland originated in 1935 as a composite of four strains—Illinois (Rahn or Letcher strain), Ohio (Kirch or Van Fossen), Indiana (Otten), and Iowa (Emerson). These several Corn Belt strains had proven to be superior in trials conducted throughout the Corn Belt over a period of years. They traced originally to well-adapted farmers’ strains which had been grown in the region for many years.

Kenland is a superior variety developed by cooperative research of the Kentucky Agricultural Experiment Sta­

CULTURAL AND MANAGEMENT PRACTICES

SOIL REQUIREMENTS. Fertile, well-drained soils of high moisture-holding capacity are best for red clover. Loams, silt loams, and even fairly heavy textured soils are preferred to light sandy or gravelly soils. The tap root of red clover often is much branched, and a large part of the root system is concentrated in the top 12 inches of soil. Red clover does not have the drought resistance of alfalfa. It will grow on moderately acid soils but maximum yields are obtained only when plenty of calcium is available and the pH is 6.0 or higher.

Phosphorus is used in large quantities by red clover and in most soils in the clover belt is a limiting factor. Farmers in the midwest generally use too little of this essential element. Potassium also may be limiting in some areas. Appropriate soil tests will aid in locating such deficiencies.

Well inoculated red clover is considered one of the most efficient legumes in the fixation of nitrogen from air. A high level of general fertility with a plentiful supply of calcium and phos-

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42 Ibid.
43 Ibid.
12. Red Clover and Alsike Clover

TABLE 12.1
FORAGE YIELDS OF MEDIUM RED AND MAMMOTH RED CLOVER WITH DIFFERENT CUTTING TREATMENTS
AT AMES, IOWA (FOUR-YEAR AVERAGE IN TONS PER ACRE AT 12 PER CENT MOISTURE)

<table>
<thead>
<tr>
<th>Date</th>
<th>State</th>
<th>Yield</th>
<th>Second crop yield</th>
<th>Aftermath yield</th>
<th>Total yield for season</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Medium Red</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>June 10</td>
<td>Early bloom</td>
<td>1.20</td>
<td>1.10</td>
<td>0.50</td>
<td>2.80</td>
</tr>
<tr>
<td>June 17</td>
<td>Full bloom</td>
<td>1.42</td>
<td>1.09</td>
<td>0.45</td>
<td>2.96</td>
</tr>
<tr>
<td>June 24</td>
<td>Late bloom</td>
<td>1.61</td>
<td>1.05</td>
<td>0.45</td>
<td>3.11</td>
</tr>
<tr>
<td><strong>Mammoth Red</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>June 21</td>
<td>Bud</td>
<td>1.77</td>
<td></td>
<td>0.82</td>
<td>2.59</td>
</tr>
<tr>
<td>June 30</td>
<td>Early bloom</td>
<td>2.17</td>
<td></td>
<td>0.92</td>
<td>3.09</td>
</tr>
<tr>
<td>July 11</td>
<td>Full bloom</td>
<td>2.43</td>
<td></td>
<td>0.54</td>
<td>2.97</td>
</tr>
</tbody>
</table>

Phosphorus are important for most effective nitrogen fixation.

Seeding practices. Red clover usually is sown with a small grain companion crop. Oats, barley, flax and winter wheat are used extensively for this purpose, with the seeding rates preferably reduced 50 to 75 per cent from normal.

Early spring seeding is favored for red clover establishment, especially in the northern part of the red clover belt, because of the favorable moisture conditions at that time. Some clover is seeded still earlier, broadcast on winter wheat or winter rye in February or March.

Farther south, in Kentucky and Tennessee, seeding during the period from February 15 to March 15 usually is preferred. Red clover may be seeded in the late summer in the southern section of the red clover area, if moisture conditions are favorable, but in the northern section summer seedings are likely to fail.

Seeding rates vary, but when seeded alone in the mid-west the usual rate is 8 to 10 pounds per acre. In the eastern states a little more seed often is used. Red clover usually is seeded in mixtures with a grass, in which case 4 to 6 pounds per acre is usual.

If moisture is limiting growth, the clover seeding will benefit if the companion crop is cut for hay. Pasturing the small grain also is a good practice as an aid in insuring the success of the clover seeding.

New seedings often are benefited by clipping some time later in the summer. This aids in controlling weeds and lessens damage from mice during the first winter. Clipping should be done before September 1 in the Corn Belt area and probably not later than September 15 in the southern section of the red clover belt.

Harvesting for hay. Data from both the Ohio and Iowa Agricultural Experiment Stations indicate that red clover should be cut for hay by the time it reaches full bloom, or slightly before that time. Total yields for the season have been highest when the first crop was cut at full bloom stage, or later, and the second crop also at full bloom. When hay quality is considered, however, best results are obtained by harvesting the first crop not later than the earlyto half-bloom stage. Forage yields for a time of cutting experiment at Ames, Iowa, are given in Table 12.1. It is to

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be noted that total yields for the season, over a period of four years, were approximately the same for the two types of clover.

SEED PRODUCTION

The production of red clover seed in the humid region of the United States is a hazardous enterprise. During the 15-year period 1935 to 1949, inclusive, in eight important seed producing states (Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, and Missouri) the average yield has been approximately 55 pounds per acre. In the northwestern states, particularly Idaho, Washington, and Oregon, yields have been much higher and more dependable, averaging approximately 218 pounds per acre over the same 15-year period. The difference in seed yield between the two regions is believed due primarily to climatic and insect factors.

Red clover seed production depends upon pollination by insects. For high seed yields weather must be favorable for insect activity, bright, warm days and cool nights being best. Also, there

20 Crop Production, loc. cit.
must be adequate populations of pollinating insects. Other contributing factors include soil fertility, soil moisture conditions, and the management of the clover stand. Bumblebees are extremely effective in pollinating red clover but are seldom present in sufficient numbers to insure a good seed crop. Honeybees will pollinate red clover under certain conditions, particularly when they are collecting pollen. Heavy concentrations of bees, three to five colonies per acre, usually are more effective than lighter concentrations. The presence of other nectar producing plants in the vicinity also is a factor. Sweetclover, white clover, and alsike clover, and also the flowers of many weed plants, are preferred by honeybees. If possible, the red clover should be brought into bloom when competing crops or weed plants are not in bloom.

Farmers often are uncertain as to whether or not they have a seed crop worth harvesting. With a thick stand, if representative clover heads picked at random show an average of 20 to 30 seed per head the crop should be worth harvesting. Seed yields of from two to three bushels per acre can be expected from good stands in the humid region if seed counts range from 40 to 60 seed per head.

If the second crop is to be used for seed, early harvesting of the first crop for hay is recommended. In an occasional season it is possible to harvest a seed crop in the fall of the seeding year.

Red clover is harvested for seed when the heads have turned brown and the stems are yellow-brown in color. A common method is to cut with a mower having a windrower attachment. After curing in the windrow the clover is threshed, either with a clover huller or with a regular grain separator with proper adjustments to handle this kind of seed. In recent years the trend has been toward combining clover seed from the windrow by means of a pick-up attachment. It is highly important to handle the crop so that shattering is kept to a minimum. Equally important is the proper adjustment of the thresher or combine to prevent seed losses and mechanical damage to the seed.

DISEASES

Southern anthracnose, Colletotrichum trifolii, is an important red clover disease in the southern part of the clover belt. The disease may be present in a mild form as far north as Canada. Light to dark brown lesions on the stems and leaf petioles are symptoms. The disease is known to increase and spread rapidly in damp warm weather.

Northern anthracnose, Kabatiella caulivora, is common in the cooler part of the clover belt, increasing most rapidly in wet cool weather. Symptoms are somewhat similar to those of southern anthracnose. Varieties resistant to this disease may be susceptible to southern anthracnose.

Root and crown rot caused by Sclerotinia trifoliorum often is a serious disease, particularly in areas having mild winters or a heavy snow cover. Other root and crown rots may cause losses, including Fusarium rot which has been reported in Pennsylvania, Kentucky and other areas.

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33 Wilde, C. P. Loc. cit.
Powdery mildew, *Erysiphe polygoni*, is prevalent in most of the clover area, at times causing a reduction in the yield and quality of forage.\(^{25}\)

Other diseases, including the mosaics, caused by viruses and transmitted by aphids and leafhoppers, leaf spots, especially *Pseudopeziza* and *Stemphylium* leaf spots, cause considerable losses at times. The development of resistant varieties probably offers the most hope in combating many of the red clover diseases.

**INSECT PESTS**

The clover root borer, *Hylastinus obscures*, often kills a good many plants by the end of the first crop year. A report by the Ohio Agricultural Experiment Station in 1899 indicated the prevalence of this destructive insect in eastern United States at that time.\(^{39}\)

Another insect which causes considerable damage is the root curculio, *Sitona hispidula*.

The chalcis-fly, *Bruchophagus gibbus*, is one of the most damaging insects to clover and other legume seed.\(^{40}\) Eggs are laid in the soft green seed pods when the pods are about half grown. The larvae feed on the young, developing seed.

The potato leafhopper, *Empoasca fabae*, often causes great damage to red clover, especially to strains of European origin which lack the heavy pubescence of stems and petioles characteristic of most plants in strains of American red clover.\(^{41}\)

Other insects injurious to red clover include the clover-flower midge, *Dasyneura leguminicola*, and the clover leafhopper, *Aceratagallia sanguinolenta*.

Grasshoppers may be a great menace to red clover, especially to the second

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\(^{25}\) Dickson, J. G. Loc. cit.\(^{36}\)


\(^{40}\) Hollowell, E. A., et al. Loc. cit.\(^{12}\)


\(^{12}\) Ibid.
stem does not terminate in a flowering head but keeps growing. Flower-bearing branches arise successively from each leaf axil, so that the youngest flowers are in the terminal heads and the older heads are located farther down on the stem toward the crown.

Cultural and Management Practices

Alsike clover grows well on rather heavy soils abundantly supplied with moisture. Although somewhat tolerant to an acid soil condition, the crop responds to lime on acid soils.

The time and method of seeding is much the same as for red clover. Six pounds per acre is considered a full rate of seeding. On wet, acid soils alsike clover is often sown with redtop, but probably by far its greatest use is in mixtures with red clover and timothy. The inclusion of timothy with alsike is highly desirable since the clover is likely to lodge badly, making curing a difficult problem.

Alsike clover usually produces but one crop of hay. Cutting for hay is recommended when the crop is in full bloom, although that stage is somewhat difficult to determine because of the plant's continuous blooming habit.

Because of its natural adaptation to wet soils, alsike is a valuable plant to establish on wet natural meadows or meadows that are under irrigation. Establishment in swales and on overflow land where legume maintenance is a serious problem often is possible with alsike clover. Farmers with bottomland fields have found that alsike may succeed where either alfalfa or red clover may be wholly unsuccessful.

SEED PRODUCTION

Most of the alsike clover seed is produced in Oregon, Idaho, Wisconsin, Minnesota, California, Ohio, and Michigan. Like Mammoth red clover, alsike cannot be expected to produce both a hay and seed crop the same year.

Alsike flowers are attractive to bees for both nectar and pollen. Both bumblebees and honeybees visit this crop freely. Seed yields in California, Idaho, and Oregon average approximately 300 pounds per acre. In the humid states yields usually range from 100 to 200 pounds per acre. Methods of harvesting are similar to those for red clover.

Diseases and Insect Pests

In general, alsike is susceptible to many of the same diseases and insects that damage red clover. It is considered resistant, however, to both northern and southern anthracnose, which often cause serious losses in red clover.

OTHER SPECIES

In addition to the true clovers used widely in agriculture, several other species should be mentioned here (see also Chap. 19) because of their importance in limited areas.

Sub' clover is a decumbent winter annual adapted to the Pacific Northwest and to limited areas in some of the southern states. The ripening heads tend to turn down and bury themselves in the soil.

The hop clovers are winter annuals adapted to the Pacific Northwest and to limited areas in some of the southern states. The ripening heads tend to turn down and bury themselves in the soil.

The hop clovers are winter annuals adapted to the southern states and to the Pacific Northwest. They tolerate rather unfavorable soil conditions. They have value for pasture. The flowers are bright yellow, borne in small heads.

Strawberry clover is a perennial adapted to wet, saline soils in the western states. Its growth habit resembles...
that of white clover, but the flowers are red. Kura clover is a rhizome-bearing perennial. Establishment is difficult and most seedings have failed, probably because no satisfactory strain of nodule forming bacteria has been found. Zigzag clover is another rhizome-producing perennial. Seed production is so poor that there has been little opportunity for adequate testing of this species for forage production.

Persian clover is a winter annual adapted to heavy, somewhat wet soils in the southern states. Berseem, or Egyptian clover, is another annual grown widely under irrigation for forage in the Nile Valley and to some extent in our Southwest.

**QUESTIONS**

1. From a geographic standpoint, where are the principal types of red clover best adapted? Why is this true?

2. Why is red clover so widely used as a rotation crop?

3. Do you consider the tendency for red clover to behave as a biennial desirable or undesirable? Why?

4. Name several fungus diseases in red clover. What do you consider the best method of attacking these disease problems?

5. How would you determine whether overwinter stand losses were due to poor management the previous autumn, diseases or insect pests, or the severity of the winter?

6. In what ways, if any, is alsike clover superior to red clover? Red clover superior to alsike clover?

7. Give several reasons why red clover seed production is hazardous in the eastern and midwestern humid areas.

8. Would you consider it economically feasible to provide honeybees for pollinating red clover? Give reasons for your answer.

9. Why is the average seed yield per acre, both in the humid and arid areas, higher for alsike than it is for red clover?

10. How is red clover pollinated? How does this affect the breeding methods used for improving this species?
Sweetclover, *Melilotus*, is native to temperate Europe and Asia as far east as Tibet. It was reported as growing in North America as early as 1739, when it was found in Virginia. By 1900 its value as a soil-improving crop was recognized. This was demonstrated by volunteer growth on certain Kentucky soils ruined by continuous heavy cropping with tobacco, and in the black calcareous soils of Alabama and Mississippi. Its use as a field crop spread gradually through the Corn Belt, the Great Plains states, and the prairies of western Canada. Also, the past decade has seen a substantial increase in acreage in the Blacklands and Grand Prairie of Texas and in the Palouse region of the Pacific Northwest. The increased use of sweetclover was most rapid from about 1900 to 1930.

The genus *Melilotus* is closely related to two other legume genera, *Medicago* (alfalfa) and *Trigonella*, and more remotely to the true clover genus, *Trifolium*.

**Chapter 13**

**Sweetclover**

**DISTRIBUTION AND ADAPTATION**

Sweetclover thrives under a wide range of soil and climatic conditions. It has one important restriction, however, in that it does not tolerate acid soils. It is drought resistant; it makes a good growth in those parts of the Great Plains with as much as 17 inches of rainfall fairly well distributed through the growing period. It is winter hardy and productive throughout the Corn Belt. It makes a lush growth in areas of adequate rainfall in Texas and on the limestone soils of Alabama and Mississippi. It is one of the first plants to invade and make a successful growth on highway cuts where subsoil is exposed. Its rapid spread and establishment along fence rows, highways and railroads resulted in its being regarded for years as a weed. It was still on the noxious weed list in several states at the beginning of the century. Its use as a crop plant in the East has been limited, probably because of the tendency of the soils to an acid reaction.

**PLANT DESCRIPTION**

The cultivated sweetclovers are typically biennial, although certain annual forms are in use. The first season's growth of the biennials consists of one central much-branched stem. Like al-
flavor. In the earlier years bee keepers were frequently charged—no doubt falsely in most cases—with scattering seed of this “weed” along the highways for the benefit of their bees.

**SPECIES, VARIETIES AND STRAINS**

Most of the sweetclover seed used in North America is either yellow-flowered, *M. officinalis*, or white-flowered, *M. alba*. Only biennial forms of *M. officinalis* are grown. Most of the acreage of this species is “common yellow,” although there are differences in different lots in time of maturity and in productivity. Both biennial and annual forms of *M. alba* are grown, but by far the larger part of the acreage is common biennial white. As with the yellow species, there are marked differences between different lots of seed.

When the two common biennials are compared, the yellow is credited with being more tolerant of adverse conditions such as drought and competition from a companion crop. It also is more regular and dependable in producing a good crop of seed. The forage of the yellow, in the first and second year, is finer-stemmed and gives a better quality but smaller yield of hay. Common yellow matures 10 to 15 days earlier than the true common white. This is considered an advantage from the standpoint of seed production, since the crop tends to ripen ahead of drought on the Great Plains. But early maturity shortens the length of the pasture season in the second year. It is for this reason that many prefer the white as a pasture legume. In a Nebraska test a second-year stand of common yellow provided 187 steer days of pasture compared with 224 for common white.

In Ohio the two types were compared as a catch crop for soil improvement in a 2-year corn and small grain rotation over 9 years (Table 13.1). Common yellow did not make as much top growth in the fall of the first year as white, but the ratio of root to top was higher; the amount of material ploughed under the following spring was essentially equal for the two species.

Madrid is a relatively new strain of *M. officinalis*, developed from seed introduced from the Madrid Botanic Garden in Spain. Its quick emergence after seeding and strong seedling vigor give it an advantage in stand establishment on the Great Plains. The foliage in the fall of the first year is less readily injured by frost than other strains, thus permitting later pasturing. The second-year growth is leafy, of medium height, and more productive and several days later in maturity than common yellow. It is an excellent seed producer. A substantial acreage of this variety is now grown with certified seed produced mainly in Kansas, Nebraska, Oklahoma and Texas.

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**TABLE 13.1**

**Sweetclover Acre Yield of Roots and Tops in Late Fall of Seeding Year: Average of 27 Tests at 12 Locations in 9 Years in Ohio**

<table>
<thead>
<tr>
<th>Species</th>
<th>Yield per acre (pounds)</th>
<th>Percentage of Total in roots</th>
<th>Nitrogen in roots</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tops</td>
<td>Roots</td>
<td>Total</td>
</tr>
<tr>
<td>Common yellow</td>
<td>1,370</td>
<td>2,210</td>
<td>3,580</td>
</tr>
<tr>
<td>Common white</td>
<td>1,510</td>
<td>1,960</td>
<td>3,470</td>
</tr>
</tbody>
</table>

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Although a very large part of the commercial seed of the species *M. alba* is common white, there are several named biennial varieties. Arctic is an early maturing variety selected in western Canada and adapted to that area, but not to the United States. Grundy County (Ill.) has been grown extensively in the Dakotas and western Minnesota where its relatively small vegetative growth and uniform early maturity—10 days earlier than common white—are desired in seed production. However, these very characteristics make the variety much less valuable than common white for pasture and soil improvement in the Corn Belt where much of this seed is used.

Spanish and Willamette are two varieties of *M. alba* similar in maturity to true common white. Spanish, also obtained from the Madrid Botanic Garden, is leafier and somewhat more productive than common white. It has been recommended as the best available strain for the Palouse area in the Pacific Northwest. Willamette was selected in Oregon for resistance to *Sclerotinia* stem rot, a disease particularly destructive on sweetclover west of the Cascade Range.

Several late-maturing strains of the biennial *M. alba* have been selected to provide a longer grazing season in the Corn Belt than common white. Evergreen in Ohio, Sangamon in Illinois and the Iowa Late and Wisconsin Late are strains which have been under test, with some seed increase. The rank growth and long flowering period of these strains have made seed production difficult and uncertain. This has hindered their commercial use.

Alpha is a strain developed by selection from Arctic of types with marked branching at the base of the stem, giving many fine shoots. The hay is leafier and of better quality than that of Arctic, but with some loss in productivity. In the United States Alpha makes a good growth only in the northeast tip of the Great Plains.

Annual forms of *M. alba* are in use. Hubam, selected in Iowa from seed obtained from Alabama, has proved less valuable than the biennial white in the Corn Belt, especially for soil improvement. Although Hubam produces somewhat more top growth than the biennial in the fall of the first year, the root development is much less. But the annual can be ploughed down in the fall without danger of regrowth in the following spring. It has been recommended for seeding in small grain as a soil-improving crop when fall plowing is particularly desirable. In recent years there has been a marked expansion in the acreage of Hubam in rotations in south central and southwestern Texas, where it is fall planted. Most of the supply of Hubam seed now comes from the Texas area.

The inclusion of this clover in the rotation furnishes pasture, hay or seed, with improvement in the physical structure and fertility of the soil. It has proved particularly valuable in rotations with cotton as a means of controlling the cotton root rot. Especially under irrigation, Hubam grows too tall for good forage. A new annual variety, Emerald, a fine-stemmed, leafy type selected from a cross between Hubam and a fine-stemmed biennial, has been developed in Texas. It is less productive than Hubam but provides forage of better quality.

Sourclover, *M. indica*, an annual yellow-flowered species, is used as a green manure in the Southwest. It is less pro-

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13 Dunkle, P. B., and Atkins, I. M. Loc. cit. 4
ductive than Hubam and the forage is less palatable. Redfield is a biennial late-maturing strain of the yellow-flowered species M. suaveolens. It was grown for several years in the northern portion of the Great Plains. Golden Annual is another strain from this species.

COUMARIN

The high content of coumarin in the commonly grown sweetclover reduces the palatability of the forage when used either for pasture, hay or silage. Livestock take some time to get accustomed to the taste. And the presence of coumarin is objectionable in another way. The feeding of spoiled sweetclover hay or silage may cause the "bleeding disease" in livestock. If hay has too much moisture when stacked or put in the barn, and if the forage is not well packed as it is put in the silo, the ensuing heating and spoilage may result in the formation of a toxic substance because of the presence of coumarin. The toxic substance, dicoumarol, reduces the clotting power of the blood when the forage is eaten and animals may bleed to death from slight wounds or from internal hemorrhages. The development of a low coumarin sweetclover would eliminate two of the undesirable characteristics of sweetclover—poor palatability and the hazard of bleeding.

Pioneer work on this problem in Saskatchewan resulted in the selection of a strain of Arctic at first thought to be low in coumarin content. It was found later to have a substantial amount of coumarin, but in a bound form. The species M. dentata has only a trace of coumarin in the vegetative tissue. A low coumarin gene has now been transferred from M. dentata to M. alba by crossing the two species. Breeding work with sweetclover is under way in an effort to combine this low coumarin character with other favorable agronomic characters.

CULTURE AND MANAGEMENT

The requirements for establishing a good stand of sweetclover are similar to those for alfalfa. It should be borne in mind, however, that the seed of sweetclover are "hard" and should be properly scarified before seeding. Inoculation of the seed will help to insure effective nitrogen fixation. It usually is recommended that if the pH of the soil is below 6.0, lime should be applied well in advance of seeding. The seed being small should not be placed deeper than one-half inch, except on the lighter soils.

In the Corn Belt, seedings usually are made in the spring with either spring or winter small grain as a companion crop. When the companion crop is a winter grain it is desirable that the seeding be early in the spring, if possible before the winter grain begins growth. When the first-year growth is to be used for pasture in the southern half of the Corn Belt and in the Pacific Northwest, or where moisture is limited as in many areas on the Great Plains, the clover usually is seeded without a companion crop. In central and eastern Oklahoma where moisture is often a limiting factor in establishing a stand, some advantage has been reported in seeding the companion crop in 14- or 16-inch rows instead of 11-inch rows.

Sweetclover instead of the more usual 7- or 8-inch drill rows. This lessens the competition from the grain crop. Grain yields were not seriously reduced.

Scarified seed usually is sown at the rate of 10 to 15 pounds per acre. If unscarified seed is used, often seeded broadcast in the late winter, a somewhat heavier rate of seeding is advised.

**Management in the Seeding Year**

The growth habit of sweetclover in the seedling differs from that of alfalfa and red clover and calls for careful management. The biennial sweetclover plant in the first year has a single main stem. If the upper portion is cut off, any new growth must come from buds along the stem—not from the crown, as in alfalfa. Removal of a substantial amount of the stem in any clipping treatment will result in a marked reduction in the size of the root going into the winter and in the vigor of the plant in the second year. When the companion crop is harvested the binder or combine should be set as high as possible. In an experiment in Ohio, harvesting the grain crop by combine in July at 2-, 8-, and 14-inch heights yielded respectively 1,100, 1,800 and 2,800 pounds of air-dry roots per acre in November. Where the oat companion crop was not harvested, with no clipping back of the stem or foliage, the yield of roots was 3,600 pounds. Time of clipping the top growth in the fall of the first year has a marked effect on the subsequent root development and on the second-year growth. In a Wisconsin experiment removal of the top growth when it had reached about a maximum in mid-September was found to be more harmful, both in reducing winter resistance and the soil-improving value the following year, than cutting the top growth in either mid-August or mid-October. If cut in mid-August a new top growth can develop to provide root reserves before winter, while deferring cutting until mid-October permits substantial storage before removal of the crop.

Work at the Iowa Station with the annual Hubam sweetclover showed that the one management practice of greater importance than any other in influencing growth and yield for the season was the height at which the companion crop was cut: the high-cut stubble produced much larger yields of both forage and seed than the low-cut stubble.

**Pasture**

In the northern states and in Canada, sweetclover grown with a grain crop has only a relatively short growing period between grain harvesting and the end of the season. The amount of growth made during this period usually is not large. In this region, heavy pasturing in the fall of the first year may result in winter killing or weak plants in the following year. If animals are allowed to graze this growth, pasturing should be light.

In the second year, a large amount of forage becomes available early in the season. This tapers off rapidly after mid-summer as the plants flower and mature. Grazing should be started when the tops are 8 to 10 inches in height, but during the period of rapid growth heavy stocking is desirable to prevent the forage from becoming tall and woody (Fig. 13.3).

The Missouri Station has reported an approach to an all-season sweetclover

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pasture. Sweetclover is seeded in early spring in winter rye or winter barley. The grain is grazed or made into silage in early summer. The first-year sweetclover is pastured from October to late November. In the second year, pasture is available from rather early in the spring until July, supplemented in late summer with lespedeza.

Bloat is recognized as a hazard when grazing sweetclover. Scouring may occur, especially early in the season. The tendency to bloat and the amount of scouring may be reduced by giving the animals access to dry roughage, such as hay, oat, or barley straw, and also by growing the sweetclover in a mixture with a quick-growing grass.

Hay

A good quality hay, somewhat comparable in palatability and feeding value to alfalfa, can be made from the first-year growth. The second-year growth is less satisfactory for this purpose. The coarse stems have a high moisture content and dry out slowly and less rapidly than the leaves, which tend to become brittle and be lost in handling. If the crop is cut in the bud stage and cured under favorable conditions it has about the same feeding value as alfalfa.

There is the hazard of the "bleeding disease" when large amounts of sweetclover hay, stored before being thoroughly cured, are fed to animals. Only a small part of the acreage is used for hay in the Corn Belt. To the west,
where lower rainfall facilitates curing, larger acreages are used for hay, especially in the Dakotas.

Soil Improvement

A 2-year rotation of small grain and corn with biennial sweetclover seeded in the small grain crop is common in the Corn Belt. The sweetclover makes a rapid growth both in tops and roots as moisture becomes available after removal of the grain. Best results usually are obtained when this legume is ploughed down in the following spring after it has made a top growth of 6 inches. If ploughing is deferred beyond this time, some additional nitrogen and organic matter will be added to the soil, but depletion of soil-moisture reserves in making the additional growth may be a hazard for the corn crop in a dry season. If ploughed in the spring before a 6-inch growth is made, or if ploughed in the fall of the seedling year, many plants will survive and become weeds in the corn crop.

Johnson et al. report an Iowa experiment 26 in which biennial sweetclover in a 2-year corn-oat rotation gave an average annual increase during a 16-year period of 13.8 per cent in the yield of corn. Sears and Burlison 27 report a similar trial in northern Illinois in which

Canada in the spring of the second year.

Blackstem frequently occurs in the Corn Belt. The blackened stems may be stunted, with poor flowering and reduced seed set. *Ascochyta lethalis* and *Cercospora Davisi* are the organisms most frequently associated. Stem canker, *Ascochyta caudicola*, sometimes causes serious damage, with the stems stunted and bent at the tip to give a characteristic "gooseneck" effect. Adequate control of these diseases appears to lie in the breeding of resistant varieties.

**Insect Pests**

Although cutworms, aphids and leafhoppers cause some damage, the most serious threat to the sweetclover crop is the destruction of stands in the seedling stage by the sweetclover weevil, *Sitona cylindricollis*. This insect apparently has a ravenous appetite for coumarin. Its feeding is confined almost entirely to sweetclover. The presence of the weevil is indicated by crescent-shaped notches on the leaf margins. When weevils are abundant, the leaves of young seedlings are soon eaten away entirely and the plants destroyed. Although economical control measures have not been fully worked out, several of the newer

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insecticides applied in early spring have given promising results. There is some evidence of natural control by predators and parasitic fungi.

**QUESTIONS**

1. Why is there a large acreage of sweetclover in the Corn Belt?
2. Where are the sweetclover seed-producing areas of the United States located? Why?
3. Why has sweetclover in recent years become more popular in Texas and other southern states?
4. Discuss the relative merits of sweetclover for hay, pasture, and green manure.
5. Compare the two biennial sweetclovers, common yellow and common white.
Questions 179

Which one would you seed in your locality? Why?
6. Under what conditions would you seed Hubam sweetclover on your farm?
7. What is the danger in feeding sweetclover hay? How may this be overcome?
8. Why must sweetclover seed be scarified before planting? How is this done?
9. How would you fit sweetclover into a pasture program on your farm?
10. When would you plow under biennial sweetclover as a green manure crop? Why?
11. Why are losses high in harvesting sweetclover seed?
12. How would you manage biennial sweetclover during the seedling year for highest production in the second year? How would you manage a seeding of Hubam clover?
White clover, *Trifolium repens* L., is a native of Europe. It probably originated in the eastern Mediterranean countries or in western Asia Minor. It is not the shamrock of early lore, but is one of the most important agricultural species of the true clovers (*Trifolium*).

Early writers who mentioned *clovers* did not differentiate between species. Reference to *white clover* appeared in Herbals in the 16th century. It is recorded as having been grown in England as early as 1707. Certainly, white clover was not an early important plant in Europe. Its low spreading habit of growth prevented successful establishment and maintenance of stands in competition with forest and shrub vegetation. White clover undoubtedly became an important plant after the early roving tribes subdued the forest by fire or cutting, followed by continual close grazing by their livestock.

The date when white clover was introduced into the United States is not definitely known. It undoubtedly came with our early forefathers, who brought *hay loft* seed with them. As the land was cleared of forests and cultivated, white clover spread rapidly. As indicative of this, the Indians called it *white man's foot*. Gist recorded it as common in Ohio in 1750–51, and Kalm reported it in Canada in 1749.1

**DISTRIBUTION AND ADAPTATION**

White clover, in one or more of its varying forms, is one of the most widely distributed legumes throughout the world. It is found on every continent and from the equator to beyond the Arctic Circle.

In the United States it is found in every state. It grows both above the timberline in the mountain areas and in southern Florida.

The rather universal occurrence of white clover presents a most intriguing and perplexing problem on seed dispersal and introduction, about which little is known. The small size of the seed, the adherence of the hull to the seed at maturity, the hard seed coat that prolongs the life of the seed, the long period of flowering and seed production, the high palatability of the plant, and the fact that certain birds feed on the seed, are all factors favoring wide seed dissemination. Cases are known where 1

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*See Chapter 8.*
In the West

Ladino was used extensively in the irrigated valleys of the western states before the development of the eastern acreage. Much of it was planted alone. The early spring growth was grazed and a seed crop harvested from the later summer growth. This practice is being followed in many locations. However, the bloat hazard from grazing Ladino has brought about the more general use of Ladino-grass mixtures. Tall fescue, domestic rye, and orchardgrass are widely used with Ladino. In almost all locations the use of phosphate fertilizers has resulted in increased yields and in many places sulphur fertilization also is required. The amount of irrigation water required varies widely with location; in general, frequent irrigations are favored since for maximum yield Ladino should be in continuous growth during the season.

DISEASES AND INSECTS

There are numerous diseases that attack white clover, some of which may cause serious losses. Many of them are becoming more serious on Ladino than on common white. The tall and dense growth of Ladino is favorable to their incidence and development. Crown or stem rot (Sclerotinia trifoliorum) thins stands and occasionally destroys large areas within fields during the winter and spring months. In certain seasons much of the loss ascribed to winterkilling may be caused by this disease. Pepper spot, Pseudopeziza trifolii; sooty blotch, Cymadothia trifolii; and black patch, caused by a non-sporulating fungus, frequently bring about severe defoliation. In the South southern blight, Sclerotium rol-

\[\text{Fig. 14A "... the bloat hazard from grazing Ladino has brought about the more general use of Ladino-grass mixtures. Tall fescue, domestic rye, and orchardgrass are widely used with Ladino."} \]

\[\text{The mixture used here—Ladino, alfalfa, and brome—is one of the most popular, and is widely used both for hay and pasture.} \]

\[\text{faii; and root knot, Heterodera marioni, are highly destructive during the summer months. The conspicuous yellow patch virus also is widely distributed.} \]

\[\text{Heavy infestations of the potato leafhopper, Empoasca fabae, during the spring and summer results in a stunted growth and causes a reddening and browning of the leaves. Ladino is particularly susceptible to leafhopper injury. Under pasture conditions, where the growth is removed about every 15 to 20 days, it does not become serious. Mites and garden flea hoppers, Halticus citri,} \]

cause a flecking and mottling of the leaf and they may do considerable damage, particularly when growth is arrested by drought. The clover leaf weevil, *Hypera punctata*, and the lesser clover leaf weevil, *H. nigrirostris*, damage the leaves during the spring months. Both roots and leaves are damaged by the feeding of the root curculio, *Sitona hespedulus*. In the Northwest, seed is destroyed by the larvae of a seed weevil, *Microtrogus (Tychius) pecerostris*. The use of insecticides to control this seed weevil has been successful.

**SEED PRODUCTION**

Since 1941 there has been an increase in the production of common white seed, and since 1944 a great increase in Ladino seed as is shown by Table 14.2. The domestic increase of common white seed corresponds to the reduction of importations of foreign seed while the increase of Ladino seed reflects a large demand and high prices.

Common white clover blooms freely over a long period of time. It produces large quantities of readily accessible nectar and pollen that make it attractive to all kinds of bees. Large quantities of seed are set but harvesting losses are great. Yields of seed, ranging from a few to over 600 pounds, will average approximately 150 pounds per acre. This is produced mostly in three general locations: (1) Louisiana, Mississippi, and Alabama, (2) irrigated valleys of the western states, and (3) the Lake States.

Practically all of the Ladino seed is produced in the irrigated valleys of the West, principally in California and Oregon. Ladino does not bloom as profusely as common white and is affected adversely in this respect by cloudy, rainy weather.

Seed yields depend on the number of flower heads produced, the thoroughness of cross pollination and the efficiency of harvesting. Bright sunny weather is conducive (a) to blooming after the plants have made a good vegetative growth, (b) to maximum pollination activity of bees, and (c) to minimum losses of seed at harvest. For this condition, the western states excel over all other regions. The early growth of white clover may be used for grazing, or in the case of Ladino, harvested for hay or silage. This brings the later growth into flower when the probability of having bright weather is the greatest.

In the West the first growth frequently is saved for seed. Sometimes two seed crops are produced and both harvested at one time. To do this, after the early crop of seed heads have turned brown, the field is irrigated as may be necessary to produce another crop of flower heads. When these are mature both crops are harvested in one operation.

Moving three to five colonies of bees per acre adjacent to or into the field at the beginning of flowering is recom-
mended. Cross pollination is essential for seed setting.

The seed crop is ready for harvest approximately one month after the greatest number of flower heads have bloomed. The crop is cut with a mower, preferably when damp with dew, and cured either in the swath or the windrow. Under humid conditions curing in the swath is usually considered the best practice. When well cured, the crop may be threshed with a combine equipped with pick-up attachments or it may be hauled to a stationary thresher. This may be either a combine or a grain separator equipped with hulling attachments. This latter method of harvesting makes it possible to rethresh the straw, which usually is profitable. After the crop is dry it should be handled as little as possible, and always with care to avoid shattering losses. The use of canvases on the bottoms of wagons hauling the crop to the stationary machines and also under the machines saves large quantities of seed. The use of vacuum harvesters has been successful. Care should be taken to prevent heating, which results in a reduction of germination and the browning of the seed. Since Ladino cannot be distinguished from common white, the production and use of certified Ladino clover seed is strongly recommended.

QUESTIONS

1. Why are the white clovers so widely distributed throughout the world?
2. Under what conditions and where in the United States are the white clovers best adapted? Why?
3. Why are Ladino clover and the common white clovers so highly regarded as pasture legumes in the United States?
4. Why is Ladino so popular in the irrigated sections?
5. List and discuss the factors which contribute to the successful establishment of a stand of Ladino.
6. Why are good stands of Ladino difficult to maintain in parts of the North?
7. Why is most of the Ladino seed now produced in certain rather limited areas?
8. How would you harvest Ladino and common white clover to avoid heavy shattering losses?

The word “lespedeza” often is used incorrectly to refer only to three annual varieties of lespedeza—Korean, Kobe, and Common (Japanese Clover).

There are some 125 species of lespedeza which have been identified and classified. *Lespedeza stipulacea* and *L. striata* are the only annuals. All others are perennials. The perennials have only minor forage value.

**ORIGIN**

The two annual species are introductions from the Orient. The first record of Common lespedeza, *L. striata*, is of 1846, at Monticello, Ga. Presumably it came in accidentally as an adulterant in other seed. A strain, Kobe, was introduced in 1920 and first grown in South Carolina.

Korean lespedeza, *L. stipulacea*, was introduced in 1919 from Korea. The first crop was harvested in 1921 at the Arlington Experiment Farm of the U.S.D.A., across the Potomac from Washington, D. C. A small quantity of this increase was distributed in 1922 and a larger volume in 1923.1

Of the perennial species of lespedeza, some 20 are native to the United States, the remainder to the Orient. Those considered of most economic importance are sericea, *L. cuneata*, bicolor, *L. bicolor*, and bush lespedeza, *L. crytobotrya*, all native to eastern Asia.

Cuneata lespedeza is of some economic importance in this country. It was first tested in North Carolina in 1896. Additional seed was introduced from Japan in 1899 and tested at the Arlington Experiment Farm. A third introduction was from Japan, in 1924, from which a selection, #12087, was increased and distributed. A second selection, #04730, from the seed introduced in 1899 likewise was distributed.2

**THE MORE IMPORTANT SPECIES, VARIETIES AND STRAINS OF LESPEDEZA**

### ANNUALS

<table>
<thead>
<tr>
<th>Variety</th>
<th>Variety or strain</th>
</tr>
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<tr>
<td><em>L. striata</em></td>
<td>Common (Japan Clover)</td>
</tr>
<tr>
<td>Kobe</td>
<td>Tenn. #76</td>
</tr>
<tr>
<td>or</td>
<td>F.C. #31057-5</td>
</tr>
<tr>
<td>strains</td>
<td>F.C. #31057-42-4</td>
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</table>

Region of General Adaptation

L. stipulacea
Korean lespedeza

Varieties or strains
Climax (F.C. #31249)
Harbin
F.C. #31480
#19604 (Early Korean)
Iowa 6
Iowa 39
Iowa 48

PERENNIALS
Herbaceous C.N.
L. cuneata
L. procumbens
L. virginica
L. timentosa
L. juncea
L. virgata
L. latissima
L. daurica
L. violacea
L. variegata
L. repens
L. cystoides
L. inschanica

Shrubby
L. bicolor
L. cytotobotria
L. thunbergii
L. Formosa
L. Japonica
L. floribunda

PLANT CHARACTER AND GROWTH HABITS OF ANNUAL LESPEDEZAS

The varieties of common lespedeza are easily identified from those of Korean by differences in the leaflets, stipules, and seed. The leaves of common are more narrow and slender than those of Korean. The stipules of Korean are quite broad, larger and much more prominent than on common.

The flowers of the lespedezas normally are self fertilized. Cross fertilization is rare. The annuals produce two kinds of flowers, blue to purple flowers easily observed, and the more numerous inconspicuous flowers without petals. Both types of flowers produce seed. The proportion of the two types varies greatly from season to season. Apparently this has no relation to the abundance of seed production.

All varieties of common set their seed in the axils, directly along the stems. In contrast, the seed of Korean are borne in clusters at the tip end of all branches developing from the leaf axils.

The annual varieties are slender and leafy. In thin stands they tend to grow prostrate. The plants in thick stands, resulting from heavy seeding or volunteering, grow erect.

Lespedeza seed do not germinate readily in low soil temperatures. The variety Korean, however, will germinate and start seedling growth at temperatures too low for Kobe, Tenn. #76, and common.

Seedling growth is slow, as compared to that of most other legumes sown in the late winter or spring. Aggressive growth develops only at relatively high soil and air temperatures. The slow growth rate in the spring and early summer is characteristic of the annual lespedezas and is in distinct contrast to that of most other commonly grown legumes.

Korean develops more rapidly than Kobe, common, and Climax. Averaging about 20 days earlier in maturity, it usually is well developed by the time small grains mature. It reaches full bloom in late summer, after which the growth rate declines sharply.

The varieties of common, being much later, develop more slowly during the earlier part of the summer and retain their growth, vigor, and usefulness for pasture later in the summer and early fall. In the northern part of the lespedeza region early frosts frequently damage the crop before the seed are fully mature.

REGION OF GENERAL ADAPTATION

Of the annual lespedezas Korean, Kobe, and common are of outstanding importance to American agriculture. Their comparative value is dependent
Lespedeza

Fig. 15.1 "... the annual lespedeza... have outstanding importance to American agriculture... from the Atlantic coast westward into eastern Texas... the southern half of Illinois, the southern part of Indiana and Ohio..." U.S.D.A. photo.

upon the area of relative adaptation and the purpose for which used. New superior strains and selections have been and are being developed from the two annual species. The perennial, sericea, is of limited value and is adapted to the same general area as the annuals.

Collectively, the limit of practical use of the three species extends from the Atlantic Coast States westward into eastern Texas, Oklahoma, and Kansas, and, to a limited extent, into southeastern Nebraska. Northward their value is sharply limited beyond the Missouri-Iowa line, the southern half of Illinois, the southern part of Indiana and Ohio and across southern Pennsylvania and New Jersey.

**Area of Varietal Adaptation**

Korean is best adapted and most useful for hay, pasture, and seed in the northern area of the general region. It is grown extensively from eastern Oklahoma and Kansas, across Missouri and northern Arkansas, and eastward to the Coastal States. It also is grown, in competition with Kobe, in the Piedmont area of the Coastal States. Southward in the region, Korean progressively declines in favor of Kobe and common lespedeza.

In the southern states, Kobe is most useful as a meadow crop, being superior to Korean in that regard. Kobe has poor seed production qualities. This results in relatively high initial acre seeding costs when compared with Korean. Unless managed carefully, Kobe frequently may fail to reseed sufficiently to renew a satisfactory stand. Kobe cannot thrive and reseed under close, continuous pasturing.

In their respective areas, both Korean and Kobe are highly valued for hay production. Korean is both prolific and profitable as a cash seed crop. Both provide excellent pasture, Kobe continuing to furnish pasture later in the season than Korean. Korean will withstand close, continuous grazing and at the same time reseed abundantly.

Common will reseed and perpetuate itself as far north as southern Missouri, Illinois, Indiana. It is the most useful and most dependable lespedeza for pasture in the southern and southeastern states. It will survive close grazing, is persistent in competition with grasses and weeds, and continues to furnish pasture until relatively late in the season. On fertile, moist soils, it compares favorably with Korean and Kobe in yield and quality of hay.

Tenn. #76 is, for all general purposes, similar to Kobe in area of adaptation and use.

Climax, a selection from Korean, is suited to the same general area and use as is Kobe. It is more prolific than Kobe in seed production, and 10 to 20 days later than Korean in maturity.

Selection #19004 from Korean has the same growth characteristics as Korean
but matures seed 10 to 14 days earlier. Because of its early maturity, it has a slight advantage over its parent along the northern limits of the region of general adaptation. Its high susceptibility to wilt, however, eliminates it as a competitor.

Three early, disease resistant varieties selected out of Korean at the Iowa Experiment Station can be depended upon to reseed as far north as Ames, Iowa. These are Iowa 6, Iowa 39 and Iowa 48. The Iowa 39 selection has a soil adaptation characteristic exactly opposite to the recognized characteristics of the lespedeza species. It thrives on soils so high in free lime carbonate that other lespedezas become extremely chlorotic and die in early stages of growth. Seed of Iowa 6 is in abundant production. It is the earliest of the three selections, and particularly resistant to the wilt disease. Seed of Iowa 48, slightly later in maturity than Iowa 6, is in good supply in southern Iowa.

Harbin, an extremely early variety of Korean, will mature seed as far north as the Canadian border. It is much too early and low in productivity to be of value within the lespedeza region. It is not of economic importance.

**DAY LENGTH AND TEMPERATURE.** The annual lespedezas are quite sensitive to the length of day. Temperature also is a growth factor. Both influence the vegetative growth, the development of seed, and the maturity of the plant. These two factors have a definite influence in determining the geographic area in which the annual lespedezas are adapted.\(^5\)

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\(^3\) Hughes, H. D. Iowa 39 lespedeza for high lime soils. *Forage Notes.* 4: 72-74. 1940.


The degree of damage is quite variable, one year with another, even in fields known to be heavily infested. Observations indicate that the damage is more prevalent in seasons in which excessive rainfall continues through the spring and early summer months.

In some seasons the injury may not be significant but in others materially reduces the yield. In seasons of heavy infection the damage is more severe toward the latter part of the growing period. This reduction in value is especially evident under pasture.

The damaging effects of wilt to Korean lespedeza is becoming so prevalent as to threaten its future usefulness in the areas where generally grown. The need to develop resistant strains retaining the other desirable qualities of the variety is urgent.

In the southern states lespedeza plants may occasionally show slight damage from southern blight, *Sclerotium rolfsii*.

SOIL REQUIREMENTS. The annual lespedezas are adapted to a wide range of soil types and fertility levels. This is in contrast to the more exacting soil requirements of such legumes as alfalfa, red and sweetclover. Lespedeza will, without soil treatment, make growth sufficient for pasture on both badly eroded soils and on acid soils low in phosphate, potash, and nitrogen. However, they will make the best growth when planted on productive land.

Lespedeza reacts favorably to lime on acid soils and to mixed fertilizers, especially phosphate, on deficient soils. On some soils an application of phosphate may be necessary for a satisfactory crop.

Of the lespedezas, the Korean is least tolerant to acid soils. On the extremely high lime soils in areas of the coastal states it replaces Kobe for general use. Lespedeza do poorly on water-logged soils.

The effect of soil treatments on Korean lespedeza varies considerably, depending upon the soil. The yields shown below were on a tight (clay pan) soil in Central Missouri. The lespedeza was grown in one-year rotations with small grain and cut for hay in midsummer after small grain harvest.

In the two-year rotation of wheat and lespedeza on a sandy loam soil in southeastern Missouri, the lespedeza, harvested for hay in the second season, produced yields over a five-year period as follows: No treatment, 1350#; lime, 3125#; lime and phosphate, 3300#.

PRODUCTION PRACTICES

WEED COMPETITION. Lespedeza, because of their growth habit, cannot compete successfully with spring and early summer weed growth. While they will survive under heavy weed competition, their growth is materially reduced, affecting their values for hay, pasture, or seed.

The annual lespedezas develop so slowly in the early spring that even dense stands, resulting from heavy volunteer reseedings, are unable to compete with and hold back the earlier and more rapid growth of annual and perennial weeds. This competition becomes even more serious when pure stands of lespedeza are allowed to continue year after year. The only exception is on extremely poor, badly eroded land, too infertile for most weeds to grow well. Here lespedeza will continue to dominate the field.

Dodder, a parasitic weed, is one of the

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7 Unpublished data. Dept. of Soils, Univ. of Missouri.
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<td>6,520</td>
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* Above figures plus the acreage in Indiana, Louisiana, Oklahoma, West Virginia, Ohio, and Kansas.

Under such conditions, and using good quality two-year-old steers as a unit of measure, the rate of gain for the season should total from 100 to 150 pounds per acre.

Lespedeza furnishes excellent pasture for dairy cows during the early and mid-season pasture period. Milk production frequently declines to a noticeable degree as the season advances and plants get beyond the full bloom stage of growth. In contrast, the rate of gain in beef cattle frequently increases during the latter part of the pasture season.

As lespedeza develops toward full maturity the protein content declines and...
TABLE 15.4
CARRYING CAPACITY OF LESPEDEZA PASTURE IN MISSOURI

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<tr>
<th>Year</th>
<th>Pasture period</th>
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<td>1942</td>
<td>7/7 - 10/9</td>
<td>49</td>
</tr>
<tr>
<td>1943</td>
<td>7/10-10/9</td>
<td>73</td>
</tr>
<tr>
<td>1944</td>
<td>7/12-10/4</td>
<td>52</td>
</tr>
<tr>
<td>1945</td>
<td>7/20-9/29</td>
<td>55</td>
</tr>
<tr>
<td>1946</td>
<td>7/4 - 10/4</td>
<td>70</td>
</tr>
<tr>
<td>1947</td>
<td>7/21-9/23</td>
<td>51</td>
</tr>
<tr>
<td>1948</td>
<td>7/31-10/1</td>
<td>87</td>
</tr>
</tbody>
</table>

11-year Av. 72.4 95

the plants become decidedly less palatable. The proportion of leaves in the total top growth also declines.

The dependable, good quality pasture provided by lespedeza during the summer months, when most other pasture crops are relatively poor, makes this legume highly valuable in a well managed pasture system.

Maximum gains and carrying capacity on lespedeza are obtainable only when the lespedeza is free from excessive competition with other crops or weeds.

The carrying capacity of lespedeza as a summer pasture after small grain harvest is indicated by the pasture record at the Missouri Experiment Station, shown in Table 15.4.

The land was sown to wheat each fall after the lespedeza had been pastured out and had matured sufficient seed to insure a good stand the following year through volunteer reseeding. These figures represent the pasturage provided after the wheat crop has been harvested for grain and removed.

A combination of a small grain, fall sown, and lespedeza may also be utilized profitably with the small grain crop used for pasture instead of being harvested for grain. Usually by the time the small grain crop has been fully grazed out in late spring, the lespedeza has developed to a degree as to continue furnishing good pasture through late spring into the late summer to fall months.

The carrying capacity, range of pasture period and acre gains are indicated by the pasture record at the Missouri Experiment Station, shown in Table 15.5.

LESPEDAEA IN PERMANENT PASTURES. Considered collectively and for the entire region, the annual lespedezas are of major importance in permanent pastures on the millions of acres of old cultivated or badly eroded lands that have been sown or allowed to go to grass with little or no soil treatment.

Common lespedeza will withstand competition and close grazing in permanent pastures and is much more persistent in this respect than are other varieties. It is preferable to the other annual varieties in most areas throughout the southern states. Korean, because of its seeding ability and its relatively early maturity, is the best variety for the northern part of the region. Kobe and Climax are not dependable in the northern area due to their late maturity and relatively poor seed production. Under
Fig. 15.6 "A combination of small grain fall sown and lespedeza . . . with the small grain used for pasture . . . Usually by the time the small grain has been grazed out lespedeza . . . furnishing good pasture through late spring and into the late summer to fall months." (See p. 200.) Fitting a seedbed for winter wheat with a field cultivator on a lespedeza pasture. The lespedeza matured an abundance of seed while being grazed, which will insure a good volunteer stand of lespedeza in the wheat the following spring. University of Missouri photo.

close, full-season grazing they will be eliminated in the southern states in favor of the common.

Lespedeza makes a large contribution in pastures of low productive capacity where the competition with grass is reduced. In well sodded, vigorous growing grass pastures, early, moderately close grazing during the spring months is needed to successfully maintain the lespedeza for use later in the season.

Lespedeza cannot maintain itself in well established sods of Carpetgrass or Bermudagrass, nor will it make a worthwhile contribution in lightly grazed, well established bluegrass pastures.

In areas where adapted, Italian rye-grass, domestic rye-grass, and rescuegrass, fall sown, may be grown with lespedeza successfully for pasture. Established early, the grass will provide some fall and winter pasture. In the spring the grass will serve the double purpose of providing spring and early summer pasture and at the same time will hold back excessive weed growth. By early summer the grass is largely finished, the lespedeza supplying the pasturage during the remainder of the summer.

Lespedeza in "open sod" grasses. The annual lespedezas are well adapted for seeding with such non-sodding grasses as timothy, orchardgrass, and tall fescue, especially if the rate of seeding of the grass is reduced to insure mod-
Lespedeza

TABLE 15.5
ANNUAL GAINS ON WINTER-GRAIN AND LESPEDEZA PASTURE IN MISSOURI

<table>
<thead>
<tr>
<th>Year</th>
<th>Pasture period</th>
<th>Acre basis</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Days cattle pasture</td>
</tr>
<tr>
<td>1937</td>
<td>4/27-9/25</td>
<td>145</td>
</tr>
<tr>
<td>1938</td>
<td>3/26-10/1</td>
<td>155</td>
</tr>
<tr>
<td>1939</td>
<td>4/12-9/24</td>
<td>126</td>
</tr>
<tr>
<td>1940</td>
<td>4/3-10/5</td>
<td>153</td>
</tr>
<tr>
<td>1941</td>
<td>5/19-10/11</td>
<td>193</td>
</tr>
<tr>
<td>5-year Av.</td>
<td>154</td>
<td>298</td>
</tr>
</tbody>
</table>

erately open stands. Such combinations are diversified as to use. They may be used to provide (a) a full season pasture; (b) for early cut hay, with a good clean stand of lespedeza for use as pasture later; and (c) a grass seed crop followed by pasture, or a lespedeza seed crop.

This grass-lespedeza combination permits continuing the stand for a long succession of seasons—the grass serving to control excessive weed growth during spring and early summer. The pasture returns from the lespedeza will, however, be considerably less and not as dependable as straight lespedeza following the removal of a crop of small grain.

LESPedeza FOR SEED

Of the annual lespedezas Korean is a heavy and dependable producer of seed. With a combine it is easily and effectively harvested standing. Kobe is less reliable than common in seed production but is more easily harvested. Climax is intermediate between Korean and Kobe. Shattering before and during harvest is excessive in the common varieties compared to those of Korean. Average to good crops of Korean can be expected to yield from 200 to 600 pounds of seed per acre. A yield of 1,000 pounds or more of seed, while exceptional, is not infrequent. Yields of common, Kobe, and Climax will range from as low as 100 to as high as 300 pounds.

At full seed maturity the leaves of Korean and Climax will have turned brown. In comparison, the leaves of Kobe and common will be partially green. Straw saved from Kobe and common is quite valuable as winter roughage.

High yields of good quality seed are obtained only under good management. Excessive weed growth is best controlled either by growing the lespedeza in association with a small grain crop, or in conjunction with a thin stand seeding of open sod grasses. In some seasons midsummer clipping of excessive weed growth above the lespedeza is necessary to insure maximum seed production.

Thin stands tend to grow prostrate and too low for combine harvesting. On soils of low fertility a dense growth may not reach a height sufficient to permit combine harvesting. Thick stands with excessive top growth are not favorable for high seed yields. Under a crowded, rank growth little seed is developed except on the top branches of the plants.

The early removal of a hay crop may, in favorable seasons, allow sufficient time for the second growth to develop and mature a normal seed crop for fall harvest. On productive soils and in normal seasons, the seed production may equal or exceed that obtained where the crop is permitted to develop the full season for seed alone.
TABLE 15.6
THOUSANDS OF ACRES OF ANNUAL LESPEDEZA HARVESTED FOR SEED IN STATES AVERAGING 10,000 ACRES OR MORE, 1938-48

<table>
<thead>
<tr>
<th></th>
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<td>16</td>
<td>8</td>
<td>15</td>
<td>16</td>
<td>10</td>
<td>13</td>
<td>8</td>
<td>8</td>
<td>7</td>
<td>9.8</td>
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<td>11</td>
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<td>27</td>
<td>22</td>
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<td>290</td>
<td>522</td>
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<td>122</td>
<td>90</td>
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<td>110</td>
<td>94</td>
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<td>17</td>
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<td>27</td>
</tr>
<tr>
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<td>25</td>
<td>30</td>
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<td>65</td>
<td>52</td>
<td>56</td>
<td>32</td>
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<td>41</td>
</tr>
<tr>
<td>Kansas</td>
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<td>30</td>
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<td>48</td>
<td>95</td>
<td>171</td>
<td>60</td>
<td>72</td>
<td>29</td>
<td>58</td>
<td>63</td>
<td>63†</td>
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<tr>
<td><strong>Total</strong></td>
<td>763.0</td>
<td>689.0</td>
<td>720</td>
<td>849</td>
<td>848</td>
<td>858.5</td>
<td>1330.6</td>
<td>922</td>
<td>974</td>
<td>1732.5</td>
<td>974.8</td>
<td>878</td>
</tr>
</tbody>
</table>

* Av. of four years.
† Av. of 11 years.

Under combine harvesting, seed shattering before or during the combining process, together with seed left on the uncut stubble, is normally sufficient to insure a dense stand for the next season.

A seed crop of Korean is not in condition to harvest until the top growth has turned brown and has lost most of its green color. In the northern part of the region this usually is after one or more killing frosts. The seed crop needs to be harvested soon after maturity. Heavy shattering loss occurs if a fully mature crop is left long exposed to excessive rain or high wind.

**Lespedeza Seed as a Protein Supplement**

The high seed yields possible from Korean and the comparatively low commercial market price for seed that sometimes exists has created an interest in the possible use of lespedeza seed as a substitute for other generally used high protein feeds. Lespedeza seed may be expected to contain from 30 to 40 per cent of crude protein.

The seed compares favorably in chemical composition to cottonseed meal and soybean oil meal. The digestion coefficient also is similar. The ground seed is palatable. It has been found to be equal to other concentrates as a protein supplement for dairy cows.13

Lespedeza seed may be substituted for soybean oil meal in chick rations up to 12 per cent of the mash.14

**PERENNIAL LESPEDEZAS**

*L. cuneata* (Sericea) is the most important of the perennial species. Along with such species as *L. bicolor* and *L. crotobotrya*, it is used to provide feed and shelter for wildlife. Sericea is an excellent soil building legume, especially valuable on badly depleted soil on which it is difficult or impossible to establish other legumes.15

It is more leafy and less woody than the other perennials. It has a limited place as a pasture, hay, and seed crop.

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12 Ibid.
Lespedeza

**FIG. 15.7** “L. cuneata (Sericea) is the most important of the perennial species. . . . Sericea is an excellent soil building legume. . . . It has a limited place as a pasture, hay and seed crop, especially on soils where soil improvement and erosion control need special emphasis.” (See p. 203.) Sericea in late June, seeded the previous April on unfertilized, flat, poorly drained, sour land. Harvested hay crop (left) 2,030 pounds per acre. Seed crop in the fall (right) 250 pounds per acre. University of Missouri photo.

especially in fields where soil improvement and erosion control need special emphasis.

The top growth is killed back to the ground in winter, a new growth coming each spring from the crown. It develops an extensive, branched, woody, deep penetrating root system.

Once established it may be used for hay, pasture, or seed. With the possible exception of certain areas on the gulf coast and in other southeastern states, it cannot compete either for hay or pasture with the annual lespedezas.

Cuneata is quite tolerant to low fertility. It will not, except on the poor soils, show any major response to soil treatments using mineral fertilizers. Some tests, however, have given a profitable response to applications of lime and phosphate.

The seed normally carries a high percentage of hard seed. Unless scarified the seed usually will not exceed 25 per cent germination. Scarification is important.

Twenty pounds of seed per acre, on a basis of 80 per cent “quick” germination, is sufficient. Well developed stands obtained from late summer seedings will make fair returns the next season. Stands from winter or spring seedings will produce no practical returns the first season.
The first season growth, though not aggressive, is quite resistant to weed and grass competition.

During the second and succeeding seasons, the crop is aggressive and develops rapidly once the spring season is well advanced.

Seeding without a companion crop is preferable. A firm seedbed is essential. Shallow covering should be emphasized.

For hay the crop must be cut early to give good quality. A growth of much more than 12 inches results in a high percentage of coarse woody stems. Thick stands made for better quality. The crop cures rapidly but unless handled properly a heavy leaf loss develops, resulting in a poor quality, stemmy, low protein hay.

The crop should not be cut too low since the recovery growth develops from the uncut stubble and not from the crown. To help insure the maintenance of a good stand in succeeding years, not in excess of two hay cuttings, or one hay cutting followed by removal of a seed crop, should be practiced.

Some difficulty in palatability may be experienced with livestock if cuneata is allowed to develop excessive growth before being pastured. The legume will not cause animals to bloat.

Hard, continuous, and close grazing will seriously damage the stand and vigor in succeeding seasons and may result in winterkilling.

Under good management, sericea may be expected to produce from 200 to 800 pounds of seed per acre, but saving most of the potential production is usually difficult.

**QUESTIONS**

1. Compare the plant and seed characteristics of common and Korean lespedea.

2. Why is the acreage of lespedea limited west of the Missouri-Kansas line, north of the Missouri-Iowa line, and in the areas east of Iowa?

3. Why is Korean lespedea superior to the common lespedea for hay and pasture in the northern area of the general region of adaptation?

4. Give several reasons why lespedea has special value as a pasture crop.

5. Why can lespedea succeed where alfalfa, red clover, and sweetclover fail?

6. How is lespedea best established and maintained in successive years for pasture?

7. In what areas would you advise seeding lespedea for hay? Why?

8. Suggest conditions where a grass-lespedea combination would probably be preferable to a pure stand of lespedea.

9. How would you utilize the perennial lespedezas? In what way is their use limited and why?

10. How have new strains of lespedea been developed? Name some strains and tell where they are adapted and why they are superior.
Crimson clover, *T. incarnatum* L., sometimes called scarlet, Italian, or incarnate clover, is native to southeastern Europe and southwestern Asia Minor. It apparently was grown in Italy, France, Hungary, and other Balkan countries in the 18th century.

The first known record of its introduction into the United States is 1819, when a small packet of seed was brought from Italy. Its spread throughout the southeastern states was rapid after 1880. By 1900 it was considered a good crop as far north as Kentucky.

**DISTRIBUTION AND ADAPTATION**

Crimson clover is now widely grown as a winter annual throughout the South and as far northward as Maryland, southern Ohio and Illinois. It also is grown in the Pacific Coast States. It is grown to a limited extent as a summer annual in northern Maine, with seedings made in late May or early June. It fails when seeded a little further south. The increase in the use of crimson clover has been most rapid since 1942. Contributing to this increase are (a) the development of reseeding or volunteering varieties, (b) recognition of the requirements of crimson clover for substantial amounts of mineral fertilizers for rapid stand establishment and vigorous growth, (c) an appreciation of its value for winter grazing, and (d) its need for thorough inoculation. Before 1942 the acreage of crimson clover centered in Tennessee, and in local sections of Georgia, Alabama, and Kentucky, and in Oregon.

The clover is tolerant of medium soil acidity and will thrive on both sandy and clay soils. After seedlings become well established it makes more growth at lower temperatures than most other clover species.

**PLANT DESCRIPTION**

Crimson clover seed are yellow in color and are larger and more rounded in shape than red clover. There are approximately 120,000 seed per pound. Under favorable soil moisture conditions seedlings make rapid growth, forming a dense crown or rosette type of leaf development. A central tap root develops, supported by many fibrous roots. This growth continues throughout the winter, the amount depending upon the temperature. The leaves are composed of three leaflets, broadly obovate at the tip and narrow at the base and densely covered

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* See Chapter 8.
is cut when about three-fourths of the seed pods have turned a golden brown color. Cutting is done with a mower or windrower, and the crop is left a few days to cure before threshing. Shattering losses may be minimized by cutting when the plants are damp with dew. In wet seasons, curing in the swath is preferred to the windrow. Grain separators also are used for threshing. The stationary machine method has the advantage of making it possible to rethresh the straw, a practice which frequently is profitable. The less the seed crop is handled when dry, the less the seed loss from shattering. Suction harvesters may have possible usage for gleaning shattered seed. Also, the artificial drying of the seed crop may come to be used in the future. Regardless of the harvesting method, the seed should be rough cleaned and dried as quickly as possible to prevent heating and browning, with a possible reduction in germination.

QUESTIONS
1. Where in the United States is crimson clover best adapted and why?
2. Why has the marked increase in the use of crimson clover been most rapid since 1942?
3. Give several reasons why crimson clover is considered the most important winter annual legume in the South.
4. Why is little crimson clover seed now imported from foreign countries?
5. Discuss the seeding of crimson clover including date of planting, rate of seeding, depth of seeding, and the use of a companion crop.
6. How would you decide the kind and amount of fertilizer to apply in seeding crimson clover?
7. What are the advantages of seeding crimson clover between the rows of cotton and corn at the time of the last cultivation?
8. How should crimson clover be harvested to keep seed losses at a minimum?
has become well established, the yield of the first cutting will often exceed that of alfalfa. However, on soil well adapted to alfalfa the yield from trefoil for the season is likely to be less. MacDonald found a protein content of approximately 28 per cent the middle of May when the trefoil was in the vegetative pasture stage, 18 per cent the first of July when in early bloom, 12 per cent the end of July when in early pod and 9 per cent the middle of August when mature. He compared the composition of trefoil, alfalfa, and red clover, each harvested in the full bloom stage of maturity, as shown in Table 17.1.

Fig. 17.1 “The birdsfoot trefoil plant closely resembles a very fine stemmed alfalfa... The leaves, like alfalfa, are in groups of three, with two small broad leaflets always present at the base of the leaf branch, one on either side, giving the appearance of five leaflets. (See p. 219.) Characteristic leaf, stem, and flower growth of the broadleaf birdsfoot trefoil. Cornell University photo.

Fig. 17.5 “The flowers... are shaped like sweet-pea flowers but much smaller. They are borne in groups, usually 4 to 8, at the end of rather long flower stems.” (See p. 219.) Three typical whorls of birdsfoot flowers. Iowa State College photo.

It will be noted that for the important items included, the composition of the trefoil approximates closely that of alfalfa, widely recognized for its high nutritive value.

**IMPORTANCE AND USE**

The characteristics of birdsfoot trefoil are such as to make it particularly well-suited to use as a permanent pasture legume. There is a well recognized need for such a legume, especially in the permanent bluegrass pastures which prevail from the Missouri east, and south to the Ohio. The acreage is as yet small, however, even in this area. It is a relatively “new” legume, seed of which has only recently become available.

By far the greatest acreage is in New York. Here the seeded acreage have been extended rapidly, both for hay and as a pasture crop. Probably the greatest con-
TABLE 17.1
PARTIAL COMPARATIVE COMPOSITION OF ALFALFA, RED CLOVER, AND BIRDSFOOT TREFOIL HAY
HARVESTED IN THE FULL BLOOM STAGE

<table>
<thead>
<tr>
<th>Legume</th>
<th>Composition in percentage *</th>
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<tbody>
<tr>
<td></td>
<td>Protein</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>17.20</td>
</tr>
<tr>
<td>Red Clover</td>
<td>15.40</td>
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<tr>
<td>Birdsfoot trefoil</td>
<td>17.25</td>
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</tbody>
</table>

* Mean of 16 determinations. N. Y. unpublished data.

centration of acreage, between 2,000 and 4,000 acres, is in Albany County, east central New York, where it was first observed to have naturalized. In the northem part of the state, Essex County, bordering Lake Champlain, 3,000 acres had been seeded by 1949. Outside of New York, acreage is expanding rapidly throughout the Corn Belt and to the east and north.

The importance and use of birdsfoot trefoil, as for other plants, will be determined by the balance of its desirable characteristics and its weaknesses, as these may relate to a given use and environment. Reports from a considerable number of different stations are in general agreement with regard to the characteristics of the broadleaf birdsfoot trefoil, listed by the Iowa station as "advantages" and "weaknesses."

Advantages: Deep-rooted perennial, heat and drought resistant—wide soil tolerance, both as to fertility and acidity—produces seed abundantly, reseeding even when close grazed—vigorouS, with high acre production when well established—palatable and with high feed value—able to maintain itself in competition with sod forming grasses, such as bluegrass—can survive severe grazing abuses—winter-hardy—no bloat.

Weaknesses: Slow in establishment—seed costs high, owing to difficulties in seed harvest—weak stems, it lodges easily when grown alone—starts rather late in spring—slow recovery after harvest.

These characteristics are such as immediately to suggest the greater suitability of this legume for use as a permanent pasture legume than for hay. The relatively high cost of seed and slow establishment are factors limiting its use for hay or for pasture in short rotation. It would appear that it has a place as a hay crop only under conditions where alfalfa and the clovers do not succeed well.

**Pasture**

Based largely on his early observations of birdsfoot trefoil in areas where it had naturalized in New York state, but also on seeded areas, MacDonald recorded these important observations:

... Many of the birdsfoot trefoil stands occurring in New York are in areas being used for pasture. In general, these pastures are being extensively grazed and are at a low state of fertility. In many instances, birdsfoot trefoil is the only legume present. In certain pastures, however, where the fertility level is higher and grazing close, birdsfoot trefoil occurs in the presence of white clover. . . .

Our most comprehensive measure of the value of the broadleaf trefoil in permanent pastures in association with Kentucky bluegrass is available from the Indiana station. From pastures established in 1941, the first comparable results were available in 1943. In this comparison both the pastures without the

18 Aldrich, Samuel. Loc. cit.
20 MacDonald, H. A. Loc. cit.
TABLE 17.2
POUNDS OF BEEF PER ACRE FROM PERMANENT PASTURE WITH AND WITHOUT BIRDSFOOT TREFOIL ON THE MILLER-PURDUE FARM, INDIANA AGRICULTURAL EXPERIMENT STATION

<table>
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<th>'46</th>
<th>'47</th>
<th>'48</th>
<th>'49</th>
<th>'50</th>
<th>6-yr. Av.</th>
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<tbody>
<tr>
<td>No trefoil</td>
<td>133</td>
<td>192</td>
<td>366</td>
<td>*</td>
<td>221</td>
<td>201</td>
<td>241</td>
<td>226</td>
</tr>
<tr>
<td>With trefoil</td>
<td>217</td>
<td>263</td>
<td>359</td>
<td>*</td>
<td>334</td>
<td>337</td>
<td>334</td>
<td>311</td>
</tr>
</tbody>
</table>

* No comparative trials in 1947.

In Iowa, beginning in 1916, birdsfoot trefoil has become the basic legume in...
Birdsfoot Trefoil has become the basic legume in the renovation of permanent pastures. Pastures with no renovation gained 97 pounds of steer gain. Comparable pastures renovated with birdsfoot and red clover gained 197 pounds of steer gain per acre.

These are steers in September on trefoil renovated bluegrass pasture, Southern Iowa Pasture Improvement Farm, Iowa State College photo.

The renovation of permanent pastures. In most cases 4 to 5 pounds of trefoil and 8 to 4 of red clover have been seeded in oats, with the small grain grazed off. From 200 to 300 pounds of 20 per cent phosphate at seeding time is supplemented with top dressings later. The average for two check pastures with no renovation for 1949-50 was 97 pounds of steer gain per acre per season. Four comparable pastures renovated with birdsfoot and red clover in 1947 averaged 197 pounds of steer gain per acre for the same two-year period.

Bloat. The bloating of farm animals on legume pastures constitutes a serious problem to livestock owners. The fact that no animals are known to have bloated when pasturing on birdsfoot trefoil is much in its favor.

Robinson is in agreement with other European writers, in observing that no bloat has been reported from trefoil. Aldrich, after years of observation of trefoil on New York farms, reported that to his knowledge no cases of bloat have occurred. Midgeley, Vermont, and Hughes and Heath, Iowa, also report that to their knowledge there has never been a case of bloat with animals grazed on trefoil.

Hay

Birdsfoot trefoil has good value for hay as well as for pasture. It produces palatable and nutritious forage and does well on soils not well suited to alfalfa and red clover. It can be cut and cured satisfactorily, but it is unlikely that it will replace other adapted legumes on the better soils and in the shorter rotations.
Susceptibility to lodging, slow establishment, and high seed costs are factors decidedly against trefoil as a hay crop in short rotations.

MacDonald 27 as early as 1940 established seedings to compare this plant with alfalfa and red clover for hay. Harvest was made when the legumes were in full bloom during 1941, 1942, and 1943. The establishment was slow in 1940 as compared with the other legumes. In the second year, the trefoil seeding compared favorably with the other seedings and was higher in total dry matter than either of the other two. By the end of the third year, the red clover was practically gone, whereas the trefoil remained the same as in previous years. These results are in agreement with the work of others. From many experimental plantings, MacDonald has had hay yields of 2 to 3 tons of hay per acre, with some going to 4 tons of cured hay.

Aldrich,28 from his survey of birdsfoot trefoil production on New York farms and throughout the Corn Belt, says 2 to 2½ tons per acre is a good yield of cured hay but that it may go as high as 4 tons per acre. The hay is fine stemmed and leafy. The protein content and feed value approximates that of alfalfa (see pp. 221, 222).

**For Erosion Control**

The ability of this legume to establish itself and hold under unfavorable soil conditions would seem to recommend it as worthy of consideration as a soil conserving legume. Glover Brown, chief of the Agronomy Division, S.C.S., after making a field survey of birdsfoot trefoil, summed it up this way: 29

... There are thousands of acres in this country that are devoted to grazing, the soils of which are not best adapted to the production of such legumes as alfalfa, Ladino, red, or even alsike clover. These are lands that are either too low in fertility, have a high water table, rather acid in reaction, or have some other physical condition that prevents the profitable production of some of the high-producing legumes. Such steep pasture lands with poor ground cover are subject to serious run-off with its consequent erosion and fertility losses. Birdsfoot trefoil being a perennial legume capable of good production on lands of such physical characteristics that hinder the growth of the other pasture legumes fills a great need in this respect.

**VARIETIES AND STRAINS**

Considerable selection and breeding work is under way in a number of states where attention has been directed especially to less seed shatter and to disease resistance. Thus far no selections from specific crosses have been released, and not much progress appears to have been made.

Some think of the broadleaf and narrowleaf trefoils as different varieties. This is not correct; they are two different species.

It is coming to be recognized that there are strains which differ considerably in winter hardness, vigor and rapidity of seeding growth, erectness, and time of maturity.

In New York, a variety of the broadleaf type has been released under the name *Empire*. This variety is the increase of a selected, naturalized stand occurring in the vicinity of Preston Hollow, N. Y., where it was first observed by Johnstone-Wallace in 1934. This variety has been widely tested and certified seed is available in quantity. It is hardy, produces a good yield, and may be used either as hay or as pasture.

The plants from seed that are coming in from Europe in considerable quantity make a distinctly different growth from that of plants that trace back to the New York strain. The European is more uni-

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27 MacDonald, H. A. *Loc. cit.*
form in habit of growth, makes a more erect growth, and comes into flower considerably earlier. It also recovers more quickly after harvest. A selection of this type is being increased by the Cornell station under the name Viking. The S.C.S. at Bellingham, Washington, originated a variety of this same general type, to which they have given the name Cascade.

Most of the European seed appears to have come from a high plateau area in north central Italy where the soil is rather low in fertility, and where the broadleaf trefoil has been grown rather extensively through a period of perhaps 50 years. Seed from this source has not been designated as a different variety; it usually is simply designated "from Italy." The growth is distinctly different, however, from our domestic New York strain. A similar type is produced in quantity in south central France.

When 10 lots of seed, five domestic and five European, were seeded in comparable replicated plantings at Ames, Iowa, there were significant differences in vigor of seeding growth. For example, the European strain that had made the least growth at the end of three months exceeded in height the most rapid growing domestic strain. A strain from Czechoslovakia made an average height growth of 5.8 inches when the most vigorous domestic strain reached a height of only 2.62 inches.30

Seed of different lots of European origin were interplanted at Ames in 1948 between seed lots of domestic origin. The average winter survival of 21 plantings of domestic seed was 88.8 per cent, as compared with 74.4 per cent survival for 24 plantings of the European seed. Two lots of the domestic seed showed less than 70 per cent survival, as compared with approximately 100 per cent survival for most of the other domestic seed lots.

Of 12 lots of European seed, six showed a survival of 90 per cent or more and three others approximately 80 per cent. It would appear that most lots of European seed are satisfactorily winter-hardy.

CULTURAL AND MANAGEMENT PRACTICES

The fact that birdsfoot trefoil is slow in establishment would suggest that seedbed and seeding practices may contribute significantly to successful establishment. A firm seedbed is particularly important. After the seedbed has been well prepared, it is desirable to firm it with a corrugated roller or "cultripacker" before seeding and again afterward. It is important that the seed shall not be covered with more than one-fourth to one-half inch of soil, and that this soil be packed firmly about the seed. Many failures to obtain good stands of birdsfoot can be attributed to loose seedbeds.

Time and Rate of Seeding

Fuelleman and Pierre31 observe that in Illinois spring seedlings have given the best results. They recommend 6 pounds of seed per acre under favorable conditions.

Dodd,32 of Ohio, also recommends seeding in early spring, at the usual time of seeding oats. He suggests 5 pounds of trefoil per acre, either alone or in combination with an equal amount of Kentucky bluegrass, timothy, or meadow fescue. There is general agreement that birdsfoot is best grown in association with an adapted grass.

MacDonald33 concluded from his many seedings on different soils and under dif-

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30 Gilliam, E. C, Loc. cit.14
33 MacDonald, H. A. Loc. cit.8
ferent conditions that “if conditions are favorable for germination and growth there is little to be gained from seeding more than 5 pounds of seed per acre.” Serviss has observed that this legume is better used in a simple mixture than alone. Timothy has given good results when grown with the trefoil in New York, seeded at the rate of from 6 to 8 pounds of timothy to 4 of trefoil. In making pasture seedings, Serviss recommends, as a desirable mixture, 4 pounds of trefoil seeded either with Kentucky bluegrass or timothy. Surface seedings on existing pastures usually have failed except where the area was fertilized, and the sod torn up thoroughly, with a good seedbed fitted. He points out that normally a better stand of trefoil is obtained when seeded with no small grain companion crop, provided that weed growth is controlled by frequent clipping. A companion crop of oats, if used, should be seeded at a reduced rate and grazed off. This is in agreement with recommendations by others.

Midgley, of Vermont, recommends 6 to 8 pounds of either bromegrass or timothy to 5 pounds of trefoil. He suggests that clover or alfalfa should not be added to the above mixture because of their rapid early growth and resulting severe competition with the slow starting trefoil.

In Iowa, where most seedings have been in renovated bluegrass pastures, “the rate of seeding in most cases has been 4 to 5 pounds of trefoil and 3 to 4 of red clover. . . . The red clover is included to give pasture while the trefoil is getting established and into production.” The seedings have been grazed sufficiently during the seeding year to minimize the effect of competition.

When seeded with a small grain, the small grain has been grazed.

Heath has reported a study of trefoil in combination with different grasses at the Soil Conservation Nursery, Ames, Iowa, in which the different mixtures were under observation and harvested annually through six years. In this comparison Kentucky bluegrass, redtop, orchardgrass and timothy were more compatible with trefoil than the several other grasses included.

**Inoculation**

Inoculation is essential to success with birdsfoot trefoil. The trefoil nodule-
forming bacteria are not naturally present in soils where this legume has not previously been grown. Trefoil does not cross inoculate with any of the other legumes of which we know (See Chapter 10).

Dodd attributes the cause of many of the failures in stand and growth of trefoil to poor inoculation. Midgley and Varney also believe that many failures are due to poor inoculation techniques. The seed coat of this legume is smooth and the bacterial culture may not adhere well. It is suggested that powdered clay or similar material be added to the water before it is used to moisten the seed and the inoculin. In this way all seed become coated with a thin layer of clay which adheres and holds the organisms to the seed.

The importance of inoculation as a factor influencing stand and early vigor is suggested by greenhouse plantings on four soils at Ames, Iowa (pH values 5.5, 5.7, 5.7, 5.5). It will be noted from Table 17.4 that the number of plants per unit of soil and the height at the end of three months was increased more than 100 per cent.

### SEED AND SEED HARVEST

Several early writers believed that the cultivation of this plant would never become an economic possibility because the seed shatter so readily when they become mature.

McKee and Schoth have pointed out that the seed ripens unevenly and that one plant may have both mature and immature pods at the same time. To get maximum seed yields it is necessary to watch the growth closely and harvest when the first pods are brown and a good number have turned a dark brown. At this time the plants will still be green and succulent. They suggest that cutting may be done at night in order to reduce seed shatter to the minimum; the cut material to be windrowed and stacked, or threshed direct from the windrow.

Aldrich, after observing many fields in New York through a period of years, describes seed harvest as a major problem. He notes that a common method of seed harvest is to cut and windrow the crop when the largest number of seed pods are turning brown. After the wind-

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38 Dodd, D. R. *Loc. cit.*
row is dry, it is threshed with a pick-up combine. Some growers prefer to cure the crop in the field only until safe to store, then to place it in the barn or stack to cure further before threshing.

Aldrich reports from 40 to 100 pounds of seed per acre as the usual harvested yield, with an occasional top yield around 300.

The usual procedure is to take the first crop for seed. Some have clipped or pastured in May. Clipping or pasturing later than about the end of May usually has reduced seed yields materially.

Early in his studies MacDonald sampled representative farm fields to get a measure of the amount of seed actually brought to maturity under different conditions, regardless of whether it shattered to the ground or could be saved in harvesting. Harvesting carefully, in order that none of the seed was lost, he obtained the following pounds of seed per acre: fertilized area, 676; unfertilized area, 312; pure stand, waste area, 282 pounds; poor meadow, weedy, 112 pounds; sparse stand, 43 pounds. The problem in seed harvest is to handle it so that a reasonable proportion of this prolifically produced seed shall get into the sack, rather than shattered onto the ground. It is a common experience to
have a heavy seed set and, because of unfavorable weather at harvest time, perhaps alternate wet and drying weather after cutting, to lose most, if not all, of the seed by shatter.

Buckley has reported the seed harvest method now being used on the Leland Cook Farm in Albany County, New York. This is one of the farms on which the naturalized birdsfoot trefoil was found to have taken over in 1934, after spreading along roadsides.

Putting the harvested crop in the barn or stacking it outdoors and later threshing it, Cook found that it made poor feeding hay and took too much labor. He now uses a combine with a separate motor to run the threshing mechanism, because it gives a steady, even speed that gets more of the seed. The hay is windrowed when cut. After the windrow has dried on top, it is turned if the growth is heavy. In combining directly from the swath, he found it dried out so quickly that he lost seed. He states that he gets his easiest and best seed from the poorer fields, when the growth is short.

The first commercial seed harvest of birdsfoot in New York was in 1937. This was in the Preston Hollow area of southern Albany County. From a 1946 harvest of less than 20,000 pounds of seed to 125,000 in 1948 in New York alone, the seed available for planting in 1951 has been estimated to approach half a million pounds.

In one area in southern Iowa, a few trefoil growers have taken seed from the standing crop with combines, following this with harvest of the leafier portion as hay. One has followed this procedure for 4 years, with seed yields ranging from 150 to approximately 250 pounds of re-cleaned seed per acre. The air and screens of the combine are set to save all pods from which the seed may not have been separated, these being spread and dried and later rerun through the combine. It would appear that this method is feasible only when the acreage to be harvested is small.

**Hard Seed**

In common with many other legumes, birdsfoot trefoil has a high percentage of “hard” seed. The seed coat of such seed prevents moisture from penetrating promptly.

**Hard seed and scarification.** Studies on the effect of scarifying trefoil seed containing a relatively high percentage of hard seed are reported from Iowa.

Of six lots of seed used in one study the lowest per cent of hard seed was 21 and the highest 64. Scarification increased the stand in every case. However, the increase in field stand did not correspond well with the reduction in the hard seed as a result of scarifying.

Samples of seed scarified to different degrees were planted in duplicate on August 19, 1948, and the number of seedlings per row determined 72 days later as shown in Table 17.6.

For all lots the maximum germination occurred when seed was scarified once; likewise, the field count was higher. It would appear that trefoil can be seriously injured if scarified too se-

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44 Gilliam, E. C. Loc. cit.14
Insect Pests and Disease

TABLE 17.5
THE EFFECT OF SCARIFYING BIRDSFOOT TREFOIL SEED ON THE RESULTING FIELD STAND IN IOWA

<table>
<thead>
<tr>
<th>Source of seed</th>
<th>Percentage</th>
<th>Av. no. plants per unit of row May 23, 1948</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Germination</td>
<td>Hard seed</td>
</tr>
<tr>
<td>Lots:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Vermont</td>
<td>71</td>
<td>21</td>
</tr>
<tr>
<td>2. New York (certified)</td>
<td>52</td>
<td>39</td>
</tr>
<tr>
<td>3. New York (Baker)</td>
<td>30</td>
<td>64</td>
</tr>
<tr>
<td>4. New York (Pellet)</td>
<td>60</td>
<td>28</td>
</tr>
<tr>
<td>5. New York (Core)</td>
<td>63</td>
<td>32</td>
</tr>
<tr>
<td>6. New York (Giese)</td>
<td>57</td>
<td>26</td>
</tr>
</tbody>
</table>

TABLE 17.6
THE EFFECT OF DIFFERENT DEGREES OF SCARIFICATION ON THE PERCENTAGE GERMINATION AND THE HARD SEED CONTENT, AND ON THE FIELD STAND OF BIRDSFOOT TREFOIL, IOWA

<table>
<thead>
<tr>
<th>Scarification treatment</th>
<th>Germination</th>
<th>Hard seed</th>
<th>Plant count per row</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Unscar.</td>
<td>59</td>
<td>29</td>
<td>351</td>
</tr>
<tr>
<td>Scar. 1X.</td>
<td>89</td>
<td>2</td>
<td>416</td>
</tr>
<tr>
<td>Scar. 2X.</td>
<td>88</td>
<td>0</td>
<td>364</td>
</tr>
<tr>
<td>Unscar.</td>
<td>71</td>
<td>18</td>
<td>311</td>
</tr>
<tr>
<td>Scar. 1X.</td>
<td>86</td>
<td>0</td>
<td>368</td>
</tr>
<tr>
<td>Scar. 2X.</td>
<td>82</td>
<td>1</td>
<td>301</td>
</tr>
<tr>
<td>Excess scar.</td>
<td>65</td>
<td>0</td>
<td>145</td>
</tr>
<tr>
<td>Unscar.</td>
<td>57</td>
<td>26</td>
<td>250</td>
</tr>
<tr>
<td>Scar. 1X.</td>
<td>80</td>
<td>7</td>
<td>310</td>
</tr>
<tr>
<td>Scar. 2X.</td>
<td>72</td>
<td>4</td>
<td>242</td>
</tr>
<tr>
<td>Excess Scar.</td>
<td>65</td>
<td>0</td>
<td>112</td>
</tr>
</tbody>
</table>

verely. If the hard seed content is not excessive, it would appear that growers may do well not to scarify, expecting some of the hard seed to make plants after a winter in the soil.

INSECT PESTS AND DISEASE

It appears that birdsfoot trefoil is less affected by insect pests and disease than most legumes.

Montieth and Hollowell have reported birdsfoot heavily infested with potato leafhopper, *Empoasca labae* Harris. The plants were observed to turn an unhealthy yellowish or brown color in midsummer. The tiny blades showed symptoms of yellowing and bronzing similar to those observed from hopper injury on alfalfa.

Lewis and Sherwin report that *Rhizoctonia solani* has caused severe damage to spaced plants of trefoil, both in mixtures and in pure stands. Damp, humid, warm weather favored disease development. A dense, heavy vegetative growth was most susceptible to invasion by the fungus.

MacDonald reports that clover root rot, *Sclerotinia trifoliorum*, has been observed to infest trefoil in some places, particularly on moist soils of high organic content and that this disease may


232 17. 

Birdsfoot Trefoil

become serious. This rot is first noticed in the autumn, when leaves of the infected plants become white and wither. Only isolated plants may be killed, or the disease may spread to adjacent plants.

OTHER SPECIES

In addition to the broadleaf birdsfoot trefoil, we have two other species of some interest and value in this country. These are the narrowleaf birdsfoot trefoil, L. tenuis, and the Big trefoil, L. uliginosus.

Narrowleaf Birdsfoot Trefoil

This species appears to be much more limited in its adaptation and value in this country than the broadleaf species. It was found to have naturalized in New York, just as the broadleaf did. It prefers the lower lying, more moist soil areas. It is much less deep rooted and less heat and drought tolerant than the broadleaf type; also, the production of top growth is proportionately less. It probably has had more use in Oregon and California than elsewhere, with some acreage also in New York. Its lower, shorter growth makes it better suited to use as pasture than for hay.48

The narrowleaf and broadleaf types are easily distinguished, especially by the difference in shape of leaf. The broadleaf trefoil has obovate to elliptical leaflets, at least half as wide as long. The leaflets of the narrowleaf are noticeably long, and relatively narrow, being described as linear or linear-lanceolate. The flowers of the narrowleaf trefoil are noticeably smaller than those of the broadleaf.

Tests in California have shown the narrowleaf to be strikingly salt tolerant. Compared with a number of other legumes recognized in the past as those having salt tolerance, the narrowleaf trefoil was shown to be so much more tolerant as almost to be in a class by itself.

Most of the seed of the narrowleaf trefoil has come from Oregon. The method of harvesting for seed has been much the same as for the broadleaf type, with the same precautions necessary because of shatter losses.

Big Trefoil

Big trefoil appears to be a useful and valuable crop plant in this country for certain areas and environmental conditions. Its characteristics and use have been best described by Howell,49 and McKee and Schloth.50

The use of big trefoil in Europe appears to have been limited, and confined to southern Europe. It appears to have been introduced into the United States only within the past 30 years. Since its introduction, it is reported to have become naturalized along the Pacific Coast, from British Columbia south to northern California. Its growth thus far has been much more extensive in Oregon than in any other part of the country. Trials with it also in the lower Atlantic Coast and Gulf Coast states indicate that it may have considerable usefulness there.

Big trefoil is a long-lived perennial, with its area of growth limited to regions of mild winter temperatures. It lacks winter hardiness. On first appearance and casual examination it resembles rather closely the other trefoils. But it differs from them in a number of important ways; this applies both to the characteristics of the plant and to its soil and climatic adaptation.

First, it spreads by means of underground stems or rhizomes, as well as from seed. The root system is shallow,

48 MacDonald, H. A. Loc. cit.8
with many finely branched roots. It is best adapted to wet, poorly drained soils and is tolerant to brackish, overflow water, even surviving weeks of submergence. It does not do well on the higher, drier soils. It is even more tolerant of an acid soil reaction than are the other species.

In appearance, the flowers have the same color and shape as the other trefoils but are noticeably smaller and finer, with 8 to 14 in a cluster, instead of the more familiar 4 to 8. The seed pods also are smaller and shorter, and noticeably tapered. The seed, a uniform olive green in color, are much smaller than any of our other generally grown legumes and are even smaller than those of white clover, running close to a million per pound.

Big trefoil is especially promising for seeding in cutover lands, especially in conifer forest areas. Such lands are likely to be rather strongly acid with no possibility of applying lime. Reports also are encouraging as a result of trials with big trefoil in such heavy sodding grasses as carpetgrass and Bermudagrass in the Carolinas, Georgia, and Florida.

In establishing big trefoil, the small size of the seed is a factor. Seedlings should always be shallow, and on a firm seedbed. Two to three pounds of seed in suitable grasses is ample. Inoculation is important. The culture must be specific for big trefoil. It will not cross inoculate even with the broadleaf or narrowleaf trefoil, to say nothing of the more generally grown clovers. Like the other trefoils, it is slow in establishment and care should be exercised to prevent crowding and competition from other more rapidly growing vegetation.

Rarely does a new crop gain favor so rapidly as birdsfoot trefoil has done and more rarely does a valuable plant appear as an accidental introduction.

Frank C. Pellett

QUESTIONS

1. Why did early writers believe that birdsfoot trefoil would never become a leading forage crop?
2. Enumerate and discuss the desirable and undesirable characteristics of birdsfoot trefoil.
3. Under what soil conditions is birdsfoot trefoil best adapted?
4. In what areas and for what purposes would you recommend seeding birdsfoot trefoil?
5. How would you establish and manage birdsfoot trefoil for hay? permanent pasture?
6. Why is a grass recommended in combination with birdsfoot trefoil?
7. Why is birdsfoot trefoil a valuable legume for renovated pastures?
8. How would you harvest birdsfoot trefoil seed to eliminate some of the excessive shattering?
9. Discuss the advisability of planting seed of foreign origin.
10. Speculate on the future of birdsfoot trefoil as a forage in the United States.
There are about 150 species of *Vicia* widely distributed over the world. These are commonly referred to as Vetch. About twenty-five of these are native to the United States. The species in commercial use are all native to Europe and adjacent Asiatic territory, being most abundant in the Mediterranean region. The date of the first introduction of vetch into cultivation in the Old World is not known, but it was in an early period. “Tares,” as referred to in the Bible, is supposed to be common vetch, *Vicia sativa*, and descriptive references to *Vicia faba* are found in early historical records. Hairy vetch, *Vicia villosa*, and common vetch were introduced into the United States at an early period, the exact dates not being known. Other vetches in cultivation were introduced in more recent times by the U.S.D.A. Their commercial use extends back but little more than a quarter of a century.  

Several species of *Astragalus* often are referred to as milk vetch. *Coronilla varia* is commonly called crown vetch. As used in this text, however, vetch refers only to the genus *Vicia*.

### SPECIES OF ECONOMIC IMPORTANCE

In the United States the species of *Vicia* of most importance are: *Vicia villosa*, hairy vetch; *V. sativa*, common vetch; *V. atrorubens*, purple vetch; and *V. pannonica*, Hungarian vetch. These are all introduced species and native to Europe. Other species of less importance are *V. articulata*, monantha vetch; *V. monantha*, Bard vetch; *V. angustifolia*, narrowleaf vetch; *V. dasyarpa*, woollypod vetch; *V. faba*, horsebean; *V. grandiflora*, bigflower vetch; and *V. cracca*, cow vetch. With the exception of *V. cracca* these likewise are all introduced European species. The native species are not aggressive in their native habitat and are of little importance, with the exception of *V. cracca* which in the extreme northern part of the United States sometimes occurs in quite dense stands. In southeast Europe and in Asia Minor, *V. ervilia*, bitter vetch, is of economic importance. All species of *Vicia* are valuable pasture plants in sections to which they are adapted and are utilized wherever they occur naturally. The total

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**ROLAND MCKEE**  
*Division of Forage Crops and Diseases, U.S.D.A.*

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**Roland McKee** was with the Division of Forage Crops and Diseases, U.S.D.A., working on forage crops research from 1905 until his retirement in 1949. His fields of special research have been green-manures, cover-crops, and miscellaneous legumes. He was born in Kansas and did his undergraduate and graduate work at Kansas State College.

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acreage planted to vetch in the United States is something over one million acres.

DESCRIPTION

With few exceptions, notably V. faba, the species of Vicia are semiviny plants with tendrils (Fig. 18.1). The leaves are pinnate and flowers vary in size and color in the different species. Seed and pods likewise vary in size and shape. The genera most nearly related to Vicia are Lathyrus and Pisum. Plants of a number of species in these genera, particularly in Lathyrus and Vicia, are very much alike. Generic distinction is based mainly on differences in the style and stigma. Species of Vicia always have a cylindric style with a ring or tuft of hair-like cilia surrounding the style just below or at the base of the stigma. In Lathyrus a tuft of hairs is likewise just below the stigma but is on the inner side of the staminal column only, and usually extends over a greater length of the style than is the case in Vicia. Species of Pisum usually have softer or more succulent stems and leaflets than Vicia and Lathyrus and differ in having the style flattened and grooved above.

ADAPTATION

The successful growth of the various vetches is largely dependent on winter-hardiness and soil adaptation.4

Hairy vetch is winter-hardy and is adapted to light sandy as well as heavier soils. It will stand below zero temperatures, suffering winter injury only when there is severe heaving of the soil. It can be grown in almost any section of the United States where production of any crop is possible. For seed production it is best adapted, and is most extensively grown, in western Oregon, north central Texas, Arkansas and Michigan. For soil improvement it is especially adapted and extensively used in all the Cotton Belt states. In all other parts of the United States it can be grown and is used to some extent.

The variety of hairy vetch that is called smooth vetch (since it appears to have no pubescence) is the strain that now makes up practically all of the commercial acreage of hairy vetch. It is somewhat less winter-hardy than the more pubescent strain, but will stand winter temperatures anywhere in the United States that the hairy vetch is grown.

Common vetch is less winter-hardy than hairy vetch but the varieties grown commercially for seed in the United States will stand a temperature of 10°F. It is best adapted to well drained loam...
Key to Commercial Vetches

Plants decidedly hairy
- Flowers many in a cluster, stalked, purple
  - Pods hairy, seed scar with white appendage... purple vetch
  - Pods smooth, seed round, seed scar smooth, without appendage
    - Banner equaling keel... cow vetch
    - Banner longer than keel... hairy vetch
- Flowers few (2-6) in a cluster, not stalked, nearly white... Hungarian vetch

Plants smooth or nearly so
- Flowers stalked
  - Flowers many in a cluster, purple
    - Pod smooth, seed round... smooth vetch
    - Pod finely hairy, seed oval to nearly round... wollypod vetch
  - Flowers one or few in a cluster, light lavender, yellow, or nearly white (except Bard vetch, purple)
    - Flowers yellow... bigflower vetch
    - Flowers not yellow
      - Leaflets without tendrils... bitter vetch
      - Leaflets with tendrils
        - Seed decidedly flattened, flowers one, light lavender... monantha vetch
        - Seed oval or round, flowers two, purple... Bard vetch
- Flowers not stalked
  - Plants upright, leaves large and very broad to nearly round; seed very large... horsebean
  - Plants viny, leaves narrow to oval and obovate, seed not large, flowers purple
    - Pods turning black, leaflets always narrow... narrowleaf vetch
    - Pods not turning black, leaflets seldom narrow... common vetch

soil though it can be grown on sandy soils if well fertilized. For economical seed production common vetch requires a comparatively cool season during the period it is developing and maturing its seed crop. The area of the United States with the most favorable conditions for seed production is western Oregon, western Washington and northwestern California. A selected strain of common vetch known as Willamette is the most winter-hardy of the common vetch varieties grown in the United States. Most of the seed produced in this country is of this variety. Most imported common vetch is much less winter-hardy than either Oregon grown common or Willamette vetch. It often suffers winter damage even in our southern areas.

Hungarian vetch is somewhat more winter-hardy than common vetch but is not as hardy as hairy vetch. It can be grown and will do well on any moderately fertile soil throughout the milder parts of the United States. It differs from other vetches in being able to tolerate quite wet soils. It is under such conditions that it is superior. In western Oregon, where it is used most extensively, it is grown mostly on the low clayey wet lands not so well adapted to common vetch.

Purple vetch is the least winter-hardy of the vetches grown commercially. Where temperatures do not change quickly it will stand 20° F. with little or no injury. A sudden change from warm to cold will do serious damage. Its extensive commercial use is in the milder parts of California. It will tolerate the milder winters of western Oregon and western Washington, but in the colder winters suffers severe damage. In the immediate coastal Gulf region of the southeastern states it will survive mild winters, but temperatures throughout the
mum of 290 plants per acre. More plants per acre can be used, depending on how quickly one wishes the land completely covered. When planting about 500 plants per acre on good land, full production is attained in the third year. The long runners root at the nodes, forming new plants called crowns. These rooted plants, or crowns, are commonly taken from old fields when new fields are to be established.

The digging and planting of kudzu crowns should be done while the plants are dormant. The first year after planting, and sometimes during the second year, row plantings of corn or other row crops can be grown between the kudzu rows. When once established the stand will remain through a long term of years if properly managed. Kudzu is available for pasturage at any time during the year. Often it can be used to advantage as an emergency reserve feed. On rough land kudzu will reduce erosion while furnishing an abundance of good pasturage. On tillable land kudzu increases the fertility in long time rotations, as evidenced by increased yields of crops following it. While kudzu will increase soil fertility, it is not a crop to be grown on poor land without fertilizer. Ample use of fertilizer at the time of planting is necessary to insure good growth and yields.\footnote{2} \footnote{3} \footnote{4}

**VELVETBEANS**

**HISTORY AND IMPORTANCE.** Velvetbeans are of tropical origin. They first received notice as a forage and cover crop in Florida about 1890. Prior to that time they had been used occasionally in ornamental plantings. When first introduced all the plants were late in maturing, which limited the production of seed and confined the use of the crop to Florida. In time early maturing plants appeared, which made possible the establishment of early maturing varieties and the extension of the crop several hundred miles farther north. In 1918 over 1,000,000 acres were in production.\footnote{5}

The main use is in livestock grazing of the mature crop.\footnote{6}

**ADAPTATION.** Velvetbeans are adapted to most of the Cotton Belt but make slow growth in the northern part of that area. In the Southwest they cannot compete successfully with other crops. Velvetbeans do much better on sandy lands than do most crops. The crop is of

\footnote{2} McKee, Roland, and Stephens, J. L. Kudzu as a farm crop. U.S.D.A. Farmers' Bul. 1923, 1933.
\footnote{5} Agricultural Statistics 1949. U.S.D.A.
special importance in the South by reason of its immunity to wilt and its resistance to the root-knot nematode.

**DESCRIPTION.** Velvetbeans are viny, summer annuals. The stems trail or climb. They attain a length of from 10 to 30 feet, depending largely on variety. The leaves are trifoliolate, with large broad leaflets. The large deep purple flowers are borne in long racemes. The hairy pods are long and somewhat curved, and contain from four to eight large, kidney-shaped seed.

**CULTURAL REQUIREMENTS.** Velvetbeans are grown in wide rows, usually with corn. Sometimes the two crops are planted in alternate rows. The corn serves as a support for the velvetbean plants. The crop usually is left in the field and grazed by livestock during late fall and winter. A support is important to keep the seed pods off the ground, thus preventing decay. The crop should not be seeded until all danger of frost is past. Seed inoculation is not practiced and apparently is not beneficial. Seed yields range up to about 1,500 pounds per acre. The average seed yield for the United States is about 800 pounds. The limited amount of seed harvested is usually picked by hand and flailed, or put through bean threshers.

**BUR-CLOVER**

**HISTORY AND IMPORTANCE.** The common name “bur-clover” is used for most of the annual species of Medicago. Occasionally they are referred to as “medics.” All of these are native to the Mediterranean region. They are weak-stemmed plants resembling the clovers. The several species now growing in the United States were introduced as escapes. The species that is found in greatest abundance in the western states is *M. hispida* (California bur-clover), while the one most abundant in the southern states is *M. arabica* (spotted bur-clover). It is not known when these were first introduced. Both have been long established. Other species that occur naturally in the United States in specific sections are *M. minima* (small bur-clover) in southern Oklahoma and eastern Texas, and *M. orbicularis* (button bur-clover) in central Tennessee. Tifton bur-clover (*M. rigidula*), introduced at the Georgia Coastal Plain Station, is one of the most winter-hardy of the bur-clovers, but thus far its use has been limited.

California bur-clover is an important constituent of the range pasturage of the foothills throughout California and Arizona. In eastern Texas it affords considerable grazing. In that region it is sometimes objected to, however, because it causes bloat in cattle and sheep. In the deciduous orchards of California volunteer bur-clover is utilized as a winter cover crop for decreasing soil erosion and adding organic matter and fertility to the soil. The acreage of bur-clover grown in pure stands is small, but it occurs in mixture on millions of acres of pasture and range lands throughout the South and in the Pacific Coast states.

**ADAPTATION.** All the bur-clovers are cool weather plants. But they lack winter hardiness and cannot endure summer heat. In the South, or where winter temperatures are mild, the bur-clovers start growth in the fall, continue through the winter, and mature in the spring. There is some difference among species with reference to shade and moisture tolerance. California bur-clover is adapted...
Bur-Clover

1. Buf-Clo1.ler

2. 245

.. grown in wide rows, usually with corn. The corn serves as a support for the velvetbean plants." U.S.D.A. photo.

...to drier and sunnier situations than spotted bur-clover. In the western states spotted bur-clover usually is found only along streams in shady and moist situations. In the humid and less intense sunlight of the southeastern states it is the dominant species. Bur-clovers require a moderately fertile soil for good growth. They do best on neutral soils but can be grown on moderately acid as well as lightly saline soils.

CULTURAL REQUIREMENTS. In the western states bur-clover volunteers naturally in range and orchard lands and is seldom seeded. In the humid region of the southeastern states seeding is required for establishment. However, once established, stands can be maintained almost indefinitely if well managed. Spotted bur-clover usually is seeded in the hull. When seeding alone, from 5 to 10 bushels of unhulled seed per acre is the usual rate. In pasture mixtures one bushel is sufficient. Seedings usually are made sometime between August 15 and October 15. Seed inoculation is essential in the southeastern states, but not necessary in the western states. When bur-clover is plowed under in late winter or
early spring as a green-manure crop it is advisable to allow the crop to fully mature for seed about every fifth year, if a good stand is to be maintained without reseeding.

SEED PRODUCTION. Most of the seed of California bur-clover is obtained as a waste product in grains or from wool. Spotted bur-clover seed is sometimes obtained as a waste product, but most of that seeded in the southeastern states is seed harvested in that region. All bur-clovers are difficult to harvest. When mature, the seed pods or burs drop from the plant. These then must be gathered from the ground. This is done by sweeping the burs into piles with heavy brooms and cleaning and sacking them by hand. A few growers with large acreages have built suction machines that pick up the burs and convey them through pipes to a large container.11

SOYBEANS

HISTORY AND IMPORTANCE. Chinese records of 2838 B.C. indicate that the soybean is one of the oldest crops grown by man. Seed probably was brought to the United States as early as the colonial period. Serious investigation as to their place and value as a crop, however, did not begin until about 1890. The first reference to soybeans in American literature was in 1804. The U.S.D.A. introduced a number of varieties in 1898.

In 1910 only about 5,000 acres were under cultivation in the United States, but in 1947 the total acreage was over 13 million. Of this acreage about 2 million were used as forage.12 Prior to 1941 the acreage harvested for hay exceeded that harvested for beans, whereas in recent years only about 10 per cent of the total acreage has been harvested for hay, while over 80 per cent was harvested for beans. The development of processing facilities and industrial uses for the beans has stimulated the harvesting of progressively larger acreages for oil and high protein meal.

ADAPTATION. The soybean is a temperate climate plant especially well adapted to the Corn Belt and to the northern half of the Cotton Belt. In general, soybeans have much the same range of adaptation as corn—from the Gulf to Canada. Several hundred varieties, varying greatly in their area of adaptation, have been grown to some extent. More than 100 named varieties are now handled by seedsmen. Varieties are classified as early, medium, or late, depending upon the time of ripening under the latitude and climatic conditions in the location where they are grown. The region of greatest soybean production is in the central Corn Belt. Soybeans will succeed on nearly all types of soil, but do best on mellow, fertile loams, or sandy loams. Although soybeans have been classified as a "poor land" crop, they respond markedly to natural soil productivity or increased fertility levels as conditioned by soil management.

CULTURAL REQUIREMENTS. Soybeans may be sown from early spring, when the soil has become warm, until midsummer. The time of planting depends upon the variety, the latitude, and the use to be made of the crop. In the northern states the best results are obtained by planting at about the same time as for corn. In the southern states the planting season may extend from early April to the last of June.

The bean crop may be planted in close drills, in rows for cultivation, or broad-

cast. The former two methods are preferable. When grown for the first time, the seed should be inoculated. For forage, two bushels per acre is recommended if in close drills, or one to one and a half if grown in rows. The frequent use of the weeder, spike-toothed harrow, or rotary hoe to control weeds when the bean plants are small is important. These tools may be used whether the crop is in rows, or in close drills, and from the time the plants are well up until they are from 8 to 10 inches high.

For hay, the crop should not be cut until the seed in the pods are well developed but should be cut before the leaves begin to turn yellow and fall. Soybeans are often grown advantageously in combination with other crops such as corn, Sudangrass, sorghums, cowpeas and millets.

Utilization. In recent years 1,200,000 acres have been used for hay, with about 10,000,000 acres or more grown for commercial and industrial purposes. The proportion of the crop harvested for hay or used for pasture varies greatly from one part of the country to another. In the east central states and the states bordering on the south, with a total of approximately 1,630,000 acres in 1950, 45 per cent were used as forage. In contrast, six states in the central part of the Corn Belt, with a total of approximately 11 million acres, harvested 96 per cent of the crop for beans. In the groups of states to the north and to the south, approximately 85 per cent and 71 per cent, respectively, were harvested for beans.

In 1950, there were over 200 mills processing soybeans in the United States, with an annual capacity of 185,000,000 bushels. Processors separate the oil and the meal. More than 90 per cent of the oil is used for human food.

Cowpeas 247

Cowpeas

It generally is presumed that cowpeas are native of Africa. They have long been in cultivation in the Old World. They were introduced into the United States in colonial times. The acreage planted has fluctuated considerably in recent years, but usually has been over one million acres. About half of this acreage is used for forage and soil improvement, and the rest harvested for seed.

One of the important forage crops of the South, cowpeas also are an important food crop. The nutritive value of cowpeas is high, comparable to other standard legumes either for forage or for food.

Adaptation. Cowpeas require comparatively high temperatures. In the United States they are grown throughout the Cotton Belt. They grow best on fertile loam soils, but can be grown on almost any type of well drained soil.

Description and Varieties. The semi-viny plants are moderately coarse summer annuals with weak stems. The bean-like pods which are somewhat curved are produced in abundance. The seed, which is kidney shaped, varies in seed coat color with variety. Some of the varieties most valuable for forage are Whippoorwill, Iron, and New Era, and their hybrids Brabham, Groit, and Victor. Varieties of lesser importance for forage are Unknown, Clay, Red Ripper, and Black.

17 Agricultural Statistics 1948. U.S.D.A.
19. Other Legumes

CULTURAL REQUIREMENTS. Good seedbed preparation is necessary for best results. Seedings are made after all danger of cold weather is past. When grown for forage, seedings are made broadcast or in close drills, using about one and a half bushels of seed per acre. Seed inoculation is not necessary on most soils in the South. Most of the seed is harvested by hand. Sometimes, however, the crop is cut and shocked to dry, and then threshed with a bean thresher. 17, 18

FIELD PEAS

HISTORY AND IMPORTANCE. Like many of our field crops, field peas originally came from the Mediterranean region. The early Colonists brought them from England. This pea differs from the garden pea mainly in the sweeter, and more delicate, flavor of the garden pea. For livestock feed their use is largely confined to the northern states, from New York west to Washington and Oregon. In some of the Rocky Mountain states they have been used for sheep pasturage. In combination with oats or other small grains, field peas make good hay and pasturage. The total acreage of field peas for forage is large, but they are important locally where grown.

The most important use of field peas is for soil improvement. For the ten-year period 1937 to 1946, the average annual production of Austrian Winter field pea seed was 58,143,000 pounds. Most of this seed was planted in the Cotton Belt for winter cover. Another variety that is useful in the extreme lower South for this purpose is Dixie Wonder.

ADAPTATION AND SEED PRODUCTION. Field peas require a temperate to cool climate. They do best where high temperatures are seldom experienced during the growing season. In northern latitudes, and in other areas where the season is comparatively cool during the maturing of the crop, field peas usually produce a good crop of seed. Yields of two thousand pounds per acre are not uncommon in the more favorable sections. In the more southern latitudes seed does not develop well. In seed producing sections, the seed crop is cut with a mower with swather attachment. A pickup combine is then used in threshing. Immediately after threshing the seed must be fumigated to check damage by the pea weevil. Also, dusting the crop with D.D.T. when in bloom is essential.

CULTURAL REQUIREMENTS. For pasturage and for hay in combination with a small grain, seedings usually are made broadcast or in close drills. When seeding alone, 60 or more pounds of seed per acre are required. When seeding with a grain crop, half that amount is sufficient. In the North, seedings are made as early in the spring as the ground can be worked. Where winter temperatures are mild, seedings are made from early to late fall, whenever moisture conditions are favorable. 19

LUPINES

HISTORY AND IMPORTANCE. There are over 250 species of the genus Lupinus. Most of these are native to America. They are referred to under the common name lupine. The species of commercial importance, however, are all native to Europe. The ones most grown are L. angustifolius (blue lupine), L. luteus (yellow lupine), and L. albus (white lupine). While lupines were known and used before the time of Christ they were of comparatively little importance until they came into common use in central Europe about two hundred or more years

FIG. 19.3 "Lupines were known and used before the time of Christ ... came into common use in Central Europe about 200 years ago. In the United States they have been in commercial use only about 10 years. The principal use is for soil improvement." (See p. 218.) Lupines being plowed under as a green manure on a Georgia plantation.

ago. In the United States they have been in commercial use only about 10 years. The species most used in this country is *L. angustifolius*. The principal use is for soil improvement. Several hundred thousand acres now are seeded annually for this purpose.

**Description and Varieties.** The plants of blue and white lupine are upright, with coarse central stems that branch except in thick sands. They attain a height of 2 to 3 feet. So far as is known, all species of lupine normally contain an alkaloid that is poisonous. Non-poisonous varieties, however, are found. Varieties within the species are not yet well established. In experimental plantings, different varieties of lupine are recognized under the names Crescent, Florida Speckled, and German White. All of these are sweet or non-poisonous. The plants of yellow lupine are quite bushy and attain a height of one to two feet. A non-poisonous strain of blue lupine known as "sweet blue" has recently become available in the trade.

**Adaptation.** Lupines require a comparatively cool climate or season for successful development. In the Southeast they are grown as winter annuals. Although they require a cool season, lupines will not survive much frost. Their northern limit of climatic adaptation is south of a line running west from Columbia, S. C., Atlanta, Ga., and Jackson, Miss. to Austin, Tex. At this northern limit the crop is not recommended for regular commercial planting. While
lupines do well on sandy soil that is regularly fertilized for other crops, they do best on fertile loams.

**CULTURAL REQUIREMENTS AND SEED PRODUCTION.** Lupines are seeded broadcast or in close drills. Seedings usually are made from October 1 to December 1. Blue lupine should be seeded at the rate of 60 to 90 pounds per acre, yellow lupine at 40 to 60 pounds. The white lupine has large seed and requires about 140 to 160 pounds per acre.

Harvesting seed is rather difficult as the crop shatters when fully ripe. Combines are commonly used and the seed, if not fully matured or properly dried after harvest, deteriorates rapidly and may germinate so poorly by fall that it cannot be used for seeding.\(^2\)\(^0\), \(^2\)\(^1\)

**CROTALARIA**

**HISTORY AND IMPORTANCE.** There are over 600 species of Crotalaria. These are distributed throughout the warm regions of the world. The species of most importance in the United States are *C. striata* (striped crotalaria), *C. spectabilis* (showy crotalaria), *C. intermedia* (slenderleaf crotalaria), and *C. lanceolata* (lance-leaf crotalaria). These have come into commercial use only within the past 25 years. Their chief value is for soil sanitation and improvement, but they also have some forage value. Their use has been confined to the Southeast. There are no official statistics on acreage, but it is estimated that the over-all total is something less than 100,000 acres. Being resistant to the root-knot nematode, crotalaria can be grown for soil improvement and reduction of the nematode population preceding the growing of nematode susceptible crops. The non-poisonous crotalarias have some value for pasturage and can be used for silage.

**DESCRIPTION.** Most Crotalaria species have upright, branching plants with trifoliolate leaves. *C. intermedia* branches somewhat less than *C. lanceolata*, *C. striata*, or *C. spectabilis*, and grows somewhat taller. *C. spectabilis* contains a poisonous alkaloid which is especially concentrated in the seed. Livestock poisoning is not uncommon for this species. *C. intermedia*, *C. lanceolata*, and *C. striata* are non-poisonous.

**ADAPTATION.** All the crotalarias are warm weather plants. In the United States early maturing strains can be grown throughout the Cotton Belt, with later maturing strains adapted only to the southern half of this region. A long growing season and moderate heat are essential to crotalaria production.

**CULTURAL REQUIREMENTS AND SEED PRODUCTION.** Crotalaria usually is seeded broadcast in late spring, using from 10 to 20 pounds of seed per acre. Wide rows can sometimes be used to advantage in growing a seed crop, if the seed is to be hand harvested, although harvesting is now done mostly with combines, the seed being artificially dried immediately after harvest. When hand picked, the seed can be allowed to ripen more fully in the field, but in any case the seed should be dried before putting into storage.\(^2\)\(^2\)

**ROUGHPEA**

**HISTORY AND IMPORTANCE.** The roughpea is a winter annual with weak stems and decumbent growth, except in
Roughpea

FIG. 19A "Crotalaria...over 600 species...distributed throughout the warm regions of the world...in the United States...have come into commercial use only within the past 25 years. Their chief value is for soil sanitation and improvement, but they also have some forage value." (See p. 250.) A typical 5-foot growth of striped crotalaria, grown as a soil improving crop in Northern Florida. U.S.D.A. photo.

thick stands when they are ascending. It is native to the Mediterranean region, but it has long been established in the United States as an escape. Other names in current use are "wild winter pea," "caley pea," and "singletary pea." The principal uses are for pasturage and winter cover. It is a weed in grain fields. The crop should not be pastured after seed is formed as the seed contains an alkaloid that is injurious, although not fatal to livestock. It is estimated that about 100,000 acres in mixtures are pastured in Alabama, with lesser amounts in other of the Gulf States.

ADAPTATION. Roughpeas are adapted to regions with mild winters. They will stand temperatures of 15° F. to 20° F. with no injury if the temperature does not drop suddenly. They are adapted throughout the Cotton Belt and the mild sections of the Pacific Coast. Roughpeas are not exacting as to soil. They can be grown on sandy or clay soils of moderate fertility.

CULTURE. The roughpea is used mostly in pasture mixtures, seeded broadcast or drilled. Once seeded, the crop volunteers almost indefinitely, by reason
19. Other Legumes

of the hard seed that continue viable in
the soil through a long term of years.
Seedlings should be in the fall, about 20
pounds per acre. Seed should be inoc­
ulated when seeding for the first time.
The use of 200 or more pounds of super­
phosphate fertilizer per acre will increase
yields on most soils.

SEED PRODUCTION. Roughpeas seed abun­
dantly and regularly in the South.
When ripe the seed shatter quite
readily, resulting in much seed loss in
harvesting. For seed harvest, the use of
an ordinary mower with windrow at­
tachment is recommended, with the
pickup-combine used later. Yields of
1,000 pounds per acre have been ob­
tained, but the average is perhaps about
half that amount.23

ALYCECLOVER

HISTORY AND IMPORTANCE. Alyceclover is
a weak-stemmed summer annual na­
tive to tropical Asia, from where it
spread naturally to parts of Africa. It
was first introduced into the United
States by the U.S.D.A. in 1910. It has
been most extensively planted in Florida
and Mississippi. The principal use of the
crop has been for hay and soil improve­
ment, but it also makes good pasturage.

ADAPTATION. Alyceclover is adapted to
the Gulf Coast area from Florida
to Texas. It cannot be grown satisfac­
torily as a commercial crop north of
the southern third of Georgia and Ala­
bama. It does not tolerate wet lands.
It makes poor growth on soils of low fer­
tility. Lands cropped for the first time
usually give heavy yields. The use of a
fertilizer high in phosphorus and with
a moderate amount of potash will in­
crease yields on old crop land. The root­

knot nematode attacks alyceclover and
may do serious damage.

CULTURAL REQUIREMENTS. Alyceclover
should be seeded broadcast or
drilled on a well prepared seedbed
about the first of May or later, at the
rate of 15 to 20 pounds of seed per acre.
If allowed to mature, volunteer crops
usually result through several years. In­
oculation of the seed usually is not neces­

ty. The cut hay crop dries readily and
in good weather can usually be stacked
or baled the day after it is cut.

SEED PRODUCTION. The seed of alyceclover
shatters or drops from the plant
when ripe, and makes harvesting
somewhat difficult. The seed crop has
been combined, but usually with con­
siderable loss of seed. Seed yields as high
as 600 pounds per acre have been ob­
tained, but half that amount or less is
average.24

HAIRY INDIGO

HISTORY AND IMPORTANCE. The hairy
indigo, a new crop, was developed
at the Florida Experiment Station
from work started at Gainesville in 1931.
It is native to tropical Asia, Australia,
and Africa. It is a summer annual which
attains a height of 4 to 7 feet. The stems
are moderately coarse, becoming woody
with age. The leaves are pinnate and
somewhat resemble vetch. Two distinct
types are in cultivation, one a large late­
maturing strain, the other a smaller type
that matures a month earlier. Although
the principal use of the crop to date has
been for soil improvement and seed pro­
duction, it has been pastured with good
results and also used as hay. Most of the
plantings have been in Florida. The first
seed was offered for sale in 1945.


ADAPTATION. Hairy indigo is adapted to moderately acid soils. It grows fairly well on moderately poor, sandy soil. It does best, however, on fertile sandy loams. It can be grown in the Gulf Coast area from Florida to Texas. The late strain, which matures in November, is best adapted to the south half of Florida. The early strain may be grown as far north as middle Georgia. It is resistant to the root-knot nematode.

CULTURAL REQUIREMENTS. Seedlings of hairy indigo can be made from March until the last of May. Early seeding is best. Three to 5 pounds of seed per acre is sufficient when drilled in close drills, and 6 to 10 pounds when broadcast on a well firmed seedbed. The smaller amounts are recommended when the crop is grown for seed, and the larger amounts when grown for hay or green manure. For hay, the crop can be handled with ordinary farm equipment. It is cut when still young—2½ to 3 feet high—and handled as other common hay crops. If cut when 8 to 10 inches high in August, before blooming time, a second growth may be expected. The aftermath may then be used for grazing.

SEED PRODUCTION. The large growth and slow drying of the plants after seed is mature makes harvesting of the seed rather difficult. In small plantings the seed has been harvested by hand. The best method perhaps is cutting with a mower and windrow drying before threshing. A combine can be used when the crop is a thin stand and short growth.25, 26

HOP CLOVERS

There are three species of Trifolium commonly known as hop clovers, viz. T. dubium (small hop clover), T. procumbens (large hop clover), and T. agrarium (field hop clover). These are indigenous to Europe. They probably were introduced into the United States in white clover seed. They are small growing plants that usually attain a height of 10 to 15 inches, and were naturalized here as escapes. T. dubium is the most widely distributed of the three species. It occurs spontaneously throughout most of the southern half of the United States, and in both the Atlantic and Pacific Coast states farther north where moisture and other conditions are favorable. T. procumbens is less widely distributed, but is adapted to the same general area. T. agrarium occurs more sparingly, and mostly in the northern United States.

The hop clovers are good forage plants and are especially valuable in pastures. They make late winter and early spring growth, affording nutritious feed at a time when it is much needed. T. procumbens and T. dubium, under the common names large or low, and small or least hop clover, are now commonly recommended for pasture mixtures in the Cotton Belt states. The seed of all the hop clovers is extremely small, and a pound or less per acre in mixtures is enough for establishing new stands. The seed of T. dubium is obtained mostly as a mixture or waste product from other crops. It is seldom harvested in pure stands. T. procumbens has been harvested in comparatively pure stands in Tennessee and adjacent territory, but also is obtained in mixture with other crops.

PERSIAN CLOVER

Persian clover was first established in the United States as a naturalized escape in the lower Mississippi delta area in Louisiana. It probably was introduced.

in white clover seed, with which it was found growing. It is native to Persia and northern India, where it is used for forage and soil improvement. It is a winter annual with weak, hollow stems that attain a length of 2 or more feet. In the South it makes but little growth until early spring. It grows rapidly in late March and April, and is ready to cut for hay by May. Its use as yet is very limited, but it has value for hay and pasturage in mixtures on low, moist soils. It is sensitive to cold, however, and its use will be confined to the extreme South. From 2 to 4 pounds of seed per acre should be used in pasture mixtures, and about 8 pounds when seeding alone. Most of the seed to date has been obtained from harvested white clover seed.

**SUB CLOVER**

Sub clover is a native of the Mediterranean region of Europe. It was introduced into the United States from Australia. Its principal use is for pasturage. It is a spreading or decumbent winter annual with stems 2 to 4 feet long, and does best in regions with but little frost and at least moderate rainfall. In general appearance sub clover is most like a large white clover. There are a number of varieties differing somewhat in general appearance, date of maturing, and adaptation.

Sub clover has done the best in this country in the coastal area of the Pacific Northwest, where it has been quite widely seeded. In the Southeast it has done fairly well in some seedings, but has not come into general commercial use. It does best on fertile loam soils. The seed crop is difficult to harvest as the seed pods are developed mostly underground, like peanuts. Special handling of the crop is necessary to avoid large loss of seed.

**STRAWBERRY CLOVER**

Strawberry clover, a native of southern and western Europe, is a perennial, resembling white clover in general appearance and habit of growth. It is especially adapted to extremely wet land, and will stand some salinity. It is relished by livestock and apparently has high nutritive value. It first received attention in the United States as a forage plant about 30 years ago. It probably was introduced in clover seed, and became established as a naturalized escape. The first seed harvested in this country was from a small field in northeastern Oregon. Additional plantings of at least several hundred acres have been established under irrigation in other western states.

**MUNG BEANS**

The mung bean is supposed to be native to India. It long has been in cultivation in the southern half of Asia and the Malayan Islands. Its first introduction into the United States was sometime prior to 1885. It can be grown anywhere corn or garden beans succeed. About 150,000 acres were seeded in Oklahoma in 1945, with much smaller acreages in other states. The main value of the mung bean is the use of the seed for “bean sprouts.” The plant, however, makes good hay. Seedings are made in late spring in rows 24 to 28 inches apart, using from 10 to 15 pounds of seed per acre. Mung bean seed ripen unevenly, making harvesting difficult. The crop should be harvested when one half to two thirds of the pods are mature. After cutting, the plants should be allowed to cure in the swath or cock until dry. Threshing can be done with an adjusted grain thresher. Seed yields are from 600 to 1,200 pounds per acre.
BLACK MEDIC

Black medic is native of Europe and Asia. It was introduced early into the United States as an escape. It is an annual, or sometimes biennial, with procumbent stems that ascend in thick stands. The stems are rather small and leafy, and usually attain a length of from one to two feet. It can be grown almost throughout the United States on reasonably fertile soils that are fairly well supplied with moisture, and are not distinctly acid. Most of the acreage is in pastures and waste places. Black medic is recognized as of some value for pasture, and has been most used in this way.

There are no cultivated varieties. The species is quite variable both with reference to appearance and adaptation. Naturalized strains occur in sections where plants have volunteered for a number of years. These usually are superior for local use and should be given preference whenever such seed is available. This is especially essential in the southern states. In the North, seedings are made in early spring. In the South, fall seeding is best. Fifteen pounds of seed per acre is the usual rate when seeding alone. In mixtures, 2 or 3 pounds per acre usually is enough. But little seed of black medic is harvested in the United States. Harvesting is difficult, and pure stands or favorable mixtures are seldom available.

FLORIDA BEGGARWEED

Florida beggarweed is a native of tropical America that has spread as far north as Florida and adjacent states. When seeded in more northern latitudes it will make considerable growth, but will not mature seed. It is an upright, branching plant attaining a height of 5 to 8 feet. In the United States it behaves as a summer annual, but is a short-lived perennial in frostless regions. Its principal value is for pasturage, quail feed and soil improvement in the area where it occurs naturally. It, however, is sometimes cut for hay which is considered quite nutritious.

Seedings usually are made in late spring from April 15 to May 15, using 10 pounds of hulled, or 40 pounds of unhulled, seed per acre following a cultivated crop. Florida beggarweed volunteers readily in cultivated fields, but cannot be maintained by volunteering in sod pastures. As the seed readily drops from the plant when ripe, it is difficult to harvest. Most of the seed harvested is stripped from the plant by hand and threshed or hulled in a clover huller-thresher. When thus harvested, seed yields of from 200 to 300 pounds per acre are average in good stands.

PEANUTS

Peanut is the common name used in the United States for what in many other parts of the world is known as ground-nut. Peanuts are native to Brazil, where they long have been used as food by native Indian tribes. The peanut plant is a low spreading summer annual with odd pinnate leaves and broad oval leaflets. About four million acres of peanuts were grown in the United States in 1948. Other countries with several million acres each are China, India, and French West Africa.

The principal value of the peanut is as a food product, but the straw from threshed peanuts is used for stock feed. The peanut is a legume, and as more or less peanut seed passes through the thresher with the straw the feeding value of the straw is quite high.

The peanut is adapted to well drained sandy, or sandy loam, soils. It can be
19. Other Legumes

grown throughout the southern half of the United States. Almost the total commercial production is in the southeastern states, from Oklahoma and Texas east to the Atlantic Coast. Peanuts are planted in rows 24 to 30 inches apart. Most of the planting is done from April 10 to May 10. From 32 to 48 pounds of unhulled seed, or 20 to 30 pounds of hulled seed per acre is commonly used. Cultivation to control weeds is essential. Harvesting is done with special peanut plows or diggers. Yields of seed range from 900 to 1,500 pounds per acre. Peanut straw averages about a half ton per acre.27

CLUSTER CLOVER

Cluster clover, an introduced small winter annual, has done well in plantings in the southern part of Mississippi. It has become established there as an escape.

LAPPA CLOVER

Lappa clover, a small winter annual, has become naturalized in the black lands of Alabama and Mississippi, where it does well.

BERSEEM

Berseem, an upright growing winter annual somewhat resembling alfalfa, has been grown in small acreage in the Imperial Valley of southern California, and the Yuma and Salt River valleys of Arizona.

ZIGZAG CLOVER

Zigzag clover, a perennial with strong creeping rootstocks, is established in a few places in the northeastern United States, but is not grown commercially. It develops seed sparingly.


ROSE CLOVER

Rose clover, a recently introduced winter annual, has made good growth in the Coastal Plains states of the Southeast, and in California. It seems quite widely adapted and may have value for winter cover and pasturage.

FENUGREEK

Fenugreek, an upright winter annual, has long been grown in Egypt as a forage crop. In the United States it is grown only in the coastal area of southern California, where it is used as a winter green manure crop.

WAGNER-PEA

Wagner-pea has been publicized somewhat as a forage crop. It is a hardy perennial resembling sweet pea. It is established as an escape in western Washington, and perhaps elsewhere. The seed is poisonous, which is against its use as a forage crop.

TEPARY BEAN

Tepary bean is native to Mexico and Arizona, where it has long been grown by the Indians. It is especially adapted to regions with low rainfall. While grown mostly for seed, it is used to a degree for forage.

GUAR

Guar, an upright, coarse growing summer annual legume, is grown in Arizona as a seed crop for commercial use. In India it is grown for seed and forage.

SAINFOIN

Sainfoin, which is adapted especially to lime soils, is occasionally planted. However, its use has never been continued anywhere in the United States. In sections of Europe it is used regularly on calcareous soils.
QUESTIONS

1. What is the value of kudzu as a forage crop?
2. Why isn't kudzu grown more extensively in the United States?
3. Under what conditions may velvetbeans be used to advantage?
4. Why are cowpeas of general use throughout the South?
5. Discuss the use of peanuts as a forage crop.
6. Why are soybeans considered a good emergency hay crop?
7. Why is there a limited acreage of field peas in the United States?
8. Why is bur-clover a valuable legume for pasture mixtures throughout the South and in the Pacific Coast states?
9. Why are lupines used principally for soil improvement?
10. Name some relatively unimportant legumes which you think might become more important in the future, and tell why you think so.
The bluegrasses, *Poa* *sp.* number about two hundred species, distributed throughout the world but mostly in the temperate and cooler regions. Most of the approximately 65 species found in North America are native to the continent. Most species of bluegrass are highly palatable and nutritious. Many are important pasture plants, but only a few are cultivated.

At one time the bluegrasses were commonly known as spear grasses and meadow grasses. The name “bluegrass” came into use at least 200 years ago, but its significance is unknown. Some believe it was applied because fields of this grass usually are bluish during anthesis. Others believe it was first applied to Canada bluegrass, which has a more or less bluish leaf color.

**Kentucky Bluegrass**

Kentucky bluegrass, *Poa pratensis*, has long been known in Europe. It is considered a native of Eurasia. The early colonists of English origin who settled the Atlantic coast of North America referred to it as English grass and speargrass. These colonists apparently knew Kentucky bluegrass in England and did not find it in the native flora of the Atlantic coast.

Some have contended, however, that Kentucky bluegrass may be native to North America. Wilson has shown that it was abundant in 1775 at Grassy Lick, in the eastern part of the Bluegrass region of Kentucky.

Kentucky bluegrass was in Kentucky and Ohio when, or shortly after, the early settlers arrived from east of the Allegheny Mountains. It has been suggested that it had been brought from Kaskaskia, Vincennes, and elsewhere in the Illinois country about 1700 by French explorers, missionaries, and settlers from Canada. Robinson and Fernald believed that it is indigenous to the western United States and Canada.

The uncertain history of Kentucky bluegrass

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7. Carrier, Lyman, and Bart, Katherine S. *Loc. cit.*
grass may be largely due to the wide dissemination of the grass east of the Mississippi River by elk, deer, and especially buffalo.

Doubtless Kentucky bluegrass was so named to distinguish it from Canada bluegrass, to identify the seed carried or sent from Kentucky to other states, or as a recognition of the excellent bluegrass pastures in Kentucky.

**DISTRIBUTION**

Kentucky bluegrass is a common constituent of the meadows of Eurasia. 10 It occurs widely in North America except in arid regions and at alpine altitudes. It is in all states of the United States, being common in northern states of the humid portion of the country but not common in the Gulf states. 11 The latitude of southern Tennessee is roughly its southern limit of satisfactory growth.

**ADAPTATION**

**SOIL REQUIREMENTS.** Kentucky bluegrass is adapted to our more or less well drained loams and heavier types of soil of medium and better productivity. It is best adapted, however, to well drained, highly productive soils of limestone origin, such as occur in southwest Virginia, west central Tennessee and east central Kentucky.

Soils of the Bluegrass Region of Kentucky vary in reaction from pH 5.4 to 6.4 and average 5.6 to 5.7. They contain approximately 2,700 to 5,800 pounds of nitrogen, 23,000 to 30,000 pounds of potassium and 2,400 to 21,500 pounds of phosphorus per two million pounds of soil. 12 Available phosphorus varies usually from 100 pounds to more than 300 pounds.

Despite its wide distribution, Kentucky bluegrass is sensitive at certain levels to slight soil variations. 13–15, 16 Typical relationships are shown in Figure 20.2.

In general, Kentucky bluegrass is dominant in pasture and turf floras only if the soil has a pH of about 5.0 or higher, and at least 12 pounds of available phosphorus and 3,000 pounds of nitrogen per 2 million pounds of soil. Percentage base saturation and organic matter content of the soil also are correlated with the degree of bluegrass dominance. Soil requirements for the best growth of bluegrass are higher than for dominance, but both vary considerably with soil type.

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11 Hitchcock, A. S. *Lac. cit.*


260  20. The Bluegrasses

Fig. 20.2 Incidence of Kentucky bluegrass on two types of soil in West Virginia in relation to specific soil factors. (A) Relationship between available phosphate in Hagerstown soil and the percentage of Kentucky bluegrass plus white clover in pasture; (B) Relationship between pH of Dekalb soil and the percentage of Kentucky bluegrass plus white clover in pasture. The percentage of white clover does not change the nature of the curve in either graph: it amounts to an average of about 10 per cent in samples shown along horizontal part of curve in (A) and to about 1 per cent in samples shown in (B).

TEMPERATURE AND PRECIPITATION. Kentucky bluegrass is best adapted to the humid portions of Canada and of the United States north of the average annual temperature isotherm for 60° F, 17 which corresponds closely with the average summer isotherm for 79° F. Within this region of adaptation Kentucky bluegrass is subjected to temperatures from below -30° F to about 105° F. 18

Optimum temperatures for herbage production of Kentucky bluegrass are between 60° and 90° F according to Harrison 19 and Brown. 20 Some growth occurs at 40° F and severe injury occurs at continuous soil and air temperatures of 100° F. Best root and rhizome growth occurs at 60° F.

Average annual precipitation varies from 20 to 50 inches within the region of Kentucky bluegrass adaptation. 21 Although the grass is essentially dormant during dry weather, it survives severe droughts.

Kentucky bluegrass prefers open sunlight, but it grows in lightly shaded situations if soil moisture and nutrients are favorable.

INSECTS AND DISEASES

Kentucky bluegrass is injured by few insects. Doubtless white grubs are the most destructive. The adults, known as May beetles, are harmless to grass but the larvae often cause extensive damage to the roots and rhizomes. 22, 23 Perhaps they damage bluegrass more in the North Central states than elsewhere.

Sod webworms feed on the leaves of Kentucky bluegrass, but their damage is difficult to estimate except in dry seasons, when large areas of sod are sometimes killed. 24

Two plant bugs attack leaves, stems, and florets of Kentucky bluegrass. 25 Both are especially injurious to the seed crop. Leafhoppers injure leaves considerably.

Kentucky bluegrass is susceptible to

powdery mildew, leaf rust, stem rust, stripe smut, and leaf spots. 26, 27

PLANT DESCRIPTION

APPEARANCE. Kentucky bluegrass is a rhizomatous plant that produces rather dense sod under favorable conditions. Its leaves, which occur in small tufts, are glabrous, soft, green to dark green, about one-eighth-inch wide, usually 4 to 12 inches long and boat-shaped at the tip. In April or May, depending upon latitude, the grass produces many erect, unbranched culms, usually 12 to 30 inches tall. The inflorescence is an open panicle.

HABIT OF GROWTH. A seedling of Kentucky bluegrass develops into a small leafy stool with two kinds of tiller buds. Some buds become culms, others rhizomes, and others remain leaf buds. New culms and new rhizomes arise from the lower nodes of aging culms. New rhizomes also arise from the nodes of older rhizomes. Kentucky bluegrass exhibits a pronounced periodicity in growth and development, induced by photoperiod and temperature but modified by soil moisture and nutrients. 28, 29 Rhizomes are formed mostly during summer and fall, and aerial shoots during fall, winter, and spring when temperatures are favorable. Inflorescences are initiated during the fall in response to combined effects of short days and cool temperatures.

In Connecticut, 30 Kentucky bluegrass yielded about the same as orchardgrass, timothy, and Rhode Island bentgrass, as shown in Table 20.1. It produced herbage practically equal in quality to the other grasses, and offered less competition to Ladino clover in association than other grasses. It was concluded from these experiments that “Kentucky bluegrass should be given serious consideration in seed mixtures for pastures and early cut hay in the Northeast.” Unpublished data from a Kentucky experiment show that Kentucky bluegrass produced an annual average of 1,833 pounds of dry matter per acre over a two year period. Comparable orchardgrass, red-

Fig. 20.3 “Kentucky bluegrass is a rhizomatous plant that produces rather dense sod. . . . In April or May, depending upon latitude, . . . many erect unbranched culms, usually 12 to 30 inches tall. The inflorescence is an open panicle.” Ky. Agr. Exp. Sta. photo.
top, timothy, and southern smooth brome produced 1,960, 2,240, 938, and 1,665 pounds, respectively.

Kentucky bluegrass is relatively unproductive in midsummer. Yields during that season can be increased substantially by irrigation and nitrogen fertilization, but the treatments do not prevent the plant from becoming semi-dormant.31

NUTRITIVE VALUE. At comparable stages of growth, Kentucky bluegrass, smooth brome, and reed canarygrass herbage contained 1,088, 699 and 825 calories per pound of dry matter, respectively, in an Illinois experiment.32 Steers grazing on the three grasses consumed 10.4 to 21.7 pounds of dry matter daily of Kentucky bluegrass, 8.5 to 14 of smooth brome and 7.4 to 15.6 of reed canarygrass.

IMPORTANCE AND USE

Kentucky bluegrass has long been considered the most important pasture grass in North America.33 It contributes largely to the grazing obtained from fifty million to one hundred million acres of humid pastures in the United States and from a substantial acreage in Canada. Though often included in recommended pasture mixtures for the larger portion of the humid pasture areas of the United States,34 Kentucky bluegrass is regarded with disfavor by some because of its low midseason yield, aggressiveness, and its high fertility requirements.35, 36 Kentucky bluegrass is also an important turf grass.

<table>
<thead>
<tr>
<th>Grasses</th>
<th>Lbs. of dry matter per acre, av. 1936–42</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kentucky bluegrass</td>
<td>579</td>
</tr>
<tr>
<td>Rhode Island bent</td>
<td>502</td>
</tr>
<tr>
<td>Orchardgrass</td>
<td>605</td>
</tr>
<tr>
<td>Timothy</td>
<td>739</td>
</tr>
</tbody>
</table>

VARIETIES AND STRAINS

Different varieties of *Poa pratensis* are reported in Europe and endemic varieties, distinct from those of the Old World, on the west coast of Canada, in Labrador, and perhaps also on the coast of New England.37 Strains which differ somewhat in appearance of growth and may differ in productivity have developed through natural selection in old pastures and meadows in America. Suggested selective factors include variations in grazing and harvesting practices38, 39 and differences in soil productivity.40 Irrespective of the selective factor, each probably consists wholly of

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37 Piper, C. V. Loc. cit. 38
The genus *Bromus* comprises about 60 species. As implied by the generic name (from *Bromus*, Greek for oat, hence, oatgrass), these species are adapted, as is oats, to cool climates or to regions in which cool seasons prevail during parts of the growing season. Such grasses are classified as cool-season grasses. Like the cereal crops, vegetative growth is produced during the early part of the season and seed is formed in the long days of early summer.

The group furnishes several important forage and range grasses with broad adaptation to soil and climatic conditions, and a few weedy species of considerable significance. Hitchcock lists 36 species of this genus as occurring in the United States.¹ These include both native and introduced perennials and a large group of introduced annuals. Most of these grasses are relatively palatable and nutritious during their respective periods of rapid early growth but they differ greatly in the length of time that they furnish valuable forage.

**SMOOTH BROMEGRASS**

Smooth brome, *Bromus inermis* Leyss, is the most widely utilized of the cultivated brome grasses. It is known by such names as brome grass, Austrian brome, Hungarian brome, and Russian brome. This grass has been cultivated in the United States since its first introduction in the early 1880's. It has gained considerable prominence in recent years as a soil crop for pasture, hay, and erosion control, usually with a legume.

**ORIGIN AND HISTORY**

The first recorded introduction of smooth brome seed into the United States was by the California Experiment Station in 1884. Presumably, the seed had been obtained from Hungary where this grass had been grown experimentally for about 30 years and was then

beginning to be utilized as a crop. Trial seed packets were distributed widely by the California station. The grass had obtained some recognition in the Midwest by the late 1890's. A few farmers from Kansas to North Dakota were growing it. Advertisements of "Hungarian bromegrass seed for sale" appeared in the local farm journals of that day. There was considerable exchange of seed between farmers and the experiment stations. Nebraska reported yield results of Hungarian bromegrass as early as 1897-98 and recommended it highly on the basis of these tests.²

During this same period, according to Fletcher, the Canadian provinces began growing brome with seed imported from northern Germany. The first seed was received in 1888.³

Seed packets of bromegrass of Russian origin were distributed in 1896 to the agricultural experiment stations in 43 states. In 1898 a large shipment of seed was received from the Penza region of Russia (latitude 55° N.) by Prof. N. E. Hanson of the South Dakota station. The large scale distribution of this and similar introductions resulted in a predominance of this type in the seed trade. Apparently no comparative trials were made of these several introductions at these early dates.

After the initial recognition of this grass in the early part of the century, interest in grasses as crops lagged. This was probably due to the large acreages of native grasses available and the emphasis placed on wheat production during World War I. A few fields in the Midwest were retained but were almost forgotten. In the Canadian provinces a considerable business was developed in the production of bromegrass seed. Following the drought years of the thirties, a demand for seed to replace depleted bluegrass and native pastures resulted in the importation of large quantities of bromegrass seed from Canada. This seed was unadapted in the southern part of the bromegrass belt.

Tests in Nebraska, Kansas, Iowa, Missouri, and other states showed the superiority of adapted strains obtained from the old established local fields for the southern part of the bromegrass region. Seed of this southern type now constitutes a considerable part of the amount annually used in the United States. As the result of naturalization of strains from the early seed importations, there are now two generally recognized

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On the origin and history of timothy, *Phleum pratense*, Piper recorded the following: 1

In the Old World timothy is native to most of Europe north to latitude 70 degrees, and eastward through Siberia. It also occurs in the Caucasus region and Algeria.

Timothy . . . was first propagated, according to Jared Eliot, by one Herd, who found the grass growing along the Piscataqua River near Portsmouth, New Hampshire. Eliot in 1747 recommends it for Massachusetts under the name Herd-grass. . . . The culture of timothy is . . . older than that of any other hay grass excepting perennial rye-grass. A letter to Eliot from Benjamin Franklin under date of July 16, 1747, states that the Herd-grass received proved to be “mere timothy.” This is the earliest record of the name timothy. This designation is supposed to be derived from Timothy Hanson, who apparently brought the grass from New England to Maryland. Later its culture spread to Virginia, and from there was sent to England about 1760 under the name timothy. In England the grass has been known also as cat's-tail, but the name timothy is now used in nearly all languages.

**DISTRIBUTION AND ADAPTATION**

Timothy is adapted to a cool and humid climate. In the United States most of the timothy is produced in the northern half of the area east of the Missouri River. In Canada, timothy alone or in mixtures is the most important grass in southern Ontario, southern Quebec, and in the provinces to the east.

The time when a timothy plant blooms and matures is affected by various conditions. According to Hopkins' Bioclimatic Law, the flowering season for the plants of any species progresses in the northern hemisphere from south to north at the uniform rate of one-fourth of a degree of latitude per day—except as modified by altitude or other local conditions.

The time when timothy heads, blooms, and matures is definitely affected by length of day. 2 Early, medium, and late timothy selections were grown at three latitudes—Washington, D. C., North Ridgeville, Ohio, and Guelph, Ontario, Canada. For the early selections the season for blooming progressed from south to north. For the late selection, however, the effects of the longer days at the northern station were greater than the effects of the higher temperatures farther south. The progress of the season for heading and blooming of the late selec-

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1 Piper, Charles V. *Forage Plants and Their Culture.* New York: The Macmillan Co. 1924.
Fig. 22.1. "The time when a timothy head blooms and matures is definitely affected by length of day." (See p. 279.) The effect of the number of hours of daily illumination on the flowering of timothy is strikingly evident. All plants were propagated vegetatively from a single original timothy plant. The control plant (C) was grown under natural length of day. Ohio Agr. Exp. Sta. photo.

The time when a timothy head blooms and matures is definitely affected by length of day.

PLANT DESCRIPTION

Timothy is a bunch grass with erect culms 20 to 40 inches tall, elongate leaves, and a dense cylindrical, spikelike inflorescence, commonly called a head. It differs from most grasses in that one (sometimes two) of the lower internodes remains relatively short, becomes enlarged in diameter, and forms the haplo-corm, often erroneously called the bulb. The haplo-corm serves as a storage organ for relatively soluble carbohydrates which accumulate rapidly until the plants are in bloom.

The root system of timothy is relatively shallow and fibrous. It does not spread laterally and form a sod by means of underground rooting stems, or rhizomes, as do Kentucky bluegrass and smooth brome.

The spikelets of the inflorescence, or head, of timothy are one-flowered. In the latitude of northern Ohio the florets of ordinary timothy bloom from about mid-June to mid-July.

Although individual timothy shoots are typically biennial, since new ones develop vegetatively each year from older ones, the plant maintains itself as a perennial.

IMPORTANCE AND USE

Timothy is grown primarily for hay. It is generally included, however, in mixtures for pasture. When timothy is grown in mixture with clover or alfalfa the first growth frequently is harvested for hay and the later aftergrowth pastured.

Where adapted, the yield of timothy compares favorably with that of other grasses. In an Ohio test timothy pro-
TABLE 22.1
Comparative Acre Yields of Timothy with Other Grasses, Ohio

<table>
<thead>
<tr>
<th>Grass</th>
<th>Av. yield, lb.</th>
<th>Relative yield, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timothy</td>
<td>5,309</td>
<td>100</td>
</tr>
<tr>
<td>Redtop</td>
<td>4,129</td>
<td>78</td>
</tr>
<tr>
<td>Orchardgrass</td>
<td>3,938</td>
<td>74</td>
</tr>
<tr>
<td>Meadow fescue</td>
<td>3,539</td>
<td>67</td>
</tr>
<tr>
<td>Ryegrass</td>
<td>3,021</td>
<td>57</td>
</tr>
<tr>
<td>Meadow foxtail</td>
<td>2,464</td>
<td>46</td>
</tr>
</tbody>
</table>

Reduced more hay per acre than redtop, orchardgrass, meadow fescue, ryegrass or meadow foxtail.

Data on timothy and clover—including red, mammoth, and alsike clover—have been presented in the census reports in various ways. In the 1900 and previous reports, timothy and clover were not recorded; they were included in "all hay crops." In 1910, 1920 and 1925 there were three classifications: (1) timothy alone, (2) clover alone, (3) timothy and clover mixed. By adding together the acreages in these three classifications, data equivalent to the single classification used in each of the more recent reports, i.e., "Timothy or clover, alone or mixed, cut for hay," may be obtained.

In the states from Minnesota, Iowa, and Missouri eastward, the acreage of clover alone for the 1909, 1919 and 1924 crop years was 5.7, 7.7, and 10.1 per cent, respectively, of the total timothy and clover acreage, an average of 7.8 per cent. These data would appear to indicate that timothy is included on 90 per cent or more of the total "timothy or clover, alone or mixed" acreage.

The 1945 census reports show that some timothy is grown in every state in the nation. However, as shown in Table 22.2, 83.9 per cent of the entire acreage for the period 1909 to 1944 was in the area east of the Missouri and north of the Ohio rivers.

From 1909 to 1939 there was an almost continuous decrease in the timothy acreage. The decrease in the acreage of timothy grown alone was marked. In the 1909, 1919, and 1924 crop years timothy alone constituted, respectively, 42.5, 35.6,

TABLE 22.2
ACRES OF TIMOTHY OR CLOVER, ALONE OR MIXED, CUT FOR HAY, 1909–1944

<table>
<thead>
<tr>
<th>Year</th>
<th>United States total</th>
<th>New England, Middle Atlantic, and East North Central sub-divisions, and Minnesota, Iowa, and Missouri</th>
<th>% of the total U. S. acreage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1909</td>
<td>36,672,038</td>
<td>31,097,700</td>
<td>84.8</td>
</tr>
<tr>
<td>1919</td>
<td>33,451,167</td>
<td>28,352,988</td>
<td>84.8</td>
</tr>
<tr>
<td>1929</td>
<td>29,749,886</td>
<td>23,354,060</td>
<td>78.5</td>
</tr>
<tr>
<td>1939</td>
<td>17,273,868</td>
<td>14,849,033</td>
<td>86.0</td>
</tr>
<tr>
<td>1944</td>
<td>22,602,650</td>
<td>19,556,033</td>
<td>86.5</td>
</tr>
<tr>
<td>Av.</td>
<td>27,949,922</td>
<td>23,441,963</td>
<td>84.1</td>
</tr>
</tbody>
</table>

and 30.8 per cent of the total acreage of timothy or clover, alone or mixed.

The decreasing production of timothy from 1909 to 1939 is closely associated with the decreasing number of horses and mules in the United States. As the number of horses and mules decreased, the demand for timothy hay produced on many farms as a cash crop also decreased. There may have been some other factors responsible for the changes in the timothy-clover acreage, however. From 1939 to 1944, while the number of horses and mules was decreasing, there was a marked increase in the timothy-clover acreage.

Acreage in Relation to Other Hay Crops

The decrease in the timothy acreage from 1909 to 1939 was accompanied by a reduced percentage which it constituted of all hay crops. In the northern states from the Missouri River eastward in 1909, 1919, 1929, and 1939 the timothy-clover acreages were, respectively, 78.9, 78.0, 71.8 and 45.0 per cent of the acreage of all hay crops. From 1939 to 1944 this downward trend was checked and, instead, the percentage of timothy and clover increased to 54.6 per cent.

During the time when the relative timothy acreage was declining, obviously some other crops must have been substituted in part for it. One of the most consistent trends in other hay crops has been an increase in the alfalfa acreage. In Missouri, there also has been a consistent increase in the acreage of lespedeza.

The increase from 1939 to 1944 in the acreage of timothy, and the percentage of all hay crops which it constituted, may be explained in part by the substitution of timothy-clover meadow mixtures for certain annual or biennial crops. From 1939 to 1944 the acres of small grains cut for hay was reduced from 319,747 to 49,611 and the acres of legumes other than alfalfa and clover cut for hay—largely soybeans and cowpeas—from 2,217,842 to 970,543.

VARIETIES AND STRAINS

Except to a very limited extent, at the present time the timothy grown in the United States and Canada has been the ordinary, unimproved strain.

Regional strains of timothy have developed naturally in different latitudes. Timothy adapted to the long summer days in northern Europe is later than that which has become adapted in the southern part of the timothy growing area in the United States.

The oldest known distinct timothy variety is Shelby, an early local variety grown in southern Indiana. It originated on William Zoebel’s farm at Shelbyville.
Orchardgrass, *Dactylis glomerata* L., is native to western and central Europe. It was introduced into the United States in Colonial times, probably accidentally, as were most of the cultivated grasses of the northern humid area of this country. It is said to have been in cultivation in North America since 1760. In his *Notes on the State of Virginia*, published in 1785, Thomas Jefferson listed orchardgrass as one of “our grasses.” In the early nineteenth century, about 1830, Philip Telfair Henshaw gathered a few seed heads of a grass growing in his father’s orchard in Orange County, Virginia, and planted the seed on his farm in Oldham County, Kentucky. Attracted by the lush and vigorous growth of the grass, a Mr. Magruder obtained seed of it from the planting made by Mr. Henshaw. This seed he planted on his farm at Goshen, Kentucky, and there orchardgrass was first raised commercially in the United States for seed.

4 Massachusetts Agricultural Repository and Journal, 10: 13, 1827.
Fig. 23.1 "Orchardgrass is found in greatest abundance and is of most importance in the southern half of the so-called timothy-bluegrass belt . . . as important constituent of many permanent pastures and hay meadows. . . . It is adapted farther south . . . and frequently considered more heat tolerant." Shown above is a characteristic orchardgrass plant with its many basal leaves. U.S.D.A. photo.

DISTRIBUTION AND ADAPTATION

Orchardgrass occurs throughout much of the temperate zone of the northern hemisphere, including all of Europe except the most northern portion, much of the northern half of Asia, the mountains of Algeria, in Madeira, and the Canaries. In North America it is found in the eastern Canadian provinces and in the United States from the Canadian border to the northern parts of the Gulf states, and from the Atlantic Coast to the edge of the dry land farm areas. It also occurs in the high rainfall areas of the Rocky Mountains, in irrigated areas throughout much of the West, and on the Pacific Coast.

Orchardgrass is found in greatest abundance and is of most importance in the southern half of the so-called timothy-bluegrass belt, extending from southern New York State to southern Virginia and westward through Kentucky, Tennessee, southern Ohio, southern Indiana, southern Illinois, Missouri, eastern Kansas, and southeastern Nebraska. Throughout much of this area, the species occurs extensively along roadsides, in orchards, woodlands, and in waste places. It also is an important constituent of many permanent pastures and hay meadows.

Climatic Adaptation

As suggested by its area of distribution, orchardgrass is less winter hardy than smooth brome, timothy or Kentucky bluegrass. It is adapted farther south than these species and is frequently considered more heat tolerant.

Although less winter hardy than timothy and smooth brome, orchardgrass starts growth earlier in the spring and grows more rapidly during the cool weather of that season than those species. It grows well into the fall, remaining green and productive until freezing weather. However, it is of less promise for winter grazing in the Upper South than tall fescue. Orchardgrass is more drought resistant than timothy, but less so than smooth brome which is better adapted in the low rainfall areas.

Soil Requirements

Orchardgrass is less exacting in soil requirements than timothy and especially smooth brome, being able to persist and to make relatively better growth on thin and somewhat infertile soils. However, it responds well to high levels of soil fertility, and particularly to adequate supplies of nitrogen. For example, in experiments conducted in Virginia, hay yields were increased sharply by addition of nitrogen fertilizer.

Because of its high yielding ability,
TABLE 23.1

<table>
<thead>
<tr>
<th>Nitrogen * lbs. per acre</th>
<th>Yield of hay Lbs. per acre</th>
<th>Protein %</th>
<th>Lbs. per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>No nitrogen ..............</td>
<td>1099</td>
<td>9.83</td>
<td>99</td>
</tr>
<tr>
<td>25 ........</td>
<td>1985</td>
<td>9.45</td>
<td>169</td>
</tr>
<tr>
<td>50 ........</td>
<td>2957</td>
<td>9.98</td>
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<tr>
<td>75 ........</td>
<td>3842</td>
<td>10.53</td>
<td>371</td>
</tr>
<tr>
<td>100 ........</td>
<td>5099</td>
<td>11.37</td>
<td>528</td>
</tr>
</tbody>
</table>

* Applied as calnitro

Orchardgrass draws heavily on the soil nutrients. Whenever adequate nitrogen is provided, either as commercial fertilizer or from an associated legume, other fertilizer elements may become limiting and must be supplied to maintain high levels of productivity.

Orchardgrass is not well adapted to tight poorly drained soils, especially when those soils tend to be cold. This is especially evident in some of the poorly drained soils of the northeastern region where the growing season is short and the spring and fall temperatures are low. Here the plants remain unproductive and yellow in color except during the warm days of the short summer.

**PLANT CHARACTERISTICS**

Orchardgrass is a long-lived perennial under favorable conditions. It is a distinctly bunch type forming an open sod. This dense bunch-forming habit, resulting in part from shortness of the basal internodes of the culms, causes orchardgrass in the absence of proper grazing or mowing to form large tussocks. When grazed or mowed, and especially when seeded with a legume such as Ladino clover, this objectionable feature of orchardgrass can be overcome. The open sod makes orchardgrass a good companion with legumes such as Korean lespedeza, while the extensive root system prevents the cutting by stock during wet weather that might be expected in this type of sod.

The flowering culms of orchardgrass are 2 to 4 feet tall. The leaves are folded in the bud, the blades are flat, V-shaped in cross section, wide, long, and sharply-pointed. The sheaths are flattened and strongly keeled. Both leaves and sheaths are somewhat rough to the touch, especially as the plant approaches maturity.

The species derives its botanical name from the panicle which is so distinctive that it will hardly be mistaken for any other cultivated grass. The panicle has stiff, finger-like branches on which the spikelets are borne in dense clusters or glomules. From its panicle also is derived the common name “cocksfoot” used throughout the other English-speaking countries.

Orchardgrass starts growth early in the spring, develops with extreme rapidity, and matures for hay and seed somewhat earlier than bromegrass and about three weeks earlier than timothy. It recovers rapidly after grazing or mowing, and as a result produces throughout the growing season. It is somewhat less productive of hay or first crop silage than bromegrass or timothy, but is superior to either species during midsummer. In total production for the growing season, orchardgrass is not greatly different from bromegrass and timothy. But its ability to grow during the drier, warmer part of the summer and its rapid recovery following defoliation results in a more uniform distribution of yield for the season.

**Chemical Composition**

Several studies of the chemical composition of orchardgrass have been reported. Sullivan and Garber, who have

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23. Orchardgrass

Fig. 23.2 "Orchardgrass is a long-lived perennial ... bunch-type, forming an open sod ... A good companion with legume ... The panicle has stiff finger-like branches on which the spikelets are borne in dense clusters or glomules." (See p. 289.) An orchardgrass head or panicle, just after the flowers have opened, showing the pollen sacs at the ends of their long filaments. U.S.D.A. photo.

summarized this literature, concluded that:

Within the grasses it is not easy to determine whether compositional differences actually exist. If a number of grasses are collected for comparison on the same date, the stages of maturity may be and usually are different. If they are compared at similar stages of maturity, it may be necessary to collect them on different days and weather may be a complicating factor. Proportion of leaves to stems, differential habit of growth as modified by management practices, and differences in the amount of disease and insect damage, are other factors which may affect the composition of species unequally and result in discrepancies in species comparisons.7

There is little or no evidence to indicate that orchardgrass at comparable stages of maturity is either better or poorer in chemical composition than other good forage grasses grown under similar conditions. Likewise, there is no evidence that orchardgrass differs from other grasses under comparable conditions in nutritive value as measured by livestock. In other words, when harvested or grazed as immature herbage, orchardgrass grown on soil of good fertility and under favorable climatic conditions is a highly nutritious feed.

**Palatability**

The palatability of orchardgrass is a much debated point and it is in this regard that the species has been and continues to be most vigorously condemned. Many livestock men know that animals will not eat orchardgrass. Others have found that it is eaten readily and apparently relished by livestock. It has frequently been observed that all other plants in a pasture have been grazed closely, while the orchardgrass proceeds to maturity untouched. Conversely, there have been instances in which the cattle were observed to be eating orchardgrass in preference to the ordinarily highly palatable Ladino clover. In some mixtures, with Kentucky bluegrass for example, orchardgrass has been eliminated by preferential grazing.

Immature, new growth is highly palatable. But orchardgrass grows rapidly and soon "gets away from" the livestock, which then concentrate on other species that develop less rapidly and with which they can "keep up."

This factor of rapid growth and ma-

its vigorous growth throughout the entire season, and is particularly a factor in the northern areas where Ladino grows less vigorously and is more susceptible to winter injury. Suitable grazing or clipping practices are effective in retaining good stands of Ladino and a reduced seeding rate of the orchardgrass is also beneficial in that regard. The possibility of developing productive varieties that are less aggressive towards the associated legume has been discussed and needs further investigation.

CULTURE AND MANAGEMENT PRACTICES

For the successful establishment of orchardgrass, the same general requirements apply as for other small seeded grasses and legumes.

Orchardgrass is a common component of mixtures used in pasture renovation through its range of adaptation. In renovation, seedbed preparation usually consists of destroying or reducing existing vegetation while leaving most or all of the residue on or near the soil surface. This is accomplished by use of a disk, spring tooth harrow, bush and bog harrow, or other similar implements. Such seedbed preparation can be effected on lands too stony for plowing or with topography conducive to erosion. Among the tall growing grasses adapted to the cool humid conditions, orchardgrass is one of the most certain of establishment under these conditions.

Fertilization

Fertilization is essential for high production throughout most of the range of adaptation of orchardgrass. Sprague estimated that on intensively managed pastures the equivalent of 500 pounds of ammonium sulfate, 150 pounds of superphosphate, and 150 pounds of muriate of potash may be removed annually in the herbage.\textsuperscript{12} Since soils throughout much of the range of orchardgrass adaptation are deficient in fertility, it is evident that

these elements must be supplied if optimum yields are to be maintained.

Orchardgrass for forage is grown almost exclusively with one or more legumes which, when properly inoculated, furnish nitrogen for growth of the grass. Although the associated legumes do not supply as much nitrogen as orchardgrass can utilize, application of nitrogen as commercial fertilizer normally stimulates growth of orchardgrass excessively and results in crowding out or weakening the legume. As a result, nitrogenous fertilizers normally are not recommended for orchardgrass-legume associations.

Although lime, phosphate and potash may be limiting for maximum production of orchardgrass when adequate nitrogen is available, those fertilizer elements usually are more limiting to growth and persistence of the associated legume. Throughout most of the area where orchardgrass is used, lime and phosphate must be supplied for successful culture of orchardgrass-legume associations. Since these elements move relatively little in the soil and are not lost by leaching, the common recommendation is to apply adequate amounts, especially of lime, during seedbed preparation to last for several years.

**Time of Seeding**

In contrast to timothy and most of the other cool, humid season grasses, orchardgrass usually is best seeded in the early spring. Fall and late summer seedings may be successful if early enough to allow good seedling establishment prior to entering the winter. Orchardgrass is less winter hardy than such grasses as timothy, smooth bromegrass, and Kentucky bluegrass. Late summer and early fall seedings are hazardous, especially in the northern half of the orchardgrass range. The best time for seeding appears to be early spring before the last frosts have occurred. This enables the orchardgrass seedlings to become established ahead of many annual weeds and before the dry, hot periods of the summer. Plantings made later in the spring may also be successful but are more hazardous.

**Seeding Rates**

Recommendations of seeding rate for orchardgrass have changed appreciably during the past few years. Not many years ago, rates as high as 25 pounds per acre were recommended. Now the more commonly recommended rates for orchardgrass sown in association with legumes are 8 to 10 pounds per acre. Where other grasses are used, the amount of orchardgrass seed may be still lower. From limited observations it appears that heavier stands are obtained with the same seeding rate in the northern than in the southern parts of the adaptation range. This is reflected in the recommended rates. In Pennsylvania, 3 to 5 pounds per acre seems to give best results, in Maryland 4 to 6 pounds are used, while in Virginia, Kentucky, and Tennessee as much as 10 to 12 pounds may be seeded.

The seeding rates now in use have been developed from experience. There is little experimental evidence on this important problem, although available evidence suggests that heavy seedings and resulting dense stands of orchardgrass are undesirable. Orchardgrass, because of its aggressive growth habit, is a strong competitor for the associated legume, particularly in the northern part of its range. Thus, one of the major problems in orchardgrass-legume associations in the northeastern region is maintenance of the legume, especially where Ladino clover is used.

Lower seeding rate and the resultant thinner stand of orchardgrass appears to be one of the important practices in facilitating maintenance of a satisfactory legume association.

In comparisons of several grass species
associated in all combinations with several legume species in a renovated pasture at State College, Pennsylvania, orchardgrass seeded at 8 pounds per acre was the lowest yielding grass as an average of all legume associations. In contrast, orchardgrass at 3 pounds was the highest yielding grass. Such divergent results may be indicative of the effects of seeding rate on performance of orchardgrass and the necessity of considering seeding rate when evaluating species.

Orchardgrass seeded alone in cultivated rows in three different fields at Moscow, Idaho, produced more hay per acre over 4 and 5 year periods than did broadcast seedings. Similar results were obtained at Aberdeen, Idaho. There were no essential differences in hay yields of orchardgrass seeded alone at 4, 6, 8, 10, and 12 pounds per acre in these experiments. Thus no advantage was gained, even in pure stand, from the higher seeding rates.

Management—Grazing

Successful management of grass-legume combinations which contain orchardgrass involves moving or grazing—or a combination of the two—to use the herbage while immature and palatable, and maintain a satisfactory balance of orchardgrass and the legume. Orchardgrass develops rapidly and reaches maturity earlier than most grasses adapted to the cool, humid conditions. Palatability and nutritive value decline rapidly with approaching maturity. Prompt removal of the herbage by mowing or by grazing is essential in order to utilize it before too mature and to provide regrowth of palatable and nutritious material for subsequent use. Probably the most common errors in management of orchardgrass-legume combinations are delaying grazing until too late in the spring and using too few animals to remove the herbage before maturity.

Undergrazing or delaying grazing until too late not only results in herbage low in palatability and feeding value, but also causes weakening of the legume stand due to excessive competition from the orchardgrass. On the other hand, too close, continuous grazing weakens the orchardgrass and causes it to be replaced by Kentucky bluegrass or other species more tolerant of close grazing, or less relished by the grazing animals.

A practice that has had limited use, but appears especially promising for orchardgrass-Ladino clover, is very early spring grazing prior to production of the hay or silage crop. At least in the northern part of the area of adaptation, combinations of orchardgrass-legumes are ready for grazing a few days earlier than the permanent pastures. Orchardgrass starts growth earlier than Ladino clover, and if unchecked, competes strongly with Ladino at that time. Heavy early spring grazing, when the orchardgrass is 6 to 8 inches tall, is conducive to better maintenance of Ladino clover, even when a hay or silage crop is taken subsequently. Furthermore, the hay or silage is better quality because of fewer flowering culms and is ready for harvest during better haymaking weather.

For Hay and Silage

An important feature of orchardgrass, contributing to its value in the forage program, is its adaptability for harvest as hay or silage as well as for grazing. Although orchardgrass recovers and produces better than most other perennial cool season grasses during midsummer, it is still more productive during the spring than during midsummer. Furthermore, there is, on most farms, abundant grazing from permanent pastures during the spring months. As a result, part—or in

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In some cases all—of the acreage of orchardgrass-legume on the farm may be harvested for hay or silage during this flush production period. Where only part of the acreage is harvested for hay or silage and the remainder is grazed rotationally throughout the year, a common practice is to graze during the first 2 or 3 years of the stand and to harvest hay or silage from the oldest field each year. In such cases, the orchardgrass-legume stand is maintained for only 3 to 4 years and a new seeding is made each year. This practice has the advantage of better maintenance of the legume in the mixture until the last year, since allowing the orchardgrass to develop to the hay stage tends to suppress the legume.

For hay or silage, the orchardgrass should be harvested in the early head stage and certainly prior to flowering. A few days' delay at this time results in rapid losses of palatability and nutritive value. For combinations with Ladino clover, early harvest for hay or silage has the additional advantage of reducing the competition with Ladino. In orchardgrass-alfalfa combinations, the alfalfa is not ready for harvest at the same time as the first crop of orchardgrass. In using this combination, it may be necessary to sacrifice somewhat on the quality of the orchardgrass to insure maintenance of the alfalfa stand.

SEED PRODUCTION

The annual crop of orchardgrass seed produced in the United States totals between five to seven and one-half million pounds.\textsuperscript{14} Virginia is the leading state in orchardgrass seed production, having produced over three million pounds in 1944 and again in 1946. Here the main production is in the northern counties. In Kentucky, where the total seed crop exceeds two million pounds annually, the production is concentrated in the central and north central counties. Oldham County alone produces approximately one million pounds.

Seed yields of orchardgrass vary widely, dependent upon soil fertility, method of seeding, and other factors. The average yield for Virginia in the period from 1930 to 1946 varied from a low of 126 pounds per acre in 1945 to a high of 224 pounds per acre in 1946.\textsuperscript{6} Yields of 300 to 400 pounds per acre are not uncommon. In an experiment in Farquhar County, Virginia, a yield of more than 1,000 pounds per acre was obtained by using heavy nitrogen fertilization.

The most important factor affecting orchardgrass seed production is nitrogen fertilization. In experiments in Virginia, increased seed yields resulted from applications up to 100 pounds of nitrogen per acre. Higher applications—150 and 200 pounds per acre—often produced lower seed yields than 100 pounds of nitrogen because of lodging and seed shattering.

Rate and method of planting also affect seed yields appreciably. Orchardgrass planted in rows will produce more seed than broadcast plantings under comparable conditions. Light rates of broadcast seeding have proved superior to heavy rates. In an experiment in Kentucky, orchardgrass seeded broadcast at rates of 3, 7, and 15 pounds per acre, produced 155, 142, and 122 pounds per acre, respectively. In the same experiment rows 27 inches apart yielded 323 pounds. These yields were in 1948 from seedings made in 1947. Yields in 1948 from broadcast seedings were only 28 per cent of those obtained in 1947, while the yield from the row seeding was 43 per cent of the 1947 yield.\textsuperscript{15}

\textsuperscript{14} Agricultural Statistics 1949. U.S.D.A.
Africa. This hybrid, selected as the best of 5,000 spaced plants set out in 1938, is characterized by larger and longer leaves, stems, and rhizomes than common Bermuda. (See Figures 24.1 and 24.2.) Coastal Bermuda-grass produces very few seed heads and those that are produced rarely contain viable seed. Its much greater resistance to Helminthosporium leaf spot means that it produces more and better quality feed than can be had from the common Bermuda-grass.

Coastal Bermuda-grass tolerates more frost, makes more growth in the fall, and remains green much later than common Bermuda. Observations at Tifton and reports from Arkansas, Oklahoma, and Texas indicate that it also is more drought resistant.

Coastal Bermuda-grass is immune to the root-knot-nematode, and as a result, root-knot susceptible legumes like the annual lespedezas have grown better in association with it than with the nematode-susceptible common Bermuda-grass. Repeated tests indicate that Coastal Bermuda-grass will spread faster and maintain a weed-free sod longer than common Bermuda-grass. Although its stems and leaves are quite coarse, cattle have consistently grazed Coastal Bermuda-grass in preference to the finer stemmed common types. When clipped frequently, to simulate close grazing, Coastal Bermuda-grass has produced over twice as much forage as common Bermuda-grass. In such tests it has been outstanding in its ability to grow and produce more forage in the later summer and fall than other summer growing grasses with which it was compared.

At the Georgia Coastal Plain Experiment Station, over a nine-year period, a 12-acre pasture of common Bermuda-

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*Coastal Bermuda-grass* is named for the Georgia Coastal Plain Experiment Station where it was developed, is a new variety that is well adapted throughout most of the Bermuda-grass belt. It is an F₁ hybrid between Tift Bermuda-grass (discovered by J. L. Stephens in an old cotton patch near Tifton, Georgia, in 1929) and an introduction from South Africa. This hybrid, selected as the best of 5,000 spaced plants set out in 1938, is characterized by larger and longer leaves, stems, and rhizomes than common Bermuda. (See Figures 24.1 and 24.2.) Coastal Bermuda-grass produces very few seed heads and those that are produced rarely contain viable seed. Its much greater resistance to Helminthosporium leaf spot means that it produces more and better quality feed than can be had from the common Bermuda-grass.

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At the Georgia Coastal Plain Experiment Station, over a nine-year period, a 12-acre pasture of common Bermuda-
Bermuda-grass carried an average of 9.7 steers for the entire grazing season, and produced an average of 161.9 pounds of beef per acre. Six acres of Coastal Bermuda in an adjacent pasture on the same soil type carried an average of 8 steers per season and produced an average of 278.2 pounds of beef per acre over a five-year test period. Both pastures received the same fertilization; namely, 600 pounds of 6-12-6 per acre every third year and 200 pounds of nitrate of soda per acre in the years when complete fertilizer was not applied. In these grazing studies Coastal Bermuda-grass produced more beef in the late summer and fall than any other grass that has been tested at Tifton.

Coastal Bermuda-grass grows tall enough to be cut for hay on almost any soil, whereas common Bermuda-grass usually is too short to cut. Its fine stems and low moisture content make it easier to cure than any other hay crop adapted to the South. Hay cured in the swath or the windrow usually is dry enough to bale 24 hours after cutting. Some farmers cut and bale the same day. The four to five cuttings per year afforded by Coastal Bermuda-grass give the farmer a good chance to save much of his hay, even though one or more cuttings may be damaged by rain. The uniform annual production of hay obtained from Coastal Bermuda-grass indicates that it is a dependable hay crop.

Most southern pasture grasses are not good hay plants. Usually when the excess growth in pastures is mowed it is allowed to remain on the ground. The excess from Coastal Bermuda-grass can be put in hay barns to help carry livestock through the winter.

Suwanee Bermuda-grass, also called Tifton Bermuda No. 99, is another hybrid developed at Tifton. It resembles Coastal Bermuda-grass in many respects. It may be distinguished from Coastal Bermuda-grass by its darker green color, its more erect leaves, and its tendency to produce more viable seed. It is unusually well adapted to light sandy soils and tends to be more productive than Coastal Bermuda on such soils, particularly if not well fertilized. It must be established by planting stolons and does not sod over as rapidly as Coastal Bermuda-grass. Once established, it appears to be equal or superior to Coastal Bermuda-grass for hay production. It makes a more open sod and will not tolerate close clipping as well as Coastal Bermuda-grass, suggesting that it might be inferior to Coastal Bermuda-grass in closely grazed pastures. Suwanee Bermuda-grass is being planted largely on the light sands in Florida.

PROPAGATION

Common Bermuda-grass may be propagated by planting either seed or vegetative sprigs. Since the seed are very small, the seeding methods recommended for small-seeded grasses and legumes should be followed. Bermuda-grass seed does not germinate well at low temperatures, hence there is little to be gained from planting seed before mean daily temperatures of 65°F prevail. Hulled Bermuda-grass seed germinate more promptly than unhulled seed and should be used when early establishment is desired. If the best seeding practices are followed five to ten pounds of seed per acre should give good stands.

More Bermuda-grass is propagated by planting sprigs than by seeding. Farmers generally have had better success by this method. The poor seeding habits of Coastal Bermuda-grass make it mandatory that it be established from vegetative material. This feature of Coastal Bermuda-grass has led to the development

herbage consumed. An experiment designed to measure the fertilizer benefit obtained from crimson clover growing in Coastal Bermuda was conducted at Tifton, Georgia, from 1943 to 1948. At Tifton, crimson clover is removed with the first cutting of Bermuda hay, and dies. A study of the yields of grass from these plots indicates that crimson clover will produce enough nitrogen to increase grass hay yields from one-fourth to two-and-one-half tons, depending upon the growth made by the clover. Nearly 100 pounds of synthetic nitrogen would be required to give these maximum increases in yield.

Most any legume will make an excellent growth in association with Bermuda-grass, provided the soil moisture and plant nutrient requirements of the legume are met, and provided the mixture is managed properly. Lime, phosphorus, potash, and sometimes some of the secondary and minor elements must be applied in generous amounts to many soils in order to successfully grow legumes with this grass. If the addition of these soil amendments will make the growth of a legume with Bermuda-grass possible, the increased production usually gives a nice profit over and above the cost involved.

Such winter legumes as Austrian winter peas, vetch and lupines are being widely used in the South for "soil building" purposes. The increased yields of corn following these crops are generally recognized. A study of the possibility of growing the nitrogen for Bermuda-grass with one of these legumes is under way. Through three years, lupines drilled into undisturbed sod in late October at rates of 50 to 60 pounds per acre have grown during the winter when the Bermuda-grass was dormant and have produced from 80 to 100 pounds of nitrogen per acre by March 1. This lupine growth, disked down in early March, has tripled the yield of hay, giving yields nearly as good as those obtained from a similar amount of nitrogen from nitrate of soda. Marked stimulation in the growth of Bermuda-grass, approaching that where lupines were disked down in early March, has been observed after a mature lupine seed crop has been harvested with a combine. Lupine seed usually are combined in June. Lupines, and some of the other winter legumes, can be grown on the deep sands where the clovers fail. There is reason to believe that in the future much of the nitrogen so badly needed for the satisfactory growth of Bermudagrass on these soils may be obtained from a growth of vetch or lupine.

**Nitrogen Fertilization**

Many deep sands that will grow excellent Bermuda-grass with commercial nitrogen are too dry to grow the small pasture legumes successfully. The use of nitrogenous fertilizers under such circumstances usually is a profitable procedure. A three-year study of the value of four different sources of nitrogen when applied to a Bermuda-grass hay meadow gave the results presented in Table 24.2. These data indicate that cyanamid and uramon are not as good as the other sources of nitrogen. Nitrate of soda and ammonium nitrate appear to be equally effective as nitrogen sources.

Split applications of nitrogen on cultivated crops growing on sandy soils generally are considered necessary to prevent leaching losses. A three-year study of the importance of splitting nitrogen applications on Bermuda-grass sod is summarized in Table 24.3. A 7.27 inch rainfall that fell in less than 48 hours on April 1 and 2, 1948, soon after the first application of nitrogen was made, prob-
TABLE 24.2

<table>
<thead>
<tr>
<th>Source of nitrogen</th>
<th>Total yield per acre in tons</th>
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<tr>
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<td>Nitrate of soda</td>
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<tr>
<td>Ammonium nitrate</td>
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<td>Uramon</td>
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<td>Cyanamid</td>
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</tbody>
</table>

* Each yield figure is the average of the yield from 24 plots of which six received 50 pounds, six 100 pounds, six 200 pounds, and six 400 pounds of N per acre. All plots received 800 pounds per acre of 0-14-10 in March each year.

ably leached enough nitrogen from the soil to give increased yields from split applications of all nitrogen sources in that year. The small increased yields resulting from split applications of nitrate of soda and ammonium nitrate during the other years suggest that leaching losses on Bermuda-grass sod are lower than on cultivated crops. Apparently little benefit will result from splitting the applications of cyanamid or uramon except when unusually heavy rains fall soon after the fertilizer is applied. Applying a part of the nitrogen in August increases the protein content and stimulates growth in the fall when it is most needed.

Anhydrous ammonia probably will always be the cheapest source of synthetic nitrogen. Studies through two years indicate that it is 90 to 95 per cent as good as nitrate of soda nitrogen when applied to Bermuda-grass at rates of 50 to 100 pounds of N per acre. At rates of 200 to 400 pounds of N per acre, it produced only about 75 to 80 per cent as much hay as the same amounts of nitrate nitrogen. Even with present application losses, the price differential is such that anhydrous ammonia will be chosen in many parts of the South as the cheapest nitrogenous fertilizer for Bermuda-grass.

**Grazing Management**

Management greatly influences the results obtained from any pasture. The young growth following close grazing usually is the most nutritious. Such grazing improves the nutritive qualities of the feed but sometimes reduces the total protein content. Studies indicate that it is 90 to 95 per cent as good as nitrate of soda nitrogen when applied to Bermuda-grass at rates of 50 to 100 pounds of N per acre. At rates of 200 to 400 pounds of N per acre, it produced only about 75 to 80 per cent as much hay as the same amounts of nitrate nitrogen. Even with present application losses, the price differential is such that anhydrous ammonia will be chosen in many parts of the South as the cheapest nitrogenous fertilizer for Bermuda-grass.

TABLE 24.3

<table>
<thead>
<tr>
<th>Source of Nitrogen</th>
<th>1947</th>
<th>1948</th>
<th>1949</th>
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<tbody>
<tr>
<td></td>
<td>Single Application</td>
<td>Split Application</td>
<td>Single Application</td>
</tr>
<tr>
<td>Nitrate of soda</td>
<td>4.4</td>
<td>4.7</td>
<td>4.6</td>
</tr>
<tr>
<td>Ammonium nitrate</td>
<td>4.4</td>
<td>4.9</td>
<td>4.3</td>
</tr>
<tr>
<td>Uramon</td>
<td>4.2</td>
<td>4.3</td>
<td>3.7</td>
</tr>
<tr>
<td>Cyanamid</td>
<td>3.3</td>
<td>3.3</td>
<td>3.4</td>
</tr>
</tbody>
</table>

1 Each figure is the average of the yield from eight plots of which two received 50 pounds, two 100 pounds, two 200 pounds, and two 400 pounds of N per acre. All plots received 800 pounds per acre of 0-14-10 in March each year.

2 Total annual supply of N applied in late March each year.

3 Annual supply of N applied in four equal amounts, one in March and one after each of the first three cuttings of hay.
quantity produced to the extent that animals are unable to get enough feed for maximum gains.

Most Bermuda-grass will give the best results under continuous grazing if not allowed to get over four to six inches tall. On rich land, or with heavy fertilization, greater production may be expected from tall-growing types like Coastal by allowing them to grow 12 inches or more in height and grazing rotationally. Removing a cutting of hay from a part of the pasture during the summer may be possible and often is highly desirable. In addition to producing a quantity of good hay, this practice will help control weeds and will scatter the animal droppings—two highly desirable management practices.

If legumes are growing in association with Bermuda-grass, the grazing intensity should be adjusted to favor the requirements of the legume. Low-growing legumes, like white Dutch clover and annual lespedeza, can best be maintained in Bermuda-grass with close grazing. More erect legumes, like sweetclover and alfalfa, must be grazed less intensively to keep them in a vigorous condition. Close grazing immediately preceding the planting of a legume greatly facilitates its establishment in Bermuda-grass sod.

The use of the mowing machine to control weeds has been mentioned. Many perennial weeds can be controlled more effectively, however, by turning the sod with a bottom plow, a practice that actually stimulates the growth of Bermuda-grass.

This grass has shown less injury from 2,4-D and many other herbicides than most southern pasture grasses. Consequently, these materials may be used with little fear of killing Bermuda should their use seem desirable.

The height or frequency of cutting the tall-growing hay Bermuda-grass, like Coastal, has a marked influence on the yield and quality of the hay. Cutting about every four weeks under optimum growing conditions, when the grass is not over 12 inches high, will result in a high protein hay. Waiting another week or two until the grass is about 18 inches high will give greater annual yields of hay, but also will give a hay higher in fiber and considerably lower in protein. This hay will be satisfactory for "roughing" stock through the winter but not as good as the earlier cut hay for milch cows and young growing animals.

**SEED PRODUCTION**

Most of the commercial seed of common Bermuda-grass is produced in Arizona and southern California. Old cultivated fields abandoned to Bermuda-grass supply much of the seed, but some is harvested with alfalfa seed from fields that have volunteer Bermuda-grass growing in association with alfalfa. One to two seed crops are harvested annually, with seed yields ranging from 100 to 200 pounds per acre.

Contrary to popular opinion, Bermuda-grass produces seed in southeastern United States. At Tifton, Georgia, the production of heads was tripled with heavy fertilization, but the percentage of florets to set seed was not affected. Over a three-year period, common Bermuda-grass florets harvested early in the season contained 78.6 per cent of caryopses by weight, whereas those harvested late in the season contained only 23.1 per cent.

**CONTROL**

In the days of the mule and single stock, it was difficult to eradicate Ber-
Bermuda-grass and almost impossible to successfully grow a cultivated crop in a heavily infested field. It is easy to understand, therefore, why most farmers refused to plant it in their cultivated fields. Modern tractor equipment has changed this situation. At the Georgia Coastal Plain Experiment Station, 60 bushels of corn were produced per acre in 1949 on heavy Bermudagrass-crimson clover sod that received 80 pounds of nitrogen per acre. The cultural operations, using tractor equipment, consisted of turning the sod about seven inches deep in April, smoothing it with a disk harrow, planting the corn with a surface planter, throwing the soil away from the corn plants with disks, then throwing it back to the corn with disks again when it was 18 to 24 inches high.Comparatively little Bermuda-grass survived the cultivations and the heavy shade. The yields were equal to those from adjacent plots that had been kept free of Bermuda-grass. The susceptibility of Bermuda-grass to shade injury has been used to good advantage as a control measure, by keeping infested land heavily shaded with shade-producing crops.

In the northern part of the Bermuda-grass belt very shallow plowing late in the fall so as to expose the rhizomes has caused Bermuda-grass to be killed by freezing.

One of the most common methods of eradication consists of harrowing the soil thoroughly with a spring-tooth harrow, and raking the rhizomes and stolons into windrows to be burned or hauled out of the field. This procedure is most effective on light, reasonably dry soils.

QUESTIONS

1. Where is Bermuda-grass adapted and what are its soil and climatic requirements?
2. What are the advantages of Coastal Bermuda over common Bermuda?
3. Discuss the different methods used in the vegetative establishment of Bermuda-grass.
4. How would you establish 100 acres of the best variety of Bermuda-grass on your farm?
5. How would you supply nitrogen to Bermuda-grass on moist heavy soils? On deep sands that tend to be dry?
6. What is the best grazing procedure for Bermuda-grass?
7. Considering both yield and feeding value, when should Bermuda be cut for hay?
8. What is the best method for controlling Bermuda-grass?
9. Why is most of the Bermuda-grass seed on the market now produced in Arizona and southern California?
10. What is the place of Bermuda-grass in the South in relation to other available adapted grasses?
Dallisgrass, *Paspalum dilatatum* Poir., is native to South America, from Brazil to Argentina. This grass was introduced into the United States sometime before 1879. It was first observed near New Orleans. It is recorded by specimens as growing in Arkansas in 1879, Texas in 1880, and Louisiana in 1883.1

Dallisgrass belongs to the genus *Paspalum*, of which there are some 400 species. *Paspalum* is one of the most economically important genera of *Panicaceae*, the tribe to which it belongs.2

From the New Orleans area Dallisgrass spread over the Gulf Coast region. A. T. Dallis, a farmer near LaGrange, Ga., first recognized its merits. It has since been known as Dallisgrass. Other common names are watergrass, large watergrass, hairy-flowered paspalum, golden crownglass, knotgrass, and Fort Thompson grass.

**DISTRIBUTION AND ADAPTATION**

Dallisgrass is found from New Jersey to Tennessee and Florida, and west to Texas. It is adventive in Oregon, Colorado, Arizona, and California. This grass is adapted to practically the same area as the cotton plant but does not go west of the humid eastern portion of Texas.

Its apparent liking for wet lands first led to the belief that it was a water grass, and it became known as “water Paspalum.” It is adapted throughout the Cotton Belt to practically every condition where the annual rainfall is as much as 30 inches.

It will grow well on a wide variety of soils but prefers heavy to loam soils. It makes its best growth on bottomland because of greater fertility and soil moisture. It thrives on lower land than carpetgrass and also goes higher on the hills. It is more tolerant to excessive soil moisture and at the same time is more drought resistant than Bermuda or carpetgrass. On heavy clay soils, this plant is able to endure extremes of drought and deficient drainage. It grows well on all soils except extremely sandy ones.

Economically, Dallisgrass is confined to the lower and more humid portions of the Cotton Belt south of Tennessee and the highlands of North Carolina.

**PLANT DESCRIPTION**

Dallisgrass is a rather stout perennial. It grows in clumps of a few to many culms. Leafl, sterile shoots arise from it.
Dallisgrass, Bahiagrass, and Vaseygrass

**Fig. 25.1** “Dallisgrass has proved to be one of the most valuable pasture grasses for the humid South . . . many basal leaves which, following grazing, make rapid recovery. It is the first grass to begin growth in the spring . . . the last grass to become dormant in the fall.” (See below.) A Dallisgrass plant. Miss. Agr. Exp. Sta. photo.

knotted base of extremely short rhizomes. It produces many basal leaves (Fig. 25.1) which, following grazing or drought, make a more rapid recovery than any other pasture grass in its region of adaptation. It is propagated from seed, produced on tall (2 to 4 feet), upright, practically leafless seed-stalks. The stems are slender and usually droop with the weight of flower clusters. Each seed stalk bears 2 to 11 racemes near its tip. The oval and hairy seed are arrayed in two compact rows on the racemes.

Its clump type of growth is considered particularly well adapted to associated growth with legumes.

The yields of three important southern pasture grasses in North Carolina, grown alone and with lespedeza, show the ability of Dallisgrass to grow in association with a legume (Table 25.1).

These results would tend to indicate that Dallisgrass may be expected to produce greater yields than either Bermuda or carpetgrass. These data also show that the Dallisgrass-lespedeza seeding was more responsive to the LPK treatment than the other two grass-lespedeza combinations. This would indicate that lespedeza grows better in association with Dallisgrass than with the other two grasses. The data show greater differences between Dallisgrass-lespedeza and Dallisgrass than is true for either carpetgrass or Bermuda-grass compared with the grass-lespedeza combination. This is in agreement with other investigators.4, 5, 6

As one goes from north to south in the Cotton Belt, the difference in the yield of these grasses becomes greater.7 On heavy soils Dallisgrass will yield twice as much as carpetgrass.

Since larger yields are obtained with grass-legume combinations, fertilizer treatments should be those that will increase the growth of legume seedings.8 In all cases in the South, legumes must be maintained in the sod if maximum production is to be realized from pastures. Nitrogen is the fertilizing element most needed by the grasses and fortunately is the one that legumes have the power of transferring from the atmosphere to the soil. It can then be used by pasture grasses in their growth processes. The ability of Dallisgrass to grow in association with legumes (Table 25.1) makes it one of the most desirable pasture grasses for the South.

Pure stands of Dallisgrass respond to applications of superphosphate and potash while Bermuda-grass and carpetgrass often do not do so.3, 4, 6, 7 Medium responses to lime have been obtained.3, 4, 5, 9 Increasing the fertility of the soil, either by applications of com-

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TABLE 25.1
YIELD OF DRY MATTER IN POUNDS PER ACRE OF GRASSES WITH AND WITHOUT LEGUMES, GROWN AT LOW AND HIGH LEVELS OF N

<table>
<thead>
<tr>
<th>Seedings</th>
<th>Seasonal yield in lbs. per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low N level + LPK</td>
</tr>
<tr>
<td>Dallis—lespedeza</td>
<td>2,238</td>
</tr>
<tr>
<td>Dallis</td>
<td>1,027</td>
</tr>
<tr>
<td>Carpet—lespedeza</td>
<td>1,715</td>
</tr>
<tr>
<td>Carpet</td>
<td>721</td>
</tr>
<tr>
<td>Bermuda—lespedeza</td>
<td>2,093</td>
</tr>
<tr>
<td>Bermuda</td>
<td>945</td>
</tr>
</tbody>
</table>

TABLE 25.2
CHEMICAL COMPOSITION OF THREE PASTURE GRASSES IN FLORIDA *

<table>
<thead>
<tr>
<th>Grasses</th>
<th>Percentage on dry basis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Phosphorus</td>
</tr>
<tr>
<td>Carpet</td>
<td>0.23</td>
</tr>
<tr>
<td>Bermuda</td>
<td>0.34</td>
</tr>
<tr>
<td>Dallis</td>
<td>0.26</td>
</tr>
</tbody>
</table>


TABLE 25.3
COMPOSITION OF DALISGRASS WHEN GROWN ALONE AND IN ASSOCIATION WITH WHITE CLOVER, MISSISSIPPI *

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Grass when:</th>
<th>Percentage on dry basis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Phosphorus</td>
</tr>
<tr>
<td>Grenada loam</td>
<td>Grown alone</td>
<td>.28</td>
</tr>
<tr>
<td></td>
<td>Grown with clover</td>
<td>.35</td>
</tr>
<tr>
<td>Sarpy sandy loam</td>
<td>Grown alone</td>
<td>.37</td>
</tr>
<tr>
<td></td>
<td>Grown with clover</td>
<td>.42</td>
</tr>
<tr>
<td>Ruston sandy loam</td>
<td>Grown alone</td>
<td>.34</td>
</tr>
<tr>
<td></td>
<td>Grown with clover</td>
<td>.39</td>
</tr>
</tbody>
</table>


Commercial fertilizer or through the growing of legumes, enables Dallisgrass to tolerate lower temperatures than otherwise.3

The composition of Dallisgrass, carpetgrass, and Bermuda-grass is shown in Table 25.2.

The associated growth of Dallisgrass and a legume not only increases the production of Dallisgrass, but also improves its composition. This is shown by the composition of Dallisgrass grown in association with white clover on three soil types in Mississippi (Table 25.3).

IMPORTANCE AND USE

Dallisgrass has proven to be one of the most valuable pasture plants for the humid south. It produces many basal leaves which, following grazing or drought, make a rapid recovery. It is the first grass to begin growth in the spring, makes continuous growth during warm weather, is not injured by moderate
frosts, and is the last grass to become dormant in the fall. It will continue growth through more nearly the entire year than any other grass in the Gulf Coast region. Its bunch habit of growth makes it better adapted to growing in association with pasture legumes than many other grasses, and also prevents it from becoming a pest in fields that are to be rotated. It is more tolerant than many grasses to excessive soil moisture, and at the same time is more drought and heat resistant. It grows well on all soils except the extremely sandy ones. It is the basic summer grass for the Gulf Coast region.

Dallisgrass is used primarily for pasture. Hay may be produced, but it is rather dark. Dallisgrass pastures produce more grazing than any other grass base used. Two acres of Dallisgrass pasture and pasture clippings will carry a cow and produce a calf.

**VARIETIES AND STRAINS**

Since Dallisgrass is one of the most important perennial pasture grasses in the humid South, a number of southern stations have work in progress looking to improved varieties.

Louisiana has produced by selection both a superior seeding and forage production strain.

The Mississippi Station has succeeded in crossing *Paspalum dilatatum* and *P. malacophyllum* by means of temperature and light control. Segregations show promise of combining good seed germination and seed production, and resistance to ergot.

Burton, at Tifton, Ga., has produced tri-hybrids involving three *Paspalum* species which are unquestionably superior to Dallisgrass vegetatively. These hybrids are so sterile that they are of little practical value unless economical methods of vegetative propagation can be developed.

**CULTURAL AND MANAGEMENT PRACTICES**

**Establishment**

Dallisgrass has the reputation of being difficult to establish. This is due to seed of a low percentage germination—due to lack of proper cleaning—and to ineffective seeding methods. That Dallisgrass can be successfully established in spite of low quality seed has been shown by tests of methods of seeding pasture grasses conducted by the Mississippi Experiment Station.

Seeding 8 pounds of domestically produced Dallisgrass seed per acre under varying practices gave the results shown in Table 25.4.

These data show that soil preparation increases the stand of Dallisgrass and that the increase is in proportion to the amount of preparation. When the seed was slightly mixed with the soil by harrowing, there were nearly twice the number of plants as where planted in

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**TABLE 25.4**

<table>
<thead>
<tr>
<th>Method of seeding</th>
<th>No. plants per sq. foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadcast—no preparation</td>
<td>0.5</td>
</tr>
<tr>
<td>Mulched—no preparation</td>
<td>6.0</td>
</tr>
<tr>
<td>Prepared seedbed—open furrows</td>
<td>5.0</td>
</tr>
<tr>
<td>Prepared seedbed—open furrows—cultipacked</td>
<td>9.0</td>
</tr>
</tbody>
</table>

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open furrows without harrowing. Seeding in open furrows only was 10 times as effective as no preparation. This test shows the advantage of seedbed preparation, if only a shallow furrow to hold the seed in place.

Probably the most significant result is from the stand obtained by mulching. This is a satisfactory method of establishing Dallisgrass. Mulching should be at the rate of 1 ton of cut material per 3 acres. The results of these tests are in agreement with other investigations in the Southeast.5 6

**Fertilization**

Pure stands of Dallisgrass respond to applications of superphosphate and potash; carpetgrass and Bermuda-grass do not.6 7 8 It gives a medium response to calcium. Significant increases in yield and density of sward follow the application of commercial nitrogen. Since larger yields are obtained with Dallisgrass-legume combinations the general recommendation is the annual application of phosphate (80 pounds P₂O₅) and potash (40 pounds K₂O) to increase legume growth.

**Management**

Dallisgrass is more sensitive to defoliation than carpetgrass and other sod-forming grasses.14 Part of this differential behavior can be explained on the basis that Dallisgrass is an upright bunch grass and little photosynthetic leaf area remains after frequent defoliation. New growth is initiated at the expense of the stored food in the roots and rhizomes. Carpetgrass is a decumbent sod-forming grass. Considerable leaf surface remains after frequent defoliations or cuttings. Dallisgrass also produces more forage growth than does carpetgrass or Bermuda-grass. Frequent defoliation of Dallisgrass is injurious, reducing yields under conditions favorable to rapid growth.7 8 Tests have shown that higher yields of forage and beef are obtained when a spring or fall rest period is given Dallisgrass. Such a period permits the storing of reserves in the rhizomes and roots.

**SEED PRODUCTION**

Dallisgrass has long had the reputation of producing an extremely low percentage of viable seed. This idea is so widespread that domestically produced seed are discriminated against. Plantings have shown that 78 per cent of a population from widespread sources produced from 40 to 59 per cent viable seed.5 Thorough cleaning of domestic seed will improve the results obtained from sowing such seed. Cytological studies have shown that the low per cent of seed-set is largely due to chromosomal aberrations.15

The yield of Dallisgrass seed varies with soil fertility, time of harvest, and ergot infestation. A yield of three hundred pounds per acre from a single harvest is considered excellent. Seed may be harvested twice per season in the deep South, i.e., June and August, or September.

Seed are harvested by direct combining, mowing, and threshing from the windrow, or by threshing pasture clippings. Seed may be harvested much sooner than is now the common practice.15

**DISEASES**

Ergot, *Claviceps paspali* (Stevens and Hall), is the first disease to appear on Dallisgrass and probably is the most important one. This disease appears after the seed heads are produced. It attacks

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the pistils and grows as a parasite in the flower. When eaten in large amounts ergot is injurious to cattle. However, injury to livestock from this source is rare. Mowing off the seed heads prevents injury. Anthracnose, a foliage disease caused by Colletotrichum graminicola, attacks the leaves, and under some conditions kills the plants. Plants allowed to mature seed are more severely injured by this disease than those closely grazed.

Other Species

Bahiagrass, *Paspalum notatum* (Fluegge), is another important species of *Paspalum. Vaseygrass, Paspalum urvillei* (Steud.), is of minor importance.

BAHIAGRASS

Bahiagrass, *Paspalum notatum* (Fluegge), is native to the West Indies and South America. It is said to have been introduced by a detachment of Union cavalry who were sent to Texas around Florida by boat. The boat stopped at Havanna, Cuba, and took on a supply of hay which contained seed of Bahiagrass. This grass is found along the Texas coast. Others report this grass as introduced into this country in 1914.

Bahiagrass is an important grass within the limits of its adaptation.

DISTRIBUTION AND ADAPTATION

Bahiagrass is adapted throughout Florida and in other locations close to the Gulf of Mexico. It has proven hardy as far north as McNeil, Miss. It is principally adapted to sandy soils of the coast area as far north as North Carolina.

PRODUCTIVITY. Yields, as determined by mower clippings, usually are higher for Bahiagrass than other grasses for its region of adaptation. When yields are determined by means of plucking by hand, the yield of Bahiagrass has proven to be a better pasture grass than carpetgrass, Bermuda-grass, or Centipedegrass. On sandy soils Bahiagrass is considered better than Dallisgrass. Bahiagrass is relatively high in chemical composition.
IMPORTANCE AND USE

Bahiagrass is widely adapted, growing on both high and low soils. It will grow on drier soils than most other pasture grasses of its region of adaptation, largely because of its deep root system. It furnishes little feed during the winter months. Primarily, it is a pasture grass adapted to the sandy soils of the Gulf Coast.24, 4, 2, 17, 15 This grass is reported to be the main constituent of native pasture in Cuba, Puerto Rico, southern Brazil, Uruguay, and the Argentine.19

VARIETIES AND STRAINS

There are three varieties of Bahiagrass; common, Paraguay, and Pensacola. Paraguay produces seed-stalks similar to common Bahia, but the leaf blades are more hairy and narrower.

Pensacola is a narrowleaf type similar to Paraguay, but is less hairy. The seed are smaller than common or Paraguay, and because of the longer branches, more seed are produced per head. This variety seeds heavily and the seed are of excellent quality. Pastures seeded with this variety sod more quickly than with other varieties. Wilmington is a strain quite similar to Paraguay, with exceptional resistance to lower temperatures. Other strains of Bahiagrass are Wallace and Tampa, which are similar to Pensacola Bahia.

CULTURAL AND MANAGEMENT PRACTICES

Bahiagrass responds to the same fertilization as Dallisgrass but will grow on much sandier and drier soils. Florida recommendations for best sodding and growth are: 16 pounds elemental N, 96 pounds P2O5, 32 pounds K2O, and 1,000 of basic slag.8

This grass may be kept in a vegetative growth condition by frequent mowing or heavy grazing.20, 21 It will withstand more frequent harvest with continued good production than will Dallisgrass or carpetgrass. Roots and stolons, however, are reduced by too frequent defoliation.

SEED PRODUCTION

Seed production of Bahiagrass is similar to that of Dallisgrass in quantity and quality. The flowers of this grass also are attacked by ergot. More seed, of a higher quality, is produced by the Pensacola variety than by others.

VASEYGRASS

Vaseygrass, Paspalum urvillei (Steud.), probably is the closest relative to Dallisgrass in the genus Paspalum. This grass was introduced from Uruguay sometime before 1880. It is native from Brazil to the Argentine.

DISTRIBUTION AND ADAPTATION

Vaseygrass is common throughout the lower South, especially along the Gulf Coast where it grows on low wastelands. Like Dallisgrass and Bahiagrass, it will withstand extremes of soil and climate. It is found growing abundantly in wet land, and also on well-drained soils where moisture may be deficient for weeks. It grows on both light and heavy soils. Its range is from North Carolina to Florida and west to Texas. It also is found in southern California.

PLANT DESCRIPTION

Vaseygrass is a stout, erect perennial, with many stems borne in clumps. The seed-stalks, hairy and purplish at the

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base, grow 2 to 6 feet tall and bear 6 to 25 (usually 12) drooping racemes. The leaf blades are 3 to 15 inches long and up to one-half inch in width. The seed is extremely hairy, light in weight, grayish brown in color, and much smaller than Dallisgrass seed.

**IMPORTANCE AND USE**

Vaseygrass is seldom cultivated or planted but is utilized where it is found growing. This grass makes an excellent quality hay and is used in Mississippi, Arkansas, and Louisiana for this purpose. Hay yields range from two to five tons per acre. The plant loses its palatability and quality with age. It should be cut for hay when 24 to 30 inches tall. Three or four cuttings usually are taken per season. Its upright growth prevents it surviving trampling or grazing. This grass is easily eliminated by grazing closely.

Vaseygrass produces more viable seed than Dallisgrass or Bahiagrass. Commercial seed production is practically nonexistent, due principally to lack of harvesting knowledge, machinery, and excessive shattering. Most of the seed now planted is hand-stripped. Mowing closely in July and combining a seed crop in late August or early September appears to be the best seed-saving practice.

**QUESTIONS**

1. Give several reasons why Dallisgrass is considered one of the leading perennial grasses in the South.
2. Where in the Cotton Belt is Dallisgrass best adapted and why?
3. Compare Dallisgrass with Bermuda and carpetgrass as to nutritive value, seasonal yield per acre, and response to fertilizer.
4. Why is Dallisgrass better adapted to growing in association with pasture legumes than many other grasses?
5. How is Dallisgrass best utilized in the South?
6. What are the prospects for developing superior varieties of Dallisgrass?
7. Why is Dallisgrass difficult to establish?
8. How should Dallisgrass pasture be managed to maintain high seasonal yields?
9. Why does Dallisgrass have a low percent seed-set?
10. How should Dallisgrass be managed for high seed yield?
11. Why is Bahiagrass grown primarily along the Gulf Coast?
12. Although seldom cultivated or planted why is Vaseygrass of some importance in the lower South?
such factors as maturity, soil fertility, moisture conditions, and temperature. Considerable variation in palatability has been reported. Alway has reported that Hesselgren of Sweden found it to be one of the most palatable of the grasses, except to swine. It is reported by Arny that hogs relish reed canarygrass, especially if it is grazed rather short. At the Iowa Station, horses consumed reed canarygrass hay cut after field maturity in preference to good quality timothy. In pasture trials with dairy cows, reed canarygrass was equal in palatability to six other grasses, including Kentucky bluegrass. Richards and Hawk reporting from Oregon, state that reed canarygrass is low in palatability as compared to a number of the other grasses when grazed by sheep.

The Wisconsin Station states that reed canarygrass when well established will hold its own against weeds. It has successfully controlled snapdragon, Canada thistles, nettles, and all annuals and biennials.

Silage

Reed canarygrass has recently come into favor as a silage crop. It makes a low cost, succulent feed, particularly where other silage crops do not grow well or are too costly to produce. By making into silage it often is possible to save the grass when conditions are such that it is difficult to cure as hay. This is a common practice in the Coos Bay section of Oregon where it is fed to dairy and beef animals with good results. The real merit of reed canarygrass is the fact that it will provide a valuable crop on land too wet for other crops—land which probably would be producing nothing if not reed canarygrass.

For Soil Conservation

Reed canarygrass is unchallenged in its value to heal and control gullies. For this purpose it stands in a class by itself. Small pieces of sod are imbedded at intervals of one to two feet in the bottom and across gullies when the soil is moist, either in early spring or in late summer. The reason for using small sods instead of seed is that seed and small seedlings are washed away with the first rain. Great volumes of water can pass over properly imbedded sod pieces without disturbing them. Reed canarygrass shoots will push up through 6 to 8 inches of sediment, should such be deposited. A small piece of sod containing rhizome material and one or more shoots establishes with assurance and enlarges and spreads rapidly.

It is recommended that farms on which gullies are forming establish so-called “sod banks” by fitting a seedbed and making a seeding of this grass. One pound of seed will sow a tenth acre—an area about forty-five by one hundred feet. A tenth acre will produce all the sod pieces necessary to control the gullies that form on a farm of average acreage and topography.

Select a good fertile site, sow the seed on a well-prepared and firmed seedbed in the spring or late summer and cover lightly. A year later sods can be “borrowed” from the sod bank and planted in gully and ditch bottoms, where they will return a high interest rate on the investment. When only a few sod pieces

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10 Alway, Frederick J. Loc. cit.
14 Cheney, H. B., and Hughes, H. D. Reed canarygrass in gully control. Farm Science Reporter. 8; (4). 1944.
Reed Canarygrass

FIG. 21 “Reed canarygrass is unchallenged... to heal and control gullies.... Great volumes of water can pass over properly imbedded sod pieces without disturbing them.... A small piece of sod containing rhizome material and one or more shoots... enlarges and spreads rapidly.” (See p. 321.) (Upper) Shoots in small pieces of sod spaced 18 inches apart in moist soil in September, 1948; (middle) the dense growth, with many basal leaves, in early July, 1948; (bottom) the five-foot growth shattering seed in July, 1950, Iowa State College photos.

are needed they can be borrowed from the bank with a spade. If a large quantity is to be used, an area may be plowed at a depth of three to four inches and a sharp disk used to cut into small chunks. Heimann found that three-inch pieces of sod, or even smaller, were as satisfactory as larger pieces. When a considerable job in gully control with sod pieces is to be done the sod can be loaded on a wagon, truck or manure spreader with a tractor scoop.

Planting the sods in gully bottoms is a hand job because of inaccessibility with farm equipment. It is best to plant the sods in the spring or fall when the soil is muddy or soft. This is best done with a spade. Push the spade down to a depth of several inches and then push the handle forward to form a V-shaped slot. Drop a small piece of sod in this slot and step on it, pulling out the spade. Now tramp the sod in firmly with the heel. Best results are obtained when the top of the sod piece is placed one to two inches below the general level of the soil surface. This prevents the sods from being washed out before becoming adequately rooted. The practicability of stopping gullies with this grass is illustrated by the following from Forage Notes:

Ben Foecke, ... in Lee county, (Iowa) fought diligently through 30 years to control gullies. And all the time new ones were forming and the old ones getting deeper and wider. Then came Reed canarygrass. Mr. Foecke ... was one of the first to get some of that Reed canary seed from the Farm Bureau office back in 1945. He seeded a narrow strip by the fence near the barn. And from that little strip, totaling only a few square rods, came the sod pieces which in the past 4 years have stopped and healed the gullies formed through all the years since this rolling farm land went under the plow. ... And with a very minimum of labor and

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FIG. 26.5 "Heiman found that 1-inch pieces of sod or even smaller were as satisfactory as larger pieces . . . a hand job . . . spring or fall . . ." (See p. 322.) Reed Canarygrass, established at the upper end of an 80-rood gully, shattered seed which established "downstream" this dense, leafy, hip-high waterway cover. Iowa State College photo.

Importance and Use

expense. On all parts of the farm, from small insignificant gullies, caught and stopped as they are formed, to big gullies that were dividing fields—unpassable—we saw the characteristic growth of Reed canarygrass . . . basal leaf growth so dense that it slows down any running water to a walk, sifting out any soil that may come that way . . . . When we asked how it had been done the answer was "Well, every 20 to 50 feet we put in a row of small pieces of Reed canary sod across the gully. We probably did most of this in the spring, as other work permitted. But we also did some at different times in the early fall. Grass was established in most of these gullies by spading it up, with a wagon or truck taking it to the gully where the work was progressing. The past couple of years we found that a manure loader scoop on the tractor could be used for this job. For gullies near the sod bank we would transport right in the scoop. Otherwise we dumped into the truck or the manure spreader and moved it to the gullies to be controlled. It surely cuts the labor to the minimum.

Where large gullies are filled and shaped into waterways, with seedings difficult to establish, reed canarygrass sods have been found to successfully prevent the central portion of the waterway from eroding or gullying. These sods can well be applied with a manure spreader on the center portion of waterways at the rate of fifteen to twenty tons per acre. They should be disked in to cover, and the area rolled to firm and make good contact. An adapted grass waterway mixture is seeded at the same time over the entire waterway area.

Reed canarygrass will send out roots and shoots from well-jointed culms that have been covered with one to two inches of moist soil.15 17 This provides another means of establishing reed canarygrass vegetatively in gullies and waterways. Some have used fresh cut, well-jointed reed canarygrass in ditch bottoms, getting it tramped into the wet soil immediately by horses and cattle.

17 Heath, Maurice E. Reed canarygrass propagated from green hay or cuttings. Forage Notes 2:90, 1947.
Fig. 26.6 "Then came reed canarygrass... from that little strip... sod pieces which in the past four years have stopped and healed the gullies formed through all the years since this rolling farmland went under the plow... very minimum of labor and expense... gullies that were dividing fields... leaf growth so dense that it slows down any running water to a walk, sifting out any soil that may come that way." (See p. 322.) Four years before this was an uncrossable gully, but now a reed canarygrass waterway, established with small sod pieces. Iowa State College photo.

VARIETIES AND STRAINS

There are two improved varieties. The Superior strain was developed in Oregon for use on upland sites. It is reported to show somewhat less tendency to shatter the seed; also to make a somewhat shorter growth than the commercial unimproved reed canarygrass. Ioreed, developed at the Iowa Station, was released in 1946. It is a recombination of the best selections from a large number of sources compared through a period of years and the best from Iowa selections. A considerable amount of improvement work is under way at different stations in the area of adaptation. Because of the variability of this species there appears to be opportunity for improvement by plant breeders.

CULTURE AND MANAGEMENT PRACTICES

There are three times during the year when reed canarygrass can best be seeded: spring, late summer, and late fall just when the ground is freezing. Usually a late summer seeding is best on poorly-drained areas, or on overflow creek and river bottom areas. Such areas can be worked when dry and the weed competition reduced to a minimum. When field conditions permit and weed competition is not a serious threat, spring seeding is satisfactory. Late fall seeding is advisable on some of the poorly-drained areas. The seed do not germinate until spring, when they produce seedlings very early.

A well-prepared seedbed is recommended. Much seed has been wasted by broadcasting on weedy, swampy areas. A few farmers have established stands in this manner but many have failed. When possible, prepare a good seedbed, similar to that for other grasses or legumes. If a late summer seeding is planned, try to plow the area four to six weeks in advance of seeding and fallow to kill weedy grasses and accumulate seedbed moisture.

When soil crusting is not a hazard, the use of the cultipacker roller is strongly recommended. The seedbed is firmed and grooved with a cultipacker, after which the seed is broadcast. To cover the seed and firm the soil about it, cultipack the field again.

A pound of reed canarygrass contains approximately 575,000 seed. When good seed is used, 80 per cent or better in germination, a seeding rate of 5 to 8 pounds per acre on a good firm seedbed is adequate. Much of the seed available is low in germination. Make sure of the vitality before seeding.

Reed canarygrass can be seeded with the ordinary farm seeding equipment such as the end-gate seeder, the drill, and the hand-operated tinhorn and cyclone seeders, as well as the more recently de-
developed precision all-purpose cultipacker seeder.

SEED PRODUCTION

The order of maturity of reed canarygrass seed is from the top of the panicle downward. The first seed to mature shatter before the bulk of the crop is far enough along to harvest. There is a period of only two or three days between the ripening of the first seed and the time when so much of the seed will have fallen to the ground that it is not worthwhile to continue harvesting. This factor partially accounts for the high price of seed. Schoth has reported that until 1924 most of the seed handled by dealers was imported from Europe. Since then much has been harvested in the United States. Seed is harvested both with machines and by hand. The heads are cut off with as little of the stems and leaves as possible. They are then spread out and dried before threshing. When harvested by hand, the heads are either stripped or are cut with a sickle or knife and placed in bags for drying.

The Wisconsin Station has reported the use of a header-like device made from a grain binder. The seed is threshed and immediately spread on a barn floor, where it is turned frequently. The Soil Conservation Service in cooperation with the Iowa Station successfully used a combine to harvest reed canarygrass seed. The combine was used as a header with the elevator canvas removed. More seed was obtained when the crop was headed than when combined direct. Experience would indicate that one cannot handle more than about five acres with a small combine because of the limited time elapse before the crop shatters.

Other Canarygrass Species

The largest seed yields were obtained by growing in either 36 or 46 inch, clean-cultivated rows, and applying 200 pounds per acre of 33-0-0 nitrogen fertilizer annually following the first seed harvest. The row yields for two years averaged 205 pounds per acre as compared to 57 pounds obtained when grown in 7 inch drills. The latter is comparable to broadcasting.

Small areas can be harvested by hand. As many heads as can be grasped in one hand are cut at one time with a knife or sickle. It is well to keep the heads in an upright position until they are dropped in the container in order to minimize the loss by shatter.

Old binders have been satisfactorily rebuilt by removing the knives and guards and gearing up the reel so it will operate at a rapid rate and beat out the ripe seed. The seed drop directly from the reel into a tight box on the platform. With proper height adjustment of the reel, little damage will be done to the standing crop and the operation can be repeated two or three times as the seed ripens.

OTHER CANARYGRASS SPECIES

Canarygrass, *Phalaris canariensis*, is an annual grown for bird food. The name
Reed Canarygrass

“canarygrass” is believed derived from the use made of this species. It is important to distinguish reed canarygrass, the perennial, from canarygrass, the annual.

Ribbongrass, *Phalaris arundinacea* var. *picta*, is a mutation of reed canarygrass. The blades are striped with white. It is commonly grown as an ornament in flower gardens and on home grounds.

Hardinggrass, *Phalaris tuberosa* var. *stenoptera*, is being grown in the Southwest and in southern California under irrigation in forage mixtures for hay and pasture. On unirrigated pastures and ranges on the lower to the middle elevations in all but northeast California, it provides an extension of green feed in the spring and fall. Hardinggrass has a more compact seed head than reed canarygrass and the seed shatters less freely.

**QUESTIONS**

1. Discuss the principal uses of reed canarygrass.
2. Describe in detail how reed canarygrass is best used for gully control.
3. Why is it desirable when possible to grow a legume in combination with reed canarygrass?
4. In what areas of the United States and Canada is reed canarygrass best adapted? Why?
5. Compare the nutritional value of reed canarygrass with some of the forages commonly grown in your area.
6. Why is reed canarygrass difficult to harvest for seed?
7. Why is reed canarygrass valuable on overflow land?
8. What is meant by a “sod-bank”? Of what value is a sod-bank to a farmer?
According to Hoover, et al., there are about 100 species of fescue in temperate or cool zones. They vary in texture and growth. Some are annuals, some perennials; some are low and others are tall. Different ones are fine, coarse, tufted, creeping, erect, and so on.

Two perennials, meadow fescue, *Festuca elatior,* and tall fescue *Festuca elatior* var. *arundinacea,* are the most important for agricultural use. Tall fescue grows under a wider range of conditions than meadow fescue, is more rust resistant, and maintains stands longer. Because of improvement and increased use of tall fescue, meadow fescue is of less importance than formerly. For these reasons, only very minor consideration is given in this chapter to species other than tall fescue.

**TALL FESCUE**

Tall fescue, *Festuca elatior* var. *arundinacea,* is a sub-species of meadow fescue and is much like it in general appearance. It grows under about the same soil and climatic conditions as meadow fescue. Tall fescue was introduced from Europe, probably at about the same time as meadow fescue. Two new strains, Alta and Kentucky 31, have aroused new interest in tall fescue. Alta was selected from a stand of tall fescue in Oregon in 1923. Kentucky 31 is an increase from tall fescue found on the farm of William Suiter in eastern Kentucky, where it has grown for more than 60 years. These two tall fescues are very similar and appear to be adapted to about the same soil and climatic conditions.

**Distribution and Adaptation**

Tall fescue is distributed to some extent over most of the humid portions of the United States and in irrigated areas of the Southwest and the Pacific Northwest. Largest acreages are in the humid parts of the Pacific Northwest, in the Southeast, and in the Western Gulf States. The acreage in the nine Southeastern States is reported to be over the half-million-acre mark, most of which was seeded in 1949. Also, about 100,000 acres is estimated to have been seeded in the Western Gulf States, most of it in 1949. The acreage of Alta fescue in Oregon was estimated by Rampant to be more than 50,000 acres in 1945, and was

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increasing rapidly.\textsuperscript{2} The greater part of the fescue in the Southeast and the Western Gulf States is Kentucky 31. Most of that grown elsewhere is Alta.

Tall fescue is adapted to a wide range of climatic conditions. It is affected more by moisture than by temperature. It grows under irrigation from the hot interior valleys of Arizona and California to the high mountain valleys of Colorado. In the East, it grows from Florida to Maine. There is no specific rainfall that is known to be the minimum. In Oregon, tall fescue is grown for forage where the annual rainfall is 15 inches or more and the elevation under 5,000 feet. In the Western Gulf States, on the other hand, it usually is not recommended for uplands in areas of less than 35 inches of rainfall.

It grows best on rich, moist soils, heavy to medium in texture, and is a good grass for wet land. It is adapted to claypan and other shallow soils that are extremely wet during rainy seasons and dry at other times. Under irrigation it is more tolerant of alkaline and saline salts than most of the other pasture grasses. It is not well adapted to extremely light soils, but has grown satisfactorily on moist lowlands and sandy loam uplands in the Coastal Plains of the Southeast.

\textbf{Plant Description}

Hoover describes tall fescue as a deep rooted perennial with stems 3 to 4 feet high, erect and smooth.\textsuperscript{1} The numerous dark-green basal leaves are broad and flat, the sheath is smooth, and the ligule short. The nodding panicle head is 4 to 12 inches long and has lanceolate spikelets, 1/2-inch or more long, and many-flowered. It flowers in June and July, except that in the lower South it is in late May.

Tall fescue can be distinguished from meadow fescue by its greater height, its broad leaf, and the deep green of the upper surface of the leaf, which is prominently ribbed and rough.

In old stands it develops a complete sod. The roots are numerous and coarse. Tall fescue has a long growing season and remains green during the entire year if it has sufficient moisture and nitrogen.

Little research has been done on nutritive value, and conclusive results are not yet available. The nutritive value no doubt depends to a great extent on the legumes grown in association with fescue and on fertilizer treatment. Farmers who have pastured cattle on fescue and Ladino clover, or other legumes on well-fertilized land, report good production of beef and milk.

There is a wide variety of opinion about the palatability of tall fescue. Saxby describes it as one of the worst weeds of high-fertility swamp country in New Zealand.\textsuperscript{3} He calls it a poor quality grass that, although eaten to a certain extent by cattle, affords little more than a starvation or maintenance diet. A different opinion has been given by farmers in the nine Southeastern States. Pasture experience results of 208 farmers who pastured livestock on 3,226 acres of fescue have been summarized and reviewed. Grazing usually was during the winter and spring while the grass was green and succulent. Almost without exception these farmers expressed satisfaction with the way the different kinds of livestock grazed tall fescue.

The palatability of tall fescue appears to be determined largely by the condition of the plants. Green, succulent plants are palatable. Coarse plants, or those that are starved for nitrogen, are less palatable.


Importance and Use

The importance of fescue varies widely from one section of the country to another. It is used extensively in irrigated pastures of the Pacific Northwest. It is also one of the more important grasses in non-irrigated pastures west of the Cascade Mountains in Oregon and Washington and in the northern coastal areas of California. It has not been used extensively in irrigated pastures in the Southwest. Observational plantings in Arkansas, Louisiana, and the eastern parts of Texas and Oklahoma indicate that tall fescue may become an important pasture grass in these areas. Tall fescue is of minor importance in the Northeastern States and in the central Corn Belt and Lake States. It probably will have its greatest value and use in the Southeastern States.

Use in Irrigated Pastures. Tall fescue probably is the best grass available for soils that are poorly drained in irrigated pastures of the Northwest. It is used in pasture mixtures in irrigated pastures from southern California to northern Washington. Its ability to grow on wet soils, its tolerance of alkalinity and salinity, and its heavy turf make fescue a good grass for these sites.

Use on Wet Lands. Tall fescue is filling an important place in land use planning in several humid parts of
The Fescues

The country. Its heavy root system and vigorous top growth make a strong turf that holds animals up on wet lands where other sods are too light to support them. It grows on claypan and other shallow soils that at certain seasons are too wet or too dry for other grasses.

WATERWAY PROTECTION. Natural depressions through fields are the logical sites for grassed waterways into which water from terraces empties. These waterways often are too wet for other pasture grasses. Tall fescue sod, anchored firmly by its deep roots, offers more resistance to flowing water than most other grasses. Where waterways can be pastured in the winter and spring, legumes are mixed with tall fescue. In areas where waterways cannot be pastured, tall fescue is usually seeded alone and fertilized with nitrogen to keep the sod in vigorous condition.

IN UPLAND PASTURES. Tall fescue is well adapted on the medium- to heavy-textured upland soils of the Southeast. Its vigorous, deep roots and basal leaf growth make effective ground cover that protects the surface of sloping land from erosion. When grown in association with legumes on these sloping uplands, tall fescue makes good pasture.

TALL FESCUE FOR HAY. Tall fescue is primarily a pasture and soil conserving plant, but it is used also for hay. Rampton reports hay yields of 1 to 2 tons per acre on farms. Higher yields were made at the Eastern Oregon Livestock Experiment Station at Corvallis. The six-year average yield of 4.8 tons per acre from Alta fescue was the highest of the several grasses tested. The leafy growth that is left after seed harvest often is mowed for hay. Such hay is coarse and not too palatable but animals eat it in winter. Hay of this kind has value for feeding in pastures while cattle are grazing Ladino clover, alfalfa, or any of the other legumes that may cause bloat. Animals that graze green clover usually will take enough of the dry hay to reduce the danger of bloat.

IN CROP ROTATIONS. Tall fescue has been used to a very limited extent in rotations on sloping cultivated land. This grass gives almost complete protection to the ground surface. Its strong, coarse roots penetrate deeply into the soil and improve its physical structure. Both roots and tops rot slowly after the sod is plowed. The coarse, slow-decaying sod gives extra protection to the plowed soil during the spring and summer while it is being cultivated. A legume must be grown with tall fescue in rotations so as to add nitrogen, along with the organic matter from the grass. Ladino clover grows well with tall fescue on cultivated land that is at least moderately produc-
tive. Red clover with tall fescue fits into rotations where sod is to remain only 2 years. Where rotations are to be extended over more years, a light seeding of Ladino with the red clover fills in after red clover fades out. Fescue-clover rotations furnish winter pasture for livestock in areas where weather permits grazing. Fescue-sericea mixtures also can be used in rotations.

**Varieties and Strains**

There are only two well-known varieties or strains of tall fescue. These are Alta and Kentucky 31. Alta is grown more extensively than Kentucky 31 in all parts of the country except in the Western Gulf States and in the Southeast. These two tall fescues are very similar, neither having shown any marked superiority over the other.

**Cultural and Management Practices**

**SEEDBED PREPARATION.** The most uniform stands of tall fescue have come where it was planted on well-prepared, firm seedbeds. Where soil conditions require plowing, the land should be plowed and harrowed several weeks before seed is planted so that the soil may be settled by one or more rains. Where seed is to be planted on a new seedbed, cultipacking before and after seeding helps to get a stand.

**HOW AND WHEN TO PLANT.** More uniform stands have resulted from drilled than from broadcast seedings. When sowing broadcast, it is a good idea to distribute half the seed in one direction and then cross sow with the second half. This gives a more uniform distribution than is possible where all seed is sown in one direction. Cover the seed by light harrowing and then firm the soil with a cultipacker.

In drilled seedings, 6 to 8 pounds per acre will give a good stand. Ten pounds gives plenty of plants in a broadcast seeding where seed is distributed uniformly and the soil is firm by a cultipacker following the drill. Heavy rates of grass seeding often crowd out legumes.

Fall seeding, that allows seedlings to develop good roots the following spring, is preferred in the South. The principal objection to spring seeding is the competition by weeds and crabgrass during the first spring and summer.

**SEEDING MIXTURES.** Tall fescue for pasture nearly always is sown with a legume. Legumes add to the nutritive value and palatability of the forage and supply at least a part of the nitrogen that is needed to keep the grass green and succulent. Ladino clover is the best legume to seed with tall fescue on good soils where adapted. Ladino grows vigorously on moderately wet soils. Other white clovers also grow satisfactorily in mixtures with fescue. Alsike may be seeded on some of the wetter soils, but it makes less forage than Ladino and is not widely used. Red clover sometimes is mixed with tall fescue on well-drained soils, with a very light seeding of Ladino added, so that it may fill in as red clover goes out at the end of the second season.

The reseeding crimson clovers, subterranean clover, wild winter peas, vetch, and annual lespedeza are some of the more important of the other legumes that have been used in mixtures with tall fescue on soils and under climatic conditions where they are adapted. Ramppton reported that under the general conditions on the unirrigated lands of western Oregon, subterranean clover of the Mt. Barker midseason strain, or the Tallarook late strain, performed well in combination with Alta fescue.
Sericea and tall fescue appears to be one of the best pasture combinations for vast acreages of upland where shallow-rooted legumes suffer during periods of summer drought. The best method of establishment is to sow sericea first and drill the fescue after a rain the next fall, or in the fall of the second year. If sericea is grazed down or is mowed for hay before seeding tall fescue, the seed can be cut in with a drill. Tall fescue usually makes moderately weak growth on such soil the first year, but develops vigorous plants by the second year when seeded on sericea.

**Liming and Fertilizing.** Lime and fertilizer must be applied on soils where needed, if tall fescue is to grow satisfactorily. Since tall fescue usually is grown with a legume, the lime and fertilizer requirements for the legume must be met. Vigorous, well-fed legumes usually stay in a mixture with tall fescue. Weak, starved legumes fade out. Best results with tall fescue-legume mixtures in the South have been where liberal applications of complete fertilizer were used to start both grass and legume plants in vigorous growth. Annual applications of phosphate and potash to maintain vigorous stands of legumes were made the second and succeeding years. Further experience will show whether nitrogen fertilizer will be needed to maintain tall fescue in mixtures with legumes.

**Grazing Management.** New stands are often weakened by overgrazing and trampling the first winter after planting, while the ground is wet. In the South, tall fescue seeded in early September often grows to a height of 5 inches or more before Christmas. Light grazing, while the ground is dry and firm, does no serious damage to these new grass stands. Close grazing and heavy trampling before a good sod develops retard root development and reduce plant vigor.

Tall fescue withstands heavy grazing for short periods, but continuous close grazing weakens the plants. Limited trials in the southern part of the Corn Belt indicate that the greatest value is obtained from tall fescue pasture by grazing very heavily in the spring and

![Fig. 27.3 Dairy cows on a mixture of tall fescue and sericea near Huntsville, Ala. Seeded in the spring of 1947. View in September, 1948. S.C.S. Photo.](image-url)
early summer, not depending upon it for grazing for a period of more than 5 or 6 weeks. Numerous observations in pastures in the Southeast have led to the opinion that the majority of tall fescue plants should have as much as 2 to 4 inches of top growth at all times.

Tall fescue used for winter pasture in the South should go into the winter with 8 inches or more of leafy growth. It furnishes little feed during the winter if grazed closely before cold weather begins.

**Seed Production**

Rampton says Alta fescue seed yields in Oregon have varied from 50 to 1,200 pounds per acre. Kentucky 31 fescue has produced as much as 1,000 pounds of clean seed per acre at the Soil Conservation Nursery, Sandy Level, Va. This exceptional yield was from grass planted in rows 33 inches apart, liberally fertilized, and cultivated. Row planting also has been favorable for seed production in Oregon. Much of the grass grown for seed in the South was drilled with grain drills, with all seed spouts open. Yields of 500 pounds per acre have not been unusual.

Tall fescue for seed should be planted on clean land. Seed of ryegrass, cheat, and such weeds as wild onion are highly undesirable in a fescue seed crop.

Most seed producers prefer to plant tall fescue alone and apply commercial
nitrogen, instead of growing in mixtures with legumes. Liberal applications of nitrogen are needed for maximum seed production. A complete fertilizer in the fall followed by nitrogen fertilizer in the spring gives good results.

Tall fescue seed is often combined direct, like small grain. Others cut the grass when the seed is mature, bind it, dry it in small shocks, and thresh from the shocks with a separator. Some pull combines alongside the rows of shocks and fork bundles from shocks onto the combine. This reduces to a minimum the loss of seed from shattering. Tall fescue seed shatters easily if allowed to get fully ripe and brown before harvesting. Direct combining is done as soon as the seed are ripe enough to shatter freely. Most seed that is harvested by direct combining has enough green seed to require drying before it is stored. Some growers have access to driers and cleaners through which they can process their seed immediately after combining. Others spread the seed over a floor and keep it stirred until dry enough to store.

After the tall fescue seed crop is harvested, the plants should be mowed as closely as possible. The new growth provides good pasture during the fall and early winter. The time stock are removed from seed fields varies in different parts of the country. In Oregon, seed fields are pastured until late fall. In the South, pasturing often is continued until early spring. Late pasturing reduces seed yields.

OTHER SPECIES

In addition to the tall fescue, there are three others which should have mention here—meadow fescue, sheep fescue and red fescue.

Meadow Fescue

According to Piper, meadow fescue, Festuca elatior, occurs naturally over all of Europe and in much of temperate Asia. Meadow fescue is a tufted, deep-rooted, long-lived perennial. It produces an abundance of dark green leaves on sterile shoots and comparatively few culms or fertile shoots. The sterile shoots are about four times as numerous as the fertile ones. The culms are not very leafy, and usually grow to a height of 18 to 24 inches. It has no rootstocks and is not bunchy, but makes a fairly good sod.

Meadow fescue is adapted to about the same conditions as timothy, but grows somewhat further south and west and stands more heat and drought than timothy. It prefers rich, moist soils, but does not grow well in sandy land. It is used for both pasture and hay, but is better adapted for pasture than for hay.

Meadow fescue has never been used extensively in American agriculture. At one time, production of seed for export to Europe was rather extensive, but fluctuation in yield and prices led to a larger utilization of meadow fescue for hay and pasture. In areas where adapted it has been used in pasture mixtures on wet land. The introduction of better varieties of tall fescue has tended to reduce the use of meadow fescue.

Sheep Fescue

Hoover states that sheep fescue, Festuca ovina, probably is a native of the Northern Hemisphere. It is a bunch grass that forms dense tufts with numerous stiff, rather sharp, bluish-gray leaves. It is adapted to about the same climate as bluegrass and can be grown in the most northern agricultural areas. It succeeds better than most grasses on sandy or gravelly soils. Cattle and sheep will graze sheep fescue but it is not gen-

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eraly recommended for pastures, being rather unpalatable. Its greatest use is for making a durable turf on sandy soils. The usual rate of seeding is 25 to 30 pounds per acre.

Red Fescue

Red fescue, *Festuca rubra*, resembles sheep fescue, but its leaves are a bright and darker green. Commercially, there are two distinct forms, red fescue and Chewings fescue.

Red fescue is a creeping grass, although this characteristic is variable. This may account for the common name creeping red fescue.

Chewings fescue is tufted and does not creep. Both red and Chewings fescue are considerably like sheep fescue and used mainly for lawns and turf. They are especially adapted to shaded, dry sites. They are used to a considerable extent for roadside revegetation in the Northeast.

QUESTIONS

1. In what areas is tall fescue grown most extensively?
2. What are the soil and climatic requirements of tall fescue?
3. Under what conditions is tall fescue likely to be most palatable?
4. What are some of the advantages of tall fescue in crop rotations in the South?
5. How and when would you seed tall fescue for pasture?
6. What legumes would you seed with tall fescue in your locality?
7. Discuss the lime and fertilizer requirements of tall fescue in mixtures with legumes and in pure stands for seed production.
8. Discuss grazing management for a new seeding of tall fescue.
9. Discuss tall fescue seed production.
10. Under what climatic and soil conditions is meadow fescue adapted?
11. Discuss soil requirements and use of red fescue.
The common name, ryegrass, applies in general to two primary cultivated species of the genus Lolium. One of these, Lolium multiflorum Lam., is most commonly known as Italian ryegrass, and the other, Lolium perenne L., as perennial ryegrass. In the United States, most of the L. multiflorum is known and marketed as common ryegrass. Much of the L. perenne is quite commonly referred to, and occasionally marketed, as English ryegrass. Many selections and hybrids of these two species have been developed and given special varietal names, or other designations, and seed of some of these is offered in the trade under such designations.

Italian ryegrass is native in the Mediterranean regions of Southern Europe, Northern Africa, and Asia Minor. History indicates that it was first cultivated in Northern Italy. It is not definitely known when it was first introduced into this country, but probably in Colonial days. According to meager information available, its introduction to the Pacific Northwest, where it is most extensively grown at present for seed production, apparently was late in the nineteenth century.¹

Perennial ryegrass is a native of all temperate Asia and North Africa. According to history it was the first perennial grass to be grown in pure culture for forage in North Europe. Its date of introduction into this country in all probability was at about the same time as that of Italian ryegrass. In the Pacific Northwest, where its culture is most concentrated for forage and seed production, its introduction apparently was at about the same time as for Italian ryegrass.

It appears that for many years after the introduction of these two ryegrasses their use was limited. There has been a rapid increase in use throughout much of the country during the past twenty years.

**DISTRIBUTION AND ADAPTATION**

The ryegrasses are not as winter-hardy as many other grasses, including orchardgrass and timothy. In the United States they are grown principally in the Pacific Coast States west of the Cascade and Sierra Nevada mountains and in the

southern humid states. During recent years their use has extended northward along the Atlantic Coast and in other locations where winter temperatures are reasonably mild, or where a uniform snow cover prevails through the winter months.

The ryegrasses have a wide range of soil adaptation. For most satisfactory production, however, they require soils of medium to high fertility. They make fair growth on soils of low fertility, but to develop good vegetative cover on such soils, heavier seedings are necessary. They will stand fairly wet soils where there is reasonably good surface drainage. They do not endure stagnant water. They are not dryland grasses and basically are not adapted to regions which have climatic extremes of cold, heat, or drought.  

**PLANT DESCRIPTION**

Italian ryegrass is commonly considered an annual. Under some conditions it assumes a biennial or even at times a short-lived perennial habit. It develops a rather distinct bunch type of growth where individual plants have room for expansion and growing conditions are good. It grows from 2 to 3 feet tall, is leafy and tender. The leaves are rolled in the bud, dark green, and smooth. The stems are cylindrical. The seed heads, or spikes, are slender and usually weak, with the several seed borne in groups on opposite sides of the stem. The seed have awns of varying lengths.

Perennial ryegrass is quite similar to Italian ryegrass. As its name indicates, it is perennial but short-lived. It is quite distinctly bunchy under any conditions. It grows from 1 to 2 feet in height and is leafy. The leaves usually are short, smooth, and quite stiff. They are folded in the bud. The seed spikes are slender and rather stiff with the several seed borne in groups on opposite sides of the stem. The seed are awnless.

**IMPORTANCE AND USE**

Both of the primary species of *Lolium* are of considerable importance to American agriculture. Italian is by far the most important and is gaining where perennial appears to have about reached its crest.

Italian ryegrass is rapidly increasing in importance as a forage, soil improvement, erosion prevention, lawn, putting green, and seed crop in the United States. Its primary forage use is as pasture. For temporary pasture it usually is seeded alone, or seeded in combination with winter grains. It makes a desirable bottom grass and increases the length of the grazing season. When seeded in combination with long-lived pasture plants it results in a quick cover for early grazing. For temporary or rapid-rotation poultry range it fits in well.

Increased use is being made of Italian ryegrass for interseeding between row crops in the fall for use as late fall, winter, and early spring pasture and cover crop. It has value as a soil improver in that it produces considerable organic material to turn under, especially when grown on reasonably fertile or well fertilized soil. Its rapid growth also makes it a good soil stabilizer on sites where erosion may occur.

In the South, it is used extensively for fall seeding on permanent lawns, or as a nurse crop for permanent lawns. Even though short-lived, it is being used for putting greens because of its rapid growth and quick comeback from reseeding.

The increased use of Italian ryegrass can be visualized from the fact that some
25 years ago we produced only 1 or 2 million pounds of seed, whereas the 1950 production was over 75 million pounds, practically all of which will be used in this country.

The production of perennial ryegrass seed 25 years ago was about one-half million pounds. The 1950 production was between 6 and 7 million, mainly used for permanent pasture seedings, prevention of soil losses, and to a limited extent for lawns.

Practically all the seed of both the Italian and perennial ryegrass is produced in the Pacific Northwest, mostly in western Oregon.¹

VARIETIES AND STRAINS

During recent years a large number of varieties and strains of both major species of *Lolium* have been developed or segregated. Because of the free cross-pollinating habits of both species, numerous types develop naturally. Many of these types have been segregated in several countries, particularly the British Isles, Sweden, Denmark, Australia, and New Zealand. Segregation has been primarily for a particular utility, soil, or climatic condition. None of these have thus far gained any prominence in the United States.

By far the most commonly used ryegrass is the strain of *Lolium multiflorum* grown primarily in western Oregon and quite generally referred to as Domestic ryegrass, although marketed under the name of Common ryegrass. It also is referred to as “Native” and as “Oregon ryegrass.” It is conveniently classed as a variety of Italian, but probably can be considered only as an agricultural variety. The seed and plant characteristics indicate a combination of characters of both *L. multiflorum* and *perenne*. The plants are mostly annual. The seed are short-awned, in comparison to the true Italian which has rather long awns.

The type of *L. perenne* generally used in the United States is the seed of which is produced mostly in western Oregon and Washington.

Certified seed of *L. perenne* is produced in the Pacific Northwest. There is no certification of seed of *L. multiflorum*, common ryegrass.

CULTURAL AND MANAGEMENT PRACTICES

Ryegrasses can be seeded either in the fall or in the early spring. In sections where winters are severe, seeding is in the spring. Where winters are mild, early fall seeding is advisable. Late fall seedings usually are successful, but severe freezing, especially when accompanied by soil heaving, may cause heavy plant loss. Spring seeding should be as early as possible and is most successful in sections having cool summers and frequent rainfall.

Ryegrass seed may be broadcast by hand or with an endgate seeder and covered with a smoothing harrow. It also is sown with a grain or grass-seed drill. The seed should be covered preferably to a depth of approximately one-half inch. When seeded alone for forage or seed the use of 20 to 25 pounds of seed per acre is recommended. When seeded with small grain for annual pasture, 8 to 10 pounds per acre will furnish a satisfactory stand. When seeded in mixtures with other grasses and legumes the rate is usually 4 to 5 pounds per acre. For erosion control the field rates of seeding usually are doubled. When used for seeding on established grasses to furnish green lawns for winter, or when seeded alone in spring or fall for a temporary lawn or putting greens, the rate is 3 to 5 pounds per 1,000 square feet.

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The seedbed preparation is similar to that for small grains. Seedings made for forage or seed production usually are without a nurse crop although in the Pacific Northwest the practice of seeding with winter oats is increasing. When seeded with oats, which should be at the rate of 1 bushel to 20 or 25 pounds of rye-grass per acre, there seems to be little or no reduction in the yield of rye-grass seed; a fair yield of oats and a good yield of rye-grass seed usually is obtained. The two crops are harvested together. Oats and rye-grass seed are separated with a fanning mill.

MANAGEMENT

Rye-grass is generally cut for hay when the seed is in the soft-dough stage. The hay cures rapidly and when handled properly has a bright green color. Because of its leafiness and medium fine stems it makes a high quality hay that is considered excellent for horses and also is fed successfully to cattle and sheep. One crop of hay is obtained. Under favorable soil and moisture conditions considerable pastureage may be produced after the hay crop is removed.

Pasture

Rye-grass makes rapid winter and spring growth. New seedings often are ready to pasture in 3 months from seeding. Unless pastured too heavily, it can be used continuously until summer in the West, and until late spring in the South. Heavy pasturing is generally desirable as it keeps the grass in succulent condition and utilizes a higher per cent of the forage during its short productive period. In early spring, when growth is especially rapid, it is often desirable to divide pasture areas into units, so that any excess feed can be harvested for hay or silage instead of being tramped down and wasted. When necessary to remove excess growth from a grazed field it is advisable to cut at least 3 inches from the ground.

For pasturage, rye-grass is not often seeded alone. Because of its rapid growth and its value in producing forage while other longer-lived plants are becoming established, it is used extensively in mixtures.

The rye-grasses respond quickly to applications of nitrogen fertilizers. The practice of fertilizing with nitrogen, in amounts determined as best by soil and climatic conditions, is increasing. Fall, spring, and split fall-spring applications are made according to the conditions prevailing.

As a Lawn Grass

Large quantities of seed of both common rye-grass and imported Italian rye-grass are used for lawns, particularly winter lawns in the Bermuda-grass area. Such seedings in the fall on other grass sod give a green, pleasing appearance during the winter months. They do not offer any interference when other grasses and legumes come into good condition.

Occasionally when the percentage of perennial rye-grass in common rye-grass seed is rather high, perennial rye-grass plants may remain for several years. Perennial rye-grass is not popular in lawns.

SEED PRODUCTION

Practically all the seed of common rye-grass is produced in the Willamette Valley in northwestern Oregon. Also a large per cent of the seed of perennial rye-grass is produced in the same area. In recent years a few Kentucky counties have produced a quantity of rye-grass seed—presumably Italian. Harvesting practices are the same as for small grains.
As the seed shatter easily, larger yields usually are obtained when the crop is cut with the binder, header, or mower when the seed is in the early hard-dough stage. Combining the standing crop when the seed is ripe enough to thresh satisfactorily often results in heavy losses from shattering. To prevent shattering, there has been a tendency to harvest the seed with a combine while it is still in a slightly immature stage. Such seed when sacked or piled in large quantities often heats and molds, with the possibility of reduced vitality.

Seed yields vary considerably. On the better soils from 1,200 to 1,500 pounds of clean seed is obtained; average yields are 400 to 700 pounds per acre. Production has been on a large scale in the Pacific Northwest for the past 22 years, and varies widely from year to year.

Rye grasses are comparatively free from disease and insect damage. Blind seed disease has caused losses of seed of perennial ryegrass in seed producing sections, but rather effective control has been developed.

QUESTIONS
1. Account for the rapid increase during the last twenty years in the use of the ryegrasses.
2. Why are the ryegrasses grown chiefly in the Pacific Coast States and the southern humid states?
3. Why is the Italian ryegrass becoming much more important than perennial ryegrass?
4. Distinguish between Italian ryegrass and perennial ryegrass in plant characteristics.
5. Although considered an annual, under what conditions would Italian ryegrass behave as a biennial or a short-lived perennial?
6. In adapted regions, how is Italian ryegrass best utilized? Perennial ryegrass?
7. What is the origin of Domestic ryegrass? How is it used in the Corn Belt?
8. Discuss cultural methods for growing the ryegrasses, including seedbed preparation, time of seeding, method and rate of seeding, and the use of companion crops.

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Agrostis is the name the botanists gave to the genus of grasses that includes redtop and the bentgrasses. It is not known for certain where the important cultivated species of Agrostis are native. They have been in use for over two hundred years. The common name "bent" is applied to all the species except the one called redtop.

There are thirty-two species of Agrostis included in Hitchcock's Manual of Grasses of the United States. Most of these are important as forage in wild meadow, pasture or range land and for lawns and putting greens.

Only the species which have been used in cultivation and the seed or stolons of those handled commercially will be considered here. These are: Redtop, Agrostis alba L; Colonial bent, Agrostis tenuis Sibth; Creeping bent, Agrostis palustris Huds.; and Velvet bent, Agrostis canina L.

Origin and History

Redtop, Agrostis alba, undoubtedly is a native of Europe, brought to America by the first colonists as hay for feed or in mattresses, or in seed mixtures. It early became naturalized in New England. The value of this grass for use in cultivation as an important meadow and pasture grass was recognized in various parts of the United States before it gained that prominence in Europe. Other common names used for redtop have been white-top, marsh bent, and Herd's grass.

Distribution and Adaptation

Under humid conditions redtop is tolerant of a wide variety of soil and moisture conditions. It grows on very acid soils, and poor clayey soils of low fertility. It will withstand considerable drought and is a good wet-land grass. However, it responds readily to fertilizer elements and lime. It is a poor-land hay crop primarily. It does not withstand continuous close grazing too well. When once established in an area it will invade adjacent areas due to its aggressiveness and often will come in where it is not desired. Piper states that it probably has a wider range of adaptation than any other cultivated grass, and that it succeeds well over most of the United

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Redtop and the Bentgrasses

States except the drier regions and the extreme South.²

Plant Description

On fertile soil, redtop grows to a height of about 3 feet; and isolated plants attain a diameter of about 3 feet. It spreads in meadows, pastures and turf by means of creeping stems. Redtop has flat, sharp-pointed leaves; the ligules are larger than on the other Agrostis species, are pointed, and about \( \frac{1}{4} \) inch long. Redtop gets its name from the color of the paniced seed heads.

Burlison indicates that fall seedings of redtop are in general superior to spring plantings for seed and hay.³ On low fertility, tight southern Illinois soils the addition of lime, phosphate, and potash increased hay yields but did not always increase seed yields. With respect to comparative feed value, when cut before too far advanced in maturity redtop compared favorably with timothy hay in composition and digestible nutrients, being slightly higher in protein and carbohydrate but lower in fats.

Use

Redtop has been one of the main constituents of pastures, and provides a considerable portion of hay in adapted areas. In the past redtop was used in mixtures with alsike, red clover and timothy. In view of recent studies and consequent utilization of other grasses and grass-legume mixtures, redtop, because of its tough and unpalatable nature, is not so popular as formerly for use in pasture mixtures or for hay.

Although redtop is often used in lawn-seed mixtures, it is not considered a permanent turf grass. In the past, when seed of redtop was much cheaper than that of the basic turf grasses such as bluegrass, the bentgrasses and the fescues, it was used to make low-cost seed mixtures. The use of redtop in a lawn-seed mixture appears questionable if a good strain of bent, such as Astoria or Rhode Island, is used in the mixture. Tests under field conditions have indicated that redtop does not germinate more rapidly than the bents, and it becomes stemmy, coarse-textured and soon dies out in the lawn under close-cut conditions.

Varieties and Strains

Plant breeders have spent their time on development and selection of other grasses, considered to be of more value for agricultural purposes, and no improved selections or varieties of redtop have been produced.

Cultural and Management Practices

Redtop is planted in mixtures with other pasture grasses and in grass-legume mixtures for pasturage and hay. It is hardly ever seeded alone except for temporary turf. Rates of seeding vary from 2 to 5 pounds in mixtures and from 10 to 50 pounds per acre when seeded alone.

Seed Production

Most of the commercial redtop seed has been produced in southern Illinois. The crop usually is harvested during the month of July, mostly by means of combines in recent years, and also by the older method of mowing, curing and threshing.

A good yield of cleaned seed is considered to be 75 pounds per acre. First-class seed has a purity of at least 90 per cent and a germination of at least 90 per cent, with 5 to 6 million seed to the pound.

The Bentgrasses

The name "bentgrass" undoubtedly was assigned in early times in England to grasses growing on bents. A bent is defined by Webster as a field; unenclosed pasture, as a common, a moor, a heath. It would seem that the word bent as related to these grasses does not mean the state of being curved, crooked, or inclined. However, Sprague states that the group of bentgrasses is so named from the characteristic position of the stems when plants are growing singly. These stems, instead of growing upright, tend to follow the ground surface for a short distance and then bend upward.

Colonial Bent

It is believed that colonial bent, Agrostis tenuis, was introduced into New England by the early colonists from England. As settlers moved elsewhere they took seed with them. Early names given the grass were Rhode Island bent, colonial bent, brown top and Burden's grass. Monteith says:

The earlier and most commonly used American name was Rhode Island bent, since in the United States seed of this grass was first harvested in Rhode Island. In more recent years, seed of this species having been raised also in other regions, seedsmen have made a practice of designating the source of origin of the seed they handle. However, a geographical name to show the origin of seed, when coupled with a geographical common name, makes a clumsy and confusing combination.

To determine upon a common name that would be generally accepted, a survey was made, which included seedsmen handling large quantities of this grass, representative greenkeepers and chairmen of green committees in the regions where the grass is used, and interested individuals at state experiment stations or other institutions. Of the 45 who expressed their choice, 40 were in favor of the name colonial bent. It was accordingly decided that the name colonial bent would be adopted by the U.S.D.A. as the common name which it would use for this grass.

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In quoting references, the author has not changed the use of the term Rhode Island bent to colonial bent, since the former holds the priority of common name for Agrostis tenuis. Thus, the two names in this respect are used here synonymously.

Colonial bent undoubtedly was taken to New Zealand from Canada via New England, or direct from the Continent, or the British Isles. Arthur, discussing New Zealand brown top, states that the species was introduced into New Zealand and that the species, New Zealand brown top, is Agrostis tenuis with its varieties. Colonial bent became naturalized in areas of well-drained soils of low fertility such as the acid, sandy loam soils in the northern parts of the United States and Canada. It also does well on heavy soils and responds to fertility. On acid soils that will not support Kentucky bluegrass or some of the other widely grown pasture grasses without application of lime, Rhode Island bent will grow with little or no attention. Much of the unimproved pastures in New England consist of Rhode Island bent. It is adapted to close cropping and to close mowing, which makes it useful for lawns, especially in mixtures with other lawn grasses.

Description

Colonial bent is much smaller in size than redtop. The stems and leaves are more delicate and finer in texture, the ligule is very short and truncate compared to the long ligule of redtop and the other bents. It grows from 6 inches to 2 feet in height.

Importance and Use

Colonial bent, according to Sprague:... is suited for lawns in mixtures with other grasses and for putting greens. It responds to close mowing by becoming more dwarfed in growth of both tops and roots, and in development of a dense sward. It is inferior, however, to velvet bent and creeping bent for putting greens and other fine turf. In contrast to creeping bent, it blends and grows nicely in mixtures with other grasses. ... Although there are many names for this grass, Agrostis tenuis, the turf produced by pure seed of any of them is essentially the same.

Plantings at the Rhode Island Station over a period of several years indicated that turf from seed of Astoria colonial bent has been indistinguishable from turf developed from seed of local grown Rhode Island bent. It appears that Astoria colonial bent is nothing more than Rhode Island bent grown in that respective area of the Northwest. Likewise, Piper noted that "... turf and plants grown from seed from New Zealand marketed under the names..."
colonial bent and browntop showed it to be identical to Rhode Island bent."\(^8\)

The so-called Highland bent, which is comparatively new in the seed trade is recognized by agronomists in the Pacific Northwest, where it is produced, as a named strain of colonial bent. The four-year average yield of seed of Rhode Island colonial bent was reported by North and Odland at 130 pounds per acre, from 1,500 pounds of a 6-6-1 fertilizer ratio.\(^9\) They stated that a fertilizer high in nitrogen, such as a 10-6-4, should prove satisfactory for general use in fertilizing Rhode Island bent for seed production and suggested an application of 800 to 1,000 pounds per acre.

South German Mixed Bent

As the name implies, this is a mixture consisting usually of about 75 per cent Rhode Island bent, 15 per cent velvet bent and 1 per cent creeping bent.\(^5\) Piper and Hillman state that South German mixed bent has been imported under various names.\(^6\) It consists of a mixture of redtop, velvet bent, and seed of undetermined fine bent, which usually predominates. Individual seeds of Rhode Island bent apparently are indistinguishable from individual seeds of the undetermined fine bent found in South German mixed seed.

Putting greens planted with seed of this mixture in the late 1890's are still in use. By virtue of the mixed seed of different species, and apparently different strains, a mottled appearance of these greens was noted—due to patches of variously colored grasses of various texture and different habits of growth. In addition, it was noted that some of the patches were less susceptible to turf diseases than others. Some of the superior strains of creeping bent selected from established putting greens by vegetative propagation by use of stolons are: Arlington, Cohansay, Collins, Congressional, Norbeck, Old Orchard, Toronto and Washington. Kernwood and Merion, velvet bent selections, are more upright growing and finer in texture than the creeping bents and not so susceptible to certain diseases. They also were selected from established greens. Little seed if any is produced from the creeping bent selections.

If a new selection is planted by stolons and maintained in a turf nursery under close-cut conditions, 1 square foot of soil when shredded into stolons is sufficient to plant from 5 to 10 square feet of new putting green. When grown in rows and not mowed closely, 8 to 10 bushels of stolons is ordinarily sufficient for 1,000 square feet of new turf.

Creeping Bent

According to Hitchcock this grass, *Agrostis palustris*, is found in marshes along the coast, from Newfoundland to Maryland, British Columbia to northern California.\(^1\) Sometimes it occupies extensive areas, as at Coos Bay, Oregon, various places in the interior of southern Canada and northern United States, and occasionally as far south as Texas and New Mexico, especially along ditches. Forms of this species, known as Seaside and Cocoses bent (propagated by seed), and Metropolitan and Washington bents (propagated by stolons, and formerly called carpet bent), are used for lawns, and extensively for putting greens.

According to Piper creeping bent is most esteemed for the beautiful fine turf it produces, superior to all other temperate grasses with the exception of velvet bent.\(^2\)

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Creeping bent gets its name from creeping stems that develop at the surface of the ground. These stems produce roots at their joints or nodes and then new plants are developed from the new shoots along the stem.

**Use of Stolons**

To plant an area by the stolon or vegetative method, Curtis and DeFrance give the following in part:

> The soil is prepared the same way as for seed, with the soil firm beneath but loose on top. If the soil is dry, the area is watered thoroughly and after the surface is dry enough it is loosened by lightly raking just before planting begins. The stolons are broadcast uniformly by hand, somewhat like seed is spread; pressed down with a light roller, and partially covered lightly by top-dressing with screened compost. For covering stolons 1 1/2 cubic yards is usually sufficient for 1,000 square feet.

The stolons should never be allowed to dry out. Light and frequent watering will insure quick rooting of the stems, development of new shoots and sod. After growth has started, frequent and light top-dressings will hasten development of the turf and help provide a smooth surface.

According to Sprague:

> "Since this method of establishing sod is several times as expensive as the planting of seed, it is usually restricted to those strains that are incapable of seed production. Since turf of equal value may be produced at far less cost by planting seed of Seaside creeping bent, there is no reason why homeowners should resort to planting stolons."

Of Seaside and other creeping bents Sprague further states:

> "All are capable of producing excellent, fine-textured turf under the close mowing practiced on putting greens and similar turf, where regular top-dressing is practiced to keep the creeping stems partially buried and well rooted. Under lawn conditions the grass tends to become matted in the course of two or three seasons, the stems are unable to make adequate contact with the soil, and hence are poorly rooted. Unless creeping bent lawns are top-dressed once or twice yearly, the surface matting becomes so pronounced and the rooting so inadequate that the turf becomes unhealthy, weak, and easily killed by unfavorable weather and other adversities. For this reason, creeping bent is not recommended for lawns and similar turf, although it is entirely satisfactory on putting greens where regular top-dressing is practiced.

Creeping bent is not well suited to shade, but is reasonably tolerant of a wide range of soil conditions. Best growth is obtained on soils of good waterholding capacity with moderate acidity, but the grass does not prefer soil acidity, despite popular theories to the contrary.

**Velvet Bent**

The aristocrat of grasses for putting greens and other fine turf areas is velvet bent, *Agrostis canina*. In a practical putting-green test by a group of golf professionals at the Arlington Turf Garden, Washington, D.C., and reported by Monteith and Welton, velvet bent received the highest rating when compared with many other grasses.\(^{11}\)

Improved selections of velvet bent, such as Piper, Merion and Kernwood, when compared with several hundred different putting-green grasses at the Rhode Island Station were found by North and Odland to give the highest estimated average turf quality on a comparative basis of color, density, texture, uniformity, and resistance to diseases and invasion of weeds.\(^{12}\)

At the Ponkapoag Golf Course near Boston, a test was made on an experimental putting green made up of various plots of the best grasses used for putting greens and fine lawns. A summary, based on the turf from a playing standpoint and appearance, showed the velvet bents were superior to other grasses used in the test.

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TABLE 30.1
COMMON AND SCIENTIFIC NAMES, NATIVITY, AND WHETHER THEY ARE BUNCHGRASSES OR SOD-FORMING, OF FIVE PROMINENT SPECIES OF WHEATGRASS

<table>
<thead>
<tr>
<th>Name</th>
<th>Common Scientific</th>
<th>Native, or Introduced</th>
<th>Bunch, or sod-forming</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crested wheatgrass</td>
<td><em>Agropyron cristatum</em></td>
<td>Introduced</td>
<td>Bunch</td>
</tr>
<tr>
<td>Intermediate wheatgrass</td>
<td><em>Agropyron intermedium</em></td>
<td>Introduced</td>
<td>Bunch</td>
</tr>
<tr>
<td>Quackgrass</td>
<td><em>Agropyron repens</em></td>
<td>Native</td>
<td>Sod-forming</td>
</tr>
<tr>
<td>Western wheatgrass</td>
<td><em>Agropyron smithii</em></td>
<td>Native</td>
<td>Sod-forming</td>
</tr>
<tr>
<td>Slender wheatgrass</td>
<td><em>Agropyron pauciflorum</em></td>
<td>Native</td>
<td>Sod-forming</td>
</tr>
</tbody>
</table>

**PLANT DESCRIPTION**

The wheatgrasses are mostly perennial, either with or without running rootstocks or rhizomes. The grasses with rootstocks form a tough sod resistant to soil erosion, thus giving them additional value. Those with a fine, fibrous root system grow in bunches which enlarge by tillering, and may be less effective in controlling the movement of soil by either water or wind.

Table 30.1 shows, for five prominent species, their common and scientific names, whether they are native or introduced, and whether they are bunchgrasses or sod-forming.

Most wheatgrasses produce an abundance of seed which with favorable moisture conditions germinate readily even at relatively low temperatures. This ability to germinate during cool, moist, early spring weather gives the young seedlings a better opportunity to become established in competition with other grasses and weeds.

The germinating seedlings of most wheatgrasses are tiny, with fine, slender leaves, making them difficult to find, especially if plantings have been made in stubble or in a weedy seedbed. Farmers and ranchers have plowed up thousands of acres seeded to crested wheatgrass because they were not able to detect a sufficient stand of seedlings to produce a satisfactory crop.

**IMPORTANCE AND USE**

Adapted wheatgrasses provide an important source of palatable and nutritious feed for livestock, whether used for pasture or harvested and fed as hay. When pastured in early spring, high production of palatable leaves rich in protein during a season when most needed by grazing livestock is extremely valuable. Richards and Hawk, after detailed studies of various grasses for sheep hay and pasture, point out that palatability along with yield, adaptability to soil and climatic conditions, and contemplated forage and conservation use affect the final selection of a grass.

Because of seedling vigor and the ease with which stands may be established, certain of the wheatgrasses are being used extensively in Canada and in the Intermountain States for revegetating lands abandoned from crop production. They also are used to revegetate grazing land on which the native grass cover has been depleted. If soil moisture is present at seeding time, good stands may be obtained by drilling into weeds or small grain stubble without seedbed preparation.

**SPECIES AND VARIETIES**

Although botanists have identified and classified more than 150 species of

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Drought resistance, extreme winter hardiness, and ability to withstand intense grazing, combined with high palatability and heavy yield of nutritious forage in early spring, make crested wheatgrass one of the most valuable forage grasses available to farmers and ranchers of the Northern Great Plains as far south as Nebraska.

Two varieties or strains of crested wheatgrass are now grown commercially in the United States and Canada. According to Westover and Rogler, \(^5\) "The taller Standard variety is the more generally planted in the United States," but "... in Western Canada, where Fairway was developed, it is used for all purposes more generally than Standard."

Crested wheatgrass responds to the cool temperatures of early spring. If adequate moisture is available in the soil, this grass is ready for grazing earlier than any other native or introduced species. Sarvis \(^6\) rated the palatability of crested wheatgrass for cattle at 80 per cent, the same as that for bromegrass and reported that "... it is usually ready for grazing about three or four weeks before native range is ready for use or should be used." Studies in Central Montana by Williams and Post \(^7\) covering a 10-year period (1934-1943) showed that, on the average, the grazing of crested wheatgrass started on April 23, bromegrass on May 5, and native grass on May 16. Growth practically stops during the dry, hot months of summer, and resumes with cool, moist weather of early fall.

Because of the availability of seed and ease of obtaining stands, it is perhaps the best of the wheatgrasses for use in the revegetation of land abandoned from crop production, which is frequently referred to as "go back land," and for range lands on which the grass cover has de-


teriorated from improper management during periods of drought. Because of an extensive root system, which takes up all the available moisture, weeds cannot grow in competition with crested wheatgrass. Kirk, et al.\(^8\) report that "... in its natural habitat, no other grass or legume is nearly as efficient in controlling weeds." Peake and Chester\(^9\) have made the observation that in the first year stand of crested wheatgrass, weed growth often is excessive, completely hiding the small grass seedlings. If left alone, in most instances the grass will eventually crowd out the weeds.

Extensive grazing experiments have demonstrated the superiority of crested wheatgrass as a pasture grass on the non-irrigated lands of the Northern Great Plains. During a 10-year period, 1934–43, 23.6 acres of this grass pastured by beef cattle at the Central Montana Branch Experiment Station averaged 914 animal days of grazing and 1,855 pounds total gain in animal weight per year. During the same period, an equal area of native grass pasture provided only 425 animal days of grazing and 870 pounds animal gain. Crested wheatgrass produced twice as much beef per acre as native grass under the conditions of this experiment.

Crested wheatgrass is extremely valuable to supplement the grazing from native grass pastures. This is because of the extra volume of succulent, high protein forage available in early spring before the normal growth of native grasses is ready for grazing. A summary of studies by Sotola\(^10\) is significant.

The dry matter of crested wheatgrass contained 20.59 per cent of crude protein in early May, but by September had decreased to 8.22. Crude fiber and nitrogen-free extract tended to increase as the season advanced. ... In the immature stages, crested wheatgrass is an excellent forage but loses much of its nutritive value as it matures. The protein of the fresh 4-inch clippings was

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\(^10\) Sotola, Jerry. The chemical composition and apparent digestibility of nutrients in crested wheatgrass harvested in three stages of maturity, Jour. Agr. Res. 61: 4, 1940.
Wheatgrasses

74.83 per cent digestible, whereas in fresh 10-inch clippings its digestibility was only 59.67 per cent.

Burkitt conducted similar studies with beardless wheatgrass, *Agropyron inerme*, in South Dakota and obtained quite similar results. Using early, 3 to 5 inch; medium, 7 to 10 inch; and late, headed clippings; he found that:

The crude protein content decreased as the plant matured while the crude fiber and nitrogen-free extract increased. The crude protein was 79 per cent digestible in the early stage as compared to 64 per cent in the late stage.

He points out further “The sheep made larger gains during the digestion trial when fed the immature grass than when fed the more mature forage.”

There also is the possibility of some additional forage in early fall when the seasonal growth of native grasses has ended. Crested wheatgrass, because of its ability to grow during the cooler seasons, supplies excellent yields of succulent nutritious grass when most needed, thus “stretching” the pasture season when used in connection with native pastures.

Crested wheatgrass is rated high as a lambing and calving pasture by Sarvis, because of its early and rapid spring growth.

At the Northern Montana Branch Station, cows with their calves were grazed on early growth crested wheatgrass, when other grasses were not available. These calves have averaged from 10 to 15 pounds heavier at weaning time than calves of similar quality which did not have access to this early grass.

**Intermediate Wheatgrass**

This is a perennial, sod-forming grass, rather recently introduced from Russia by the U.S.D.A. Adaptation and cultural tests in the Northern and Central Great Plains and in the Pacific Northwest indicate adaptability to a wide variety of climatic and soil conditions, and considerable value as a pasture and hay crop throughout these two important agricultural areas. Under Great Plains conditions, intermediate wheatgrass exhibits somewhat less winter hardness than crested wheatgrass. Like the latter, an abundance of leafy forage, palatable to all classes of livestock, is produced by the cool temperature and abundance of moisture in early spring. Growth almost ceases during the hot, dry summer period, with moderate growth for fall grazing.

**Quackgrass**

Quackgrass, a native of Europe, and best known on North American farms as a weed, is not entirely worthless. It spreads either by seed or by running rootstocks. It is frequently carried from one field to another on plows and other tillage implements.

Many fields in the cooler, more moist sections of the United States have heavy infestations of quackgrass. Before landowners decide on a program of elimination or control, which at best will be expensive, they may well weigh the value of other crops that might be raised against the returns to be obtained from using this grass for pasture, hay, etc.

According to Kephart:

Quackgrass possesses nearly all of the qualities desired in a hay plant, being palatable, nutritious, prolific, hardy, leafy, easily harvested, and adapted to wide variations of soil and climate.

When harvested for hay, quackgrass should be cut not later than the early

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blossoming stage to reduce the danger of maturing and scattering viable seed. It is quite satisfactory for pasture, starting early in the spring and furnishing grazing until late fall.

Extremely aggressive, quackgrass quickly establishes a tough sod, making it valuable for holding soil in place on waterways, embankments, terraces and steep slopes that are subject to water erosion.

Quackgrass sod requires frequent rejuvenation by thorough cultivation early in the spring. The roots, easily cut and torn apart by tractor-drawn tillage implements, are stimulated to produce vigorous leafy plants. Adapted legumes can be introduced successfully into sod thus treated. Annual top-dressings of barnyard manure and applications of fertilizers containing nitrogen and phosphorus are beneficial.

**Western Wheatgrass**

This native, perennial, sod-forming grass has rather general distribution throughout the United States, except in the southeastern states. Western wheatgrass perhaps is best known in the central and northern parts of the Great Plains, where it often constitutes the dominant grass species in native plant associations. It is adapted to a wide variety of soils. It appears to thrive best on the heavy and more or less alkaline soils characteristic of the valleys of meandering streams, “gumbo flats,” intermittent swales, and shallow lake beds subject to overflow or excess surface drainage from spring runoff. In the Great Plains, it is one of the first grasses to become re-established on “go back land,” providing the original stand of western wheatgrass was not entirely destroyed by plowing and subsequent tillage.

Western wheatgrass produces an abundance of forage which is eaten readily by livestock until it becomes harsh and fibrous during late summer. If the grass is allowed to “cure standing,” it furnishes nutritious forage for grazing during the winter months. Pure stands produce a leafy hay of excellent quality, if cut while the grass is succulent and before the leaves and stems become woody.

Growth characteristics, including drought resistance, winter hardiness, wide adaptability to soil and climatic conditions, and ability to spread rapidly by means of running rootstocks or rhizomes as well as by seed, make western wheatgrass particularly valuable for use in revegetation and soil erosion control. In the western Corn Belt, this grass has found a place in mixtures for revegetation of critical subsoil and droughty sites, including road cuts and fill slopes, and waterways. It appears much more resistant to grasshoppers than is smooth brome.

**Slender Wheatgrass**

This is a perennial bunchgrass, native to the northern states and Canada. It was the first native forage grass to be domesticated and introduced into American agriculture. It is now most prevalent in the Northern Great Plains and the Rocky Mountain Region.

Slender wheatgrass begins growth fairly early in the spring and produces an abundance of foliage readily grazed by livestock. If allowed to mature the forage furnishes nutritious winter grazing. High quality hay is obtained if cut before the plants become woody.

Because slender wheatgrass is short-lived, it is best used in mixtures with

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other grasses which require a longer period of time to become established and reach maximum production.

According to Schwendiman and Law, "Primal is a new, early-maturing, leafy, disease-resistant, rapid-developing variety" of slender wheatgrass, and is specifically adapted for use in the Palouse area of the Pacific Northwest. It was developed for use in sweetclover-grass mixtures and to meet a demand for a more productive, locally adapted slender wheatgrass.

Mecca, Fyra, and Grazier are other varieties of slender wheatgrass, developed by Canadian workers. They are leafy and late-maturing, especially adapted to the western provinces and other summer rainfall areas.

OTHER SPECIES

TALL WHEATGRASS. Wolfe reports that tall wheatgrass, *Agropyron elongatum*, which has a bunch type growth, is rapidly becoming important in the Northern Great Plains, despite the fact that it was only recently introduced. Although it has not yet been tested as thoroughly as some of the older grasses now in use, the outstanding advantage of this grass is its tolerance of wet, alkaline conditions. Thus far, most of the plantings have been made in Kansas, Nebraska, and Wyoming. However, since this wheatgrass shows promise of producing pasture and hay on large areas of land removed from production because of irrigation seepage, high water tables, or wet alkaline conditions, its use undoubtedly will increase rapidly.

REE WHEATGRASS. This grass, *Agropyron intermedium—Agropyron trichophorum*, has been released by the South Dakota Station. Franzke reports that this strain has been classified by the U.S.D.A. as a combination cross of *Agropyron intermedium* and *Agropyron trichophorum*. In South Dakota, this grass grows best on fertile, loamy soils, but tolerates a higher salt (alkali) concentration than does crested wheatgrass. It is excellent for pasture and is recommended as a component of grass mixtures.

BLUEBUNCH WHEATGRASS. This grass, *Agropyron spicatum*, is a native, drought-resistant bunchgrass, important principally for grazing on the native grasslands of the Pacific Northwest and the Intermountain States. It produces an abundance of palatable forage which is best grazed in late spring and early summer, since early spring use interferes with seed production.

Klages and Stark report that there are two species: "The bearded *Agropyron spicatum* which is the more common, and the beardless type, *A. inerme*, of which Whitmar is a good example."

CULTURAL AND MANAGEMENT PRACTICES

Considered as a group, the wheatgrasses, important as sources of feed for livestock, are sufficiently versatile that they respond satisfactorily to a wide range of cultural and management practices.

Good stands of crested wheatgrass are not difficult to establish. Ordinarily, best results are obtained by seeding—6 to 10 pounds per acre close drilled for pasture, and 2 to 4 pounds in spaced rows for seed production—on a relatively firm, moist seedbed, free of weeds at time of planting, being careful not to cover the seeds.
seed more than one to one and one-half inches deep. Reitz, et al.\(^{17}\) state:

There are three periods during the year when crested wheatgrass may be seeded: early spring (the last week of April or the first two weeks of May), early fall (September 1 to 15), and late fall (sometime in November). So late that the plants will not emerge until spring. Early spring planting generally may be recommended where a good seedbed has been prepared, early fall sowing mainly where fall-sown crops survive and do well, and late fall seeding on poor methods of seedbed preparation such as abandoned cropland, in stubble, and in old thin stands of alfalfa, where low cost of seeding is of primary importance.

Whitman, et al.\(^{18}\) recommend land which has produced corn or some other cultivated crop the preceding year, or land which has been summer fallowed, as offering the most desirable seedbed for wheatgrass to be planted in the eastern part of North Dakota. They especially emphasize good clean corn land over other cultivated cropland or fallow:

... the primary considerations (in the western section of North Dakota) in establishing grass stands where rainfall is inadequate, are not so much those of tillage and seedbed preparation, as they are of providing protection for the young seedlings, preventing soil erosion, and at the same time conserving the largest possible amount of soil moisture.

In that part of the state, late fall seeding in clean small grain stubble may be more dependable in most years. Grain stubble provides seedling protection, reduces danger of erosion of top soil, and blowing out of seed; also, the catch of snow results in more favorable moisture conditions the following spring.

In the Northern Great Plains, good stands of crested wheatgrass have been obtained on thousands of acres of land by late fall drilling in small grain stubble, or into weeds on abandoned plow land.

Idaho experiments\(^{19}\) point to summer fallowing as “the surest and best method of preparing abandoned land for seeding.” Reduced competition from weeds of various kinds made it possible to obtain uniform stands of perennial grasses from both spring and fall seedings, and to bring these grasses into full production one to two years earlier than plantings made on other types of seedbeds. Other methods of seedbed preparation gave satisfactory stands of crested wheatgrass and bluebunch wheatgrass when planted in the fall, but there was evidence that stands were delayed in reaching full production.

There is increasing evidence that mixtures of grasses and legumes are more productive than seedings of single species. Ensminger, et al.\(^{20}\) report that “grass-alfalfa mixtures produced nearly three times as many pounds of beef per acre as pure grass pastures” during 1941 to 1943 inclusive. Based on forage yields determined at monthly intervals, pastures seeded to grass-alfalfa mixtures produced three times as much oven-dry forage per acre as pastures seeded to grass species alone.

The protection from grazing of lands newly seeded to perennial grasses is of sufficient importance to justify additional research to determine under what conditions this practice is or is not advisable. Hull\(^{21}\) points out that:

Generally, results from investigations and experience in handling newly reseeded range justifies the general principle which states that complete protection from grazing should be given the seeded area during the first year.

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KEY TO THE MOST IMPORTANT CULTIVATED WHEATGRASSES *

1. Plants with creeping rhizomes (spreading).
   Lemmas awnless or with a short straight awn
   Glumes rigid, gradually tapering into a short awn
   Culms 30 to 60 cm tall, exceeding the leaves, interior.  A. smithii—Western wheatgrass
   Glumes not rigid, acute or abruptly awn-pointed
   Lemmas glabrous
   Blades lax, usually sparsely pilose on the upper surface.  A. repens—Quackgrass
   Lemmas awnless
   Blades short, involute, acutish glumes about 5-nerved.  A. intermedium—Intermediate wheatgrass

2. Plants without creeping rhizomes (hunch).
   Spikelets much compressed, closely imbricate, divergent  A. cristatum—Crested wheatgrass †
   Spikelets not much compressed, nor closely imbricate
   Spikelets awnless or awn-tipped only
   Lemmas glabrous
   Internodes of rachilla villous; glumes broad, nearly as long as the spikelet  A. pauciflorum—Slender wheatgrass
   Spikelets awned
   Culms erect
   Rachis continuous
   Awns divergent when dry
   Spikelets distant
   Spikelets mostly more than 7 in a spike, usually shorter than the internode; spikes mostly more than 8 cm long
   Spike 8 to 15 cm long; blade 1 to 2 mm wide  A. spicatum—Bluebunch wheatgrass

* Adapted from Hitchcock, A. S.—"Manual of the Grasses of the United States."
† Chase has suggested A. desertorum for Standard crested wheatgrass, reserving A. cristatum for the Fairway variety, which has only half as many chromosomes.

However, he reports on studies in southern Idaho which indicate that under certain conditions of soil and weather, moderate grazing of crested wheatgrass during the first year may be practiced.

SEED PRODUCTION

Most of the wheatgrasses important as forage produce an abundance of seed, providing the stand is not too thick and the crop has not become "sod-bound." Unfortunately, the supply of seed of these adapted grasses often is not sufficient to meet the demand.

Numerous experiments in the Northern Great Plains indicate that close-drilled crested wheatgrass will produce 200 to 250 pounds of seed per acre, with yields of over 600 pounds from cultivated rows grown under favorable seasonal conditions. Irrigated crested wheatgrass at Bozeman, Mont., produced seed in excess of 1,000 pounds per acre from all plantings during a two-year period.3

Idaho workers also report that crested wheatgrass is an excellent producer of seed, with yields running from 400 to 500 pounds per acre during the first two years of production at Moscow. Seed yields of 200 pounds per acre are common in dry areas of that state.

For harvesting a wheatgrass seed crop, some farmers prefer the selfbinder, cutting just before the seed is thoroughly ripe. Others are successful with the header, and with the combine. Where
the combine is used, the seed crop is mowed a little on the green side, cured in swath or windrow for a few days, and then threshed with the combine by using a pick-up attachment.

To produce a high-quality product, special seed cleaning equipment is required and a thorough knowledge of pure seed production will be helpful.

**QUESTIONS**

1. Why are the wheatgrasses ready for grazing before other grasses in the Northern Great Plains?
2. Why are the intermediate and western wheatgrasses superior to crested and slender wheatgrass for protecting soil against water and wind erosion?
3. Why is crested wheatgrass popular for pasture and hay in the northern half of the Great Plains?
4. Explain how farmers and ranchers in the Northern Great Plains can “stretch” the pasture season.
5. What are the soil and seedbed requirements for western wheatgrass?
6. Which of the wheatgrasses is best adapted and most commonly used to reseed “go back,” idle, or abandoned cropland?
7. In the Northern Great Plains and Intermountain Region, there are several million acres of plowed land lying idle or abandoned from crop production. On what basis can a farmer or rancher justify the expense of regrassing this low value land?
8. Discuss how a successful stand of the wheatgrasses may be obtained in the Northern Great Plains.
Some thirty agronomists and animal production specialists, located in the southern states from North Carolina south and west to Florida and Texas, listed “in order of relative importance or promise in the South” some twenty grasses regarded as adapted for use in that area, or in some parts of it. A few of those who reported are believed to have listed the grasses somewhat more in order of importance for their particular areas than for the South as a whole. The consolidated ranking by states, with the number of rankings considered in any one state, is shown in Table 31.1.

Information on Bermuda, Tall Fescue, Rye, Orchard, Dallis and its related species Bahia and Vaseygrass is presented in separate chapters.

In this chapter special attention is given to Johnsongrass and carpetgrass, with somewhat less attention to the other grasses listed as of some importance or promise. These are presented somewhat in order of their importance or promise for the South. It is recognized that for a given area or environment the order of value will differ considerably from that indicated. The order of presentation in this chapter is Johnson, Carpet, Pangola, Saint Augustine, Napier, Rescue, Natal, Para, Centipede, and Coganggrass.

JOHNSONGRASS

Johnsongrass, *Sorghum halapense* L. Pers., usually is not classed as a cultivated grass. However, it is one of the most important perennial hay grasses in the Southeast. Because of its aggressiveness and extensive system of underground stems, or rootstocks, it is considered by many as a noxious weed. Prejudice against the grass has prevented its taking a more favorable place in our forage program. A crop with the persistence, palatability, and nutritive value of Johnsongrass offers an opportunity for the better utilization of many acres and for increased livestock production. The scope of usefulness of this grass has been broadened to such an extent that its value as a hay and pasture overshadows its disadvantages as a weed.

Origin and History

Johnsongrass is an introduction native to South Asia, and to the Mediterranean area of North Africa and southern Europe. It was introduced into the United States from Turkey about 1830.
TABLE 31.1

The Relative Importance or Promise of Different Grasses for Use in the South, as Indicated by Consolidating the Rankings of Some 30 Agronomists and Animal Production Specialists in the States Shown

<table>
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<td>Number making rankings</td>
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</table>

Governor Means, of South Carolina, sent a planter to Turkey to teach cotton culture, and on his return the planter brought seed of this grass with him. In South Carolina, it is still known as "Meansgrass." About 1840, Colonel William Johnson of Selma, Ala., carried seed of the grass from South Carolina to the black clay soils of central Alabama. Col. Johnson's utilization and enthusiasm for this grass gave it its present common name. Other common names under which the grass is known, or has been known, are Aleppo, Cuba, Guinea, Egyptian, Alabama Guinea, False Guinea, Evergreen Millet, Racehorse, and Meansgrass. Phares 1 definitely gave this grass the name Johnsongrass in his publication of 1881. This publication, along with Phares' teaching, did much to spread Johnsongrass as a crop in the Black Prairie of Alabama and Mississippi.

Distribution and Adaptation

Because of its aggressive vigor, Johnsongrass spread rapidly over the entire Cotton Belt. It is adapted to all sections where cotton is grown. The northernmost limit of its perennial habit is stated

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FIG. 31.1 "A crop with the persistence, palatability, and nutritive value of Johnsongrass offers an opportunity for the better utilization of many acres and for increased livestock production. The scope of usefulness of this grass has been broadened to such an extent that its value as a hay and pasture overshadows its disadvantages as a weed." (Sec p. 358.) Putting up Johnsongrass hay in the Mississippi Black Belt. Miss. Agr. Exp. Sta. Photo.

to be about the 42nd parallel. Above the 38th parallel it usually acts as an annual, since it is killed by freezing. Vinnal\(^3\) authored the statement that throughout the area south of the 35th parallel it is a true perennial. Winter temperatures limit its northern adaptation as a perennial. Only in certain areas has it survived winter conditions north of the Missouri-Iowa line.

Johnsongrass is best adapted to heavy clay soils of relatively high fertility and water-holding capacity. However, it also grows well on fine sandy loams. Good yields may be obtained on any soil that will produce good yields of cotton or corn. It is not adapted to poor or depleted soils.

**Plant Description**

Johnsongrass is a monocotyledon belonging to the **Gramineae**, or grass family, and to the genus **Sorghum**. A single seed may produce from one to more than 100 culms or stems\(^4\) per plant, depending upon fertility, moisture and space, as well as inherent differences. The grass grows to a height of 3 to 6 feet. The erect stems arise from extensively creeping and scaly rhizomes, or underground stems. It has fibrous roots. The leaf blades are broad, approximately two centimeters in width. The head, or inflorescence, is an open panicle resembling Sudangrass. It is highly cross-fertile. The spikelets are sessile, plump, and pubescent. The awns are 1 to 1.5 cm. long and deciduous. Some seed of Johnsongrass have short stems because of failure to separate at the articulation of the rachis and spikelet. In such cases, the distinct suture at the articulation in Johnsongrass seed distinguishes it from that of Sudangrass.\(^4\) This difference is shown in Fig. 31.2.

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JOHNSONGRASS

TABLE 31.2

THE EFFECT OF FERTILIZERS ON THE YIELD OF JOHNSONGRASS IN ALABAMA

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Pounds of hay per acre</th>
<th>Minerals</th>
</tr>
</thead>
<tbody>
<tr>
<td>No fertilizer</td>
<td>2,015</td>
<td>P = 1,000 lbs. of superphosphate</td>
</tr>
<tr>
<td>FN</td>
<td>4,310</td>
<td>K = 500 lbs. muriate of potash</td>
</tr>
<tr>
<td>LN</td>
<td>6,000</td>
<td>L = 4,000 lbs. ground limestone</td>
</tr>
<tr>
<td>N</td>
<td>5,220</td>
<td>N = 400 lbs. nitrate of soda</td>
</tr>
<tr>
<td>PLN</td>
<td>5,710</td>
<td></td>
</tr>
<tr>
<td>LNPK</td>
<td>6,380</td>
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</tr>
<tr>
<td>PK</td>
<td>1,765</td>
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</tr>
<tr>
<td>PKN</td>
<td>6,105</td>
<td></td>
</tr>
<tr>
<td>PLN</td>
<td>5,710</td>
<td></td>
</tr>
</tbody>
</table>

JOHNSONGRASS is different from all other species of sorghum in that it is a perennial that spreads by vigorous underground stems or rootstocks.

Productivity

JOHNSONGRASS is primarily a rich-land crop. It responds to fertilization on eroded or depleted soils. The results of fertilizer applications on a Norfolk sandy loam in Alabama are shown in Table 31.2. It will be noted that fertilization, especially with nitrogen, doubled and trebled the acre yield.

The effect of fertilizers on JOHNSONGRASS, with and without interplanted legumes, on an eroded soil in Mississippi is shown in Table 31.3.

The yield of JOHNSONGRASS was increased from a third to more than half when fertilized with nitrogen, both when grown alone and when grown in combination with a legume. The dry weight yields given are those of JOHNSONGRASS. Phosphorus and potash greatly increased the growth of the legumes and, although these were removed for hay, increased yields of JOHNSONGRASS resulted. Phosphate increased the phosphorus content of the grass from .16 per cent to .27 per cent. The calcium and crude protein content of the JOHNSONGRASS was only slightly influenced by the application of minerals, whether with or without an interplanted legume.

Scarseth has shown the need for the fertilization of JOHNSONGRASS on several soils in Alabama. Without phosphorus, the yield of JOHNSONGRASS was increased from a third to more than half when fertilized with nitrogen, both when grown alone and when grown in combination with a legume. The dry weight yields given are those of JOHNSONGRASS. Phosphorus and potash greatly increased the growth of the legumes and, although these were removed for hay, increased yields of JOHNSONGRASS resulted. Phosphate increased the phosphorus content of the grass from .16 per cent to .27 per cent. The calcium and crude protein content of the JOHNSONGRASS was only slightly influenced by the application of minerals, whether with or without an interplanted legume.

Fig. 31.2. Distinguishing characteristics of JOHNSONGRASS and SUDANGRASS. Note differences in the appendages of the seed, with the expanded cup-shaped apexes of the JOHNSONGRASS seed; also the differences in seed size. JOHNSONGRASS (below); SUDANGRASS (above).
Grasses for the Humid South

FIG. 31.3 "Much of the Johnsongrass hay on the market is of inferior quality due to delayed cutting, lack of proper curing, and contamination with weeds and other foreign matter." (See p. 363.) Making Johnsongrass hay, bringing it to the baler with a buck rake.

On Eutaw, Lufkin, Oktibbeha, and Sumter soils, Johnsongrass plants yielded less than 20 grams per plant even when fertilized with nitrogen and potassium. The addition of phosphorus to these soils caused Johnsongrass to yield 80 to 120 grams per plant. The application of phosphorus and nitrogen doubled the yield of Johnsongrass over the yield obtained from nitrogen alone on Houston and Bell soils.

Experiments in Mississippi compared three nitrogen carriers at different rates of application. These carriers were nitrate of soda, uroform (a slowly available nitrogen compound formed by treating Uramon with formaldehyde), and Uramon. The yield of Johnsongrass was

TABLE 31.3
Effect of Fertilizers on Yield per Acre of Johnsongrass Alone and with Interplanted Legumes, Austin Soils, Miss.

<table>
<thead>
<tr>
<th>Fertilizer treatment</th>
<th>No legume</th>
<th>White clover</th>
<th>Black medic</th>
<th>Rough peas</th>
<th>Persian clover</th>
<th>Hop clover</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 lb. P.</td>
<td>5,417</td>
<td>6,307</td>
<td>7,804</td>
<td>8,621</td>
<td>6,807</td>
<td>5,908</td>
</tr>
<tr>
<td>60 lb. P.</td>
<td>6,088</td>
<td>6,953</td>
<td>8,706</td>
<td>9,649</td>
<td>7,165</td>
<td>5,998</td>
</tr>
<tr>
<td>90 lb. P.</td>
<td>6,759</td>
<td>6,550</td>
<td>8,701</td>
<td>10,385</td>
<td>7,457</td>
<td>6,175</td>
</tr>
<tr>
<td>30 lb. K.</td>
<td>5,582</td>
<td>5,296</td>
<td>7,325</td>
<td>7,775</td>
<td>6,183</td>
<td>5,496</td>
</tr>
<tr>
<td>32 lb. N.</td>
<td>7,972</td>
<td>7,680</td>
<td>8,443</td>
<td>9,664</td>
<td>8,989</td>
<td>8,227</td>
</tr>
<tr>
<td>None</td>
<td>6,054</td>
<td>5,344</td>
<td>7,087</td>
<td>7,627</td>
<td>6,192</td>
<td>5,157</td>
</tr>
<tr>
<td>30P 30K</td>
<td>6,953</td>
<td>6,241</td>
<td>8,106</td>
<td>9,243</td>
<td>7,118</td>
<td>5,611</td>
</tr>
<tr>
<td>30P 32N</td>
<td>9,330</td>
<td>9,376</td>
<td>10,702</td>
<td>11,052</td>
<td>10,104</td>
<td>8,993</td>
</tr>
<tr>
<td>30P 30K 32N</td>
<td>8,930</td>
<td>9,211</td>
<td>10,668</td>
<td>10,711</td>
<td>9,098</td>
<td>8,288</td>
</tr>
<tr>
<td>60P 30K</td>
<td>5,685</td>
<td>7,077</td>
<td>8,894</td>
<td>10,242</td>
<td>7,084</td>
<td>6,817</td>
</tr>
<tr>
<td>60P 32N</td>
<td>9,375</td>
<td>8,830</td>
<td>10,641</td>
<td>12,179</td>
<td>10,004</td>
<td>9,275</td>
</tr>
<tr>
<td>60P 30K 32N</td>
<td>9,440</td>
<td>9,596</td>
<td>11,385</td>
<td>12,228</td>
<td>10,167</td>
<td>9,681</td>
</tr>
<tr>
<td>90P 30K</td>
<td>6,795</td>
<td>8,258</td>
<td>9,410</td>
<td>11,175</td>
<td>7,766</td>
<td>6,815</td>
</tr>
<tr>
<td>90P 32N</td>
<td>9,515</td>
<td>9,357</td>
<td>10,383</td>
<td>11,127</td>
<td>9,961</td>
<td>9,080</td>
</tr>
<tr>
<td>90P 30K 32N</td>
<td>9,566</td>
<td>9,576</td>
<td>10,714</td>
<td>11,943</td>
<td>9,780</td>
<td>9,333</td>
</tr>
</tbody>
</table>

\[ P = P_2O_5 \quad K = K_2O \quad N = N \]
bushels per acre. Ten bushels is considered a good yield. Much of the seed now sold is obtained from barn lofts and feeding stacks or troughs, rather than by machine harvest.

Johnsongrass seed are markedly dormant when first matured. They require a number of months for complete after-ripening and then do not germinate completely except with the use of alternating temperatures in a warm temperature range. Seed of its close taxonomic relative, Sudangrass, germinate freely under a wide range of temperature conditions, either constant or alternating, and without any appreciable period of after-ripening.

The inner integument and the various layers of the pericarp of Johnsongrass contain tannin compounds which decrease their permeability. These layers and the need for after-ripening explain the excellent results obtained from winter and fall seeding of Johnsongrass.

OTHER SPECIES. Tunis grass, Sorghum virgatum Hack, is a tall annual, with a slender open panicle and with green, finely awned spikelets. This grass is inferior to Sudangrass and has not been brought into commercial production. According to Piper there also is an awnless variety, Sorghum submuticum.

Sudangrass, Sorghum vulgare var. sudanense (Piper) Hitchc., is an annual form of forage sorghum. It closely resembles Johnsongrass but lacks the underground stems or rootstocks and is an annual. It is adapted to an extremely wide range of soil and climatic conditions and is one of the most important cultivated grasses in the South. It tolerates droughty conditions, and its rapid growth from late seedings makes it an ideal emergency forage for pasture, hay, or silage. Attempts to grow it on poor soils without adequate fertilization, however, invariably result in low yields of hay or pasturage. Foliage diseases occur throughout the Southeast and often reduce materially the yield and quality of Sudangrass forage. Tift and Sweet are the varieties most widely used in the Southeast. Tift is resistant to certain foliage diseases. Sweet combines the sweet-stem characteristic of sweet sorghum with the fine stems and leaves of common Sudan. Grazing animals show a distinct preference for the Sweet Sudan variety.

Johnsongrass as a Weed

Johnsongrass probably has been more frequently classed as a weed than as a forage crop. A number of publications have appeared throughout the temperate

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and tropical regions on methods for its control.\textsuperscript{25} 26, 27, 28, 29

Instead of attempting to eradicate Johnsongrass, which is both laborious and expensive, it often is more profitable to utilize the plant as fully as possible.

The control of Johnsongrass is based on three procedures: (1) exhaust existing rootstocks by repeated and close mowing or grazing,\textsuperscript{30} (2) kill new seedlings, and (3) prevent seed production.\textsuperscript{31}

Smaller infestations may be controlled with chemicals. Sodium chlorate perhaps is the most practical of these. See Chapter 40 for details on the use of chemicals in the control of weed growth.

Other Considerations

Johnsongrass hay and Johnsongrass mixed hay are listed as Group IV in the Handbook of Official Hay and Straw Standards. The federal standards for Johnsongrass are much the same as for other grass hays. Special grades are given for extra green, green, and fine hay.

Forage Poisoning. Vinall\textsuperscript{32} made a comprehensive review some years back of the available information on forage poisoning in cattle. No cases of a serious nature due to Johnsongrass were reported. This conclusion has also been reached by other investigators.\textsuperscript{33} 34 35

One goes north the danger of prussic acid poisoning increases but even after periods of extended droughts no bad effects have been noted with Johnsongrass.

Diseases. Johnsongrass is subject to a number of diseases common to members of the Sorghum genus. The diseases most prevalent in Johnsongrass\textsuperscript{36} have been shown to be as follows:

<table>
<thead>
<tr>
<th>Common name</th>
<th>Scientific name</th>
<th>% population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smut</td>
<td>Sphacelotheca sorghi</td>
<td>6.2</td>
</tr>
<tr>
<td>Holeus spot</td>
<td>Pseudo-nomas syringae</td>
<td>74.6</td>
</tr>
<tr>
<td>Leafspots</td>
<td>Helminthosporium sp.</td>
<td>12.7</td>
</tr>
<tr>
<td>Leaf spots</td>
<td>Helminthosporium sp.</td>
<td>6.5</td>
</tr>
</tbody>
</table>

Leukel, \textit{et al.},\textsuperscript{37} have shown that Johnsongrass smut is not a menace to sorghum because of its short-lived spores. According to Johnston, \textit{et al.},\textsuperscript{38} Johnsongrass diseases are not considered serious in the Southeast.

CARPETGRASS

Carpetgrass, \textit{Axonopus affinis} Chase, is a native of Central America and the West Indies. It was introduced into the United States sometime prior to 1832. Its first recorded appearance was near New Orleans. Carpetgrass has now spread over the Coastal Plain area from southern Virginia to Mexico and inland to Arkansas and north central Alabama. It is sometimes called Louisiana grass.

Distribution and Adaptation

Carpetgrass is especially adapted to sandy or sandy loam soils, particularly where moisture is near the surface most of the year. Because of its adaptation to low fertility and its prolific seeding, it

\textsuperscript{28} Pauline, J. R. Johnsongrass as a weed in Missouri. \textit{Mo. Agr. Exp. Sta. Cir.} 517. 1945.
\textsuperscript{30} Pauline, J. R. \textit{Loc. cit.}\textsuperscript{28}
\textsuperscript{31} Talbot, M. W. \textit{Loc. cit.}\textsuperscript{29}
\textsuperscript{36} Bennett, Hugh W. \textit{Loc. cit.}\textsuperscript{15}
tends to become established naturally throughout the entire Gulf Coast area. It is moisture loving but does poorly in swamps or where seepage is continuous. Under these conditions Vaseygrass is better adapted.

**Plant Description**

Carpetgrass is a low-growing, sod-forming, perennial (Fig. 31.5) which spreads both by surface runners and seed. Because of its prostrate growth habit and rooting joints it forms a dense sod.

This grass is distinguished by its compressed, two-edged, creeping stems, and its blunt leaf tips. The slender seed-stalks grow 6 inches to 1 foot high (rarely 2 feet), usually have 3 branches, and bear many brownish to gray oblong seed. Because their sod is dense and their habit of growth is aggressive, legumes are maintained with difficulty in a cultivated pasture when this grass predominates.

In Florida, unfertilized pastures of carpetgrass have yielded 75 pounds of beef per acre when fertilized carpetgrass produced 148 pounds. The estimated oven-dry feed consumption per pound of weight gain and maintenance was 31 pounds of unfertilized and 21 pounds for fertilized carpetgrass. When clover was added to the grass only 13 pounds of oven-dry material was needed per pound of gain. The fertilization was 32 pounds N, 32 pounds P₂O₅, and 20 pounds of K₂O. Other data show that unfertilized carpetgrass grown without legumes resulted in small animal gains from pasture. Legumes and other grasses must be incorporated into a carpetgrass sod for profitable gains.

On fertile soils it makes a good growth, but generally is not high enough in feed nutrients to furnish a balanced diet. It is not generally recommended for improved, high producing pastures.

**Importance and Use**

Carpetgrass is the most common permanent pasture grass over most of the Gulf Coast area and is the basic grass in unimproved pastures in this area. Its prolific seeding characteristic has caused it to become established naturally in vast areas of cut-over timber land.

The light-green color of this grass makes it desirable for lawns in regions of its adaptation. It is used widely for the prevention of erosion and for the stabilization of road banks and fills. Carpetgrass is ideal for firebreaks in forests in the Gulf Coast region.

**Cultural and Management Practices**

Carpetgrass is established from seed, which is available in quantity at moder-
Grasses for the Humid South

Seeding rates range from 5 to 15 pounds per acre. Seed may be broadcast without seedbed preparation or covering. However, sods are obtained more quickly by seeding on a well prepared seedbed. The seed require a firm soil for germination and growth. Winter and early spring seedings are preferred.

Carpetgrass is able to withstand more severe grazing or clipping than most of the grasses used for permanent pasture in the Deep South. Where grown in mixtures, the preference of animals for other grasses often permits the carpetgrass to crowd out these grasses much sooner than if grazing was not permitted.

Seed Production

Carpetgrass produces seed profusely, but a seed crop is harvested with some difficulty. Direct combining recovers approximately one half of the seed produced. Cattle should be removed from seed areas a month before harvest for greatest yields. Seedstalks may be mowed, raked immediately and threshed from the windrow. The air blast must be greatly reduced and small screens used either in threshing or in cleaning. One pound of carpetgrass seed contains approximately 1,800,000 seed.

Other Species

Flat crabgrass, Axonopus furcatus Fluegge, is similar to carpetgrass but has a coarser growth and is not quite as aggressive. The leaves have more of a yellowish green cast than carpetgrass. It is found in small amounts in the Gulf Coast region. It has about the same nutritive value as carpetgrass.

Carpetgrass, Axonopus compressus (Swartz) Beauv., is often confused with A. affinis. The former is found only in Florida and southern Louisiana. It is less winter hardy than the common form.

Sourgrass, Paspalum conjugatum, also is often confused with carpetgrass. This is a worthless grass of the tropics and subtropics. It has much the same habit of growth as carpetgrass.

PANGOLAGRASS

Pangolagrass, Digitaria decumbens Stent., is a native of South Africa. It was introduced into the United States in the early 1930's. It belongs to the wooly-finger grasses. This grass has been called Digitaria or Digit grass.

Distribution and Adaptation

Pangolagrass is adapted to all of Florida and to the Gulf Coast westward to Texas and southern California. It rarely withstands the winters 100 miles north of the Gulf.

This grass is best adapted to fertile and moist soils. It does not grow well on flooded soils but will thrive on well drained soils. Tests have shown that this grass needs a complete fertilizer and lime. It is more sensitive to a low nitrogen level than carpetgrass or Bahia grass. When phosphorus is omitted, irrespective of other fertilizer elements, the grass makes poor growth and establishment is extremely slow. Properly fertilized Pangolagrass will yield to 3.5 tons of hay per acre.

Pangolagrass 371

TABLE 31.8

COMPOSITION OF GRASSES GROWN ON PEAT SOIL AND CUT AT HAY STAGE, IN FLORIDA

<table>
<thead>
<tr>
<th>Grass</th>
<th>Crude protein</th>
<th>Calcium</th>
<th>Phosphorus</th>
<th>Magnesium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dallis</td>
<td>13.63</td>
<td>0.80</td>
<td>0.32</td>
<td>0.74</td>
</tr>
<tr>
<td>Centipede</td>
<td>9.98</td>
<td>0.56</td>
<td>0.25</td>
<td>0.59</td>
</tr>
<tr>
<td>Bahia</td>
<td>9.68</td>
<td>0.39</td>
<td>0.22</td>
<td>0.78</td>
</tr>
<tr>
<td>Para</td>
<td>7.62</td>
<td>0.83</td>
<td>0.19</td>
<td>0.53</td>
</tr>
<tr>
<td>St. Augustine</td>
<td>12.56</td>
<td>0.56</td>
<td>0.29</td>
<td>0.38</td>
</tr>
<tr>
<td>Wooly-finger</td>
<td>9.28</td>
<td>0.37</td>
<td>0.27</td>
<td>0.62</td>
</tr>
<tr>
<td>Sudan</td>
<td>15.27</td>
<td>0.91</td>
<td>0.27</td>
<td>0.77</td>
</tr>
</tbody>
</table>

TABLE 31.9

YIELD AND QUALITY OF BEEF FROM VARIOUS GRASSES, IN FLORIDA

<table>
<thead>
<tr>
<th>Grass</th>
<th>Yield in lbs. of beef per acre</th>
<th>Quality or grade of carcass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pangola</td>
<td>216</td>
<td>3 commercial, 2 utility</td>
</tr>
<tr>
<td>Coastal Bermuda</td>
<td>258</td>
<td>1 commercial, 3 utility</td>
</tr>
<tr>
<td>Pensacola Bahia</td>
<td>210</td>
<td>1 commercial, 4 utility</td>
</tr>
</tbody>
</table>

Plant Description

Pangolagrass is a creeping perennial that grows to a height of 2 to 4 feet, depending upon the fertility of the soil. It produces many surface runners which are semi-decumbent. These runners form roots at the joints or nodes. The seedstalks produce many branches but few viable seed.

This grass is established vegetatively by using plants, stems, and runners. Rooted plants, spaced 2 to 3 feet apart in 4-foot rows, give the best stands. Green but rather mature stems and runners, spread at the rate of one-half ton per acre, may be disked into the soil and packed. This technic of establishment requires favorable soil moisture. Plants and plant parts decay when covered with too much soil.

The composition of wooly-finger grass compares favorably with other grasses. 50

Grazing data from Florida 51 have shown that Pangolagrass compares favorably in beef per acre with Coastal Bermuda and Pensacola Bahiagrass (Table 31.9). These pastures were grazed from March 30 to November 1. There were no significant differences in the average daily gain of steers on these pastures.

Importance and Use

Pangolagrass is of considerable importance in regions where it is adapted. Its principal use is as a pasture plant. The Florida station maintains areas of this grass for distribution of vegetative seed stocks to farmers. This grass has not been fully tested, but it is believed that it may prove to be one of the more productive grasses for the Deep South.

Cultural and Management Practices

Areas to be planted to Pangolagrass should be well drained. Fertilization with a complete fertilizer, 600 pounds of


Grasses for the Humid South

**TABLE 31.10**

<table>
<thead>
<tr>
<th>Grass</th>
<th>Pounds gain</th>
<th>Green weight, pounds</th>
<th>Dry weight, pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>St. Augustine</td>
<td>2,088</td>
<td>111,478</td>
<td>21,181</td>
</tr>
<tr>
<td>Carib</td>
<td>958</td>
<td>62,017</td>
<td>11,783</td>
</tr>
<tr>
<td>Pangola</td>
<td>958</td>
<td>39,847</td>
<td>11,371</td>
</tr>
<tr>
<td>Para</td>
<td>541</td>
<td>47,601</td>
<td>9,044</td>
</tr>
<tr>
<td>Coastal Bermuda</td>
<td>622</td>
<td>48,807</td>
<td>9,273</td>
</tr>
</tbody>
</table>

6-6-6 per acre, is necessary for establishment. Annual applications are needed for maintenance. Lime is needed on acid soils. This grass should be sprigged, allowing some of the tops to protrude from the soil for best results. Partial stands can be obtained by disking in plants, stems, and runners.

**SAINT AUGUSTINEGRASS**

Saint Augustinegrass, *Stenotaphrum secundatum* (Walt.) Kuntze., is a native of the West Indies, Australia, and southern Mexico. It is also found in South Africa, from Cape Town to Natal. It has been introduced into southern France and Italy. It probably was introduced into the United States from Cuba. Sheepgrass, jointgrass, and saltgrass are other common names given this grass.

**Distribution and Adaptation**

Saint Augustinegrass is found along the southern Atlantic and Gulf Coast regions from South Carolina to Florida and Texas. It is not winter hardy much over 150 miles north of the Gulf. It is naturally a seashore plant and will withstand salt spray.

It is adapted to practically all soil types, provided plenty of moisture is present. It is especially adapted to moist, muck soils. This grass thrives in partially shaded areas and is well suited to lawns.

**Plant Description**

This is a broad-leaved grass, generally light-green or yellow-green in color. It is an extensively creeping, rather coarse, smooth, perennial. It produces stolons with long internodes and branches that are short, leafy, and flat. This grass forms a dense sod and usually crowds out other grasses and weeds. It will grow to a height of 4 to 18 inches under conditions of high soil fertility and favorable moisture. This plant does not produce seed.

Rich soil and an abundant supply of moisture are necessary for pasture production. These conditions do not exist over much of the area of its adaptation. It is not considered as an important pasture plant except in limited areas. Recent tests have shown it to be an excellent pasture grass for muck soils in the Florida Everglades area. Yields produced with heavy fertilization are given in Table 31.10.

Under the conditions of this test there was abundant moisture and grazing was practically year-long. Later reports have shown that Saint Augustinegrass is the only grass which is capable of maintaining a high level of production for several years without renovation. The creeping, flat stems of Saint Augustinegrass root to form dense sods which stand trampling on these low wet soils.

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Pastures or lawns must be established by means of vegetative material.

This grass is attacked by the brown patch fungus. The disease is controlled easily by stimulating plant growth with nitrogen fertilizers. The disease has not been a serious factor.

Chinch bugs also attack this grass. Small brown areas that soon widen indicate their presence. These insects may be controlled by spraying with nicotine sulfate, using 1 part of nicotine sulfate to 500 parts of water.

It is widely used as a lawn and golf fairway grass. It appears to have limited use as a pasture grass.

**NAPIERGRASS**

Napiergrass, *Pennisetum purpureum* Schum., is native to Africa between the latitudes 10° north and 20° south. It was introduced into the United States in 1913 by the U.S.D.A. The name Napiergrass has been generally adopted and was the one originally applied to it in this country. The agricultural value of this grass was established through the enterprise of Colonel Napier of South Africa.

**Distribution and Adaptation**

Napiergrass is adapted to all of Florida and to the Gulf Coast area westward to Texas and southern California. On fertile soils with sufficient moisture, it can be grown from Charleston, S. C., west to Shreveport, La., and southward. Napiergrass can be grown wherever sugarcane is grown.

It is adapted to a wide range of soil types and will produce well on most soils that produce ordinary field crops. Yields vary with soil fertility. Continuous heavy cropping requires fertilization. It makes good growth on droughty soils when properly managed.

**Plant Description**

Napiergrass is a tall perennial plant which grows in clumps of 20 to 200 stalks, much the same as sugarcane. It grows 6 to 12 feet tall, depending upon conditions, with stalks up to 1 inch in diameter. Many erect branches are produced from the leaf axils of the main stems. The leaf blades are 1 to 3 feet long and usually less than 1 inch wide. If allowed to grow to maturity, all stalks bear seed spikes. A single stalk may yield as many as ten spikes.

At the Florida station animals fed Napiergrass silage required 6.3 pounds of digestible nutrients per pound of gain, those fed sorghum silage required 6.2 pounds, and those fed sugarcane silage 6.3 pounds. The Napiergrass silage supplied 1.42 pounds of the total digestible nutrients required per pound of gain while sorghum silage supplied 1.92 pounds and sugarcane silage 1.34 pounds. In another report from Florida Napiergrass silage from grass cut as seedheads began to appear provided two-thirds as much total digestible nutrients as corn silage.

**Importance and Use**

Napiergrass is of considerable importance in areas where adapted. Its principal use is for soiling and as a grazing crop. It is excellent for dairy cattle because of its rapid, tender growth, and relatively high crude protein content. Its use as a silage crop is limited.

**Varieties and Strains**

Varieties of Napiergrass resistant to eyespot disease, *Helminthosporium ocellatum*...
Grasses for the Humid South

lum, Faris., have been distributed from the Florida station since 1938. Resistant varieties also have been produced at the Coastal Plains station of Georgia. These varieties have maintained good stands greatly outyielding susceptible strains.

Cultural and Management Practices

Napiergrass may be propagated by portions of the canes, by divisions of the clumps, or by seed. Propagation by seed is practical in Florida and along the Gulf Coast. Farther north the most common method of propagation is by planting sections of the stems, each section containing two nodes. The stems of Napiergrass intended for propagation are protected in winter by bedding them in the same manner as sugarcane. The plants are cut and spread horizontally in thick layers and overlapping. The bed is covered with a thin layer of soil. The soil and leaves protect the buds from freezing.

When seed is used it should be at the rate of 3 pounds per acre, in rows six feet apart. Better results will be obtained if seed are planted in flats and seedlings transplanted to the field when 6 inches high than if seeded directly in the field.

An erect plant such as Napiergrass is readily exterminated by continuous heavy grazing. When it is to be maintained in a productive condition two or more fields should be used and grazed intermittently or rotationally. The recommended practice is to graze when 4 feet high until most of the leaves are gone, then remove animals for rapid new growth.

Napiergrass is best used as a soiling crop when 4 feet high.

Other Species

Merkergrass, Pennisetum merkeri, is closely related to Napiergrass and is much like it in appearance. It recently has been designated as only a selected variant of Napiergrass. Merkergrass was introduced into the United States in 1916.

RESCUEGRASS

Rescuegrass, Bromus catharticus Vahl., is thought to be native to South America. It is extremely abundant in Argentina and Uruguay. It is not known when it was introduced into this country, but it was first identified in 1806 from a specimen sent from the Carolinas. Seed was advertised by B. V. Iverson of Columbus, Ga., in 1853, and he gave it the name "Rescue." Other common names are Shrader's bromegrass, Australian oats, Southern chess, and Australian prairiegrass.

Rescuegrass is adapted to regions of the South and Southwest where the winter months are mild and humid. Its agricultural value is limited to areas southward from North Carolina and Tennessee and to limited areas in the humid sections of the Pacific Coast. It has become quite important in Australia. It is adapted to rich soils. It does not make a satisfactory growth on low fertility soils without fertilization.

Description and Use

This is a short-lived perennial bunchgrass, but it acts as an annual under cultivation. Plants grow to a height of 2 to 4 feet with drooping, open panicles. The panicles are easily identified by the large flattened spikelets which contain a number of seed almost as large as oats. Leaf blades are 8 to 12 inches long and

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up to 1/2 inch in width. Seedlings are pubescent but lose much of this character as they get older.

Growth starts in the fall, continues through the winter, and matures in late spring. On rich land the grass is quite palatable and will yield as much as two tons of hay per acre. In the vegetative stage Rescuegrass has approximately the same nutritive value as oats grown on soil of the same fertility. It will produce more than either oats or rye on good soils.

Rescuegrass is not grown to any great extent as a cultivated crop. It possibly is deserving of wider use in the Deep South for winter and spring pasture.

Texas 46 is a strain of Rescuegrass selected in 1942 by workers in that state. It is superior to other strains and foundation seed stocks have been distributed to registered seed growers.

**Cultural and Management Practices**

Rescuegrass is best seeded in the fall on a well-prepared seedbed. The seeding rate is 30 to 40 pounds per acre. It can be seeded with available machinery, or broadcast. It will reproduce from shattered seed if allowed to produce a seed crop. Land growing Rescuegrass may be utilized for growing another crop during the summer after the grass has reseeded. Rescuegrass seeds profusely. Yields of 400 pounds of clean seed per acre are not uncommon.

**Other Species**

Chess or cheat, *Bromus secalinus* L., is considered a weed and a pest in grain fields. This is a smooth annual and grows 3 to 4 feet high. Chess begins growth in the fall and matures seed the following May and June. It can be used for hay when cut in the dough stage, but does not make as good hay as the small grains.

Downy chess, *Bromus tectorum* L., is another related plant considered as a weed.

**NATALGRASS**

Natalgrass, *Tricholaena rosea* Nees., is native to much of South Africa. It was introduced into the United States before 1866. It first attracted attention as an ornamental grass because of its dark, rose-colored, loose panicles. It also is known as Hawaiian and Australian redtop.

Natalgrass is adapted only to Florida, southern Texas, a narrow strip along the Gulf Coast, and to southern California. It is recommended only for regions free from freezes. Freezes will kill not only the plant but may even destroy the shattered seed. It now occurs generally in all tropical and subtropical regions. It is especially well adapted to well-drained, poor, sandy soils.

**Description and Use**

Natalgrass is a slender, tall grass that continues to thicken by developing new stems throughout its long growing season. A plant may form a tuft 2 to 3 feet in diameter with flowering culms 2 to 4 feet high. Flowers are produced all season. The exceedingly light and small seed are borne on spreading panicles the size and shape of oat panicles. The panicles are of a beautiful rosy color.

Natalgrass will yield two to four cuttings of hay per season. The hay produced has been shown to be equal to timothy hay in total digestible nutrients.

Natalgrass is of special importance in the extreme lower South as a pasture, hay, and cover crop. As a pasture it is nutritious and readily grazed by live-

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Grasses for the Humid South

stock. The hay is palatable and similar to timothy in nutritive value. It is used on areas heavily infested with nematodes as a control. Nematodes do not infest Natalgrass roots. The principal advantage of Natalgrass is its ability to produce good grazing and hay on poor, dry, sandy soils where few other grasses succeed.

**Cultural and Management Practices**

This grass needs no soil preparation and may be seeded in any month, preferably in the spring. The seed are so silky and small that it is advisable to mix with soil before seeding. On new land the use of 8 to 10 pounds of seed per acre is recommended. Once established Natalgrass perpetuates itself indefinitely by reseeding. It does well in rotations of winter crops. After a winter crop is harvested Natalgrass volunteers freely. The plant is easily destroyed by plowing. There is no danger of its becoming a pest.

The grass should be cut for hay when the flowers are of a bright-rose color. Natalgrass seeds profusely, but no method of mechanically harvesting the seed has been devised.

**Paragrass**

Paragrass, *Panicum barbinode* Trin., probably came originally from Africa, but is now widely grown in Central and South America. It was from the West Indies that it first became known to botanists.

This grass is grown somewhat commonly in Florida. It is adapted in this country only to Florida and the Texas Gulf Coast. It is adapted to moist soils rich in organic matter. It has been grown with success on heavy soils without irrigation, where other crops need irrigation. Paragrass grows extremely well on soils too moist for many other crops, on margins of lakes and streams, marshes, and on bottomland subject to prolonged overflow.

**Description and Use**

This is a coarse growing perennial, easily identified by the length—sometimes 30 feet—of its coarse surface runners. The surface runners root at the joints, giving rise to independent plants. These plants grow to 15 feet in length. The leaves are generally 4 to 12 inches long and less than one-half inch in width. Leaf sheaths and nodes are extremely pubescent.

The plant is coarse, grows rapidly, and is therefore a heavy yielder of forage. In the subtropics, as southern Florida, it may be cut 3 to 4 times per season, yielding as high as 4 tons per cutting. The hay is coarse but palatable and readily eaten by cattle.

Paragrass has been used extensively in southern Florida and recently has been coming into some use under irrigation in southern Texas. In a warm, humid climate, with sufficient soil nutrients and moisture, no other grass will equal it in tonnage. It is used as a soil improvement, hay, and pasture crop. In Cuba it has become a pest in sugarcane fields. This grass, along with Guineagrass, are the two most widely cultivated grasses in the tropics.

**Cultural and Management Practices**

This grass is propagated by planting divisions of the root clump, or cuttings of runners consisting of two to three nodes. It may be established by spreading runners, or mature stems, and covering by subsequent diskig. The upper bud should be left at or near the surface when planting.

Newly established paragrass pastures or meadows should not be grazed or
TABLE 31.11
AVERAGE HERBAGE YIELDS AND PROTEIN CONTENT OF VARIOUS GRASSES IN FLORIDA

<table>
<thead>
<tr>
<th>Grass</th>
<th>Five-year avg. yield in pounds per acre, oven-dry grass</th>
<th>Crude protein content percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carpet</td>
<td>1,602</td>
<td>11.25</td>
</tr>
<tr>
<td>Bermuda</td>
<td>1,948</td>
<td>11.15</td>
</tr>
<tr>
<td>Centipede</td>
<td>1,534</td>
<td>9.04</td>
</tr>
<tr>
<td>Bahia</td>
<td>2,250</td>
<td>10.39</td>
</tr>
</tbody>
</table>

mowed until well sodded and 2 to 3 feet tall. It should be grazed rotationally rather than continuously. It is best cut for hay when at a height of 3 to 4 feet. Meadows and pastures of this grass should be plowed or disked each spring. This stimulates new growth by breaking the runners which form new plants. It also allows for the inclusion of some crop, such as cowpeas, in the first cutting of hay.

Paragrass will produce seed, but the germination usually is extremely low. Seed has not been handled in commercial quantities because vegetative propagation is more reliable and easier.

Other Species

Caribgrass, *Eriochloa subglabra* (Nash.) Hitch., is similar in growth habit to Paragrass but produces less extensive runners. It has no characteristics which give it an advantage over Paragrass.

CENTIPEDEGRASS

Centipedegrass, *Eremochloa ophiuroides* (Mumo.) Hack., was introduced into the United States from China in 1918.72 This grass is adapted to a wide range of soils. It will grow both on heavy clay soils and on the poorest of sand, if enough plant food and moisture are available for establishment. It will thrive under more adverse conditions than will Bermuda, growing well on land that is difficult to maintain in other grasses.73 Its range is from North Carolina to eastern Texas and along the lower Pacific Coast.

Centipedegrass is a slow-growing, creeping perennial with a medium width leaf, light green in color. It spreads by means of short-jointed, thick, leafy stolons. These root readily and form a dense sod. The nodes are shorter than those of Bermuda-grass and the leaves shorter than those of carpetgrass. This grass grows to a height of only 3 or 4 inches. As a lawn grass it does not require frequent mowing. In some sections this grass seldom reaches a height where cattle can graze it successfully.74

This grass yields less than the carpet, Bermuda, or Bahia grasses, and has a lower protein content (Table 31.11).75 Because of its low nutritive value its best use is for lawns and erosion control. Since it is aggressive it often crowds out more desirable grasses and legumes. It is difficult to eradicate. Care should be taken to avoid it in established pastures. Because of its low fertility requirements, it has a place as a lawn or turf grass on low-fertility soils.76, 77

COGONGRASS

gated vegetatively. New plants form at the joints of the underground stems. It has an upright growth habit. Growth is to a height of 2 to 6 feet, depending upon the soil fertility. It occasionally produces seed. Because of its vigorous spreading by underground stems, as well as from seed, it is classed as a serious weed pest.

QUESTIONS

1. Why is Johnsongrass considered a noxious weed in some areas while in others it is considered a valuable forage crop?
2. Where and under what conditions in the Cotton Belt could you best utilize Johnsongrass in a forage program?
3. How does Johnsongrass differ from all other species of sorghum?
4. Compare the nutritive value of Johnsongrass with Sudangrass and timothy.
5. In the Cotton Belt, how would you use Johnsongrass in a system of year-round grazing?
6. How should Johnsongrass be managed to obtain high yields and to maintain stands?

7. How is Johnsongrass as a weed best controlled?
8. How would you renovate an unproductive meadow of Johnsongrass?
9. Why is interest in seed production of Johnsongrass on the increase?
10. Why is it difficult to maintain legumes in association with carpetgrass?
11. How is carpetgrass best utilized in the South?
12. Why is carpetgrass generally not recommended for improved, high-producing pastures?
13. Why does carpetgrass tend to crowd out other grasses in pasture mixtures?
14. How does Pangolagrass compare with Bermuda and Bahia as a pasture grass?
15. What is the principal use made of Saint Augustinegrass? Why is its use for other purposes limited?
16. Where is Napiergrass adapted, and of what value is it in that region?
17. Under what situations would Rescuegrass be grown?
18. What is the principal advantage of Natalgrass over some of the other grasses grown in the South?
19. Where is Paragrass best used for pasture? Why?
20. Why is Centipedegrass not recommended for pastures?
21. Why was Cogongrass introduced as a pasture plant? What makes it a noxious weed?
Prior to 1930, the only truly native cultivated forage grass of importance was slender wheatgrass. The use of native grasses received its greatest impetus in the droughts of the thirties and the development of the “Dust Bowl.” Concurrent with this was a growing national recognition of soil erosion. The control of soil erosion by grass in the low rainfall areas could only be accomplished with native grasses. Large-scale native grass seed collections by the Nursery Division of the Soil Conservation Service made extensive reseeding possible.

The distribution of native grasses can only be discussed in general terms. The nine grazing regions of the West which are homogenous as to plant composition or range value are: tall grass, short grass, desert grass, bunchgrass, northern shrub, southern shrub, chaparral, pinonjuniper, and coniferous forest.

Others have referred to regions, such as the Corn Belt, Great Plains, Intermountain States, and Pacific Coast, based on geography, climate, soils, and vegetation in a broad sense.

No botanical descriptions will be attempted for the species discussed here. Excellent keys will be found in Hitchcock, Chase, and Dayton. An understanding of the botany of grasses can be obtained from Chapter 7.

A wide variety of grasses are available. Only the most important can be discussed here. Common names are used throughout; for the scientific names of these grasses, see Chapter 7.

**USES FOR NATIVE GRASSES**

Native grasses and closely related introduced species are chiefly used for reseeding abandoned farm lands, severely eroded sites, droughty soils, rangelands, and other areas where common cultivated grasses often fail. As predicted in the 19th century, a persistent faith, coupled with improvement by plant breeding, has led to the domestication of several native grasses.
Cultural and management practices have not been completely worked out for many species. Companion crops are not generally used with many of these grasses but noncompetitive cover crops, grown prior to seeding grass, have been found to be extremely helpful in establishing grass stands in the Great Plains. Corn has been used as a cover crop in the Corn Belt.

Native grass seed often is low in quality. Some species, such as little bluestem, are difficult to clean. Others, such as buffalograss, are difficult to germinate. A good many, such as Canada wild-rye, have awns or appendages which interfere with seeding. Such undesirable propagable characteristics have prompted attempts at establishment by broadcasting hay containing a percentage of viable seed. It has been possible to propagate some species vegetatively.

The low-down fertilizer spreader has been effectively used for broadcasting trashy seed. Seed dilution with sand, sawdust, and cracked grain has been used to facilitate drilling chaffy seed. Some of the need for special drills for handling native grass seed has been eliminated by improved methods of processing.

Seed production of some native grasses has been difficult. Much of the native grass seed has been collected directly from wild stands.

The following brief descriptions of a few of the many species that might be considered are drawn from regional compilations on native grasses. Such

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6 Savage, D. A. Grass culture and range improvement in the central and southern Great Plains. U.S.D.A. Cir. 491, 1939.
9 Savage, D. A. Methods of re-establishing buffalo grass on cultivated land in the Great Plains. U.S.D.A. Cir. 228, 1934.
summaries are available for the Southwest, Pacific Northwest, northern and southern Great Plains, and for the United States in general.

**SPECIES FOR DRYLAND AREAS**

**Bluestems**

The bluestems are of southern origin, thus they make their growth in the warm summer months. There are a large number of species of bluestems. Only three native and two introduced species are important forage crops in this country. Big bluestem often reaches heights of more than six feet at maturity. Its strong, deep roots and short underground stems produce a sod highly resistant to erosion. Growth begins with the advent of warm weather and continues until fall. Its major distribution is on moist, well-drained loams of relatively high fertility in the Central States and on the eastern edge of the Great Plains. The leafy forage is highly palatable to all classes of livestock. It makes good-quality hay, if mowed before it becomes stemmy and seed heads form.

As pasture, big bluestem is palatable and nutritious in its earlier stages of growth. It is vigorous, stands close grazing and will recover from excessive grazing if protected during the first part of the season. The seed matures in late September and October. Seed processing is moderately difficult.

Little bluestem is smaller than big bluestem. Plant height is from 2 to 4 feet. It is more drought resistant than big bluestem. Its major distribution is more westerly and in drier areas of the Great Plains than big bluestem. It is found on gravelly soils, on ridges, and in other exposed locations. One of the main areas where it grows naturally is the Flint Hills section of east central Kansas and Oklahoma.

Under some conditions little bluestem is low in palatability. Seed production is difficult.

Sand bluestem resembles big bluestem, but the heads are conspicuously hairy. It is a vigorous, perennial grass with creeping underground stems. A single plant may spread to cover 30 feet. It grows to a height of five to seven feet. It occurs on deep sandy soils with its major distribution in western Nebraska, Kansas, Oklahoma, and Texas and eastern Colorado and New Mexico.

Turkestan bluestem is a perennial, semi-prostrate bunchgrass introduced from India. It appears to be best adapted to the southern Great Plains. It is quite leafy and palatable, and adapted to grazing. Seedlings are vigorous, and the grass volunteers readily. Seed production is difficult.

Caucasian bluestem, a perennial bunchgrass, is an introduction from Russia which shows promise as a pasture and hay grass in the central and southern Great Plains. It is easily established from seed and makes good growth, even if moisture supplies are low. It bears an abundance of small, viable seed which shatter readily.

Silver bluestem is a perennial bunchgrass which shows promise of fair forage value in the Southwest.

Yellow Indiangrass is a perennial grass similar to big bluestem. It differs from big bluestem in its distinctive, plume-like, densely branched panicle of a
golden, or coppery, color. As a component of the tall-grass prairie it was a valuable hay grass.

Grama Grasses

The grama grasses are warm-season grasses which are of major importance in the Great Plains. They have, in general, received a high rank as range forage. Two species are highly important forage plants of the Great Plains, and four others have shown possibilities in localized areas or in isolated trials.

Side-oats grama, a perennial, usually assumes a bunch form and only occasionally forms a sod. Plant height rarely exceeds three feet. It is easily recognized by its long flower stalks with short, dangling purplish spikes. It is found on favorable sites in the Great Plains. In drier sections it is replaced by blue grama. It rarely forms pure stands, usually growing in association with bluestems. It is palatable to all classes of livestock, having about the same forage value as big bluestem. Seed matures in late summer and can be combined. Yields of seed are good.

Blue grama is smaller, finer, and more drought resistant than side-oats grama. It is found in association with buffalo-grass in the short-grass prairie. Blue grama has no stolons, but it has a dense mass of fine roots and a low, basal type of growth which does form a sod. The fine, curling basal leaves have a distinc-
tive grayish-green color. Plant height at maturity is from 6 to 12 inches. It is found in abundance in the drier sections of the Great Plains. It will stand more drought and alkali than side-oats grama. Thus, it is well adapted for use on lands which cannot or should not be plowed. It is highly palatable and retains its feeding value into the winter months. The short growth precludes its use for hay. Seed usually is harvested from native stands. The chaffy material is difficult to process. In seeding, it is im-

Fig. 32.3 "Blue grama . . . found in abundance in the dryer sections of the Great Plains . . . well adapted for use on lands which cannot or should not be plowed . . . highly palatable . . . " (See below.) (Top) A good stand of blue grama which affords good carrying capacity for grazing animals and holds the soil in place. (Below) Once a verdant and productive range changed to a desert of drifting sand, the result of the destruction of the grass cover. New Mexico S.C.S. photos.

important that native strains be used in the vicinity of origin. There is a wide range of types from north to south in the Great Plains. Each is well adapted locally.

Slender grama, hairy grama, black grama, and Rothrock grama are of some importance on the native range and have been cultivated locally.

**Buffalograss**

Buffalograss is a low-growing perennial which spreads by surface runners or stolons. The seed is unusual, being enclosed in a hard bur with one or several caryopses per bur. The plant height is about 2 to 6 inches. The foliage is a grayish-green color until maturity when it becomes a light straw color. Buffalograss occurs mainly in the central and southern Great Plains. It usually is found on "hard lands" with a high clay content. It is quite drought resistant, and even if killed by prolonged drought and over-grazing, it regenerates from dormant seed in the soil. It is tolerant to alkali but does not succeed on sandy soils. On fertile, deep, moist soils it is replaced by tall grasses unless these have been suppressed by over-grazing. Buffalograss has a wide renown as a range pasture plant. Not only is it highly palatable and nutritious in the green summer state, but it maintains its feeding value in the dry, cured stage during winter months. It is tolerant to heavy grazing. There is almost a romantic interest in buffalograss among the stockmen of the Plains States.

This grass may be propagated either by sod pieces or by seed. Seed is harvested by altering small-grain combines so that the sickle can be run close to the ground. When the grass has been closely grazed, suction machines, brooms, or beater equipment must be used to collect the burs.

**Lovegrasses**

The lovegrasses are chiefly noted for their ability to grow on low-fertility soils or sandy soils. Many of the lovegrasses produce an abundance of seed which germinates readily and establishes easily. There are one native and three introduced species worthy of serious consideration. Sand lovegrass is native to the central and southern Great Plains. It is an erect, perennial bunchgrass, usually about three feet tall. It was first introduced into agriculture about 1937. It is a highly palatable grass which produces good yields from early April to late October. It also has some value as a winter feed. Savage reports that it is much more palatable to livestock than weeping lovegrass. Sand lovegrass is small seeded and is usually seeded at the rate of one-half pound per acre in mixtures, and about two pounds per acre alone. Seed is generally produced in cultivated rows. The seed is fairly easy to combine and cleaning presents no problems.

Weeping lovegrass is an introduction from East Africa which has shown considerable promise in the Southwest. It has been used considerably in Oklahoma for erosion control and forage on low fertility soils. It is a perennial bunchgrass with an extensive but shallow fibrous root system. It grows to a height of 4 feet and forms a bunch 12 to 15 inches in diameter. Like sand lovegrass, the seed are small and heavy with about two million seed per pound. The

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adaptation is southern. North of the Oklahoma-Kansas line winterkilling is rather common. The palatability of weeping lovegrass is not high except during the season of lush spring growth. According to Staten,\textsuperscript{24} it has possibilities (as a pasture plant) when properly used for a supplementary pasture.

Other lovegrasses of promise include Boer lovegrass, and Lehmann lovegrass. Boer lovegrass is a long-lived perennial bunchgrass, less winter hardy than weeping lovegrass. Lehmann lovegrass is a perennial grass with prostrate stems which root and produce new plants at the nodes. It is the least winter hardy of the three introduced lovegrasses.

\textbf{Panicgrasses}

There are three perennial species in this genus which are important. Proso millet is an annual forage crop discussed in another chapter. Switchgrass is a tall, perennial, sod-forming grass which occurs naturally in most of the United States east of the Rocky Mountains. Its chief center of use is in the Great Plains. It is a coarse-stemmed, broad-leafed plant which grows from three to five feet high. The grass spreads slowly by short rhizomes. Switchgrass occurs naturally on fertile soils well supplied with moisture. It is a summer grass. Its value for standing winter feed is poor. Excellent yields of seed, vigorous seedling growth, and high forage yields have made it one of the easiest native grasses to bring under cultivation.

Vine mesquite is native to the Southwest where it is used to a limited extent in seeded pastures and for range reseeding. Because of its long creeping stems which root at the nodes, it is one of the most valuable erosion-control plants in the Southwest. The stolons may be eight to twelve feet long. The erect culms seldom exceed 2 feet. Forage value is fair, when green and tender.

Blue panicgrass is an introduction which has shown promise in the Southwest. It is a tall growing, coarse, vigorous plant like switchgrass. It differs from switchgrass in its ability to root at the nodes, taller growth (six to eight feet), and definite adaptation to hot summers and mild winters. Like reed canarygrass, blue panicgrass can withstand silt deposition and will form new plants at buried nodes. Seed production and quality are good.

\textbf{Dropseeds}

The dropseed grasses are characterized by their high yields of small hard seed which are shattered at maturity. They are "invader" grasses which grow under unfavorable conditions. Their presence on the range often indicates overgrazing, drought, or unfavorable soil conditions. The forage is of low quality.

Sand dropseed occurs on sandy soils. It is most common in the Great Plains and Southwest. It is particularly valuable in mixtures to provide cover until other slow-developing native grasses can become established. Giant dropseed is a tall, robust grass resembling in many ways a giant form of sand dropseed. Spike dropseed has a use and adaptation similar to sand dropseed. Mesa dropseed is found in the southern part of the Southwest region, and prairie dropseed is common in the Central States.

Alkali sacaton and sacaton are tall, coarse, perennial bunchgrasses found on flood plains and alkali soils of the Southwest. Of the two, alkali sacaton is the most palatable and is most apt to become an important cultivated grass. Both species are unpalatable except when green and tender. Other grasses of minor im-

importance in the Southwest include Galleta, Tobosa, curly mesquite, bush muhly, plains bristlegrass and cottontop.

Wild-ryes

The wild-rye grasses are closely related to the wheatgrasses but are often confused in the literature with the unrelated ryegrasses, *Lolium species*. Wild-rye differs from wheatgrass in having two spikelets at each rachis node. There are several native and introduced species which may have a place in grassland agriculture.

Russian wild-rye is an introduction. It is a drought-resistant, widely variable, bunch-type grass with erect culms, terminal spikes, and an abundance of basal leaves. Growth starts early in the spring and the leaves tend to remain green during the summer. Seed production is fair. The seed is easily processed. Russian wild-rye compared favorably with other grasses in digestion trials in Montana.

Canada wild-rye is a large, coarse, short-lived, perennial bunchgrass, widely distributed in the United States. Plant height is from 3 to 5 feet, and the stems are coarse and woody. The seed heads are a thick nodding spike from 6 to 10 inches long. The seed is awned, giving the spike a bristle appearance. It is a cool-weather grass but begins growth later in the spring and lasts longer into the summer than crested wheatgrass and smooth brome. Palatability is only fair. It produces the best hay when cut at the boot stage. The long awns are readily removed by hammermill processing. Canada wild-rye has been used in mixture with biennial sweetclover as a two-year meadow. The seedlings are vigorous, quick-establishing, and not highly competitive with other grasses in mixtures.

Blue wild-rye is a short-lived bunchgrass commonly found in cut-over or burned-over lands of the Pacific Northwest. It resembles slender wheatgrass in adaptation and use. The plants are 3 to 4 feet tall. It is shade tolerant. Seed production is good.

The type species of the genus, Siberian wild-rye, is closely related to Canada and blue wild-rye but has not been well adapted in most tests. Virginia wild-rye appears to be an awnless strain of Canada wild-rye, but it is not as vigorous or productive. Giant wild-rye is a tall, long-lived, coarse, perennial grass with short, thick rootstocks. It is common on wet, alkaline soils of the West. On the range, it was an important source of winter feed in pioneer days. The tall growth, 6 to 10 feet, was nearly always available, even with deep snow cover. Its cultivation is doubtful because of its poor seed habits and lack of palatability. Creeping wild-rye, is closely related to giant wild-rye. It is not as coarse and tall as giant wild-rye. It spreads vigorously by rhizomes. It is well adapted to alkaline soils and is well regarded as range feed.

In many ways creeping wild-rye resembles western wheatgrass, and the two are often confused.

Dune wild-rye, mammoth wild-rye, and yellow wild-rye have little forage value, but are useful in the control of sand dunes. Other grasses which are of value for coastal sand dune control include European beachgrass and American beachgrass. Control of shifting sand

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Grasses for Cool, Moist Climates

Grasses for Cool, Moist Climates

Indian ricegrass is a densely tufted perennial bunchgrass commonly found on sandy soils subject to wind erosion. It is a highly palatable grass. It may be reproduced vegetatively or by seed. Planting of tillers is useful for sand control after initial stabilization.

Smilagrass is a hardy, drought resistant, palatable, long-lived perennial bunchgrass, native to the mountains of southern Europe and the Mediterranean region. It is being cultivated in California, and has possibilities for reseeding range lands, cut-over land, and abandoned cultivated land in the Pacific Southwest. Seed production is good.

Needlegrasses

Many needlegrasses are found in the arid rangelands of the West. One of the more common is needle-and-thread, which has sharp pointed seed which may be injurious to livestock. Sleepy grass has been accused of having a narcotic effect on grazing horses. The two important species are green needlegrass and California needlegrass.

Green needlegrass is a perennial bunchgrass which grows to a height of 1 and one-half to 3 feet. The seed are awned but not of a type injurious to livestock. Green needlegrass is found as a secondary constituent of the native prairie of the northern Great Plains. An improved strain, known as "Green Stipagrass," has been developed at Mandan, N. D.

California needlegrass is a perennial bunchgrass which may be distinguished by its purplish glumes. It originally constituted an important part of the prairies of California.

Of the 1,100 species representing 149 genera in the United States, many must go without discussion. It is believed that many of those listed above will come to be important in grassland agriculture of the arid West.

GRASSES FOR COOL, MOIST CLIMATES

Foxtail

Meadow foxtail is native to temperate Europe and Asia. Since about 1750 it has been widely used as a hay-grass in Europe for wet lands of high fertility. It has been found particularly well adapted to the Pacific Northwest and Alaska. It makes its best growth on moist, fertile soils in a cool, moist climate. It is not drought-hardy or resistant to continuous high temperatures. Under suitable soil and climatic condition, it is a long-lived perennial. At heading, meadow foxtail superficially resembles timothy.

Loosely tufted, with rootstocks and underground branches short and few, it does produce a dense sod in older stands. It starts growth early in the spring, being about the earliest of all cultivated moist-land grasses. The seed are fluffy and light colored, with an occasional brown or black seed.

Meadow foxtail is primarily a pasture grass. Where adapted, it produces over a long grazing season. Palatability, as either pasture or hay, is excellent. As pasture, it is often seeded with big tre-
foil or Ladino clover. Since 1940, it has increased in importance and use in this country. Because of the light, fluffy seed, machine seeding is difficult.

Before 1940, little seed was produced in the United States. One Pacific Northwest seed company reports that its production has increased from zero in 1940 to a few carloads in 1949.

Reed foxtail is strongly rhizomatous and forms a dense sod rapidly. It is sometimes known as creeping foxtail. A high percentage of the awnless seed are black, while most seed of meadow foxtail are awned and white.

**Oatgrass**

Tall oatgrass is quite generally grown in Europe, where it once comprised a part of the grassland climax. It has been cultured in the United States since about 1807. It has generally been considered a grass of secondary importance in this country.  

Production is largely limited to the Virginias and the Pacific Northwest. It prefers a cool, moist climate, and is not extremely drought or heat resistant.

Tall oatgrass under favorable conditions is a long-lived perennial. In many sections it is used as a rapid-developing, short-lived grass. It is strictly a bunchgrass, growing four to six feet tall. Like oats, it produces seed in open panicles, but the seed are smaller and much more chalky. The grass comes on early in the spring and remains green during the summer.

*Fig. 32.1 "Tall oatgrass... prefers a cool, moist climate... not extremely drought or heat resistant... comes on early in the spring and remains green during the summer... palatable to sheep and to dairy cattle." (See below.) Sheep in tall oatgrass palatability trials, with 20 grasses included, at Union, Ore. Oregon S.C.S. photo.*

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### TABLE 32.1

**STRAINS OF NATIVE GRASSES AVAILABLE FROM EXPERIMENT STATIONS, SOIL CONSERVATION NURSERIES, DIVISION OF FORAGE CROPS AND DISEASES, AND STATE CROP IMPROVEMENT ASSOCIATIONS**

<table>
<thead>
<tr>
<th>Species</th>
<th>Strains</th>
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<tbody>
<tr>
<td>Andropogon gerardi</td>
<td>KG 1579 *</td>
</tr>
<tr>
<td>Andropogon ischaemum</td>
<td>King Ranch *</td>
</tr>
<tr>
<td>Andropogon intermedium</td>
<td>Caucasian *</td>
</tr>
<tr>
<td>Andropogon scoparius</td>
<td>KG 1580 *</td>
</tr>
<tr>
<td>Bouteloua curtipendula</td>
<td>El Reno *</td>
</tr>
<tr>
<td>Bouteloua filiformis</td>
<td>Tucson *</td>
</tr>
<tr>
<td>Buchloe dactyloides</td>
<td>Hays *</td>
</tr>
<tr>
<td>Elymus canadensis</td>
<td>Mandan *</td>
</tr>
<tr>
<td>Elymus junceus</td>
<td>PI75737 *</td>
</tr>
<tr>
<td>Eragrostis trichodes</td>
<td>Neb 27 §</td>
</tr>
<tr>
<td>Eragrostis curvula</td>
<td>A-67 †</td>
</tr>
<tr>
<td>Eragrostis lehmanniana</td>
<td>A-68 †</td>
</tr>
<tr>
<td>Panicum virgatum</td>
<td>Blackwell *</td>
</tr>
<tr>
<td>Panicum antidotale</td>
<td>A-130 †</td>
</tr>
<tr>
<td>Stipa viridula</td>
<td>Stipagrass *</td>
</tr>
<tr>
<td>Sideochagmu nutans</td>
<td>M2-10302 †</td>
</tr>
</tbody>
</table>


Spring and remains green during the summer. Its growth period coincides with that of orchardgrass.

The palatability of tall oatgrass has long been questioned. Recent palatability studies have shown that this grass is palatable to sheep and to dairy cattle.

In the Pacific Northwest a mixture of tall oatgrass and sweetclover is used for a biennial pasture or green manure combination. A 2:1 combination of tall oatgrass and orchardgrass with a legume, such as alsike clover or red clover, has long been standard practice. Tall oatgrass cannot stand continuous, close grazing. Early maturity is its only disadvantage as a hay plant. The seedlings are not winter hardy, and spring seedings are best in the Corn Belt. The rate of seeding should be at least double that for orchardgrass. The test weight per bushel and number of seed per pound when processed is greatly different as compared to natural seed. If carefully done and the seed planted shortly afterward, processing does not injure seed germination.

Seed production and cleaning are difficult. Processing facilitates cleaning. Seed yields are good, if not lost by shattering.

Tualatin, a selection developed in Oregon, shatters less readily than common tall oatgrass. Also, there is a tendency for the caryopsis to thresh free from the
hull, which facilitates processing. In addition, Tualatin is finer, shorter, leafier, and later maturing than common tall oatgrass.

There is a closely related weedy variety known as bulbous oatgrass, which develops creeping underground stems with bulbous swellings about the size of a pea. This weedy variety should not be introduced in agricultural areas. An unrelated species known as California oatgrass is becoming popular in the Pacific Southwest. 42

A number of other grasses adapted to cool, moist climates which have been grown to a limited extent in Europe have never been accepted in the United States. They include sweet vernalgrass, velvetgrass, yellow trisetum, and crested dogstail.

QUESTIONS

1. What factors favor, and what factors limit, the adaptation of native grasses to culture in modern grassland farming?

2. Select a particular state, zone, or region and list native grasses best adapted to culture on farm lands. Why did you select them?

3. What methods have been used to overcome the problems of propagation of native grasses?

4. After a review of the literature, or key textbooks in plant ecology and range management, give a brief discussion of the basic facts underlying the tendency of certain grasses to grow in associations.

5. In the preliminary stages of grassland agriculture, what type of grasses are apt to be used; in the final, or perfected, stages? (You will not find the answer in this chapter alone.)

6. Select a particular region, state its climate, soils, type of farming, livestock, and type of management. Indicate which legume (and defend your selection) you would use with meadow foxtail, with weeping lovegrass, with tall oatgrass, with buffalograss, with Russian wild-rye, and with big bluestem.

7. Select, or accept, an assignment of one of the grasses in this chapter. Prepare a paper discussing its origin and history, distribution and adaptation, plant description, importance and use of varieties and strains, cultural and management practices, seed production, processing, and marketing.

8. What prompted soil conservationists to take such an active interest in the development of native grasses for farm use?

Cereals play a vital role in our livestock enterprise. Their utilization as forage, however, has shifted in the last half century from predominantly a hay crop to that of pasture and silage. In 1949, 4.7 per cent of our corn acres were harvested as silage and another 4.5 per cent were used for forage, hogged down, or grazed. Lesser amounts of small grains, either with or without a legume, were put into the silo. More than 2.5 million acres of cereal grains were harvested for hay. For the 10-year period of 1938-47 almost 4 per cent of all hay in the United States was made from cereal grains.

Only a small percentage of the cereals pastured is sown solely for grazing. It has been estimated that 65 per cent of the wheat acreage of Kansas was grazed in 1935. During the last decade, this practice has become more widespread throughout the country and particularly in the Southern and Eastern States.

HAY

Acreages of cereals for hay have decreased about 50 per cent since the dry years of 1934-36. This decrease is related in part to the gradual reduction in horse population. Prior to World War I the 20 million horses on farms consumed the larger part of the cereal hays. Throughout the years 1920-40, the Army was the greatest market outlet. Today, racing stables are the only large purchasers of choice lots of cereal hay. Now, the greatest percentage of cereal hay is grown for home consumption by cattle.

The cereals have many characteristics that make them valuable as a crop for hay. Yield is high, and the forage is rich in protein, vitamins and digestible carbohydrates. The climatic adaptability of the small grains is well known and methods of culture are familiar because of the wide usage of these crops for grain. Improved varieties are available to meet all extremes of climate. The annual and winter-annual habits, coupled with rapid growth to maturity, permit them to fit into nearly any rotation. An emergency crop of hay may be produced during seasons in which perennial hay crops have proved unproductive. In California, Washington and Oregon, where nearly half the cereal hay in the country is grown, the crop is ready for harvest before the dry summer season, thus making

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Chapter 33

Cereals As Forage

Milton A. Sprague spent several years at the University of Arkansas where he did research on southern hay and pasture problems. He then joined the staff of the New Jersey Agricultural Experiment Station, where he is currently engaged in farm crops research and teaching. Wisconsin born, he had his undergraduate work at Northland College, and graduate training at the University of Wisconsin, completing work for his Doctor's degree in 1941.

Cereals As Forage

FIG. 33.1 "The cereals . . . valuable as a crop for hay. Yield is high and the forage rich in proteins, vitamins, and digestible carbohydrates . . . grasses and clovers, commonly sown in grains . . . more likely to flourish when the cereals are cut early for hay." (See p. 391.) Two varieties of oats showing striking differences in plant characteristics. N. J. Agr. Exp. Sta. photo.

the best use of winter and spring moisture reserves.

Cereals sown for other uses in the rotation may be harvested as hay or silage, or as grain, according to farm needs. Perennial grasses and clovers, commonly sown in grains in many sections of the country, are more likely to flourish when the cereals are cut early for hay. In California, winter grains are frequently disk-seeded into old alfalfa stands as a means of increasing the yield of the first crop. In many instances badly lodged grains are cut and cured. More value is thus realized from the crop as hay than could be obtained from the damaged grain. In the Southeastern, North Central and Pacific States nearly as many acres of oats are cut when approaching maturity and fed unthreshed as are cut when less mature and cured as hay. This practice is particularly common on small units where use of expensive machinery for grain harvest is not warranted.

Choice of Grain for Hay

The principal grain chosen for hay in moist climates is oats, either alone or in combination with a legume. This choice is based chiefly on fineness of stem resulting in greater palatability. The numerous tillers formed during vegetative development produce a fine quality hay that can be cured satisfactorily. A high proportion of leaves to stem (Table 33.1), combined with high yields per acre, add to the desirability of oats for hay. In parts of the semi-arid West, barley is chosen in preference to oats because of its greater drought resistance. Wheat is grown farther north than oats and barley because of its greater winter-hardiness. Rye is grown for hay where severe winters require extreme winter-hardiness, or on the poorest soils, where it is known to make more growth than the other grains. Greater resistance to disease and insect attacks also favors rye as a crop.

Palatability. Oats are generally regarded as the most palatable of the cereal hays because of their high percentage of leaves and moderate percentage of head and stalk. Unless rye is cut in very early stages, its tough, relatively leafless stalk makes it the least desirable for hay. Wheat and smooth-awned, hooded or awnless barleys are intermediate in palatability. When eaten in quantity, rough-awned barleys cause serious mouth disorders and are to be avoided.

Productivity. In California, barley yielded less hay per acre than did other grains during years of favorable growth. It was superior to rye, wheat and oats during a dry year. Barley is generally recommended for the more droughty soils.

TABLE 33.1
PHYSICAL ANALYSIS AND YIELDS PER ACRE OF FOUR GRAINS AS HAY *

<table>
<thead>
<tr>
<th>Grain</th>
<th>Varieties tested</th>
<th>% composition by weight</th>
<th>Hay yield, tons/A.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Stems</td>
<td>Leaves</td>
</tr>
<tr>
<td>Barley</td>
<td>3</td>
<td>42</td>
<td>30</td>
</tr>
<tr>
<td>Wheat</td>
<td>5</td>
<td>48</td>
<td>29</td>
</tr>
<tr>
<td>Oats</td>
<td>4</td>
<td>44</td>
<td>31</td>
</tr>
<tr>
<td>Rye</td>
<td>1</td>
<td>54</td>
<td>25</td>
</tr>
</tbody>
</table>


TABLE 31.2
YIELD OF HAY PER ACRE FROM BARLEY, WHEAT, OATS AND RYE DURING FAVORABLE AND DROUGHT YEARS *

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield in tons per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Favorable year 1979</td>
</tr>
<tr>
<td>Coast barley</td>
<td>4.5</td>
</tr>
<tr>
<td>White Austrian wheat</td>
<td>7.0</td>
</tr>
<tr>
<td>Coast black oats</td>
<td>6.6</td>
</tr>
<tr>
<td>Rye</td>
<td>6.8</td>
</tr>
</tbody>
</table>


TABLE 33.3
YIELDS OF CEREAL HAY AT SUCCESSIVE STAGES OF MATURITY *

<table>
<thead>
<tr>
<th>Stage cut</th>
<th>Av. yield in tons per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wheat</td>
</tr>
<tr>
<td>Blossom</td>
<td>6.32</td>
</tr>
<tr>
<td>Milk</td>
<td>7.65</td>
</tr>
<tr>
<td>Soft dough</td>
<td>8.20</td>
</tr>
<tr>
<td>Ripe</td>
<td>7.42</td>
</tr>
</tbody>
</table>


In California, oats, barley, and rye yield the most hay when the crop is in the milk stage of maturity. Wheat produces its greatest yield when cut in the soft dough stage. Thereafter, total yield of hay from all grains becomes less as the grains ripen. The same is true of oats in Maine. In Kansas the greatest increase in total dry weight of wheat occurs between jointing and blooming, but these increases continue until nearly a week before maturity.

Cultivation

Seeding. The culture of cereals for hay is essentially the same as for grain. Less emphasis need be placed on seedbed preparation when cereals are grown for forage since many weeds are not objectionable in hay. Early planting

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is essential to high yields, particularly in drier areas.

In many states up to 50 per cent more seed is recommended in seedings for hay than for grain. However, in Ohio tests seeding more than one and one-half bushels per acre of oats did not result in yield increases. At lower rates of seeding, tillering is encouraged, which tends to mask differences in yield due to stand. The hay becomes finer-stemmed at higher rates of seeding but danger from lodging increases, particularly on productive soils. Cereals sown with a legume are generally seeded at half or two-thirds the normal rate for grain. A mixture of two or more grains is generally considered to have no advantage over a single grain. The mechanical difficulties encountered in seeding a mixture of grains with modern machinery generally discourages the practice.

FERTILIZATION. Cereals grown for hay are considered to make efficient use of greater amounts of nitrogen fertilizers than when grown for grain. In Washington, tests on 19 soils showed an average of 60 per cent increase in the yield of oat hay with 80 pounds of nitrogen per acre. However, when more than 60 pounds of nitrogen was used serious lodging frequently resulted. In most regions 1-1-1 fertilizers are recommended for cereal hays when seeded alone and 1-2-2 fertilizers where grown with a legume. Spring topdressings with nitrogen on fall-seeded grains are frequently recommended on the less productive and lighter soils.

STAGE FOR CUTTING. In Ohio, cutting of oats when in the milk to the soft-dough stage is recommended for cattle and sheep. Horses make good use of a more mature hay. In fact, racing stables usually insist on oat hay cut in the late-dough stage. Bearded barleys and wheats should be cut in the milk stage to avoid toughness, and rye must be cut prior to full bloom to be at all acceptable.

Winter barley is quickest to make a hay crop, requiring about 175 days from planting to the soft-dough stage of maturity. Rye and wheat are intermediate, followed by oats, requiring approximately 187, 193 and 205 days, respectively, to reach the hay stage.

METHODS OF HARVESTING. The same methods are used for cutting, curing and storing cereal hay as are employed with other crops. Cereals alone cure more quickly than when grown with a legume. Both may be chopped and preserved as silage with excellent results. Grains ensiled without chopping are hard to handle and do not preserve well because of the hollow stems, which discourage exclusion of air.

Nutritive Value

The variation in chemical composition of cereal hays is greater between the physiological stages and different parts of the plant than between the cereals themselves. In Washington, protein of whole plants varied nearly 4 per cent from milk to ripe stage. In the same test, wheat and barley varied only 1 per cent in protein content. Still greater margins were observed in percentages of fat, fiber and nitrogen-free extract.

In Maine the total protein and the carbohydrate content of oats have been found to be highest at the milk stage and to decrease toward maturity. In Missouri, the percentages of most vitamins, protein, fat and chlorophyll in plant tops

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TABLE 33.4
CHEMICAL COMPOSITION OF CEREAL HAYS AT THE MEDIUM-DOUGH STAGE OF MATURITY

<table>
<thead>
<tr>
<th></th>
<th>Ash</th>
<th>Crude Protein</th>
<th>Fiber</th>
<th>N-free Extract</th>
<th>Fat</th>
<th>Ca</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat, Albit</td>
<td>5.97</td>
<td>9.36</td>
<td>23.39</td>
<td>59.14</td>
<td>2.07</td>
<td>.16</td>
<td>.17</td>
</tr>
<tr>
<td>Rye, Rosen</td>
<td>5.14</td>
<td>10.60</td>
<td>24.87</td>
<td>57.17</td>
<td>2.22</td>
<td>.28</td>
<td>.30</td>
</tr>
<tr>
<td>Oats, Markton</td>
<td>7.20</td>
<td>7.95</td>
<td>24.16</td>
<td>58.36</td>
<td>2.33</td>
<td>.19</td>
<td>.29</td>
</tr>
</tbody>
</table>


were found to reach a peak at or near the jointing stage in barley and oats. The concentration of crude fiber continues to increase with maturity.

Chemical analyses are generally a fair indication of nutritive value. In California oats tested higher than rye and wheat in protein and fat content. Barley and wheat were low in fiber and high in available carbohydrates. In the same trials, oat hay as an exclusive ration for dairy heifers was inferior to barley and wheat in producing body gains and in yield of digestible feed per acre. Oat hay is the most palatable and is consumed by animals in greatest quantities, but it is less nutritious than wheat, barley or rye. In Washington, the chemical composition of cereals was determined at the medium-dough stage of maturity (Table 33.4). Oat hay was higher in fiber and lower in nitrogen-free extract than other grains.

**CHOICE OF VARIETIES FOR HAY AND PASTURE**

**OATS.** The same varieties of oats are usually recommended for hay as for grain, except where volunteer wild oats, *Avena fatua* and *A. sterilis*, are encouraged in California. Cut prior to the milk stage, wild oat hay has become a favorite on the rougher lands in that state.

**BARLEY.** A barley for hay must be smooth-awned, awnless or hooded. Of these, the first and last are most frequently chosen. In California, *Hero* and *Hojo* are common hay varieties. *Meloy*, *Union Beardless*, *Belsford* and *Horsford* are used in the Pacific Northwest, where it is a common practice to sow the perimeter of wheat fields to a hooded barley, later to be cut for hay. *Colless*, another hooded type, is used in a similar way in Colorado. In the Southeastern States,
Tennessee Beardless, Tredell and Missouri Early Beardless are grown to a limited extent for hay. In the Middle Atlantic States, Wong serves both forage and grain requirements.

California studies showed considerable variation among barley varieties in percentages of leaves, stems and heads. These characteristics, as well as uprightness and earliness, determine the varieties most suitable for hay. A test of more than 200 varieties in Washington showed a range in hay yields from 2,884 to 7,435 pounds per acre. Spring varieties yielded 15 per cent more than the winter group. The bearded varieties yielded about the same as the hooded. Two-row varieties outyielded the 6-row group by about 10 per cent. The naked barleys yielded the least of all the varieties tested.

Less information is available on barley varieties ideally suited for grazing. A variety able to make rapid growth at near-freezing temperatures seldom possesses sufficient winter-hardiness. Accordingly, recommendations generally compromise with locally adapted varieties used for grain.

WHEAT. Variation in the composition of the forage produced by different varieties of wheat was found to be small in Kansas. The Turkey types are preferred for pasture because of their greater ability to tiller. Varieties recommended for grain are in general use for forage except that bearded wheats are undesirable as hay for horses.

RYE. No varieties of rye have been generally recognized as superior for hay.

Balbo rye is generally considered superior for grazing because of its more rapid growth in very early spring. The Tennessee, Michigan, Missouri and Kansas stations report that Balbo as pasture imparts less of the undesirable flavors to milk than is usual from other varieties. Abruzzi, the most extensively grown variety in the Southeast, boasts greater yields and palatability than common rye. Common rye, yielding less, is generally sown in the North where an extremely winter-hardy variety is required.

PASTURE

The grazier's dream of year-round grazing is brought closer to reality when the cereal grains are used extensively for pasture. In the United States, far more use is made of winter grains for grazing than for hay or silage. Every year large acreages that have been seeded primarily for winter cover, green manure or grain are grazed. So widespread is the practice of grazing fall-sown grains in the Wheat Belt that the feeder-steer market is strongly influenced by the fall growth of this cereal.

Although growth rates diminish as winter approaches, forage accumulated during the fall can provide almost a continuous supply of pasture throughout the winter in the South. In other regions the grazing season can be extended through one to two months in fall and spring.

Fall-sown spring oats are used in the South to supply early fall pasture and greater fall yields. Spring-sown fall grains provide late spring and early summer forage which will remain vegetative longer at this season than will spring grains. Aftermath growth of rice is sometimes grazed following the harvest. Green corn is frequently used as a soiling crop when summer pasture is short.

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Choice of Grain for Pasture

PRODUCTIVITY. Rye is preferred for grazing in nearly all regions because of its greater winter-hardiness and superior yielding ability during the cooler seasons of the year. The total yield of dry matter has been found to be twice that of wheat and barley and three times that of oats in New Jersey. Rye also has been found to be superior with respect to total yield in Georgia, Oklahoma and Tennessee. Oats yield nearly as much as rye farther south and more than wheat and barley where winter temperatures are more moderate.

In Georgia rye carried more animals per acre than a mixture of oats and vetch, and nearly twice as many as oats alone (Table 33.5). The mixture of oats and vetch, however, produced nearly 25 per cent more beef per acre than did rye and 126 per cent more than oats alone.

PALATABILITY. The relative palatability of the small grains generally places oats and wheat first, followed by rye and barley. All of the grains are readily grazed when grown in pure stands. No advantage is to be gained from mixed seedings of grains, although seeding with a legume increases the yield and feeding value of the forage.

TABLE 33.5
PERFORMANCE OF THREE WINTER GRAZING CROPS WITH BEEF ANIMALS, 1936-44 * †

| Characteristic measured | Av. performance record of:
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oats</td>
</tr>
<tr>
<td>Days of grazing ..........</td>
<td>86</td>
</tr>
<tr>
<td>Av. no. animals per acre.</td>
<td>0.62</td>
</tr>
<tr>
<td>Grazing days per acre</td>
<td>51.6</td>
</tr>
<tr>
<td>Av. gain per animal in lbs.</td>
<td>97.4</td>
</tr>
<tr>
<td>Av. daily gain per animal in lbs.</td>
<td>1.2</td>
</tr>
<tr>
<td>Av. gain per acre in lbs.</td>
<td>67.6</td>
</tr>
</tbody>
</table>

* Except 1938.

Chemical Composition

The chemical composition of small grains in their young stages is, with the exception of calcium and phosphorus, practically identical with that of alfalfa. Young plants frequently contain 28 to 30 per cent protein on a water-free basis and are dehydrated commercially for use as feed concentrates. Only a small variation exists between the chemical composition of the different grains in the young vegetative stages.

In Kansas, a 3-year study showed that two varieties of wheat sown in early October consistently contained more than 20 per cent protein up to the end of the following March. During April the protein dropped to 15 per cent, and by the first week in May the percentage was less than 12. In Oklahoma, the forage of barley, wheat and rye consistently decreased in protein content with each successive harvest from October to April.

Culture

Seeding Practices. Fall-sown cereals for pasture are frequently seeded earlier than those intended solely for grain, except where insect and disease problems interfere. In Georgia, oats sown October 1 yielded more than 3 times the total forage of those sown November 1. To obtain grazing sooner, seeding rates generally are increased slightly. With these exceptions seeding recommendations of cereals for pasture correspond to those for grain.

Fertilization. Small grains for grazing are able to make efficient use of large amounts of nitrogen fertilizer. In the South a 1-1-1 fertilizer is generally recommended at planting time, and topdressing with nitrogen during winter and spring is a common practice. The extra nitrogen alleviates the usual reduction in protein content of the forage during these seasons. Increases up to 200 per cent in forage production were observed in Georgia with as much as one ton of nitrate of soda applied in split applications, fall and winter. Lesser amounts are considered economical on most soils. Although nitrogen increases the danger of lodging in crops to be harvested for grain, either fall or spring grazing will eliminate this difficulty in most instances.

Management. Management of small grains as pasture varies with the choice of using the crop entirely for grazing or for grazing plus grain production. Overgrazing is the most common...
the offspring of such crosses is completely fertile. Johnsongrass, which has 20 haploid chromosomes, crosses very rarely with the *S. vulgare* varieties.

**DISTRIBUTION AND ADAPTATION**

Since sorghum is quite resistant to drought, the species is grown most in areas where rainfall is insufficient for corn production. Sorghum responds well to irrigation, however, and is an important grain crop in the hot irrigated valleys of Arizona and California. The species is well adapted to regions of limited rainfall where the average annual rainfall is only 17 to 25 inches. The most favorable mean temperature for growth is about 80 degrees F. The minimum temperature is 60 degrees F. On account of temperature requirements, sorghum is rarely grown at elevations above 6000 feet. The adaptation of sorghum makes it particularly suited to the Great Plains region of the United States from Texas to North Dakota.

Sorghum is a short-day plant but most of our forage varieties are relatively insensitive to photoperiod. Sorghum is produced successfully on all types of soil, growth being dependent upon the relative fertility and soil moisture supply. It is more tolerant to alkali or salts than most cultivated crops of the Great Plains region. Sorghum is more important for forage than for grain in the more northern part of the area of adaptation. In the Corpus Christi area of Texas, the crop is planted as early as March when the daylight period is shorter than 12 hours. At this time of year there are no extremes of temperature in that region. Sorghum is frequently planted in July in parts of Oklahoma and Kansas when temperatures are high and the period between...
sunset and sunrise more than 14 hours. In the interior valleys of California and in the Coastal area of Texas, sorghum is frequently planted in September. It is apparent that sorghum can be grown under diverse environments but different varieties are grown at the extreme conditions.

PLANT CHARACTERISTICS

Sorghum is a coarse grass. The stems are erect and solid and grow in height from 2 to 15 feet. There is a lateral bud at each node on alternate sides, much as in corn. Both corn and sorghum have internodes that are grooved and the grooves alternate from side to side in company with the lateral buds and the leaf arrangement. There is a tendency, especially in some varieties, for the lateral buds at the lowermost nodes to develop into tillers. If plants are thick in the row, these tillers are suppressed or never begin development. The length of the internodes determines the height of the plant. Varieties with the same maturity but different heights have the same number of nodes and leaves, but have internodes of different lengths. A leaf arises at each node. Sorghum leaves are shaped like corn leaves but are smaller. The leaf blades are glabrous with a waxy surface. Sorghum leaves inroll during periods of drought. This characteristic, along with the waxy surface, contributes to the drought resistance of the species. At maturity the profusely branching root system supplies a leaf area approximately half that of corn.

Sorghum plants can be readily distinguished from corn plants because of the presence of saw teeth on the margins of sorghum leaves. The pith in the culms of sorghum may be either juicy or dry and sweet or non-sweet. There are varieties with each of the possible combinations. The culms of most forage varieties are both juicy and sweet. Juicy pith may be easily recognized since the leaf midribs are opaque. Dry pith causes the leaf midribs to be white as there are air spaces rather than juice in the pithy tissues.

The inflorescence of sorghum is a panicle, usually called a head. The head is compact except in Sudangrass, broom-corn, and a few sorgos. There are many primary branches that bear paired ellipsoidal spikelets. The spikelets are of two kinds, sessile and pedicillate, the latter usually being staminate but sometimes sterile. There are two florets in the sessile or fertile spikelet, the lower sterile and the upper fertile. The lemma and palea are thin and translucent. The lemma may be awned or awnless. Some sorghum varieties, including several important sorgos, have seed that are completely covered by glumes that are not removed in threshing. All grain varieties and many sorgos have seed that thresh free from the glumes. Panicles usually are erect but sometimes recurve. A sorghum panicle may contain as many as 6,000 fertile spikelets. A panicle ordinarily blooms in five to seven days, but consumes a longer time in cool weather. Sorghum is generally self pollinated, but there is no barrier to cross fertilization. When varieties are grown adjacent to one another, cross fertilization of about 6 per cent is common.

Sorghum grains are small in comparison to those of corn and 12,000 to 30,000 weigh a pound. The seed may be white, red, yellow, or brown. A large part of the caryopsis is endosperm, made up almost wholly of starch. Certain layers of some seed contain considerable amounts of tannin. If the grain is ground, the tan-
nin disappears as it is soon oxidized. Sorghum fodder contains more than 50 per cent digestible nutrients which consist of 8 per cent protein, 2.5 per cent fat, and 45 per cent nitrogen-free extract. Sorgo fodder usually contains less than 20 per cent grain by weight. Grain sorghum fodder, since the plants are shorter, usually is more than one third grain. There is a tendency for the nutrients produced per acre to be the same whether much of the carbohydrates is in the grain in the form of starch or in the stem and leaves as starch or sugar. Air-dry sorghum stover, on the average, is about 13 per cent leaves and 87 per cent stalks. Average yields of green fodder of sorgo varieties over a period of years on good land vary from 6 to 15 tons per acre, the lower yields being made by early maturing varieties. The dual purpose forage and grain types produce about 75 per cent as much dry fodder as the highest yielding forage types. The dual purpose varieties will produce slightly more grain than the highest grain yielding forage types but as much as 75 per cent more than poor seeding types such as Honey.

Prussic Acid Content

Plants of sorghum and Sudan grass, and also Johnsongrass, sometimes contain a glucoside called dhurrin, which may break down into prussic acid or hydrocyanic acid. A few cattle, sheep, and goats die each year when grazing these plants. Silage and dry fodder may contain toxic amounts of prussic acid, but usually can be fed safely. The free acid volatilizes as the silage is being handled in feeding. Also, the poison decreases during the curing process of the fodder. The prussic acid content in the green plant decreases as maturity approaches. The amount of prussic acid varies in different sorghum varieties. Sudan grass contains less than most sorghum varieties and Johnsongrass. Most of the losses from prussic acid poisoning occur in the more northern areas of the sorghum growing region. Poisoning resulting from sorghum fodder, or Sudan or Johnsongrass hays, are almost unheard of in the states that border the Gulf of Mexico. Unless low prussic acid varieties are grown, danger from prussic acid poisoning makes it unsafe to graze green sorghum in the northern part of the sorghum region.

IMPORTANT AND USE

Twenty years ago the area in the United States planted to sorghum for forage usually was less than 5 million acres. The acreage gradually increased to a maximum of almost 13 million in 1940 and remained high until 1947. The 1948 and 1949 acreages were back to 4 or 5 million. The acreage and production of sorghums for forage for the 10-year period 1937–1946 were:

<table>
<thead>
<tr>
<th>Uses</th>
<th>Forage and hay</th>
<th>Silage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acres *</td>
<td>8,413</td>
<td>907</td>
</tr>
<tr>
<td>Tons *</td>
<td>11,992</td>
<td>5,300</td>
</tr>
<tr>
<td>Yield †</td>
<td>1.4</td>
<td>5.9</td>
</tr>
<tr>
<td>* In thousands</td>
<td></td>
<td></td>
</tr>
<tr>
<td>† Acre tons</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Although sorghum is not one of the major crops of the United States it is one of the most important in the areas where production is concentrated. Sorghum fodder is especially valuable for winter

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feeding in the Great Plains region where other forage crops are not well adapted. In western Texas, Oklahoma, Kansas, eastern New Mexico, and southeastern Colorado, sorghum fodder is the basic feed for livestock. Cattle make better use than sheep of a coarse feed such as sorghum fodder. Cattle will always be the predominant kind of livestock in the sorghum producing region. Properly cured sorghum fodder, with a little protein supplement, will maintain cattle in good condition throughout the winter with little or no grain supplement.

The palatability and feeding value of the fodder of the dual purpose types—kafir, hegari, and feterita—and of Sumac sorgo are quite similar. Due to the larger acre yields, sorgo varieties are to be preferred over grain sorghum varieties for forage production. When fed to cattle, there is only a slight advantage in chopping the forage.

Sorghum silage has largely replaced corn silage in Kansas, Nebraska, Texas, and Oklahoma. Where sorghums are well adapted the acre production of sorghum silage is usually one to two-thirds higher than from corn. The feeding value of silage made from corn and from sor-
desired stand of most varieties. Actually, the planting rate can vary widely with little difference in yield.

IN CLOSE DRILLS OR BROADCAST. When a grain drill is used, the rate is from 15 to 90 pounds per acre. Stalks are coarser where the rates are low and there is a tendency for the plantings to become weedy. The usual rates for broadcast plantings are 30 to 45 pounds in the drier and 60 to 90 pounds in the more humid areas.

Harvesting

Sorghum forage to be stacked is harvested with a row binder and shocked. It is the general practice to allow the bundles to lie in the field for two or three days before shocking. After the forage has thoroughly cured in the shocks it is hauled and stacked at a convenient place. There is spoilage in the stack unless care is taken in its construction to see that rain will not penetrate. If sorghum forage is needed as an emergency feed it is more economical to store as silage, since in this form it will keep almost indefinitely.

Sorghum hay from broadcast planting is mowed and raked into large piles that are left to dry. After curing in such large piles, the hay is either baled or stacked as any other hay.

Sorghum preferably should not be harvested until it approaches maturity. Mature sorghum produces a greater tonnage, is more palatable, contains less prussic acid, and is easier to preserve either in the stack or silo than an immature crop.

SEED PRODUCTION

Formerly, very little sorgo was grown as a seed crop. Farmers and ranchers would chop off the heads before feeding the bundles, thresh the heads at some convenient time, and sell the surplus seed. In recent years there has been a shortage of seed of adapted varieties. Such varieties as Sumac, Sourless, and Atlas are grown as seed crops under cir-
cumstances where good use cannot be made of the stover.

As a usual thing, seed crops of sorgo and of dual purpose forage and of grain varieties are harvested with a low binder, shocked in the field, and later threshed with a combine driven from shock to shock. Seed crops also are occasionally harvested with a combine.

It is not as important to have pure seed of forage sorghums as of grain sorghums that must be combine harvested. If pure seed is to be produced, it is necessary to isolate the fields as much as 200 yards to prevent cross pollination with other varieties. Sorghum varieties are all genetically pure lines. Seed production of the dual purpose varieties usually is 1,000 to 3,000 pounds per acre and of sorgo varieties about 20 per cent less.

All of the varieties used for forage production are susceptible to one or more of the strains of kernel smut, and it is a wise precaution to treat planting seed for the control of this disease.

**SUDANGRASS**

No statistics on Sudangrass acreages are available. The average production of seed in the United States for the twenty years ending in 1948 has been more than 44 million pounds, indicating that the area planted must be between 3 and 4 million acres annually. Most of this acreage is pastured, as Sudangrass is an excellent annual grass. It is used extensively throughout the United States except in the extreme north, and in the humid southeastern states where foliage diseases are such a problem that pearl-millet is frequently used instead of Sudangrass.

**Plant Characteristics**

Sudangrass resumes growth after pasturing or mowing and three or four cuttings a year can be obtained in the southern Great Plains region. A crop of hay is produced in 60 days. The plants will stay alive during periods of drought even after mowing or heavy pasturing and will resume rapid growth after rainfalls. Like other sorghums, Sudangrass prefers a warm summer climate of relatively low humidity and is sensitive to frost. The growing season is limited to the warmer months of the year.

Sudangrass is a grassy counterpart of the ordinary sorghums. Unlike Johnsongrass, Sudangrass has no rootstocks and does not become a weed in cultivated land. Sudangrass is an erect growing plant that reaches a height of 5 to 6 feet under ordinary conditions. The stems rarely grow larger than \( \frac{3}{16} \) of an inch in diameter and are solid with pith and not hollow. There are usually 10 to 14 long and narrow leaves. The seed head ranges from 10 to 16 inches long and frequently attains a breadth of 10 to 12 inches when the panicle is spreading. The culms of common Sudangrass as well as several improved varieties are pithy, but Sweet Sudangrass has juicy and sweet stems. The glumes that cover the seed of all varieties are of different colors. The common variety and California No. 23 are straw colored, with occasional seed with glumes that contain blackish red color. Tift Sudan has glumes that are usually mahogany colored and Sweet Sudan has glumes that are sienna in color.

While most of the acreage planted to Sudangrass is pastured, considerable acreages are mowed for hay or bundled. The hay is palatable and nutritious and is used in the same way as sorghum hay and other bundled forage.

**Sudangrass Varieties**

The early efforts at Sudangrass breeding were aimed at making it easier to detect mixtures of small amounts of Johnsongrass seed in Sudangrass seed. Selec-
Fig. 35.1 "Millet is essentially a warm weather crop ... grown most in semi-arid regions. ... Grain and forage varieties ... outrank all other crops ... efficient in the use of water." (See p. 412.) Different types and varieties of millet. (Left) Pearl; (center) proso; (right) foxtail. Iowa State College photo.

Foxtail millets are annual grasses characterized by slender, erect, mostly simple but sometimes branching stems which grow from 1 to 5 feet in height. The seed is borne in a rather dense, spikelike panicle. Pearl millet grows from 5 to 16 feet in height. The plants tiller freely and the stems are pithy. Japanese barnyard millet is a thick-stemmed plant and grows 2 to 4 feet tall. The spikelets are on one side of the rachis. Proso millet is distinguished from foxtail types by having a panicle type head. Proso has coarse stems and is not as leafy. The seed is larger and not as tightly held in the hull as that of the foxtail group.

The color of the hulls vary greatly with different varieties. Some have hulls that are white; others cream, yellow, red, orange, green, purple, black, or mixtures of various colors. Millets are largely self-pollinated though pearl millet is largely cross-pollinated.

**Importance and Use**

The place of millet in agriculture is largely limited to its use as an emergency crop, or as a late-sown catch crop. The total area in millet for the United States in 1899 amounted to 1,117,769 acres. Since then its production has decreased to the extent that at present probably less than 100,000 acres are being grown in this country.

**Hay.** Foxtail millets make a fair quality hay, which, although somewhat inferior to timothy, seems to be...
FIG. 3.2 “Several distinct varieties are available ... for hay. ... The most commonly grown ones ... Dakota Kursk, White Wonder, Siberian ... early maturing varieties ...” (See below.) A field of White Wonder millet growing near Enid, Okla.

relished by livestock. The hay from proso is of poor quality because of the coarser stems and hairy leaves. While millet may be used as a pasture, cattle will leave it for such crops as Sudangrass, small grains or grass-legume mixtures. Millet hay is palatable to all classes of livestock, but if fed to horses it should not exceed one-third of the forage ration.

GRAIN. The grain of proso is readily eaten by all kinds of livestock and, when ground, has about the same feeding value as barley or corn. It is used extensively in chick feed and bird-seed mixtures. Grain from foxtail millets is slightly less palatable than proso and has about 83 per cent the feeding value of corn.4

COVER CROP. The use of millets as a cover crop in orchards to control soil erosion and for weed control is increas-

ing. Where good stands are obtained millets are quite effective in controlling weeds.

HUMAN FOOD. In Russia, China, Siberia and India proso is used as food. The hulls are removed and the seed then ground into a meal which makes thickening for soups. In Russia the meal is cooked into a mush, called “kaska.”

VARIETIES

FOXTAIL TYPES. Several distinct varieties are available for hay production. The most common ones grown in this country are as follows: Dakota Kursk, White Wonder, Siberian, Goldmine, Hungarian, German (Golden), Turkestan, and Empire. Dakota Kursk and White Wonder are early maturing, whereas German and Empire are late in maturity.

PROSO TYPES. The most widely-grown proso varieties probably are Yellow Manitoba, Turghai, and Early Fortune. Red Russia, Tambov, Crown, Deerbrook, White French, Red Lump, and Black Voronezh are grown to a lesser extent.6 Early Fortune is an extremely early, red-seeded variety. It does not yield as well as the later varieties. Yellow Manitoba matures too late to be of value in the northern Great Plains area but is recommended in Michigan. Turghai, a medium early, reddish brown seeded variety, has proven quite satisfactory in Colorado, North Dakota, South Dakota, and Wyoming.7,8

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CULTURAL AND MANAGEMENT PRACTICES

SEEDBED PREPARATION. Seedbed preparation for millet is similar to that for small grains. Since millet is planted late as a catch and emergency crop, one or two weed crops should be destroyed by cultivating before sowing.

TIME OF SEEDING. Millet is a warm weather crop. Generally, millets can be seeded 2 to 4 weeks after corn is planted, or from about the last week in May through the first week of July. Approximately 60 to 80 frost-free days are required from the time of seeding to harvest.

RATE OF SEEDING. Seeding rates for millet may vary from 10 to 45 pounds per acre. Satisfactory stands may be obtained with 10 to 15 pounds but ordinarily 20 to 35 pounds are sown.

METHOD OF SEEDING. Millets are sown with the ordinary grain drill or the seed may be broadcast. The 6-inch to 8-inch drills are preferable to wider ones as the closer spacing helps the crop to compete with weeds.

HARVESTING FOR HAY. For best hay quality the crop should be cut just before or when the first heads appear. It is more palatable and nutritious at the earlier stages of growth than when more mature.

HARVESTING FOR SEED. Millets should be harvested when the seed in the upper half of the heads are mature. The plants are still green at this time but if allowed to proceed beyond this stage there will be undue shattering and loss of seed. The binder usually is the best machine to cut millet. Millet can be harvested with a windrower and when dry threshed with a combine equipped with a pickup attachment. Direct combining usually is not very satisfactory. Also, the seed drops off easily soon after it is ripe and may shatter badly before the crop can be combined.

KOCHIA

At long intervals a plant previously classified strictly as a weed is found to have agricultural value. Such a plant is kochia, Kochia scoparia L.

Research with kochia to determine its agricultural value was begun at the South Dakota Experiment Station in 1910 and continued to 1946. The studies...
In composition, kochia hay compares favorably with alfalfa, both showing a high protein content. Samples of kochia obtained from different parts of South Dakota in 1942 ranged from 11.34 to 22.58 per cent protein. In leaf-stem ratio studies kochia was found to average 62.4 per cent leaves, which is higher than ratios reported from various sources for alfalfa. Leaves are resistant to shattering in haying and baling operations. The leaves have a tolerance to shade, remaining green and functioning. In 1945 the leaves remained green to the base of the plants in late September when the plants were 5 feet tall in a close-drilled seeding. Viewed from the standpoint of acre production kochia in seven trials averaged 1.8 tons per acre.

A good stand may produce as much as 1,000 pounds of seed per acre. The seed does not carry over as "hard" seed in the soil and under storage conditions is not safe after two years. The
seed are capable of germinating at low temperatures and the seedlings are extremely resistant to injury from freezing.

Drought resistance is a highly desirable characteristic in a forage plant for the Great Plains region. Observations on the palatability of kochia as pasture indicate that it is eaten readily by cattle, sheep, and hogs. Animals have been observed eagerly grazing the early spring growth. During the summer of 1943 several pastures were found to be producing mainly kochia which cattle were grazing as their principal source of feed. Kochia harvested at 20 to 26 inches in height and before flowering gives a palatable and nutritious forage hay.

**QUESTIONS**

1. What are the important groups of millets grown in the United States? What bases are used for their classification?
2. Under what conditions do millets grow best? Why? Where and under what conditions should they be recommended?
3. What are the common uses of the millets? Why has the acreage declined?
4. Name several of the better hay varieties grown in this country.
5. Describe briefly the more important steps in the growing of this crop.
6. What methods should be used in making palatable millet hay?
7. Why is kochia a desirable forage plant for the Great Plains region?
8. How does kochia compare with alfalfa in yield, nutritive value, and palatability?
Rape, Kale, and Similar Forages

The agricultural varieties of *Brassica* fall into three groups, the cabbages, the swedes, and the turnips. The cabbages, *B. oleracea*, comprise the familiar garden vegetable and also the well-known farm crops, thousand headed kale, kohlrabi, and marrowstem kale. The swede group, *B. napus*, includes besides the swedes proper, the common rape and the colza, or oil bearing rapes. The turnip group, *B. rapa*, includes both the turnips proper and certain rapes which have a turnip-like foliage.

**RAPE**

Rape has been known in England since the 16th century and is now distributed over much of Europe, northern Asia, Canada and the United States. In the northern part of the United States rape probably is more widely grown for hog and sheep pasture than any other annual crop. It thrives on any fertile soil adapted to corn, needs no cultivation, and the seed is relatively low in cost. In the South, rape is an excellent winter forage on the better soils. In dry seasons, or in areas of low rainfall, forage yields may be seriously reduced by plant lice.

Rape is an outstanding emergency pasture crop. Comparative tests show that it compares favorably with alfalfa in producing rapid and economical gains with hogs. Rape is best seeded in the spring. The young plants are hardy and not injured by light frost nor killed by ordinary frosts in the fall. A seeding of rape may be expected to furnish pasture for a period of 5 to 6 months in the Corn Belt, from early summer until severe freezes in the fall.

**Nutritive Value**

The crop is an excellent source of vitamins A and C, and contains an appreciable amount of vitamin B. Hogs pastured on rape maintain an unusually thrifty appearance. Their coats are sleek and glossy, which may be due to the fact that the rape plant is rich in sulfur and protein, important constituents of hair. The succulence of the plant tends also to keep the digestive system in good shape. In feeding and digestion trials at the Iowa station the rape leaf portion grazed by hogs contained 28.22 per cent protein, water-free basis, as compared to

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Rape

TABLE 36.1
RED CLOVER COMPARED WITH RAPE FOR PIGS, OHIO

<table>
<thead>
<tr>
<th></th>
<th>Red clover</th>
<th>Rape</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of trials</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>No. of pigs</td>
<td>57</td>
<td>58</td>
</tr>
<tr>
<td>Av. daily gains, lbs.</td>
<td>1.20</td>
<td>1.13</td>
</tr>
<tr>
<td>Feed per 100 lbs. gain</td>
<td>357.22</td>
<td>364.18</td>
</tr>
<tr>
<td>Cost of feed and pasture per 100 lbs. gain</td>
<td>$4.86</td>
<td>$4.93</td>
</tr>
<tr>
<td>Gains per acre of forage, lbs.</td>
<td>2,212</td>
<td>2,205</td>
</tr>
</tbody>
</table>

* Corn, tankage, linseed meal, salt.

TABLE 36.2
FEEDING SPRING PIGS ON ALFALFA AND RAPE PASTURE, MICHIGAN

<table>
<thead>
<tr>
<th></th>
<th>Av. daily gain—lbs.</th>
<th>Three-year av.</th>
<th>Lbs. feed required per 100 lbs. gain</th>
<th>Feed cost per 100 lbs. gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa pasture</td>
<td>1.309</td>
<td>347.11</td>
<td>$6.60</td>
<td></td>
</tr>
<tr>
<td>Rape pasture</td>
<td>1.304</td>
<td>361.88</td>
<td>$7.07</td>
<td></td>
</tr>
</tbody>
</table>

30.09 per cent for alfalfa. Rape contains 35 to 50 per cent less crude fiber than red clover and is very succulent, having as much as 80 to 90 pounds of water in 100 pounds of the green plant. Animals on rape, to get as much dry matter as the animal on alfalfa or red clover, must eat 1½ to 2½ times as much forage by weight. Possibly this is the reason why livestock on rape show a need for a more concentrated protein supplement than is apparently required on leguminous pastures such as clover and alfalfa. In the Iowa tests, by allowing free access to shelled corn and meat meal, as many as 40 shoats were carried on an acre of rape for a period of 5½ months. The usual rate of stocking, however, is 18 to 22 spring pigs or about 10 fall pigs.

Robison, reporting on experiments at the Ohio station, concluded that rape is one of the most satisfactory annual forage crops for pigs. He reports comparisons with red clover, as shown in Table 36.1. Robison points out that rape is sometimes severely damaged by plant lice. This is particularly true if grown on soils of low fertility.

Rape sometimes causes white and thin-skinned hogs to blister or sunscald. The back and ears of the hog are usually affected. Sunscalding, or blistering, seems to be worse during early summer than later. It is caused by the pigs getting wet in the rape and then into the hot sunshine. If the pigs are treated promptly with applications of grease, hard oil, or carbolated petrolatum, the blistering is not apt to be serious.

At the Michigan station rape was compared with alfalfa as pasture for spring pigs. When shelled corn, protein supplements, and minerals were fed, alfalfa and rape pastures produced almost identical daily gains. The pigs on the rape ate 40 per cent more protein supplement than did the pigs on alfalfa.

Rape is a desirable pasture for sheep. It is used chiefly as a supplement to

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permanent pastures, especially in late summer and early autumn. A combination of oats and rape gives excellent results as a pasture for ewes and lambs. Seedings are made with oats at the rate of 2–3 pounds of rape per acre. In Ohio, as an average for three years, an acre of rape pasture produced as much gain on fattening lambs as $3\frac{1}{2}$ acres of fairly good bluegrass.\(^5\)

**Cultural Requirements and Management Practices**

The seedbed for rape should be well worked and clean, either by diskimg down. Rape is best sown in early spring, about grain seeding time, but it can be seeded as late as midsummer with the expectation of profitable returns. A good method of seeding is to drill with a grain drill, using 5 or 6 pounds of seed per acre. Broadcasting also gives satisfactory results, in which case the rate should be increased to 7 pounds per acre. On soils that dry out easily in summer, rape is sometimes drilled alone in rows 2 or 3 feet apart, using 2 to 3 pounds of seed per acre. Weeds must be kept under control by cultivation until the crop is ready for grazing.

Rape is used either for grazing or as a soiling crop. Seeded early, it should be ready to pasture by around June 1 in

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the central Corn Belt. Livestock should not be turned in until the plants are about 12 inches high. Over-stocking should be avoided. Should the plants become pastured down to 4 or 5 leaves to the stalk the animals should be taken out to give the crop a chance to recover. In the fall, as cool, frosty weather approaches, the field may be stocked to its limit so as to have the forage well consumed before heavy freezes come.

Varieties

There are both annual and biennial varieties of rape. The annual, or summer varieties, are grown almost entirely for the seed while the biennial, or winter sorts, are grown for forage. The annuals are not desirable for forage because of their low production and short period of utility. Of the biennials, Dwarf Essex is considered the most satisfactory for general use. In the Corn Belt this variety produces a large quantity of succulent feed during the first year, but usually does not live over winter. Victoria and Dutch Broadleaf are practically the same as Dwarf Essex. The biennials are especially well suited to mild, moist climates and rich mellow soils, as found so extensively throughout the Corn Belt regions.

Seed Production

In general, our rape seed has been imported from western Europe and Japan. When war conditions cut this supply, it was found that profitable seed crops could be produced in western Oregon where yields of 700 to 1,000 pounds per acre have been obtained. The seed is produced in the second summer. When rape pods are yellowing and the seed becomes dark brown in color the crop is ready for harvest. Seed crops are sometimes harvested with the combine from standing or windrowed plants. Care is needed to avoid serious shattering in the field. Rape seed contains considerable oil and after threshing should be spread out to prevent molding or spoilage.

KALE

Kale, a cabbage-like plant that does not form heads, is grown extensively for livestock feeding in the United States only in the northern Pacific Coast district. A large growing variety, "thousand headed kale," is there considered the best fall and winter soiling crop for dairy cows and is used also for sheep and swine. In that district, kale usually will remain green most of the winter. Marrowstem kale represents an intermediate condition, between kohlrabi and kale. This kind is used to some extent in England, especially for sheep. Where adapted, the plant stands 3 to 5 feet in height, the whole stem being swollen and forming a large weight of feed for stock.

Nutritive Value

Excellent silage of high protein value may be made from a leafy crop of kale, particularly from the marrowstem kale. If the crop is cut early its protein content is sufficiently high for it to be used as the sole feed for milk production, complementary to a maintenance ration. It is rich in calcium and is considered a good source of vitamins, particularly vitamin A.

At the Oregon station corn silage was compared with kale for dairy cows. Results of four feeding trials are summarized as follows:

1. 74.6 pounds of total digestible nutrients in hay, grain and kale were required to produce 100 pounds of milk as compared to 82.2 pounds in hay, grain and corn silage.

2. The most economical weight of kale to feed per day was from 30 to 35 pounds. At this rate of feeding, kale gave practically the same milk and butterfat production pound for pound as corn silage.

3. When kale was fed 1 hour before milking, the milk and butter produced were found to have an objectionable flavor and odor. There was no noticeable effect when kale was fed shortly after milking.

As a result of a three-year state-wide survey, the Oregon station found the average cost of production for kale, with a yield of 18.1 tons per acre, to be $3.78 per ton; for vetch silage at 7.9 tons per acre, $4.27 per ton; for corn silage at 5.7 tons per acre, $7.40 per ton.\(^9\)

**Cultural Requirements and Management Practices**

Kale is sown in rows at the rate of 3 to 4 pounds per acre during the spring season, preferably soon after danger of severe frost is past. On clean land it may be broadcast at the rate of 4 to 5 pounds per acre. The crop can be cut for silage in late autumn. It can be harvested over a comparatively long period without appreciable variation in food value. Kale makes a uniformly good quality silage, fermenting readily with resulting good color, and a pleasant, slightly acid smell. It must be chopped before placing in the silo. The use of molasses may be a valuable insurance against possible spoilage if the kale is very leafy and young. The chopped crop packs closely and needs no tramping. Most silos built for corn need extra reinforcing. Marrowstem kale on good soil may yield 20 tons per acre.

**KOHLRABI, CABBAGE, AND PUMPKINS**

Kohlraibi—*Brassica oleracea* var. *caulorapa*, can be grown wherever rutabagas thrive. Since the thickened stems stand well above the ground, the crop is readily pastured by sheep, who also relish the leaves. When fed to dairy cows it apparently does not taint the milk.

*CAabbage—* *Brassica oleracea*, is prized by shepherds when preparing stock for show, and is also used for poultry and milk cows. Like most other plants of the mustard family, it should be fed after milking to avoid tainting the milk. When produced for market, small heads and leaves may be fed to stock unless the leaves carry too much spray residue.

*Pumpkins—* *Cucurbita pepo*, are sometimes planted in corn fields and used as relish for horses, cattle and pigs. Pumpkins are mostly water, containing but 10.4 per cent dry matter. For feeding dairy cows, one ton (including seed) is equal to 300 to 400 pounds of mixed hay or 800 pounds of corn silage. For pigs, pumpkins may be fed along with grain or protein supplement, approximately 10 tons being required to equal 1 ton of grain.

**ROOT CROPS**

The root crops grown for feeding livestock include mangels, rutabagas, turnips, and carrots.\(^10\) These crops require a cool, moist climate for their best development. Under such conditions they may sometimes be grown to better advantage than corn. A well-prepared seedbed and an abundance of available plant food are essential to large yields. Thorough cultivation and thinning are necessary.

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for normal root development and involve considerable hand labor. Roots should be harvested before severe frost and stored in cellars or pits. Under favorable conditions, mangels, rutabagas and turnips yield 20 to 30 tons per acre, while carrots yield about half as much.

**Nutritive Value**

These crops are similar in composition, all having more water and less protein, fat and carbohydrates than corn silage. On a dry matter basis, roots have a feed value about equal, pound for pound, to that of the cereal grains. They can be used to replace a portion of the grain in the ration. They are chiefly valuable as a source of succulence and as appetizers. Roots are highly prized by breeders and exhibitors of purebred stock. They are especially good for cows being milked. Roots are sometimes fed whole, but should generally be chopped. Usually the limit in feeding is 3 to 5 pounds per 100 pounds of liveweight. The usual amount fed is not more than one-half this quantity. Excessive feeding may cause indigestion.

**QUESTIONS**

1. To what plant family does rape belong? What kinds have agricultural value?
2. In what respects does rape qualify as an emergency pasture crop?
3. How does rape pasture compare in feeding value with alfalfa and red clover pasture for hogs?
4. Analyze the drawbacks of rape as a pasture crop for hogs.
5. Enumerate the features that make rape a valuable hog pasture.
6. Where has kale been grown in the U. S. and how does it compare with corn silage?
PART III

Forage Production Practices
Establishment of New Seedings

The importance of forage crops to soil conservation and animal feeding is recognized; but no cow was ever fed, and no erosion ever stopped, by a forage seeding which failed to catch. We tend too much to accept failures of forage seedings as "acts of God."

WHY DO FORAGE SEEDINGS FAIL?

If asked why his seeding failed the average man will say "poor seed," "a dry season," or "it winterkilled." Some plants usually survive, even in a "failure," and a "stand" is made up of individual plants. We usually plant from 3 to 1,000 times as many forage seed as we want plants. Each plant comes from one seed, not from 10 seed or 100 seed. To solve seeding problems, we must know why some plants live and why so many die.

The development of seedling forages may be divided into three stages, each with hazards to the plants: 1. Germination; 2. Establishment; 3. Growth.

1. Germination of live seed requires:
   a. Permeable seed coats (see "hard seed," Chapter 13).
   b. Sufficient air. This is seldom a problem in forage seedings. Some seed sown deep may be killed by a lack of air in a wet soil.
   c. Favorable temperature. This usually is obtained by choosing the proper date of seeding.
   d. Sufficient moisture. Usually enough rain falls at some time to germinate the seed, even though planted shallow. But the rain may not come before dampness and heat have destroyed the viability of the seed.

2. Establishment. Failure of germinated seed to establish seedlings may result from:
   a. Drying. Most forage seed are small and must be sown shallow. A light rain after seeding shallow on loose soil may germinate the seed, but they may die before the seedlings root enough to become established.
   b. Freezing. Forage seed are especially sensitive to freezing just as, or just after, the young root breaks the seedcoat. At this stage any temperature below 26°F will kill them.¹ Seed can be sown in January and make successful stands.

Establishment of New Seedings

FIG. 38.1 "The importance of forage crops to soil conservation and animal feeding is recognized; but no cow was ever fed and no erosion ever stopped by a forage seeding which failed to catch. We tend too much to accept failure of forage seedings as "an act of God."" (See p. 431.) An excellent stand of alfalfa seeded in an oat companion crop.

if there is no period of thawing weather long enough to germinate them until temperatures stay above 26°. After the seedling is rooted in the soil it will withstand much lower temperatures, dependent on the heredity of the seed.

c. Insufficient coverage. A slight soil cover will protect considerably against both drying and freezing. Only when there is a considerable period when the surface of the soil does not dry can one successfully sow on the surface without covering the seed.

d. Too deep coverage. Probably more forage seed is wasted by too deep coverage than in any other way.

e. Crusted soil surface. These often prevent emergence of seedlings, especially when sown too deep, or on too loose a seedbed.

3. Growth. Seedlings may die after establishment because of:

a. Lack of inoculation (Legumes only—see Chapter 10).

b. Lack of sufficient lime to provide a desirable soil reaction and calcium and magnesium as nutrients.

c. Lack of other nutrients, especially phosphorus for legumes and nitrogen for grasses.

d. Poor drainage. Too much water on or in the soil.

e. Drought. This is the reason most commonly given for stand failures. But drought is seldom the sole, or even deciding factor. Failure usually is complicated by the competition of weeds or "nurse" crops.
the seed. If many weeds are present, it may be desirable to plow them under in order to make seeding easier; the same may be true of trash on the surface, but many seedings are better when made on trashy surfaces. Since the soil beneath the seed should be firm for all forage seedings, disking or other suitable surface preparation is preferable to plowing for forage seedings, whenever a seedbed can be prepared in that way. Shallow plowing may serve the same purpose as disking. Where volunteer grain is a problem, deep plowing may bury much of the shattered grain so that it does not interfere. If the ground is plowed just before seeding forages, every effort should be made to thoroughly firm it before seeding.

### Tables

#### Table 38.1

**Effect of Alfalfa on the Protein Content of Grasses, Wooster and Columbus, Ohio**

<table>
<thead>
<tr>
<th>Station</th>
<th>Grass</th>
<th>Protein in Grass in mixture (Percentage)</th>
<th>Protein in Grass in pure culture (Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wooster</td>
<td>Orchardgrass</td>
<td>9.6</td>
<td>8.8</td>
</tr>
<tr>
<td></td>
<td>Timothy</td>
<td>7.3</td>
<td>6.2</td>
</tr>
<tr>
<td></td>
<td>Smooth brome</td>
<td>9.0</td>
<td>8.6</td>
</tr>
<tr>
<td></td>
<td>Tall oatgrass</td>
<td>8.1</td>
<td>7.4</td>
</tr>
<tr>
<td></td>
<td>Orchardgrass</td>
<td>9.4</td>
<td>6.5</td>
</tr>
<tr>
<td>Columbus</td>
<td>Timothy</td>
<td>7.2</td>
<td>4.8</td>
</tr>
</tbody>
</table>


#### Table 38.2

**Rate of Seeding Alfalfa in Relation to Acre Yield and to Plants per Unit Area in Holgate, Ohio, Average of 5 Years in 3 Tests, 2 Cuttings a Year**

<table>
<thead>
<tr>
<th>Rate of seeding per acre</th>
<th>Yield hay per acre (Lbs.)</th>
<th>Leaves in hay (Lbs.)</th>
<th>Protein in hay * (Percentage)</th>
<th>Plants per sq. yard † (No.)</th>
<th>Stems per sq. yd. ‡ (No.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1st Cutting</td>
<td>2nd Cutting</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1st Planting</td>
<td>2nd Planting</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2½</td>
<td>4,080</td>
<td>48.0</td>
<td>55.6</td>
<td>18.1</td>
<td>17.2</td>
</tr>
<tr>
<td>5</td>
<td>4,300</td>
<td>47.0</td>
<td>54.9</td>
<td>17.9</td>
<td>16.7</td>
</tr>
<tr>
<td>7½</td>
<td>4,560</td>
<td>47.5</td>
<td>54.8</td>
<td>17.9</td>
<td>16.9</td>
</tr>
<tr>
<td>10</td>
<td>4,580</td>
<td>48.2</td>
<td>54.7</td>
<td>17.8</td>
<td>17.2</td>
</tr>
<tr>
<td>12½</td>
<td>4,710</td>
<td>48.1</td>
<td>53.1</td>
<td>18.0</td>
<td>16.8</td>
</tr>
<tr>
<td>15</td>
<td>4,560</td>
<td>48.3</td>
<td>54.4</td>
<td>18.0</td>
<td>17.0</td>
</tr>
<tr>
<td>20</td>
<td>4,540</td>
<td>48.9</td>
<td>54.3</td>
<td>17.9</td>
<td>16.8</td>
</tr>
<tr>
<td>25</td>
<td>4,660</td>
<td>47.0</td>
<td>55.2</td>
<td>18.0</td>
<td>17.3</td>
</tr>
<tr>
<td>50</td>
<td>4,590</td>
<td>49.3</td>
<td>54.8</td>
<td>17.9</td>
<td>17.4</td>
</tr>
</tbody>
</table>


* Four years only.
† In fall of seeding year, 2 years only.
‡ Three years only.

RATES OF SEEDING FORAGE CROPS. Recommended rates of seeding forage crops vary much more than those of grain. Methods of seeding forages have gen-
TABLE 38.3
RATE OF SEEDING TIMOTHY IN THE FALL, WITH NO CLOVER PRESENT, AND THE TIMOTHY SOWN IN THE FALL OF 1930 AND HARVESTED IN 1932, UNFERTILIZED *

<table>
<thead>
<tr>
<th>Rate of seeding</th>
<th>Yields hay</th>
</tr>
</thead>
<tbody>
<tr>
<td>pounds per acre</td>
<td>pounds per acre</td>
</tr>
<tr>
<td>2½</td>
<td>4,690</td>
</tr>
<tr>
<td>5</td>
<td>4,930</td>
</tr>
<tr>
<td>10</td>
<td>4,640</td>
</tr>
<tr>
<td>20</td>
<td>3,550</td>
</tr>
<tr>
<td>40</td>
<td>2,990</td>
</tr>
</tbody>
</table>


Establishment of New Seedings

Generally been poor, and heavy rates of seeding can, to a slight extent, make up for poor methods of seeding. Anyone making recommendations wants to suggest enough seed to get good results if possible, so many recommended rates are higher than are generally justified. Moreover, excessive rates of seeding do not reduce the yield of forage crops as soon, or as much, as they do yields of grain. For example, alfalfa at 50 pounds per acre (Table 38.2) did not yield less than the best rate. This is because for forage we harvest the vegetative parts of plants. These can develop as much growth as the soil and weather will produce, from many small plants or a few large ones. Nevertheless, excessive seeding rates may reduce the yield of forage (Table 38.3).

A prime objective of better seeding methods is to economize on seed. As better seeding methods are used, lower rates of seeding can be recommended. (For rates of seeding individual crops, see the chapters on those crops.)

Sow shallow! On most soils in humid areas, practically all of the small-seeded forage crops are best sown one-fourth to one-half inch deep, or less (Table 38.4). Anything deeper than 1 inch is fatal to seed the size of clover and timothy, unless the covering soil is loose. Even when seed are large enough to come up from greater depths, they emerge so much more slowly that deep planting is a handicap.

Sometimes small seed must be sown deeper than one-fourth to one-half inch to reach moisture in dry climates, or on sandy soils. The hazard of a dashing rain crustng the soil surface is always present.

Methods of seeding. There are few machines which will place field seed accurately at a one-fourth to one-half inch depth. Many methods place seed at random over a wide range of depths. The most satisfactory machine for sowing accurately on a prepared seedbed broadcasts them between the sections of a corrugated roller with narrow corrugations. All drills, even the special "grass-seed" drills, place forage seed too deep on loose seedbeds. It is a special advantage of the corrugated roller seeders that the seed fall on firm soil in the bottom of the furrows. If crusts form over the seed, they have firm soil to push against, and can break rather severe crusts. Seed in loose soil under a crust may actually push themselves deeper into the soil.

On settled soils, drills, either special grass-seed drills or attachments on the grain drill, sow seed satisfactorily at shallow depths.

Apply a mulch where possible. Nothing will do more to insure the success of any forage seeding than a light mulch. A Uniform Cover of mulch is essential for the better establishment of seedlings. A mulch of 1 to 2 inches.of straw, or a 1/2 to 1 inch of light dusting of peat moss, is all that is necessary to establish seedlings of clover and timothy under favorable conditions. Over a medium sized seeding, a mulch of 1 inch is the equivalent of a 1 lb. broadcast of seed.

<table>
<thead>
<tr>
<th>Rate of seeding</th>
<th>Yields hay</th>
</tr>
</thead>
<tbody>
<tr>
<td>pounds per acre</td>
<td>pounds per acre</td>
</tr>
<tr>
<td>2½</td>
<td>4,690</td>
</tr>
<tr>
<td>5</td>
<td>4,930</td>
</tr>
<tr>
<td>10</td>
<td>4,640</td>
</tr>
<tr>
<td>20</td>
<td>3,550</td>
</tr>
<tr>
<td>40</td>
<td>2,990</td>
</tr>
</tbody>
</table>

mulch (Table 38.4) of any sort of material—straw, manure, stalks, stubble. The ideal amount is about 1 ton of dry matter per acre; much more than that may bring on difficulties with "damping-off." Mulches should be applied at once after seeding, or on winter grains any time after planting the grain before the legume seeding—preferably before winter freeze-up. Apply with a spreader, so that a uniform coat is applied—it is next to impossible to put on so light a coat by hand.

Mulches conserve moisture at the surface where the seeds need it and reduce soil temperatures. Moore,13 in the test reported in Table 38.4, found the surface inch of soil to average 6.4 per cent higher in moisture and 10.3°F. lower in temperature where mulched with 1 ton of straw per acre than not mulched. The greatest differences were 9.1 per cent moisture and 14°F. Mulches break the force of raindrops on the soil and retard its drying, and thus reduce the formation of crusts. In winter and early spring, mulches reduce winter heaving and protect germinating seeds from freezing injury.

Shall We Seed With a Companion Crop?

In the humid areas, sowing forages in small grain companion crops is almost universal. The primary reason for this is to obtain a return from the land while the forage is being established. Moreover, experience in humid regions shows that forage crops sown alone get a "companion crop" of weeds, which usually does more harm to the forage seedlings than to the grain crops.

On sloping land, small grains produce an erosion-resisting growth more rapidly than forages alone. Also, the winter cereals may protect early sown legumes from freezing injury.

Companion crops are supposed to choke out weeds. They do this, but they tend to "choke" the forage seedlings also. The important difference between the weeds and the small grain crops is that, except at the extreme North, the small grains mature and are removed long before the end of the season. If the

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13 Moore, R. P. Loc. cit.9

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### TABLE 38.4

DEPTH OF SEEDING FORAGE CROPS IN RELATION TO EMERGENCE OF SEEDLINGS *

| Crop | Percentage emergence of viable seed after 25 days when at depths of: | | | | | | | | | |
|------|------------------------------------------------------------------|---|---|---|---|---|---|---|---|---|---|
|      | Not mulched | Mulched, 1 ton of straw per acre | | | | | | | | |
|      | 0" | ¼" | ½" | 1" | 1¼" | 2" | 0" | ¼" | ½" | 1" | 1¼" | 2" |
| Alfalfa | 42 | 75 | 63 | 48 | 7 | 1 | 76 | 85 | 82 | 73 | 45 | 16 |
| Yellow sw. cl. | 35 | 44 | 43 | 30 | 6 | 2 | 53 | 78 | 67 | 73 | 36 | 12 |
| White sw. cl. | 15 | 34 | 30 | 15 | 2 | 0 | 49 | 60 | 62 | 42 | 15 | 5 |
| Red clover | 40 | 44 | 39 | 25 | 1 | 1 | 74 | 85 | 86 | 70 | 26 | 3 |
| Alsike clover | 39 | 21 | 22 | 7 | 0 | 0 | 70 | 91 | 91 | 46 | 7 | 1 |
| Crimson clover | 57 | 83 | 78 | 50 | 9 | 0 | 78 | 95 | 93 | 75 | 45 | 5 |
| Korean lespedeza | 48 | 88 | 82 | 33 | 3 | 0 | 70 | 96 | 92 | 66 | 9 | 1 |
| Orchardgrass | 37 | 58 | 59 | 40 | 9 | 3 | 78 | 95 | 86 | 69 | 36 | 10 |
| Timothy | 30 | 46 | 27 | 3 | 0 | 0 | 49 | 70 | 68 | 23 | 1 | 0 |

forage seeding has survived it can then grow until frost. Most weeds, on the other hand, do not die until the end of the season, and so may compete more seriously with forage seedings than cereal companion crops. When seedings made alone and in a companion crop give stands, there is little difference in the yields of hay the next year (Table 38.5).

<table>
<thead>
<tr>
<th>Station</th>
<th>Crop</th>
<th>No. Cuttings each year</th>
<th>No. years averaged</th>
<th>Companion crop</th>
<th>Yields, pounds per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Alone</td>
<td>With companion crop</td>
</tr>
<tr>
<td>Wooster</td>
<td>Alfalfa</td>
<td>3</td>
<td>3</td>
<td>Wheat</td>
<td>8,580</td>
</tr>
<tr>
<td>Wooster</td>
<td>Alf.-timothy</td>
<td>3</td>
<td>3</td>
<td>Wheat</td>
<td>9,760</td>
</tr>
<tr>
<td>Wooster</td>
<td>Alfalfa</td>
<td>3</td>
<td>2</td>
<td>Oats</td>
<td>9,010</td>
</tr>
<tr>
<td>Columbus</td>
<td>Red clover</td>
<td>4</td>
<td>3</td>
<td>Oats</td>
<td>4,240</td>
</tr>
<tr>
<td>Columbus</td>
<td>Sweetclover</td>
<td>1</td>
<td>4</td>
<td>Oats</td>
<td>4,280</td>
</tr>
</tbody>
</table>

### TABLE 38.6
**EFFECT OF REMOVAL OF COMBINED STRAW AND OF CLIPPING STUBBLE ON THE YIELD AND QUALITY OF HAY CROP AT COLUMBUS, OHIO; A 3-YEAR AVERAGE**

<table>
<thead>
<tr>
<th>Treatment of field in year preceding hay harvest</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Relative yield * of clean hay, No. 1–100</td>
</tr>
<tr>
<td>1. Mowed at once after combining, everything taken off</td>
<td>100</td>
</tr>
<tr>
<td>2. Mowed at once after combining, everything taken off, mowed again late August</td>
<td>100</td>
</tr>
<tr>
<td>3. Mowed at once after combining, material left</td>
<td>75</td>
</tr>
<tr>
<td>4. Loose combined straw removed at once after combining, nothing else done</td>
<td>85 †</td>
</tr>
<tr>
<td>5. Loose combined straw removed at once, stubble cut and everything removed late August</td>
<td>98</td>
</tr>
<tr>
<td>6. Nothing done combining</td>
<td>52</td>
</tr>
</tbody>
</table>

† One year's data lost, but clearly inferior to No. 1 and No. 5 in that season: not in one other season.

Because of these values of companion crops, seedings will be made in them wherever it is feasible. However, they are not necessary, except for crops like sweetclover and lespedeza, in which weeds cannot be controlled by clipping.

**What Is the Best Companion Crop?**

The answer depends on the crop being sown, as well as many other factors. Under some conditions there is little difference. The winter grains are already established when legumes are sown in them and are ready in the spring to make a relatively thick cover quickly. If the legumes are not sown early they suffer much more severe competition than when sown at the same time with spring grain. On the other hand, red clover endures shading well, and drought poorly. If sown early in winter wheat, it is often better than in oats in a dry season, or sown a little late. The best companion crop is the one which gives the least competition to the forage.

**CLIPPING SMALL GRAIN STUBBLE TO CONTROL WEEDS.** After small grain harvest, the weeds, already started, grow rapidly, and it is a good practice to control these by clipping. Following binder harvest this is best done after the weeds have made considerable growth, but it should not be done later than four to six weeks before the average date of killing frost. This period of growth after clipping is necessary to permit storage of food reserves in the roots of forages, and provide top growth for mulch over winter.

**TREATMENT OF COMBINED STRAW.** East of the Mississippi, it is advantageous to remove combined straw from seedings of red clover (Table 38.6). Taking the straw and stubble off has practically doubled the yield of the red clover crop as a 3-year average, as compared to leaving it untouched. This damage is not primarily from direct smothering by the straw, although in seasons of heavy straw growth that also is important. Excellent red clover in early fall will be largely or entirely dead by spring, where a mass of organic material—straw, stub-
ble, clover, weeds, or any combination of them—amounting to more than a ton per acre is left on the field. The reason for the difficulty is not known, but it is like a disease similar to “damping-off” favored by heavy mulch. In areas of heavy mulch, serious damage may be caused by field mice either before or at the time of clipping for weed control. Many persons have objected to this removal because of the loss of organic matter, but straw left on a new seeding is largely decayed by the following June. It adds little organic matter to the soil.

DON’T PASTURE A NEW SEEDING LATE! It is advantageous to pasture a new seeding off once, preferably ending 4 to 6 weeks before killing frost. After that, keep stock off a new seeding to permit late fall growth.

In a real feed shortage emergency, less harm will be done by moderate pasturing just before freeze-up than by continuous pasturing almost to freeze-up. The mulch removed by this late pasturing may profitably be replaced by a thin coat of the most strawy manure available.

SPECIAL SITUATIONS

The following sections take up problems of seeding in special situations. The preceding comments apply to most of these situations.

Seeding Forages Alone

WHEN ARE SUCH SEEDINGS USED? Spring seeding alone may be a desirable procedure in areas of limited rainfall where the small grain crop is not likely to leave enough soil moisture to bring through the clover-grass seeding; on clean land to avoid the labor of harvesting a grain crop; or to sprout and kill weeds before seeding the forage.

Summer seeding in most localities is more hazardous than spring, because: Summer brings higher evaporation, hence more difficulty in establishing seedlings; summer is the period of thunderstorms, when erosion is a serious hazard on sloping land. Summer seedings often are incorrectly called fall seedings.

True fall seedings, made at the time of sowing winter grain, are too late for legume seedings north of the Cotton Belt, although grass can very well be seeded at this time.

The most common reason for making summer seedings is to sow after a small grain, or other early crops, have been harvested, or to reseed when forage in small grain failed. South of approximately Parallel 39, seedings of perennial forages after a small grain crop become more practical than a spring seeding, since the forage seedlings do not have to compete with weeds during the long, hot summer.

Subsurface moisture is essential for summer seedings. Small grains dry the soil to considerable depths, so that the success of seedings after small grain harvest is dependent upon good rains between harvest and seeding.

USE CORRUGATED ROLLER-SEEDERS WHERE POSSIBLE. Since these summer seedings will be on prepared seedbeds, the use of the corrugated roller-seeder is always the preferable seeding method. If not available, use the best combination of tools at hand to obtain shallow coverage on top of firm soil.

DON’T USE COMPANION CROPS IN SUMMER.

Sowing oats with the forage is sometimes recommended for summer seedings “to provide a mulch for winter protection.” The forages will protect themselves if given a chance to grow. In true fall seedings, made late enough so that oats or other crop make so little
growth that they do not compete with forage seeding, a readily frost-killed crop for winter protection is sometimes practical.

**VOLUNTEER GRAIN INJURES SEEDINGS.** Combine harvesting has resulted in large amounts of volunteer grain. This is a serious hazard to summer seedings.
444  38. Establishment of New Seedings

TABLE 38.7
RATE OF SEEDING SMALL GRAIN CROPS AS INFLUENCING YIELD OF GRAIN, IN WOOSTER, OHIO

<table>
<thead>
<tr>
<th>Rate of seeding in pecks</th>
<th>Yield in bushels per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oats 27-yr. av.</td>
</tr>
<tr>
<td>4</td>
<td>49.6</td>
</tr>
<tr>
<td>6</td>
<td>54.9</td>
</tr>
<tr>
<td>8</td>
<td>57.1</td>
</tr>
<tr>
<td>10</td>
<td>58.9</td>
</tr>
<tr>
<td>12</td>
<td>58.8</td>
</tr>
</tbody>
</table>


which follow harvest. Where the climate permits, a period of 4 to 8 weeks between harvest and seeding, with frequent disk­ing, helps greatly; if this is not feasible, deep plowing is probably the best solution.

**DON'T CLIP FORAGES SOWN ALONE TOO SOON!** Spring seedings alone almost inevitably have a crop of weeds with them. The purpose of clipping is to **kill** the weeds. This cannot happen unless they are fairly good sized when cut. If there are live buds on the weed stubble they will continue to grow. Hence, a spring seeding alone should be left as long as possible—at least until the weeds are 2 or 3 feet high. Then cut **low**. The forages will recover from the crown, whatever height you cut; the weeds recover better the higher you cut, so clipping high favors the weeds against the forages. Sweetclover recovers from the buds along the stem, thus weeds in sweetclover cannot be controlled by clipping. For this reason it should never be spring sown alone. The same is true of lespedeza. Summer seedings should not be clipped unless it is essential to save the stand.

**Seeding in Spring Grains**

**CUT RATE OF SEEDING COMPANION CROP.**

The rate of sowing spring grains intended as companion crops should not be over three-fourths the usually recommended rate—Flax is an exception. This helps in two ways: Less competition with the forage seedings, especially in dry seasons; and less likelihood of lodging, in wet seasons. The loss in grain yield from lower seeding rates is not as large as many suppose (Table 38.7). The advantage to the forage is seen only in dry seasons, or when the grain lodges.

**SOW FORAGE SEED BACK OF GRAIN SPOUTS.**

Almost universally, grass seed attachments on grain drills are in **front** of the grain box, and broadcast the seed in front of the grain spouts, so that the forage seed are covered much too deep. Sowing back of the grain spouts can be done by putting long delivery tubes on the grass-seed attachment and tying them back. It also is possible to mount the grass-seed attachment on back of the grain box. Without a grass-seed attachment, forage may be sown with the corrugated roller-seeder (best, but requiring extra trips over the field) or any broadcast seeder. Except occasionally on dry seedbeds, forage seed should never be sown down the grain tubes with the grain being sown.

**PASTURE OFF THE GRAIN CROP WHEN FEASIBLE.** This is practically always favorable to forage seeding if ordinary care is used, and is one of the best ways to get additional pasture in a hurry.
### TABLE 38.8

**DATE AND METHOD OF SOWING LEGUMES IN WHEAT, COLUMBUS, OHIO; 4-YEAR AVERAGE, EXCEPT AS NOTED**

<table>
<thead>
<tr>
<th>Date and method of seeding</th>
<th>No. plants per square yard, summer of seeding year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Alfalfa</td>
</tr>
<tr>
<td>Jan. 1 Broadcast</td>
<td>49 *</td>
</tr>
<tr>
<td>Feb. 1 Broadcast</td>
<td>53 *</td>
</tr>
<tr>
<td>Feb. 20 Broadcast</td>
<td>103</td>
</tr>
<tr>
<td>Mar. 1 Broadcast</td>
<td>143</td>
</tr>
<tr>
<td>Mar. 10 Broadcast</td>
<td>178</td>
</tr>
<tr>
<td>Mar. 20 Broadcast</td>
<td>181</td>
</tr>
<tr>
<td>Apr. 1 Broadcast</td>
<td>139 *</td>
</tr>
<tr>
<td>Apr. 1 Drilled</td>
<td>172</td>
</tr>
<tr>
<td>Apr. 10 Broadcast</td>
<td>95 *</td>
</tr>
<tr>
<td>Apr. 10 Drilled</td>
<td>109</td>
</tr>
<tr>
<td>Apr. 20 Broadcast</td>
<td>80 *</td>
</tr>
<tr>
<td>Apr. 20 Drilled</td>
<td>117 *</td>
</tr>
<tr>
<td>Split seeding; ½ seed broadcast Mar. 10, ½ drilled Apr. 1</td>
<td>171</td>
</tr>
</tbody>
</table>

* 3-year average
† 2-year average
Table from Willard, C. J. Unpublished data, Ohio Agr. Exp. Sta.

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### Seeding in Winter Grain

In general, legumes cannot be sown in winter grains in the fall. An exception is winter oats. Some excellent stands of alfalfa have been obtained by seeding alfalfa with early seedings of winter oats. Many grasses, especially timothy and bluegrass, are best sown in the fall. Seedings with winter grain are best made as previously described for seeding with spring grain.

**NOT PROFITABLE TO REDUCE RATE OF SEEDING WINTER GRAIN.** Winter grains have such a long period of development that any reasonable rate of seeding gives about the same number of heads and amount of straw. Consequently, reducing the rate of seeding winter grain below the standard grain rate is not recommended.

**DON'T SOW TOO MUCH FALL GRASS WHEN SPRING LEGUMES ARE TO BE SOWN.** See Table 22.3, Chapter 22.

**TOPDRESSING WITH MANURE.** This will do more to make safe forage seedings in winter grain than any other practice. As an 18-year average at Wooster, Ohio, manure topdressed on wheat during the winter increased the yield of clover the next year by 1,600 pounds per acre. Apply about 4 tons per acre any time before seeding the forages. If applied before midwinter it helps the grain as well as the seeding.

**SOW FORAGES EARLY IN THE SPRING.** Many forages germinate at low temperatures and if broadcast as the frost is coming out of the ground the seed can germinate on the surface because the surface remains moist (Table 38.8). In humid climates the ground is too soft to go on with machinery as frost is coming out of the ground. Seed is frequently sown in the morning with hand broadcasters during the period when the ground freezes at night and thaws in the
Establishment of New Seedings

day. “Honeycombed ground,” which covers seed on some soil types at this time, is not essential.

SHOULD FORAGES BE DRILLED OR BROADCASTED IN WINTER GRAIN? Drilling forage in winter grain is often recommended, and is desirable in an early spring. Whenever the soil is dry enough to get on with a drill, drilling will be preferable to broadcasting on that day (Table 38.8).

However, it is not always possible to drill early and when the ground is fit for drilling there are other jobs to do. Broadcasting early gets the job out of the way at a slack time and the results are equal to drilling later. Winter grains grow so rapidly in the spring that early seeding is essential to avoid excessive competition. Consequently, in practice early broadcasting is preferred to late drilling. There is a freezing hazard at this time, of course, but the grain affords a considerable protection. Making a split seeding—half as the frost is coming out of the ground, half two to three weeks later, drilled if possible—is good insurance, but more than doubles the labor.

PASTURE OR CLIP RANK WINTER GRAIN BEFORE JOINTING. Winter grain in a favorable spring often grows at a rate that any experienced farmer knows will result in lodging later. This excessive growth injures all forage seedlings, but especially alfalfa.

Pasturing this early growth is the best way to reduce it, and is almost essential for vigorous competitors like winter rye and winter barley on good soils. Many farmers cannot pasture winter grain, however. A similar effect can be obtained by clipping the growth back to about half its height before the grain heads are appreciably above the soil surface. South of parallel 41 with soft wheat, winter barley or winter rye, this may mean cutting an 8-inch to 12-inch growth back to 4 to 6 inches; north of this the growth is shorter. This will reduce the yield of wheat 5 to 15 per cent if the unclipped wheat does not lodge—if it lodges badly, clipping may save the forage stand and also increase the yield.

Seeding in Row Crops

These seedings are always hazardous. Since they must be made in the summer, they have all the hazards of summer seedings. In addition, they have the competition of the established, vigorously growing row crops. They are successful only on fertile soils, or with less-than-maximum competition from the crop, obtained by wider or thinner planting than that which would give the maximum yield. No experiments have given satisfactory stands of forages in soybeans left for grain, although some have been obtained under early-cut soybean hay, sown in rows.

The crops best adapted to sowing in row crops are alfalfa, the ryegrasses, orchardgrass, Korean lespedeza, hairy vetch and yellow (not white) sweetclover. Crimson clover is good after establishment in its area of adaptation, but sprouts readily in seedbeds too dry to permit establishment.

EARLY SEEDING HELPS. Crops sown in corn should be sown early, with the last cultivation earlier than usual. (Note that this does not apply to crops sown in cotton.)

The advantages are:

a. Forages have less competition from the corn at seeding time.
b. Forages become better established before winter.
c. Seeding is more easily done.
METHODS OF SEEDING. Hand seeding is almost universal. Some excellent homemade broadcasting attachments for cultivators have been developed. Vetch and larger seed should be sown ahead of the last cultivation, and cultivated in. Smaller seed are best broadcast immediately on the loose soil left by the last cultivation. The next good rain will cover them at about the right depth. The rate of seeding in row crops must be one-fourth to one-half greater than normal, to compensate for the many hazards of this method of seeding.

Seeding in Rundown Meadows or Pastures Without Plowing

RENOVATION OR TRASH-MULCHED SEEDINGS. In recent years it has been found desirable to make many forage seedings directly in existing meadows or pastures—usually poor ones. It is hard to over-state the value of such seedings for hilly areas that should not be plowed, or to increase the production of thin, weedy, unprofitable pastures. This development is one of the great advances of the last 25 years in the production of forage.

The surface is prepared with a disk or field cultivator. This is best done in the early spring. Apply lime first where needed. Part of the preparation may well be done the fall before. Keep sod and mulch on the surface. Apply fertilizer and get it down into the soil before seeding.

QUESTIONS

1. What in your opinion are the main reasons for forage seeding failures in your area?
2. In what way does the seeding of mixtures of legumes and grasses help insure a successful stand?
3. What would you consider an ideal seedbed for making an alfalfa or clover seeding?
4. What factors determine the proper depth at which to seed the different forage crops?
5. Why is it difficult to recommend specific rates for seeding legumes and grasses?
6. How can you economize on the amount of seed sown without decreasing the field stand?
7. What method would you recommend to insure accurate seeding depth and coverage?
8. Why is the term companion crop better than nurse crop for a small grain sown with a new forage seeding?
9. Why are companion crops generally sown with forage seed?
10. How would you handle the companion crop during the growing season in order to help insure a successful stand of the forage seeding? Under what conditions would you clip the companion crop?
11. If the grain crop is combined, how would you handle the field after combining and why?
Chapter 39

Fertilization of Forages

Most soils in the humid region of the United States are acid and low in available phosphate and nitrogen. Soils that have been farmed for many years, or are light in texture, may also be low in potash. Research has shown that most of the grasses and legumes will usually respond to additions of one or more of the major plant nutrients—calcium, nitrogen, phosphorus and potassium. Ahlgren 1 points out that nature did not provide the soil with an inexhaustible supply of plant nutrients which could be drawn upon indefinitely by plants. Phosphorus, nitrogen, calcium, and potassium have been sold from the farm in the form of livestock, manure and cash crops.

Robinson and Garber 2 have emphasized the important relationship between forage fertilization and the entire farm program. On farms that lack enough roughage to grow livestock, the use of lime and fertilizer permits reduction in the amount of concentrate required. The increased production of hay and pasture, made possible by the use of lime and fertilizer, enables the farmer either to increase his herd numbers or use part of his land to produce cash crops.

Limiting Factors in Forage Production

The maximum production of forages depends upon several factors. Among the most important are the use of adapted species of forage crops, favorable climatic conditions, an adequate supply of plant nutrients, control of plant diseases and insects, and intelligent management of the hay or pasture crops. In forage crop fertilization all factors affecting their growth must be considered.

MOISTURE. Potential supply of soil moisture is an important factor in determining the response to fertilizer treatment. On sandy soils or very shallow soils moisture frequently becomes a limiting growth factor. Even in the humid region, drought-tolerant legumes and grasses are most desirable. Shallow-rooted legumes such as white clover and Ladino do not respond well to fertilizer treatment on droughty soils, or during years when moisture is deficient.

Prince et al. 3 obtained results during

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1 Ahlgren, H. L. Our pastures need to be fed. Wis. Agr. Ext. Stencil Clr. 201, 1938.

G. O. MOTT
Purdue University
both a wet and a dry year from the same fertilizer treatments on permanent pastures. They found that complete fertilizer gave a greater increase in production in a wet year than in a year when moisture was a limiting factor for the pasture species. Mott found that moisture was a limiting factor at some time during the growing season for bluegrass-white clover sod in Indiana. The influence of moisture supply upon the response to fertilizer treatment during years when moisture was considered adequate, and when deficient during all or part of the growing season, is shown in Figure 39.1. Shown are the results of an application of (A) lime, phosphate and potash and (B) lime, phosphate, potash and nitrogen during three years with different moisture conditions. The increases due to fertilizer were much greater under adequate moisture.

Nitrogen is the plant nutrient usually most lacking for the growth of grasses such as bluegrass, timothy, bromegrass, and Dallisgrass. If no legume is present in a forage mixture, an application of lime, phosphate, or potash will give only a slight response, if any. In well established mixtures of legumes and grasses, nitrogen taken from the air by the symbiotic bacteria on legume roots becomes available to the legumes and to the associated grasses. This results in increased production of both.

Prince et al. compared five grass pastures with live clover-grass pastures in their response to lime, phosphate, potash, and nitrogen. The check plot was untreated, superphosphate \( P \) was applied at the rate of 600 pounds of 16 per cent, potash \( K \) was used at the rate of 200 pounds of 50 per cent muriate of potash and one ton of lime \( L \) was top-dressed. Nitrogen \( N \) was applied annually as 312 pounds of nitrate of soda. Their results are presented in Table 39.1.

These data heighten the importance of fertilizer in supplying the needs of the forage species. Permanent pastures lacking in legumes, lime, phosphate, and potash can be expected to produce only a minimum increase the first year or two after application. For white clover, the application of lime, phosphate, or potash, or a combination of these materials, will encourage the clover and give a satisfactory increase in production. In the New Hampshire experiments, only nitrogen gave significant increases on grass pastures. Clover pasture production, on the other hand, was significantly increased by application of lime, phosphate, potash, and nitrogen. Soils deficient in phosphates, potash, nitrogen, or lime will respond to these nutrients if the legume population is high enough.

The importance of legumes in a forage mixture is further emphasized by Robinson and Pierre. They studied the contribution made by white clover to the increases in yield of forage from fertilizer and lime treatments. In two experiments, the lime, phosphate, and
TABLE 39.1
RESPONSE TO LIME AND FERTILIZER OF FIVE GRASS AND FIVE NEW HAMPSHIRE CLOVER-GRASS PASTURES

<table>
<thead>
<tr>
<th>Pounds of dry matter per acre</th>
<th>Av. five grass pastures</th>
<th>Av. five grass-legume pastures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check</td>
<td>786</td>
<td>949</td>
</tr>
<tr>
<td>P</td>
<td>916</td>
<td>1,393</td>
</tr>
<tr>
<td>LP</td>
<td>975</td>
<td>1,802</td>
</tr>
<tr>
<td>LPK</td>
<td>923</td>
<td>2,316</td>
</tr>
<tr>
<td>LNPK</td>
<td>2,173</td>
<td>2,862</td>
</tr>
<tr>
<td>Increase for:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>130</td>
<td>444</td>
</tr>
<tr>
<td>L</td>
<td>59</td>
<td>409</td>
</tr>
<tr>
<td>K</td>
<td>-52</td>
<td>514</td>
</tr>
<tr>
<td>N</td>
<td>1,250</td>
<td>546</td>
</tr>
</tbody>
</table>

Fig. 39.2 The effect of the presence of white clover on the yield response obtained with lime and different fertilizers.

clover at the Pasture Laboratory. They found that where the first cutting was delayed until the late hay stage, Ladino clover was eliminated in less than one year. Clipping the mixture repeatedly to a height of 1 inch when the herbage reached a height of 5 inches resulted in good stands of Ladino clover, but bromegrass was practically eliminated by the end of the second year.

Graber studied the food reserves in bluegrass in relation to fertilization. He concluded that plants may be deficient in organic foods, even though the soil may be abundantly supplied with plant nutrients. The deficiency retards plant growth. He states that:

> The productivity of bluegrass with relation to nitrogenous fertilization is dependent, not only upon adequate supplies of moisture, phosphorus, potash, and other limiting elements within the soil, but also upon the reserve foods within the plant which are also limiting factors of growth.

In one experiment in which fertilization increased the yield of bluegrass cut six times by 11 per cent, the increase for that cut but once was 21 per cent. The results are presented in Table 39.2.

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7 Robinson, R. R., and Garber, R. J. Loc. cit.2

Soil Tests Help

Chemical methods to estimate the available supply of plant nutrients in soils have been developed. A laboratory analysis of the soil may be made, but it is well known that there is no close relationship between the amount of nutrients in the soil and that available to the plant. In most states of the humid region tests are used to help agronomists diagnose soil nutrient deficiencies before suggesting fertilizer recommendations. Tests for the soil pH and for phosphorus are most widely used. Potash tests are considered reliable by some states. Schreiner and Anderson⁹ state that the quantity of nitrates present at any one time is seldom high in soils of humid regions. The quantity of nitrates in a soil is a poor index of the capacity of a particular soil to produce a sufficiently available supply regularly. Nitrogen is frequently the element grasses lack most often in permanent pastures and forage crop mixtures.

How Lime Is Used

Correcting the soil acidity is the first step in improving forage production. Most soils in the humid region are in need of lime. Some form of lime should be applied where the soils are too acid for the optimum growth of legumes.

The use of lime for improving soils has been practiced for many centuries. It is used as a soil amendment to change the reaction of the soil and also as a source of calcium. Truong⁰ states that soil reaction has two direct influences on plants, namely: (1) a toxic or destructive effect on plant tissues through an excess of either hydrogen or hydroxyl ions and,

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TABLE 39.2
COMPARATIVE AMOUNTS OF BLUEGRASS, Poa pratensis L., OBTAINED FROM SIX CUTTINGS AT IMMATURE STAGES OF GROWTH AND ONE CUTTING NEAR MATURITY WHEN GROWN ON FERTILIZED AND UNFERTILIZED SOIL, WITH BLUEGRASS SOWN JULY 22, 1926

<table>
<thead>
<tr>
<th>Fertilization</th>
<th>Dates and amounts of oven-dried top growth removed during 1927, in pounds per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>244</td>
</tr>
<tr>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Abundant *</td>
<td>146</td>
</tr>
<tr>
<td>Abundant *</td>
<td></td>
</tr>
</tbody>
</table>

* Fertilizer applied 1927, in pounds per acre:
  March 18—220 pounds of superphosphate (16 per cent P₂O₅)
  140 pounds of potassium sulfate (40 per cent K)
  70 pounds of sodium nitrate (16 per cent N)
  May 26 —140 pounds of ammonium sulfate (20 per cent N)
  July 30 —200 pounds of ammonium sulfate (20 per cent N)

(2) an unfavorable balance between the acidic and basic constituents available for absorption by plants. Some of the indirect effects of lime on acid soils are to:
(1) improve the physical condition of the soil, (2) increase the availability of essential plant nutrients, and (3) improve the soil environment for growth of soil microorganisms. Truog further emphasizes that the availability to plants of all the essential plant nutrients is affected in one way or another by the reaction of the soil. In general, as soils become more acid the calcium, magnesium, and phosphates become less available. As soils become more alkaline above a pH of 7, iron, manganese, copper, zinc, and possibly boron become less available.

TOLERANCE TO SOIL ACIDITY. Most of the soils in the humid region range from slightly acid to highly acid in reaction. The most desirable pH for most legume crops grown for forage is between a pH of 6.0 and 7.5. Farmers having acid soils are usually advised to apply enough lime to raise the pH of their soils to from 6.2 to 6.8. Legume crops are more sensitive to soil acidity than grasses, although this sensitivity varies considerably among both groups of plants. Alfalfa and sweetclover are highly sensitive to acid soils while alsike clover, lespedeza, and vetch are tolerant of moderately acid soils. Crimson, Ladino, white, and red clovers are intermediate in their tolerance of soil acidity.

Applying Lime to Forage Crops
The application of lime presents no particular problem. Recommendations from soil tests are usually based on the lime being distributed through the plow layer of soil. Lime is most effectively applied at a point in the rotation when it can be thoroughly mixed with the surface soil.

Applying lime to established sods, however, presents a wholly different problem. Numerous investigators have studied how lime penetrates soils under grass. Some of the factors affecting the rate of penetration are texture of the soil, temperature, rainfall, and other plant nutrients added to the soil. Differences in texture as it affects rate of penetration is well illustrated in Figures 39.4 and 39.5. Robinson and Pierre found that thirteen years after the application of 3,000

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is a wide range of temperatures—as well as the length of the growing season—from the northern to the southern parts of the region. These factors determine in part the forage grasses and legumes best adapted in each climatic area.2

Soils of the Region

Soil is another important factor determining the forage crop best adapted to a particular area or field. Some areas are characterized by heavy clays such as those of the Lake Champlain Valley. Others are extremely sandy, such as those in southern New Jersey. Poorly drained areas may be found in any state in the Northeast. Excessively drained, shallow soils over sandstone or shale are not uncommon.

The soils of the Northeast were developed under a forest vegetation. While those in the northern part of the region were glaciated, those in about the southern third are residual soils derived from limestone, sandstone, and acid shales.3

When the land was first cleared and cropped by the early settlers it was relatively productive, but under cultivation it soon lost its original fertility and organic matter. These soils now generally require lime and phosphate fertilizer. More recently potash fertilizer also is being used to advantage in many areas.4

Topography

Under cultivation, the generally hilly land of the region has suffered from erosion and leaching. Where land is free enough of rocks to cultivate, it often is contour strip-cropped. More cropland is being seeded and maintained in sods of perennial grasses and legumes longer than formerly. Not only does such a

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2 U.S.D.A. Yearbook, Climate and man, 1941.
system minimize soil erosion losses and the leaching of plant nutrients, but it also increases the organic matter of the thin hillside soils and makes them more productive.

**KINDS OF PASTURES**

Permanent pastures comprise the largest acreage of grazing lands. Most of these have developed from land that at one time had been cleared and planted to cultivated crops such as corn, small grains, or potatoes. As fertility declined these fields were fallowed, or occasionally seeded to red clover and timothy for hay. When the timothy fields became unproductive from continuous cropping without the replacement of the mineral nutrients removed in the crops, they were pastured for whatever could be had.\(^5\)\(^6\)

**Permanent Pastures**

Since the bent grasses and Kentucky bluegrass are well adapted to the climate of most of this region and will persist under moderate grazing, these species replaced timothy, and the one-time hayfields became the permanent pastures. Where lime and fertility were too limiting, poverty grass, broom sedge, and other weeds occupied the land. Soon brush and trees reoccupied the area. However, where the soils had sufficient lime and some available phosphorus was still present, white clover and Kentucky bluegrass became the dominant species on grazed fields. On the wetter and more acid soils the bent grasses replaced part of the Kentucky bluegrass.

This plant species cycle can proceed in either direction. Good pastures of Kentucky bluegrass and white clover revert to poverty grass and weeds if plant nutrients are continually removed and none returned. The reverse change, from a poverty grass pasture to a productive Kentucky bluegrass-white clover pasture occurs when soil fertility is restored and proper grazing management is used.\(^7\)

**Semi-Permanent Pastures**

Semi-permanent pastures intensively managed meet the need for larger amounts of highly nutritious feed. By fertilizing to supply adequate amounts of soil nutrients, by using vigorous-growing and adapted species and varieties, by managing them in ways to favor their maximum growth, and by adapting farm practices best suited to the full utilization of this growth, farmers find that one such acre will provide sufficient nutritious herbage to produce about 8,000 pounds of milk during a five-months pasture season.

Such pastures are seeded to the larger-growing grasses and legumes such as orchardgrass, smooth brome, Ladino clover, and alfalfa. They are not expected to be completely permanent. They will be re-established whenever their productivity is decreased by such hazards as winter injury, diseases, and drought. However, under adapted grazing practices and high fertility, such pastures will continue from three to six years, and sometimes longer.

One main advantage of a pasture composed of large-growing grassland legumes is its versatility. It may be used either for grass silage, for hay, or for grazing, as the needs of a particular farm or season may require.

**SEEDING ESTABLISHMENT**

The grasses and legumes seeded either for hay or for pasture are small-seeded plants and must be treated as such. The
seedlings are small and carry with them only a limited amount of stored food with which to become established. Thus, a basic factor in obtaining good stands is to favor these small seedlings in every way possible. First there is the seedbed, free of large clods and lumps, but not pulverized to the extent that it will puddle and crust. Then the seed must be sown shallow, seldom over one-fourth inch deep, so that the young plant can rapidly reach the surface and begin to manufacture its food. 8

Time of Seeding

Over much of the Northeast early spring seedings often are more successful than seedings made later, since the grasses and legumes begin to grow at lower temperatures than most annual weeds. Also, in early spring, soil moisture is least apt to be limiting. In the winter-wheat areas timothy usually is seeded with the wheat in the fall. Legumes like alsike, red, and Ladino clover are seeded on top of the frozen and honey-combed ground in late February or March. Freezing and thawing covers the seed and as soon as temperatures are warm enough the clovers germinate.

This same practice of seeding on frozen ground also is followed where grass-legume mixtures are to be seeded on renovated seedbeds, prepared the previous summer or fall by disking and harrowing. Excellent results using this method have been obtained from Vermont 9 to Pennsylvania 10 in seeding such grass species as orchardgrass, smooth brome, timothy, tall fescue and reed canarygrass, and such legumes as red clover, Ladino clover, alfalfa, and birdsfoot trefoil.

Spring seedings also may be made on prepared ground with oats as a companion crop. Here, as elsewhere, early spring seeding is important to obtain a good stand. When oats are used and a grain crop is to be taken, about one-half the usual seeding rate of oats is recommended. To be more certain of a vigorous and full stand of the seeded legumes and grasses, the oats may be cut for hay or silage before they are in bloom or they may be grazed off as soon as the head is out of the boot.

In certain more southern areas of the Northeast, late summer seedings of forage crops are successful. These seedings are made in early or mid-August without a companion crop. Late seedings result in plants too small to survive the winter. Species that are often fall-seeded include alfalfa, Ladino clover, smooth brome, and orchardgrass. Other grasses such as timothy and Kentucky bluegrass also do very well when fall-seeded.

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SEEDING MIXTURES

A number of different seeding mixtures are in use on different soils and for different purposes in the Northeast. The most common hay mixture includes red clover and timothy, with more recently the addition of a small amount of Ladino clover. This hay mixture is used largely in 3- or 4-year rotations. It usually provides for only one main crop of hay plus a smaller aftermath crop, or else midsummer grazing.

Where alfalfa can be grown it is more commonly spring-seeded with a companion crop of oats. In the southern part of the region a small amount of timothy often is added, or more recently and farther south smooth brome may be included. Alfalfa fields usually are maintained for 3 to 5 years or as long as they are productive. The length of time over most of the region depends largely upon the prevalence of the bacterial wilt disease. Several wilt-resistant alfalfa varieties are available but these are not particularly well adapted to this region. Their use is not widespread.

Pasture Seedings

Ladino clover is widely used in pasture mixtures throughout the Northeast. In the more northern states in the region—where the soils are cooler and wetter—it is seeded in association with timothy, and also to some extent with smooth brome. Farther south in parts of New York, Connecticut, Pennsylvania, New Jersey and Maryland, Ladino is more often seeded with orchardgrass. This provides an unusually good combination that can be used for grass silage and aftermath grazing, or for grazing in the spring followed by good grazing throughout the summer months.

During the past several years birdsfoot trefoil has shown possibilities for pasture and to a lesser extent for hay in Vermont, New York, and Northern Pennsylvania. This legume, while not as productive as alfalfa on good alfalfa land, will grow and persist under soil and management conditions not suitable to the more rapid growing legumes like alfalfa and Ladino clover. Although birdsfoot trefoil grows best on fertile, well-drained soil, it will persist and make appreciable growth on poorly-drained soils; similarly it will persist on droughty hillsides. It will continue growth on infertile acid soils but best growth is made on limed soils supplied with phosphate and probably potash.

SEEDING RATES

Seeding rates and the mixtures used throughout the Northeast are similar, with only slight variations in the species and seeding rates recommended in the different states. The seeding rates and mixtures recommended for use in Pennsylvania (Table 41.1) and New York (Table 41.2) indicate the mixtures and rates often used.

PASTURE RENOVATION

Renovation of pastures on the rough and rolling land general throughout much of the Northeast may be somewhat different than on the more level land of the Midwest.

Preparing a Seedbed

Erosion is a serious hazard following the plowing of these hillsides. Also, an abundance of rocks on many of these areas makes plowing difficult. A heavy disk has proved better adapted than anything else. Particularly effective is a heavy cut-away disk known in the region as a "bush and bog harrow." This heavy disk may be loaded with stone when used in cutting thick sods and even small brush. It turns the roots up so that the
**Pasture Renovation**  471

**TABLE 41.1**  
**GRASSLAND MIXTURES FOR PENNSYLVANIA**  
(for permanent pasture)

<table>
<thead>
<tr>
<th>Plant species</th>
<th>Seeding rate under various conditions (Pounds per acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Good conditions</td>
</tr>
<tr>
<td>Kentucky bluegrass</td>
<td>8</td>
</tr>
<tr>
<td>Timothy</td>
<td>4</td>
</tr>
<tr>
<td>Orchardgrass</td>
<td>4</td>
</tr>
<tr>
<td>Red clover</td>
<td>4</td>
</tr>
<tr>
<td>Alsike clover</td>
<td>1</td>
</tr>
<tr>
<td>Ladino clover</td>
<td>1</td>
</tr>
<tr>
<td>Birdsfoot trefoil</td>
<td></td>
</tr>
</tbody>
</table>

*Prepared by Agronomy Extension and Experiment Station staffs of Pennsylvania State College.*

**For pasture plus silage or hay**

For all conditions, the basic mixture should be used with modifications as noted:

**Basic mixture**

<table>
<thead>
<tr>
<th>Plant species</th>
<th>Seeding rate (pounds per acre †)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timothy</td>
<td>4</td>
</tr>
<tr>
<td>Red clover</td>
<td>2</td>
</tr>
<tr>
<td>Alsike clover</td>
<td>1</td>
</tr>
<tr>
<td>Ladino clover</td>
<td>1</td>
</tr>
</tbody>
</table>

*To the basic mixture add one of the following grasses depending upon the conditions indicated:*

1. For maximum production of July and August pasture except on poorly-drained areas:
   - Orchardgrass 4

2. Only under fertile well-drained conditions:
   - Smooth brome 8

3. On poorly-drained areas:
   - Meadow fescue 6

*Add to the basic mixture on fertile well-drained soils:*

- Alfalfa 6

† 25% additional seed to be used if seedlings are established in oats as a companion crop.

Plants will be killed by dry weather in mid or late summer. An organic mulch also is left on the surface to prevent erosion. Further, the old sod worked into the surface layer prevents puddling, thus facilitating the emergence of the small-seeded grasses and legumes. It also permits the penetration of rain.

Other implements such as the field cultivator, orchard disk, and a heavy spring tooth harrow may be used where the original sod is not too heavy. The primary object in preparing a seedbed by renovation is to eliminate the competition of the species originally present and to provide optimum conditions for the emergence of the newly seeded species.  

**Fertilizer Practices**

Fertility is another important factor in successful renovation. Usually, the fields selected for this type of improvement are those which had been in cultivated crops several generations earlier, but which had received little or no fertilizer. When they became so infertile and unproductive as to be impracticable to farm, they were allowed to revert to pasture with

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11 *Spring, V. G. et al. Loc. cit.*
TABLE 41.2

HAY AND PASTURE SEEDINGS FOR NEW YORK *

<table>
<thead>
<tr>
<th>Use</th>
<th>Formula</th>
<th>Pounds per acre</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa-Grass Mixtures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For hay or silage...........</td>
<td>Alfalfa</td>
<td>8</td>
<td>Soil: Fertile and well-drained.</td>
</tr>
<tr>
<td></td>
<td>Timothy</td>
<td>6</td>
<td>Timothy: Preferable to bromegrass on less fertile soils or</td>
</tr>
<tr>
<td></td>
<td>or</td>
<td></td>
<td>in short stands.</td>
</tr>
<tr>
<td></td>
<td>Alfalfa</td>
<td>8</td>
<td>Bromegrass: Very palatable and productive for hay or</td>
</tr>
<tr>
<td></td>
<td>Smooth brome</td>
<td>8</td>
<td>pasture. Use for long-lived stands.</td>
</tr>
<tr>
<td>For hay, silage or pasture.</td>
<td>Alfalfa</td>
<td>8</td>
<td>Not difficult to cut while alfalfa persists. If managed</td>
</tr>
<tr>
<td></td>
<td>Ladino clover</td>
<td>1</td>
<td>to retain alfalfa, Ladino may be crowded out. If</td>
</tr>
<tr>
<td></td>
<td>Smooth brome</td>
<td>8</td>
<td>closely grazed, alfalfa will go out.</td>
</tr>
<tr>
<td>General Purpose Mixture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For hay, silage, or pasture.</td>
<td>Alfalfa</td>
<td>6-2</td>
<td>Soil: Fields on which alfalfa does well in parts.</td>
</tr>
<tr>
<td></td>
<td>Medium red clover</td>
<td>2-5</td>
<td>Drainage medium to good.</td>
</tr>
<tr>
<td></td>
<td>Ladino clover</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Timothy</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Clover-Grass Mixture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For hay, silage and pasture.</td>
<td>Medium red clover</td>
<td>6</td>
<td>Recommended only on soils not suited for alfalfa.</td>
</tr>
<tr>
<td></td>
<td>Ladino clover</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Timothy</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Modification for dry,</td>
<td>Mammoth red clover</td>
<td>6</td>
<td>Clover will last only one year.</td>
</tr>
<tr>
<td>shaley soils..............</td>
<td>Timothy</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Modification for wet land.</td>
<td>Alsike clover</td>
<td>3</td>
<td>Use of timothy optional. Redtop:</td>
</tr>
<tr>
<td></td>
<td>Ladino clover</td>
<td>1</td>
<td>If chaffy seed, sow double the amount.</td>
</tr>
<tr>
<td></td>
<td>Timothy</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Redtop</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>For pasture or silage.......</td>
<td>Ladino clover</td>
<td>1</td>
<td>Soil: All except very wet or very droughty. Very</td>
</tr>
<tr>
<td></td>
<td>Orchardgrass</td>
<td>8</td>
<td>productive mixture. Makes more midsummer growth than</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>other pasture mixtures. Careful management required</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>for satisfactory results.</td>
</tr>
</tbody>
</table>

* Source: "Cornell recommends for field crops," prepared by the New York State Extension Service, Cornell University.

the hope that fertility would be restored.
Many areas became so unproductive that they were no longer grazed and brush took over.

A number of these areas are potentially productive, so that when lime is applied (before disking) and phosphate is supplied to meet the requirements for that plant food element, excellent pastures result. After the pasture is established and in use, phosphate must be applied every year or two to replace that removed by the herbage and fixed by the soil. In many areas of the Northeast, potash also is limiting—particularly a few years after a highly productive pasture is established.

Renovating a Pasture

Early in July is a good time to begin renovation. This practice uses the hotter and drier months of the summer to kill the existing vegetation. Several diskings usually are required to turn up sods that may root down following a rain. The necessary lime is applied before disking. The phosphate and potash usually is applied just prior to the last disking in late
CLIMATIC CONDITIONS GENERALLY FAVORABLE FOR FORAGES

Information on the general climatic conditions which prevail in the region is given in Table 4.2.2. Rainfall conditions are generally favorable for the growth of forages throughout the area. There is a marked tendency for the annual rainfall to increase from north to south and from west to east, within the region. The average number of days without killing frost varies from 80 to 180 days in Michigan to 140 to 210 days in the southern portion of the region.

NATIVE GRASSES REPLACED BY INTRODUCED SPECIES

The native grasses which occurred commonly on the upland soils of the prairie areas of the region at the time of settlement by the white man have been largely replaced by introduced forages. Lacking the aggressiveness, competitive ability, and good seed habits of most introduced forages, the native grasses failed to re-establish naturally after plowing, or were eliminated as a result of grazing practices commonly followed in the region.

Most of the native upland forage species can still be found in the region, but their habitats have been narrowly restricted. In general they occur on infertile, abandoned sandy soils, in undisturbed waste areas, and on infertile slopes and other areas relatively inaccessible to livestock. In contrast to the native upland species, native lowland species generally have successfully resisted the invasion of introduced species on wet, poorly drained, uncultivated soils. The more important native upland and lowland grasses are listed here by their commonly used names. For the botanical names of these grasses see Chapter 7.

NATIVE UPLAND GRASSES. Big bluestem, Broomsedge, Canada wild-rye, Green needlegrass, Hairy grama, Indian grass, Junegrass, Little bluestem, Longleaf rushgrass or rough rushgrass, Muhly grass, Needle-and-thread, Porcupine grass, Prairie dropseed, Prairie sandgrass or sand reedgrass, Sand dropseed, Side-oats grama, Switchgrass.

NATIVE LOWLAND GRASSES. American sloughgrass, Bluejoint, Common reedgrass, Mannagrasses, Prairie cordgrass, Reed canarygrass.

Many Introduced Forages

None of the introduced forage grasses and legumes are well adapted to all of the soil and climatic conditions which prevail in the region. The use for which the seeding is intended and the local adaptation of the species serve as the basis for devising seeding mixtures. The most important of the introduced grasses and legumes currently being grown in the region are the following:

GRASSES. Barley, Canada bluegrass, Italian ryegrass, Kentucky bluegrass, Meadow fescue, Meadow foxtail, Millet, Oats, Orchardgrass, Red fescue, Redtop, Rough stalked meadowgrass, Rye, Smooth bromes, Sorghum, Sudangrass, Timothy and Wheat.

LEGUMES. Alfalfa, Birdsfoot trefoil, Clovers, (Alsike, Mammoth red, Medclium red, Common white and Ladino), Field peas, Korean lespedezas, Soybeans, Sweetclovers (Annual, Biennial white, Biennial yellow), Vetches.
<table>
<thead>
<tr>
<th>State</th>
<th>All hay</th>
<th>Clover and timothy</th>
<th>Alfalfa</th>
<th>Soybeans</th>
<th>Sweetclover</th>
<th>Wild hay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illinois</td>
<td>2,866</td>
<td>2,688</td>
<td>1,252</td>
<td>1,597</td>
<td>494</td>
<td>536</td>
</tr>
<tr>
<td>Indiana</td>
<td>1,951</td>
<td>1,807</td>
<td>938</td>
<td>1,132</td>
<td>445</td>
<td>358</td>
</tr>
<tr>
<td>Iowa</td>
<td>3,514</td>
<td>3,244</td>
<td>1,851</td>
<td>2,359</td>
<td>944</td>
<td>702</td>
</tr>
<tr>
<td>Michigan</td>
<td>2,699</td>
<td>2,798</td>
<td>1,215</td>
<td>1,494</td>
<td>1,221</td>
<td>1,040</td>
</tr>
<tr>
<td>Minnesota</td>
<td>4,484</td>
<td>4,032</td>
<td>922</td>
<td>1,284</td>
<td>1,229</td>
<td>913</td>
</tr>
<tr>
<td>Missouri</td>
<td>3,276</td>
<td>3,545</td>
<td>1,108</td>
<td>1,361</td>
<td>267</td>
<td>283</td>
</tr>
<tr>
<td>Ohio</td>
<td>2,530</td>
<td>2,536</td>
<td>1,771</td>
<td>1,994</td>
<td>463</td>
<td>420</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>4,009</td>
<td>4,106</td>
<td>2,405</td>
<td>2,963</td>
<td>1,079</td>
<td>984</td>
</tr>
<tr>
<td>Total for Central and Lake States</td>
<td>25,329</td>
<td>24,756</td>
<td>11,462</td>
<td>14,184</td>
<td>6,142</td>
<td>5,197</td>
</tr>
<tr>
<td>Total for U. S.</td>
<td>72,373</td>
<td>74,173</td>
<td>20,732</td>
<td>24,320</td>
<td>14,565</td>
<td>14,412</td>
</tr>
<tr>
<td>% Total in Central and Lake States</td>
<td>35.0</td>
<td>33.4</td>
<td>55.3</td>
<td>58.3</td>
<td>42.2</td>
<td>36.1</td>
</tr>
</tbody>
</table>
FORAGES PROVIDE STABILITY AND PERMANENCE

Rotations which include the systematic use of small-seeded grasses and legumes are essential to the maintenance of a permanent and profitable system of livestock agriculture. Without well arranged rotations which include soil-conserving and soil-improving grasses and legumes, yields cannot be maintained at high levels even on the most productive prairie soils of the Corn Belt. For example, on the Morrow plots at the Illinois Station, corn grown in rotation with oats and clover averaged 48 bushels per acre for the period 1888 to 1944, compared to 36 bushels in a rotation with oats only. When corn was grown continuously the average yield per acre for the same period was 29 bushels. Sod crops in the rotation are important in soil improvement and in maintaining production of row and grain crops at high levels. They also are extremely valuable in providing the feed necessary to support an extensive livestock enterprise. Along with corn and small grains, roughages such as hay and pasturage must be provided each year. These are made available with greatest ease by the use of rotations which include ample proportions of grains and roughages.

PROBLEMS OF ESTABLISHMENT ARE BEING SOLVED

The continued and systematic use of grasses and legumes in rotations is dependent to a considerable extent on their successful establishment following seeding. Failures apparently were rare immediately following the breaking of the virgin soil. However, continuous cultivation resulted in the subsequent depletion of available lime, phosphate, potash, and organic matter. This was due to cropping, leaching, and erosion, so that soil conditions gradually became less favorable for the successful establishment of small-seeded grasses and legumes. Pieters has stated that there were reports of clover failures in Ohio as early as 1866. In 1908 the Ohio Agricultural Experiment Station found that clover failures were becoming increasingly prevalent, especially in eastern and southern Ohio. Later, particularly dur-

![Fig. 12.1 “Rotations which include the systematic use of small-seeded grasses and legumes are essential to the maintenance of a permanent and profitable system of livestock agriculture. Without well arranged rotations which include... grasses and legumes, yields cannot be maintained at high levels even on the most productive prairie soils of the Corn Belt.” (See below.) A good catch of red clover in a companion oat crop. Red clover is one of the most extensively grown legumes throughout the region and is most often established by seeding in oats. Iowa State College photo.](image-url)
<table>
<thead>
<tr>
<th>State</th>
<th>Annual precipitation (inches)</th>
<th>January temperature range (° F.)</th>
<th>July temperature range (° F.)</th>
<th>Days without killing frost</th>
<th>Date of last killing frost, spring</th>
<th>Date of first killing frost, fall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illinois</td>
<td>32-46</td>
<td>18-56</td>
<td>72-78</td>
<td>150-210</td>
<td>April 5-May 10</td>
<td>Oct. 5-Oct. 25</td>
</tr>
<tr>
<td>Indiana</td>
<td>34-46</td>
<td>26-34</td>
<td>74-78</td>
<td>150-190</td>
<td>April 15-May 10</td>
<td>Oct. 5-Oct. 20</td>
</tr>
<tr>
<td>Iowa</td>
<td>26-36</td>
<td>14-24</td>
<td>72-76</td>
<td>140-170</td>
<td>April 25-May 15</td>
<td>Sept. 10-Oct. 10</td>
</tr>
<tr>
<td>Michigan</td>
<td>26-36</td>
<td>10-26</td>
<td>60-72</td>
<td>80-180</td>
<td>April 25-June 10</td>
<td>Aug. 30-Oct. 20</td>
</tr>
<tr>
<td>Minnesota</td>
<td>20-32</td>
<td>0-16</td>
<td>60-74</td>
<td>100-160</td>
<td>April 30-June 5</td>
<td>Sept. 10-Oct. 5</td>
</tr>
<tr>
<td>Ohio</td>
<td>32-44</td>
<td>24-34</td>
<td>72-76</td>
<td>140-200</td>
<td>April 30-May 10</td>
<td>Oct. 5-Oct. 20</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>28-32</td>
<td>10-22</td>
<td>66-72</td>
<td>90-170</td>
<td>April 30-June 5</td>
<td>Sept. 10-Oct. 20</td>
</tr>
</tbody>
</table>
Mixtures More Productive Than Pure Seedings

After the first 25 to 30 years immediately following 1900, increasing numbers of clover failures were reported from almost all parts of the region.

No matter what the cause, seeding failures are costly. Not only have time and labor used in preparing the seedbed largely been wasted, but also money spent for seed has been a direct and total loss. Moreover, seeding failures make reseeding necessary and result in hay and pasture shortages that often require the purchase of additional feed. Seeding failures necessitate the expense of providing emergency hay and pasture, they disrupt planned rotations, and result in increased erosion and reduced soil organic matter and fertility.

Procedures which provide reasonable assurance of success in the establishment of small-seeded grasses and legumes have been developed. Among the more important practices which are recognized in reducing seeding hazards are: (1) liming and fertilizing with phosphate and potash, (2) preparing a firm, moderately smooth seedbed, (3) shallow coverage of seed, (4) reducing competition from the companion crop and weeds, (5) proper inoculation of legumes, (6) use of adapted seed of good quality, (7) seeding at the right time, (8) mulching, (9) maintaining adequate reserves of organic matter, (10) control of injurious insects, and (11) proper management of the seeding following establishment. The importance of these factors in establishment is considered in detail in Chapter 38.

**MIXTURES MORE PRODUCTIVE THAN PURE SEEDINGS**

Considerable evidence is available which shows that mixtures of grasses and legumes usually are more productive than seedings of either grasses or legumes grown alone. For example, studies in Illinois in 1944 by Fuelleman, et al., have shown that smooth bromegrass and orchardgrass seeded alone produced approximately 40 per cent less forage and 50 per cent smaller gains in live-weight than when grown in mixtures which included alfalfa. In Wisconsin, Alilgren and Burcalow noted that when timothy, smooth bromegrass, and alfalfa were seeded alone they were much less productive than mixtures including one or more of these grasses and alfalfa. In addition, better weed control usually is obtained when grasses are included in seeding mixtures with legumes. The productive life of mixed stands may be lengthened because grasses are hardier and last longer than the legumes com-

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### TABLE 42.3
Grasses and Legumes Used for Hay, Pasturage, Silage, Soil Improvement and Seed Production in the Central and Lake States

<table>
<thead>
<tr>
<th>Seeding number</th>
<th>Seeding</th>
<th>State or states making recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>III.</td>
</tr>
<tr>
<td>1</td>
<td>Alfalfa 8-15</td>
<td>x</td>
</tr>
<tr>
<td>2</td>
<td>Alfalfa 8-12, timothy 2-6</td>
<td>x</td>
</tr>
<tr>
<td>3</td>
<td>Alfalfa 10, Orchard 6</td>
<td>x</td>
</tr>
<tr>
<td>4</td>
<td>Alfalfa 6-12, smooth brome 3-10</td>
<td>x</td>
</tr>
<tr>
<td>5</td>
<td>Alfalfa 6-8, meadow fescue 8</td>
<td>x</td>
</tr>
<tr>
<td>6</td>
<td>Alfalfa 6-8, smooth brome 6, meadow fescue 2</td>
<td>x</td>
</tr>
<tr>
<td>7</td>
<td>Alfalfa 8, smooth brome 4-6, timothy 1-5</td>
<td>x</td>
</tr>
<tr>
<td>8</td>
<td>Alfalfa 7, medium red 5, orchard 6</td>
<td>x</td>
</tr>
<tr>
<td>9</td>
<td>Alfalfa 8-10, Ladino 1/2-1, smooth brome 3-12</td>
<td>x</td>
</tr>
<tr>
<td>10</td>
<td>Alfalfa 6-10, medium red 1-3, smooth brome 4-12</td>
<td>x</td>
</tr>
<tr>
<td>11</td>
<td>Alfalfa 5-8, medium red 3-5, timothy 3-6</td>
<td>x</td>
</tr>
<tr>
<td>12</td>
<td>Alfalfa 6-8, medium red 3-4, Ladino 1/2-1, smooth brome 6-8</td>
<td>x</td>
</tr>
<tr>
<td>13</td>
<td>Alfalfa 4, medium red 4, alsike 1-2, timothy 3-6</td>
<td>x</td>
</tr>
<tr>
<td>14</td>
<td>Alfalfa 4, bi. sweetclover 2-4, alsike 2, timothy 4-6</td>
<td>x</td>
</tr>
<tr>
<td>15</td>
<td>Alfalfa 3, bi. sweetclover 4, medium red 2, alsike 1</td>
<td>x</td>
</tr>
<tr>
<td>16</td>
<td>Alfalfa 4, bi. sweetclover 4, medium red 2, smooth brome 4, timothy 3</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td></td>
<td>III.</td>
</tr>
<tr>
<td>17</td>
<td>Alskle 4-6</td>
<td>x</td>
</tr>
<tr>
<td>18</td>
<td>Alskle 5, timothy 4</td>
<td>x</td>
</tr>
<tr>
<td>19</td>
<td>Alskle 2-3, medium red 5-6</td>
<td>x</td>
</tr>
<tr>
<td>20</td>
<td>Alskle 3, Ladino 1/2, reed canary 5-10</td>
<td>x</td>
</tr>
<tr>
<td>21</td>
<td>Alskle 4, timothy 2-4, redtop 2-4</td>
<td>x</td>
</tr>
<tr>
<td>22</td>
<td>Alskle 2-4, medium red 4-8, Ladino 1/2-2, timothy 3-10, smooth brome 6-8</td>
<td>x</td>
</tr>
<tr>
<td>23</td>
<td>Alskle 2 or Ladino 1-2, timothy 2, reed canary 4-6</td>
<td>x</td>
</tr>
<tr>
<td>24</td>
<td>Alskle 2, bi. sweetclover 5-8, medium red 3, alone or with smooth brome 6-8</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td></td>
<td>III.</td>
</tr>
<tr>
<td>25</td>
<td>Birdsfoot trefoil 4-5, medium red 3-4 alone or with orchard 6-8 or Kentucky blue 6-8</td>
<td>x</td>
</tr>
<tr>
<td>26</td>
<td>Birdsfoot trefoil 4-6, alone in renovation of bluegrass sod or with Kentucky blue 6-8, or orchard 6-8 or smooth brome 6-8 or timothy 2-4</td>
<td>x</td>
</tr>
<tr>
<td>27</td>
<td>Field peas 90, oats 48</td>
<td>x</td>
</tr>
<tr>
<td>28</td>
<td>Korean lespedeza 6-50</td>
<td>x</td>
</tr>
<tr>
<td>29</td>
<td>Korean lespedeza 4-6, alsike 4, timothy 1-2, redtop 2-4</td>
<td>x</td>
</tr>
<tr>
<td>30</td>
<td>Korean lespedeza 10-15, timothy 3-5, or orchard 6-10, or redtop 3-5</td>
<td>x</td>
</tr>
<tr>
<td>31</td>
<td>Korean lespedeza 20-25, small grains 64-120</td>
<td>x</td>
</tr>
<tr>
<td>Seeding number</td>
<td>Seeding</td>
<td>State or states making recommendations</td>
</tr>
<tr>
<td>----------------</td>
<td>------------------------------------------------------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ill.</td>
</tr>
<tr>
<td>32</td>
<td>Korean lespedeza 4–6, medium red 5, alsike 3.</td>
<td>x</td>
</tr>
<tr>
<td>33</td>
<td>Korean lespedeza 4, medium red 4, alsike 2, timothy 2–5.</td>
<td>x</td>
</tr>
<tr>
<td>34</td>
<td>Korean lespedeza 8, redtop 2, timothy 3, tall fescue 4.</td>
<td>x</td>
</tr>
<tr>
<td>35</td>
<td>Korean lespedeza 5, Ladino 2, tall fescue 5.</td>
<td>x</td>
</tr>
<tr>
<td>36</td>
<td>Korean lespedeza 7, alsike 2, timothy 4, redtop 3.</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>For short rotations, on moderately fertile, to well-drained upland soils</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>Medium red 8–10 or mammoth red 8–10.</td>
<td>x</td>
</tr>
<tr>
<td>38</td>
<td>Medium red 6–8, timothy 2–10.</td>
<td>x</td>
</tr>
<tr>
<td>39</td>
<td>Medium red 4–6, alsike 2, timothy 4–6, and/or smooth brome 6.</td>
<td>x</td>
</tr>
<tr>
<td>40</td>
<td>Medium red 4, Ladino 1–2, timothy 3–4 or smooth brome 6–8.</td>
<td>x</td>
</tr>
<tr>
<td>41</td>
<td>Medium red 4, Ladino 1, alsike 2, timothy 5–6.</td>
<td>x</td>
</tr>
<tr>
<td>42</td>
<td>Medium red 3, bi sweetclover 7, timothy 5.</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Emergency annual hay crops</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>Millet 20–30.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>In short rotations for soil improvement, pasturage or seed production, or in renovation of permanent pastures on moderately fertile to fertile, well-timed soils</td>
<td>x</td>
</tr>
<tr>
<td>44</td>
<td>Bi. white sweetclover 10–12 or bi. yellow sweetclover 10–12.</td>
<td>x</td>
</tr>
<tr>
<td>45</td>
<td>Bi. white or yellow sweetclovers 6–15, smooth brome 10–12 or timothy 3–6, or Alta or Kentucky 31 fescue 6–10 or orchard 6 or common ryegrass 8.</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Temporary or supplementary hay, pastures or grass silage</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>Soybeans 40–75 in rows or 90–120 drilled.</td>
<td>x</td>
</tr>
<tr>
<td>47</td>
<td>Soybeans 90, oats 32.</td>
<td>x</td>
</tr>
<tr>
<td>48</td>
<td>Soybeans 60–90, millet 5–8 or Sudangrass 5–10.</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Temporary or supplementary hay, pastures or grass silage</td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>Small grains (barley, oats, rye, wheat) 56–150.</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Temporary or supplementary hay, pastures or grass silage</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>Sudangrass 15–35.</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Temporary or supplementary pasture mostly for swine</td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>Rape 3–7 or rape 3–7, oats 64–112.</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Low, wet, poorly-drained soils subject to periodic overflowing</td>
<td></td>
</tr>
<tr>
<td>52</td>
<td>Reed canarygrass 5–10.</td>
<td>x</td>
</tr>
<tr>
<td>53</td>
<td>Reed canarygrass 6, timothy 2–4.</td>
<td>x</td>
</tr>
</tbody>
</table>

* The addition of 3 to 5 pounds of Kentucky bluegrass and 1/2 pound of Ladino clover to Indiana mixtures numbered 2, 4, 7, 13, 33, and 39 makes them suitable for permanent pasture.
† One to 2 pounds of Ladino clover may be added to regular grass-legume mixtures for hay or pasturage.
‡ If permanent pasture is desired add 3 to 5 pounds of Kentucky bluegrass and 1/2 to 1 pound each of Ladino and Louisiana white clovers to any hay mixture adapted to the situation.
monly grown with them. It is primarily for these reasons that mixtures containing both grasses and legumes are commonly seeded throughout the area. The seeding mixtures vary greatly depending upon the purpose for which they are intended, and the soil and climatic conditions prevailing in the locality in which they are to be grown.

**MOST SOWN SPECIES EVENTUALLY REPLACED**

When left down for a considerable number of years—and especially when grazed—most species which comprise the initial seeding are eventually replaced by other species not included in the seeding mixture. Kentucky bluegrass eventually becomes the dominant species on fertile upland soils in almost all portions of the region. On relatively infertile upland soils the species which are sown may be replaced by Canada bluegrass. Vegetation on impoverished soils, particularly in the eastern and southern portion of the region, reverts eventually to broomsedge and poverty grass. Species sown on wet, poorly drained soils are gradually replaced by redtop. Well established and managed stands of reed canarygrass on lowland areas—and to a lesser extent smooth brome grass on fertile, upland soils—are capable of resisting the encroachment of most other species.

**SEEDING MIXTURES VARY WIDELY**

The more important forage species introduced into the region during the period of early agricultural development were medium red clover, alsike clover, white clover, timothy, Kentucky bluegrass, Canada bluegrass, and redtop. From various local areas into which they were introduced by early settlers, white clover and Kentucky bluegrass have spread rapidly and spontaneously to all cleared and moderately fertile to fertile upland soil areas which are removed from cultivation for a few years. At present these two species represent the most important and extensively grown forages in pastures throughout almost all parts of the region. The more recent introduction of the giant white clover known as Ladino is of great importance due to its recognized value in providing greater returns from pastures. The history and development of redtop and Canada bluegrass is somewhat comparable to that of Kentucky bluegrass and white clover but their spontaneous occurrence is more restricted and less widespread. Redtop predominates on relatively infertile, acid, poorly drained soils while Canada bluegrass occurs commonly only on relatively thin, infertile, acid upland soils.

With the gradual intensification of agriculture, other valuable forages were successfully introduced into the region. Smooth brome, alfalfa, soybeans, and the biennial sweetclovers are now grown extensively in many parts of the region. The value of smooth brome as a dependable source of highly nutritious, palatable forage was first recognized in the drier western portion of the region. More recently this grass has proved valuable on fertile, well-drained soils in almost all parts of the region. White clover and Ladino clover are of greatest value in the more humid eastern portion of the region.

Timothy is replaced by orchardgrass to a certain extent in southern Ohio, Indiana, Illinois, and Missouri. Korean and common lespedeza, crimson clover, and cowpeas are grown only in the southern portion, whereas meadow fescue is restricted primarily to the western portion and to fertile, moist, heavy soils in Indiana, Illinois, and Missouri. Reed canarygrass is restricted to low, wet soils,
cured as hay. A complete program for forages integrates permanent pasture, temporary grazing, hay, and sometimes silage. A year-round program utilizes forage in its various forms to the maximum.

In a strict sense, a year-round grazing program either does not permit enough forage for continuous livestock production (growth in weight of beef or continuous flow of milk) or it results in a surplus that is likely not to be fully utilized at certain times of the year. Due to the combination of such climatic factors as rain, cold, drought, and photoperiod, we have peaks and low points in the growth of plants which result in a deficit or a surplus of forage at certain times. If the amount of livestock is based on maximum utilization of the forage at peaks, there will be a shortage of feed at the low points. If based on the amount available at the low points there will be a surplus at the peaks. Information of the forage available from different crops for a given area and for various seasons of the year should have careful consideration in planning a hay and pasture program.

PASTURES

A good pasture provides a large yield of nutritious forage over a long grazing season. A permanent pasture is covered with perennial or self-seeding annual or biennial plants which are left indefinitely for grazing as contrasted with a temporary pasture grazed for only a short time. Thus, in the South a temporary pasture usually is part of a rotation system and the area is frequently in different crops, often cultivated or row crops. Management of a temporary and a permanent pasture is likely to be different, but the need for fertilization and selection of the area often are quite similar.

ESSENTIAL QUALITIES OF GOOD PASTURE.

Pastures usually should be so handled that they will endure as long as possible. Endurance of a pasture usually calls for a mixture of grasses and legumes that either are long-lived or can reproduce themselves under pasture conditions. A good pasture should start growth early in the spring and continue production until late in the fall. The plants should be palatable and nutritious and give abundant growth. They should form a compact turf that can withstand the trampling of animals. A mixture of deep-rooted and shallow-rooted plants is desirable though not always possible. No single plant, whether a grass or a legume, makes an ideal pasture. Some, such as alfalfa or Bermuda-grass may approach it, but livestock seem to prefer a mixture of plants for maximum growth.

Evidence from all parts of the South indicates that a legume must be maintained in the pasture sod. Grass alone will not continue productive. Legumes add nitrogen to the soil and thus increase the growth and nutritive value of the grasses. Any treatment that increases legume growth will either directly or indirectly increase the grass. Pastures that do not contain legumes generally show a marked reduction in yield. The reduction is often so great that the pasture is almost worthless. For example, a mixture of grasses and legumes that will produce 300 to 600 pounds of beef per acre per year in the carpetgrass area, after reverting to a solid carpetgrass stand will produce less than 100 pounds of beef per acre per year.

CHOICE OF AN AREA. As is true with all crops, more fertile moist soils make the best pastures. Fertility may be changed by the use of fertilizers but man has little control over the factor of moisture. In selecting pasture land for winter
or spring grazing, care should be taken to put the crops on the driest, best-drained land. Summer and fall pasture crops should be on the lower areas. By doing this, one will provide maximum production and use from each area. In the winter, when rainfall is excessive, the crops will thrive on the drier, well-drained areas and the cattle can graze most, if not all, of the time. The low, moist areas will be boggy and the crops may drown out, or the land will be too wet for the cattle to stay on. Such wet areas will provide excellent grazing in the summer. Some pasture plants will stand more moisture than others while others are better suited to the high drier areas.

In general, deep-rooted perennials such as sericea lespedeza or alfalfa should be planted on the dry areas while shallow-rooted annuals and perennials should be planted on the lower areas. Some crops like Bermuda-grass and Dallisgrass will thrive under either condition, and when planted in combination with reseeding annuals make an excellent pasture much of the year. In fact, by combining certain winter legumes such as crimson clover, rough peas (Caley-pea; Singletary pea), and others with Bermuda-grass, Dallisgrass or sericea lespedeza on the drier areas, the total production of beef per acre often has been greater than that from the more low-lying areas once considered the choice pasture land. By the choice of proper crops and by proper fertilization, almost all of the land in the South can be made to produce excellent pasturage.

Deep sandy soils often leach so readily that it may not be profitable to maintain them in pasture. In other cases the land may be full of stones or the topography irregular, or the fertility so low that they cannot be profitably maintained as pasture.

This classification varies somewhat in different sections. It applies mainly in the southern half of the Cotton Belt. In the northern half, grasses such as orchardgrass, redtop, Kentucky bluegrass, and fescue are often considered as warm season grasses.

Permanent Pasture

In general, in the upper South, Kentucky bluegrass is the basic grass. Orchardgrass, redtop, and tall fescues are used to some extent. White clover is the dominant legume. Ladino is rapidly becoming important, and lespedeza also is important.

In the lower South, Dallisgrass, carpetgrass, and Bermuda-grass, are the basic grasses: white clover and common lespedeza are the basic legumes. Ladino, orchardgrass, and tall fescues are increasing in importance. In the extreme lower South, Bahiagrass, Pangolagrass, and St. Augustinegrass are used in addition to the above listed.

In most instances it is impossible to
produce both white clover and lespedeza on the same area. The white clover smothers out the young lespedeza seedlings in the spring. When lespedeza is desired for good summer pasture, white clover should be left out of the mixture. With conditions such that white clover grows slowly and with a thin stand, lespedeza included in the mixture makes a good growth the first summer. By the second summer the white clover will smother out the lespedeza.

Temporary Pasture

In all sections, the small grains or Italian ryegrass, alone and in mixtures with clovers, are used for winter and spring grazing. These often are followed with lespedeza, Sudangrass or other crops to provide pasture later in the season. For summer grazing, Sudangrass, lespedeza, millets, soybeans, kudzu, Johnsongrass and sericea lespedeza are most frequently used. Alyceclover is suited to the extreme southern portion of the area.

The conditions under which the tall fescues will be most used have not been definitely determined. In Kentucky and Tennessee they are often used on dry areas while in Alabama, Georgia, and other states further south they appear suited to low or moist areas. Perhaps they will come to have an important place in pasture systems of the future.

The use of reseeding annual winter legumes such as reseeding strains of crimson clover, bur-clovers and roughpeas, grown in combination with Bermuda-grass or Johnsongrass, is proving an excellent system for providing temporary grazing in the lower South.

It seems that annual lespedeza and sericea lespedeza are suited best for growth north of the lower Coastal Plain area. In the lower Coastal Plain they frequently persist for only a year or two at the most. Damage by nematodes probably is one of the important causes for the failure of lespedeza in this area.

Fertilization

In the South, the soil fertility factor is by far the most important problem in the establishment and production of good pastures. In most instances the soils are low in fertility and deficient in one or more elements. The best procedure, and perhaps the only one under average conditions, is to apply appropriate amounts of lime and fertilizers and thus provide conditions favorable for growth of desirable pasture plants.

Agricultural experiment stations in the South have found by tests which elements usually are deficient, and thereby are able to make definite recommendations for the application of the needed elements. Recommendations as to the kind of materials, amount to use, and frequency and method of application are available for most areas from the respective agricultural experiment stations.

Adequate fertilization not only results in increased acre yields but in addition, increases the proportion of the more desirable plants. The content of calcium and phosphorus in the herbage is increased also. The effect on the composition of the herbage is so marked that animal gains on fertilized pastures are much greater than the increase in yield of herbage would indicate. In some instances nearly twice as many pounds of herbage are required per pound of gain from an unfertilized pasture as from a fertilized pasture.

LIME. Soils vary considerably in their need for lime, depending upon texture, and acidity. In general, applications of approximately 1 ton are recommended on the light soils and 1
to 2 tons on the heavy soils. Experiments indicate that applications of lime should be made every 8 to 10 years. In establishing a pasture the lime should be thoroughly incorporated in the soil if possible. Later applications are applied as top dressings.

**PHOSPHATE.** In general, phosphates are needed on pastures throughout the South, with the possible exception of some areas in Kentucky and Tennessee. Pasture legumes vary considerably in their response to phosphorus. White and Ladino clover probably require the most, while hop clover and lesions require the least when compared to the commonly used pasture legumes. Heavy initial applications are needed for the establishment of clovers; smaller amounts may be sufficient for maintenance. An initial application of 600 to 800 pounds of 20 per cent superphosphate per acre seems to be adequate on most soils; 200 to 400 pounds per acre should be applied annually for maintenance. The preferred time for fertilizer application is in the fall.

**POTASH.** The response to potash is less general than that of phosphorus. However, Ladino clover and alfalfa are heavy feeders on potash and adequate amounts must be applied if these crops are to be maintained. White clover and other pasture crops often need potash and on many soils an application of potash is a must. Most recommendations are 25 to 50 pounds of K₂O per acre annually for pastures. For maximum production the rate may need to be 100 to 200 or more pounds of K₂O per acre annually.

**NITROGEN.** The use of nitrogen in addition to lime and mineral fertilizer is often recommended for the initial treatment in establishing pastures. Nitrogen helps get the clover established and maintains it until the legume bacteria can supply sufficient nitrogen for the needs of the plant. Nitrogen is especially stimulating to grasses. After seeding is established, applications of nitrogen often are considered detrimental. Nitrogen stimulates the grasses and thus reduces the legumes. There is no appreciable increase in the total yield of the pasture. Sods in which grasses predominate will respond to nitrogen, but due to the cost the practice may not be justified. Most agronomists agree that if a suitable mixture of clover and grass is obtained the application of nitrogen is of doubtful value and is not generally recommended. For special cases, notably on dairy farms, applications of nitrogen to stimulate growth in the early spring may be profitable. Nitrogen applications are needed when temporary grazing crops such as oats, ryegrass, Sudangrass, millets, *et al.* are used.

**MICRONUTRIENTS.** The general need for applications of micronutrients such as boron, manganese, zinc, copper, and cobalt has not been established. Light applications, 5 to 10 pounds per acre, of borax have been shown to be beneficial to the clovers. The need for copper and manganese for plant growth and cobalt for growth of animals has been shown in some cases. In general, the research with micronutrients in the South has not been adequate thus far either to definitely prove or to disprove their value for growth of crops or their need by animals, except in special cases on some soils.

**MIXED FERTILIZERS.** Most pasture recommendations carry suggestions for the use of mixed fertilizers in adequate

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amounts to supply the needs of the plants. The particular formula will vary from state to state. Usually the recommendation is to apply mixed fertilizers annually in the fall in order to stimulate the growth of clovers. The initial application is made before the pasture is seeded and the fertilizer is worked into the soil by diskning.

Maintenance applications are made as top dressings on the soils. Usually no attempt is made to incorporate the fertilizer in the soils. The fertilizer might be more effective if a practical method of getting it into the soil were available. However, a few studies made thus far have not shown a definite value for applying the maintenance fertilizer below the surface of the soil.

**Seedbed and Seeding**

**Preparation.** Poor preparation of seedbed often results in failure. The soil must be firm in order to make shallow seedings and to enable the seed to make close contact with the soil. The soil should be turned and disked long enough before seeding to allow the seedbed to firm. A well firmed soil is essential for pasture seedlings. The additional expense of good seedbed preparation will be repaid in better stands and better growth of the pasture plants.

Well-prepared summer fallow is the best seedbed preparation for late summer and fall seedings. Moisture stored in fallow results in better stands and faster growth than any other method of preparation. In summer fallowing care should be exercised to insure a firm seedbed before the time of seeding.

**Seeding.** Climate and elevation divide the South into three rather distinct regions: (1) the sections of cool climate or high elevation, (2) warm climate or upper Coastal Plains, and (3) the extreme southern Coastal Plains, and Florida. Pasture seedings are made at three periods of the year: summer, fall, and late winter or early spring. Climate and the crops used will determine to a large degree when the seeding can best be made. In general, the cool-weather legumes and grasses are seeded in late summer, August and September, or early fall in the more northern portion of the area. The seeding date is progressively later to the south. In the warm climate section, seeding is made in the fall; in the Gulf Coast and Florida region often as late as November. The earlier the plants can be established, the earlier grazing will be available. Pastures seeded in late July or early August in Tennessee, Kentucky, and northern Alabama and Georgia are ready for grazing by October.

The warm season plants like lespedeza and Dallisgrass are seeded in February or early March (early spring). Bermuda-grass and other grasses propagated vegetatively should be sprigged or sodded in the spring because of more favorable moisture conditions at that time.

In the warm upper Coastal Plain and Gulf regions it is difficult to get inoculation on white clover and other legumes if they are planted too early in the fall.

In some instances spring seeding of clovers and grasses normally seeded in the fall may be practiced. This is somewhat risky and the results usually are not as satisfactory as from fall seeding. The practice is more successful in the northern portion of the area than further south. In the lower Coastal Plain and Gulf Coast regions such seedings almost always fail.

Shallow seeding is important in the establishment of grasses and legumes. The proper depth is determined by species, size of seed, soil type, and mois-
Hay and Pasture Seedings in the Humid South

Fig. 43.1 “The South has been a region of annual hay crops... a costly hay, a luxury the South can no longer afford. The more general use of perennial hay crops is a major advance for the South.” (See below.) Alfalfa on Orangeburg sandy loam soil in southern Alabama, fertilized annually with 400 pounds of muriate of potash and 600 of superphosphate. Yield five tons per acre from four cuttings per season. Ala. Agr. Exp. Sta. photo.

Grazing should not begin until the plants are well enough established to withstand trampling and will not be pulled up by the grazing animals. Plants usually are 5 to 6 inches in height when ready for grazing. The grazing should not be close enough to weaken the plants—for most species not closer than 2 or 3 inches. Overgrazing favors one plant over another in the pasture combination, and the proper balance for maximum yield is disturbed. The calcium, phosphorus, and digestible protein content of forage is highest, and the palatability best when the plants are kept grazed close enough to keep them in a vigorous growing condition. Undergrazing is undesirable because of loss of quality in the forage. Undergrazing also may permit some plants to smother out others, thus reducing the value of the pasture. Undergrazing of summer grasses may result in the elimination of winter clovers from pasture mixtures.

It generally is impractical to control the growth of plants to the ideal stage by proper grazing management alone. Mowing is a necessary part of good pasture management. Mowing helps in the control of weeds and removes the more mature unpalatable forage. Mowing at least twice during the season usually is necessary in the control of weeds and to keep the forage in the proper stage for best grazing.

Fertilization such as will maintain a vigorous growth of legumes is the cardinal principle of pasture maintenance in the South. Annual top dressing probably will be best. Certainly fertilization should be repeated as often as two or three years.

**HAY CROPS**

The South has been a region of annual hay crops such as cowpeas, soybeans, and millets. Annuals make a costly hay, a luxury the South no longer can afford. Neither can it afford to get along without hay. The more general use of perennial hay crops is a major advance for the South.

There are many excellent perennial hay plants available which are well adapted to the South. Johnsongrass, Bermudagrass (hay types like coastal or Suwannee), Dallisgrass, and orchardgrass produce excellent yields of good quality...
Hay Crops

FIG. 43.2 "It has been established that legumes such as kudzu, sericea lespedeza, and alfalfa can be grown successfully in most parts of the South . . . probably should be grown alone to produce the best quality of hay. Mixtures of grasses and these plants have been difficult to maintain." (See below.) Kudzu gives a high acre production of highly palatable and nutritious forage. Ala. Agr. Exp. Sta. photo.

hay. It has been established that legumes such as kudzu, sericea lespedeza, and alfalfa can be grown successfully in most parts of the South.

A mixture of a reseeding winter legume, such as reseeding crimson clover, bur-clover or roughpeas, with Johnson-grass or Bermuda-grass makes an ideal combination to produce winter grazing and a good summer hay. Alfalfa, kudzu, and sericea lespedeza probably should be grown alone to produce the best quality of hay. Mixtures of grasses and these plants have been difficult to maintain. Perhaps sometime a grass will be found that can be used satisfactorily in a mixture with these plants.

**CHOICE OF AREA.** In selecting the area for a hay crop, consideration must be given to both the production and harvesting of the crop. Rough, irregular areas, or areas with boulders or stumps, are not suited to the operation of modern hay making machinery. Nearly level, smooth, well-drained, fertile land is preferable. Low, wet areas are not suitable. Land that is very low in fertility should be avoided. This will apply particularly to the more sandy soils.

**Fertilization**

**LIME.** An application of lime will be needed in practically all cases, except on lime lands. The amount of lime to use will depend upon the crop. On sandy soils one ton may be sufficient while on heavy clays one to two tons may be needed. The application of lime is not needed for sericea lespedeza and kudzu except on unusually acid soils.
For alfalfa, doubling the rate of lime suggested will be necessary.

PHOSPHATE AND POTASH. All the hay crops respond to applications of phosphate and potash. Applications of 300 to 400 pounds of 20 per cent superphosphate and 50 of muriate of potash usually are sufficient. In the case of alfalfa, however, the potash will need to be much higher, ranging from 200 to 400 pounds of muriate per acre on many soils.

NITROGEN. The grasses need large amounts of nitrogen for maximum growth. Nitrogen may be supplied through the use of legumes used as winter crops in many instances. This usually is the cheapest and best way to supply it, but it also may be supplied through commercial fertilizers. Applications of 60 pounds or more of nitrogen per acre are recommended when legumes are not used. The nitrogen fertilizer is applied as a top dressing about the time the grass begins growth in the spring and again after the first cutting is made. About 200 pounds of nitrate of soda, or its equivalent in other forms, usually is recommended for each cutting. Tests have shown that yields of 5 to 10 tons of hay per acre can be produced if the nitrogen supply is adequate. To produce these unusually large yields, however, requires the use of more nitrogen than is profitable.

MICRONUTRIENTS. Borax is needed for alfalfa on many soils throughout the South. An application of 15 to 25 pounds of borax per acre annually is usually recommended. The need for borax on crops other than alfalfa and the clovers has not been demonstrated. The need for other micronutrients is not known to exist, except that in some instances in Florida copper is needed.

TIME OF APPLICATION. Fertilizer and lime are applied before the crop is seeded, and incorporated in the soil by disk- ing. Applications made after the crop is established are as top dressings. The preferable time is just prior to the time the plants begin growth. In the case of alfalfa, kudzu, and sericea lespedeza this is in late winter (February or March). In the case of grasses grown with reseeding legumes, it is applied in late summer to stimulate the clovers. If grasses are grown alone it is applied in early spring.

Seedbed and Seeding

Hay crops should be sown on a well-prepared, firm seedbed. Sowing on too loose a seedbed often results in failure. Summer fallowing is very desirable when crops are to be seeded in the late summer. This is especially true with alfalfa.

The preferable time to sow is in late summer or early fall (August and September) for alfalfa, clovers, or cool season grasses. The warm season grasses and legumes such as Johnsongrass, cowpeas, or soybeans are planted in the spring and early summer. The preferable time to sow sericea lespedeza is early in the spring (March and April) though seeding as late as July may be made in the lower South. Bermuda-grass usually is established from sprigs or sod. This should be done in early spring when moisture is ample.

Kudzu is propagated from crowns or seedling plants which are set out during the dormant period.

The seeding of sericea lespedeza, alfalfa, and other small seeded crops should be very shallow. The seeding depth of Johnsongrass should be about 1 to 2 inches. Seed of Johnsongrass usually are covered by light disking. The seed of small seeded plants are covered with a spike tooth harrow or soil pulverizer (cultipacker) to an optimum depth
of a half inch. Seed of large seeded crops like cowpeas and soybeans are usually covered 2 to 3 inches in depth.

Grazing and Mowing Practices

It is very important to maintain an adequate supply of reserve food in the root system of perennials. They should not be grazed too closely or mown too often. Kudzu must be handled very carefully; one cutting made in June is preferable. It should never be grazed so heavily that the ground is visible. Johnsongrass, Bermuda-grass, and sericea lespedeza can be mown 2 or 3 times a year without seriously damaging the stand. Too frequent mowing of these plants, however, will reduce the yield.

QUESTIONS

1. Is the diversity of crops suitable for growth in the South an advantage or disadvantage? Why?
2. In planning a year-round grazing system for the South what are some of the important things that need to be considered?
3. What are the more important causes of poor pastures in the South?
4. How can the problem of weeds in pastures best be handled?
5. Does the production of high quality hay work against large yields? Explain.
6. What are the more important factors to be considered in seeding pasture and hay crops?
7. How are perennial meadows best maintained?
8. Outline a lime and fertilizer program necessary to produce high quality and high yielding pasture.
9. What are some of the forage mixtures and species that will provide year-round grazing?
Climate and soil are factors that largely control the choice of small seeded grasses and legumes used for hay and pasture seedings in the Northern Great Plains and Intermountain States. These mid-continent areas exhibit great extremes in climate, soil, and natural vegetation. This diversity of environment requires special procedures of farming and ranching, including dry farming methods, grazing management, and irrigation practices.

EXTENT AND LIMITS OF THE AREAS

The Northern Great Plains area comprises approximately 192 million acres and the Intermountain States about 455 million. The Northern Great Plains are bounded on the east by a transition zone, which divides the native short grass country on the west, and the region of tall native and introduced grasses on the east. This line closely corresponds to the 98th meridian. The Intermountain region joins the Northern Great Plains on the west and extends westward to the Sierra Nevada mountains, and south to Mexico.

Climate of the Regions

The climate of the Northern Great Plains is semi-arid. Precipitation and temperature are the limiting factors in hay and pasture production. The average rainfall along the eastern border is 26 inches. This gradually decreases to as low as 10 inches in the west. The elevation above sea level averages from 1,400 feet on the east to more than 5,000 feet on the west. The latitude ranges from 40° on the south to 49° on the north. The great difference in elevation and the distance of approximately 600 miles from south to north is the cause for a range in length of growing seasons from 160 days in the southeast to 110 days in the northwest.

The climate of the Intermountain region is classified as arid. The elevation ranges from below sea level to 14,000
Extent and Limits of the Areas

feet. The precipitation averages from around 5 inches in the lower, drier areas to 50 inches in parts of the Rockies. The maximum shade temperatures range from 105° to 120° F. in the low, hot areas of southern Nevada, southeastern California, Arizona, New Mexico, and southwestern Texas to 70° to 90° F. in the high mountainous areas. The lengths of the growing season vary accordingly. This is a region of extremes, consisting mostly of mountains, narrow valleys, lowlands and high plateaus. Of the 455 million acres in this region only 6.9 million produce harvested forage. Some 5.4 million acres are in farm pastures and 142 million are private range land. Public range comprises about 300 million acres.1

General Crop Conditions

Growing conditions in the Great Plains and Intermountain States regions include great extremes, with drier and more adverse conditions increasing from east to west. The type of farming also varies with the changes in climate and soil. Along the eastern border of the Great Plains region, the hay and pasture seedings are only a part of a general diversified farming system. Most of the grain crops, such as corn, wheat, oats, and barley, are grown. Also, most farms have fields of alfalfa, smooth brome, or prairie hay, which are used at various times of the year for hay and pasture. The prairie is made up of tall native grasses including big bluestem, side-oats grama, switchgrass, and the wheat grasses. West of the 100 meridian, the hay and pasture seedings gradually change from the tall grasses to the short grasses, such as blue grama and buffalo grass. General farming is the common practice, but the native pastures and meadows take up much more of the land area than is used for plow crops. The tall grass prairie vegetation extends westward into the drier areas along the river valleys and on irrigated and sub-irrigated lands.

Hay and pasture seedings have increased rapidly during the past decade in both the Northern Great Plains and Intermountain regions. The drought of the thirties and the threat of surplus grain production in the more favorable years have caused some abandonment of tilled acreages. There is a need for returning such unproductive land to grass, to bring a return from hay and pasture, making possible a more profitable and better balanced system of farming.

Certain simple but important facts and findings of agricultural workers are greatly increasing the uses and value of grasses for these areas of limited rainfall in the West. Not only are a few of the introduced grasses being recognized as suitable in these regions, but many of the native grasses are being domesticated.

Cool-season and Warm-season Grasses

The recognition that grasses fall into two general categories as to season of the year in which they make their growth has been an important step. Bromegrass, wheatgrasses, bluegrasses, wild-rye, and needlegrasses make their best growth in the early spring and again in the fall. The bluestems, switchgrass, side-oats grama, blue grama, and buffalo grass however, come on slowly in the early part of the season and are known as summer-growing grasses. A system of permanent grassland, which will provide a maximum of season-long utilization, may be developed by carefully planning a pasture and hay program, making use of both the cool-season and the warm-season grasses.

An understanding of the growth characteristics of the native grasslands and of

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the adapted grasses available for planting is essential to their proper management. It also furnishes the key to proper times of year for seeding and for grazing or harvesting pastures and meadows. The warm-season grasses should be planted in midspring and never in the fall. The cool-season grasses may be planted either in late summer for fall establishment or in early spring.2

ADAPTATION OF HAY AND PASTURE PLANTS

For many years it has been common knowledge that corn varieties or hybrids are limited to certain areas of adaptation. In recent years varietal adaptation of grasses and legumes to specific areas has been recognized. Varieties which do well in one region may not mature seed in another, or they may be more subject to disease or winter-killing. At the Nebraska station, and at stations of other states in the southern part of the Northern Great Plains region, strains of smooth brome adapted to Canada and the north do not produce a dense sod. In some experiments yields of seed and forage of Northern strains are only about half those obtained from Southern varieties such as Lincoln, Achenbach, and Fischer.3-4 Due to this finding, brome-grass is now grown on most farms bordering the 98th meridian. The same principle of adaptation holds for many of the native grasses.

It is not good practice to bring the long-season native grasses, such as blue-stem and switchgrass or the grama grasses from Texas, Oklahoma, and southern Kansas into Nebraska, or further north. In the northern area they may not mature seed before frost, or they may lack in winter-hardiness. Nor is it good practice to use the lower yielding northern strains of these grasses farther south.5 If these facts are not observed, disappointment in yield, stand, winter-hardiness, and other important factors, are sure to result.

Collection and Processing of Native Grass Seed

By far the greatest acreage of hay and pasture in the Northern Great Plains and Intermountain regions is made up of the native grasses. Due to the efforts of the Nursery Section of the Soil Conservation Service, the experiment stations, the seedsmen and other agencies, seed of many of these native grasses now can be purchased on the market. Much progress has been made in processing seed of the native grasses by removing the light chaff, awns, and other appendages, so that most of them can be planted with a drill.

Seed processing is accomplished by running the field-harvested seed through a hammermill and especially adapted cleaning machinery.6 As a result of this development, the best adapted native grasses can now be seeded on abandoned land, or used in rotation without waiting for the area to slowly go back to grass. Progress has been made in revegetating land. In the Great Plains area, during the years 1944 to 1948 inclusive, some 3,176,700 acres are reported to have been seeded back to grass, including both natural and artificial plantings.7

Obtaining Stands of Grasses and Legumes

Improved Varieties of Grasses and Legumes

Many improved strains of grasses and legumes have been released by the experiment stations and the U.S.D.A. In addition to strains of smooth brome, such as the Achenbach, Lincoln, and Fischer, selected strains of tall fescue such as Alta and Kentucky 31, Ranger and Buffalo alfalfa, Madrid sweetclover, Midland red clover, and many other grasses and legumes are now widely grown. The appraisal of new breeding stocks now growing in the state stations and the U.S.D.A. nurseries discloses that other improved varieties are now available or soon will be. A study of the new varieties listed in the various state certified seed directories gives the farmer or student an opportunity to learn what is available. Those interested in improved crop varieties should see certified seed directories published by the different state crop improvement associations.

Obtaining Stands of Grasses and Legumes

Artificial seeding in arid and eroded areas is difficult and therefore rejuvenation of forage plants that are present is of great importance. Stands of grasses...
and legumes frequently can be much improved by deferred grazing, rotational grazing, and control of weeds either by mowing or use of chemicals.8

Much progress has been made in the Northern Great Plains and Intermountain States in the procedure for obtaining stands of small seeded grasses and legumes. All of the principles of early and proper preparation of the seedbed usually should be followed (Chapter 38). A number of new methods of obtaining stands of the small seeded hay and pasture crops have been developed in recent years.

Summer fallow is commonly used as a method of seedbed preparation where blowing of the soil is not serious. Where lands are subject to wind erosion, a cover crop such as Sudangrass, or other sorghums and millets can be used to stabilize the land before the grass and legume crop is directly drilled into the stubble or residue. The cover crop catches snow during the winter and improves the moisture content of the soil for spring seeding and in addition keeps the land from blowing.9

Through the efforts of several of the state experiment stations and the research division of the Soil Conservation Service a method has been devised that has given marked success in the sub-humid and more arid areas. It is accomplished by the use of a sub-surface tillage machine which leaves all residues on the surface, a packer that thoroughly packs the soil and residue, and either a broadcast seeder that places the seed under the residue in moist soil, or a drill with special openers to go through the residue. The principle involved is that the seed is placed under the residue in moist soil rather than on the surface or in dry soil.10

TYPES OF VEGETATION IN THE NORTHERN GREAT PLAINS AND INTERMOUNTAIN STATES

The environment of the Northern Great Plains and Intermountain States is extremely variable. Range and pasture plants that make up the vegetation likewise vary from the most arid types of grasses and legumes to those that are adapted to humid and high elevation conditions. A condensed summary of the types of vegetation with suitable environments is shown in Tables 44.1 and 44.2.

GRASS AND LEGUME ADAPTATION

Perennial grasses and legumes constitute most of the useful permanent cover in the Great Plains and Intermountain regions. On the basis of acreage, the native grasses are the outstanding hay and pasture crops of these areas but adapted strains of cultivated grasses and legumes are being used extensively, especially in those areas where the conditions for growth are more favorable, such as river valleys and where irrigation is available.

Legumes

Alfalfa is one of the most widely grown legumes in both of the areas under study. It is found in all of the Northern Great Plains and Intermountain States. Great care should be taken to secure seed of a variety with proper winter-hardiness and disease resistance.

Sweetclover is ordinarily a biennial but there are a few strains of the annual varieties, such as Hubam. The biennial yellow, biennial white, and Madrid are commonly grown. This legume will

9 Savage, D. A. Methods of re-establishing buffalo grass on cultivated land in the Great Plains. U.S.D.A. Cir. 328, 1934.
<table>
<thead>
<tr>
<th>Location</th>
<th>Approximate acres</th>
<th>Tall and medium tall grasses</th>
<th>Sandhills type</th>
<th>Sagebrush saltbush</th>
<th>Open forest Blackhills etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>145,920,000</td>
<td>32,000,000</td>
<td>13,760,000</td>
<td>28,520,000</td>
<td>11,520,000</td>
</tr>
<tr>
<td>Location</td>
<td>Eastern Montana</td>
<td>Eastern North Dakota</td>
<td>North Central</td>
<td>Dry western</td>
<td>Blackhills Reg. Big-</td>
</tr>
<tr>
<td></td>
<td>Wyoming Colorado</td>
<td>South Dakota Nebraska</td>
<td>Nebraska</td>
<td>great plains</td>
<td>horn and Laramie Mts.</td>
</tr>
<tr>
<td></td>
<td>Western North Dakota</td>
<td>South Dakota Nebraska</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rainfall inches</td>
<td>11 to 17</td>
<td>17 to 30</td>
<td>15 to 22</td>
<td>7 to 12</td>
<td>12 to 18</td>
</tr>
<tr>
<td>Elevation above sea level in feet</td>
<td>2000 to 6000</td>
<td>1000 to 2000</td>
<td>1500 to 3500</td>
<td>5000 to 7500</td>
<td>5000 to 7500</td>
</tr>
<tr>
<td>Soils and topography</td>
<td>chestnut dark-brown</td>
<td>chernozem black-earth</td>
<td>sand valleys to rolling dune sand</td>
<td>brown soils often highly alkaline or saline</td>
<td>brown soils region-mostly mountain uplifts</td>
</tr>
<tr>
<td>Principal species</td>
<td>blue grama buffalograss</td>
<td>big bluestem prairie beard needlegrasses blue grama side-oats grama western wheatgrass prairie dropseed bluegrass brome grass crested wheatgrass switch grass</td>
<td>sand reedgrass blue grama blue jointgrass Junegrass needlegrasses sand dropseed sandhill muhly sand bluestem little bluestem big bluestem switchgrass</td>
<td>wheatgrasses needlegrasses wildrye spp. Indian ricegrass Sandburg bluegrass sand dropseed sagebrush saltbushes greasewood</td>
<td>wheatgrasses mountain bromegrass pinegrass blue grama</td>
</tr>
<tr>
<td>Carrying capacity, acres per animal unit (1 cow or 5 sheep) for grazing season</td>
<td>5 to 15</td>
<td>1 to 3</td>
<td>3 to 20</td>
<td>3 to 25</td>
<td>3 to 20</td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Types of Intermountain Range Vegetation and Related Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approx. acres</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Rainfall inches</td>
</tr>
<tr>
<td>Elevation</td>
</tr>
<tr>
<td>Soils and topography</td>
</tr>
<tr>
<td>Principal species</td>
</tr>
<tr>
<td>Carrying capacity acres per animal unit (1 cow or 5 sheep) for grazing season</td>
</tr>
</tbody>
</table>

grow under more adverse conditions than will alfalfa.

Red clover is extensively grown in the Snake River Valley of Idaho, which is the leading seed-producing region for this legume. It is found in most of the favorable irrigated valleys of the other Intermountain States. In the Great Plains region it is found only along the eastern border, or in favorable irrigated or sub-irrigated valleys. It is commonly planted, or found growing naturally, in mixtures with the native grasses in the sub-irrigated valleys in the sandhills of Nebraska.33

Other legumes—alsike, white clover, Ladino clover, and birdsfoot trefoil—are grown in local favorable areas. Alsike grows exceptionally well and is associated with the tall native grasses in the wet meadow areas of the Nebraska sandhills. These legumes are not well enough adapted to the adverse conditions of the West to be commonly seeded except under irrigation.

**Cool-season Grasses**

Smooth brome is the most widely grown cultivated grass in the eastern part of the Northern Great Plains. This grass also is well adapted to the high altitudes with favorable moisture in the Intermountain States and is grown under irrigation. In eastern Kansas, Nebraska, and the Dakotas it corresponds in importance to timothy in the eastern

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parts of the United States. It spreads by underground stems or rhizomes and frequently becomes "sod-bound." This condition can be much improved by applying 60 pounds of nitrogen per acre. The nitrogen should be applied in the late fall or very early in the spring.

Crested wheatgrass is adapted farther west and north than smooth brome. It grows satisfactorily in the heavier soils in Montana, Wyoming, Colorado, North and South Dakota, and Nebraska and at other elevations of 2,500 to 3,000 feet. For the non-irrigated dry-land pastures of the Central Mountain States crested wheatgrass is the standard grass and is used in nearly all mixtures.

Intermediate wheatgrass is a promising grass for the more favorable conditions in the West. It corresponds in adaptation to smooth brome. It is not as drought resistant as crested wheatgrass or as western wheatgrass.

Western wheatgrass is the most drought resistant and widespread of the native cool-season grasses. It forms a dense sod due to its rhizomatous characteristics and as a result the yields are sometimes low. If cut before the bloom stage, western wheatgrass makes an excellent hay. It grows quite well on low, poorly drained land or alkaline soils.

Tall wheatgrass is more alkaline tolerant than all the other wheatgrasses and seems well adapted to low, poorly drained areas. It yields more than western wheatgrass due to its tall and luxuriant growth.

Slender wheatgrass forms a solid sod but does not spread by underground stems. It grows rather widely over both regions. It is usually found in mixtures. It is not as well adapted to drought as crested wheatgrass, nor to low, wet conditions as western wheatgrass or tall wheatgrass.

Canada wild-rye makes a good growth on sandy land. It covers the land rapidly.

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Fig. 44.3 "Blue gramagrass is one of the most widely adapted species of any of the native grasses. . . . It constitutes one of the chief range grasses throughout the Northern Great Plains. . . ." (Sec p. 507.) Blue gramagrass grown in rows for seed production at the Nebraska North Platte Station. Neb. Agr. Exp. Sta. photo.
Seeding Grasses in the Region

TABLE 45.1
STEER GAINS ON SEEDED WESTERN WHEATGRASS AND BLUE GRAMA, AMARILLO, TEXAS

<table>
<thead>
<tr>
<th>Month</th>
<th>Av. daily gains—lbs. per head</th>
<th>Av.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1943</td>
<td>1944</td>
</tr>
<tr>
<td>April</td>
<td>1.98</td>
<td>2.13</td>
</tr>
<tr>
<td>May</td>
<td>2.40</td>
<td>2.13</td>
</tr>
<tr>
<td>June</td>
<td>1.33</td>
<td>1.88</td>
</tr>
<tr>
<td>July</td>
<td>1.52</td>
<td>1.65</td>
</tr>
<tr>
<td>Aug.</td>
<td>1.75</td>
<td>1.31</td>
</tr>
<tr>
<td>Sept.</td>
<td>1.33</td>
<td>1.20</td>
</tr>
<tr>
<td>Days of grazing</td>
<td>92</td>
<td>213</td>
</tr>
<tr>
<td>Gains per head</td>
<td>141</td>
<td>310</td>
</tr>
<tr>
<td>Daily gain</td>
<td>1.53</td>
<td>1.46</td>
</tr>
</tbody>
</table>

TABLE 45.2
GERMINATION AND EMERGENCE OF PERENNIAL GRASS SEEDLINGS UNDER DIFFERENT SOIL TREATMENTS

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No. of seedlings per sq. ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Black grama</td>
</tr>
<tr>
<td>None</td>
<td>6</td>
</tr>
<tr>
<td>Raked lightly</td>
<td>19</td>
</tr>
<tr>
<td>Covered with straw</td>
<td>26</td>
</tr>
<tr>
<td>Covered with burroweed</td>
<td>46</td>
</tr>
<tr>
<td>Covered with open-mesh gauze</td>
<td>86</td>
</tr>
<tr>
<td>Raked lightly and covered with straw</td>
<td>23</td>
</tr>
<tr>
<td>Raked lightly and covered with burroweed</td>
<td>21</td>
</tr>
<tr>
<td>Raked lightly and covered with open-mesh gauze</td>
<td>84</td>
</tr>
</tbody>
</table>

Staten gives two general methods of seeding grasses. Scattering mature hay harvested from native meadow or waste land over the pasture area proved economical and feasible. After the grass is mature in the fall it is cut and distributed evenly over pasture areas at the rate of approximately 1,000 pounds of hay material per acre. The land is then disked in order to tie the hay material to the soil. Care should be exercised not to cover the seed too deeply.

The second method is to drill good quality native grass mixtures in sorghum stubble. This method can be used throughout the region. The sorghum crops, i.e., cane, Sudan, or grain sorghum, are broadcast or drilled the year prior to seeding the grass. The sorghum crop may be harvested for hay, but if handled in this way it should be harvested early enough in the season that a second growth will come on and be eight to ten inches high at the time of frost. Sorghum stubble on the land during the winter months usually reduces weed growth, protects the soil from blowing, reduces water erosion, increases water intake, decreases evaporation, prevents excessive baking of the soil, and furnishes a more natural condition for seedling growth. The native grasses are drilled into the stubble after the last killing spring frost without any other seedbed preparation.

Wenger gives several advantages of the hay method of seeding over seed drilled into a clean seedbed. These are: (a) When native grass seed is harvested there is no cash outlay for seed; (b) A natural mixture of adapted native grasses is obtained; (c) The hay applied with the seed provides both wind and water erosion protection until the seedlings become established; (d) No special seed processing or drilling equipment is necessary; (e) Better stands with fewer failures result.

Table 45.3 reports Kansas results, comparing the spreading of hay and the drilling of seed of blue grama grass. Excellent stands were obtained by the use of 650 pounds of blue grama hay per acre. A manure spreader was satisfactorily used to spread the seed hay.

### TABLE 45.3
**Comparison of Spreading Hay and Drilling Seed of Blue Grama Grass in May, 1940, Kansas**

<table>
<thead>
<tr>
<th>Preparatory cropping and tillage</th>
<th>No. of plants per sq. yd. at the end of 1940</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Drilled seed</td>
</tr>
<tr>
<td>Fallow</td>
<td>66</td>
</tr>
<tr>
<td>Barley</td>
<td>56</td>
</tr>
<tr>
<td>Corn</td>
<td>53</td>
</tr>
<tr>
<td>Kafir</td>
<td>44</td>
</tr>
<tr>
<td>Sudan, 21-inch</td>
<td>25</td>
</tr>
<tr>
<td>Sudan, drilled</td>
<td>38</td>
</tr>
<tr>
<td>Weeds</td>
<td>19</td>
</tr>
</tbody>
</table>


### SEEDING EQUIPMENT

Seed of many of the native grasses when harvested are light and chaffy and therefore not adapted to seeding with the ordinary grain drills. Special drills have been developed by several agencies and experiment stations capable of seeding light chaffy seed as well as small, free-flowing seed. The large cans are cotton hopper boxes with a stirring mechanism. These boxes are provided with an assortment of plates which allow for various seeding rates with different species. The small, garden-seed boxes can be used in seeding all free-flowing seed. The separate hoppers allow for seeding alone or in different mixtures and in rows or in close drills. In many instances, grain drills can be used for chaffy seed when the seed box is equipped with a special agitator.

### METHODS OF PLANTING

Depth of planting is of prime importance. Shallow planting, about ¼-inch deep, under ideal moisture conditions usually gives the best results. However, ideal moisture conditions seldom prevail under dryland farming conditions. Shallow seedings often germinate and then die before sufficient additional moisture for establishment becomes available. It is advisable, therefore, to plant seed at or near their maximum depths. These depths vary with the species. Seed of most grasses native to the Southern Great Plains should not be covered more than ¼ of an inch. Grass drills equipped with double-disk coulter openers, with depth bands set to prevent placing the seed more than an inch below the soil surface, have proven satisfactory. Such equipment allows the farmer to plant either in stubble, in mulch, or in litter. Drills should be equipped with heavy press wheels so the soil will be forced into direct contact with the seed. Nurse or companion crops should not be sown with grasses or legumes in the region. Such crops offer too much competition for moisture.

### ADAPTED SPECIES

There are approximately 400 species of grasses native and growing wild in this area. However, many of these native species are not of economic importance for forage production. Information on a number of the native and introduced grasses which have proved their place

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and value in the Southern Great Plains, or have shown promise of possible value in future years, is presented in Chapter 32.

A few of the more important of these, considered briefly here from the standpoint of their adaptation to this area alone, are blue grama, side-oats grama, buffalograss, big bluestem, little bluestem, Indiangrass, switchgrass, sand bluestem, blue panic, sand lovegrass, weeping lovegrass, yellow beardgrass, western wheatgrass, and crested wheatgrass.

Blue grama is generally adapted to the western half of the region under a wide variety of soil and environmental conditions. It is often desirable to seed blue grama and buffalograss in a mixture, since these grasses are commonly found growing together on the native range. Five to eight pounds of seed per acre when drilled alone, and two to four in a mixture, are the recommended rates.

This grass is seeded in the spring after danger of a killing frost is past. Seedling stands should be mowed the first season to control weeds and reduce competition. Unless competition is severe, it is not necessary in most cases to mow in the second and succeeding years.

Side-oats grama is the most widely adapted of the grama grasses. It may be seeded alone or in mixtures with such grasses as blue grama, buffalo, or little bluestem. It should not be seeded until after the last killing frost of the spring. However, in the southern part of the region it may be planted in the early fall.

Buffalograss is native throughout the region. It is drought resistant and adapted to a wide variety of soils. It is planted where the rainfall is from 15 to 35 inches annually. It may be propagated either from seed or sod. The seed may be planted either at the time of seed harvest
or during the fall or late winter. Germination of untreated seed usually is low. Wenger treated buffalograss seed with an 0.2% solution of potassium nitrate and increased germination from 47.1 for untreated seed to 77.4 for treated seed.5 Sodding should be done in late winter or early spring when moisture and temperature are favorable. Hoover reports that in establishing buffalograss, best results have been obtained when seeded or sodded in rows and then cultivated to control weeds and reduce competition until the stolons began to take root in the middle of the row.6

**Big bluestem** is native to the eastern one-third of the region, suitable both for hay and for pasture. Seed mixtures of this species with little bluestem, and a small percentage of other native species, are available through commercial channels.

Seed should be planted after the last killing frost in the spring. The rate of seeding depends to a large extent upon the quality of the seed used. Ten to twenty pounds per acre are commonly planted. There should be enough seed planted to furnish a minimum of ten plants per square yard.

**Little bluestem** is a native, warm season, perennial bunchgrass. It is native from east to west and north to south in the Southern Great Plains. It is best adapted to areas of more than 25 inches of rainfall but may be planted on sandy soils where rainfall is no more than 20 inches per year. It makes excellent hay and is a good pasture grass. Controlled grazing is necessary in order to maintain a good stand. This grass usually is seeded in the early spring in dead sorghum stubble or on a prepared seedbed, in rows or broadcast. Seed is so variable in quality that it is not advisable to recommend a given poundage per acre. Ten to twenty pounds of seed of average quality are usually planted. It should be seeded at a high enough rate to provide at least ten seedlings per square foot. It is advisable to protect the seedlings from grazing until the plants are well established. Excellent stands have been obtained by the seed hay method.

**Indiangrass**, native to the more humid parts of the region, is a tall bunchgrass used both for meadows and pastures. It may be planted alone or in mixtures with other native grasses. It is best adapted to lowlands along streams and on certain sandy soils of the region. It should be seeded in a prepared stubble seedbed in the spring after danger of frost is past. It is seeded in rows at the rate of three to five pounds per acre or broadcast at the rate of six to ten pounds per acre, depending on seed quality. There should be enough viable seed to have at least ten seedlings per square foot. This grass is very palatable and is relished by livestock. Care must be exercised not to over-graze and weaken the stand.

**Switchgrass** is a perennial, warm season grass which grows in dense clumps and is often found in pure stands. Two native types are recognized, the lowland and the upland types. The lowland type is much taller and coarser stellata than the upland type. The most satisfactory stands have been obtained when planted in rows on a well prepared seedbed or in dead stubble.

**Sand bluestem** is a tall, coarse species, well adapted to the northern and eastern half of the area. It is best adapted to deep sands. It has the ability to reclaim sandy upland areas that have a tendency to blow. On sandy soils it is important

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that seedlings be protected from wind erosion by a sorghum stubble. Best stands have been obtained from the use of unthreshed hay material which forms a mulch protecting both the soil and the seedling plants. Planting eight to twelve pounds of good quality seed per acre also has resulted in good stands.

Blue panic is adapted to the sandy loam soils of the region where the rainfall is more than 20 inches. It responds well to cultivation, fertilization, and good management. Best results have been obtained when seeded in rows and cultivated. If the seed is of good quality one-half to one pound per acre, planted in 40-inch rows, is sufficient to obtain good stands.

Sand lovegrass is a leafy, warm season perennial bunchgrass native throughout the region. It is best adapted to the light textured soils in the northern two-thirds of the area. Good stands have been obtained by drilling or broadcasting two to three pounds of seed per acre. The seed of sand lovegrass are extremely small, therefore special equipment is necessary for handling. In most instances the seed are left uncovered, and are never covered more than 1/4-inch.

Weeping lovegrass is an introduction from East Africa. It is a warm season perennial bunchgrass with basal leaves 24 to 48 inches long. There has been a great deal of controversy concerning its value as a forage plant. Crider presents data which show this grass to be equal to little bluestem in chemical composition. Good results have been obtained by planting it in sorghum stubble after the last killing frost in the spring at the rate of 1½ to 2 pounds of seed per acre.

Yellow beardgrass is a warm season perennial bunchgrass. It is an introduction adapted throughout the region wherever the rainfall is above 20 inches. Stands may be obtained either by using seed or seed hay material. If the seed is of good quality, 2 pounds per acre in 36-inch rows is enough. Use 5-6 pounds per acre if the seed is drilled or broadcast. In most of the region, spring seedings are recommended. However, in the southern part, early fall seedings have been satisfactory.

Western wheatgrass is native to the central and northern part of the region. It is a cool season grass that spreads both from seed and from rhizomes. At Amarillo, Texas, this grass furnished an average of 124 days of grazing. Average steer gains of more than two pounds per day were obtained during April, May, June, and July.

This grass is adapted for seeding pastures and meadows in the deeper, more fertile soils of the area. It is well suited for planting in stream bottoms and terrace outlets. Best results have been obtained from fall seeding, or from very early spring seeding in stubble mulch. When broadcast, ten to twelve pounds of seed per acre are recommended. Thin stands of this species thicken rapidly. Western wheatgrass has aggressive rhizomes and forms a good turf in a relatively short time.

Crested wheatgrass, an introduction, is a hardy, drought resistant perennial adapted to the northern part of the region. This species fits well into crop rotations. Good results have been obtained both from fall and from spring seedings. Broadcast seedings are made at the rate of eight to twelve pounds per acre. There are two recognized strains, Standard and Fairway. Standard appears to be better adapted to the Southern Great Plains Region.

Adapted Species 515


LEGUMES

Perennial legumes have not generally been successful on the heavier soils of the region where the annual rainfall is less than 20 inches. However, on sandy soil and in the better watered areas, sweetclovers and alfalfa are well adapted.

Alfalfa is recognized as having outstanding value in the area for hay. On soils where wind erosion is a problem the seedbed should be firm but trashy. There are several ways to obtain such a seedbed:

(a) Plant cowpeas in the spring, work the residue lightly into the soil with a stalk cutter or other suitable equipment. (b) Plant vetch and rye for seed production; after harvest follow with a late crop of cowpeas, then work the residue into the surface soil. (c) Plant a companion crop of sorghum or millet at the time of seeding the alfalfa in the fall. This will make some growth but will be killed by frost. It will protect the soil and the young plants from the wind.

When alfalfa is planted on eroded or depleted soil a complete fertilizer should be applied at the rate of 300 to 400 pounds per acre. On other soils, 300 pounds of 20 per cent superphosphate per acre should be applied at planting time. On all sandy soils an annual application of 200 pounds of 20 per cent superphosphate should be made to established alfalfa. Southwestern or Oklahoma common alfalfas have produced the largest yields of hay. Alfalfa may be planted, 12 to 15 pounds per acre, from late August to the middle of October. The main objective is to get a good root system started before cold weather.

The biennial sweetclovers are adapted for forage and for soil improvement throughout the region where there is more than 20 inches of rainfall. In addition to the commercial white and yellow flowered varieties, Madrid yellow and Evergreen are varieties found to be well adapted.

If stands are to be obtained on soils subject to wind erosion, sweetclover should be seeded on a trashy seedbed or in a stubble mulch. In areas where wind erosion is not a problem, a clean tilled seedbed is advantageous. Late February or early March seedings usually are recommended. If there is sufficient moisture, late summer or early fall plantings may be made. Seeding rates when broadcast are 10 to 15 pounds per acre, and when in 36 to 42 inch rows, 3 to 5 pounds per acre.

In areas of above 28 inches of rainfall sweetclover may be overseeded in small grain stubble after the grain has been harvested. The biennial sweetclovers will furnish grazing in the fall and again the following spring.

QUESTIONS

1. What methods may be used to establish seedlings of perennial grasses in the Southern Great Plains?
2. Why do many farmers favor the hay method of seeding over the seed drilled into a clean seedbed?
3. Why is the depth of planting so important in seeding native grass seed under dryland farming conditions?
4. Why are special grass seed drills needed for planting native grasses? Describe how the seed drills are equipped and tell why.
5. Why are legumes seldom used in combination with perennial grasses in the Southern Great Plains Area?
6. Where might alfalfa and sweetclover be seeded in the Southern Great Plains Area? What method or methods would you use to successfully establish stands of these legumes?
7. List several of the perennial native grasses used in the Southern Great Plains for hay and pasture seedings. Discuss their relative merits and how each may be best established.

Hay and Pasture Seedings for Pacific Coast States

Water is by far the most important factor affecting the choice of grass and legume species for hay and pasture in the Pacific Coast area. All but a small part of the region where farms and ranches are found is essentially arid or semiarid. The north Pacific Coast west of the Cascade Mountains and extending along the northern coast of California is humid. High plateaus in northern and southeastern Idaho and in eastern Oregon and Washington receive as much as 16 to 25 inches of rainfall and are classed as subhumid. Even in the humid and subhumid areas the climate is known as summer-dry, and supplemental irrigation is required to maintain forage production.

Soil conditions, as a second factor affecting the choice of species for forage production, are depth, drainage, structure, and—under irrigation—amount of alkali. These factors often determine whether hay or pasture is grown.

Temperature also influences the choice of grasses and legumes. This climatic factor is associated with both latitude and elevation. This makes the region one of extremes. There is a wide difference in latitude from south to north. Elevations above sea level vary rapidly in any latitudinal belt because several chains of mountains parallel the coast. Bailey illustrates the influence of topography on climate in one latitudinal belt crossing the region from San Francisco to Denver. The same quick changes occur at other latitudes. Farming is carried on at sea level and up to 6,000 feet.

Differences in latitude combined with differences in elevation bring about conditions ranging from (a) a long growing season in a hot climate at low elevation to (b) a short growing season in a cold climate at high elevation. When the growing season is short, provision must be made for adequate supplies of winter feed. When the winter is severe and the rancher does not have enough feed, his

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Hay and Pasture Seedings for Pacific Coast States

TABLE 46.1

ACREAGE AND AVERAGE YIELD PER ACRE OF DIFFERENT KINDS OF HAY IN THE PACIFIC COAST STATES

ACREAGE IN THOUSANDS OF ACRES (1945)

<table>
<thead>
<tr>
<th>Kind of hay</th>
<th>Unit</th>
<th>Calif.</th>
<th>Idaho</th>
<th>Nev.</th>
<th>Ore.</th>
<th>Utah</th>
<th>Wash.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>Acres</td>
<td>945</td>
<td>799</td>
<td>107</td>
<td>258</td>
<td>442</td>
<td>319</td>
<td>2,870</td>
</tr>
<tr>
<td></td>
<td>Tons/acre</td>
<td>4.54</td>
<td>2.40</td>
<td>2.54</td>
<td>2.55</td>
<td>2.51</td>
<td>1.90</td>
<td>3.06</td>
</tr>
<tr>
<td>Clover</td>
<td>Acres</td>
<td>39</td>
<td>122</td>
<td>31</td>
<td>129</td>
<td>34</td>
<td>194</td>
<td>549</td>
</tr>
<tr>
<td></td>
<td>Tons/acre</td>
<td>1.79</td>
<td>1.37</td>
<td>1.19</td>
<td>1.84</td>
<td>1.56</td>
<td>2.00</td>
<td>1.73</td>
</tr>
<tr>
<td>Small Grain</td>
<td>Acres</td>
<td>287</td>
<td>49</td>
<td>3</td>
<td>219</td>
<td>13</td>
<td>215</td>
<td>786</td>
</tr>
<tr>
<td></td>
<td>Tons/acre</td>
<td>1.45</td>
<td>1.37</td>
<td>1.33</td>
<td>1.45</td>
<td>1.08</td>
<td>1.36</td>
<td>1.41</td>
</tr>
<tr>
<td>Other Tame</td>
<td>Acres</td>
<td>245</td>
<td>46</td>
<td>25</td>
<td>132</td>
<td>19</td>
<td>157</td>
<td>624</td>
</tr>
<tr>
<td></td>
<td>Tons/acre</td>
<td>1.48</td>
<td>1.26</td>
<td>1.32</td>
<td>1.60</td>
<td>1.37</td>
<td>1.71</td>
<td>1.54</td>
</tr>
<tr>
<td>Wild</td>
<td>Acres</td>
<td>196</td>
<td>135</td>
<td>266</td>
<td>277</td>
<td>105</td>
<td>45</td>
<td>1,022</td>
</tr>
<tr>
<td></td>
<td>Tons/acre</td>
<td>1.10</td>
<td>1.11</td>
<td>0.99</td>
<td>1.15</td>
<td>1.23</td>
<td>1.13</td>
<td>1.10</td>
</tr>
</tbody>
</table>

The livestock enterprise may suffer. The "hay-lift" operation during the winter of 1948–49 provides a dramatic example. In the south, where the hot rainless season may extend from May through October or longer, grain or protein supplements are required when livestock are grazed on unirrigated pastures, or on the range.

The above conditions make it necessary to use a large number of species for hay and pasture. A few species have rather wide adaptation. Under specific combinations of climatic and soil conditions the use of many different species are required to obtain maximum production.

HAY

Many different kinds of hay are produced where conditions are so diverse in an area as large as the Pacific Coast States. Table 46.1 shows the kinds and amounts grown in 1945 as reported in the U. S. census. Almost 18 million tons of hay of all kinds were harvested from a little less than 6 million acres. During the past 20 years some changes have occurred in the kinds of hay grown and these will be described.

Alfalfa is the principal hay crop on farm lands throughout the region. A total of 2,870,000 acres was reported in 1945. This represents 60 per cent of the acreage in tame hay. An increase of 25 per cent in acreage occurred from 1920 to 1940. High yields per acre, high quality of hay, and the influence of the legume on the yield of other crops in the rotation are responsible for its dominant place among hay crops. The average yield per acre in 1945 was 3.06 tons. The yield in California averaged about 4.50 tons while production in the other states has been about 2.50 tons. The chief reason for this difference is the longer growing season in California, where 5, 6, and as many as 9 cuttings can be obtained.

The 1945 census reports 551,000 acres of clover or clover and timothy hay. Most of this was in Idaho, Oregon, and Washington. This is a decrease of nearly 19 per cent from 1925. Clover and timothy were more popular when there was a demand for horse feed on farms and in the lumbering industry. Clover and clover-grass mixtures are still used where

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the soils are too shallow for alfalfa. Clover hay also is harvested from fields used to produce seed; the first crop usually is cut for hay and the second for seed. The average yield of clover is about 1.75 tons per acre.

There were 786,000 acres of small grain cut for hay in 1945, a reduction of 65 per cent from 1920. The reduction in grain hay also coincides with the replacement of horses by tractors on farms, and the use of cultivated grasses in rotation with grain, a practice that began about 1935. Grain hay is harvested primarily from semiarid lands in California, Oregon, and Washington. The average yield has been slightly less than 1.50 tons per acre.

Other tame hays are grown in localized areas where special conditions prevail. Oat and vetch mixtures are grown west of the Cascade Mountains in Oregon and Washington, where they can be cut and cured after the rainy season. These mixtures also are grown along the coast of California, where no water is available for irrigation. Other special conditions associated with soil, drainage, and kind of farm enterprise, especially along the Pacific Coast, result in the use of many different mixtures of grasses with clover, trefoil, or other legumes. These usually result from the invasion of tame grasses into meadows originally planted to legumes. The average yield is about 1.50 tons, but this figure has little real value when comparing kinds of hay.4,5

Wild hay is harvested from meadows in the arid interior and in the mountain valleys. This kind of hay is an important asset to the range livestock industry. It usually is grown on land that is not easily tilled, has a high water table, may be flooded during the winter, or is high in alkali. It consists of various native grasses or a mixture of grasses with sedges, rushes, and forbs. The average yield is about 1.10 tons per acre. The quality is relatively low. A total of 1,022,000 acres in wild hay was reported

in 1945. The area harvested annually may be somewhat larger than this.

**Alfalfa Hay.** Alfalfa is the important hay crop in the Pacific Coast area. It is harvested from more acres than all other hay crops, and contributes more than twice as much tonnage per year as all other hays. There are two principal reasons for the dominance of alfalfa. It is broadly adapted to wide differences in temperature and to the neutral or alkaline soils that predominate in most of the region.

The principal limitations to the use of alfalfa are moisture, shallow soil, poor drainage, excessive salinity, alfalfa wilt, and winterkilling. Most of the alfalfa is grown under irrigation but its use in subhumid areas is increasing. Irrigation provides the moisture the crop needs to produce 3 or more cuttings. On non-irrigated land 12 to 16 inches of rainfall are required, depending on elevation, and one cutting usually is all that can be taken. The use in the northern states of wilt-resistant and cold-hardy varieties, such as Ranger, Buffalo, and Ladak, has overcome wilt and winterkilling. There are as yet no wilt-resistant varieties for California and for southern Nevada and Utah where common alfalfa is grown. When the soil is shallow, poorly drained, or excessive in alkali, other legumes are used in place of alfalfa.

Alfalfa responds favorably to phosphates and sulphur on most soils in the region. In the northern states, boron often is required for maximum production. Lime is beneficial to establishment and production only in some parts of western Oregon and Washington, where the soils tend to be acid in reaction.6,7

**Alfalfa-Grass Mixtures.** Alfalfa-grass mixtures came into use on non-irrigated land soon after 1930. The practice of using them has spread to irrigated land in some places. Such mixtures have several advantages. Grass in the mixture gives greater protection against soil erosion, keeps out weeds and weedy grasses such as downy brome and adds a large quantity of fibrous roots to the soil. The grass roots greatly improve the structure of the soil. Measurements to compare five-year-old stands of alfalfa and alfalfa-crested wheatgrass showed that the mixture produced 4,270 pounds of roots per acre in the surface 8 inches, while alfalfa alone produced only 2,950 pounds.8 A mixture containing alfalfa and big bluegrass produced 7,275 pounds of roots. The use of mixtures in rotations with grain and row crops has increased because of the influence of the grass on the soil structure. Mixtures are preferred on cattle and sheep ranches where the aftermath of the hay meadow often is grazed.

Alfalfa-grass mixtures that contain 20 to 30 per cent of grass by weight yield as much hay per acre as alfalfa. In trials with sheep there has been no significant difference in feeding value between the two hays. The desired proportion of grass in the hay is easier to maintain when the grass and alfalfa are seeded in alternate drill rows and phosphates, or sulphur, or both, are used.

**Key to Mixtures.** A large number of legume-grass mixtures are planted for hay in the Pacific Coast area, because there are so many combinations of moisture, drainage, elevation, and farming enterprises. An effort has been made by state and federal workers to

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standardize these mixtures for well-defined but broad combinations of the factors affecting production. They also have standardized the rates of seeding for each species and listed the preferred varieties.

There is presented herewith a key to the principal mixtures for the major combinations of climate, soil, and other factors affecting the growing of hay. Eleven grasses and five legumes are included. These mixtures have been abstracted from many different sources. Preferred varieties are shown for many of the legumes and grasses. Rates shown are pounds per acre (Table 46.2). Although many hay mixtures are required to meet the several conditions, the species used fit into some general patterns. Alfalfa is the legume used on irrigated and subhumid lands except where shallow soil, poor drainage, or moderate alkali is encountered. Alsike clover, red clover, or birdsfoot trefoil replace it under these conditions. Orchardgrass is not used in many mixtures for hay because it is too mature when the legumes are ready for cutting. Smooth brome is a part of many hay mixtures in the interior or intermountain zone, but it requires good, well-drained soils. Intermediate wheatgrass is gaining in favor over smooth brome. Alta fescue and meadow foxtail replace these grasses on tidalflats, poorly drained soils, and alkaline soils. The wheatgrasses, crested and beardless, and big bluegrass, are adapted to semiarid and arid lands. Legumes are omitted, or greatly reduced in rate of seeding, for the arid and semiarid areas. Ryegrass, alone or with tall fescue, and sometimes orchardgrass, is used with alsike clover, red clover, or one of the trefoils west of the Cascade Mountains. In this area, and in California, oats and vetch are used extensively. The differences in the proportionate seeding rate of these two plants in the north and in the south is a reflection of a major difference in climate.

PASTURE

AREA IN PASTURE. A large part of the land in the Pacific Coast States is grazed.

A little more than 70 per cent of the 100 million acres in farms was used for this purpose in 1940, as is shown in Table 46.3. Much of this was land that could not be used for crops and included 9 million acres of woodland pasture and 56 million acres of range land. In addition to these unimproved pastures on farms, millions of acres of publicly-owned range and forest lands are used for grazing. More than one-fourth of the cropland, or 8 million acres, is devoted to seeded pastures. Pastures, therefore, are important to western agriculture and are of many kinds. Some of the best improved pastures under irrigation produce as much as 24 animal-unit-months of grazing per acre. Production of forage on some arid desert ranges may be so low that 6 to 8 acres are required to provide one animal-unit-month of grazing.

Kinds of Improved Pasture

Improved pastures may be classified in many ways. They may be divided according to the length of time a seeding remains on the land (longevity), the kind of stock for which the pasture is grown, or the conditions that affect growth and production.

LONGEVITY. Pastures on farms in the Pacific Coast States are either permanent, rotation, or supplemental pastures. Rotation pastures, or those used in
TABLE 46.2

**Hay Seeding Recommendations for Different Soil and Climatic Conditions of the Pacific Coast States**

<table>
<thead>
<tr>
<th>Interior or intermountain zone</th>
<th>Coastal zone</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Irrigated land</strong></td>
<td><strong>Non-irrigated land</strong></td>
</tr>
<tr>
<td>1. Ample water during growing season</td>
<td>1. Arid, less than 10 inches rain</td>
</tr>
<tr>
<td>(a) Deep, well-drained soils, none or slight alkali</td>
<td>Crested wheatgrass</td>
</tr>
<tr>
<td>Alfalfa (Ranger, Buffalo)</td>
<td>or beardless wheatgrass (Whitmar)</td>
</tr>
<tr>
<td>Smooth brome (Manchar)</td>
<td>or big bluegrass (Sherman)</td>
</tr>
<tr>
<td>or intermediate wheatgrass</td>
<td>Bulbous bluegrass</td>
</tr>
<tr>
<td>(b) Shallow, poorly drained soils, slight to moderate alkali</td>
<td>Smooth brome (Manchar)</td>
</tr>
<tr>
<td>Tall fescue (Alta)</td>
<td>or red clover</td>
</tr>
<tr>
<td>Alsike clover</td>
<td>Crested wheatgrass</td>
</tr>
<tr>
<td>or red clover</td>
<td>or beardless wheatgrass (Whitmar)</td>
</tr>
<tr>
<td>or intermediate wheatgrass</td>
<td>or big bluegrass (Sherman)</td>
</tr>
<tr>
<td>Alfalfa (Ladak)</td>
<td>2-5</td>
</tr>
<tr>
<td>2. Shortage of irrigation water</td>
<td>2. Semi-arid, 10 to 16 inches rain</td>
</tr>
<tr>
<td>(a) Deep, well-drained soils, none or slight alkali</td>
<td>Smooth brome (Manchar)</td>
</tr>
<tr>
<td>Alfalfa (Ladak, Ranger)</td>
<td>Crested wheatgrass</td>
</tr>
<tr>
<td>or intermediate wheatgrass</td>
<td>(8)</td>
</tr>
<tr>
<td>or big bluegrass (Sherman)</td>
<td>Alfalfa (Ladak)</td>
</tr>
<tr>
<td>or red clover</td>
<td>4</td>
</tr>
<tr>
<td>(b) Shallow soils, flooded part of year, slight to moderate alkali</td>
<td>Birdsfoot trefoil (Broadleaf)</td>
</tr>
<tr>
<td>Tall fescue (Alta)</td>
<td>Meadow foxtail</td>
</tr>
<tr>
<td>or alsike clover</td>
<td></td>
</tr>
<tr>
<td>or tall fescue (Alta)</td>
<td></td>
</tr>
<tr>
<td>1. Annual Hay</td>
<td>2. Perennial Seedings</td>
</tr>
<tr>
<td>(a) Northern part of area</td>
<td>(a) Well-drained soils</td>
</tr>
<tr>
<td>Oats (Gray winter)</td>
<td>Ryegrass (Common or perennial)</td>
</tr>
<tr>
<td>Vetch (Common or Willamette)</td>
<td>Orchardgrass</td>
</tr>
<tr>
<td>(b) Southern part of area</td>
<td>Red clover</td>
</tr>
<tr>
<td>Oats (California red or Ventura)</td>
<td>or alsike clover</td>
</tr>
<tr>
<td>Vetch (Purple or common)</td>
<td>Tall fescue (Alta)</td>
</tr>
<tr>
<td></td>
<td>or orchardgrass</td>
</tr>
<tr>
<td></td>
<td>Birdsfoot trefoil (Broadleaf)</td>
</tr>
<tr>
<td>(b) Poorly drained soils or tideflats</td>
<td>Tall fescue (Alta)</td>
</tr>
<tr>
<td>Meadow foxtail</td>
<td>Birdsfoot trefoil (Broadleaf)</td>
</tr>
<tr>
<td></td>
<td>or big trefoil</td>
</tr>
<tr>
<td></td>
<td>or alsike clover</td>
</tr>
</tbody>
</table>
Pasture

Fig. 4.5.2 "A large part of the land in the Pacific Coast states is grazed . . . 70 per cent . . . of the acres in farms . . . More than one-fourth of the crop land . . . devoted to seeded pasture . . . Some . . . under irrigation produce as much as 24 animal-unit-months of grazing per acre." (See p. 521.) An over-utilized, under-improved, irrigated pasture such as this provides scanty grazing, indeed, when viewed from the standpoint of the returns possible with good management. S.C.S. photo.

Pastures that remain on the land for relatively long periods of time, and often referred to as permanent, usually are on the poorer sites. The soil may be shallow or of low fertility, drainage inadequate, slopes steep, or the land may be tough or stony. Low-producing plants tend to invade these pastures. All of these factors combine to make the grazing capacity relatively low, as compared with the rotation pasture.

Some temporary pastures are used. Sudangrass often is planted to provide summer feed where irrigation is not practiced. Some small grains are grazed. Legume-grass mixtures grown primarily for soil improvement are sometimes pastured. Meadows, seed fields, and grain
Hay and Pasture Seedings for Pacific Coast States

### TABLE 46.3

<table>
<thead>
<tr>
<th>Item</th>
<th>Calif.</th>
<th>Idaho</th>
<th>Nev.</th>
<th>Ore.</th>
<th>Utah</th>
<th>Wash.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cropland used for pasture</td>
<td>(4,243)</td>
<td>(779)</td>
<td>(374)</td>
<td>(1,214)</td>
<td>(395)</td>
<td>(951)</td>
<td>(7,956)</td>
</tr>
<tr>
<td></td>
<td>2,196</td>
<td>322</td>
<td>36</td>
<td>566</td>
<td>127</td>
<td>439</td>
<td>3,686</td>
</tr>
<tr>
<td>Woodland pasture</td>
<td>3,341</td>
<td>946</td>
<td>76</td>
<td>2,772</td>
<td>173</td>
<td>1,862</td>
<td>9,170</td>
</tr>
<tr>
<td>Other land pastured</td>
<td>18,211</td>
<td>6,229</td>
<td>5,420</td>
<td>11,086</td>
<td>8,263</td>
<td>6,803</td>
<td>56,012</td>
</tr>
<tr>
<td>Total pasture</td>
<td>25,795</td>
<td>7,954</td>
<td>5,870</td>
<td>15,072</td>
<td>8,831</td>
<td>9,616</td>
<td>73,138</td>
</tr>
<tr>
<td>Cropland harvested</td>
<td>7,535</td>
<td>3,442</td>
<td>3,276</td>
<td>487</td>
<td>1,248</td>
<td>4,290</td>
<td>20,278</td>
</tr>
<tr>
<td>Total acres in farms</td>
<td>35,054</td>
<td>12,503</td>
<td>6,178</td>
<td>19,754</td>
<td>10,309</td>
<td>16,720</td>
<td>100,500</td>
</tr>
</tbody>
</table>

* Figures in parentheses are from the 1940 census because the 1945 census listed cropland used for pasture only if it has been plowed within 7 years.

† All figures are in thousands of acres.

stubble provide aftermath grazing. Temporary pastures contribute only a small part of the pasture feed.

**Kinds of stock.** Sometimes pastures are classified according to the kind of stock being grazed. Pastures for cattle and sheep are in the majority. Few hogs are raised and horses are not common except in restricted areas. The total acreage for poultry pasture is small. Accordingly, farm pastures are used primarily for dairy and beef cattle and sheep.

**Site conditions.** Moisture, drainage, and amount of alkali have such a controlling influence on crop growth in the Pacific Coast Region that they are the basis on which pastures usually are classified. There are pastures for irrigated, humid, subhumid, semiarid, and arid lands. Drainage, whether good or poor, subdivides all but the two arid classes. Degree of salinity or alkalinity is an important factor in irrigated areas. Length of growing season may affect the final choice of species in some cases.

**Choice of Species**

A long list of grasses and legumes is found among the recommended pasture mixtures. This is to be expected in a region large in area and diverse in conditions affecting crop growth. The use of many different species is required to obtain maximum production under diverse combinations of climatic and soil conditions. A few species have rather wide adaptation.

When choosing species, attention is given to yield, season of growth, relative palatability, and compatibility in mixtures, as well as to adaptation, water, soil conditions, and temperature requirements. The management of pasture has an important influence on the performance of any grass or legume.

New grasses and legumes have been introduced, and superior new varieties have been developed by plant breeders. Many nurseries have been planted, and there are some intensive studies to compare species and varieties for pasture. Most of this work was begun after 1930, when increased attention was given to grassland agriculture. These studies have shown that greater returns are realized from the larger grasses such as orchard, smooth brome, tall fescue, Dallisgrass, and tall oatgrass, also from the more vigorous legumes such as Ladino clover, alfalfa, and birdsfoot and big trefoil, as
PART IV
Forage Utilization
What Is Quality Hay?

Hay is the most important winter feed in northern regions, both as to the amount fed and the nutrients which it contains. A number of these nutrients are frequently called "protective" nutrients. Grain fed with hay or other forage is the "power" feed and for the most part supplies energy. When fed with poor hay, liberal amounts of grain tend to exhaust the reserves of vitamins and certain minerals which the animals have laid up as body reserves during the previous pasture season.

IMPORTANCE OF QUALITY HAY

When low quality hay is fed during long winters, there are frequently symptoms of mineral and vitamin deficiency diseases. In young animals they exhibit themselves as rickets, night blindness, pneumonia, and scour.

Grown animals are apt to become poor breeders. Bulls at times lose their reproductive ability and cows may abort or produce young at full term that die soon after birth. Mature cattle, including fattening steers, often develop swellings about the shoulder veins, brisket, and legs when suffering from a carotene or vitamin A deficiency.

Hay in winter rations is the most important carrier of protective vitamins including carotene, or provitamin A. It is fortunate that animals can be on pasture each time after a long winter season, for the body reserves of protective minerals and vitamins have become more or less depleted. This can be avoided to a large extent by the feeding of good hay during the winter. If everyone could be made to see the picture of hay in its true light, undoubtedly a great deal more effort would be put into the production of good hay than in the past.

What Is Good Hay?

High quality hay is characterized by leafiness, bright green color, a pleasant odor or aroma, pliable texture, high nutrient value, and palatability. The latter is determined in part, no doubt, by aroma but also by a relatively high sugar content. The latter seems to differentiate Ladino clover, for instance, from alfalfa. Alfalfa leaves have relatively little sugar —less than the stems. This may explain why cattle often prefer to eat normal alfalfa hay rather than alfalfa leaves alone. No matter how favorable the nutrient...
TABLE 47.1
U.S. GRADES OF HAY

<table>
<thead>
<tr>
<th>Hay Type</th>
<th>Color (%)</th>
<th>Leafiness (%)</th>
<th>Maximum foreign material (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa hay</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U.S. No. 1</td>
<td>60</td>
<td>40</td>
<td>5</td>
</tr>
<tr>
<td>U.S. No. 2</td>
<td>35</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>U.S. No. 3</td>
<td></td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Clover and timothy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hay U.S. No. 1</td>
<td>45</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>U.S. No. 2</td>
<td>30</td>
<td>25</td>
<td>15</td>
</tr>
<tr>
<td>U.S. No. 3</td>
<td></td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Soybean hay</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U.S. No. 1</td>
<td>40</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>U.S. No. 2</td>
<td>25</td>
<td>25</td>
<td>15</td>
</tr>
<tr>
<td>U.S. No. 3</td>
<td></td>
<td>10</td>
<td>20</td>
</tr>
</tbody>
</table>


content of a hay, if livestock do not care to eat it, it is not good hay.

Characteristics that can be determined by physical means are laid down by the United States Department of Agriculture as shown in Table 47.1.

Color and leafiness are prime considerations in judging the quality of hay. Foreign material is important to the practical feeder only when it consists of low feed-value material, rather than merely hay of another kind that may be worth nearly as much as the basic hay itself.

Odor and flavor, or palatability, are definitely identified with good hay and usually, but not always, are correlated with color and leafiness. This also is true of carotene or provitamin A (Table 47.2). Carotene, the yellow butter vitamin, is one of the most important vitamins for livestock in regions of the country where long winters and relatively low-grade winter forage are apt to cause carotene deficiencies.

A carotene analysis of hay when freshly cut may not mean very much for the reason that heavy losses occur during storage (Table 47.10).

**Good Hay Saves Grain**

At the New Jersey station cows fed all they would eat—25 to 30 pounds of U.S. No. 1 very leafy green alfalfa hay and corn silage at the rate of 3 per cent of body weight, but no grain—produced 83 per cent of their potential production. The latter was gauged by feeding grain at the rate of 1 pound for every 3 pounds of milk produced, along with hay and silage. As much as 11,000 pounds of 4 per cent milk were produced on excellent quality alfalfa hay and corn silage.

At the Wyoming station it was concluded that "When cows on roughage alone are changed from a poor quality roughage to one of good quality, they will increase in milk yield as much as...

What Is Quality Hay?

TABLE 47.2  
CAROTENE IN HAY AND OTHER FEEDS*

<table>
<thead>
<tr>
<th>Feed</th>
<th>Carotene, milligrams per kilogram of dry matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa hay</td>
<td></td>
</tr>
<tr>
<td>U. S. No. 1 in color</td>
<td>43</td>
</tr>
<tr>
<td>U. S. No. 2 in color</td>
<td>15</td>
</tr>
<tr>
<td>U. S. No. 3 in color</td>
<td>4</td>
</tr>
<tr>
<td>Alfalfa leaf meal, artificially dried</td>
<td>151</td>
</tr>
<tr>
<td>Timothy hay</td>
<td></td>
</tr>
<tr>
<td>U. S. No. 1 in color</td>
<td>21</td>
</tr>
<tr>
<td>U. S. No. 2 in color</td>
<td>9</td>
</tr>
<tr>
<td>U. S. No. 3 in color</td>
<td>5</td>
</tr>
<tr>
<td>Clover hay, U. S. No. 1</td>
<td>23</td>
</tr>
<tr>
<td>Corn silage</td>
<td>14</td>
</tr>
<tr>
<td>Corn stover</td>
<td>4</td>
</tr>
<tr>
<td>Carrots (yellow, garden)</td>
<td>91</td>
</tr>
</tbody>
</table>


when 8 to 12 pounds of grain are added to the ration. The reverse is also true. When cows on good quality roughage are changed to roughage of poor quality, they will drop in milk flow as much as if 8 to 12 pounds of grain are dropped from the daily ration.”

FACTORS MAKING FOR GOOD HAY

The essential requirements for making high quality hay are:
1. The right kind of hay crop.
2. Grown on fertile soil.
3. Grown under favorable weather conditions.
4. Cut at an early stage of growth.
5. Cured rapidly with minimum losses.
6. Stored with a low moisture content.

Application of this six-point requirement will depend upon a farmer's experience, information, judgment, and upon conditions of labor, machinery, and weather.

Kinds of Hay

A number of grasses and cereals make excellent hay. However, legumes are so much richer in the various nutrients that it is almost essential for the livestock man to grow legumes with his grasses. Legumes are a means of producing homegrown protein. They also are richer in vitamins and minerals, (Table 47.3), and are considered almost indispensable for feeding dairy cattle.

Considering the composition of hay crops, if a choice were to be made by stockmen it would undoubtedly be overwhelmingly in favor of legumes as compared to grasses. However, a mixture of grasses and legumes is frequently preferred for various reasons, including that of palatability.

Fertile Soil

There is a fairly intimate response by forage crops to the fertility of the soil or the availability of various plant nutrients in the soil. Crops are affected both in yield per acre and in composition, thus making soil fertility of great importance to the livestock man. Table 47.4 presents the effect of soil treatment on yield and composition of kleeedcea hay.

The above results were obtained from the major mineral fertilizers. It may be assumed that the minor minerals, or so-called trace minerals, follow the same
Mechanization of Haymaking and Storage

Much progress has been made in mechanizing hay and forage handling. But progress has not been as fast or gone as far as the mechanization of corn and small grain handling. Wheat is being produced with as little as 1\(\frac{1}{2}\) man hours per acre, including all operations. Corn is produced under favorable conditions, with less than 4 man hours per acre. The work with these crops is light, with all hand work eliminated. Hay harvest under favorable conditions requires 3 to 5 man hours per acre per cutting. Since more than one cutting per year is the rule, the man hours per acre is frequently three times as great as for the major grain crops. Many of the methods used generally in handling the hay crop require considerable hard manual labor. Only recently have methods been developed that completely eliminate hand work. These methods as yet are in only limited use.

Forage handling is complicated by the nature of the product. Some of the pertinent characteristics of the crop that must be given consideration are as follows:

1. Hay is a crop of great bulk and weight. A 1\(\frac{1}{2}\) ton hay crop in the loose form occupies about 800 cubic feet, a 75 bushel corn crop in the ear 187 cubic feet and a 70 bushel oat crop 87 cubic feet.

2. The feeding quality factors of forage are delicate and easily lost; when dry the leaves are easily lost and they are the most nutritious part of the plant. Prolonged exposure to sun, dew, and rain results in the loss of valuable nutrients, especially carotene and vitamin A.

3. Forages, at the stage of maturity satisfactory for harvest, are high in moisture and must be dried, either naturally or artificially, to a safe storage level. The standing plants contain over 70 per cent of water. The best levels when ready for storage are 20 per cent or below. The equilibrium moisture of hay in the barn may be as low as 11 per cent. The control of moisture content is a problem of major proportion.

4. The period of time during which the forage crop is at the best stage of maturity for harvest is relatively
short. Quality is lost if harvest is not timely.
5. Hay is frequently grown on rolling land, steep slopes and other conditions unfavorable to machine operation. The fact that the forage crops help prevent soil erosion makes them well adapted to such terrain.

As proof that progress has and is being made in hay and forage mechanization, it should be recognized that handling strictly by hand methods as much as 10 man hours of heavy work is required per ton. In contrast, hay is currently being harvested, from the standing crop to the barn, with less than 2 man hours per ton.

Forages are harvested and stored in four basic forms. These are: (1) loose long hay, (2) baled or packaged hay (3) chopped hay and (4) silage. The application and performance of machines commonly used in harvesting and storing forages in these different forms will be discussed briefly and evaluated in this chapter.

EQUIPMENT FOR CUTTING AND WINDROWING

Mowers for cutting the crop are common to all methods of harvesting. Tractor mowers, power take-off driven, with 6 and 7 foot cutter bars, are currently popular. They are made in types determined by the way they attach to the tractor. They are (1) mounted, (2) semi-mounted and (3) trailer types. The first attaches directly to the tractor and is carried on the tractor frame or draw bar. The second type attaches to the draw bar and has one or more easter
wheels at the rear. Trailer types are similar to horse drawn mowers but have short hitches and controls are extended forward to the tractor seat. If they are power take-off driven their wheels are transport wheels only.

Power mowers are operating at capacities of three to four acres per hour. The mowing operation accounted for only 0.39 hours per ton in a series of tests with 6-foot tractor mowers. This is shown in Table 48.1, together with the total labor requirement for harvesting hay with the automatic baler.\(^1\)

*Rakes* for windrowing hay are commonly of two types; side delivery and dump rakes. Side delivery rakes handle the hay more gently and with less leaf loss. They produce uniform windrows that are continuous and well adapted to picking up with loaders, field balers and choppers. Raking with the side delivery rake is a high capacity operation and accounts for only 0.24 man hours per ton, as shown in Table 48.1.

Dump rakes are used extensively in some areas. They work well where hay is stacked outside and sweeps or bucks are used to gather up the hay. They are not satisfactory to use when pick-up devices, such as those on balers and choppers, are to take up the windrow.

The *sweep rake* or buck rake is an old device that as a horse drawn implement was an efficient means of moving hay from the windrow short distances to stack or storage. They are not rakes in the sense that they may be used to windrow. They have been adapted to tractor mounting. Also, a modification which attaches to an old car chassis has been popular in some areas. Figure 48.2 shows a car-mounted sweep. The sweep rake is best adapted to areas where outdoor stacking is feasible. It also is efficient on short hauls from windrow to barn where a fork is available for lifting the hay into the barn. Table 48.2 shows the performance of the tractor sweep and the auto sweep in handling loose hay. In general the performance is good but the length of haul is a limiting factor. It also is limited to long, loose hay.

### LONG LOOSE HAY

Hay to be farm fed has traditionally been in the long loose form. It offers the least opportunity for complete mechanization. The investment in equipment is low and for some time to come it will be a popular method on small farms and in those areas where outside stacking and sweep rakes are adaptable.

Long loose hay is the most tolerant of moisture. Varying with the type of storage structure and the size of the hay mass, or pile, moisture up to 25 to 28 per cent has been found safe, with good quality usually resulting.

Table 48.2 gives the results of field tests with practically all types of forage handling machines. These data do not include mowing-raking operations, which are uniform for these different methods. The capacity of the operation is given in tons per hour and the labor requirement in man hours per ton. To get the total

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<table>
<thead>
<tr>
<th>Operations</th>
<th>Man hours per ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mowing—with 6 foot mower</td>
<td>0.39</td>
</tr>
<tr>
<td>Raking—using side-delivery rake</td>
<td>0.24</td>
</tr>
<tr>
<td>Baling—with automatic baler</td>
<td>0.44</td>
</tr>
<tr>
<td>Loading—with mechanical loader</td>
<td>0.23</td>
</tr>
<tr>
<td>Hitching &amp; unhitching bale loader</td>
<td>0.10</td>
</tr>
<tr>
<td>Hauling—with truck 2 3/4 miles</td>
<td>0.45</td>
</tr>
<tr>
<td>Unloading—at barn with fork</td>
<td>0.39</td>
</tr>
<tr>
<td>Stacking in barn</td>
<td>0.28</td>
</tr>
</tbody>
</table>

**Table 48.1**

Man Hours Required to Handle Hay from Standing Crop to Barn Mow, Using Automatic Baler
Mechanization of Haymaking and Storage

Fig. 48.2 "Dump rakes are used extensively . . . work well where hay is stacked outside and sweeps or bucks are used to gather up the hay . . . . The sweep rake is . . . an efficient means of moving hay from the windrow short distances to stack or store." (See p. 551.) A sweep rake mounted on an old car chassis, modified to run backwards. Iowa State College photo.

labor requirements one must add the mowing and raking time in Table 48.1.

Seven different combinations of equipment for handling loose long hay are shown in Table 48.2. Where the hay loader, racks, and barn fork and track are used, the labor required averages about 3 man hours per ton, and up to 5 is not at all uncommon. Also, the work is arduous and disagreeable. It will be noted that the use of the sweep rake in each case reduces the labor requirement. With stackers and sweeps a low of 0.8 man hours per ton was obtained. This does not represent the whole picture, however, since feeding will add labor. Large volumes of hay in the loose form can be gathered up with sweep rakes and put in stacks or ricks as rapidly and with as few hours of man labor as any method yet devised.

BALED HAY

Baled hay is packaged hay. A man’s load in handling bales is regulated by the size of the bale, and because of the convenience of measured units, the workman is more efficient in handling baled hay than loose hay. The bale size and weight of farm fed hay need not follow commercial bale requirements. Loose bales are more tolerant of moisture. Also, the smaller bales in the 50 to 60 pound range are easier handled. Automatic balers make small bales efficiently since the number of bales to be tied is not a limiting factor. Custom rates based on a per bale price encourage the making of large bales. Commercial hay is preferred in 70 to 80 pound bales.

Baled hay shows medium tolerance to moisture and percentages up to 25 per cent can be tolerated.

It has not been possible to completely mechanize baled hay handling. Use of the bale loader eliminates much heavy work in loading but bales must be stacked on the truck or trailer by hand. Unloading with elevators requires hand lifting. Stacking bales in storage requires hand lifting. Table 48.1 gives the results of a time study of making hay with an automatic baler. Table 48.2 compares the baler method with the other methods.

Field Balers

Field balers with pickup attachments for taking hay up from the windrow are rapidly displacing the stationary type.
<table>
<thead>
<tr>
<th>Form of hay Kind of storage</th>
<th>Equipment used</th>
<th>Number men in crew</th>
<th>Labor Tons handled per hr.</th>
<th>Man hours per ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loose dry hay stored in field stack</td>
<td>Bunch, load, unload by hand, rack</td>
<td>3</td>
<td>0.44</td>
<td>7.0 *</td>
</tr>
<tr>
<td></td>
<td>Hay loader, racks, hay fork and carrier</td>
<td>8</td>
<td>3.28</td>
<td>2.44 †</td>
</tr>
<tr>
<td></td>
<td>Tractor sweep rake, slings and carrier</td>
<td>3.4</td>
<td>1.1</td>
<td>3.1 ‡</td>
</tr>
<tr>
<td></td>
<td>Auto sweep rake, hay fork and carrier</td>
<td>4</td>
<td>2.72</td>
<td>1.47 †</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.6</td>
<td>1.3</td>
<td>2.00 ‡</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.1</td>
<td>3.31</td>
<td>1.71 †</td>
</tr>
<tr>
<td>Loose dry hay stored in field stack</td>
<td>Hay loader, wagon racks, pole stacker, hay fork</td>
<td>5</td>
<td>2.7</td>
<td>1.85 †</td>
</tr>
<tr>
<td></td>
<td>Hay loader, wagon racks, pole stacker</td>
<td>3</td>
<td>1.2</td>
<td>2.50 †</td>
</tr>
<tr>
<td></td>
<td>Tractor sweep rake and stacker</td>
<td>2.2</td>
<td>2.8</td>
<td>0.8 †</td>
</tr>
<tr>
<td>Baling in field stored in barn</td>
<td>Pickup baler, bale loader, trailer</td>
<td>6</td>
<td>3.2</td>
<td>1.89 §</td>
</tr>
<tr>
<td>Chopped hay stored in barn</td>
<td>Sweep rake, stationary chopper</td>
<td>4</td>
<td>2.4</td>
<td>1.66 †</td>
</tr>
<tr>
<td></td>
<td>Field forage harvester, blower at barn</td>
<td>4</td>
<td>2.9</td>
<td>1.56 †</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.6</td>
<td>1.2</td>
<td>1.2 ‡</td>
</tr>
<tr>
<td>Chopped hay stored in stack</td>
<td>Sweep rakes and stationary chopper</td>
<td>4</td>
<td>4.2</td>
<td>0.95 †</td>
</tr>
<tr>
<td>Grass silage stored in silo</td>
<td>Hay loader, rack, stationary chopper</td>
<td>8</td>
<td>5.72</td>
<td>1.4 †</td>
</tr>
<tr>
<td></td>
<td>Forage harvester, trailer, blowers</td>
<td>5</td>
<td>6.58</td>
<td>0.76 †</td>
</tr>
</tbody>
</table>

Sources of Data:
† Farm Science Reporter, (Iowa) April, 1943.
Field pickup balers may be used for stationary or stack baling and the automatic tie machines are highly efficient in stationary operation. Field balers are made in both hand tie and automatic tie machines.

HAND TIE BALERS. Hand tie balers require a crew of three, consisting of two on the baler to do the tying and a driver on the tractor. The capacity of hand tie machines is limited by the speed at which men can tie the bales. About 20 seconds per bale, or 3 bales per minute, is the limit. Hand tie machines are capable of making well shaped, sturdy bales. But the operators are required to work in disagreeable conditions. The simplicity of the machines results in few mechanical failures. The restricted capacity and speed of the hand tie baler makes it well adapted to towing a trailer and direct loading of bales.

AUTOMATIC BALERS. Three main classifications of automatic balers exist. They are wire tie and twine tie machines making rectangular bales and round bale machines which secure the bale with twine. Tests have shown all types to have about the same capacity under similar conditions. Their capacity is high, ranging up to 7 bales per minute.

One entire season’s test of two balers averaged 8.08 bales per minute, with 1 1/2 per cent of the ties missed. It was about the same for both the twine and the wire machines. Twenty-pound balls of twine were found to tie an average of 227 bales of 50 pounds average weight. This is 3.15 pounds of twine per ton of hay. The length of an operating day for balers of this type is limited by factors including climatic conditions, mechanical failures and having a supply of hay sufficiently dry for storage. Service meters on test machines gave an average of 6.25 hours per day of actual operating time for an entire season’s operation.2

Bale Handling

The baling operation has been developed into a highly efficient operation.

FIG. 484 “Three main classifications of automatic balers... wire tie and twine tie machines, making rectangular bales, and round bale machines... all types to have about the same capacity under similar conditions... capacity is high, ranging up to seven bales per minute.” (See p. 554.) (Upper) Wire tie; (middle) twine tie; (lower) round bale. Iowa State College photos.
Mechanization of Haymaking and Storage

Fig. 48.5 The number of acres of hay to be baled to make ownership desirable would appear to be 80 or more.

Only 0.23 man hours per ton is required with the automatic machines. Baling is only packaging the hay; however, the hay may still be on the ground, so that baling does not constitute a complete harvest operation.

Bale loaders. Loading bales by hand has little to recommend it, other than the low cost of equipment. It is heavy work. A three man crew was found to have a capacity of 7 tons per hour, or 2 1/3 tons per man hour.

The use of bale loaders reduces the labor in handling bales. Its main advantage is in eliminating the heavy work of lifting. Also, the performance of a baler is improved if the bales are allowed to drop on the ground, with no trailer being towed. Loading with a mechanical loader required 0.44 man hours per ton, with a two-man crew. (See Table 48.1.)

In addition there were 0.10 man hours per ton hitching and unhitching from the loader, thus accounting for 0.54 man hours per ton in the loading operation. The two-man crew loaded at the rate of 3 1/2 tons per hour, or 1 1/4 tons per hour per man.

The bale loader works well with either trucks or tractor drawn trailers. Large trailers of 5 tons capacity or more pulled with a tractor were highly efficient when loaded with the bale loader and the length of haul about one mile.

Another method of loading bales is the direct bale chute. With one man on the trailer, towed behind an automatic baler, bales were loaded at the rate of 3 3/4 tons per man hour. This is the most efficient method of loading bales but it is heavy work and with automatic machines it usually is a two-man job.

Towing a trailer reduces the capacity of a baler. The average reduction was 15 per cent, which meant about 1 ton less per hour. Under extreme conditions on rough land the reduction was as high as 50 per cent.2

Unloading bales. Throwing bales into the barn by hand is the most difficult, but a three man crew working hard can unload an average of 2.8 tons per hour.

The loose tine grapple fork handles bales into the barn satisfactorily if the barn is equipped with a track. Eight to 16 bales can be handled at a time. Dropping the bales breaks open a small percentage. Not over 3 1/2 per cent breakage resulted, in tests. When the barn is empty the impact of falling bales has broken floor joists. The unloading capacity by this method was 3.19 tons per man hour.

The bale elevator is faster and the bales are handled in better shape. The capacity was 3.50 tons per man hour.

The pneumatic bale gun is a method that has been used experimentally. The bales are shot with compressed air into the barn. Two per cent of the bales were broken in the process. If the gun is adjusted so the bales never go higher than is necessary the breakage can be reduced.3


CHOPPED HAY

By chopping hay with field choppers, hay making can be completely mechanized. Mechanical unloading of field chopped hay makes it possible to put hay into storage without being lifted by hand. By using the best methods, chopped hay can be stored with an expenditure of from 1.0 to 1.5 man hours per ton. Also, the labor is lighter than with other methods. Dustiness is a problem and tends to make some parts of the operation disagreeable.

The chief purpose of chopping is to reduce the plant to a size that can be moved in an air stream. Finer chopping than necessary is a questionable practice. Fine chopping increases density and aggravates the effects of high moisture. Chopped hay can be expected to be less tolerant of moisture than other forms of hay. The finer particles with increased density favor the reactions which cause heating. Twenty to twenty-two per cent moisture has been found safe under most conditions of storing chopped hay. Twenty-five per cent has been found to be a maximum safe moisture content for hay cut in 2 inch lengths.4 Longer lengths of cut and coarser chopping results in less heating and better keeping, but increases the storage space required.

Field Choppers

Field choppers or forage harvesters can be classified under two general types, according to the type of cutting mechanism used. Radial knife or flywheel type machines have 4 or 6 knives attached radially on a wheel which combines cutting and blowing parts. The fan blades or paddles are attached to the outer edge of the wheel of the blower. The other common type of chopper utilized a lawn mower type of cutting head. It may have a separate blower for elevating the chopped material into the wagon or, as in one case, the knife blades may also be the blades of the fan. It is somewhat easier to remove and replace knives on the radial type. However, the lawn

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Mechanization of Haymaking and Storage

Fig. 48.7 The cost of harvesting forage by field chopping can be reduced by spreading the cost over additional crops. The above cost curve includes the entire cost of harvesting and storing, including labor. Iowa State College data.

The mower head is adapted to sharpening with built-in sharpeners that eliminate the need for removing knives for sharpening.

The choppers may be powered with power take-off from the tractor or by mounted engines. Mounted engines are desirable when the tractor available is not large enough to power and tow the machine and pull a trailer as well. When relatively large tractors are available it is practical to power the chopper with a power take-off.

Field choppers are made with attachments for (a) cutting and chopping standing forage crops, (b) pickup attachments for taking up and chopping windrows and (c) row-crop attachments for corn and sorghum silage harvest. Usually at least two of the attachments will be needed if the chopper is to be used efficiently.

Cost of Chopping

It is a fundamental principle that the cost of using any machine is dependent upon the amount of use. Figure 48.7 shows the effect of total tons harvested on the cost per ton of using chopping equipment. All power, labor and machinery costs are included, in arriving at the relationship shown. Labor is figured at a dollar per man hour. The equipment costs and capacities of field choppers and balers are similar and therefore Figure 48.7 may be used as an indicator of the amount of forage that must be handled annually to make either chopping or baling practical. Something over one hundred tons must be handled per season to make these methods economical. While one hundred tons may represent the product of only 30 or 40 acres it still may represent more than is produced on the average farm. Joint ownership of part of the equipment by two or more farms, or custom operation, may be the best procedure to increase the volume per machine.

Forage Blowers and Elevators

Elevation of chopped material into storage usually is done with a blower designed especially for this purpose. Well designed blowers will elevate 1,000 pounds of green chopped forage per minute. Dry material is handled with lesser capacities. Blowers represent a high capacity device. They are low in mechanical efficiency, however, as compared to elevators of the drag or flight type. Efficiencies vary with speed of blowers and height of lift but 10 per cent is good blower efficiency.

Their capacity, simplicity, and dependability make them attractive. Forage blowers usually have hoppers that lift up or swing horizontally to the side to permit driving the trailer or wagon into the unloading position. Hoppers should be low and broad, to permit unloading trailers from the rear end with a minimum amount of spilling. To operate the blower to full capacity,

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5 Targer, E. L. Making silage can be easy. Hoard's Dairyman. 95:15, Aug., 1950.
mechanical unloading is a necessity. Three or more men are required to feed a good blower to capacity by hand. (Figure 48.8.)

ELEVATORS. Portable ear corn elevators may be used to elevate chopped forages when the heights are not too great. Forage storage in low barns, temporary silos, or low cribs or ricks may be handled with elevators. Elevators for greater heights, especially designed for forage handling, have been used to a limited extent only. Mechanical efficiencies of experimental chopped forage elevators have run as high as 30 per cent. 9

Mechanical Unloading

Mechanical unloading is the latest development in the mechanization of forage handling. Chopped forage is adapted to mechanical unloading. Devices which move the forage to the rear of the wagon or truck box are most commonly used. Side unloading devices have some advantages but mechanical problems with side unloading devices and blowers have not been as well developed as rear unloading devices.

These devices can be separated generally into dumping systems and controlled rate of unloading systems. Dump boxes and beds for trailers and trucks are used. Forages do not have a fixed flow angle or angle of repose. It is necessary to lift dump beds to an angle where sliding is imminent and then feeding by hand is easily accomplished. The chief disadvantage with dumping is that the rate of unloading is not easily related to the capacity of the blower.
Controlled rate of unloading devices, or the rear unloading type, use several different methods of moving the forage to the rear of the wagon box. One type uses a canvas floor covering which is rolled over a heavy roller at the rear. Another uses cables and a fake front endgate. As the cables are wound over a roller at the rear, the hay or silage is slid to the rear. Chains and cross flights also are used. This is the common type of bottom used in manure spreaders to move manure to the rear of the spreader. Another type uses a steel webbing which is carried around a roller at the front and over sprocket wheels at the rear. When power is applied to the rear shaft carrying the sprocket wheels the webbing moves toward the rear, carrying the load. All of the systems mentioned have given good performance. The false endgate tends to pack the load and some delay exists before the load starts to move but its cheapness and simplicity are offsetting features.

Power for operating the unloading devices may be from electric motors or from small engines attached directly to gear boxes. Low speed and high torque drives are required. The power requirement seldom exceeds 3/4 horse power for any of the devices. Usually 1/2 horse power is sufficient. This requirement is too great for hand powering the device unless the loads are small and the rate of unloading limited. Using suitable take-off devices, power for unloading may be taken directly from the blower. Tractor power take-off devices through shafting to the rear of trailers are used in a few cases. Hydraulic operated false endgates are available in one make. Hydraulic pressure may be taken from the tractor, or a separate pump may be attached to the blower.

A blower that will handle up to 1,000 pounds per minute is not easily fed by hand. Three men are required. With a mechanical unloading device one man can feed a blower at any desired rate and the work is light.

**HAY CRUSHERS**

For about twenty years devices have been used where freshly cut hay is passed between rollers under pressure. The objective is to crush or break the stems so they will dry at a rate nearly equal to the leaves. Tests have shown drying time to be reduced about 50 per cent. Many tests have shown an increase in hay quality due to the shorter drying period and exposure to the weather. Increased quality is not assured however, if weather conditions are unfavorable. The machines have been costly to manufacture.

**SILAGE**

Equipment for making silage varies widely. In some parts of the world grass silage is made of full length stalks packed so as to exclude air. American practice favors chopping. The purposes of chopping silage are (a) to make it possible to handle in an air stream; (b) to facilitate packing, thus excluding air; and, (c) to make feeding easier. Finer chopping than necessary should be avoided since the power requirement for the chopping is increased and the capacity of the equipment reduced. A theoretical cut of 1/2 inch is generally adequate. The theoretical cut is the advance in inches made by the feed roll and feeder apron between two successive knives. Grass silage pieces usually will average twice the theoretical setting, since the stems of grass do not feed in straight at all times.

**Stationary Cutters**

Stationary silage cutters or choppers are fast giving way to field choppers. The reason is the increased efficiency.
TABLE 48.3

<table>
<thead>
<tr>
<th>Operation</th>
<th>Equipment</th>
<th>Labor man hours per ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutting and windrowing</td>
<td>Mower (1 tractor 1 man)</td>
<td>.06</td>
</tr>
<tr>
<td></td>
<td>Side Delivery rake</td>
<td>.04</td>
</tr>
<tr>
<td>Chopping and loading</td>
<td>Field chopper (1 tractor 1 man)</td>
<td>.10</td>
</tr>
<tr>
<td>Hauling</td>
<td>3 wagons (1 tractor 1 man)</td>
<td>.10</td>
</tr>
<tr>
<td>Unloading and elevating</td>
<td>Power drive unit or attachment</td>
<td>.10</td>
</tr>
<tr>
<td></td>
<td>(1 tractor 1 man)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Forage blower (or power unit)</td>
<td>.10</td>
</tr>
<tr>
<td>Packing</td>
<td></td>
<td>.50</td>
</tr>
</tbody>
</table>

This combination is for chopping wilted silage from the windrow. Economies in equipment are possible. Direct cutting would eliminate the mower, rake and one tractor. Hauling might be done by truck, or trailers may be towed by truck. Pit or trench silos would not require the blower or tractor at the silo if other provisions are made for dumping the silage.

possible with field equipment. Loading and unloading of uncut material have not been mechanized properly and the work is extremely heavy. Field harvesters combine loading with the pickup and chopping operation and mechanical unloading of chopped silage is readily accomplished. Table 48.2 shows results of tests of equipment for making grass silage, in which field chopping had a labor requirement of about half of that required with a stationary chopper. The results were 0.76 and 1.4 for field and stationary equipment, respectively.

Field Choppers

Field cutters for silage are the same machines used for chopping hay. There are three combinations of equipment used in field chopping silage, however, while hay is chopped with one and a windrow pick-up. Grass silage may be cut direct as it stands in the field, with a cutter bar attachment available on some machines. It also may be chopped from the windrow. Direct cutting has the advantage of eliminating mowing and windrowing operations but it produces a high moisture silage. Windrow pick-up equipment must be used if wilting and moisture control is desired. The silage from direct cutting will normally contain from 70 to 80 per cent of water. Silage of 65 per cent water is desirable for good keeping qualities and low leakage, or drainage of juices. 8

The third combination used for field harvesting of grass silage also is used for corn and other row planted crops. Harvesting row crops for silage usually is at a stage of maturity where excessive moisture is not a problem.

Table 48.3 shows the machines and man power required to make grass silage at the rate of 10 tons per hour.

STORAGE

The primary objective in storage of hay and silage is to maintain the quality of the product until it is fed. This means protection from the weather, sun and moisture. Other considerations are convenience in feeding and efficiency in handling the crop into storage. This can be accomplished in any one of many ways.

**TABLE 48.4**

<table>
<thead>
<tr>
<th>Material</th>
<th>Wt.—Lbs./Cu. Ft.</th>
<th>Cu. Ft./Ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hay—Loose in shallow mows</td>
<td>4</td>
<td>512</td>
</tr>
<tr>
<td>Hay—Loose in deep mows</td>
<td>4.5</td>
<td>444</td>
</tr>
<tr>
<td>Hay—Baled loose</td>
<td>10.4</td>
<td>200</td>
</tr>
<tr>
<td>Hay—Baled tight</td>
<td>25</td>
<td>80</td>
</tr>
<tr>
<td>Hay—Chopped, long cut</td>
<td>8</td>
<td>250</td>
</tr>
<tr>
<td>Hay—Chopped, short cut</td>
<td>12</td>
<td>167</td>
</tr>
<tr>
<td>Straw—loose</td>
<td>4</td>
<td>512</td>
</tr>
<tr>
<td>Straw—baled</td>
<td>12</td>
<td>167</td>
</tr>
<tr>
<td>Silage—shallow</td>
<td>30</td>
<td>67</td>
</tr>
<tr>
<td>Silage—deep</td>
<td>50</td>
<td>40</td>
</tr>
</tbody>
</table>

It has been common practice to provide hay storage overhead, in a barn mow or loft. This was logical, since the space could be provided economically and the feed was readily available to animals quartered below. It was well adapted to long, loose hay and the use of tracks and forks. Indications are that this type of storage will become less popular. Reasons favoring change are: (a) baled and chopped hay are less satisfactorily handled in overhead storage, (b) self feeding and more efficient hand feeding from storage space is desired, (c) loafing pen sheltering of dairy cows does not require overhead hay storage to the same degree as stall and stanchion sheltering; (d) horses are fewer and feeding in barn stalls is less popular.

Most barns with hay mows were designed for loose hay. Overloading and breaking structural parts of the barn are common with both baled and chopped hay.

Table 48.4 gives the weight per cubic foot and the cubic feet per ton for forages in various forms.

The heavier, more dense forms of hay favor structures where the hay is stored on ground level floors. Bales are handled easier into ground level storage barns. Figure 48.9 shows one type of storage for chopped hay that incorporates self feeding features. Self feeding is gaining in popularity because of the high labor requirements in feeding livestock when the older types of storage are employed.

**Barn Curing of Hay**

Forced circulation of air through hay in storage provides a means of curing hay. The barn or storage structure is equipped with air ducts, false floors, or other suitable air passages so that air can be forced through the hay.

Experience with this system of making hay has shown it to be desirable to field
<table>
<thead>
<tr>
<th>Material</th>
<th>Enrolling period (A = moisture)</th>
<th>Date harvested</th>
<th>Months in silo</th>
<th>Number of samples</th>
<th>Moisture Range</th>
<th>Chl. peel</th>
<th>Other extract</th>
<th>Nitrogen-free extract</th>
<th>Ash</th>
<th>Phosphorus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn plants</td>
<td>9/17/36</td>
<td>None</td>
<td>4</td>
<td>73.7-78.7</td>
<td>1.6-2.4</td>
<td>1.0-0.7</td>
<td>5.0-6.2</td>
<td>13.2-16.3</td>
<td>1.4-1.6</td>
<td>0.05-0.05</td>
</tr>
<tr>
<td>Corn silage</td>
<td>9/22/36</td>
<td>None</td>
<td>3</td>
<td>70.7-76.1</td>
<td>1.1-1.8</td>
<td>0.5-1.0</td>
<td>5.6-6.3</td>
<td>15.0-19.3</td>
<td>1.6-1.5</td>
<td>0.06-0.06</td>
</tr>
<tr>
<td>Mixed grasses</td>
<td>6/29 to</td>
<td>100 M</td>
<td>3-5</td>
<td>59.1-77.7</td>
<td>2.4-4.3</td>
<td>0.7-1.7</td>
<td>6.3-8.3</td>
<td>11.5-16.4</td>
<td>1.7-2.5</td>
<td>0.05-0.06</td>
</tr>
<tr>
<td>Grass silage</td>
<td>7/1/36</td>
<td>100 M</td>
<td>2</td>
<td>67.0-72.0</td>
<td>3.0-3.6</td>
<td>0.7-1.0</td>
<td>8.1-9.5</td>
<td>14.6-16.7</td>
<td>2.1-2.5</td>
<td>0.05-0.07</td>
</tr>
<tr>
<td>Mixed grasses</td>
<td>7/10/37</td>
<td>100 M</td>
<td>3-6</td>
<td>58.8-77.7</td>
<td>1.8-3.5</td>
<td>0.7-1.1</td>
<td>7.6-12.6</td>
<td>10.1-22.1</td>
<td>1.4-2.2</td>
<td>0.06-0.07</td>
</tr>
<tr>
<td>Mixed grasses</td>
<td>7/2/38</td>
<td>100 M</td>
<td>8-9</td>
<td>64.5-73.0</td>
<td>2.4-3.9</td>
<td>0.7-1.0</td>
<td>7.3-9.3</td>
<td>13.7-19.0</td>
<td>1.7-2.9</td>
<td>0.06-0.09</td>
</tr>
<tr>
<td>Mixed grasses</td>
<td>6/17/38</td>
<td>16 A</td>
<td>7</td>
<td>71.2-75.0</td>
<td>2.5-3.5</td>
<td>0.7-1.0</td>
<td>8.1-9.6</td>
<td>11.1-13.5</td>
<td>1.4-2.5</td>
<td>0.15-36.24</td>
</tr>
<tr>
<td>Soybean plants</td>
<td>7/15/35</td>
<td>100 M</td>
<td>5</td>
<td>76.3-83.4</td>
<td>2.4-3.2</td>
<td>0.4-0.7</td>
<td>3.4-5.4</td>
<td>5.9-11.2</td>
<td>2.9-4.0</td>
<td>0.04-0.06</td>
</tr>
<tr>
<td>Soybean silage</td>
<td>7/15/35</td>
<td>100 M</td>
<td>8</td>
<td>65.0-73.0</td>
<td>3.0-4.3</td>
<td>0.4-0.8</td>
<td>7.8-10.6</td>
<td>8.2-14.5</td>
<td>4.8-7.6</td>
<td>0.09-10.09</td>
</tr>
<tr>
<td>Soybean plants</td>
<td>8/19/38</td>
<td>100 M</td>
<td>10</td>
<td>72.8-78.7</td>
<td>2.0-5.0</td>
<td>0.5-0.6</td>
<td>7.8-9.5</td>
<td>7.6-13.0</td>
<td>1.9-4.6</td>
<td>0.07-11.09</td>
</tr>
<tr>
<td>Soybean silage</td>
<td>8/18/38</td>
<td>20 A</td>
<td>6</td>
<td>70.5-85.3</td>
<td>2.0-3.9</td>
<td>0.2-5.4</td>
<td>4.8-6.4</td>
<td>5.1-7.8</td>
<td>6.4-11.2</td>
<td>0.05-0.62</td>
</tr>
<tr>
<td>Alfalfa plants</td>
<td>5/29 to</td>
<td>45 M</td>
<td>8</td>
<td>73.6-84.1</td>
<td>2.2-4.7</td>
<td>0.5-1.0</td>
<td>4.4-6.8</td>
<td>6.9-11.4</td>
<td>1.7-3.0</td>
<td>0.04-0.09</td>
</tr>
<tr>
<td>Alfalfa silage</td>
<td>6/7/35</td>
<td>45 M</td>
<td>8</td>
<td>71.9-77.0</td>
<td>2.8-4.0</td>
<td>3.1-1.1</td>
<td>6.2-8.5</td>
<td>8.7-12.7</td>
<td>10.1-2.9</td>
<td>0.05-0.06</td>
</tr>
<tr>
<td>Wheat and wheat silage</td>
<td>6/10/36</td>
<td>110 M</td>
<td>4</td>
<td>58.4-63.9</td>
<td>2.6-4.3</td>
<td>3.6-0.8</td>
<td>7.5-10.6</td>
<td>18.7-24.5</td>
<td>2.0-3.1</td>
<td>0.08-0.09</td>
</tr>
<tr>
<td>Wheat and wheat silage</td>
<td>6/10/36</td>
<td>110 M</td>
<td>4</td>
<td>65.2-79.8</td>
<td>3.0-4.3</td>
<td>2.9-1.0</td>
<td>5.6-10.0</td>
<td>11.8-17.5</td>
<td>1.2-2.9</td>
<td>0.05-0.11</td>
</tr>
<tr>
<td>Cowpea silage</td>
<td>1956</td>
<td>M</td>
<td>5</td>
<td>73.3</td>
<td>3.1</td>
<td>7.0</td>
<td>5.0</td>
<td>8.3</td>
<td>5.4</td>
<td>0.07</td>
</tr>
<tr>
<td>Oat silage</td>
<td>1936</td>
<td>M</td>
<td>8</td>
<td>71.4</td>
<td>5.5</td>
<td>1.0</td>
<td>10.0</td>
<td>13.0</td>
<td>2.1</td>
<td>0.09</td>
</tr>
<tr>
<td>Wheat silage</td>
<td>HCl + HSO₄</td>
<td>1935</td>
<td>4</td>
<td>73.6-79.8</td>
<td>2.2-2.5</td>
<td>3.4-1.2</td>
<td>6.1-7.7</td>
<td>9.1-12.1</td>
<td>1.9-3.0</td>
<td>0.06-0.08</td>
</tr>
<tr>
<td>Peavine silage</td>
<td>None</td>
<td>1937</td>
<td>5</td>
<td>73.5</td>
<td>2.3</td>
<td>1.3</td>
<td>8.8</td>
<td>9.9</td>
<td>1.9</td>
<td>0.05</td>
</tr>
<tr>
<td>Peavine silage</td>
<td>10 A</td>
<td>1937</td>
<td>5</td>
<td>71.3</td>
<td>4.8</td>
<td>1.1</td>
<td>7.1</td>
<td>10.4</td>
<td>5.3</td>
<td>0.10</td>
</tr>
</tbody>
</table>

† The results of the moisture determinations on these silages were lost. The values shown are based on an estimated probable range of the average moisture content.
the silo should take care of the situation.

For the best preservation of silage the silo should be airtight and the doors in good condition, so there is no air leakage. If air comes in contact with the silage molds will develop. A silo with smooth walls can be packed with silage without side wall spoilage.

Trench and pit silos can be used for the storage of grass silage if well drained and of sufficient depth so that the chopped material is thoroughly compacted. Many operators use the tractor to compact the green material. If the sides of the trench are smooth and if when filling is completed the top is thoroughly compacted, covered with paper, and covered with a foot or more of soil, spoilage losses will be low.

Seepage From Silos

When high moisture legumes and grasses are ensiled there will be seepage. If this green material is ensiled with a moisture content of from 72 to 82 per cent, the moisture content of the silage will stabilize at 74–75 per cent. The rest of this moisture finds its way out of the silo. If these juices penetrate the ground around the silo, putrefaction starts on the organic compounds and the odor is unpleasant. In order to overcome this odor the juice should be directed away from the silo by drains. The movement of expressed moisture is lateral in the silage and then down the walls either on the inside or the outside of the silo. If several loads of heavily wilted material are put into the silo, followed by loads of high moisture material, there is no blending of the moisture contents of the respective loads. The high moisture section stabilizes at about 74 per cent, but the heavily wilted section has not picked up the moisture that was lost from the high moisture section.

Coating the Silo

Because of the action of the acids on concrete, coating concrete silos with an acid resistant material is desirable. One of the most satisfactory materials is boiled linseed oil. By suspending a can of the oil with a brush on the inside of the silo, this coating job can be done while the silage is being fed out. After a three foot section of silage has been removed the silage adhering to the side wall should be brushed off and the oil applied. The concrete footings also should be recoated before refilling. With new concrete silos, boiled linseed oil applications should be applied to the inside walls before filling starts.

Nutrient Losses in Silage Seepage

Many farmers worry over the possible loss of nutrients in the seepage water. When molasses is used as a preservative these points should be remembered: (1) Molasses itself has more dry matter in it than the green material being ensiled. (2) It only takes a little molasses to color a lot of water. (3) When there is seepage from a silo one may be certain that sufficient pressures have developed in the silo to exclude the air which causes mold development.

Studies of silo seepage in New Jersey, with all seepage juice recovered and weighed, showed total weight losses of from 2 to 18 per cent but the dry matter loss was only 0.19 to 1.7 per cent. In terms of the farm silo of 100 tons capacity, this was equivalent to the nutrient loss of three-quarters of a ton of hay. Archibald, in similar studies on a silo of 100 tons capacity over a seven year period, found an average dry matter loss of 0.54 per cent.27

A New Industry Develops

TABLE 50.1
ANNUAL U. S. PRODUCTION OF SUN CURED AND DEHYDRATED ALFALFA MEAL,
1943-1949, THOUSANDS OF TONS

<table>
<thead>
<tr>
<th>Year</th>
<th>Sun cured</th>
<th>Dehydrated</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1943-44</td>
<td>421.6</td>
<td>245.4</td>
<td>667.0</td>
</tr>
<tr>
<td>1944-45</td>
<td>491.1</td>
<td>377.1</td>
<td>868.2</td>
</tr>
<tr>
<td>1945-46</td>
<td>604.6</td>
<td>497.1</td>
<td>1101.7</td>
</tr>
<tr>
<td>1946-47</td>
<td>484.2</td>
<td>569.0</td>
<td>1053.2</td>
</tr>
<tr>
<td>1947-48</td>
<td>381.1</td>
<td>730.5</td>
<td>1111.6</td>
</tr>
<tr>
<td>1948-49</td>
<td>303.5</td>
<td>728.3</td>
<td>1031.8</td>
</tr>
</tbody>
</table>

alfalfa meal currently produced is by company members of this association. A commendable "code of ethics" and "set of trade rules" have been formulated and are in effect.

GROWTH OF THE INDUSTRY. Statistics on alfalfa meal were separated by the U.S.D.A. for the first time in 1943-44 to show the tonnage of dehydrated and sun cured meals which were produced. Data in Table 50.1, from a U.S.D.A. report, show the annual production of the different kinds of alfalfa meal. It also serves to point out the wide acceptance which has been given to the dehydrated product and emphasizes the rapid growth experienced by the industry. The amount of sun cured meal produced in the year 1943-44 was nearly twice as great as the amount of dehydrated meal. Four years later, the situation was reversed and the production of dehydrated meal was nearly double the production of sun cured meal. Over one million tons of the combined meals have been produced during each of the last four years listed in Table 50.1.

LOCATION OF PLANTS. Alfalfa dehydrators are operated in widely separated parts of the United States, from Minnesota to the lowest tip of Texas and from New York to California. Arkansas, California, Colorado, Kansas, Missouri, Nebraska, Ohio, Pennsylvania, and Texas are the largest producers of dehydrated alfalfa. The greatest concentration of plants is in the Platte River Valley of Nebraska and in the Kansas River Valley of Kansas. Most dehydration plants are located on railroad sidings, but some portable units are now being manufactured which may be operated in the field.

DRYING CAPACITY. Most dehydrators have a rated capacity of 1 ton of meal per hour. The actual output varies greatly, however, dependent to a large degree on the quality and condition of the fresh material. When the moisture content is especially high, the output per unit may be little more than half a ton of meal per hour. On the other hand, 1½ tons of good meal may be realized when the hay has an unusually low moisture content. Normally, three tons of water vapor are expelled for each ton of meal. In good seasons, single units produce more than three thousand tons of meal. The average over the United States is somewhat below two thousand tons per unit.

The fuel most commonly used is natural gas, although considerable oil is also used. In some instances, propane and coal have been used. The dehydration drums may be either direct fired or have hot gases supplied by an auxiliary furnace.

The introduction of automatic feeders

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effected a great saving in hand labor and convey the chopped material into the dehydrator at a more nearly uniform rate. Optimum drying conditions can be maintained more easily when the fresh material is introduced at a uniform rate. This also has a marked effect on the quality of the product.

**DEHYDRATOR EQUIPMENT**

The development of rotary drum driers and the improvement of field equipment account in large measure for the successful results now being obtained, along with a high quality product. Rotary drum driers used in the dehydration of alfalfa usually are 10 to 12 feet in diameter and approximately 30 feet long. While various dehydrators may appear very similar to one not familiar with their construction, there are two general types.

**SINGLE DRUM.** The Howard type of dehydrator uses a single rotating drum which has baffles arranged along its inner surface. The baffles keep the undried material from clinging to the surface of the drum and cause it to be mixed with the stream of hot air and combustion gases drawn or blown through it. The freshly chopped material enters one end of the drum and ordinarily is dried to a moisture content of 4–8 per cent during a single pass through the rotating drum. In Figure 50.1 two double sized units of this type are shown, also the special hydraulic lift for unloading trailers and an automatic feeder.

**MULTIPLE DRUM.** The Heil dehydrator actually consists of three concentric drums with different drying conditions in different compartments. The fresh material enters the inner drum, in
which the highest temperature is main-
tained, and then passes in successive
stages to the second and third drums,
which are maintained at lower tem-
peratures. Figure 50.2 represents the con-
struction of the multiple drum dehy-
drator, and Figure 50.3 shows two of
the regular installations of this type. It
will be noted that auxiliary furnaces are
used to furnish the heat for drying the
alfalfa.

CONTINUOUS CONVEYOR. A third type of
dehydrator, often spoken of as a
tunnel or continuous conveyor type,
is used to a limited extent. Most of the
dehydrators of this type are located in
Ohio and Pennsylvania. One of the most
modern and best engineered continuous
conveyor dehydrators is, however, lo-
cated in the Imperial Valley at Brawley,
California.

FROM FIELD TO DEHYDRATOR

Fields which furnish alfalfa for dehy-
dration usually are harvested at intervals
of three or four weeks, depending upon
the soil fertility and general growing
conditions. It is customary to cut the al-
falfa before the bloom stage to insure
a meal of higher quality than would be
realized from a more mature growth.
The dehydrators operate on a twenty-
four hour schedule during seasonable
weather. Cuttings of alfalfa have been
made during 8 or 9 consecutive months
in certain locations when the growing
season was unusually long.

Some companies still use field ma-
nines only for mowing the hay and
elevating it onto trucks or trailers. The
fresh material is then transported to the
plant site, where it is chopped just be-
fore being introduced into the dehy-
drator. The more common procedure at
present is to use field machines, many of
which are now self propelled, that both
mow the crop and chop it. The fresh
material is cut into lengths varying
from 1 to 4 inches and is then blown
into a truck or trailer for transportation
to the dehydrator. The harvesting and
chopping equipment, as well as the
trucks, are owned and operated by the

*Fig. 50.2 "... development of rotary drum dryers and the improvement of field equip-
ment account ... successful results now being obtained, with a high quality product.
Rotary drum dryers ... usually are 10 to 12 feet in diameter and approximately 30 feet
long." (See p. 580.) Cutaway showing Heil type rotary dehydrator and auxiliary furnace.
Arnold Drier Co. photo.*
50. Dehydration of Forage Crops

Dehydration of Forage Crops

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Fig. 50.3 Twin installation of Heil type rotary dehydrator. In this installation the long cut hay is chopped as it is fed into the drums at right and left. Observe extra emergency chopper ready at hand. The more common practice is to chop in the field as cut and blow into trucks. Arnold Drier Co. photo.

dehydrating company. The farmer who produces the alfalfa is paid on the basis of the tons of dehydrated material which are manufactured from his crop. The quality of the fresh alfalfa, season of the year, availability of material, and market price of the finished product are factors which determine the price which the farmer receives.

CAROTENE LOSS BEFORE DEHYDRATION.

Destruction of carotene begins as soon as the growing plant is cut, but losses from the chopped material are not appreciably different from those of long cut hay. A study in 1945 showed that the loss of carotene from fresh chopped alfalfa was most rapid immediately after chopping but amounted to less than 3 per cent per hour over a period of several hours. The average length of time between cutting the hay and feeding it into the dehydrator will be less than 1 hour, if good plant management is practiced.

STORAGE PROBLEMS AND FACTORS

Much dehydrated alfalfa meal is shipped directly to the feed manufacturers as soon as it is produced. However, large supplies must be stored for use during the winter months, when production of fresh meal is limited to small areas. Some refrigerated storage is utilized, but normal warehouse storage must be used for a large tonnage of meal.

Dehydrated alfalfa meal suffers loss of carotene and represents a problem which probably is the most serious one confronting the industry. Wilder and Bethke reported on the carotene losses under variable conditions of storage in 1941. Workers at Kansas State College reported on the storage of alfalfa meal under normal warehouse conditions and under constant temperature and relative humidity conditions, as available at the Natural Cooler Storage Facility of the U.S.D.A. Multi-wall paper bags of different types, as well as burlap bags, were used in these studies.

EFFECT OF MOISTURE. At the spring meeting of the American Chemical Society in 1946, attention was called to the apparent correlation between moist-

4 Silker, Ralph E., et al. Loc. cit. 3.
ture content and carotene retention in dehydrated alfalfa meal. These data were subsequently published by Silker, et al. Several other workers also have pointed out that carotene is retained in alfalfa meal which has a relatively high moisture content. However, air must be excluded from the container.

GAS STORAGE. Hoffman et al. and others have shown that storage of dehydrated meal in an atmosphere of inert gases serves to minimize the loss of carotene during storage. A patented process covering the bulk storage of dehydrated products is being used commercially at present.

CHEMICAL REAGENTS. The use of chemical agents for the stabilization of carotene has been the object of many researches. Researchers of the Western Regional Research Laboratory have been active in this field. A recent patent employing substituted diphenyl amines has been issued and is assigned to the National Alfalfa Dehydrating and Milling Company.

REFRIGERATION. Some concerns refrigerate a portion of the high quality dehydrated meal which they produce.

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5 Ibid.
10 Wilder, O. H. M., and Betiske, R. M. Loc. cit. 8
11 Graham, W. R., Jr. Preserving organic materials, such as forage crops or vitaminic vegetables, in large quantities in storage. U. S. Patent No. 2353209. 1944.
Fig. 50.5 "Much dehydrated alfalfa meal is shipped directly to the feed manufacturers as soon as it is produced . . . suffers loss of carotene and represents a problem." (See p. 582.) Alfalfa meal in multi-walled paper bags in car, with tags attached showing guaranteed analyses. Note gunny sacked meal in warehouse at left. *Kan. Agr. Exp. Sta. photo.*

during early spring or late fall. The refrigerated meal accounts largely for the availability of meal with high vitamin A potency during that part of the season when fresh material is not being produced in appreciable quantities.

THE PRODUCT AND ITS USE

CHOPS, MEAL, PELLETS. The term "chops" is used to designate the mixture of dehydrated leaves and stems which come from the dehydrator. Most of the chops are ground into a fine meal with a high-speed hammer mill fitted with a 1/6 inch screen, but a coarser screen is used at times. The dehydrated meal usually is packed in burlap bags which contain 100 pounds net, but recently there has been a demand for multi-wall paper bags containing 50 pounds of meal. The practice of pelleting dehydrated alfalfa meal started about 1945. An increasing interest is being shown in this form by feed manufacturers and feeders. The pellet form largely eliminates the dust problem experienced with meal. Also, the pellets can be shipped in bulk and stored more easily.

Important Components

PROTEIN, CAROTENE. Dehydrated alfalfa has a large number of components which are responsible for its use in many different types of feeds for poultry and livestock. The protein of alfalfa is of high quality, since all 10 of the essential amino acids may be obtained from it. Most of the essential amino acids
are found in appreciable amounts, but only a relatively small amount of methionine is present. Quantitative data have been published by Stokes et al. Carotene, one of the important precursors of vitamin A, is the component which perhaps has received most attention. Its importance should not be minimized. Appreciable quantities of dehydrated alfalfa meal are now sold on a guaranteed basis for both protein and carotene.

VITAMINS. The presence of vitamins and vitamin-like substances in dehydrated alfalfa is important to the feeder. Biotin, carotene, choline, folic acid, grass juice factor, inositol, niacin, pantotheneic acid, para amino benzoic acid, phytol, pyridoxin, riboflavin, thiamin, vitamin C, vitamin E, and vitamin K are among the nutritionally important substances known to be present. There are other nutritional factors present in the meal which have not been isolated or identified. The colored xanthophylla also are important to the egg and broiler producers.

MINERALS. The importance of minerals is recognized. Alfalfa contains appreciable quantities of calcium, magnesium, potassium, and sodium, with smaller amounts of boron, cobalt, copper, iron, manganese, silicon, and zinc. In addition, there are the non-metallic elements, chlorine, iodine, phosphorus, and sulfur.

EXTRACTIONS. Limited amounts of dehydrated alfalfa are solvent-extracted primarily for the various colored pigments, which may be isolated. The carotene concentrates which have high vitamin A activity are the most important products of this class, but some use is made of chlorophyll. It may well develop that the sterols and other extractable compounds will be separated industrially from dehydrated alfalfa.

USE IN LIVESTOCK FEEDS

POULTRY. Most of the dehydrated alfalfa meal produced during the first 15 years of the industry was used in the manufacture of poultry feeds. Varying amounts of alfalfa meal are included in starting, growing, and laying mashes. The proportion of dehydrated meal is greatest in the growing mash. It usually varies between 5 and 7 per cent. Introduction of the so-called "high energy" broiler rations resulted in using approximately 1 per cent dehydrated alfalfa, but the trend is again toward formulas which use larger amounts. The percentage of alfalfa used in turkey rations is somewhat above that used for chickens and will average approximately 7.5 per cent. An interesting and instructive article gives the use of dehydrated alfalfa in poultry rations.

SWINE. Reports from Illinois and Iowa research show the value of high quality dehydrated alfalfa meal in swine rations.

The number of pigs farrowed and weaned is greatly increased when high quality dehydrated meal is included in the ration of sows during the gestation period. Benefits for growing pigs, and particularly for breeding stock, also have been pointed out.

Use in Livestock Feeds 585

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CATTLE. It appears that increasing amounts of dehydrated alfalfa will be fed to both dairy and beef cattle, as pelleted meal becomes more readily available.

FORAGES OTHER THAN ALFALFA

GRASSES. A number of crop plants other than alfalfa are dehydrated in the equipment described earlier in this chapter. U. S. patent 10 No. 1942943 applies to the dehydration of grasses prior to jointing. Oats, rye, wheat, barley, Sudan, and certain perennial grasses are crops harvested in limited amounts during early spring, or late fall, for dehydration. The principal locations for these operations in the United States are in Kansas and Missouri in the middle west, and in Louisiana and Texas in the south. England and parts of Canada produce dehydrated cereal grasses, principally in areas where they may be grown more readily than alfalfa.

MISCELLANEOUS. Some of the clovers, especially bur, Persian, and white, are dehydrated to a limited extent, as also are kudzu, birdsfoot trefoil, sorghum, soybean, and pea-vines. Workers at the Eastern Regional Research Laboratory, U.S.D.A., have investigated the utilization of vegetable wastes by dehydration.

uses. The dehydrated products from the above materials are used primarily in animal feeds in place of dehydrated alfalfa and for the same reasons. Some straight dehydrated cereal grass, and some which is fortified with synthetic B complex vitamins and vitamin D, are marketed for human consumption.

QUESTIONS

1. Where are most of the dehydration plants located in the United States and why?
2. Describe the methods by which alfalfa and other forages are dehydrated.
3. List several advantages of dehydrating forage crops.
4. Why was there a rapid growth in the dehydrating industry between 1943 and 1948?
5. What are the principal uses of dehydrated alfalfa meal?
6. Name ten nutritionally important substances contained in high quality dehydrated alfalfa.
7. Why is dehydrated alfalfa meal included in poultry and livestock rations?
8. Why is the protein of dehydrated alfalfa of high quality?
9. Discuss the importance of dehydrated alfalfa as a source of vitamins.

Emergency Hay and Pasture Crops

Emergency hay and pasture crops are those either diverted from other uses, or grown especially to provide for unexpected forage shortages.

Drouths cause the majority of emergencies in forage supplies. General drouths like those of 1934 and 1936, which affected nearly three-fourths of the country, occur infrequently. Local drouths occur in some parts of the country every year.

In the North, stands of alfalfa and red clover are the main hay and pasture crops thinned out or lost entirely due to winterkilling. Every year hail storms cause considerable crop loss. Usually these storms are local. However, occasionally they cover many square miles of area—as those in Connecticut, Kansas and Montana in 1931. Leguminous hay crops in advanced stages of growth may be seriously injured as to both yield and quality.

The carrying capacity of most permanent bluegrass pastures is extremely low during the mid-summer months and low to negligible in September and October. Also, during July and August the carrying capacity of rotational pastures usually is down considerably. But on many farms no supplementary crops, such as Sudangrass for summer use or spring oats for later fall grazing, are planned for or grown to meet these seasonally occurring pasture shortages.

Meeting Emergencies in Hay and Pasture Supplies

Feed is produced at lowest cost from good pastures, and next lowest from good hay crops. Therefore, unexpected forage shortages can be met most economically by providing additional hay and pasture. Diverting part of established meadows when they can be spared to pasture use for the entire season, or grazing the latter part of the season, provides emergency pasture at the lowest cost per feed unit. For most of the annual emergency crops the cost of production per feed unit is somewhat higher. Barn feeding is highest in cost per feed unit and should be practiced only when adequate pasturage cannot be provided.

COOL WEATHER EMERGENCY CROPS

Oats is the spring grain most generally grown to make up shortages of hay and pasture when the emergency can be recognized early. This popularity of oats is
justified by carefully conducted experiments.

In Western Canada, May and June sown oats averaged 2.1 and 1.5 tons of dry forage per acre, respectively. Barley seeded under the same conditions averaged 81 and 91 per cent and wheat 69 and 81 per cent the yield of oats.

In Minnesota similar results were obtained, except that winter rye was included also and produced somewhat more than the oats.

Of early spring sown emergency crops for Illinois, oats is recommended as giving the greatest amount of pasturage in the shortest time and at the lowest cost. In Ohio, oats is first choice of cereals for hay production and in New York for early recognizable emergencies in hay and pasture supplies.

Early spring sown oats in Minnesota averaged 1.5 tons of hay for the two drouth years 1934 and 1936 when rainfall averaged only about half normal. Under these conditions oats averaged as high an acre yield as corn, soybeans, millet or sorghum, but not as high as Sudangrass or a Sudangrass-soybean mixture. Under average rainfall conditions the oats averaged 2.8 tons per acre. This equaled soybeans in yield but was lower than that of warm season crops planted June 15.

In Georgia, oats and wheat sown in the spring averaged for the four-year period 1932-1936, 1.76 and 1.69 tons of hay per acre, air-dry basis, respectively.

A Connecticut method of providing emergency pasturage in the late fall can be used to advantage in other states. Oats or barley is sown about August 1. These spring grains grow much more rapidly than winter rye. Pasturing the first growth at a height of 8-10 inches permits a second growth to develop. The average carrying capacity has been 26 standard cow days per acre in September and 16 in October.

### Winter Grains

Pasture emergencies in the states where winter grains are adapted can be met by continuing to graze winter grain to the end of the growing season, instead of removing the livestock early enough for a grain crop. Georgia suggests that this may be done at a profit with the oat crop in the Coastal Plain area of that state.

In Missouri, whether to graze winter grain out completely, or to discontinue grazing the middle of April to permit a grain crop, depends on the need at the time.

An Oklahoma report concludes: "The pasture value of winter small grains is so high that livestock farmers might profitably use them entirely for pasture without taking a grain crop. The number of pounds of high protein pasturage per acre obtained after the stubbling stage of
development averaged 1,280, air-dry basis. This compared favorably with the 1,321 pounds of grain per acre, air-dry weight, obtained from areas not clipped after the stooling stage.

A yield of 1,180 pounds of pasturage on a 15 per cent moisture basis was obtained in Minnesota from grazing winter rye beyond the stooling stage. This compared favorably with the 1,321 pounds of grain per acre, air-dry weight, obtained from areas not clipped after the stooling stage.14 The pasturage averaged 22.7 per cent protein on the dry matter basis. This yield of high protein pasturage would go a long way toward equalizing the value of the possible grain crop.

Grazing rank growing winter wheat during the first part of April in Indiana, and March 1 to April 15 in Kansas provided considerable pasturage during these periods and grain yields were increased.15, 16 Under less favorable growing conditions grain yields were reduced somewhat.

HOT WEATHER EMERGENCY CROPS

The crops suitable for late planting to take care of unexpected shortages of hay and pasture during the hot dry months of midsummer are Sudangrass, soybeans, the millets and sorghums, field corn, cowpeas and velvet beans. Of these, Sudangrass and soybeans have the widest soil and climatic adaptation.

Sudangrass

It is reported from Michigan that on infertile, sandy loam, during two of the driest summers ever experienced, 1929 and 1930, Sudan had a carrying capacity of a cow per acre for 60 and 57 days, respectively.17

Sudangrass, 30-35 pounds of seed per acre, or Sudangrass 5-8 pounds and soybeans 90 pounds per acre, are recommended in Wisconsin for succulent midsummer pasture, or for hay.18 Highest carrying capacity was obtained by grazing at a height of 2-3 feet. On good land soybeans produce up to 3 tons of hay per acre, practically equal to alfalfa in feeding value. Sudangrass is recommended in North Dakota as a hay crop and in South Dakota as a hot weather pasture crop.19, 20 In the latter state, over a 10-year period, Sudangrass and second year alfalfa averaged 51 and 67.4 days of grazing and 1,572 and 1,917 pounds of total digestible nutrients, respectively, or 98.3 and 119.8 standard cow days per acre. During its shorter grazing season Sudangrass averaged 1.93 cows per acre carrying capacity as compared with 1.78 for the alfalfa. In Texas in the very dry summer of 1938 Sudangrass provided 70 days grazing for light steers, with an average gain of 172 pounds each.21 Heavier steers in 1940 grazed Sudangrass for 141 days and averaged 116 pounds gain.

In Oregon, particularly in the areas with a dry, warm summer, Sudangrass is considered superior to any other crop for pasture. It is also used as a soiling crop, and is cut in the soft dough stage as a hay crop.22

Sudangrass and Soybeans

In Ohio, Sudangrass is recommended to provide emergency summer pasture.23 Soybeans planted in May and June averaged 2 to 2.5 tons of hay per acre, air-dry basis.24 These yields com-
Fig. 51.1 "... reported from Michigan ... during two of the driest summers ever experienced ... Sudan had a carrying capacity of a cow per acre for 60 and 57 days, respectively. ... In Oregon, particularly in the areas with the dry warm summer, Sudangrass is considered superior to any other crop for pasture."

pare favorably with those ordinarily obtained from alfalfa. Planting as late as June 15, as might be necessary in an emergency, gave an average yield of 2.1 tons of hay per acre.

In Minnesota, Sudan grass 30 pounds, also Sudan grass 10 pounds—soybeans 60 pounds, seeded June 15, proved to be a more satisfactory hay crop than sorghum, millet, or field corn during both extreme drought years and seasons with average or better rainfall. They averaged the 2.2 tons per acre for the drought years and approximately four tons in favorable years. Soybeans drilled solid 90 pounds per acre averaged 1.4 tons hay per acre for the drought years and 2.9 tons for the years with average or better rainfall.

Based on extensive tests, Sudan grass is recommended as one of the most satisfactory nonlegume emergency hay and pasture crops for Iowa.29 Two cuttings, the first made when half the stems are fully headed, averaged 3.55 tons of hay per acre compared with 2.47 tons from one cutting, made when the seeds were in the dough stage. Soybeans have proven a valuable emergency hay crop to take the place of alfalfa or clover when these fail.26, 27

For Illinois, the Sudan grass and soybeans combination is recommended for

Sowing on soils of medium low fertility to obtain emergency pastures of highest carrying capacity. Sudangrass 20 pounds or Sudangrass 10–15 pounds and soybeans 90 pounds, are the seeding rates recommended. Seedings of Sudangrass as late as the first week in August in the central part of Illinois will provide good pasture until killing frost.

In Missouri, where Korean lespedeza in annual rotation with winter wheat provides summer grazing of highest quality at the very minimum of cost, Sudangrass is strictly an emergency pasture crop. When lespedeza sown in the spring with grain fails to make a stand Sudangrass may be sown in early June after the grain has been grazed out or harvested for grain. “Altogether, Sudangrass is one of the most reliable and productive crops for summer pasture.” If a legume hay is needed, soybeans may be planted on part or all of the land from which the winter grain has been grazed off and harvested in time for early fall seeding of rye or barley again.

**Soybeans**

In eastern Kansas, difficulty in maintaining alfalfa stands directed attention to soybeans for hay. Drilling solid resulted in an average yield of 1.58 tons of hay per acre at Manhattan and 1.16 tons in the southeastern part of the state. Soybean hay was found practically equal to alfalfa in feeding value.

In Mississippi, soybeans averaged 2.5 tons air-dry hay per acre from plantings made March 15–May 15. Yields from the June 1, June 15, and July 1 plantings were 2.8, 1.7, and 1.4 tons per acre, respectively.

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**Miscellaneous**

In Connecticut, Japanese millet yielded 3.99 tons of 15 per cent moisture hay per acre as compared with 3.08 tons for Sudangrass. Soybeans yielded 3.55 tons per acre and contained 1,307 pounds of protein. This was over three times the amount of protein produced by either of the other two crops. “Its satisfactory yield of high protein hay and its soil improving feature make the soybean the preferred summer annual hay for the state.”

In Rhode Island, seedings of Japanese millet averaged 2.36 tons of 15 per cent moisture pasturage per acre. In comparison, Sudangrass averaged 1.55 tons of pasturage. Late seeded Sudangrass had a slight advantage. In another test soybeans averaged 2.82 tons of hay per acre with a protein content of 20 per cent.

In eastern Nebraska, black amber sorghum produced higher yields of hay than Sudangrass during the four year period 1921–24. The sorghum averaged 4.72 tons of hay per acre on a 15 per cent moisture basis, as compared with 3.38 tons for Sudangrass. Field corn drilled solid, 250 pounds per acre, averaged 3.98 tons and kafir drilled 100 pounds per acre, 3.65 tons. In another comparison, soybeans averaged 1.25 tons of hay per acre compared with 2.25 tons of alfalfa and 4.89 tons of sorghum.

On the Coastal Plain area of Georgia, steers grazed on cat-tail millet averaged gains, over a 6-year period, of 148.2 pounds per acre in comparison with 101.7 for lespedeza and 98.3 for soybeans. The seeding time for cat-tail millet extends to June and the grazing period, July through most of September. Sudangrass was not included in these grazing tests.

**SUMMARY**

Oats is the spring grain most widely grown for emergency hay or pasture purposes. It provides 6 to 7 weeks of grazing during May, June and July, usually up to the time Sudangrass sown in early May is ready for grazing. Sweetclover or fieldpeas sown with the oats increases the carrying capacity. Grazing the crop off or cutting it as emergency hay results in better stands of grasses and legumes sown with it. Sown in August, it provides more late summer and early fall pasture than winter rye.

Sudangrass is the most widely adapted and used nonleguminous hot weather hay and pasture emergency crop. Japanese millet, cat-tail millet, and black amber or atlas sorghum may be superior to it in limited areas.

The soybean is the most widely used hot weather leguminous crop for hay, or in combination with Sudangrass or Japanese millet for either hay or pasture.

**QUESTIONS**

1. A livestock farmer finds in the spring that practically all the alfalfa in his bromegrass–alfalfa meadow has winterkilled. How can he best provide hay for use the following winter which will be similar in feeding value to the alfalfa?

2. What are the main causes of emergencies in hay and pasture supplies?

3. How can a pasture emergency which developed during the last half of March and the first part of April in the states growing winter wheat, oats and barley be met to advantage?

4. What effect does grazing off a companion grain crop have on the stand of grasses and legumes sown with it and on the hay or pasture yields the following year?

5. Why is it usually more desirable to divert biennial or perennial crops, if they can be spared, to emergency pasture use rather than growing annual crops for that purpose?
A permanent pasture is one that is maintained indefinitely for grazing and may be composed of the perennial plants, annual plants that propagate themselves by self-seeding, or frequently both. It may be either an area that has been established by seeding, or the result of the occupation of uncultivated fields by pasture plants that are sufficiently aggressive so they spread without the aid of man. (Once a permanent pasture has become established it is seldom plowed for use in crop rotation.

"Tame pastures," "improved pastures," or "plowable pastures," as used in census reports, are those planted or covered with domestic or other pasture plants. These names also are often applied to many pastures that are classified as permanent pastures.

Permanent pastures are of great importance in the United States. Although some livestock producers could better utilize more of their permanent pasture areas for rotation or supplemental pastures, a rather large percentage of the land area on farms is allocated to permanent or native pastures.

There are in the United States something over 2 billion acres of land. Of this, 1,126,000,000 acres are in grassland. In the United States as a whole there are 74 million acres of hay, 48 million acres of crop land, and 61 million acres of plowable pasture. These statistics illustrate the land devoted to pasture and its importance in supplying feed to our livestock population.

In recent years permanent pastures have undergone marked changes. Their value and importance have been recognized and they are now the foundation of the livestock industry. It is estimated that land in plowable pastures is approximately 35 per cent of the total crop land, or 25 per cent of all the total farm land in the United States. Ordinarily grasses and legumes supply about 48 per cent of the total feed nutrients of our livestock as grazing, and about 12 per cent as hay. The remaining 40 per cent of the feed is supplied by corn and other harvested feeds.

**IMPORTANCE**

The importance of pastures in our grassland agriculture is well demonstrated in the study of the feed consumption of livestock. In this study the different kinds of feed have been converted to *feed units*, one feed unit being equal in nutritive value to one pound of corn (Table 52.1).

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1. Jennings, R. D. Feed consumption by livestock 1910-41, relation between feed, livestock, and food at the National level. U.S.D.A. Cir. 670, 1943.
TABLE 52.1
AVERAGE ANNUAL FEED CONSUMPTION, U. S. 1929-33, 1938-40, EXPRESSED IN FEED UNITS

<table>
<thead>
<tr>
<th>Percentage of total</th>
<th>1929-33</th>
<th>1938-40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed units (1,000 tons)</td>
<td>Proportion (%)</td>
<td>Feed units (1,000 tons)</td>
</tr>
<tr>
<td>Total grains</td>
<td>85,679</td>
<td>35.3</td>
</tr>
<tr>
<td>Total commercial feed materials</td>
<td>11,682</td>
<td>4.8</td>
</tr>
<tr>
<td>Total miscellaneous concentrates</td>
<td>6,462</td>
<td>2.7</td>
</tr>
<tr>
<td>Total, all concentrates</td>
<td>103,823</td>
<td>42.8</td>
</tr>
<tr>
<td>Total hay and other roughage (except pastures)</td>
<td>49,621</td>
<td>20.4</td>
</tr>
<tr>
<td>Pastures</td>
<td>89,380</td>
<td>36.8</td>
</tr>
</tbody>
</table>

TABLE 52.2
PERCENTAGE OF TOTAL FEED UNITS UTILIZED BY LIVESTOCK (1938-1940)

<table>
<thead>
<tr>
<th>Kind of livestock</th>
<th>% concentrates</th>
<th>% roughage</th>
</tr>
</thead>
<tbody>
<tr>
<td>All grain</td>
<td>Other</td>
<td>All</td>
</tr>
<tr>
<td>Milk cows</td>
<td>15.6</td>
<td>8.4</td>
</tr>
<tr>
<td>All dairy cattle</td>
<td>14.8</td>
<td>7.4</td>
</tr>
<tr>
<td>All beef cattle</td>
<td>13.0</td>
<td>8.3</td>
</tr>
<tr>
<td>Beef cows</td>
<td>7.6</td>
<td>4.4</td>
</tr>
<tr>
<td>All sheep &amp; goats</td>
<td>4.1</td>
<td>.3</td>
</tr>
<tr>
<td>All horses &amp; mules</td>
<td>31.4</td>
<td>1.5</td>
</tr>
<tr>
<td>All hogs</td>
<td>84.0</td>
<td>10.8</td>
</tr>
<tr>
<td>All poultry</td>
<td>71.9</td>
<td>23.7</td>
</tr>
<tr>
<td>All livestock</td>
<td>31.5</td>
<td>8.6</td>
</tr>
</tbody>
</table>

As would be expected, the importance of each kind of feed varies with the different classes of livestock. Hogs and poultry use relatively high quantities of grain and concentrates. Dairy cattle also are heavy consumers of concentrates. However, a well balanced pasture program can do much in reducing the need for these feeds and still maintain maximum production. In Table 52.2 will be found a summary estimating the percentage of feed units obtained from concentrates, roughage, and pasturage utilized by different classes of livestock. In this table it is estimated that dairy cattle obtain about 38 per cent of their feed from pasture, while beef cattle and sheep together take about 46 per cent.

PERMANENT PASTURE REGIONS OF THE UNITED STATES

The United States is divided naturally into about five main pasture regions in accordance with varying climatic conditions. There is, of course, some overlapping in types of pasture plants at the boundaries of the different regions. In the Great Plains and Intermountain regions will be found the native short grasses, the tall growing bluestems, and the native desert grasses and shrubs. In these regions native range makes up the permanent grazing land. It is in the humid regions only that the permanent pastures will be considered here. In Figure 52.1, the types of pasture plants that provide the majority of the pasturage in each part of the United States are indicated by divisional lines.

Too often many of the so-called permanent pastures are simply worn out or unproductive fields that have been taken out of cultivation or abandoned. The undirected and unaided establishment of

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permanent pasture regions of the united states

permanent pastures require many years for their full development and have been a waste of potential resources. In general, it can be said that the broad natural climatic regions determine the botanical composition of permanent pastures. The important grasses and legumes that occur in the permanent pastures in the humid regions depend upon climatic and soil adaptation, palatability, fertilizer treatments, culture and grazing management practices.

Throughout the northern regions (1-a, 1-b, and 5-a), on the more fertile soils, Kentucky bluegrass, with varying amounts of white clover, is widely distributed. Smaller percentages of such grasses as redtop, timothy, orchardgrass, the fescues, Canada bluegrass, and others are found in permanent pastures. The fine-leaved fescues and Canada bluegrass will predominate on drier and poorer soils, while timothy and redtop predominate on the more moist soils. In the Central Belt between the North and South (1-b) annual lespezedas are prominent in many of the pastures. In recent years birdsfoot trefoil has come into prominence in the permanent pastures of the northeastern states. In some of the central Corn Belt states birdsfoot trefoil has been planted in permanent pastures and is a valuable addition to the Kentucky bluegrass for summer grazing.

In the South (regions 2-a and 2-b) through what is generally considered the Cotton Belt, Bermuda-grass and annual lespezedas are the predominating pasture species on the uplands, while on the lowland pastures carpetgrass, Dallisgrass and the white, hop, and Persian clovers will predominate.

All of these plants are hardy and the combination gives a longer grazing period and a forage that is more varied. Carpetgrass and Dallisgrass start growth
in the spring as soon as frost will permit and the increased growth continues into the summer. By August these plants slow down in vegetative growth and become tough.

Usually lespedeza does not show very much growth until June. It continues to give growth and excellent grazing until frost, or until November in the Deep South or Coastal Plains region. White clover is a fall and spring growing plant, growth starting in October and November. Its growth is fairly slow during the extremely cold mid-winter months. On the uplands, Bermuda-grass predominates, usually in combination with lespedeza or, on the more fertile soils, clover will predominate. Bermuda-grass requires special management for best results as a pasture crop. Late in the summer it tends to become tough and unpalatable unless carefully grazed. Carpetgrass is widespread over much of the South, especially in more moist situations. Because of its dense growth, it offers too much competition for growth of legumes. On the more fertile soils Dallisgrass predominates to a greater or lesser extent.
Fertilizing and Liming

If a fair stand of desirable pasture plants is present, much improvement in botanical composition, nutritive value, and productivity can be obtained through top-dressing with lime, manure, and fertilizers. Pasture plants, like crop plants, require these treatments when deficiencies exist in the soil. Such deficiencies may be the result of naturally low fertility, overgrazing, long continued use without treatment, and many other factors. The most common deficiencies on pasture soils are lime and phosphate. On other soils, potash deficiency is prevalent. Lack of nitrogen may also be a limiting factor. Such existing conditions must be reckoned with seriously. By the use of mineral fertilizers it is possible to encourage the growth of legumes and thus build up the nitrogen through the legumes. If pasture is urgently needed, nitrogen fertilizer can be applied with good success.

The amount and kind of fertilizer to use will depend upon many factors, such as soil, vegetative cover, and general environmental conditions. Usually it is best to apply enough lime at one time to meet the needs for at least four or five years. In North Carolina, yields of permanent pastures have increased from 25 to 200 per cent in response to limestone and further gains were made when phosphate was added with limestone. As to phosphate and potash, this may be applied at more frequent intervals.

Tests in Michigan have shown that the production of forage in permanent bluegrass pasture can be increased approximately 100 per cent during May, June, and September, by spring applications of complete fertilizers at the rate of 500 pounds to the acre.

In West Virginia, pastures treated with lime and phosphate have given increases of about 75 per cent over untreated pastures. On similar pastures with lime, nitrogen and phosphorus, the increase has

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### TABLE 52.3

**Comparison of Annual Grazing and Yearly Milk Yield per Acre on Unfertilized and Fertilized Pastures in Louisiana**

<table>
<thead>
<tr>
<th>Year</th>
<th>No. days grazed</th>
<th>Cow days per acre</th>
<th>Lbs. milk yearly per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unfertilized</td>
<td>Fertilized</td>
<td>% increase</td>
</tr>
<tr>
<td>1937</td>
<td>59</td>
<td>83</td>
<td>48</td>
</tr>
<tr>
<td>1938</td>
<td>72</td>
<td>99</td>
<td>38</td>
</tr>
<tr>
<td>1939</td>
<td>75</td>
<td>123</td>
<td>64</td>
</tr>
<tr>
<td>1940</td>
<td>79</td>
<td>137</td>
<td>73</td>
</tr>
<tr>
<td>Av.</td>
<td>70</td>
<td>110</td>
<td>57</td>
</tr>
</tbody>
</table>

598 52. **Permanent Pastures**

been as high as 100 per cent, while with those receiving lime and complete fertilizer, increases up to almost 125 per cent have been obtained.  

At Tifton, Georgia, on Coastal Plains soils, a lowland untreated pasture gave a seven-year average of approximately 82 pounds of beef to the acre, while similar pastures receiving 6–12–6 fertilizer every third year produced about 356 pounds of beef for the same period.

The production of typical untreated permanent pastures in Maine was about 700 pounds of 4 per cent milk per acre, as compared with a permanent pasture that had been liberally fertilized with a complete fertilizer and produced over 4,000 pounds of 4 per cent milk equivalent per acre. The vegetation in the fertilized pastures carried three times as much phosphorus, twice as much protein and potash, and almost 50 per cent more calcium and magnesium per acre.

In Louisiana good returns also are obtained by improving permanent pastures. Pastures receiving 350 pounds per acre of 4–12–4 fertilizer in the fall and 50 pounds nitrate of soda in the spring on the acre basis average 57 per cent more cow days of grazing, 64 per cent more milk and 44 per cent more returns over cost of grain fed and fertilizer used than did the unfertilized pastures. (Table 52.3.)

Another benefit from lime and fertilizer is the increase in type of desirable pasture plants and density of stand. In North Carolina the total vegetative cover was increased one-third by the use of fertilizer. The annual clover, white clover, and Kentucky bluegrass were increased as high as 65 per cent. In addition, this improvement resulted in early spring grazing and extended the pasture season. Other figures presented indicate that excellent native pastures require for maintenance the annual application of about 60 pounds each of nitrogen, phosphoric acid, and potash per acre. In view of the low phosphorus reserve in soils of the Northeast, and in view of information on phosphate fixation, 60 pounds of \( P_2O_5 \) per acre per year is by no means more than should be applied for perhaps a good many years. All New England states now recommend 20 to 30 pounds of nitrogen for grass pastures or hay lands, plus additional nitrogen if available.

**RESEEDING**

Reseeding of grasses and legumes in thin pasture sods without cultivation

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has not been successful in increasing the production of permanent pastures. The seeded grasses are seldom able to become established under such conditions. Of the legumes, annual lespedezas, sweetclover, and in more recent years birdsfoot trefoil, have been of the most promise. In the north central region of the United States seedings of birdsfoot trefoil are showing great promise on permanent pastures and are contributing largely to their improvement. This legume has been found to have characteristics long needed for permanent pastures. In Missouri it was found that in a permanent Kentucky bluegrass pasture in which Korean lespedeza had been established without the addition of lime or fertilizer, beef cattle gains were 37 per cent greater than where no legume had been established. Where lime and phosphate were applied the beef gains were increased by 60 per cent. The largest gains of beef cattle were made on bluegrass pasture in which biennial sweetclover had been seeded and the best gains were when the second year plants of sweetclover predominated. Smaller gains were made when the grazing was deferred in May and June in order to protect the first-year clover plants. The average annual beef gains from this type of pasture were 73 per cent greater than unimproved pastures. It is difficult to maintain stands of sweetclover in permanent pastures even under controlled or deferred grazing practices. The best method for improving rundown permanent pastures is by renovation rather than by reseeding.  

**RENOVATION**

Another practice that can be used, and which is coming into prominence, is renovation. Renovation is the process of converting old rundown pastures directly to improved pastures by discing or other cultivation, applying lime and fertilizer, and seeding high-yielding grasses and legumes without subjecting the land to cropping.  

Much of the poor permanent pasture is on land that is not suitable for cultivation. It is covered with thin sods of broomedge, poverty grass, and remnants of desirable pasture grasses, such as bluegrass or Bermuda-grass. Usually there are no legumes present and the grasses make little growth. Most of this vegetation is unpalatable and has low feeding value. Its principle use is for early spring grazing. In midsummer such pastures are worthless for producing milk or maintaining other classes of livestock. Such pastures can be restored to greater productivity through renovation. With this method there is little danger of soil losses, since in the renovation practice the old vegetation remains on the surface. By thoroughly discing, spring tooth harrowing, or otherwise tearing up the old sod, mixing in lime, manure, and fertilizer, and seeding to adapted grasses and legumes such pastures can be restored profitably in one growing season. Another advantage of renovated pastures is that a portion of the permanent pasture can be treated at a time when there is usually an excess of pasturage. The new seeding of renovated pasture under average rainfall conditions is established by midsummer and can be grazed without injury if managed properly. At Beltsville, Maryland, on two different years of renovation, the total seasonal production the first year of renovation was larger than the permanent pas-

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In the renovation practice, seedings are made using the taller growing and deeper rooted grasses and legumes. Alfalfa, Ladino clover, red clover, lespedeza, bromegrass, orchardgrass, and Dallisgrass are but a few of these pasture plants that are usually seeded to improve the productive carrying capacity. In such renovation the pasture being treated should be protected from grazing until the plants are well established. Then, of course, grazing should be controlled so that the pastures may have an opportunity to keep on making good growth to maintain a productive stand. During the first year the distribution of yield is affected by time of seeding, but in the succeeding years these renovated pastures are much more productive during the midsummer season, when the untreated permanent pastures are dormant.

**ROTATION GRAZING**

The practice of rotation grazing consists in grazing two or more pastures in regular order with varying rest periods for the pastures. When two pastures only
are involved, this type of grazing is known as alternate grazing. In the rotational plan a field containing the same mixture is divided into several equal parts. As the forage is consumed in one pasture the livestock are moved to the next, and so on, until the animals have grazed all fields. This system should not be confused with rotation pastures. A rotation pasture is a farm plan in which the pasture is a part of the rotation system and is considered one of the crops the same as corn, wheat, or a hay crop.

The value of rotation grazing on permanent pastures is questionable. The results indicate that usually there is insufficient increase in production or carrying capacity to justify the additional expense necessary to provide fencing, water, and shade.12

An experiment was conducted at Beltsville, Maryland, comparing rotation vs. continuous grazing with dairy cattle over a six-year period. This experiment was set up under the so-called "Hohenheim" type of pasture management. This system involved primarily the use of dairy cattle on pastures with heavy fertilization, plus rotation grazing. One field was divided into six equal units fertilized each year with a complete fertilizer. This area was grazed in rotation.13

It was concluded that on most dairy farms in the United States the increase in the yields of nutrients in permanent pastures would hardly be sufficient to justify the cost of permanent division fences.

RATE AND METHOD OF GRAZING

Different intensities and methods of grazing have a pronounced effect on the livestock gains, milk produced, and on the plant population. In the northern temperate climates Kentucky bluegrass and white clover will predominate under heavy, continuous grazing, assuming the fertility is maintained. Under light, continuous grazing, Canada bluegrass, orchardgrass, timothy, and lespedeza, where adapted, will be more prevalent. In lightly grazed pasture the herbage will not be entirely consumed, but the excess growth that accumulates during the early season of growth will provide feed for the livestock during the late summer and early fall.

In controlled experiments at Beltsville, Maryland, 1929–34, no significant differences were observed in gains made by steers on pasture grazed heavily, continuously, or alternately over a six-year period.14

If animals are to make satisfactory gains when heavy grazing is practiced, some provision must be made for supplemental feed or pasture during late summer. The heavy grazing also reduces the productivity of permanent pastures. Such pastures should be protected from grazing to allow the grasses and legumes to build up root reserves and prevent weed encroachment.15

TIME OF GRAZING

Pasture deterioration is often the result of lack of good system in handling the grazing stock. Many of our pasture grasses will make a good showing if given the opportunity by good management.

Stockmen frequently turn their animals out to pasture very early in the spring since their stocks of hay often are

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depleted by early March. Allowing the stock to graze too early in the spring is a serious error. This is especially important in the northern part of the United States unless there is a good cover. In the early spring the ground is loose because of thawing and the disappearance of snow cover, and the forage has not yet gained sufficient growth to withstand cropping. In the Corn Belt it has been found that stocking the permanent pastures heavily during the spring and early summer when bluegrass and clovers are at the peak growth will give greater production. Thus capacity grazing at this season of the year will give greater production than will rotation grazing. The disadvantage of the heavy spring grazing is that other pasturage must be supplied during the summer deferred grazing period.

Where invasion of broomsedge or other early spring growing plants occur it is desirable to start grazing as early in the spring as possible. The livestock will graze these plants when immature. Grazing at this period reduces the root reserves, thus killing them out or preventing any serious encroachment of these undesirable plants. When annual lespedeza is present it is desirable to practice early spring grazing to allow the young lespedeza seedlings sufficient light and space for development.

Grazing pastures closely in the late fall is also harmful. It is equally, if not more, important that special care should be taken to avoid depletion of the reserves in roots and crowns of the plants in the fall of the year. The desirable plants require some food reserves and cover to protect them during the winter months. Bluegrass, Bermuda-grass, white clover, and others will withstand early or late seasonal grazing. In the South, late fall grazing to reduce the competition of the summer growing grasses with the cool season growing legumes, white, hop, and Persian clover, is a desirable practice.

**EFFECT OF MIXED GRAZING**

The grazing animal has a profound influence on the quality and quantity of the pasture. It has long been recognized that continuous grazing by sheep alone has a deleterious effect on the pasture. The reason for this is that sheep are by nature selective grazers and short croppers.

By selective and close grazing the animals overgraze the more palatable grasses and skip over the unpalatable species. Continuous overgrazing of the more palatable species results eventually in their disappearance from the pasture. The neglected, less palatable species take advantage of the opportunity to spread, and ultimately the pasture, devoid of palatable species, is worthless as such.

There are indications that where sheep are grazed in conjunction with cattle the production of the pasture is increased. The introduction of cattle on the grazing may not reduce the number of sheep and will have a beneficial effect on both the sheep and the botanical composition. Grazing conditions are thereby improved and made suitable for the spread of the better grasses, while the less desirable grasses are decreased if pastures are properly managed.

In Texas and some other localities it has been found that the productiveness of the pasture is increased when several kinds of animals are allowed to graze it. Sheep and goats eat plants that are not relished by cattle. Their presence helps keep down weeds and brush and may in that way accomplish an improvement in the pasture conditions which would otherwise be attained at considerable expense only. Little active research work of this nature has been conducted with mixed grazing in the United States. Re-
ports from foreign sources indicate that mixed grazing has been practiced with the following results:

In South Africa it has been found that where sheep and cattle are kept on the same pasture, the pasture did not deteriorate to any marked extent and the weight increase of the sheep was higher than where sheep were grazed alone.

In Scotland, where cattle were introduced on the grazing without reduction in the number of sheep, there was a salutary effect on both the sheep and the pasture. While there are many phases yet to be worked out in this mixed grazing, such as ratio of sheep to cattle and system of control, it is believed that when a sound proportion of sheep to cattle has been established it will be recognized that cattle are an essential requisite to successful sheep farming in this country.

**WEEDS IN PERMANENT PASTURE**

Low fertility, lack of moisture, and poor grazing management result in more and more weeds in permanent pastures. The most common weeds are broomsedge, thistle, dandelion, buckhorn, and mullein. Woody plants commonly present are black locust, hawthorn, sumac, and brambles. Mowing weeds and brush at the proper time and application of fertilizer are the best means of control. Shrubs and tree sprouts can best be controlled by cutting at the proper time. In the northern states apparently the critical period for brush is when the roots contain the smallest amount of starch. Generally this is at time of blooming. In the southern states the eradication of brush and sprouts is much more difficult and expensive. Many plants can be con-
trolled by spraying with chemicals (See Chapter 40).

PLACE OF PERMANENT PASTURE

A properly treated and managed permanent pasture can be one of the most profitable areas of the farm. Managed as it is ordinarily, it is not highly profitable. Too often the amount of feed supplied by these pastures is much less than is needed to maintain the animals in healthy condition and return a profit.

The permanent pasture can best be used to supply spring and early summer pasturage when the rotation and temporary pastures are soft and will be injured by trampling. This same situation often exists during the late summer and fall. The well managed permanent pasture can be used for winter seasons whenever weather conditions are favorable for livestock out of doors. This is important in maintaining the health and production of all classes of livestock. It must be recognized that permanent pastures have their limitations, but they are as essential as any of the other feed crops for the livestock producer.

Regardless of the type of pasture, the objective in a sound, well balanced and economical pasture program should be enough pasture of high quality to support adequately the livestock population during as much of the year as possible.

QUESTIONS

1. Define the term permanent pastures.
2. What proportion of livestock feeds are obtained from pastures and roughage? Give percentage of total units in pastures obtained by the four main classes of livestock.
3. Name and define the principal pasture regions of the United States.
age may do fairly well for the more mature beef animals if gain in body weight is the objective, but is not so good for young growing animals and milk and wool producing livestock. With these latter types of livestock, the younger herbage with its higher mineral and protein content is more desirable.

Generally, the requirements of farm livestock are best provided by the intermediate stage of growth rather than either extreme. For maximum production of livestock products per acre this also is desirable. The close grazing of new spring growth results in low yields of herbage per acre. Withholding grazing until these hay-type plants approach maturity results in much waste, because of excessive herbage trampled down and the smothering of new growth.

Growth Habits of Rotation Pasture Plants in Relation to Grazing Practices

There is a wide range in the types of plants used in rotation pastures. Production obtained depends to a considerable degree on how well grazing practices are adjusted to a particular type of pasture. Plant growth results only from materials manufactured in the green portion of the plant, generally in the leaves. Generally speaking, growth is possible only because of the green top, and is proportional to the amount of green top. Weeds are killed by frequent and complete removal of the green top. The less mature the plant, the more damaging is the removal process. The parallel between this and continuous or frequent close grazing is at once recognized.

Not all rotation pasture plants are damaged to the same degree by close grazing. Alfalfa and timothy, for example, have few leaves at the ground level and must be permitted 9 to 15 inches top growth before sufficient green surface is present to maintain a satisfactory growth rate. On the other hand, Ladino clover, annual lespedeza, orchardgrass, and perennial ryegrass may have a greater leaf area at half this height. Biennial sweetclover is notorious for its inability to withstand close grazing in its first year. Most of the other common rotation type legumes and grasses, such as red clover, alsike clover, cuneata lespedeza, smooth brome, meadow fescue, and tall fescue are more or less intermediate in amount of top growth that should be maintained or permitted.

As a general rule, the taller growing rotation pasture plants of the hay type should not be used exclusively for pasture any one year if they are to be maintained for such use again the next year. A better plan seems to be to permit, some time during the season, enough growth for a hay crop. This can be accomplished and still maintain adequate pasture by removing hay from some areas in the early part of the season and from others later. If the crop is not needed for hay, these taller hay-type plants may be used for later grazing. Where it is known at seeding time that the crop is not to be used for hay, but for grazing only, the mixture may be made up only of lower growing types such as Ladino clover, perennial ryegrass, and meadow fescue or orchardgrass. Ladino is not as deep rooted or drought resistant as alfalfa but it does hold up pretty well. Gausman and Fuellman of Illinois report Ladino roots 12 feet deep.

Effect of Time and Manner of Grazing

Alfalfa and Ladino. During recent years Ladino clover has become an important constituent of many rotation pasture mixtures. It improves the quality and greatly increases the yield. Ladino clover...
clover, with its mat of roots near the surface and runners on the surface of the soil, adds much nitrogen and conserves moisture. It comes back quickly with a heavy growth after grazing. If grazing of an alfalfa-Ladino-grass mixture is delayed till the late hay stage or longer, however, the Ladino may be largely eliminated. If grazing starts early and is fairly close, Ladino may predominate and alfalfa be largely eliminated. These are two very valuable legumes commonly included in the same mixture but it is difficult to maintain both satisfactorily. In some sections, particularly in Pennsylvania and the Northeast, many prefer to put them in different mixtures, making it possible to graze each according to its particular requirements. Where the two legumes are used in the same mixture, the general practice is to let the mixture grow for an early hay crop in order to save the alfalfa, than to mow and graze to save and get the greatest value from the Ladino. Where the two are in separate mixtures, the Ladino mixture may be used for early pasture, and supplemented insofar as necessary in midsummer by the alfalfa mixture that previously has been cut for hay. Alfalfa is a better midsummer producer than Ladino clover in dry seasons.

**EXPAND PASTURE ACREAGE IN MIDSUMMER.**

No single plant, or combination of plants in the same mixture, has been found that produces uniformly from spring till fall. If surplus spring growth is held in ungrazed reserve for midsummer use it deteriorates in quality and is not very satisfactory for young growing animals and milk and wool producing
livestock. Generally, to avoid overgrazing, it is desirable to expand the pasture acreage sufficiently to provide adequately for midsummer—cutting any surplus for hay or silage as conditions may indicate.13, 14

ADJUST GRAZING TO TYPE OF PASTURE. It has been pointed out that the different rotation pasture plants vary greatly in the amount of leaf area developed within the first few inches next to the ground, and that the amount of green leaf area largely determines the amount of growth. It is obvious that one type of pasture might be producing its optimum yield when grazed at an average height of 4 to 5 inches while another grazed at the same height would produce only a half of its optimum.

DANGER IN EARLY AND LATE GRAZING. Early spring grazing of most hay type rotation legume-grass pastures has two disadvantages. Such pastures are relatively more succulent than the lower growing permanent pasture types, such as Kentucky bluegrass and Bermuda-grass—the latter is a summer grass—when these are first ready to graze. If grazed too early, this characteristic of the hay type legume-grass plants sometimes produces digestive troubles. The second difficulty is that the early grazing of such plants soon reduces the root reserves, and since no top development has been permitted for further plant food manufacture, the plants become weak and remain at a low production level for the remainder of the season. Such overgrazing may reduce production to a half, or even a fourth, of what it might have been.14

These rotation hay-type plants, to a greater degree than the lower growing permanent pasture types, build up large food reserves in the roots, rhizomes or corms in the fall. This enables them to start growth rapidly in the spring. Fall grazing, especially the last month before killing frost, removes the green tops and prevents the manufacture and storing of growth producing reserves. This results in plants that may winterkill, or, in the event they do winter, start growth slowly in the spring.

This discussion of habits of growth of a few common rotation pasture plants and the effects of grazing should enable one to classify other plants being considered in rotation pastures and determine suitable grazing procedure for them.

ROTATIONAL vs. CONTINUOUS GRAZING. There have been a number of experiments in which continuous and rotational grazing have been compared.15 The differences have not been very significant and have not always agreed. The main reasons advanced for rotational grazing are: (a) It makes possible more complete utilization of the pasture herbage at the most ideal pasture stage. (b) It prevents over and under grazing and maintains a better balance of grass and legumes. (c) It helps in the control of parasites in some livestock, such as sheep. (d) It keeps the pasture cleaner and more palatable.

Rotational grazing requires careful attention. If the livestock are not shifted at the right time both the pasture and livestock suffer. When carefully handled, rotational grazing usually produces favorable results. However, some of the advantages of rotational grazing can be attained by other features of management such as mowing and alternate grazing.

With continuous grazing the animals can obtain young or old herbage accord-

ing to their choice. If the pasture is ade-
quately in size and amount of herbage pres-
ent, one may expect animals—beef ani-
mals in particular—on continuously
grazed pastures to do as well or better
than animals on rotationally grazed pas-
ture. It is well to remember that when
we are restricting animals to a particular
type of pasture and stage of growth we
are assuming that we know, and are giv-
ing these animals, what they need. This
may not be true. When we restrict ani-
mals we should make certain that we
“know as much as the cow knows.”

The production per acre and the main-
tenance of stand are other matters. In
these respects rotational grazing gener-
ally gives better results, assuming that
the pastures are properly managed and
grazed to capacity but not overgrazed.

It is common observation that in con-
tinuously grazed pasture some areas are
overgrazed. Such areas are greatly re-
tarded in growth and the seeded legumes
and grasses may even be eliminated. This
fact may be checked by the placement of
harvest cages. For some reason other
areas are grazed little or not at all. Here
the herbage is wasted. Frequently, the
rank growth falls over or is mashed down
and some of the plants, Ladino in par-
ticular, may be smothered out. In both
cases production is reduced. Alternate or
irregular rotational grazing is more gen-
erally followed than strict regular pe-
riodic shilting. However, some high pro-
ducing dairymen like to shift their cows
to a fresh pasture area every 3 or 4 days.
Rotational grazing seems to be in greater
favor with dairymen than with beef cat-
tlemen. This may be because the dairymen
check more frequently on both their
herd and their pastures.

The important thing to keep in mind,
whether continuous or rotational grazing
is being followed, is to avoid grazing so
close as to keep the green leaf area re-
duced to a low level for any considerable
period, but at the same time utilize the
production.

MANURE AND FERTILIZER TOP
DRESSINGS

Many rotation pastures are worn out
hay fields two, three, or more years old.
Seldom have these pastures been fertil-
ized since establishment. Their produc-
tion is low, frequently not exceeding 100
pounds of beef or 1,200 pounds of milk
per acre. A considerable expense is in-
volved in a rotation pasture and such
yields are not profitable. First of all is
the fact that the land might have been
used for the production of a grain crop.
The original seed, fertilizer, lime, labor,
fuel and use of equipment are other costs
that must be charged against the area.

It is necessary to hold the area in sod
to build up soil structure and thus im-
prove its productivity in preparation for
another grain crop. The question is what
can be obtained from this rotation pas-
ture year or years.\[6, 16, 17\]

With a good seeding and adequate
lime and fertilizer, plus good manage-
ment, the rotation pasture year may be
the most profitable one in the rotation.
One has a chance when establishing rota-
tion pasture to put in the seed and fer-
tilizer desired and where desired. The
more liberal the treatments, the greater
will be the productivity of the sod
crop.\[3, 4\]

The value of the sod crop in rebuild-
ing the soil structure and improving the
nitrogen, available mineral, and
organic content is evidenced in the yield
of grain crops to follow in the rotation.
For each pasture year there is the possi-
bility of producing 4,000–6,000 pounds


Building a Pasture Program With Rotation Pastures

per acre of milk, or its equivalent in beef, pork, lamb, or poultry. With such production it is obvious that substituting a sod crop for an 80 bushel corn crop is no sacrifice at all, but rather a means of producing additional income. The removal of hay or pasture in the equivalent of 4 tons of alfalfa-grass hay takes from the soil about 150 pounds of nitrogen, 42 pounds of phosphoric acid and 170 pounds of potash. If the above mentioned production is to be obtained, the nutrient content as well as the physical condition of the soil must be maintained. Frequently the fertilizer application at the time of establishment, and that liberated from soil reserves, are not adequate to meet the requirements of the small grain and the pasture year or years. Additional nutrients, as manure or commercial fertilizer or both, should be applied.

Usually such applications should come between the first and second hay or pasture year and be repeated every other year thereafter so long as the sod is maintained. The application might be manure and phosphate, phosphate and potash, or nitrogen, phosphate, and potash, depending upon the location and condition of the soil and the legume content of the crop. Such applications have been highly profitable and detailed suggestions may be obtained from agronomists in various states. As a rule, much more liberal treatments are now practiced in the East than in the Midwest. There is also a tendency in these top dressings to increase the potash content and include nitrogen more frequently than formerly.

Mowing Rotation Pasture

Mowing rotation pasture in order to save the surplus growth for hay or silage is good practice. There also are times when the mowing of a surplus and matured growth is desirable to encourage the development of a more palatable and nutritious herbage. Such mowing, if needed, should be at about the time a hay crop would normally be removed. Mowing at the beginning or during a dry period serves only to reduce the herbage available and retard future growth.

By mowing only a portion of the pasture at one time, the possibility of an inadequate pasture supply occasioned by unfavorable growing weather following mowing may be overcome. Both mowing and rotational grazing are means to an end and are not ends in themselves. They should be used only when and if needed. They may be omitted from the program if the same ends can be otherwise attained.

BUILDING A PASTURE PROGRAM WITH ROTATION PASTURES

On most farms, regardless of how level, there is some permanent pasture. On many farms of the Corn and Cotton Belts, however, and on other specialized grain farms, the permanent pasture acreage is absent or limited. Permanent pastures and their management have been discussed in another chapter. We shall consider here only those pasture crops that are grown as a part of a regular crop rotation. Our problem is to devise a procedure whereby suitable crops and pasture management practices can be selected and fitted together in a pasture program that will adequately provide for the livestock on the farm. Such a procedure has been worked out for use in Ohio. The procedure consists of three steps. First, the cow or animal-unit-days of grazing required by all the livestock on the farm is determined for each month. This is accomplished by dividing the number of animals of the various kinds on the farm each month by respective animal-unit-pasture equivalent figures and then adding all together. Sec-
"The value of the sod crops in rebuilding the soil structure and improving the nitrogen, available mineral and organic content is evident in the yield of grain crops to follow in the rotation. For each pasture year there is a possibility of producing 4,000 to 5,000 pounds per acre of milk or its equivalent in beef, pork, lamb, or poultry... substituting a sod crop for an 80-bushel corn crop is no sacrifice..." (See p. 612.) A group of Adams County, Ohio, high school students on a farm tour learn of the returns possible from well managed acres in rotation pasture from D. R. Dodd, pasture specialist on the Ohio State University staff.

Second, the number of animal-unit-grazing-days for each month provided by the types of pasture on the farm is determined, or estimated. This is accomplished by multiplying the number of acres of each type of pasture on the farm by the respective number of animal-pasture-days that particular type of pasture will furnish. The total of these for each month indicates the number of animal-unit-grazing-days available for each month.

Third, is a comparison of the requirements and the supply, and the making of necessary adjustments to bring the two into balance.

A table of equivalents in animals and one indicating the days grazing provided by different types of pasture as used in Ohio are reproduced in part in Tables 53.2 and 53.3.

In adapting these to other states, the values probably would be modified and

**TABLE 53.2**

**APPROXIMATE NUMBER OF ANIMALS REQUIRED TO CONSUME AS MUCH PASTURE AS ONE 1,000-POUND DAIRY COW (OHIO)**

<table>
<thead>
<tr>
<th>Kind of livestock</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy cows</td>
<td>1.0</td>
</tr>
<tr>
<td>Dairy heifers</td>
<td>2.0</td>
</tr>
<tr>
<td>Beef cows</td>
<td>1.0</td>
</tr>
<tr>
<td>Beef steers and heifers</td>
<td>2.0</td>
</tr>
<tr>
<td>Horses and mules</td>
<td>1.0</td>
</tr>
<tr>
<td>Colts</td>
<td>2.0</td>
</tr>
<tr>
<td>Fine wool ewes with lambs</td>
<td>6.0</td>
</tr>
<tr>
<td>Coarse wool ewes with lambs</td>
<td>5.0</td>
</tr>
<tr>
<td>Lambs after weaning</td>
<td>12.0</td>
</tr>
<tr>
<td>Sows at 300 pounds</td>
<td>5.0</td>
</tr>
<tr>
<td>Pigs at 50 pounds</td>
<td>50.0</td>
</tr>
<tr>
<td>Hogs at 150 pounds</td>
<td>16.0</td>
</tr>
</tbody>
</table>
Opportunities for improving the rangelands of America are almost unlimited. Possibilities of expanding the acreage of range are few. The greatest opportunity for increasing the nation's range livestock production is the development of its present forage resources. Complete application of currently available information on range management and improvement could easily double grazing returns from the ranges of America. Increases of even greater magnitude would be possible through further and more comprehensive research on all phases of range and pasture improvement and plant development.

Over half the land area of continental United States is used for pasture and range for livestock, compared with only 21 per cent as cropland.1 The 17 Western States account for 73 per cent of the nation's pasture and grazing land; the South, a region of growing range importance, 17 per cent. In 1949, the western states possessed nearly all of the goats, three-fourths of the sheep, and about half of the country's entire cattle population.2

Range improvement problems therefore are of vital interest. They are made highly complex by the extremely variable conditions that prevail. The principal purpose here is to present some of the more important range problems, with certain suggestions for their solution.

NOXIOUS PLANTS

Much of the western range has become seriously infested with a rank growth of shrubs and other troublesome plants. Their competition represents the greatest single deterrent to range forage production on millions of acres. Their control constitutes the most valuable range improvement practice in such areas.

Various forms of sagebrush occupy over 115 million acres of western range. Nearly 100 million acres of rangeland in the Southern Great Plains and Southwest is heavily infested with mesquite, cedar, scrub-oak, sand sagebrush, and other noxious plants. The brush becomes taller, thicker, and more vigorous from north to south, but is equally detrimental throughout its occurrence.

---

These troublesome plants have increased greatly in recent years. Control of range fires and an increase in grazing pressure have accelerated spread of deep-rooted brush at the expense of shallow-rooted grass. The problem is especially alarming in its rapid expansion over the once famous grasslands of the region.

Dense brush not only decreases forage production but lowers the quality of feed and causes many other disadvantages. The sun-loving grasses of the West become fibrous and lacking in essential nutrients when growing in shade. Brush also interferes seriously with the care of range livestock. The annual loss of livestock from animal diseases and predators is greatly increased by the presence of brush.

**Control of Sagebrush**

Treatments that have proved successful in controlling one or more species of sagebrush include mowing, beating, rail- ing, plowing, burning, and chemical application. Few of these treatments are feasible and effective on all types of sagebrush.

**Sand Sagebrush.** Results in control of sand sagebrush *Artemisia filifolia*, at the U.S.D.A. Southern Great Plains Field Station, show conclusively that sand sagebrush may be effectively controlled and grazing returns doubled by mechanical or chemical treatment. None of the many other practices tested at Woodward, except reseeding of abandoned farmland, has accomplished this outstanding degree of range improvement.

Mechanical treatment of sand sagebrush, through the use of heavy duty mowers or brush beaters, gave best results in June when the brush roots contained the least amount of carbohydrates.
Much of the western range . . . seriously infested with a rank growth of shrubs . . . the greatest single deterrent to range forage production. . . . Various forms of sage brush . . . 115 million acres . . . increased greatly in recent years . . . rapid expansion over the once famous grasslands of the region.” (Sec p. 617.) (Left) Range infested with sagebrush and weeds; (right) controlled by mowing and spraying. U.S.D.A. photo.

and other food reserves. Mowing the brush in June for two successive years, accompanied by grazing deferment during the growing season of those years, eradicated 60 per cent of the brush, greatly reduced the vigor of the remaining brush plants, and doubled the density and vigor of grass. These treatments increased subsequent carrying capacity 50 to 65 per cent, gain per head of beef cattle 3 to 15 per cent, and gain per acre 70 to 75 per cent, depending on whether the ranges were grazed only during the growing season or on a yearlong basis. These advantages, when coupled with the increased market value of cattle from the improved ranges, resulted in double the grazing returns from the land (Table 54.1).

Control of sand sagebrush with 2,4-D has been cheaper, faster, and usually more effective than mechanical treatment. One proper application of 2,4-D usually has accomplished more brush control and greater grass improvement than two mechanical treatments. The chemical method kills many range weeds and eradicates up to 80 per cent of the sagebrush plants at a cost of $2.00 to $2.25 an acre, compared with $3.00 an acre as the average for each mechanical treatment. Chemical applications usually gave best results in May when soil and atmospheric conditions were moist and the brush was growing vigorously.

Applications of 2,4-D were more effective on second growth sagebrush following mowing or burning than on
plants that had not been previously treated. Mowing one year, followed by spraying the next, resulted in a 99 per cent kill of the brush. Rates of application for satisfactory control varied with the type of season. Chemical treatment gave uniformly poor results under extremely dry weather conditions.

The chemical may be applied with equally good results by airplane or well-constructed ground sprayers. Burning was not effective in controlling sand sagebrush at Woodward, unless it was done at the minimum point of root storage in June. The treatment was extremely detrimental to the grasses. The injurious effect of burning was apparent in reduced vigor of grass for three to five years.

**OTHER SAGEBRUSH.** In contrast with the burning results on sand sagebrush, Pechanec and Stewart report good success in the control of big sagebrush, *Artemisia tridentata*, and threetip sagebrush, *A. tripartita*, through controlled burning in southeastern Idaho. The areas included in this study had a good understory of perennial grasses and weeds before burning. The fires were set in late summer and were held within bounds by fire lines and trained crews. Grazing was excluded for a full year; thereafter use was moderate and well reg.

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TABLE 54.1
BRUSH CONTROL AS AFFECTING POUNDS OF BEEF PRODUCED AT WOODWARD, OKLA.

<table>
<thead>
<tr>
<th>Sagebrush control treatment</th>
<th>7-summer av.</th>
<th>4-year-long av.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. head</td>
<td>Gain</td>
</tr>
<tr>
<td>Mowed</td>
<td>139</td>
<td>345.2</td>
</tr>
<tr>
<td>Non-mowed</td>
<td>93</td>
<td>301.5</td>
</tr>
<tr>
<td>Increase due to brush control</td>
<td>46</td>
<td>44</td>
</tr>
<tr>
<td>%</td>
<td>50</td>
<td>15</td>
</tr>
</tbody>
</table>

ulated. The treatment increased carrying capacity 69 per cent for sheep; doubled the perennial grass, encouraged palatable weeds, and changed availability of forage from 64 to 93 per cent.

Morris reported even more striking results—a 300 per cent increase in grazing capacity—from similar burning tests on big sagebrush in northwestern Colorado.

Destroying sagebrush with wheatland plows or other tillage implements and following with seedings of adapted grasses have resulted in outstanding range improvement in many parts of the West. The method has been particularly successful on brush-covered ranges depleted of grass. Crested wheatgrass, *Agropyron cristatum,* has been commonly and successfully used for this purpose on big sagebrush range in the Intermountain region.

Sand lovegrass, *Eragrostis trichodes,* has been used with equal success in reseeding depleted ranges in southwestern Kansas from which sand sagebrush was eliminated by tillage.

Preliminary studies with 2,4-D and 2,4-5-T on big sagebrush usually have shown less effective results than were reported for 2,4-D on sand sagebrush. However, some promising leads in the control of big sagebrush with these selective herbicides have been reported informally by Don F. Hervey of the Colorado Agricultural Experiment Station. Bohmont also reports effective results in Wyoming in controlling (big) sagebrush with 1 to 2 pounds of the ester formulations of 2,4-D, applied when the plant is fully leafed out and growing actively.

MESQUITE CONTROL

Chemical treatment offers promise for low-cost, effective control of mesquite, from tests at Spur, Tex.

Successful control resulted from kerosene and diesel fuel applied to the base in sufficient quantity to soak through the bark and throughout the sprout bud zone below the ground surface. The method works best on open stands of the tree form growing on porous soils. It is considered too costly for brush mesquite on heavy soils.

Similar but less satisfactory results were reported by Parker for the trunk saturation method in Arizona. But he reports more promising control of mesquite by poisoning the roots with sodium arsenite, applied in a basin or girdle at the base of the plant, using 1 quart of 1:12 arsenite solution in a basin or a 1:2 arsenic solution in the girdle.

studies indicate that 2,4-5-T offers promise for large scale control operations. The most effective results were obtained with the ester form of this chemical, applied at 2/3 of a pound of acid per acre in an emulsion of 1 gallon of No. 2 diesel oil and 4 gallons of water. Best results are expected from applications made a few weeks after mesquite has made heavy foliage growth in the spring.

CONTROL OF OTHER BRUSH

Research is now in progress and much preliminary information is available on the control of other brush, weeds, and trees that infest the range. Elwell and Cox report varying degrees of success in Oklahoma in the control of oaks and other competitive plants with 2,4-D, 2,4-5-T, combinations of the two, ammonium sulfamate, and cutting machinery.11 Ammonium sulfamate, a non-selective herbicide, gave good control of all woody plants common to the Cross Timbers but also was injurious to grasses. White oak, blackjack oak, dwarf chinguapin oak, and hickory were controlled with heavy applications of 2,4-D, 3 pounds or more per acre, under favorable conditions but combinations of 2,4-D and 2,4-5-T were more effective. Sprays of 2,4-5-T alone were superior to the combinations under adverse conditions of drought and low humidity.

Elder reports that 2,4-D and 2,4-5-T acid sprays cause the greatest deadening effect when applied on brush just after the plants have attained full leafage.12 Humphrey 13 of Arizona reported good results in control of burroweed, Aploppus tenulsectus, by burning at the end of the dry season after the range had been protected long enough to provide sufficient vegetation for a clean burn. He also indicates that the treatment has promise for control of catclaw, Acacia greggii; creosote bush, Larrea tridentata; Mormon tea, Ephedra trifurca; velvet mesquite, Prosopis velutina; and graythorn, Candelaria lycioides.

GRAZING MANAGEMENT

All factors considered, some form of grazing management offers the surest means, and in some instances the only feasible method, of improving many depleted ranges and maintaining production on those in good condition. Moderation in stocking rates, seasonal use of range types, deferred grazing, rotational grazing in some cases, and other factors contribute to proper management. Every major range type and every productive condition of each type usually has its own peculiar management requirements, according to Chapline.14

Degree of Use

Stockmen are urged to make annual appraisals of the condition of their range lands and to determine the trend for better or worse.15 Accurate inventories of this kind are dependent upon a thorough knowledge of, and the ability to recognize, desirable and undesirable plants.

The range forage should receive attention at all times. It is the crop which the livestock operator has for sale; the animals are merely a means of harvesting and processing it. In the long run, conservative use of grass pays the best dividends in grass and livestock production.

---

Ranges may be classified as excellent, good, fair, or poor, depending on the vigor, density, and kind of grasses and other forage plants available. Evidences of erosion, decreases in density, and increases in the less desirable plants are readily discernible indications of deterioration. Range recovery usually is a slow process. Relief from excessive grazing pressure, or from long-continued drought, is frequently followed by an immediate growth of weeds which slowly give way to better grasses.

When the condition of a range has been judged and the estimated proper number of livestock placed on it, the degree of forage utilization should be watched closely. One or more checks should be made during the season to allow for needed adjustment in livestock numbers. The amount of ungrazed stubble required to maintain production varies with the species. In general the short grasses should have a stubble at least 4 or 5 inches high.

Conservative grazing is imperative at all times. The greatest total pounds of beef, mutton, or wool, or the greatest number of animals may show the greatest profit for a few years, but not in the long run. A relatively high income may be obtained even under light grazing which permits the most rapid recovery of deteriorated ranges. The cumulative results of heavy stocking are a gradual decrease in plant cover, loss of desirable grazing plants and erosion.

Results of grazing studies on short-grass range at the Central Plains Experimental Range in Colorado strikingly illustrate the benefits of conservative use of forage. The 7-year average gross return from three degrees of grazing (57, 38, and 22 head per section) were, per section: Heavy, $1,024.93; moderate, $1,068.06; and light, $744.05. The heavy rate caused both soil and forage deterioration. The moderate rate resulted in some range improvement, and the light rate marked improvement.

Similar but less positive results were obtained on sandy range land at the Southern Plains Experimental Range near Woodward, Okla. Three degrees of continuous yearlong grazing and two degrees of continuous summer grazing of native range were much more evident in their effect on the vegetation than on cattle gains during the 8-year period, 1941-49. Yearlong grazing rates of 6.6, 9.9, and 13.2 acres per yearling steer were compared. The heavier rate produced annual gains 35 pounds per head less and 19 pounds per acre more than the average of the two more conservative rates of stocking. The detrimental effect of overgrazing on the vegetation was increasingly evident throughout the period, indicating that a stockman should pay more attention to his grass than to his cattle in determining proper stocking rates. The gain-per-head advantage of conservative grazing jumped from an average of 22 pounds for the first four years to 50 pounds for the last four years.

Other ranges at Woodward were grazed only from April to October at the overgrazed rate of 4.3 acres per yearling and the moderate rate of 6.3 acres per head. In these comparisons, the heavy rate reduced the 8-year average gain per head 39 pounds and seriously damaged the vegetation. There was a 13-pound increase in gain per acre. Of primary importance, however, is the fact that the moderately grazed pastures have been maintained in good condition, while the overgrazed vegetation is rapidly declining in vigor and becoming seriously infested with less palatable plants.

Light grazing showed outstanding advantages over heavy grazing in a 4-year
FIG. 54A "Grasses are most nutritious, and promote the most rapid growth . . . when . . . green and growing vigorously. . . . But . . . more susceptible to grazing injury at that time . . . greatest possible gain from grazing . . . moderate use of the range when the vegetation is growing actively." (See below.) Yearling steers grazing on native sand lovegrass seeded on abandoned farm land, Woodward, Okla. U.S.D.A. photo.

Season of Use

Most grasses are considered especially susceptible to heavy use early in the spring. Protection from too much grazing at that time is essential in renewing the vigor of depleted ranges. Some grasses are more vulnerable to heavy use in the late summer than at any other time. Extremely heavy grazing at Woodward, for example, was more damaging to blue grama when the abusive use was in August and September than at other seasons in the year. This grass, which heads in late summer, apparently exhausts the food in its roots by the production of forage in the summer and is likely to be damaged if grazed heavily before the root reserves are replenished in the fall.

Grasses are most nutritious, and promote the most rapid growth of livestock, when the plants are green and growing

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TABLE 54.2
SUMMER TREND IN GRASS NUTRIENTS AND YEARLING GAINS AT WOODWARD, OKLA.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass nutrients, 6-yr. av.</td>
<td>15.5</td>
<td>15.5</td>
<td>8.1</td>
<td>8.1</td>
<td>5.5</td>
<td>5.5</td>
<td>5.0</td>
<td>4.9</td>
</tr>
<tr>
<td>Carotene, p.p.m.</td>
<td>345</td>
<td>345</td>
<td>276</td>
<td>276</td>
<td>106</td>
<td>106</td>
<td>97</td>
<td>88</td>
</tr>
<tr>
<td>Phosphorus, %</td>
<td>.30</td>
<td>.30</td>
<td>.21</td>
<td>.21</td>
<td>.16</td>
<td>.16</td>
<td>.16</td>
<td>.14</td>
</tr>
<tr>
<td>Calcium, %</td>
<td>.43</td>
<td>.43</td>
<td>.39</td>
<td>.39</td>
<td>.36</td>
<td>.36</td>
<td>.37</td>
<td>.33</td>
</tr>
<tr>
<td>Yearling steer gains, 8-yr. av.</td>
<td>2.27</td>
<td>2.27</td>
<td>1.98</td>
<td>1.98</td>
<td>1.70</td>
<td>1.70</td>
<td>1.34</td>
<td>1.10</td>
</tr>
</tbody>
</table>

vigorously. But it is also true that they are more susceptible to grazing injury at that time. To realize the greatest possible gains from grazing, stockmen should make moderate use of the range when the vegetation is growing actively (Table 54.2).

Deferred Grazing

Excluding livestock from ranges during the growing season has proved to be extremely beneficial to the vegetation in all tests conducted throughout the West. Unless accompanied by a sharp temporary reduction in livestock numbers on a ranch, however, the damage from enforced concentration of stocking on grazed areas is likely to offset the benefits derived from resting deferred portions. Deferment, when tested without a reduction in the total cattle numbers on comparable pastures at Woodward, showed no advantage over continuous moderate grazing.

The end result from using the deferred and reduced stocking system in successive years over an entire ranch, is improvement sufficient to permit continuous moderate grazing in the future with more livestock than was possible at the outset.

An important consideration in connection with deferment is that continuous nongrazing for several years not only is wholly impractical but has proved detrimental to the vigor, density, and composition of the native vegetation. Most native grasses of the West, and particularly of the Great Plains, were evolved, developed under, and respond to, some degree of use.

In contrast with some of the advantages derived from season-long deferment, the deferred-and-rotation system of grazing has not shown enough advantage over continuous grazing to justify the extra expense involved in fencing and water development, in tests conducted at Woodward, Okla.; Mandan, N. D.; Spur, Tex.; Burns, Ore.; Manyberries, Alberta, Canada; and in North Carolina and Australia.18, 19, 20, 21, 22 The deferred-and-rotational system consists of moving livestock from one part of a pasture to another at intervals during the growing season. Its purpose is to enable seed produced by deferment one year to become established before grazing occurs the next year and to improve the vigor


20 Hargrave, H. T. Dominion Range Experiment Station, Manyberries, Alberta, Canada. Progress Report 1937-47. 1949.


of the deferred plants. In the long-time grazing studies at Mandan, N. D., continuous grazing at moderate rates resulted in significantly higher gains and better range than were obtained from deferred-and-rotation grazing at heavier rates. The results as reported by Sarvis in 1941 and Rogler in 1944 showed conclusively that the deferred-and-rotation system of grazing was detrimental to yearling gains and had no advantage for 2-year-olds, except when compared with continuous grazing at abusively heavy rates of stocking.\(^{16, 21}\)

Alternate grazing of native range at Aridmore, S. D., showed slight advantages over continuous grazing in gains per steer and per acre, but the differences were not significant nor sufficient to offset the extra costs.\(^{24}\)

Continuous grazing of native range from April to October through the 8-year period 1942-48 gave slightly higher gains of yearling steers than deferred-and-rotation grazing by either the two- or three-divisional system, under both heavy and moderate stocking rates, near Woodward, Okla. (Table 54.3). These results may be explained partly by the inability of yearlings to make maximum use of the coarser and more mature forage on deferred parts of the range and the successive decreases in nutritive qualities of the vegetation during the growing season. Undoubtedly the main reason for failure of the rotation system to show an advantage sufficient to justify its use is the fact that concentrated stocking, an inherent part of any rotation scheme, results in abuse that offsets the natural benefit of deferment.

The alternate grazing of beef animals, between cool-season grasses in the winter and native range in the summer, is the only rotation system that has been clearly superior to continuous grazing of native range in tests at Woodward. Native western wheatgrass and Texas bluegrass, used during the cooler seasons of the year in this rotation system, resulted in saving on winter supplements, promoted winter gains, and increased yearlong

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**TABLE 54.3**  
CONTINUOUS VERSUS DEFERRED AND ROTATION GRAZING FOR SUMMER SIX MONTHS ON THE SOUTHERN PLAINS EXPERIMENTAL RANGE

<table>
<thead>
<tr>
<th>System and degree of grazing</th>
<th>8-Year Av.</th>
<th>Gain in lbs. of beef produced</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. acres per head</td>
<td>Per acre</td>
</tr>
<tr>
<td>Under heavy grazing:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous</td>
<td>4.3</td>
<td>61.0</td>
</tr>
<tr>
<td>Rotation (3-Div.)</td>
<td>4.3</td>
<td>57.4</td>
</tr>
<tr>
<td>Advantage of continuous</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under moderate grazing:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous</td>
<td>6.3</td>
<td>47.6</td>
</tr>
<tr>
<td>Rotation (3-Div.)</td>
<td>6.3</td>
<td>45.2</td>
</tr>
<tr>
<td>Advantage of continuous</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous</td>
<td>6.8</td>
<td>44.7</td>
</tr>
<tr>
<td>Rotation (2-Div.)</td>
<td>6.8</td>
<td>42.7</td>
</tr>
<tr>
<td>Rotation (3-Div.)</td>
<td>6.2</td>
<td>41.7</td>
</tr>
<tr>
<td>Advantage of continuous</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over 2-Div.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over 3-Div.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


gains. Similar results have been obtained in the Northern Great Plains and Intermountain regions in providing early spring and late fall grazing through the use of crested wheatgrass, Russian wildrye, intermediate wheatgrass, tall wheatgrass, and smooth brome. These cool season grasses also relieve grazing pressure on native range during the critical spring period.

MECHANICAL TREATMENT

Various types of contour furrowing, ridging, and cultivating were employed to advantage in conserving moisture and promoting rapid recovery of depleted ranges following the great drought of the 1930's. In many instances, the advantages failed to compensate for the costs involved. Exceptions include the excellent results reported by Barnes. He obtained a one-third increase in grazing capacity with a corresponding increase in gains of sheep from pitting and furrowing shortgrass ranges in Wyoming. Treatments of this kind offer possibilities not only for native range but also in overcoming the sod-bound condition of reseeded pastures.

WATER DEVELOPMENT

Construction of stock watering facilities throughout the West has been an important factor in distributing grazing and obtaining proper range use. More structures of this kind are needed on many ranges to relieve grazing pressure in localized areas and to utilize forage now far removed from water.

Diversion terraces and other water spreading devices also have been constructed to marked advantage in making greater use of runoff water for range forage production. More of these structures are needed in many parts of the West.

RANGE RESEEDING

Full restoration of much of the range land in need of improvement will require more than better grazing management. About 80 million acres of range land have been so badly depleted that they must be reseeded artificially if they are to recover in our generation, reports Pearse. Satisfactory methods have not yet been developed for reseeding all situations but progress is being made. Already more than 5 million acres have been so improved.

Range reseeding usually is on an extensive scale and at comparatively low cost. Plowing, except to reduce competition from undesirable plants, usually is not attempted. Seedbeds in the Great Plains are not generally prepared, ex-

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Reseeding often gives the greatest returns where it can best aid in meeting seasonal shortages in good forage. In most of the Intermountain West early spring forage is inadequate. Sowing crested wheatgrass, an early-spring and fall-growing species, provides valuable grazing. The same advantages accrue in the Southern Great Plains from the use of reseeded western wheatgrass in conjunction with native range.

Reseeding fire lanes and other portions of the piney woods ranges in the South and Southeast, to adapted grasses that retain their protein and mineral content longer than the native species, prolongs the period of good grazing.

Necessary Soil Moisture

Reseeding should be done only with protection from grazing until the seedlings are established, and only moderate grazing in the proper season thereafter.

The success and productivity of artificially seeded ranges depends largely on the use of species that are adapted to local soil and climate, and that will persist under reasonable grazing use. In this connection, probably of first importance on most western ranges is the amount of precipitation and its seasonal distribution.

Less than 8 inches annually, even in the northern part of the western range country, generally is too little to justify the risk of large-scale reseeding. Even with as much as 12 inches, a considerable part of it must be available during the growing season and very drought resistant plants must be used. A larger number of desirable forage grasses are adapted where the yearly precipitation exceeds 15 inches.

Species and Varieties

The wheatgrasses, bromes, fescues, bluegrasses, ryegrasses, and other cool-

cept for reseeding abandoned cultivated fields.

Reseeding should be where the chance of success is good. Success depends on knowing what to seed, when to seed, and how to seed economically.

Practical answers to these questions are available on several important range types, especially on depleted big sagebrush sites of the Intermountain region, on abandoned cultivated lands in the plains and foothills, on mountain meadows below good condition in other parts of the West, and more limitedly on other depleted ranges. The chance for improvement consistent with cost is greatest where valuable forage plants have been largely lost but the good topsoil retained.
season grasses can be used where soil moisture is available in the cool spring and fall seasons, as in the valleys, foothills, and mesas of the Intermountain West. Where summer rainfall is the rule, as in the Southwest and Southern Great Plains, the warm-season kinds are best adapted. These include the gramas, buffalograss, bluestems, lovegrasses, and others.

About the only species that can survive consistently in the northern range country are the hardy natives, or introductions from comparable latitudes. The former include western wheatgrass, slender wheatgrass, and mountain brome. The latter include crested wheatgrass, Russian wild-rye from Siberia, and smooth brome from Hungary.

Native species of warm-season grasses have been used most extensively for reseeding in the Southern Great Plains. A few introduced species also show promise. Chief among these at the present time are King Ranch bluestem, Turkestan or yellow bluestem, and Caucasian bluestem. These imported bluestems show unusual ability to reseed, persist, and spread under competition from other plants. These characters make them especially well adapted for the reseeding of depleted ranges.

A mixture of grasses usually is preferred to a pure seeding of a single species. Exceptions include species that differ in season of usefulness and palatability.

Comparatively unpalatable species, such as many of the wheatgrasses and weeping lovegrass, are best sown in pure stands or with species of similar palatability, and then grazed heavily enough to utilize them and maintain their succulence.

The source of seed is extremely important in successful establishment, productivity, and persistence of reseeded stands, especially for native species. Locally grown seed from plants that have proved their adaptability usually is preferred. Slender wheatgrass seed harvested in the Northern Great Plains, for example, is well suited for planting there, but in Utah produces small plants with little forage and no seed.

In the Plains it has been found that forage yield and length of growing period are greatly increased by using southern sources of seed. It is advisable at any given latitude to use seed harvested south of that latitude. Seed may be used several hundred miles north of its source without much danger of winterkilling. In contrast, seed planted south of its source usually produces plants decidedly lacking in vigor, production, and period of growth.

**Seeding Method**

Best results usually are obtained by drilling the seed to a depth of \( \frac{1}{2} \) to 1 inch and pressing the soil firmly over the seed with heavily-weighted packer attachments. Special grass drills have been perfected and widely used in the Southern Great Plains. These are equipped with depth-regulating flanges on the disks. The machines consist of a series of garden-planter-type hoppers for fine seed and a separate set of hoppers equipped with cotton-stirring devices for the chaffy seed.

Broadcasting is of limited value. Fall, winter, or early-spring seedings give best results for the cool-season species. For warm-season species, spring seedings are preferred in the Southern Great Plains and early summer seedings in the Southwest.

If wisely used, reseeded ranges will support more livestock, for longer periods and in better condition, than com-

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parable unseeded ranges. The increased productivity can be maintained indefinitely.

**RESEEDING ABANDONED FARMLAND**

Reseeded pastures on abandoned farmland at Woodward have produced two to four times the grazing from well managed native range. Similar results have been obtained elsewhere in the West. Crested wheatgrass produced over twice as much gain per acre as was obtained from native range at Moccasin, Mont. At Mandan, N. D., crested wheatgrass, grazed in the spring and early summer in combination with native range for the remainder of the season, provided a longer grazing season, and produced more beef on fewer acres than did either native range alone or crested wheatgrass alone. At Ardmore, S. D., crested wheatgrass supported more cattle and produced 41 pounds more gain per acre than native western wheatgrass.

The stubble-mulch method of seeding cultivated and abandoned farmland has proved most successful among the many methods tested in the Great Plains. The grass is drilled in undisturbed wheat stubble in the Northern Great Plains and in undisturbed sorghum stubble (broadcast or close drilled) in the Southern Great Plains. This method is especially well adapted to the warm-season grasses, which are less able than the cooler types to compete with weeds. Advantages of the stubble-mulch method include a firm seedbed fairly free of weeds at the outset, protection by stubble and hay residue against wind and water erosion, and reduced rapidity of surface drying to prevent crusting.

**QUESTIONS**

1. Why are range improvement problems so complex?
2. In your estimation, what is the major problem in the improvement of the western range lands? Why?
3. Why have brush and other troublesome plants increased generally on range lands in recent years?
4. Outline a program of control for sagebrush.
5. How is mesquite best controlled?
6. How would you recognize a range that has been overgrazed?
7. List and discuss the relative merits of several grazing management practices.
8. Outline step by step the methods recommended for the reseeding of depleted grass ranges.

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Irrigation of pastures in the arid regions of this country has been practiced since near the first settlement of the western states. The most rapid expansion in irrigated pasture acreage, however, has occurred since 1930. In 1940, there was an estimated 2.7 million acres in irrigated pasture in the 17 western states. Thousands of acres have been developed since that time. Much valuable knowledge has been gained by experience and research in recent years which has helped to improve management practices and returns from irrigated pastures.

The development of new lands for irrigation has been partially responsible for the rapid increase in pasture acreage. Discovery of the high productive capacity of Ladino clover under irrigation also has been a tremendously important factor. Economic influences, such as the low labor requirements for irrigated pastures compared with most other irrigated crops, has stimulated pasture development. Most important of all has been the need for additional summer feed to balance or supplement the ranges.

PLANT ADAPTATION

Much of the irrigated pasture acreage is on soils typical of arid conditions. Such soils usually are low in organic matter but contain adequate or excessive amounts of calcium, sodium, magnesium, potassium, carbonates, and sulfates. When brought under irrigation, these soils often contain insufficient phosphorus and nitrogen for maximum production.¹

Some of the soils of arid regions contain enough salts to depress, or even prohibit, plant growth. Many of these soils are reclaimed for pasture production by, (a) providing adequate drainage, (b) frequent irrigation to leach salts away from the root zone of plants, and (c) seeding forage plants which are tolerant to salt.²

The relative tolerance of different forage plants to salt is shown in Table 55.1. The narrowleaf birdfoot trefoil has been the most satisfactory and the most extensively used legume in irrigated pasture on salty soils. Rhodesgrass also is used for this purpose in regions of mild winter temperatures. On very salty

TABLE 55.1
SALT TOLERANCE OF DIFFERENT FORAGE PLANTS USED IN IRRIGATED PASTURES *

<table>
<thead>
<tr>
<th>Good salt tolerance</th>
<th>Moderate salt tolerance</th>
<th>Poor salt tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bermuda-grass</td>
<td>White sweetclover</td>
<td>White Dutch clover</td>
</tr>
<tr>
<td>Rhodesgrass</td>
<td>Yellow sweetclover</td>
<td>Meadow foxtail</td>
</tr>
<tr>
<td>Rescuegrass</td>
<td>Perennial ryegrass</td>
<td>Alfalfa</td>
</tr>
<tr>
<td></td>
<td>Birdsfoot trefoil</td>
<td>Tall fescue</td>
</tr>
<tr>
<td></td>
<td>Strawberry clover</td>
<td>Orchardgrass</td>
</tr>
<tr>
<td></td>
<td>Dallisgrass</td>
<td>Big trefoil</td>
</tr>
<tr>
<td></td>
<td>Sudan grass</td>
<td>Tall oat grass</td>
</tr>
<tr>
<td></td>
<td>Alfalfa</td>
<td>Ladino clover</td>
</tr>
<tr>
<td></td>
<td>Tall fescue</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Orchardgrass</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Big trefoil</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tall oat grass</td>
<td></td>
</tr>
</tbody>
</table>

* Listed in the order of decreasing tolerance within each division (Richards, 1947).

soils this grass may absorb enough salt to cause scouring of livestock which feed upon it.

Some of the soils used for pasture are heavy textured and high in organic matter. Water penetration of these soils is slow and tillage difficult. Ladino clover and narrowleaf birdsfoot trefoil produce abundantly on these soils when the phosphorus requirements of the plants are met by adequate fertilization. Deeper rooted species such as alfalfa are unsatisfactory. Ladino clover is grown successfully on soils underlaid with a clay pan layer a few inches below the soil surface. This impervious subsoil increases the efficiency of water use by preventing the percolation of water below the root zone.

Excessively wet soils are found in irrigated regions because of over irrigation, seepage from canals or ditches, and subsurface movement of water from other areas. Where this condition is difficult to correct, species tolerant to excessive moisture are used. Most outstanding among the water tolerant species used are reed canarygrass, alsike clover, strawberry clover and big trefoil.4

Numerous pasture mixtures are used in the irrigated regions of the west. Many species are sometimes used in a single mixture. The present tendency is toward simpler mixtures. As more is learned of the adaptation of species those less well suited are eliminated. Mixtures used under different situations within a state may vary as greatly as between states, depending on soils, climatic conditions, type of livestock, and personal preferences. Excellent results have been obtained using Ladino clover alone. Dallisgrass and the ryegrasses are commonly used in regions of mild winter temperatures. In colder climates, smooth brome, Kentucky bluegrass, tall oat grass, and white clover are seeded.4 Orchardgrass, tall fescue, and alfalfa also are species widely grown and well adapted for use on irrigated pastures.

LAND PREPARATION AND SEEDING

Various methods are used for irrigating pastures.5,6 Topography, soil and sub-soil texture, and the amount of available water influence irrigation procedures. Irrigation practices also are strongly influenced by local custom.


Land Preparation and Seeding

Water is applied either by sprinkling or flooding; the latter method being the most widely used. Land leveling is required for most flooding systems.

The strip-check or border method of flood-irrigation is one of the methods widely used on relatively flat areas. The land is graded to provide 0.2 to 0.5 foot fall per 100 feet; much steeper slopes also are frequently used. Small levees, about 6 inches high and 2 feet wide at the base, are built at regular intervals to guide the water across the field. The spacing between levees is influenced by soil texture, slope, length of strips and rate of water delivery to each. Narrower and shorter strips are required on sandy soils than on heavy soils, in order that the water can be forced through the field rapidly to reduce loss by percolation.

The relationships between rate of water delivery, length of check and spacing between levees for clay loam and clay soils is shown in Table 55.2. For porous loam or sandy loam soils, the rate of water delivery should be increased from two to five times, or the size of the checks correspondingly decreased. Drainage always should be provided at the lower end of fields to carry away excess water.

The contour-check method of flood irrigation is frequently used on heavy soils where the land is nearly flat or only gently sloping. Levees are constructed on the contour to form irregular basins of varying sizes. Fields are irrigated from basin to basin, starting at the upper side of the field. The vertical intervals between basins are usually 0.2 feet, or even less on very level land. Levees are often 1 or more feet high and 3 or more feet in width at the base. A large head of water is required for this system of irrigation, to prevent water from standing too long on any one basin.

Wild flooding is practiced in the Sierra Nevada foothills and throughout much of the Intermountain Region. Irrigation ditches are built on grades of $1\frac{1}{2}$ to 2 inches per 100 feet and are spaced at
intervals of 50 to 300 feet or more, depending upon the steepness of the slope. Water is applied by simply raising its level in the ditch with a dam on the downstream end of the section to be irrigated. The water spills over the lower side of the irrigation ditch flooding the land below. Little land preparation is required for this system of irrigation.

Sprinkling is used most commonly on land too steep for flood irrigation, on sandy soils requiring frequent light applications of water, and where only a small flow of irrigation water is available. Sprinkler irrigation has increased rapidly in recent years with the development of greatly improved portable systems. This method is advantageous on shallow soils which would be damaged by removal of surface soil in leveling for flood irrigation. Little or no land preparation is needed for sprinkling, other than seedbed preparation. The initial cost for equipment is rather large.

The preparation of seedbeds, seeding methods, and management of new stands for irrigated pastures differ but little from methods used when establishing all small seeded grasses and legumes (see Chapter 38). In much of the irrigated pasture region, seedings are made at the season when natural rainfall is most abundant. Establishment of stands by flood irrigation is often difficult because of soil cracking and crusting. The crusting problem is largely avoided when the sprinkler method of irrigation is employed.

**MANAGEMENT OF IRRIGATED PASTURES**

The amount of irrigation water used and frequency of application differ greatly, depending on many factors and conditions. The objective in pasture irrigation is to have at all times readily available moisture in the soil occupied by the roots of the pasture plants. Soils differ greatly in water holding capacity, and plants vary in depth of rooting. Temperatures influence the rate of water extraction. Also, growing seasons are much longer in some areas than in others. In California, a total use of 60 inches, applied in 15 irrigations, may be considered as average. However, total applications per season have ranged from 30 to 120 inches. Pastures in the interior valleys which have Ladino clover are irrigated about every 10 days.

Some of the water applied to a pasture during irrigation is wasted or lost by evaporation, penetration below the root zone, and by running off the field. In

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**TABLE 55.2**

<table>
<thead>
<tr>
<th>Flow delivered to each strip</th>
<th>Length of check for various widths of strip</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10 ft. wide</td>
</tr>
<tr>
<td>cu. ft. per sec.</td>
<td>feet</td>
</tr>
<tr>
<td>0.2</td>
<td>440</td>
</tr>
<tr>
<td>0.3</td>
<td>660</td>
</tr>
<tr>
<td>0.4</td>
<td>880</td>
</tr>
<tr>
<td>0.5</td>
<td>1320</td>
</tr>
<tr>
<td>0.6</td>
<td>1320</td>
</tr>
<tr>
<td>0.7</td>
<td>1320</td>
</tr>
<tr>
<td>0.8</td>
<td>1320</td>
</tr>
<tr>
<td>0.9</td>
<td>1320</td>
</tr>
<tr>
<td>1.0</td>
<td>1320</td>
</tr>
</tbody>
</table>

*Jones and Brown, 1949.*
Fig. 55.2 Sprinkling is one of the newer methods of pasture irrigation. Light weight, portable pipes as used here contribute greatly to the feasibility of this method. The sprinkling method is especially favored on soils which are difficult or impossible to level for flood irrigation. Northrup King and Company photo.

some cases, the amount of water lost may be as much as the amount used. Evaporation losses increase with increasing frequency of irrigation. The application of too much water, particularly on permeable soils, increases losses by penetration. In studies reported by the Irrigation Division of the California Agricultural Experiment Station, the amount of water used in transpiration and evaporation by Sudangrass, alfalfa, and Ladino clover was 17, 40 and 44 inches, respectively. The distribution of water use by months emphasizes the importance of the season of the year upon the water requirements of plants.

Ladino clover, alfalfa and other legumes may “scald” if irrigated during extremely hot weather. Stands are completely killed in severe cases. The condition is most likely to occur when temperatures are above 100°F, with little or no wind, and water stands on the field for several hours. This is avoided by providing good drainage and by irrigating at night during extremely hot weather.

Fertilization

High fertility is essential for good production from irrigated pastures. Since water is not limiting, higher rates of fertilizer application can be safely used than on most non-irrigated pastures. The fact that a considerable part of the crop harvested from irrigated pastures usually is returned to the land as manure, seems to be a good argument in favor of building up a high level of fertility.

Barnyard manure applied at 10 to 12 tons per acre has proved highly beneficial to most irrigated pastures. Liquid manure containing some solids, urine,
TABLE 55.3
WATER USED (ACRE-INCHES PER ACRE) BY TRANSPIRATION AND EVAPORATION OF THREE PASTURE CROPS GROWN AT DAVIS, CALIFORNIA *

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>1.5</td>
<td>3.9</td>
<td>5.3</td>
<td>6.5</td>
<td>8.0</td>
<td>6.6</td>
<td>5.0</td>
<td>2.0</td>
<td>1.2</td>
<td>40.0</td>
</tr>
<tr>
<td>Ladino clover</td>
<td>1.8</td>
<td>4.5</td>
<td>6.0</td>
<td>7.5</td>
<td>9.0</td>
<td>7.5</td>
<td>5.5</td>
<td>2.2</td>
<td>1.2</td>
<td>44.0</td>
</tr>
<tr>
<td>Sudan grass</td>
<td>2.0</td>
<td>3.2</td>
<td>4.0</td>
<td>3.4</td>
<td>2.2</td>
<td>1.2</td>
<td>2.0</td>
<td>1.2</td>
<td>1.2</td>
<td>17.0</td>
</tr>
</tbody>
</table>

* Data from Irrigation Division, California Agricultural Experiment Station.

and barn washings, has been applied in the irrigation water with highly satisfactory results. Nitrogen and phosphate have been the most widely needed and used. Potassium and sulfur are needed on some soils. General recommendations as to fertilizer kinds and rates cannot be made because of wide variations in soil and in plant requirements.

Grazing Management

During and immediately after irrigation, stock should be kept off irrigated areas. Because of this restriction, rotation grazing has been a common practice on irrigated pastures. Another reason for rotation grazing is to provide an adequate interval between grazings to allow the grasses and legumes to reach the period of rapid growth before removal. The rate of growth increases as the leaf area increases. A closely grazed pasture is likely to grow slowly and become weedy and unproductive. If intervals between grazings are too great, the forage will increase in fiber content and be less palatable and nutritious. Selective grazing is less common on pastures grazed in rotation than on continuously grazed pastures.

The number of subdivisions in the pasture and the number of days of grazing on each can be adjusted to provide the desired days of regrowth for a particular pasture. The relationships between numbers of pastures, days of grazing on each, and days of regrowth are shown in Table 55.4. Most of the pasture plants are productive and palatable when grazed at intervals of 20 to 30 days.

A disadvantage of rotation grazing is the difference in the quality and palatability of the forage when stock are first turned on a new field and that which remains near the end of the grazing period. Some farmers use dry cows or calves to clean-graze the field after the producing dairy cows have grazed off the best of the forage.

TABLE 55.4
PASTURE REGROWTH *

<table>
<thead>
<tr>
<th>Days on each subdivision</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>9</td>
<td>12</td>
<td>15</td>
<td>18</td>
<td>21</td>
<td>24</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>12</td>
<td>16</td>
<td>20</td>
<td>24</td>
<td>28</td>
<td>32</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>15</td>
<td>20</td>
<td>25</td>
<td>30</td>
<td>35</td>
<td>40</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>18</td>
<td>24</td>
<td>30</td>
<td>36</td>
<td>42</td>
<td>48</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>21</td>
<td>28</td>
<td>35</td>
<td>42</td>
<td>49</td>
<td>56</td>
<td>63</td>
</tr>
</tbody>
</table>

* Number of days of regrowth obtained between grazings when 3 to 10 pasture subdivisions are grazed from 2 to 7 days each.
Prevention of Bloat

The prevention of bloat is a major problem in the management of irrigated pastures. Practical experience has shown that bloat is much reduced or eliminated in pastures containing 40 to 50 per cent or more of grasses. This desired ratio is nearly impossible to maintain throughout the season. Nitrogen fertilization usually increases grasses at the expense of the legumes.

Grazing pasture legumes after they have reached the bloom stage, and feeding dry hay or straw on the pasture, have been useful bloat control measures. The overnight pasturing of Sudan grass is effective in preventing bloat the following day if cattle are on legume pasture. Bird’sfoot trefoil apparently does not cause bloat in either cattle or sheep and some farmers are using it in preference to alfalfa or Ladino clover for this reason.

Molybdenum Toxicity

Some irrigated pastures in portions of the San Joaquin Valley of California have caused a disease of cattle characterized by scouring, loss of weight, and fading and eventual loss of hair. In severe cases death may occur. The cause of this condition has been found to be the ingestion of green feed containing abnormally high quantities of molybdenum. Forages containing 20 or more parts per million cause difficulty. Pasture plants with less than 10 p.p.m. have been used with no indications of injury. Abnormally high concentrations of soluble molybdenum in the soil have been found in areas affected.

No entirely satisfactory solution has been found. Since legumes usually contain greater quantities of molybdenum than grasses, they are sometimes reduced in amount or left out of pasture mixtures. The feeding on pasture of dry roughage, produced on soils which do not have high molybdenum content, has been helpful. Rotation of livestock between badly affected and less badly affected areas also has been practiced. Use of copper in the form of copper sulfate in the drinking water has been helpful in overcoming molybdenum poisoning in some instances.

Production and Costs of Irrigated Pastures

The productivity of irrigated pastures has been measured in terms of forage yields, carrying capacities, and weight gains of cattle and sheep. Unpublished data from the California station indicate yields of green forage ranging from 22 to 36 tons per acre. In Utah, with a comparatively short growing season, yields of 16 to 17 tons of green forage per acre have been obtained. Experimental plots in Utah using fertilized improved varieties produced 5,200 pounds of total digestible nutrients per acre, or an equivalent of over 5 tons of alfalfa hay per acre.

Production in terms of live weight gain of lambs and steers has ranged up to between 400 and 500 pounds per acre in the Sacramento Valley in California. Carrying capacity records have averaged 10 animal-unit-months per acre per year in this region. An animal-unit-month is defined as the feed required per month for a mature cow producing 200 pounds of butterfat per year. This amount of feed is estimated to contain 400 pounds of total digestible nutrients. Production records as high as 30 animal-unit-months have been obtained under

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excellent management in southern areas where a long grazing season is available.

Costs of developing an irrigated pasture frequently are high. Initial costs include surveying, leveling, construction of irrigation ditches, drainage ditches, levees and turnout structures, seedbed preparation and seeding. The total of these costs has ranged from $30.00 to $130.00 per acre in California, based on 1948 price standards. Annual costs of production include labor, materials such as irrigation power and fertilizer, taxes, general expenses, depreciation, and interest on investment. The total annual costs have ranged from $17.00 to $58.00 per acre for different operating units. A little over 60 per cent of the total cost was for water and irrigation labor.

QUESTIONS

1. How do soil types influence the selection of forage species? Give examples of legumes adapted to deep well-drained soils, salty soils, heavy clay soils.


3. Discuss factors which influence frequency of irrigation and amount of water used on irrigated pastures.

4. State reasons why rotation grazing is practiced on irrigated pastures. Discuss some of the practical problems in handling livestock under a rotation grazing system.

5. Name the various methods which are used to measure the production of irrigated pastures. Which methods appear to be the most convenient to use? Which are of most use to the farmer? Why?
Dairying can be conducted most efficiently on farms where the supply of forage is adequate at all times. Pasturage and harvested forages of high quality are usually the cheapest source of the feed nutrients required by dairy animals for growth, body maintenance, or milk production. This is particularly true when the forages are grown on the farm where they are fed. Milk is produced most economically when forages make up the greater part of the ration.

**NUTRITIONAL ELEMENTS**

Forages contain practically all the essential nutritive materials, but the amounts vary with the conditions under which the forage is produced. It is important to understand these conditions in order to produce forages of high nutritive value.

**Total Digestible Nutrients**

The total digestible nutrient content of forage is affected by several factors, perhaps the most important being the stage of maturity of the plant. As forage plants mature, the protein, fat, and nitrogen-free extract fractions decrease in content while the fiber content increases. When forages are in the young stage, such as the pasture stage, the total digestible nutrient content may average 75 per cent or more, and in the hay stage it may average 50 to 55 per cent. The digestibility of all these constituents, including fiber, decreases as the plants mature.

Roughages generally are bulky feeds and since the cow’s capacity is limited, it is important to feed the kind or quality of roughage that is easily utilized. Thus, the most value can be derived from roughages if they are grazed or harvested at early stages of maturity, at which time they have a high total digestible nutrient content. The objective in producing forages should be to have them contain the largest possible amount of all the nutrients required by the cow, so they will enable her to be nourished adequately and to produce milk efficiently.

**Digestible Protein**

Cattle need digestible protein for growth, maintenance, and production. The amounts required depend on the size of the animal and the yield and butterfat content of the milk. Forages.
are good sources of protein, but their content varies greatly. Legumes generally are higher in protein than the grasses, especially at the more advanced stages of maturity. The protein in both grasses and legumes is more digestible, however, when the plants are in the early stages of growth than when they are more mature. This is illustrated in Table 56.1.

Pasturage in the immature stage is high in digestible protein and will easily meet the requirements of high milk production.¹

### Minerals

As a general rule, forages are good sources of calcium. This is especially true of legumes and mixtures consisting largely of legumes. Forages may also supply all the phosphorus needed for average production, but they are not always a dependable source of this element.

It frequently is desirable to feed more calcium and phosphorus than is provided in the forage. This can be done easily by providing the cows free access to sterilized bone meal or adding 1 per cent of bone meal to the concentrate ration.

Forages apparently supply plenty of

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TABLE 56.1

<table>
<thead>
<tr>
<th>Stage of maturity when harvested</th>
<th>% total protein</th>
<th>% coefficient of digestibility</th>
<th>% digestible protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial-bloom</td>
<td>18.2</td>
<td>77</td>
<td>14.0</td>
</tr>
<tr>
<td>Half-bloom</td>
<td>17.7</td>
<td>74</td>
<td>13.1</td>
</tr>
<tr>
<td>Full-bloom</td>
<td>16.1</td>
<td>73</td>
<td>11.8</td>
</tr>
</tbody>
</table>


sulphur, potassium, and magnesium for cattle, but not enough sodium and chlorine. Common salt is a practical way to provide these elements and cattle should have access to it at all times. Forages grown on cobalt deficient soils may not provide enough of this mineral to supply the needs of the cow.

**Vitamins**

The principal known vitamins needed by dairy animals, beyond the baby-calf stage, are vitamins A and D. Dairy animals can obtain the vitamin A they need by consuming feeds that contain vitamin A itself or they can make it from the carotene in the feed. Green plant tissue is the principal source of carotene. Good quality forages, especially pasturage and grass silage, are dependable sources of carotene. Grass silage, sometimes referred to as a hay-crop silage, refers to silage made from grasses, legumes, or grass- legume mixtures.

Vitamin D also is obtained from feeds, but the ultraviolet rays of the sun produce vitamin D in the skin of animals, and also in plant tissue after the forage has been cut. Forage that has had considerable exposure to the sun when fed to cows in liberal amounts provides the extra vitamin D needed for all practical purposes.

**PERFORMANCE OF COWS ON FORAGES**

There is plenty of experimental evidence that cows will maintain themselves, reproduce normally, and produce liberal amounts of milk and butterfat when fed entirely on forages.2, 3, 4, 6, 7

In general, when cows are fed good quality hay as the entire ration, they will produce 60 to 65 per cent as much milk as when they are fed concentrates (in addition to the hay) at the rate of 1 pound for every 3 pounds of milk produced daily. They will produce about 70 to 75 per cent as much milk on the hay alone as when fed concentrates (in addition to the hay) at the rate of 1 pound for every 4 to 6 pounds of milk produced daily.

It appears that the amount of total digestible nutrients required per unit of production is somewhat less when concentrates make up part of the ration. Milking cows generally remain in somewhat better condition and they gain more weight when concentrates are fed, but they will remain in good condition on forage alone when it is of good quality and is fed in liberal amounts.

**What the Average Cow Is Doing**

The average dairy cow in the United States weighs about 1,000 pounds and

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produces about 5,000 pounds of milk (testing 4 per cent of butterfat) per year. Assuming a lactation period of 10 months, her average daily production would be 17 pounds. During the peak of the lactation she should average about 28 pounds. To produce these amounts of milk the average cow would need 27 and 34 pounds, respectively, of average hay having a total digestible nutrient content of 50 per cent.

Woodward found that 1,000-pound Jersey cows consumed about 30 pounds of grass (hay equivalent) and 1,300-pound Holsteins, 35 pounds of grass (hay equivalent) daily when on good pasture.8,9 A survey of numerous experiments reveals that a cow weighing about 1,000 pounds will consume 28 to 30 pounds of good quality hay daily, or the equivalent in hay and silage, when this is the only feed.

It is apparent that when plenty of good quality forage is available the average cow can be fed adequately on roughage alone for at least the major part of the lactation—all except the first 2 or 3 months of the milking period. The average cow obtains about 74 per cent of her feed from forage and 26 per cent from concentrates.

In deciding how much grain to feed, the farmer will have to determine whether the saving in forage and the returns from the extra milk obtained by feeding concentrates will be worth more than the cost of the concentrates.

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TABLE 56.2

COMPARATIVE YIELDS AND COSTS OF PRODUCING TOTAL DIGESTIBLE NUTRIENTS IN FARM CROPS *

<table>
<thead>
<tr>
<th>Crop</th>
<th>Total digestible nutrients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yield per acre</td>
</tr>
<tr>
<td>Oats</td>
<td>932</td>
</tr>
<tr>
<td>Wheat</td>
<td>1,146</td>
</tr>
<tr>
<td>Barley</td>
<td>1,217</td>
</tr>
<tr>
<td>Corn silage</td>
<td>2,320</td>
</tr>
<tr>
<td>Corn grain</td>
<td>1,778</td>
</tr>
<tr>
<td>Timothy hay</td>
<td>1,257</td>
</tr>
<tr>
<td>Mixed clover and timothy</td>
<td>1,347</td>
</tr>
<tr>
<td>Soybean hay</td>
<td>1,725</td>
</tr>
<tr>
<td>Red clover hay</td>
<td>1,622</td>
</tr>
<tr>
<td>Alfalfa hay</td>
<td>2,522</td>
</tr>
<tr>
<td>Pasturage</td>
<td></td>
</tr>
</tbody>
</table>

* These are unpublished data compiled by the Bureau of Dairy Industry from studies on the costs of producing feed nutrients as published by 16 state stations prior to 1932.

IMPORTANCE OF PASTURES

Nutrients can be grown in pasturage and other forages at lower costs than in grains. It may pay to feed some concentrates to milking cows under most economic conditions. Good pastures and forage crops should be relied on to provide most of the nutrients for milk production.

Good Pasturage the Best Feed for Dairy Cattle

Pasturage is the best feed for dairy cattle and, as shown in Table 56.2, it is also the cheapest way to grow feed nutrients. The pasture program, therefore, should be given first consideration on the dairy farm. When properly developed and managed, pastures can provide the major feed supply for the dairy herd for 5 or more months of the year, depending on the area and climatic conditions. Statistics indicate that dairy cattle obtain about 37 per cent of their feed from pasture. By further development, this important crop can be made to contribute a considerably larger part of the total feed supply for milk production. The objective of a good pasture program should be to provide the herd with a uniform and abundant supply of palatable nutritious pasturage over the longest possible grazing season.

Milk Production Follows Pasture Production

One of the limiting factors in milk production is the inadequate supply of pasturage during the hot, dry summer months. During this period the growth of pasture crops falls off greatly and, because farmers do not provide enough other feed, milk production also falls off materially. The condition of the cows deteriorates also. As a result, it is difficult to get them back on a higher level of production later in the season when pasturage becomes more plentiful, or in the fall when they are maintained under barn-feeding conditions. This contributes greatly to the uneven milk supply and the demoralization of markets.

Pasture Programs for Abundant Grazing

Permanent pasture cannot meet the needs of the herd during all of the season. It is too irregular in production, except possibly when irrigated. This type of pasture must be supplemented with
grazing from rotation pasture, temporary pasture, or meadow aftermath. Grain crops and certain annual or perennial grasses and legumes, together with proper fertilization, can be used to provide adequate grazing in the hot, dry midsummer and also to extend the season earlier in the spring and later in the fall and early winter. This is especially true in the southern states where there is opportunity to approach year-round grazing. To provide year-round grazing it often is necessary to allow forage crops to grow ungrazed for a period in the late fall and early winter, in order to produce an accumulation of herbage for grazing during the periods when the temperature is too low to support growth. Figure 56.1 illustrates how different crops and types of pastures can be used to develop an adequate supply of pasturage on farms in northern and southern areas.

Rotational Grazing Increases Utilization of Pasturage

It should be remembered that for the best results pasturage must be grazed or harvested when it is in an immature stage of growth. At that stage it is more nutritious and palatable and it has a more stimulating effect on milk production. Various management practices can be used to keep pasturage in this condition throughout the summer.

Under most conditions it is advisable to divide a pasture area into smaller units that can be grazed in rotation. This makes for more efficient utilization of the herbage and it confines the grazing animals so that they can obtain their fill without walking great distances.

Pasturage generally is at its best when the grasses and legumes are from 4 to 8 inches in height.

Several researches have shown that increases of 7 to 10 per cent in milk yields are obtainable from rotational grazing. In addition, rotational grazing aids in keeping the herbage in a uniform stage of development and in giving it a rest period after each grazing; it helps to control the amount and quality of herbage on the pasture, by enabling the farmer to harvest a portion for hay or silage and thus avoid excess early spring growth which would soon become too mature for grazing. It aids in maintaining a desirable grass-legume mixture; it enables the farmer to clip the pastures, apply fertilizer, manure, or water without disturbing the cattle; and helps him follow a renovation program on a portion of the pasture each year if that seems desirable.

Clipping Pasture Is Important

From the standpoint of efficient utilization of pasturage, it is important to control the amount of ungrazed herbage and weeds and to spread the dung from time to time. This should be done by clipping the pasture as often as seems necessary each season. Clipping should be done right after the cows have finished grazing a plot and are moved on to the next. Yields have been increased as much as 20 per cent by this practice.

Preventing Bloat

As indicated earlier in this chapter, a relatively high percentage of legumes in the pasture is desirable because legumes increase the yield, palatability, and nutritional value of the forage. It is also important, however, to have considerable grass present in the herbage. Pastures that are composed almost entirely of legumes, such as alfalfa, Ladino clover, and sweetclover, are more likely to cause bloat in the grazing animals.

It is a good idea to give the cows some dry hay or silage in the morning before they go on pasture, because such ma-
terial in the rumen tends to prevent bloat. Some farmers apparently have avoided bloat by keeping their cows off legumes early in the mornings when there is heavy dew on the pasturage. The exact causes of bloat are not too well known, but its development can be pretty well kept under control by following the above suggestions.

**Preventing Cyanide Poisoning**

Sudangrass is a popular supplementary pasture crop in many areas because of its high productivity and because it is suitable for grazing in midsummer when permanent pasture is apt to be scarce. It should be used much more extensively in those areas where it does well.

Farmers sometimes experience losses from cyanide poisoning in cattle grazing Sudangrass. If proper care is taken in grazing Sudangrass, little trouble need be encountered. Sudangrass is most dangerous when it is young and dark green in color. Sudangrass should be allowed to grow to a height of 1½ to 3 feet before it is grazed.

**Preventing Grass Tetany**

Many farmers, particularly in the southern areas, use grain crops for grazing in the early spring and late fall. Occasionally cows that are turned on lush, green, rapidly growing grain forage develop a condition known as grass tetany, which frequently results in sudden death. Farmers should use this kind of pasture with caution, allowing the cows on it for only short periods of time until they are thoroughly accustomed to it.

**Keep Cows on Pasture Comfortable**

Consideration should be given to the comfort of the cows on pasture. They should not be required to travel long distances to and from pasture and during grazing. Energy expended in this way cannot be used for milk production. Plenty of water, salt, and shade should be provided and the cows should be kept free of flies and other insect pests.

**Supplementing Pasturage With Barn Feed**

While it has been amply demonstrated that productive pastures can provide the essential nutrients for liberal milk production throughout the summer season, relatively few of them do so. In the case of cows that are capable of high production, it is difficult for them to consume enough nutrients even on good pasture to support them.

It usually is profitable to feed milking cows enough nutrients to enable them to produce at, or near, their maximum ability and to maintain themselves in good condition. On pasture alone, unless it is very poor, dry cows should be able to maintain themselves in good condition for calving.

Much of the supplemental nutrients needed when cows are on pasture can be provided by feeding hay or silage in racks in the pasture or in the barn at milking time. Grass silage that is made from surplus pasture in the spring may be fed in this manner later in the summer. If good hay or silage is scarce or not available, a low-protein concentrate mixture or one of the grains such as corn can be fed. Table 56.3 gives a suggested schedule for feeding hay and silage, or concentrates, to cows producing at different levels when grazing on good or average pasture.

**Pasturage for Heifers and Calves**

Pasturage is an excellent feed for dairy heifers and calves. However, young animals may not have capacity to consume enough young succulent pasturage or coarse dry pasturage to meet their requirements. For this reason, it is prefer-
Forages for Dairy Cattle

TABLE 56.3

SUPPLEMENTARY FEEDING SCHEDULE FOR COWS ON PASTURE

<table>
<thead>
<tr>
<th>Milk butterfat test (%)</th>
<th>Lbs. of milk daily that pasture alone might produce</th>
<th>Lbs. of hay, corn silage, or concentrates needed to produce each additional 5 Lbs. of milk daily</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Good pasture *</td>
<td>Average pasture †</td>
</tr>
<tr>
<td>3</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>30</td>
<td>15</td>
</tr>
<tr>
<td>5</td>
<td>25</td>
<td>12</td>
</tr>
<tr>
<td>6</td>
<td>20</td>
<td>10</td>
</tr>
</tbody>
</table>

* Good pasture is young and succulent and abundant enough so that cows can graze their fill in 1 to 1½ hours several times daily.
† Average pasture is short and young or of somewhat advanced growth and is not palatable or abundant enough to permit cows to graze their fill in 2 to 3 hours several times daily. Poor pasture will no more than maintain the weight of cows. Some hay, silage, and/or grain may be necessary for cows to maintain their weight if the pasture is very poor.
‡ If hay and silage are fed together, 3 pounds of silage will replace 1 of hay.

able to provide young animals with pasturage that consists of a mixture of grasses and legumes and that is in the intermediate stage of growth. A study by Hodgson at the Washington Agricultural Experiment Station illustrates how well heifers will do on good pasturage. In this study Holstein heifers ranging in age from 8 to 13 months were carried on good pasture for 200 days. They made normal growth in stature and gained at the rate of 1.5 pounds per day.

Heifers of this age can be supported on good pasture alone up to their first calving at 2 to 2½ years of age, and they will be in suitable condition to begin lactation. If the pasturage is not plentiful, however, supplemental feed (either hay or concentrates) should be fed to put them in suitable condition for calving.

Calves ranging from 6 to 8 or 10 months of age may obtain a considerable part of their nutrients from pasture, but they should be given hay and some concentrates in addition, to promote satisfactory growth and development. If given unlimited access to succulent pasturage, young calves will not eat enough dry feed in addition to maintain proper conditions in the digestive tract and to sustain adequate growth. While pasturage is good for these young calves, their access to it should be controlled.

HARVESTED FORAGES FOR WINTER FEED

In most dairy sections, pasturage provides the major feed supply for at least 5 months of the year. Harvested forages, including hays and silages, are produced to take the place of pasturage during the nonpasture season and to supplement deficient pasturage in season. Therefore, they should approximate pasturage as nearly as possible in palatability and nutritive value. The same considerations should be given to the production of these forages as is given to the production of pasturage in order to obtain the maximum yield of feed.

Since forage crops make their growth in the summer, but for the most part are fed during the winter, it is necessary to harvest and store them for later use. This presents one of the most difficult problems with which the farmer has to cope in most areas of our country—that of efficiently conserving the high nutritional properties of forages during harvesting and storage.

Hay alone contributes 26 per cent of
the total feed supply of dairy cattle. Another 10 per cent comes from other harvested roughage, such as silage—both corn and grass—and fodder. Because of the important position these feeds occupy in the dairy-cow ration, they must be of good quality if the best results are to be obtained from their use. More dependence could be placed on harvested forages by increasing the amounts included in the average ration, if they were of the right kind and of high quality. One of the greatest defects in present-day feeding of dairy cattle is the poor quality of the hay that makes up a large part of the ration. Generally speaking, the silage is of much better quality than the hay. Poor quality hay is lower in feeding value because much of the original nutrient content of the standing crop was lost during the time it was being made into hay. New and improved methods of hay making and alternatives to field curing are aiding farmers in correcting this situation, with the result that more and better roughage is being produced.

**Effect of State of Maturity on Value of Harvested Forage**

One of the important factors affecting the feeding value of harvested forages is the stage of maturity at which the crop is cut. The effect of stage of maturity on the yield and nutritional value of alfalfa has been studied by the Bureau of Dairy Industry. Results of these studies are shown in Table 56.4.

In this research it was found that not only the protein content, the digestibility of the protein, and the total digestible nutrient content decreased, but also the yield of dry matter and total digestible nutrients decreased, as the crop advanced in maturity from the initial-bloom stage, through the half-bloom stage to the full-bloom stage.

When the three kinds of hay were fed to milking cows as their only feed it was found that the initial-bloom alfalfa was
TABLE 56.4

EFFECT OF MATURITY STAGE ON ALFALFA YIELD AND ITS MILK-PRODUCING VALUE

<table>
<thead>
<tr>
<th>Stage of maturity when harvested</th>
<th>Initial bloom</th>
<th>Half bloom</th>
<th>Full bloom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield from hay, per acre:</td>
<td>Lbs.</td>
<td>Lbs.</td>
<td>Lbs.</td>
</tr>
<tr>
<td>Dry matter</td>
<td>7,896</td>
<td>7,778</td>
<td>6,061</td>
</tr>
<tr>
<td>Total digestible nutrients</td>
<td>4,660</td>
<td>4,413</td>
<td>3,269</td>
</tr>
<tr>
<td>Digestible protein</td>
<td>1,106</td>
<td>1,016</td>
<td>722</td>
</tr>
<tr>
<td>Milk-producing value, per acre:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production of 4% fat-corrected milk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hay consumed by experimental cows:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per cow per day</td>
<td>40.6</td>
<td>41.0</td>
<td>40.9</td>
</tr>
<tr>
<td>Per lb. of butterfat produced</td>
<td>36.8</td>
<td>44.5</td>
<td>45.4</td>
</tr>
</tbody>
</table>


the most nutritious and the full-bloom stage the least nutritious, although the amount of the different hays consumed per day by the cows was about the same. When both the yield of alfalfa per acre and the effect of the hays on milk production are considered, harvesting alfalfa in the initial- and half-bloom stages is to be preferred. This is important from the standpoint of realizing the greatest milk production from the acres a farmer has in hay production.

Other researchers, who studied other kinds of forages, have confirmed these results. Under present-day average farm conditions, most farmers allow their forages to become too mature before harvesting. This may result in higher yields of dry matter per acre but, from the standpoint of feeding value and total nutritive effect in terms of animal production, farmers should be more interested in the yield of digestible protein and total digestible nutrients than in yield of dry matter.

AMOUNTS OF HARVESTED FORAGE COWS WILL CONSUME

An important factor determining the extent to which farmers can depend on forages for nutrients for milk production is the amount of hay and silage the cows will eat. This depends on a number of conditions, not all of which are well understood.

Size and Production

Undoubtedly the size of the animal, or its physical capacity, is an important factor. A good producing cow should eat about 2.5 to 3 pounds of hay daily (or the equivalent in other forage) per hundred pounds body weight, when it is her only feed. Within the limits of her physical capacity, the amount of hay or other forage a cow will consume is related to the amount of milk she is producing.

Silage and Concentrates

The addition of silage and concentrates to an all-hay ration reduces the consumption of hay. For example, when the experimental cows were fed the all-alfalfa ration during the nonpasture period they consumed an average of 34.8 pounds of hay per day. When they were fed alfalfa hay and corn silage they consumed 22.8 pounds of hay and 42.2 pounds of silage daily.

Legumes Compared With Grasses

Hays made from legumes generally are considered better for milk production than those made from grasses. Legume hays usually are more palatable but good
production can be realized from grass hays. It is more important to cut grasses for hay at an earlier stage of maturity than is necessary with legumes, especially clovers and soybeans, in order to obtain a feed of high palatability and nutritional value. In experiments reported by Graves cows fed good quality immature grass hay produced 11,146 pounds of milk and 404 pounds of butterfat, as compared with 11,762 pounds of milk and 437 pounds of butterfat when on good alfalfa hay.\(^9\)

Experience has shown that cows will get along well on either legume hay or grass hay but they will not eat as much of either as they will of a combination of the two. This will vary, of course, depending on the kind and quality of the hays. Cows fed for entire lactations on concentrates and alfalfa hay, or on concentrates and alfalfa and timothy hay, consumed an average of 2.2 pounds more hay per day on the latter ration.\(^10\)

**FORAGE HARVESTED AS SILAGE**

Forages harvested and preserved as silage also make excellent feed for dairy cattle. Making silage is a good way to hold forage not needed in one season in reserve for future periods of short feed supply.

**Corn Silage**

Corn silage is very palatable and cows consume it in large amounts. It supplements others feeds effectively and appears to have a favorable effect on cows. When good quality corn silage is the only roughage fed it will be consumed in large amounts over long periods of time. Cows fed corn silage and concentrates have produced per year as much as 8,000 to 10,000 pounds of milk. For best results corn should be ensiled when the kernels are in the late dough or early dent stage. When ensiled by this time at least, corn silage is a good and dependable source of carotene. It is a poor source when ensiled after the grain has matured.

**Grass Silage**

Grasses and legumes are being made into silage in increasing amounts in the humid regions. It is an effective way to reduce the loss of feed nutrients during harvesting. Recent research indicates that siloing forages conserves a larger part of the feed nutrients in these crops and that the silages are as valuable for milk production as hays made from the same crops.\(^11\) See Table 56.5.

It would appear that good grass silage can be substituted for part or all of the hay in the ration with satisfactory results. Whether or not forages should be made into hay or silage, therefore, will depend on which method will be most effective in conserving the largest amount of feed nutrients contained in the crop.

**ROUGHAGE AND CONCENTRATE FEEDING SCHEDULE**

The foregoing discussion shows that harvested roughages can be depended on to make up the major part or all of the ration of dairy cows, depending somewhat on the producing ability of the cows or on the level of milk production desired. The extent to which roughage can be relied on will depend also on its total digestible nutrient content and on its digestible protein content, and to some extent on its palatability. Mixtures of grasses and legumes, where the latter make up an important percentage of the mixture, and losses due to harvesting are

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not great, can be depended on to provide a high enough digestible protein content. Table 56.6 lists a number of different kinds of hays, together with their digestible protein and total digestible nutrient contents.

It is apparent from Table 56.6 that high-protein concentrates are not needed to supplement roughages that contain considerable legumes. Cereal grains or mixtures of these grains and their by-products with a digestible protein content of 8 to 10 per cent also are adequate. Small amounts of the oil seed meals can be used to increase the protein content to a desired level.

**ROUGHAGES FOR DRY COWS, HEIFERS AND CALVES**

Dry cows are able to maintain themselves, and develop a satisfactory condition for calving and subsequent lactation, with no other feed than plenty of good roughage. In fact, they frequently
Roughage for Dry Cows, Heifers and Calves

TABLE 56.5
Harvesting Losses and Production Values of Alfalfa Preserved as Silage and Field-cured Hay

<table>
<thead>
<tr>
<th></th>
<th>Experiment 1</th>
<th>Experiment 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Silage</td>
<td>Field-cured hay, well-cured</td>
</tr>
<tr>
<td>Crop dry matter conserved, %</td>
<td>84</td>
<td>79</td>
</tr>
<tr>
<td>Crop protein conserved, %</td>
<td>87</td>
<td>70</td>
</tr>
<tr>
<td>Milk yield per cow, lbs. daily</td>
<td>34.2</td>
<td>34</td>
</tr>
<tr>
<td>Weight gain per cow, lbs. daily</td>
<td>0.4</td>
<td>0.2</td>
</tr>
<tr>
<td>Dry matter consumed per 100 lbs. milk, lbs</td>
<td>91.5</td>
<td>92.9</td>
</tr>
<tr>
<td>Indicated milk yield per acre, %</td>
<td>112</td>
<td>100</td>
</tr>
</tbody>
</table>

TABLE 56.6
Digestible Protein Content and Total Digestible Nutrient Content of Commonly Used Forages *

<table>
<thead>
<tr>
<th>Forage</th>
<th>% Digestible protein</th>
<th>% Total digestible nutrients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa hay, av.</td>
<td>10.6</td>
<td>50.3</td>
</tr>
<tr>
<td>&quot; &quot; leafy (25-28% fiber)</td>
<td>12.4</td>
<td>53.7</td>
</tr>
<tr>
<td>&quot; &quot; stemmy</td>
<td>8.2</td>
<td>47.5</td>
</tr>
<tr>
<td>&quot; &quot; 1/2 to 3/4 bloom</td>
<td>11.0</td>
<td>50.1</td>
</tr>
<tr>
<td>Alfalfa and timothy hay</td>
<td>6.8</td>
<td>50.2</td>
</tr>
<tr>
<td>Smooth brome hay, av.</td>
<td>5.0</td>
<td>48.9</td>
</tr>
<tr>
<td>Smooth brome hay, before bloom</td>
<td>7.4</td>
<td>48.2</td>
</tr>
<tr>
<td>Clover hay, red, av.</td>
<td>7.0</td>
<td>51.9</td>
</tr>
<tr>
<td>Clover hay, red, before bloom</td>
<td>12.0</td>
<td>56.4</td>
</tr>
<tr>
<td>Clover hay, sweet, second year</td>
<td>10.5</td>
<td>49.9</td>
</tr>
<tr>
<td>Clover and mixed grass hay</td>
<td>5.2</td>
<td>50.5</td>
</tr>
<tr>
<td>&quot; &quot; &quot; 2nd crop</td>
<td>7.9</td>
<td>53.6</td>
</tr>
<tr>
<td>Clover and timothy, av.</td>
<td>4.4</td>
<td>48.0</td>
</tr>
<tr>
<td>Grass hay, good quality</td>
<td>3.5</td>
<td>51.7</td>
</tr>
<tr>
<td>Lespedeza hay, av.</td>
<td>9.2</td>
<td>52.2</td>
</tr>
<tr>
<td>Soybean hay, av.</td>
<td>11.1</td>
<td>50.6</td>
</tr>
<tr>
<td>Timothy hay, av.</td>
<td>2.9</td>
<td>46.9</td>
</tr>
<tr>
<td>&quot; &quot; &quot; before bloom</td>
<td>5.6</td>
<td>50.2</td>
</tr>
</tbody>
</table>


will do this on the poorer part of the roughage supply, especially if the dry period is prolonged somewhat.

Heifers 10 months of age and older can be carried through the winter satisfactorily and economically with no other feed than roughage. For the younger heifers, however, the roughage should be of good quality and palatable so they will eat enough to satisfy their nutrient requirements for growth. Older heifers generally will consume enough of the lower quality roughage to keep them in satisfactory condition and growing normally. A considerable part of the roughage for heifers of this age can be grass silage or corn silage. It usually is good practice to give late springing heifers some concentrate feed in addition to the roughage.

Good quality roughage, preferably legume or mixed hay, should be given the young calf as early in life as it will begin eating it. The roughage should be green in color and high in carotene because, after whole milk is removed from the ration, carotene in forage is the calf's main source of vitamin A unless a vitamin A supplement is added to the ration. In addition, it is important to get young
calves eating significant amounts of roughage early because this promotes the development of the rumen and the activity of the microflora in the rumen, which synthesize certain vitamins and perhaps other nutritive substances that contribute to the nutritional welfare, health and development of the calf.

While the young calf should be encouraged to eat as much roughage as possible, it should also be fed concentrates to provide additional amounts of digestible protein, total digestible nutrients, and minerals, until it has developed enough to obtain these nutrients from roughage. It is seldom necessary to feed a calf under 6 or 8 months of age more than 5 pounds of concentrates daily. Many farmers feed no more than 3 pounds.

Providing the Feed Required by the Herd

In developing a cropping program, the dairy farmer should endeavor to grow crops that will produce as nearly as possible all the nutrients required by his herd. On most farms, a crop rotation should be employed which places emphasis on pasture and other forages, but which also includes corn for silage and grain and some small grains that will serve as companion crops for new seedings and at the same time provide energy-rich concentrates to supplement the forages. It ordinarily is not profitable to depend on purchased forages and concentrates for a large part of the feed supply.

EFFECT OF FORAGES ON NUTRITIONAL VALUE OF MILK

The primary interest in forages has been the efficient feeding of dairy cattle, but forages also are important from the standpoint of improving the nutritional value of milk. Milk and butter are important sources of vitamin A. The cow makes vitamin A from the carotene in the forage she consumes. Since the cow gets most of her carotene from forage, the amount she consumes governs the vitamin A value of the milk and its degree of yellow or golden color.

Green growing forage is rich in carotene. Dry, mature, bleached-out forage is not. Milk produced by cows on pasture varies in its vitamin A value according to the greenishness and abundance of the herbage. Carotene is found mainly in the leaves of the plants. When forage is exposed to light and air during harvesting and when leaves are lost, carotene is lost. Ensiling forages is a good way to conserve carotene. Drying methods, such as barn finishing and dehydration, which speed up the removal of forage from the field and shorten the drying time, reduce carotene loss. Such methods do not prevent storage losses of carotene, however.

Farmers may not be receiving a monetary reward for supplying milk of high vitamin A value. But in doing so they build public confidence in their product.

QUESTIONS

1. Develop a cropping program, major emphasis on grassland farming, for a 120-acre dairy farm that will furnish the necessary pasture, forage and grain crops to feed a dairy herd. Determine how many milking cows and young stock the farm will support using average crop yields for your area.
2. What are the important factors determining the amount of hay dairy cows will consume?
3. Plan a rotational grazing scheme for a herd of 30 milch cows and a 50 acre permanent pasture. List five important advantages of rotational grazing.
4. On a dairy farm, what are the objectives of a good pasture program?
5. To what extent can dairymen depend on forages for feeding milking cows? What factors should be considered in determining the amount and kind of supplemental feed that should be given in addition to the forage?
Utilization of Forages With Beef Cattle

The beef cattle of the United States obtain more than one-half of their total feed in the form of pasturage, and more than 90 per cent of their total intake is hay, silage and pasturage. This gives a good indication of the importance of roughages to the man with a beef herd.

The average beef steer will consume from 50 to 75 pounds of green forage daily, depending upon animal size and the moisture content of the forage. The grazing of beef cattle is one of the easiest, most convenient and most economical methods of marketing an important agricultural product, namely pasturage. Large acreages of land unsuited for cultivated crops or forest are an important source of income and the basis of our livestock industry.

Also, pasture grasses and legumes are considered natural resources which rank high in the conservation of soil and water.

Beef cattle are particularly well suited to the utilization of pasturage. They are hardy, requiring little attention on good pasture from the beginning to the end of the grazing season. Beef cattle are able to thrive on a variety of pastures, the chief requirement being sufficient forage of suitable nutrient quality to meet their requirements for maintenance and growth. Beef cattle are not as selective in their grazing habits as some other classes of livestock and therefore present fewer problems in pasture management.

IMPORTANCE OF PASTURES IN BEEF PRODUCTION

Pastures and pastureage are important in a livestock economy from several points of view:

- PROVIDE ECONOMICAL FEED SOURCE. This statement is open to challenge only on poor, unproductive pasture land. Good pasture will produce gains at a much lower cost per pound than any other method of feeding.

- ENHANCE HEALTH OF LIVESTOCK. Cattle, as well as other classes of livestock, are more thrifty on good pasture. They derive the maximum benefit from fresh pasturage. Losses of nutrients occurring in harvesting and storing forages are eliminated when the animal harvests its own forage directly.

- SAVE LABOR. Pastures save labor in that livestock on pasture harvest their own feed. Every added day that cat-
tle are on pasture saves the labor necessary to harvest and store crops to feed the animals. Obviously each season credited to a pasture decreases the accumulated annual costs of that field.

**PASTURE LAND GIVES FLEXIBILITY.** In cash grain areas a good pasture program gives flexibility to the cropping system. Beef cattle are particularly well adapted to cash grain areas because they consume large quantities of coarse roughage, as cornstalks and other crop residues, that otherwise would be lost.

**CUSHION FLUCTUATIONS IN MARKETS AND PRICES.** Pasture and range act as a cushion against the flooding of markets and sharp price declines. Beef cattle are well suited for grazing rough land, and make good use of forages under climatic conditions unsuited for some other classes of livestock.

**PROBLEMS OF BEEF PRODUCTION ON PASTURE**

As opposed to the favorable statements previously made, there are some factors that militate against the production of beef on pasture. Some of the more important of these are as follows:

1. The production of feeder cattle is an enterprise calling for larger pasture acreages than ordinarily are found on average midwestern farms. It is essentially a large acreage farm or range enterprise. Beresford states that the average Iowa farm is too small to provide an adequate income when the entire farm is used for growing pasture and roughage. At the Dixon Springs Station in southern Illinois, where large acreages are available for pasture and

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Grasses and Legumes for Beef Cattle Pasture

TABLE 57.1
CARCASS DATA ON STEERS SLAUGHTERED AT URBANA IN 1935 *

<table>
<thead>
<tr>
<th>Ration</th>
<th>Carcass grade</th>
<th>Color of fat</th>
<th>% dressing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full fed, dry lot †</td>
<td>Choice</td>
<td>Creamy white</td>
<td>58.3</td>
</tr>
<tr>
<td>Full fed on alfalfa pasture</td>
<td>Choice</td>
<td>Slightly yellow</td>
<td>57.3</td>
</tr>
<tr>
<td>Full fed on sweetclover pasture</td>
<td>Choice</td>
<td>Creamy</td>
<td>58.5</td>
</tr>
<tr>
<td>Full fed on bromegrass pasture</td>
<td>Good</td>
<td>Yellow</td>
<td>55.7</td>
</tr>
<tr>
<td>Alfalfa pasture</td>
<td>Medium +</td>
<td>Slightly yellow</td>
<td>56.8</td>
</tr>
<tr>
<td>Sweetclover and lespedeza pasture</td>
<td>Medium +</td>
<td>Slightly yellow</td>
<td>55.2</td>
</tr>
<tr>
<td>Bromegrass pasture</td>
<td>Medium −</td>
<td>Yellow</td>
<td>51.7</td>
</tr>
</tbody>
</table>

* Adapted from Bul. 478, Ill. Agr. Exp. Sta.
† The roughage was alfalfa hay.

roughage production on land of relatively low initial cost, cattle production is a profitable enterprise. The same can be said of other areas in the several midwestern states.

2. Difficulty in getting cows to calve within a reasonable period in the fall has been stated as an obstacle. This is primarily a matter of management. Many beef cattle producers in the Corn Belt prefer spring calving and manage their cow herds accordingly.

3. Grass-fattened cattle usually are graded lower than grain-fed cattle and hence bring a lower price on the market. Few areas produce highly finished beef on grass alone, but thousands of head of grass-fat cattle are marketed annually.

Bull and Francis gave the following carcass data from a pasture experiment at Urbana, Illinois.2,3

GRASSES AND LEGUMES FOR BEEF CATTLE PASTURE

The grasses and legumes well suited to provide beef cattle pasture are the same as those used for other classes of livestock. In addition to the commonly cultivated grasses and legumes found in permanent and rotation pastures of the humid states, they utilize the native range vegetation of the less humid areas of the Great Plains and the western states. Since the production of milk and other dairy products is a negligible factor with beef cattle, forages ordinarily not acceptable for dairy cattle because they may taint milk and butter usually are acceptable for beef cattle. Certain areas of the United States, where prevalence of wild onions, garlic, and leeks make the production of market milk and butter costly, are good beef production areas.

In the humid areas, smooth brome, orchardgrass, Kentucky bluegrass, timothy, tall fescue, Bermuda-grass, Dallisgrass, redtop, and reed canarygrass are the most widely grown species. These species vary widely in their production, adaptation, nutritive value, and growth habits. The more important forage legumes include alfalfa, alsike, red, Ladino, hop, and white clovers, the sweetclovers, and the lespedezas.

Differences in soil fertility cause variations in forage yields and animal gains. Snapp has reported the gains by yearling beef cattle on several pasture species and mixtures for the period 1935 to 1940 (Table 57.2).4 Soil type and fertility were comparable.

Kentucky bluegrass and orchardgrass are two of the earlier developing and ma-

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TABLE 57.2
SEASON GAINS OF YEARLING CATTLE ON DIFFERENT KINDS OF PASTURE AT URBANA, ILLINOIS

<table>
<thead>
<tr>
<th>Kind of forage</th>
<th>Net gain in lbs. per acre *</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1935</td>
</tr>
<tr>
<td>Kentucky bluegrass †</td>
<td>170</td>
</tr>
<tr>
<td>Bromegrass-alfalfa</td>
<td>342</td>
</tr>
<tr>
<td>Orchardgrass-alfalfa</td>
<td>245</td>
</tr>
<tr>
<td>Brome and bluegrass †</td>
<td>317</td>
</tr>
<tr>
<td>Timothy and clover mixture</td>
<td>172</td>
</tr>
<tr>
<td>Reed canarygrass †</td>
<td>170</td>
</tr>
<tr>
<td>Timothy, sweet and red clover</td>
<td>170</td>
</tr>
<tr>
<td>Sweetclover (2nd year)</td>
<td>220</td>
</tr>
<tr>
<td>Alfalfa (2nd year)</td>
<td>383</td>
</tr>
<tr>
<td>Korean lespedeza</td>
<td>166</td>
</tr>
<tr>
<td>Oats (green)</td>
<td>223</td>
</tr>
<tr>
<td>Timothy</td>
<td>243</td>
</tr>
</tbody>
</table>

* Net gain per acre after deducting the gain equivalent of any feed fed on pasture.
† Forage yields shown in Table 57.3.

... turing species of grasses valuable as beef cattle pasture. The latter species is not as prevalent over as large an area as is the bluegrass. However, where it occurs it furnishes more good succulent pasturage than bluegrass. Unless it is maintained in a relatively close-cropped condition, it quickly becomes coarse and unpalatable. Both of these grasses are ready for pasturing by mid-April in the lower Corn Belt.

Timothy is less valuable as a pasture grass than is bromegrass. Bromegrass has become one of the foremost pasture grasses in the Corn Belt and in the Northwest. It does not become dormant as early as bluegrass, and often continues in good grazing condition during the entire summer.

The present trend in pastures for cattle favors a good percentage of legumes in the seeding mixture. Legumes such as alfalfa, sweet, red, and alsike clovers, lespedeza, and other species provide excellent summer forage, usually available in a green and nutritious condition after grasses have passed the best stage of utilization. To bring about a balance between grass and legume species in a seeding mixture, many farmers use higher percentages of legume seed than of grasses. A common seeding proportion has been 12 or more pounds of smooth bromegrass seed plus 5 or 6 of alfalfa an acre. At the present time these proportions are almost reversed. The more common rate is 12 pounds of alfalfa and 5 or 6 of bromegrass.

In the central states, many livestock producers make large use of sweetclover. Although it is lacking in palatability, it has a high carrying capacity. Cattle do not seem to gain rapidly on the green, succulent pasture of early spring. Sweetclover, especially, is "washy," or laxative. Cattle make the best gains on both grass and legumes after these crops have passed the early stages of growth.

Forage yields on several of the fields included in Table 57.2, for the years 1935 to 1937, inclusive, are shown in Table 57.3. Some difference in the quality of the forages must be considered as being the reason for differences in animal gains since forage yields were sufficiently high in all cases.

FORAGE CONSUMPTION AND YIELDS

Forage yields and forage consumption per acre by cattle are not closely correlated. Obviously the relationship is dependent upon the stocking, age, and size
Forage Consumption and Yields 657

Fig. 57.2 "Bromegrass has become one of the foremost pasture grasses... It does not become dormant as early as bluegrass... The present trend... a good percentage of legumes... alfalfa, sweet, red, and alsike clovers, lespedeza and other species... in a green and nutritious condition after grasses have passed the best stage of utilization." (See p. 656.) Steers on a bromegrass-Ladino clover experimental pasture at the Illinois Station. Ill. Agr. Exp. Sta. photo.

of animals and such climatic conditions as temperature and moisture in relation to the characteristics of the herbage growth. One of the most important factors is the kind and condition of the forage and stage of growth. Some investigators use an arbitrary figure to indicate the quantity of forage consumed from a given pasture. This figure, based on normal stocking of animals, is frequently estimated as 70 per cent. For example, if a field produces 5,000 pounds of dry matter an acre, the normal consumption is calculated as 3,500 pounds. The difference of 1,500 pounds is considered as residual yield at the end of the grazing season and forage unavailable or not acceptable to livestock because of droppings, trampling, bedding down areas, or for other reasons. One of the serious weaknesses in pasture research is the lack of a simple, economical, and rapid method of obtaining accurate consumption and utilization data.

Garrigus devised a method for calculating forage consumption. This method is based on the assumption that if the consumption defecation ratio by a given steer could be determined, his dry matter intake could be calculated from data on dry matter defecated. In an Illinois experiment the net energy maintenance requirements of each steer, the net energy values of the tested forages when fed at the maintenance level, and the pounds of dry forage needed to provide a daily maintenance ration of net energy for each steer were either determined or calculated. Garrigus and Rusk, using this method, found that the relationship between steer weight and per cent of maintenance requirement consumed was not

658 57. Utilization of Forages With Beef Cattle

**TABLE 57.3**

**ACRE YIELDS OF OVEN-DRY FORAGES FOR THE YEARS 1935 TO 1937—URBANA, ILLINOIS**

<table>
<thead>
<tr>
<th>Kind of forage</th>
<th>Yield, lbs. per acre</th>
<th>1935</th>
<th>1936</th>
<th>1937</th>
<th>Av.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reed canarygrass</td>
<td>6,426</td>
<td>4,975</td>
<td>5,700*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bromegrass</td>
<td>10,640</td>
<td>4,631</td>
<td>6,765</td>
<td>7,345</td>
<td></td>
</tr>
<tr>
<td>Kentucky bluegrass</td>
<td>6,001</td>
<td>3,159</td>
<td>4,815</td>
<td>4,658</td>
<td></td>
</tr>
<tr>
<td>Orchardgrass</td>
<td>5,906</td>
<td>4,189</td>
<td>6,407</td>
<td>5,501</td>
<td></td>
</tr>
</tbody>
</table>

* 2 years only.

**TABLE 57.4**

**FORAGE CONSUMPTION OF STEERS CLASSIFIED AS TO WEIGHT**

<table>
<thead>
<tr>
<th>Individual steer designation</th>
<th>No. of experiments</th>
<th>Av. weight of steer, lbs.</th>
<th>% of maintenance requirement consumed</th>
<th>Lbs. of dry matter consumed daily per 100 lbs. live weight</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Kentucky bluegrass and red clover</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>373</td>
<td>240</td>
<td>3.20</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>596</td>
<td>242</td>
<td>2.74</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>847</td>
<td>209</td>
<td>2.03</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>948</td>
<td>265</td>
<td>2.41</td>
</tr>
<tr>
<td><strong>Reed canarygrass and bromegrass</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>440</td>
<td>122</td>
<td>1.82</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>552</td>
<td>199</td>
<td>2.68</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>825</td>
<td>165</td>
<td>1.87</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
<td>780</td>
<td>154</td>
<td>1.85</td>
</tr>
</tbody>
</table>

* Adapted from Garrigus and Rusk.
† Maintenance requirement of each steer is the amount of dry forage needed to meet his daily requirements for net energy.

A difference also occurred in the quantity of different forages consumed. The pounds of dry matter consumed daily per 100 pounds of live weight was not correlated with steer weights. The data illustrate individual differences between steers and also show that forages vary in their value for cattle pasture.

Palatability of forages, according to Stapledon, "probably is of greater importance than the inherent nutritive value of herbage." Forages may contain all necessary nutrient materials, but if they lack palatability, animals do not consume as much as of palatable forages, even though the nutritive value of the latter may be lower. Palatability is affected by the species, stage of maturity, local climatic conditions and other factors. Webb has indicated that the dominant species found in a given field has a marked effect on animal gains (Table 57.5).

These data show relatively high yields of dry matter, also large acre gains by livestock. Careful management was practiced on all fields. The average animal gains apparently were related to the palatability of the forage. Garrigus and Rusk also have shown that the species and species-maturity have a profound effect on forage consumption.
An important factor in forage consumption and animal gains, and one that parallels palatability, is forage quality. Investigations have been conducted by many experiment stations, and most of the results point to excellent results obtained with such species as alfalfa, Ladino clover, and annual legumes in mixtures with grasses. The literature on pastures has many examples that indicate a decline in animal gains with a concurrent decline of legumes in the pasture. Ensminger, in eastern Washington, found that a bromegrass-alfalfa mixture produced 225 pounds of beef per acre in 87 days, as compared to 84 pounds in 80 days for smooth brome alone.  

**FERTILE PASTURES BENEFIT BEEF CATTLE**

Soil fertility is of basic importance to the production and utilization of forages
# TABLE 37.6

**Effect of Fertilizer Treatments and Grazing Management on Forage Production and Animal Gains**

<table>
<thead>
<tr>
<th>Items compared</th>
<th>Treatment No. 1</th>
<th>Treatment No. 2</th>
<th>Treatment No. 3</th>
<th>Treatment No. 4</th>
<th>Treatment No. 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Av. no. of steers per acre</td>
<td>.93</td>
<td>1.40</td>
<td>2.09</td>
<td>2.55</td>
<td>2.29</td>
</tr>
<tr>
<td>Days in grazing period</td>
<td>140</td>
<td>140</td>
<td>140</td>
<td>84</td>
<td>140</td>
</tr>
<tr>
<td>Total steer days</td>
<td>130</td>
<td>196</td>
<td>294</td>
<td>215</td>
<td>324</td>
</tr>
<tr>
<td>Total gain per steer, pounds</td>
<td>169</td>
<td>159</td>
<td>112</td>
<td>139</td>
<td>123</td>
</tr>
<tr>
<td>Daily gain per steer, pounds</td>
<td>1.14</td>
<td>1.16</td>
<td>.81</td>
<td>1.61</td>
<td>1.03</td>
</tr>
<tr>
<td>Beef production per acre</td>
<td>150</td>
<td>221</td>
<td>237</td>
<td>346</td>
<td>334</td>
</tr>
<tr>
<td>Feed nutrients (T.D.N.) per acre</td>
<td>1,220</td>
<td>1,830</td>
<td>2,380</td>
<td>2,320</td>
<td>2,830</td>
</tr>
</tbody>
</table>

* Adapted from Purdue Agronomy Mimeo. AY-11A. For the 1948 growing season at Miller-Purdue Farm, Indiana.
TABLE 57.7
AVERAGE GAINS BY YEARLING STEERS ON LEGUME AND GRASS MIXTURES ON THREE 10-ACRE FIELDS, 1929-1940 *

<table>
<thead>
<tr>
<th>Field no.</th>
<th>Treatment</th>
<th>Av. no. of steers per field</th>
<th>Av. yearly gain per field, lbs.</th>
<th>Av. cost per lb. of gain, cents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>None</td>
<td>2.6</td>
<td>461</td>
<td>10.5</td>
</tr>
<tr>
<td>2</td>
<td>Rock phosphate</td>
<td>6.4</td>
<td>1,640</td>
<td>3.1</td>
</tr>
<tr>
<td>3</td>
<td>Limestone and superphosphate</td>
<td>6.7</td>
<td>1,695</td>
<td>3.2</td>
</tr>
</tbody>
</table>

* Adapted from Kentucky Agricultural Experiment Station Circular 52.

by cattle. The availability of a fertile soil increases the productivity and also the quality of the forage. Results from many sources show the influence of fertility and fertilization on both forages and animal production. Mott, of the Purdue Experiment Station, has obtained excellent gains on beef steers in experiments with different fertilizer treatments on permanent pasture, and on birdsfoot trefoil—bluegrass (Table 57.6).10

Lowry and Caldwell, reporting on an experiment on fertilized permanent pastures in western Kentucky covering 11 years, state that "the gains made by steers on treated fields the first 90 days of the first year, and market price for grass beef, were sufficient to pay the cost of the original treatments."11 Table 57.7 gives a brief summary of their results. Similar results have been obtained by a number of experiment stations.

The student of forage and beef cattle production should keep in mind the following points about pasture fertilization:

1. Fertilization is not a substitute for good management. Overgrazing and undergrazing are as serious on fertilized as on unfertilized pastures.

2. Fertilizing materials and lime are plant nutrients, and as such must be replenished from time to time.

3. Barnyard manure is an excellent fertilizer and is just as beneficial to pastures as to other crops.

4. Fertilization does not keep weeds from becoming established in over-grazed or undergrazed pastures.

5. Timing of fertilizer applications is important.

ALTERNATING OR Rotating Pastures FOR BEEF CATTLE

Few experimental results have shown much benefit in better livestock gains from alternate or rotation grazing. It is recognized by some that such practices may benefit the forage cover. Comparing continuous and alternate grazing over a four-year period at Urbana, Illinois, on Kentucky bluegrass-Ladino clover and on bromegrass-Ladino clover, distinct differences in gains by steers have not been shown. Some differences in species percentages have occurred. Hein and Cook found no significant difference in the gains made by steers on pastures grazed heavily and continuously and on pastures grazed heavily and alternately.12 The classic experiments of Carrier and Oakley indicated that some benefits are derived from both heavy and light grazing.13 Fuellman, reporting results for a seven-year period at the Dixon Springs Station, concluded that "differences in

average annual animal gains and forage production

<table>
<thead>
<tr>
<th>Method of grazing</th>
<th>Days pastured</th>
<th>Animal gains</th>
<th>Forage production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy continuous</td>
<td>153</td>
<td>135</td>
<td>4,809</td>
</tr>
<tr>
<td>Moderate continuous</td>
<td>137</td>
<td>104</td>
<td>4,553</td>
</tr>
<tr>
<td>Heavy alternate</td>
<td>115</td>
<td>158</td>
<td>4,168</td>
</tr>
<tr>
<td>Moderate alternate</td>
<td>121</td>
<td>143</td>
<td>4,357</td>
</tr>
</tbody>
</table>

* Dixon Springs, Ill. Station. 1940-46.

annual gains resulted more from rates of stocking than from variations in kinds and amounts of forage available” (Table 57.8). The matter of having the right number of animals on a given pasture and at the right time appears to be an important factor in obtaining maximum returns.

It would appear that, in general, in the humid areas of the United States where the best animal gains are made during the early months of the season and again during the cool fall periods of grazing, largest animal gains are obtainable from heavy alternate grazing, or a system making the best use of the forage when succulent and palatable.

Methods of utilizing bromegrass-alfalfa rotation pastures as feed for fattening choice yearling Hereford steers were compared in Iowa. The study included: (a) dry lot feeding as a check, (b) continuous grazing, (c) rotation grazing; and (d) feeding grain on pasture. At the end of four years it was concluded that grazing bromegrass-alfalfa pastures during May and June and then self-feeding corn-and-cob-meal on the pasture was the most profitable of the methods compared. The cattle required less hay and supplement and returned the greatest margin above feed costs. Cattle grazed rotationally made more beef per acre and returned a higher margin per steer than the continuously grazed cattle.

**Utilization of Pastures and Grain for Fattening Cattle**

When cattle in fair to good flesh are turned on pasture they do not gain as well as thin cattle. Therefore, it is well if the best gains are to be obtained from pasture alone, to use thin cattle. Some grass-fattened cattle are marketed from areas like the Flint Hills of Kansas and similar parts of Oklahoma. Grass-fattened cattle usually command a somewhat lower price on the market than animals finished in dry lot on grain, or grain fed on pasture.

The feeding of grain to steers on pasture has several points in its favor. Steers require less grain to achieve the same end result and on good pasture less concentrates are needed. Cattle suffer less from flies when on grass. They scatter the manure on the fields, less labor is required and the cost of feed is less than when harvested hay is fed.

The type of pasture available, whether permanent, temporary or rotation, also the kind of forage, whether dominantly grass or legume, or a mixture of grasses and legumes, may make a marked difference in the quantity of grain required and gains by animals. In some western areas where irrigated pastures are available, cattle have been fattened economically on grass alone.
### TABLE 57.9
Feeding Yearling Steers in Dry Lot and on Permanent Pasture, Nebraska *

<table>
<thead>
<tr>
<th></th>
<th>Lot 6 Dry lot</th>
<th>Lot 7 Permanent pasture</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total steers used</strong></td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td><strong>Av. daily feed</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shelled corn, lbs.</td>
<td>16.14</td>
<td>15.69</td>
</tr>
<tr>
<td>Alfalfa hay, lbs.</td>
<td>4.07</td>
<td>2.63</td>
</tr>
<tr>
<td><strong>Av. initial weight, lbs.</strong></td>
<td>654</td>
<td>658</td>
</tr>
<tr>
<td><strong>Av. final weight, lbs.</strong></td>
<td>1,048</td>
<td>1,073</td>
</tr>
<tr>
<td><strong>Av. gain per head, lbs.</strong></td>
<td>394</td>
<td>415</td>
</tr>
<tr>
<td><strong>Av. daily gain, lbs.</strong></td>
<td>2.19</td>
<td>2.31</td>
</tr>
<tr>
<td><strong>Total feed consumed per head</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shelled corn, bus.</td>
<td>52.28</td>
<td>50.84</td>
</tr>
<tr>
<td>Alfalfa hay, lbs.</td>
<td>737</td>
<td>465</td>
</tr>
<tr>
<td><strong>Pasture days for 1 steer.</strong></td>
<td></td>
<td>116</td>
</tr>
<tr>
<td><strong>Av. weight per head, Omaha.</strong></td>
<td>1,013</td>
<td>1,029</td>
</tr>
<tr>
<td><strong>Av. shrink in shipment.</strong></td>
<td>35</td>
<td>44</td>
</tr>
<tr>
<td><strong>% shrink in shipment.</strong></td>
<td>3.34</td>
<td>4.10</td>
</tr>
<tr>
<td><strong>Dressing %</strong></td>
<td>61.73</td>
<td>61.13</td>
</tr>
</tbody>
</table>

* This pasture consisted essentially of bromegrass with a little mixture of timothy, meadow fescue, bluegrass and orchardgrass.
† Average of three trials:
April 22 to October 22, 1933, 183 days.
April 22 to October 29, 1933, 190 days.
April 25 to October 10, 1934, 168 days.
Fed on dry lot at the beginning and end of the tests and as supplement to short pasture in 1934.
Adapted from Nebraska Experiment Station Bul. 354.

Thalman, at the Nebraska Station, used several lots of steers on different pastures and in the dry lot to obtain information on feed intake, economy of gains, and marketing data. Table 57.9 reports the results from one of several comparisons between dry lot and permanent pasture.

Francis, in a series of comprehensive experiments initiated at the Dixon Springs Station in 1913 (still in progress) has accumulated valuable data. The data in Table 57.10 are from a progress report when the first phase of the experiment was completed in 1946. The data are averages for three groups of cattle in each lot.

The steers in lot 1 were full fed in the dry lot for six months. Those in lot 2 were wintered on silage, hay, and protein supplement, then were on pasture alone approximately four months and full fed on pasture for 100 days. The lot 3 animals were wintered in the same manner as lot 2, then were on pasture for six months and marketed direct from grass with no grain.

The data point to the economy of feeding on pasture as compared with dry lot feeding. Also, the data provide an interesting comparison between dry lot and pasture plus roughage methods of feeding. Brananan and Harrison, in experiments varying somewhat in methods of procedure from those of Francis and his associates, obtained approximately the same results.
### Utilization of Forages With Beef Cattle

**TABLE 57.10**

**SUMMARY OF DATA FROM STEER MANAGEMENT EXPERIMENT AT DIXON SPRINGS STATION, 1946**

<table>
<thead>
<tr>
<th>Lot 1</th>
<th>Lot 2</th>
<th>Lot 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of steers</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Date of experiment</td>
<td>May 7</td>
<td>Nov. 13</td>
</tr>
<tr>
<td>Days on experiment</td>
<td>165</td>
<td>357</td>
</tr>
<tr>
<td>Total gain, lbs</td>
<td>374</td>
<td>456</td>
</tr>
<tr>
<td>Av. daily gain, lbs</td>
<td>2.27</td>
<td>1.28</td>
</tr>
<tr>
<td>Feed per head</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn, bu</td>
<td>29.5</td>
<td>23.6</td>
</tr>
<tr>
<td>Soybean oil meal, lbs</td>
<td>320</td>
<td>267</td>
</tr>
<tr>
<td>Silage, lbs</td>
<td>776</td>
<td>3,227</td>
</tr>
<tr>
<td>Hay, lbs</td>
<td>341</td>
<td>397</td>
</tr>
<tr>
<td>Feed per cwt. gain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn, bu</td>
<td>7.9</td>
<td>5.2</td>
</tr>
<tr>
<td>Soybean meal, lbs</td>
<td>86</td>
<td>57</td>
</tr>
<tr>
<td>Silage, lbs</td>
<td>205</td>
<td>726</td>
</tr>
<tr>
<td>Hay, lbs</td>
<td>93</td>
<td>91</td>
</tr>
<tr>
<td>Cost of feed per cwt. gain</td>
<td>$14.19</td>
<td>$12.02</td>
</tr>
<tr>
<td>Pasture data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Days, no grain</td>
<td></td>
<td>119</td>
</tr>
<tr>
<td>Days with grain</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Gain, no grain, lbs</td>
<td></td>
<td>145</td>
</tr>
<tr>
<td>Gain with grain, lbs</td>
<td></td>
<td>184</td>
</tr>
<tr>
<td>Time on pasture, %</td>
<td></td>
<td>62</td>
</tr>
<tr>
<td>Acres pasture per head</td>
<td></td>
<td>1.7</td>
</tr>
<tr>
<td>Dry lot data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Days, roughage only</td>
<td></td>
<td>138</td>
</tr>
<tr>
<td>Days, full fed</td>
<td></td>
<td>165</td>
</tr>
<tr>
<td>Gain, roughage only, lbs</td>
<td></td>
<td>127</td>
</tr>
<tr>
<td>Gain, full fed, lbs</td>
<td></td>
<td>374</td>
</tr>
<tr>
<td>Time in dry lot, %</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Price of steers</td>
<td>$53.41</td>
<td>$52.86</td>
</tr>
<tr>
<td>Cost of feed</td>
<td>$53.08</td>
<td>$54.79</td>
</tr>
<tr>
<td>Cost of feed and steer</td>
<td>$106.49</td>
<td>$107.65</td>
</tr>
<tr>
<td>Necessary selling price</td>
<td>$14.66</td>
<td>$13.72</td>
</tr>
<tr>
<td>Sales weight, lbs</td>
<td>762</td>
<td>822</td>
</tr>
<tr>
<td>Shippin' shrink</td>
<td>24</td>
<td>40</td>
</tr>
<tr>
<td>Actual market price</td>
<td>$5.18</td>
<td>$5.10</td>
</tr>
<tr>
<td>Market price per cwt.</td>
<td>$16.33</td>
<td>$17.80</td>
</tr>
<tr>
<td>Value per head at market</td>
<td>$124.43</td>
<td>$146.32</td>
</tr>
<tr>
<td>Net farm value</td>
<td>$119.25</td>
<td>$141.22</td>
</tr>
<tr>
<td>Net farm value less cost of feed and steer</td>
<td>$12.76</td>
<td>$33.57</td>
</tr>
<tr>
<td>Credit to pasture per acre</td>
<td></td>
<td>19.75</td>
</tr>
</tbody>
</table>

* No pasture included. Feed values: Corn, $1.25 per bu.; hay, $20.00 per ton; soybean oil meal, $60.00 per ton; silage, $8.00 per ton.

† Includes marketing expense.

‡ Weighted averages.

§ Actual marketing expense deducted.

**Utilization of Temporary and Supplementary Pasture**

Temporary and supplementary pasture crops such as Sudan, oats, winter annual legumes, winter rye, and wheat frequently are used with beef cattle. Winter rye in early spring is high in protein, succulent, and palatable, and has a high carrying capacity. Steers roughed through the winter on silage, hay, and protein supplement may make gains of from two
to three pounds per day during the early spring pasture period. Wheat also provides good early pasture. Oats are often used as early pasture and have high carrying capacity. In the Corn Belt, sweet and red clovers, seeded for plow-down crops, usually are pastured late in the seeding year and again in the second year. An acre of good sweetclover frequently carries two or more animal units during several months of the second year.

**QUESTIONS**

1. Why are pastures and pastureage important in a livestock economy?

2. Why are beef cattle particularly well adapted to the utilization of forages?

3. Why are forage yields and forage consumption per acre by cattle not more closely correlated?

4. Why should a high percentage of legumes be maintained in a beef cattle pasture?

5. For highest livestock gains, should pastures be continuously or rotationally grazed? Discuss.

6. What are the advantages of feeding grain to steers on pasture?

7. How may temporary and supplementary pastures be best utilized in a pasture program for beef cattle?

8. Why is palatability of forage of primary importance in evaluating a pasture species?

9. What points should be considered in planning a fertilizer program for pastures?
Sheep lead all farm animals in the capacity to utilize pastures alone for fattening and the production of high quality carcasses. Many thousands of lambs that have had no grain are sold each year for slaughter, but their carcasses carry sufficient fat to place them in the choice grade. However, this is accomplished only with carefully selected and managed animals grazing very palatable and highly nutritious pastures. The coarser, low quality plants, lacking succulence, are suitable for the maintenance of mature sheep, but are wholly unsatisfactory for ewes in lactation and for young growing lambs. To enable sheep to thrive on pastures, skill is needed in pasture production and in sheep management.

Although sheep can utilize some grain to advantage, farm records show that the average flock in the central states uses thirteen acres of pasture and roughage for each acre of grain. Thus sheep, being physiologically adapted to forage utilization, are raised chiefly where there is some emphasis on grassland farming.

Many sheep obtain all their nutrients from the grasses, legumes, weeds, herbs, and shrubs found on extensive areas of cultivated and uncultivated lands. Because sheep can live on this natural vegetation and because wool is relatively imperishable, most sheep raising has been conducted under conditions of extensive rather than intensive agriculture. But when good land use requires increased acreages of legumes and grasses, sheep merit attention as a means of utilizing such crops.

Different types of pastures will show the widest limits in their comparative values. The difference for the same pasture from year to year or from season to season may show a greater range than the difference between two pastures the same year or the same season. In assessing the relative merits of pastures, it is very difficult if not impossible to control environmental factors affecting both the plants and the grazing animals. This is one of the reasons for the lack of widespread adaptability of much of the research reported. However, the careful winnowing and sifting of these numerous and often conflicting reports is the basis of an understanding of the two chief problems in using pastures for sheep production.

These problems concern both the effect of the pastures on the animals and
the effect of the animals on the pastures. The practical problem confronting the producer is one of balancing the two to get the greatest economic return. The crux of the matter is to combine pasture and sheep management to reduce to a minimum the damage to pastures and increase to a maximum the benefits to the animals. It is possible that the management of the pastures and the sheep may be combined in some seasons, at least, to result in mutual benefit although much will depend upon the criteria used in determining damage and benefit.

There are many data to show that pastures are more productive in the spring than in the summer and fall.¹

Sheep are able to graze very selectively because of certain anatomical features. The muzzle is narrow compared with the wide muzzle of the cow. The lips of sheep are thinner and move more readily than those of the cow. These features combined with an apparently extremely accurate sense of smell, permit sheep to locate and consume only those plants, or parts of plants, which they like. The sheep often gather the leaves and forego eating the stems. They may and often do eat the seed of such plants as bluegrass and sweetclover, and they may graze one variety or strain of some plant and not eat another adjacent-growing variety at all.

Sheep often are credited with being destructive grazers as they may graze some plants very close to the ground. While sheep may be able to bite closer to the ground than cattle do, the difference in this respect is much less than usually thought. However, sheep are likely to graze a pasture less uniformly than cattle. Because of this, it is often advisable to put both cattle and sheep on the same pasture either at the same time or at different periods. For example, the Oklahoma station reported that sheep used two years added materially to the carrying capacity of the pastures and helped control weeds.

These investigators reported "an interesting side-light on the cattle grazing results is the fact that the carrying capacity of the pasture was nearly doubled during the 1940 and the 1942 grazing seasons by pasturing sheep to utilize surplus Russian thistles in 1940 and rapidly growing grass in 1942 that the cattle could not fully utilize." The authors do not give the data for the sheep.

In another report it is stated "the figures show a very marked beneficial effect from grazing either cattle or sheep alone." The numbers of cattle and sheep used in this work were too small to be considered wholly reliable and the statements are and should still be considered as tentative conclusions only. Although sheep will not eat all kinds of weeds, there are many weeds that sheep may prefer at times to other types of vegetation.

There have been many discussions of the natural diet of sheep and of the difficulties encountered in experimental studies of it. One of the earliest studies was that of Carolus Linnaeus, the Swedish systematist, renowned for his classification of plants. He made his report in 1748 pointing out that his experiments were conducted with well-fed animals. Linnaeus repeatedly offered a total of 618 plants both singly and in various combinations to sheep and arrived at definite conclusions. Because he found that sheep and goats ate many more different kinds of plants than cattle, horses, or pigs, sheep were considered as showing the least discrimination on selecting their diets. This is an interesting conclusion in view of the rather widespread opinion about the selective grazing habits of sheep.

Linnaeus reported that of the 618 plants offered to sheep 449 were always eaten, 32 were sometimes eaten and the other 137 were never eaten.

A study of 473 of the plants used by Linnaeus that grow in England showed that sheep prefer those belonging to the grass (Gramineae) and the legume (Leguminosae) families. When these 473 plants were grouped (Table 58.1) accord-

---


TABLE 58.1

<table>
<thead>
<tr>
<th>Plants Eaten and Refused</th>
<th>Number</th>
<th>Aromatic</th>
<th>Poisonous</th>
<th>Hairy</th>
<th>Glabrous</th>
<th>Woody</th>
<th>Succulent</th>
<th>Scented</th>
</tr>
</thead>
<tbody>
<tr>
<td>Studied</td>
<td>16</td>
<td>16</td>
<td>135</td>
<td>278</td>
<td>66</td>
<td>126</td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>Eaten</td>
<td>9</td>
<td>45</td>
<td>100</td>
<td>218</td>
<td>44</td>
<td>99</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Sometimes eaten</td>
<td>1</td>
<td>9</td>
<td>25</td>
<td>43</td>
<td>18</td>
<td>19</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Not eaten</td>
<td>6</td>
<td>19</td>
<td>19</td>
<td>15</td>
<td>27</td>
<td>15</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>% of total not eaten</td>
<td>38</td>
<td>26</td>
<td>19</td>
<td>15</td>
<td>27</td>
<td>15</td>
<td>34</td>
<td></td>
</tr>
</tbody>
</table>

ing to certain characteristics, it was found that there was no common factor which decided whether or not a plant was eaten.

**FORAGE CONSUMPTION**

The amount of forage consumed by a sheep depends greatly upon the size of the animal, its health, the general environmental conditions and the palatability of the forage. Sheep may eat from 9.8 to 24.2 pounds of green grass in a 24-hour period.

Under most conditions the consumption of green grass would not usually exceed 15 pounds per day for sheep weighing about 130 pounds. The variation in dry matter consumption is a significant point. It is undoubtedly influenced by many factors.

Observations made of sheep while on pasture showed that about half the time is spent grazing and chewing the cud. In the report of Stapleden and Jones cited above, sheep spent an average of about 26 per cent of the day (24 hours) grazing; 24 per cent ruminating; 31 per cent lying down but not ruminating, and the rest of the time standing and not ruminating. Early morning and late afternoon and evening are preferred grazing periods. Little grazing is done during the hottest period of the day or when much rain is falling. Since high temperatures reduce grazing activity and feed intake, sheep

TABLE 58.1

<table>
<thead>
<tr>
<th>Number</th>
<th>Aromatic</th>
<th>Poisonous</th>
<th>Hairy</th>
<th>Glabrous</th>
<th>Woody</th>
<th>Succulent</th>
<th>Scented</th>
</tr>
</thead>
<tbody>
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<td>16</td>
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<td>Eaten</td>
<td>9</td>
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<td>100</td>
<td>218</td>
<td>44</td>
<td>99</td>
<td>26</td>
</tr>
<tr>
<td>Sometimes eaten</td>
<td>1</td>
<td>9</td>
<td>25</td>
<td>43</td>
<td>18</td>
<td>19</td>
<td>16</td>
</tr>
<tr>
<td>Not eaten</td>
<td>6</td>
<td>19</td>
<td>19</td>
<td>15</td>
<td>27</td>
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<td>34</td>
</tr>
<tr>
<td>% of total not eaten</td>
<td>38</td>
<td>26</td>
<td>19</td>
<td>15</td>
<td>27</td>
<td>15</td>
<td>34</td>
</tr>
</tbody>
</table>

do better on pastures during the cool seasons of the year.

**MEASURING THE VALUE OF PASTURES FOR SHEEP**

The nutritive value of a pasture depends largely upon the palatability of the herbage, its chemical composition and digestibility. Very likely the palatability of a plant is related to its composition, but the entire matter of palatability is not well understood. There are intricate relationships among the many factors influencing palatability, and nutritive value and seasonal variations in these are pronounced. A grass such as Kentucky bluegrass that is apparently highly palatable at one season is often passed at other times for some other plant not eaten earlier.

Many criteria used to measure the values of pastures are not only imperfect but may be misleading. Actual grazing tests are considered as the only method advanced to date by which the feeding value of the pasture herbage can be estimated with any certainty, and it is the only method by which the effect of the animals on the pastures can be observed, studied, and appraised. Hundreds of pasture investigations are of little or no value, even in the localities where they are conducted, because of the fragmentary character of the work.

The relation of soils to the value of pasture is not thoroughly understood at

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Sheep Are Efficient Users of Forage

Fig. 58.2 "Sheep are able to graze very selectively . . . consume only those plants, or parts of plants, which they like . . . likely to graze a pasture less uniformly than cattle. . . . It is often advisable to put both cattle and sheep in the same pasture, either at the same time or at different periods."

this time. There is a close relationship between the soil and the plant species that can be grown successfully therein. Fertility of the soil may influence to some degree the composition of plant species. There is proof that certain soil deficiencies, such as a lack of cobalt or copper, may have a serious effect on the health of animals grazing plants growing on such soils. A cobalt deficiency may be corrected either by providing cobalt directly to the animals or by applying it to the soil to be taken up by the plants, although it is apparently not necessary for plant growth (see Chapter 5).

Because a soil may be low in productive capacity is not in itself an indication that plants grown on it will show a deficiency of nutrients. The results of many investigations show that the uptake of minerals by plants is very complex and many factors may influence their chemical composition. The mineral content of the soil is at times one of the less important. "The major result of differences in soil fertility, so far as the ability of the soil to furnish feed for livestock is concerned, may be the amount of growth or other animal product produced per unit of land area rather than any marked or measurable effect upon the composition of the gains of the animal or upon other animal products produced." 7

It has been proved that some plants under certain conditions are harmful to animals. In some instances this is due to the mineral content of the soil where the plants grow. Certain plants grow on soils containing selenium which may occur in various forms or combinations in the plants. Sheep or other animals feeding on these plants may be poisoned.\textsuperscript{8}

Some plants have poisonous properties regardless of the soil on which grown.\textsuperscript{9} Other plants which may at times be of value in pastures may be harmful because of the awns or spines which may get into the eyes and wool, or even penetrate through the skin and become imbedded in the flesh.\textsuperscript{10}

**GENERAL REQUIREMENTS OF GOOD SHEEP PASTURES**

Sheep seem to prefer pastures which are well drained, but it is not essential to have rough hilly lands for them. Sloping lands should have a more continuous vegetative cover than level areas to reduce water and soil losses and hence the rolling areas are often considered more usable for sheep pastures. But management is important in accomplishing soil and water conservation on sloping lands and in obtaining good gains in weight on sheep on such areas. Runoff is less and soil infiltration of rainfall is greater on treated pasture land that is moderately grazed than on untreated pasture that is severely grazed.\textsuperscript{11} Controlled grazing on improved pastures is also an effective way to increase sheep gains.

Sheep cannot do well on pasture or other feed unless they are in good health.

Some difficulties are associated with grazing. For example, sheep are subject to damage by various internal parasites and are most likely to become infested by these parasites when grazing. Hence any system of pasture management must take this into consideration. Since heavy infestations of parasites do not persist on pastures for long periods without the presence of host animals, rotational grazing may be helpful in controlling some parasites. This is not the only means necessary to control parasites and some help in parasitic control is not the only benefit from rotational grazing. Other benefits may be increased yield of meat per acre and the persistence of legumes in a mixed pasture for a greater length of time.\textsuperscript{12}

**PASTURE MANAGEMENT**

Seasonal and rainfall conditions affect greatly pasture yields in terms either of forage or of meat. Poor pastures are not good sheep pastures. There are reports from every section of the country to support the statement that fertilization of pastures increases the yield of meat. But fertilization must be coupled with good management. Good management on an unimproved pasture may result in greater meat yield than is obtained from a good pasture that is overstocked and overgrazed.

The intensity of grazing may be as important as following a continuous or rotational grazing system. The importance of these considerations has been indicated repeatedly in various pasture investigations, but no system has been devised to predict the seasonal or yearly carrying capacity of a pasture. Data gathered at two points in Illinois show larger animal gains and greater persistence of legumes in a mixed pasture when...
a system of heavy-alternate or moderate-alternate grazing was used.\(^{12,13}\)

Regardless of the grazing system, pastures should be considered as crops to be harvested when in the most palatable and nutritious condition. Grazing should not be started too soon or delayed too long. In this, as in many other matters relating to sheep raising, good judgment is an important "ingredient" of the operator. Sheep increase in weight only when they have an abundance of feed.

**TYPES OF SHEEP PASTURES**

Grasses are more widely used as sheep pastures than other types of vegetation. No one grass is most important in all the different states and regions. Hundreds of grasses, the seed of which is not harvested and sold, are eaten by sheep, but there seems to be no definite information regarding their values.

*Cereals*, especially wheat and rye, are used for fall, winter and early spring pastures in many states. Oats and barley are less extensively used. All are palatable and nutritious in early growth stages, but are not eaten readily if approaching maturity.

*Sudangrass* is often used in an emergency or as a regular summer pasture in Central and Midwestern states. It is nutritious and has a high carrying capacity on fertile soil. Because Sudangrass grows very fast, grazing should not be delayed beyond an eight or ten inch growth stage or there will be much waste from trampling.

*Kentucky bluegrass*, especially as a permanent pasture, is probably more widely used in the Central States than any other grass. It is very nutritious and palatable when young but is of only fair usefulness in summer. Canada bluegrass is of less usefulness. In using bluegrass as a sheep pasture it seems probable that reasonably early, heavy grazing is advisable. This will permit white clover or other summer growing legumes to develop and provide good pasture.

*Redtop* is probably second in extent of distribution to bluegrass as a sheep pasture. Management should be similar to that of a bluegrass pasture.

*Smooth bromegrass* on fertile soil and in regions where adapted is more productive than bluegrass. While smooth bromegrass may be green during midsummer, gains in weights of sheep may not be as great during this period.

*Orchardgrass* and tall oatgrass are palatable and nutritious in the early spring.

*Timothy* is one of the grasses most palatable to sheep and is a useful addition to mixtures. Reed canarygrass is not recommended for sheep in most areas as it is not relished by them and in no case at the Illinois station have good gains been recorded from its use.

The *tall fescues* apparently are reasonably satisfactory for very early pastures but are of low palatability and productivity in summer. In many regions it is difficult to keep legumes in a fescue pasture because of the heavy growth of fescues and also because the legumes, being more palatable, are grazed heavily.

*Bermuda-grass* is of medium to low value for sheep. Many other grasses not only of the southern states but of many other areas may be similarly classified, although factors other than kind of plant may be involved.

**LEGUMES ARE IMPORTANT FORAGES FOR SHEEP**

As in the case of grasses, not all of the legumes eaten by sheep are commercially important. The vegetation of the western ranges and of other pastures contains many leguminous plants which are grazed. Apparently these are nutritious...
and palatable although there are no data from controlled research work on which to base comparisons.

Of the commercially grown legumes, alfalfa and the clovers, both as pasture and hay, are of most importance in sheep raising. No other feeds surpass these as harvested roughages for sheep, and few equal them. As hays, they need to be supplemented with grains for the fattening of lambs and often for best results with bred ewes, late in pregnancy and in lactation, but in other cases they leave little to be desired. As pastures, either alone or with various grasses, they are excellent. There are considerable data to show that alfalfa and clover—or in fact most legumes—are superior to the best of the grasses in carrying capacity and in meat production per acre. Ladino clover, burclover, Korean lespedeza, birdsfoot trefoil, kudzu, soybeans, and many others, are excellent alone or in mixtures in various localities. Under good climatic and soil conditions, Ladino clover in many areas seems to be especially productive.

**BLOAT MAY OCCUR ON LEGUME PASTURES**

The problem of bloat is far from solution. The general tendency is to blame the forage as a cause of bloat. In some cases this may be true, but in many others the animals may be at least equally at fault. In pasturing legumes one of the best procedures is to give the animals a "good fill" of palatable feed before turning them onto the legumes. They are then left on the pasture continually, night and day, in rainy or clear weather. Some dry feed such as hay placed in a rack in the field may be advisable. Plenty of salt and water should be available at all times. Bloat may be much more serious in some seasons than in others. On certain types of legume pasture, such as lespedeza and trefoil, there are only very few cases of bloat.14 Mixtures of grasses and legumes likewise are often superior to grasses alone or to legumes alone.

Table 58.2 shows per acre gains made on various pastures by sheep as reported by the Michigan station and the Illinois station.15

There are innumerable mixtures which may be sown. The choice for any locality should be based on the recommendations of the experiment station and on the experience of farmers as to results obtained.

**MAKE USE OF LOW QUALITY FORAGES**

On all farms and ranches there are considerable quantities of forages of relatively low quality such as straws, cornstalks and dry unharvested grasses. Sheep will eat some of these feeds and a saving of the more desirable feeds is effected in this way. Such feeds are not good for fattening lambs, or ewes in late pregnancy or during lactation, but are suitable for dry ewes, especially early in the fall, or for lambs that are "cleaning up the farm" before being put in the fattening pens.

Field feeding of fattening lambs often

### Table 58.2

<table>
<thead>
<tr>
<th>Kind of pasture</th>
<th>Shropshire ewes and lambs (Mich.)</th>
<th>Yearling wethers (Ill.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>309</td>
<td>270</td>
</tr>
<tr>
<td>Alfalfa-bromeegrass</td>
<td>352</td>
<td>250</td>
</tr>
<tr>
<td>Bromegrass</td>
<td>251</td>
<td>193</td>
</tr>
<tr>
<td>Alfalfa-orchardgrass</td>
<td>54</td>
<td>130</td>
</tr>
</tbody>
</table>

* The data from Michigan represent one year—those from Illinois are an average for five years.

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Sheep Are Efficient Users of Forage

is advantageous, but good feeds are needed for them. Many lambs are fattened on good pastures adjoining cornfields where the lambs get their grain.

HARVESTED ROUGHAGES IMPORTANT

Pastures and forages grazed by sheep are in general more important than harvested roughages. However, there are many areas where hays and silages are of great significance. Legume hays, like legume pastures, are generally more palatable and nutritious than grass hays. However, there is much variation depending upon the time of cutting and general quality factors. A daily feeding of 3.5 to 4.5 pounds of best quality alfalfa, red clover or Korean lespedeza hay is sufficient for a sheep weighing about one hundred fifty pounds. Less will be fed to fattening lambs or ewes near lambing when they are receiving grain. Often sheep will not maintain their weight on grass hay alone.

SILAGE GOOD SHEEP FEED

Contrary to the opinion of many, corn silage is a very satisfactory feed for sheep. It is deficient in calcium and in protein, but when these nutrients are provided in supplements, corn silage of good quality may be expected to produce as good gains, or maintain sheep in as good health, as comparable quantities of dry matter in hays.

Silages from the legumes or mixed legumes and grasses are also good, although less extensively used than silage from corn or sorghums.

RELATIONSHIPS IN SHEEP AND PASTURE MANAGEMENT

The student of pastures and sheep must know more than mere facts about pasture plants and about sheep. He should try to keep the many relationships in agricultural production in mind. The production of grasses and legumes has important relationships to the maintenance of good soil tilth and to the improvement of soil fertility. These in turn have important effects on the kinds and amounts of pastures and forages which can be produced in any area or on any farm. Likewise, there are important relationships between the kinds of pastures and forages, their palatability and nutritive value, their carrying capacity per acre, and the health and productivity of sheep and lambs. To get the greatest economic return from the utilization of pastures by sheep, these various relationships must be carefully controlled. In no other feature of agriculture are relationships more numerous, more varied and more important than in livestock production on pastures.

QUESTIONS

1. Why do sheep fit so well in a program of grassland farming?
2. Why is it often advisable to graze both cattle and sheep on the same pasture, either at the same time or at different periods?
3. Under what conditions might rotation pastures be expected to give better results for sheep grazing than permanent pastures?
4. What factors contribute to a poor rating for many pastures, from the standpoint of quality, quantity and economic return?
5. List the general qualifications of a good sheep pasture.
6. List and give the relative merits of the grasses and legumes most commonly used for sheep pasture.
7. Of 500 sheep on practically pure Ladino clover during the summer, seven bloated. On the basis of those figures discuss the causes of bloat.
8. With what classes of sheep may low quality forages be best utilized?
9. State the procedures to follow in fattening lambs for market, making maximum use of forages.
10. Evaluate comparatively corn and grass-legume silages for sheep.
Forages have been used in swine production for many years. Farmers recognize the fact that pigs do better when given access to green forage. The more economical gains are attributed to the sanitary conditions associated with pasture feeding as well as to the nutritive value of the forage. The digestive system of the hog does not have the capacity to utilize large quantities of forage. A relatively small portion of the total feed units necessary for growing and fattening hogs usually is supplied by pasture. Research has shown, however, that pasture will increase the daily gains of pigs, bringing them to a market weight at an earlier date and produce more efficient gains in terms of concentrate feed required per 100 pounds gain. The use of forages in swine feeding has taken on added significance with the development of better forages and feeding systems especially designed to obtain maximum utilization of pasture.

DRY LOT VERSUS PASTURE FEEDING

Pasture feeding of spring pigs on full rations has given more economical gains than dry lot feeding. This has been shown by numerous experiments conducted throughout the country. Smith has summarized the results of twenty-five experiments comparing dry lot and forage feeding of spring pigs. A summary of his results is presented in Table 59.1.

Only those experiments are included in which full rations were fed and an adequate supply of protein provided. The average length of an experiment was 106 days, beginning at weaning time and continuing until market weights were reached. Various forages were supplied in the different experiments.

Forage fed pigs made more rapid gains, showing an increase in daily gains of one-fourth pound, and a greater average weight at the end of 106 days of about 26 pounds. The consumption of concentrates for each 100 pounds gain was reduced by 48 pounds. Smith calculated that this had the effect of saving 1,172 pounds of concentrates for each acre of forage.

Morrison has prepared a similar summary of 15 experiments. He compared pigs full-fed in dry lot on corn and an efficient supplement including alfalfa hay, with similar pigs fed corn and supplement on good pasture. Those in dry lot gained 1.28 pounds per head daily and required 391 pounds of feed per

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100 pounds gain. Those on pasture gained 1.34 pounds and required only 351 pounds of concentrate per 100 pounds of gain. Morrison calculated that pasture feeding saved 40 pounds of concentrates in producing each 100 pounds of gain in weight, when compared with efficient dry lot feeding.

For a partial explanation of the difference in performance of pigs in dry lot and those on pasture we must consider the nutrients essential for the pig and those supplied by the pasture forage.

**Nutritive Value of Pasture for Hogs**

The composition of forages varies widely, but experiments conducted with green forages of various kinds show that more rapid growth of pigs usually results...
Supplementing Hogs on Pasture

when on pasture than from the most efficient dry lot ration. Information now available indicates that green forages contain some nutritional factor, or factors, not found in the best ration from harvested crops. Further research no doubt will give a better understanding of the nutritive value of forage crops. A brief summary of several nutritional factors may be helpful to an understanding of the value of green forages for swine.

PROTEIN. The protein content of many pasture crops used by swine is high. In some cases it may be sufficient to meet the needs of fattening pigs. Most experiments indicate, however, that a good quality protein supplement gives faster gains, with less feed required per 100 pounds of gain. Elimination of the protein supplement in the ration for either fattening hogs or for brood sows is considered too much of a risk by most hog farmers. Legumes such as alfalfa and Ladino clover contain the essential amino acids known to be required by swine. These legumes may not, however, contain certain amino acids in sufficient quantity to meet the needs of fattening pigs, even though the total protein consumption on pasture is adequate. The quality of protein in forages for swine is very important and may account for the difference between even good forages, such as alfalfa and Ladino clover.

VITAMINS. Pasture crops are a good source of vitamin A. No vitamin A needs to be included in the ration during the pasture season. Pigs being fattened on pasture, where they are exposed to sunshine, are well supplied with vitamin D. In winter fattening, or for pregnant sows, high quality sun-cured legume hay is essential for meeting the requirements for both vitamins A and D. Pasture also is considered a good source of the B complex vitamins. Considerable research is being done on the vitamin B\textsubscript{12} animal protein factor and certain antibiotics in their relation to swine feeding. No definite conclusions can as yet be drawn with respect to their use for pigs on pasture. Lepley studied the supplemental value of APF—animal protein factor (dried whole unextracted aureomycin mash)—without meat and bone scraps and with two levels of meat and bone scraps, for growing-fattening pigs in dry lot.\textsuperscript{4} He also compared a ration containing 5 per cent meat and bone scraps to a ration in which the latter was replaced with additional soybean oil meal and dried whole aureomycin mash on good alfalfa pasture. The results of this experiment are given in Table 59.2.

The addition of dried whole aureomycin mash (APF), either with or without the addition of meat and bone scraps, increased average daily gains. A comparison of lots V and VII indicates that alfalfa pasture furnished nutrients not supplied in adequate amounts by the basal ration or the APF. Further research is needed.\textsuperscript{4}

SUPPLEMENTING HOGS ON PASTURE

The quality of pasture will determine whether vitamin and mineral supplements are needed; also the extent to which additional protein is required. Pastures do not furnish hogs with sufficient energy for both growth and fattening. Concentrates such as corn, wheat, barley and other cereals need to be fed.


TABLE 59.2

SUPPLEMENTAL VALUE OF APF IN DRY LOT AND ON ALFALFA PASTURE, SUMMER 1949 (IOWA)

<table>
<thead>
<tr>
<th>Lot</th>
<th>Ration</th>
<th>Avg. daily gain, lbs</th>
<th>Feed consumed per 100 lbs. gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry lot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Basal ration</td>
<td>1.36</td>
<td>339</td>
</tr>
<tr>
<td>II</td>
<td>Basal including 5% meat and bone scraps</td>
<td>1.38</td>
<td>371</td>
</tr>
<tr>
<td>III</td>
<td>Basal including 5% meat and bone scraps + 0.25% APF</td>
<td>1.56</td>
<td>337</td>
</tr>
<tr>
<td>IV</td>
<td>Basal including 2.5% meat and bone scraps + 0.25% APF</td>
<td>1.61</td>
<td>327</td>
</tr>
<tr>
<td>V</td>
<td>Basal + 0.25% APF</td>
<td>1.53</td>
<td>323</td>
</tr>
<tr>
<td>Pasture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VI</td>
<td>Basal including 5% meat and bone scraps</td>
<td>1.40</td>
<td>320</td>
</tr>
<tr>
<td>VII</td>
<td>Basal + 0.25% APF</td>
<td>1.80</td>
<td>294</td>
</tr>
</tbody>
</table>

Full Versus Limited Grain Feeding on Pasture

Spring pigs are either full grain fed or are fed only a limited amount of grain during the pasture season. Early spring pigs can more profitably be full fed if corn is available on the farm to bring the pigs to market weight early in September. If corn is not available it may be advisable to have late spring pigs and feed only a limited grain ration during the summer, finishing the pigs in dry lot in the fall on the new crop of corn.

Morrison has summarized the results of 28 experiments in which one lot of pigs was full fed on good pasture and another lot was fed a limited amount of concentrates during the pasture season and then full fed until they approximated the same weight as the first lot, as shown in Table 59.3.

An additional month is required to bring the pigs to market weight if fed on a limited grain ration in the summer. Limiting the grain in the ration is of doubtful value in increasing the efficiency of gains. Nearly as much corn and supplement was required on the limited ration as when full fed. When the date of farrowing and the feed supply permit full feeding on pasture, greater profits will result by reaching an early market.

Protein Supplement for Hogs on Pasture

Pigs receiving a full grain feed on pasture usually will make more rapid and efficient gains if fed a high quality protein supplement. A mixture of an animal and a plant source of protein usually is recommended. It is a well known fact that weanling pigs have a higher protein requirement than pigs

<table>
<thead>
<tr>
<th>TABLE 59.3</th>
<th>LIMITING THE CONCENTRATES DURING THE SUMMER FOR PIGS ON GOOD PASTURE *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily gain, lbs</td>
<td>Time to reach market weight, days</td>
</tr>
<tr>
<td>Lot I Full fed on pasture</td>
<td>1.44</td>
</tr>
<tr>
<td>Lot II Limited ration in summer, dry lot</td>
<td>1.12</td>
</tr>
</tbody>
</table>

* From Morrison; Feeds and Feeding, 1948.
TABLE 59.4
LIMITING THE PROTEIN SUPPLEMENT FOR HOGS ON PASTURE *

<table>
<thead>
<tr>
<th>Lot</th>
<th>Supplement allowance</th>
<th>No. of days supplement was fed</th>
<th>Days required to reach 200 lbs.</th>
<th>Av. daily gain, lbs.</th>
<th>Lbs. feed for 100 lbs. gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>None .................</td>
<td>0</td>
<td>78</td>
<td>1.62</td>
<td>corn 329.1, minerals 2.4, total 331.5</td>
</tr>
<tr>
<td>2.</td>
<td>35% to 100 lbs. ......</td>
<td>15</td>
<td>73</td>
<td>1.72</td>
<td>corn 320.8, sup. 9.4, minerals 2.1, total 332.3</td>
</tr>
<tr>
<td>3.</td>
<td>35% to 125 lbs. ......</td>
<td>29</td>
<td>72</td>
<td>1.76</td>
<td>corn 314.0, sup. 18.9, minerals 1.3, total 334.2</td>
</tr>
<tr>
<td>4.</td>
<td>35% to 150 lbs. ......</td>
<td>41</td>
<td>70</td>
<td>1.81</td>
<td>corn 308.7, sup. 33.5, minerals 0.9, total 343.1</td>
</tr>
<tr>
<td>5.</td>
<td>35% to 175 lbs. ......</td>
<td>53</td>
<td>68</td>
<td>1.86</td>
<td>corn 299.3, sup. 43.9, minerals 0.8, total 344.0</td>
</tr>
<tr>
<td>6.</td>
<td>35% to 200 lbs. ......</td>
<td>67</td>
<td>67</td>
<td>1.89</td>
<td>corn 283.2, sup. 55.8, minerals 0.6, total 339.6</td>
</tr>
</tbody>
</table>

* Average for 1944, 1945, 1946 (Indiana).

Further along in the growing-fattening period, Vestal made a 3-year study of the effect of limiting the protein supplement for hogs on pasture. His results are presented in Table 59.4.

The 35 per cent protein supplement used contained 60 pounds of soybean oil meal, 15 of wheat middlings, 10 of cottonseed meal, 5 of meat and bone scraps, and 10 of minerals. Lot 1 received no supplement. Lots 2 through 6 received the supplement until they reached an average weight of 100, 125, 150, 175 and 200 pounds, respectively. Vestal concluded that spring pigs on good alfalfa pasture will gain efficiently on a full feed of corn, mineral mixture and salt, without receiving a protein supplement after they weigh 100 to 125 pounds. Maximum gains can be obtained by feeding a full supplement during the entire fattening period, but at a slightly higher cost.

FORAGE CROPS FOR SWINE

The adaptation of a forage to a particular soil, climate and use probably is the most important factor to consider in choosing the crops to be grown. The use of certain crops for winter hog pasture, especially for brood sows, has received special attention in recent years.

Some characteristics of forages which make them well suited to grazing by swine are: (a) high production of succulent forage; (b) palatability; (c) high protein and vitamin content; and (d) a long productive growth period. Following is brief information on some of the

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more important forages for swine pasture.

Legumes

The legumes as a group have a high protein and calcium content and usually contain a high percentage of carotene.

As a rich source of high quality protein they may make up for deficiencies of amino acids in grain rations. They also furnish an adequate supply of all the known vitamins, with the exception of vitamins D and B₁₂.

*Alfalfa* probably is the most widely used legume for swine pasture. The forage is of high quality and very palatable. Where both alfalfa and Ladino clover are adopted, the use of the two together has further increased the production and also has improved the nutritive value.

*Ladino clover* has proved to have wide adaptation. Where alfalfa is well adapted, Ladino clover will not produce as much forage per acre but the nutritive value of the clover probably is superior to the alfalfa.

*Alfalfa and Ladino clover* were compared by Vestal and Mott in Indiana during 1948 and 1949.³ Weanling pigs were grazed for periods of 81 and 90 days during 1948 and 1949, respectively. Each forage was grazed with a protein supplement and without a protein supplement. The basal ration consisted of shelled corn self-fed, and a simple mineral mixture and salt self-fed. The protein supplement was equal parts soybean oil meal and meat and bone scraps, self-
Forage Crops for Swine 681

TABLE 59.5
PASTURE VALUE OF LADINO CLOVER COMPARED WITH ALFALFA FOR PIGS *

<table>
<thead>
<tr>
<th>Ration</th>
<th>Forage</th>
<th>No. pigs grazed per acre</th>
<th>Av. daily gain, lbs.</th>
<th>Concentrates to produce 100 lbs. gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal + Supplement</td>
<td>Alfalfa</td>
<td>20.6</td>
<td>1.60</td>
<td>Corn 301</td>
</tr>
<tr>
<td>Basal + Supplement</td>
<td>Ladino</td>
<td>20.6</td>
<td>1.70</td>
<td>Supp. 37</td>
</tr>
<tr>
<td>Basal only</td>
<td>Alfalfa</td>
<td>13.75</td>
<td>1.37</td>
<td>Corn 297</td>
</tr>
<tr>
<td>Basal only</td>
<td>Ladino</td>
<td>13.75</td>
<td>1.51</td>
<td>Supp. 26</td>
</tr>
</tbody>
</table>

* Average of 4 experiments (Indiana).

TABLE 59.6
COMPARISON OF CRIMSON CLOVER AND WINTER OATS WITH AND WITHOUT LIMITED PROTEIN SUPPLEMENT IN FATTENING HOG RATIONS *

<table>
<thead>
<tr>
<th>Ration</th>
<th>Pasture</th>
<th>Av. daily gain, lbs.</th>
<th>Lbs. concentrates to produce 100 lbs. gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>I  Basal + Supplement</td>
<td>Oats</td>
<td>1.58</td>
<td>Corn 344</td>
</tr>
<tr>
<td>II Basal + Supplement</td>
<td>Crimson clover</td>
<td>1.71</td>
<td>Supp. 23.4</td>
</tr>
<tr>
<td>III Basal only</td>
<td>Oats</td>
<td>1.23</td>
<td>Corn 321</td>
</tr>
<tr>
<td>IV Basal only</td>
<td>Crimson clover</td>
<td>1.62</td>
<td>Supp. 21.8</td>
</tr>
<tr>
<td>V  Basal + Supplement</td>
<td>Dry lot</td>
<td>1.82</td>
<td>Corn 337</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Supp. 146.2</td>
</tr>
</tbody>
</table>

* 3-year average, Florida.

The superiority of Ladino clover for hog pasture, whether with or without a protein supplement, is indicated. The rate of gain was greater for Ladino and the feed required per 100 pounds gain was less. It will be noted that the Ladino clover pasture reduced the protein supplement consumed by 11 pounds for each 100 pounds gain, even though the supplement was self-fed. This is equal to a saving of 30 per cent on the supplement.

Crimson clover provides good, succulent pasture in late winter and spring in the southeastern states. The development of reseeding varieties promises to make this clover increasingly popular. It fits well in a pasture containing a warm season grass, such as Bermuda-grass, producing pasture during the winter months when Bermuda is dormant. Baker compared the value of crimson clover and winter oats as supplements to fattening rations for feeder pigs. Results are given in Table 59.6. Corn and minerals were fed free choice. The protein supplement was hand fed to lots I and II and self-fed to lot V. The protein supplement consisted of a mixture of equal parts of 60 per cent tankage and 41 per cent peanut oil meal in 1946. Digestion tankage—60 per cent—was used in 1947 and 1948.

Crimson clover showed a greater advantage over oats without a protein supplement than where the supplement was fed on a limited basis. Clover gave a higher daily gain and less corn was required per 100 pounds of gain. It would appear that crimson clover furnishes nutritional factors not supplied by oats and probably not supplied by the protein supplement.

Sweetclover, red clover and lespedeza

are legumes that should be mentioned for swine pasture. Red clover and sweet-clover were formerly of greater importance. They have been replaced to a considerable extent by alfalfa and Ladino clover in the Corn Belt. Lespedeza frequently is used during the summer months, especially in the southeastern states.

**Grasses**

Forage grasses such as bromegrass, wheat and Sudan grass are not such rich sources of protein and vitamins as are the legumes. There are several grasses, however, that are especially useful in supplying green forage under special conditions, or during seasons of the year when other forage crops are dormant.

*Winter cereals* commonly are used in the humid region as pasture for brood sows or fattening pigs in late fall, winter, and early spring. The choice of the crop to use is dependent upon the adaptation of the numerous varieties of each to a particular situation. Balbo rye is used extensively in the southern Corn Belt, winter oats and barley in the southeast and winter wheat in the middle and lower Missouri Valley. Present research does not indicate any particular difference among the four crops as far as their nutritional value is concerned.

Bromegrass has been compared with alfalfa and with an alfalfa-bromegrass mixture for hog pasture. Growing-fattening pigs self-fed to 200 pounds required 5.5 per cent more concentrates per 100 pounds of gain on bromegrass than on alfalfa pasture. The pigs on alfalfa pasture consumed 33 per cent less protein supplement and 13 per cent less minerals per unit of gain and reached the final weight one week earlier. A mixture of alfalfa-bromegrass was fully equal to alfalfa alone for self-fed pigs.

*Sudangrass*, an annual, is considered an emergency summer pasture in most sections. It provides an excellent emergency pasture in case a new seeding of legumes is winter killed or otherwise fails. Pigs require more protein supplement when on Sudangrass than on alfalfa. They usually gain faster on alfalfa and have a lower feed requirement per 100 pounds gain.

**RAPE MAKES EXCELLENT HOG PASTURE**

Rape is neither a legume nor a grass. In nutritional value it approaches the legumes. It is still considered by many hog growers as the premier swine pasture. It is a succulent annual, usually planted in the spring in the Corn Belt and in the fall in the southeastern part of the country.

Many experiments have been conducted by the different state experiment stations comparing rape with such legumes as alfalfa and red clover as a pasture for hogs. It has been shown repeatedly that this annual, which can be seeded in an emergency, will in a few weeks provide a pasture for hogs which compares very favorably with alfalfa (see Chapter 36).

**QUESTIONS**

1. What are the advantages of pasture feeding over dry lot feeding for spring pigs?
2. Why do pigs usually make more rapid and economical gains when on pasture?
3. Why are protein supplements recommended for hogs on pasture?
4. Give the characteristics of forages which make them well suited to grazing by swine.
5. List and discuss the relative merits of the legumes and grasses which you might use for hog pasture in your locality.
6. Why is Ladino clover superior for hog pasture?
7. Compare rape with grasses and legumes as a hog pasture.

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Forage in the past has constituted an important part of the feed consumed by poultry. From the beginning, chickens and turkeys, and the jungle fowl and the wild turkey before domestication, depended entirely upon a diet of pasturage. The term *pasturage* as used in this chapter includes in addition to forage, such other incidental nutritive material as insects, seeds, minerals, etc.

With the domestication of chickens, forage was supplemented with grain. Around 1880 came the *balanced ration* in which meat and milk products were included. During the balanced-ration era and before the discovery of vitamins, forage was by necessity of major importance in the diet for chickens.

The discovery of vitamin D in the early twenties permitted the successful feeding of chickens indoors, and the trend turned towards confinement of chickens away from pasturage, except for the growth of pullets for egg production.

With the advent of Ladino clover and some of the other newer forages such as smooth brome, Sudangrass, Italian ryegrass, birdsfoot trefoil, and alfalfa has come a reversed trend towards the greater use of pasturage for chickens. This applies not only to growth of chickens, but also to egg production. The *barracks system*, by which hens are put in shed-like shelters on range in late spring and carried on range until marketed in the fall, has become a common practice among many poultrymen, especially in the New England area.

Where climatic conditions are favorable, the trend towards greater use of forage for chickens is being stimulated by three factors:

1. Economy in feeding for growth and egg production;
2. Economy in housing and management, with the laying quarters made available for the new crop of pullets and the hens kept on range until they finish laying in the fall;
3. Superior forages now available.

**WHAT IS GOOD RANGE AND PASTURAGE?**

Good range and good pasturage may be quite different. A range may be a bare lot or an area with little or no forage. It may be a good or poor range depending upon sanitary conditions. A nearby range may provide good pasturage but may be unsafe because of its close proximity to the premises of older disease and parasite-carrying chickens. Also, the contaminated soil or the as-
sociation of growing chickens with older birds may have a disastrous effect upon the young. This would be an example of a poor range with good forage. A good range is one that is well isolated and free from soil contamination or association of the young and older chickens, even if the forage is less desirable. If a choice must be made between a good range with poor pasturage and a good pasturage on an unsafe range, it is more important to have a safe range well isolated from older chickens. Fortunately, a good range will generally provide the needed pasturage. Experimental results have shown a saving of 5 to 20 per cent in feed by using a good range as compared to no range. The greater saving, however, can be realized in the cost of feed by the use of a simple, less expensive feed to supplement good range and pasturage.

Run-of-Farm Pasturage

Forage need not always be a crop planted for the special purpose of poultry pasture if the chickens have free range over livestock pastures. Field crops, orchards, and hedgerows where bluegrass, orchardgrass, and the many succulent edible weeds, such as broad-leaved plantain and dandelions, are available. This natural or wild pasturage will suffice on many farms where not more than 100 to 300 pullets are raised each year.

Poultry Range Plantings

If a larger number of pullets are to be raised, it usually is advisable to provide a well-isolated range planted to a special forage crop.

Numerous forage crops such as Ladino clover, crimson clover, alfalfa, smooth brome, Sudangrass, birdsfoot trefoil, Korean lespedeza, Italian rye grass and the cereal grasses can be used to advantage. The choice of the forage will be largely determined by the soil and climatic conditions of a given locality. For

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*In rotation, preferable to livestock and poultry running together.
example, red clover may thrive where Ladino or alfalfa will not. Bluegrass and white clover are desirable where they remain succulent during the summer months.

The Tennessee station found crimson clover and winter oats an excellent winter pasture for the laying flock. 1 Alfalfa, on the other hand, proved the best all-around summer pasture for the growth of pullets. The North Carolina station found Italian ryegrass the best single all-around forage crop for chickens. 2 In comparisons continued through five years at Cornell University about equally satisfactory growth of chickens was obtained on bluegrass-white clover as on Ladino clover. 3

The Kansas station has recommended drilling oats at two- or three-week intervals, beginning in early March, to provide green forage from April to early June. 4 This should be followed by Sudangrass drilled on winter fallowed land in rows 20 to 30 inches apart, for summer and early fall pasture. To provide fall and early winter forage, oats was drilled on summer fallow land about September 15 to 20.

In northern Ohio and other areas of similar soil and climatic conditions, Ladino clover usually would be the preferred forage for chickens or turkeys. 5 These examples from different sections of the country indicate how soil and climate determine the particular kind of forage best suited to a given area. Moreover, there are the variable conditions within a given area. Poultrymen should obtain the best information available before deciding upon the kind of forage that will serve their purpose in a given locality.

Size of the range should be such as to provide good pasturage even during a rather severe period of hot, dry weather. For growth, the number of chickens per acre will vary from 100 to 400 or more, depending upon the climate, weather, soil fertility, kind of forage, and the feed supplement.

**UTILIZATION OF PASTURAGE FOR GROWTH OF CHICKENS**

Growth of chickens involves two feeding periods: (1) the starting or brooding period (the first 7 to 10 weeks), when each chick requires about 5 pounds of feed and (2) the growth or range period (from the end of the starting period to around 21 weeks) with a feed requirement of 15 to 25 pounds per bird. Obviously it is during the range period when only a low-cost feed is needed to supplement good pasturage that the poultry raiser can materially lessen the feed costs for the growth of his chickens.

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**Fig. 60.2** "The trend in commercial egg production . . . to confine the layers indoors . . . may present many advantages of forage. . . . The Ohio Station . . . with a Ladino clover pasture . . . 13 cents per dozen eggs, versus . . . 25 cents per dozen from the hens indoors."
(See p. 688.)
To realize this economy, however, the forage must be utilized to the fullest extent. The feed used should be considered only as a supplement to the forage. Chickens need to be given a job to do if they are to utilize the forage effectively, otherwise little economy in feed may be realized. In other words, if the feed contains all or most of the dietary requirements, the chickens will depend on the feed instead of the forage.

Feed for chickens on range needs to be in accord with the kind and quality of the forage. This has been clearly demonstrated in experiments by the Cornell, Delaware, Kansas, Ohio, and Virginia stations, where the feed requirements of growing pullets on a range with good forage were compared to those on a bare yard without forage. Satisfactory growth was obtained from good forage supplemented by comparatively simple, less expensive feeds. Without forage, the feed requirements were similar to those for growth of chickens indoors, with the exception of vitamin D.

FEED SUPPLEMENTS FOR GROWTH OF CHICKENS ON PASTURAGE

The feed to supplement pasturage has varied all the way from the same complete ration used for chickens indoors to only whole grain (without mash). The Cornell University and Ohio stations have reported the successful growth of pullets on good pasture when the ration was limited to either wheat or corn, plus minerals. These wide variations give rise to the question of what feed supplements are actually necessary to supplement forage for the satisfactory growth of chickens. Extensive experiments have been in progress for ten years at the Wooster, Ohio, station in an effort to answer this question.

The Ohio experiments, begun in 1940, were with simple feed mixtures, without alfalfa, milk products, and vitamin supplements. The good results from these simple feed mixtures suggested the desirability of learning what might be obtained from feeding whole grain (without mash) and pasturage.

In two experiments, one dealing with the growth of white Leghorn pullets and the other with the growth of Rhode Island Red pullets, on unlimited run-of-farm range and pasturage with whole grain without mash, a very satisfactory growth of pullets was obtained. Although these pullets were somewhat lighter in weight when taken from range, they started to lay only 2 weeks later than similar pullets that received the mash ration. They soon caught up in body weight and rate of egg production after receiving the laying ration. The unlimited range provided the necessary insects, etc., to supplement the forage. In a third experiment the growth of 250 Rhode Island Red pullets on one acre of Ladino clover was very unsatisfactory. The Ladino clover provided a generous surplus of succulent green feed, but the limited range failed to supply sufficient insects, etc.

In view of the foregoing results and experiences, a new type of ration and method of feeding was designed for growing the Station's 2,500 pullets on range and pasturage in 1945. These

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Common Minerals the Missing Links in Pasturage 687

TABLE 60.1

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>12 % protein</th>
<th>14 % protein</th>
<th>Corn and minerals; free choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole corn *</td>
<td>60</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Whole oats</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Coarsely ground corn</td>
<td>15</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Wheat bran</td>
<td>5</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Meat scraps, 50% protein</td>
<td>3</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Soybean oil meal</td>
<td>4</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Bone meal, steamed</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Salt</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Oyster shell, chick size †</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Granite grit, medium  ‡</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

* or coarsely ground if preferable
† or high calcium limestone
‡ or silica gravel grit. Omit insoluble grit if otherwise provided.

rations and methods of feeding proved so satisfactory that they have been continued without change during the past 5 years. A 12 per cent protein ration enabled a saving of nearly 50 per cent of the protein meals and proved as good for supplementing Ladino pasturage as the 14 per cent protein ration. The success of the 12 per cent protein ration and the results with whole grain (without mash) on free-range pasturage suggested that perhaps some of the common minerals might be the limiting factor when chickens are grown on whole grain (without mash) and limited pasturage. Consequently, a third ration of corn and minerals was included in the 1946 experiments.

The three rations were composed as shown in Table 60.1.

The equally satisfactory growth of chickens on Ladino clover pasturage, obtained in the three previous experiments from the use of either the 12 or the 14 per cent protein ration, was a surprise. The big surprise, however, was when the corn and minerals ration, with no protein supplement, yielded as satisfactory a growth of Leghorn and Rhode Island Red pullets in 1946 as did either the 12 or 14 per cent protein rations.

The successful results with the corn and minerals ration in 1946 were repeated in large scale experiments in 1947-49 with the growth of Leghorn, Rhode Island Red, and Leghorn-Rhode Island Red crossbred pullets. Moreover, the pullets were continued in experiments during their first years' egg production to determine how their egg production, body weight, and livability might be affected by the different rations received while on range. As layers, the pullets that received the corn-minerals ration and Ladino clover pasturage proved equal in all respects to those that received the more elaborate rations while on range.

These results indicate that the primary function of the 12 and 14 per cent protein rations as supplements to Ladino clover was to provide the necessary minerals. This was contrary to the previous point of view; it was supposed that the primary need was supplemental protein.

COMMON MINERALS THE MISSING LINKS IN PASTURAGE

Limiting dietary factors for the growth of chickens on pasturage are the well-known, inexpensive minerals (sodium, chlorine, calcium, and phosphorus) provided by common salt, oyster shell or high-calcium limestone, and feeding-
grade or steamed bone meal or defluorinated rock phosphate. In other words, Ladino clover can be depended upon to provide all of the proteins and vitamins required for the growth of chickens if the pasturage is supplemented with either whole corn or wheat (or probably other whole grains) and the previously named minerals. Other forages which furnish less protein will generally need additional protein such as is provided by the 12 or 14 per cent protein rations.

METHOD OF FEEDING. The ration used is fed once daily, about 4 P.M., in the amount that will be nearly consumed between feeding periods. At the Ohio station the whole corn and ground corn-minerals mash are fed in separate feeders. If the corn and minerals ration in a single all-in-one mixture is preferred it can be prepared by mixing the ingredients as follow:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarsely ground corn</td>
<td>95</td>
</tr>
<tr>
<td>Steamed bone meal or defluorinated phosphate</td>
<td>3</td>
</tr>
<tr>
<td>Common salt</td>
<td>1</td>
</tr>
<tr>
<td>Oyster shell, chick size of high calcium limestone</td>
<td>1</td>
</tr>
<tr>
<td>Insoluble grit (if not otherwise provided)</td>
<td>1</td>
</tr>
</tbody>
</table>

LADINO CLOVER VERSUS BLUEGRASS AND RUN-OF-FARM PASTURAGE

In an experiment at the Ohio station, Rhode Island Red pullets which received the 12 per cent protein ration and Ladino clover, made 17 per cent more growth than did similar pullets on run-of-farm range that received the 14 per cent protein ration. Feed consumption of both groups was much the same.

Rhode Island Red pullets on Ladino clover range in two experiments averaged 9 per cent faster growth with 12 per cent less feed than did similar pullets that received the same ration (12 per cent protein) on run-of-farm range.

Likewise, White Leghorn pullets on Ladino clover in another experiment made 11 per cent more growth with 12 per cent less feed than did similar pullets that received the same 12 per cent protein ration on bluegrass range.

The high protein content and palatability of Ladino clover throughout the growing season permits the successful use of either low protein rations or the corn and minerals ration. These rations on Ladino pasture enable the poultry raiser to realize the maximum feed economy in raising chickens.

Many poultry raisers will have available forages other than Ladino which may be better suited for local conditions of soil, climate, and rainfall. The 14 per cent protein-range-ration will prove more satisfactory than lower protein rations to supplement the hay and pasture grasses and run-of-farm pasturage, orchards and hedgerows with their wild grasses and many succulent edible weeds.

FORAGE FOR EGG PRODUCTION

The trend in commercial egg production during the past twenty-five years has been to confine the layers indoors. This procedure is better adapted for the feeding and management of larger flocks, in contrast to smaller farm flocks of 100 to 300, which are often ranged out of doors. Nevertheless, poultrymen might consider the advantages of forage for layers. In the past, the usual procedure has been to feed the layers on range much the same kind of feed as used for layers indoors. In contrast to this, many small farm flocks often receive only grain and run-of-farm forage. Between these extreme procedures are those indicated by recent experiments conducted by the Alabama and Ohio stations.

In two years' experiments (1947–48) the Alabama station reported that egg production from such green crops as al-
falfa, crimson clover, and soybeans, or irrigated white clover, supplemented with one-fourth the usual amount of laying mash, was as good as that from hens fed a full ration of mash and grain without green feed. Similar results were obtained from green crops whether grazed or cut and fed daily.

The Ohio station in 1919 had Rhode Island Red hens on Ladino clover pasturage versus comparable hens indoors. All the hens used in this study had been confined indoors and received the complete ration for layers from October to April 26, 1919. On that date one group of 90 hens was moved to one acre of Ladino clover. The other group of 90 continued to receive the complete ration indoors. The range group received the corn and minerals all-mash ration that had proven so good for the growth of chickens on Ladino.

The egg production of the hens on Ladino clover from April 27 to November 15 averaged 51 per cent as compared to 49 per cent from those indoors. The percentage mortality was 7 and 14 per cent, respectively. There was little difference in the monthly weights of the hens.

Since it was necessary for the birds that received the corn and minerals to complete their ration with Ladino clover pasturage, it required only 4.6 pounds of corn and minerals at a cost of 13 cents per dozen eggs, versus 7 pounds of feed at a cost of 25 cents per dozen for the hens indoors.

In other words, the Ladino clover pasturage permitted a saving of one dollar per bird in the cost of feed from April 27 to November 15. The acre of Ladino clover would have served 100 or more hens, which means that this acre of Ladino clover was capable of yielding $100 in reduced feed costs for egg production.

In some markets, graded fresh eggs with pale yolks sell for a higher price than eggs with a more deeply colored yolk from layers having access to green forage. Often there would be no price difference. In any event, the price difference would be small in comparison to the lower feed cost of the eggs from layers on a good range. If the fresh eggs with the deeper colored yolks were priced on the basis of their nutritive value, they would command a premium.

FORAGE FOR TURKEYS

A forage that is suitable for chickens will likewise prove good for turkeys. The special factor in the ranging of turkeys is ample space—50 to 100 per acre—depending on the forage, soil, and climate. Rotation to a fresh range each year—or at most every two years—is considered advisable to avoid the liability of over-contamination of the soil. Moreover, it usually is recommended that turkeys be rotated regularly to different parts of the range to lessen the degree of contamination. Another special precaution is that the range be completely isolated from chickens. If the range has been used previously for chickens there should be an interval of two years before its use for turkeys. This precaution is primarily concerned with the control of the black-head disease of turkeys. This disease is readily transmitted by infected carrier chickens.

Good forage can provide a large part of the feed required by turkeys. Since turkeys grow more rapidly than chickens, the feed supplement to forage needs a correspondingly higher percentage of protein. A common practice is the free-choice feeding of whole grain and an 18, 20, 24 or 32 per cent protein mash. Even if turkeys require more protein to sup-

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plement their forage, a good forage crop will yield high dividends per acre for the growth of turkeys.

FORAGE FOR DUCKS AND GEESE
Ducks, especially the breeders, can obtain a large proportion of their feed requirements from good forage.
Geese are the best of all domestic poultry foragers. They can be raised and kept on good forage with little or no other feed except during the breeding season, when some special feed may be desirable. Only during bad weather, when suitable forage is not available, do they need much feed besides forage.

CARE OF RANGE AND NUMBER OF BIRDS PER ACRE
The bird capacity per acre can be increased by proper management precautions. These include avoiding too-early use of the range in the spring when the forage will be injured before growth is well started, overstocking, and use too late in the fall. Moreover, the clover forages, especially Ladino, need to be clipped during the spring to avoid excessive growth of grass and weeds at the expense of the clover. Due consideration also should be given to soil fertilization and mulching in late fall where the clovers are subject to extensive winter injury.

The number of birds per acre a given range will accommodate varies greatly, depending upon the kind of forage, the weather, the kind of soil, soil fertility, and the feed supplement. Clover forages generally will serve 150 to 400 growing chickens, 50 to 100 layers, and 50 to 75 turkeys.

Chickens, turkeys, ducks, and geese can utilize pasturage to much the same advantage as livestock. In many instances, the return per acre of good forage used by chickens or turkeys will be greater than from its use by livestock.

With the information now available on improved forages, their culture, and the feed necessary to supplement forage, poultrymen can take advantage of the saving that can be made in the cost of feeding, either for growth of poultry or for egg production.

QUESTIONS
1. How do you account for the increased interest in more forages for poultry?
2. Why is a good range more important than good pasturage?
3. What factors determine the forage crops you would use for poultry?
4. List and discuss the relative merits of several forage crops used for poultry.
5. During what growth period of the chicken may forages best be used to reduce feed costs?
6. Discuss the use of feed supplements for poultry on pasture.
7. What are the limiting dietary factors for the growth of chickens on pasture and how may they be provided?
8. To what extent may forages be used for laying hens?
9. Why is it more difficult to provide range for turkeys than it is for chickens?
Terminology
Adventive—Growing spontaneously in an area, but not native.
Acid soil—A soil with a reaction below a pH of 7.0 (usually less than pH 6.6). More technically, a soil having a preponderance of hydrogen ions over hydroxyl ions in the solution.
All-grass farming—A farming system in which no cultivated crops are grown. The sods are renewed by direct renovation and reseeding or with a small grain crop.
Allopolyploid—A polyploid with chromosome sets from different sources, such as different species.
Alternate grazing—Grazing two pastures in alternate succession.
Annual—A plant which completes its life cycle from seed in one year.
Anthesis—The time of expansion of a flower, but often used to designate the flowering period.
Apomictic—A type of asexual reproduction. Individual is developed from a specialized cell without sexual fusion.
Autotetraploid—A plant which has four identical sets of chromosomes.
Biennial—A plant which produces leaves and roots the first year and flowers, fruits and seed the second, and then dies.
Bloat—Excessive accumulation of gases in the rumen, probably formed to a large extent by bacterial action.
Canopy—The layer of stem and leaf growth above the ground surface.
Carotene—A yellow pigment in green leaves and other plant parts. Certain of the carotenoid pigments are a source of Vitamin A.

Terminology*

Caryopsis—The seed (grain) or fruit of grasses.
Catch crop—A crop planted on land where other crops have failed, or that follows a crop harvested earlier.
Clones—Individual plants propagated vegetatively by rooting portions from a single original plant.
Continuous grazing—Grazing animals on a pasture area continuously throughout the pasture season.
Cool-season grass—Species of the family Gramineae that make rapid growth during the cool, moist periods of the year. The term "cool-season" usually is preferred to "cool-weather."
Coumarin—The odor and flavor substance of sweetclover; also found in lesser amounts in other plants. (A crystalline compound, C₉H₆O₂, which also can be made synthetically.)
Cover crop—A soil-protecting crop planted and left on the land to prevent leaching and erosion by wind or water; usually turned under for soil improvement.
Cross inoculation—The inoculation by symbiotic bacteria of one legume species by those of another legume species.
Crude fiber—The coarse, fibrous portions of plants, relatively low in digestibility and in nutritive value.
Deferred grazing—Withholding animals from a pasture for a period of time beyond the normal beginning of the grazing season.
Digestible protein—That portion of the ingested food protein which is absorbed.

* The editors acknowledge the assistance of E. A. HOLLOWELL, I. J. JOHNSON, and C. J. WIL- LARD in the preparation of this section.

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**Dioecious**—The male and female flowers borne on separate plants.

**Dockage sample**—Usually refers to a representative sample of seed used to determine the amount of inert material and other crop seed.

**Endemic**—A plant native to a particular environment or locality; not introduced.

**Forage**—Vegetable food for domestic animals. In its broadest sense, all livestock feed is included. More generally, the term refers only to such material as pasturage, browse, hay, straw and silage.

**Forage crops**—Those plants grown primarily for feed, harvested by man to be fed later, or harvested direct by grazing animals. Included are all plants grazed by animals or harvested for soiling, silage, or hay.

**Forb**—A nongrasslike range herb.

**Grass**—Botanically, any plant of the family Gramineae. Generally, in grassland agriculture “grass” includes the forage species of Gramineae, grown alone or with legumes.

**Grassless agriculture**—Cropping systems devoid of, or having a very small proportion of, soil-forming grasses or grass-legume combinations.

**Grass waterway**—A surface drainage-way, usually broad and relatively flat, protected with natural or seeded grass cover.

**Grazier**—One who pastures livestock, usually for commercial purposes.

**Grazing capacity**—Number of animals a given pasture will support at a given time, or for a given period of time.

**Green manure**—A crop grown and plowed under to improve the soil.

**Herbaceous**—Plant growth relatively free of woody tissue, characterized by the absence of a persistent stem above the soil surface.

**Herbage**—The leaves, stems and other succulent parts of plants upon which animals feed.

**Herbivorous**—Animals which live on vegetation.

**Heterosis**—Increased growth stimulus, often exhibited in the F₁ generation of a cross.

**Hulled seed**—Seed from which the pods, glumes or other outer coverings have been removed; as for example, such legume seed as red clover and alfalfa, and grasses such as timothy and redtop, with the lemma, palea and outer glumes removed. (Some prefer the term “de-hulled.”)

**Humus**—The well-decomposed, more or less stable, part of the organic matter of the soil.

**Hybridization**—Cross fertilization of plants belonging to different genotypes.

**Hydrocyanic acid**—A violent poison, also called prussic acid, developed under certain conditions by cyanogenic species.

**Indeterminate**—A plant that blooms over a long period; usually characteristic of legumes such as sweetclover, alsike, and birdsfoot trefoil.

**Indigenous**—Produced or living naturally in a specific environment.

**Inoculation**—Introduction of bacteria on seed or into the soil; i.e., symbiotic bacteria for the benefit of legumes.

**Intermittent grazing**—Allowing animals to graze a pasture only at certain intervals.

**Mixed grazing**—Two or more classes of livestock, such as sheep and cattle, grazed on the same pasture.

**Monococious**—Male and female parts in separate flowers on the same plant.

**Mulch**—Any material, either dead or living, that forms a covering above the soil surface.

**Nitrogen-free-extract**—The unanalyzed substance of a plant (consisting largely of carbohydrate) that remains after protein, ash, crude fiber, ether extract, and moisture have been determined.

**Pasture**—An area of land covered with forage plants, usually grasses and legumes, and used by grazing animals.

**Pasture renovation**—The process of subduing a sod by cultivation, followed by fertilizing and reseeding for a sod crop, without subjecting the land to a row crop.

**Perennial**—A plant having a duration of three or more seasons.

**Permanent pasture**—A pasture of perennial, or self-seeding annual or biennial,
plants that is kept indefinitely for grazing.

pH—The pH scale is the chemist's measure of acidity and alkalinity. For example, pH 7 is neutral; pH's above this represent alkalinity and below this, acidity. The scale is logarithmic; i.e., a solution with a pH of 4 is 100 times as acid as one with a pH of 6 and 10 times as acid as one with a pH of 5.

Photoperiodic response—The response that a plant makes to length of day and night (light and dark), particularly in respect to floral initiation.

Photosynthesis—The process by which carbohydrates are manufactured by the chloroplasts, or chlorophyll-bearing cell granules, from CO₂ and water by means of the energy of sunlight.

Phylogenetic—The race history of a plant or animal.

Plant nutrients—The elements taken in by the plant which are essential to its growth and used by it in the elaboration of its food and tissue. These include nitrogen, phosphorus, calcium, potassium, magnesium, sulfur, iron, manganese, copper, boron, zinc, and perhaps others obtained from the soil; also carbon, hydrogen and oxygen, obtained largely from air and water.

Polyploid—A plant having two or more basic sets of chromosomes.

Prairie—A level or rolling area of treeless land covered with grass, under which fertile soils usually have developed.

Protein—Complex organic compounds composed largely of the elements carbon, hydrogen, nitrogen, oxygen and sulfur. Some also contain phosphorus and a small amount of other elements. There are many proteins, differing from one another both chemically and physically. They are characterized by their relatively high nitrogen content.

Pro-vitamin—The material from which an animal may produce vitamins. Certain vitamins need not be consumed by animals, since the body has the capacity of producing them from the pro-vitamins, as for example carotenoids (pro-vitamin A).

Regional strain—A strain developed under a given environmental condition as a result of the survival of the fittest through many seed generations.

Reseeding variety—A variety that perpetuates itself by volunteering from seed; usually made possible because of a high percentage of hard seed, or seed with high dormancy.

Rhizome—A rootstock; a creeping stem below the soil surface, usually horizontally elongated. The rhizomes of grasses bear scales at the nodes and usually are slender and creeping.

Rootstock—See rhizome.

Rotation grazing—Grazing two or more pastures in regular sequence, with rest periods for the recovery of herbage.

Roughage—Refers to feed stuffs that are high in crude fiber and low in total digestible nutrients, such as pastureage, hay, straw and silage.

Rumen—The first compartment of the stomach of a ruminant or cud-chewing animal.

Rotation pasture—Pasture crops grown as a part of a planned cropping system.

Scarification—The process of scratching the seed coat of "hard" or impervious seed in order to make good germination possible.

Seed-hay method—A seeding method used in the West in which mature plants with seed attached are cut, as for hay, but used to establish new plants.

Selective grazing—Grazing of the more palatable species while others are neglected or refused.

Self fertilization—The process by which egg cells of a plant are fertilized by the sperm cells of the same plant.

Self incompatibility—Inability of a plant to set seed from its own pollen.

Self-pollinated—Pollination of an individual floret or flower with its own pollen.

Self sterile—See self incompatibility.

Semi-permanent pasture—A pasture that is only occasionally renewed; usually in a long rotation.

Short-grass prairie—Generally refers to that area of the Great Plains covered with relatively low-growing native grasses.

Sib-mating—Brother-sister mating.

Sod—The top few inches of soil, permeated by and held together with grass roots, or grass-legume roots.

Sod-bound—A term commonly used to describe the unproductiveness of a nitrogen deficient, or nitrogen starved, grass sod.
Soiling crop—A crop grown to be cut and fed in a fresh condition.

Soil structure—Refers to the arrangement or grouping of soil particles.

Soil tilth—The physical condition of a soil in respect to its fitness for good plant growth.

Spot grazing—Uneven grazing; the young, tender, recovery growth on certain areas are grazed repeatedly, while the more mature plant areas are neglected.

Spontaneous combustion—Self-ignition in a substance by the chemical action of its constituents; as in high-moisture hay.

Stolon—A creeping stem above the soil surface; roots usually form at the nodes.

Strain—A somewhat distinct group of plants within a variety of an open-pollinated species which differ consistently from other plants of the same variety; also, a term often used synonymously with variety.

Stubble mulch—Crop residue left on the surface of the land that is being cropped.

Synthetic variety—A variety obtained by combining selected cross-pollinating lines or plants.

Tallgrass prairie—Generally refers to that area in the Corn Belt originally covered with tall native grasses.

Temporary pasture—A pasture crop grown to provide grazing for only a short period in one crop season.

Tetraploid—A plant with four times the primary chromosome number.

Top-dressing—A fertilizer application on a crop any time after its establishment.

Total digestible nutrients (T.D.N.)—The total of all of the digestible organic nutrients, including protein, carbohydrates, and ether extract; in calculating the T.D.N. the latter is multiplied by 2.25 because its energy value for animals is approximately 2.25 times that of protein or carbohydrates.

Tripping—The release of the sexual column from the keel of the flower in the process of pollination. (Said of alfalfa and a few other legumes.)

Turf—The upper stratum of a soil when filled with the roots and stems of low-growing plants, especially grasses.

Unhulled seed—Seed with the pods, glumes or other outer covering retained when ripe, as for example is usual for seed of timothy and redtop; also sweetclover when the pods are intact.

Variety—A subdivision of a species, the plants of which differ from other plants of the species in one or more recognizable inherited characters.

Vitamin—An organic compound, occurring in minute amounts in natural foods and feeds, which must be available to the animal in order that a specific metabolic function or reaction may proceed normally.

Warm-season grass—Species of the Gramineae family that make their major growth during the warmer part of the year. The term “warm-season” usually is preferred to “hot-weather.”

Winter annual—A plant which germinates in the fall, lives over winter, and produces its seed the following spring, after which it dies.
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