FORAGE CROPS OF INDIA

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PREFACE

This book on the Forage Crops of India is the outcome of a decision taken by the Indian Council of Agricultural Education at its third session held at Bangalore in August, 1958, that the Indian Council of Agricultural Research should sponsor the preparation and publication of text-books in various agricultural subjects, with a view to meeting the shortage of suitable text-books for students in agricultural colleges. The author was assigned the work of writing a book on forage crops, with the assistance of Shri P. M. Dabadghao, Director, Grassland Research Institute, Jhansi.

Shri Dabadghao has contributed material towards the chapters (Nos. 10, 11, 12, 13, 20 and 21) relating to grasses and grassland improvement. The information contained in these and other chapters has been drawn from various sources and these are indicated in the bibliography. The author is indebted to Shri Dabadghao for the photographs in figures 21, 51 and 56. Thanks are also due to the Director of Agriculture, Madras, for the photographs in figures 12, 18, 22, 35 and 37. The other photographs and the line drawings have been prepared specially for this book.

An attempt has been made in this book to present both the principles and the practical aspects governing the cultivation of forage crops, with special reference to Indian conditions, in a manner which, it is hoped, would be useful to students in agricultural colleges and to progressive farmers.

T. R. NARAYANAN

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INTRODUCTION

The term forage crops denotes plants used for feeding domestic animals that are reared on a farm, namely, cattle, buffaloes, horses, sheep, goats, pigs and poultry. The term includes wild as well as cultivated plants that are used as stock feed. Domestic animals are either allowed to roam about and graze for themselves, or fed with cut grass in stalls. The term 'grass' in the context of feeding livestock and grassland agriculture is not limited to the narrow botanical sense alone, but also includes their common associates of the legume family. 'Soiling crops' are green forage crops that are cut and fed in fresh condition to the stock.

India has the largest cattle population in the world. It was 198 million ten years back, i.e., nearly a quarter of the world's then bovine population. This works out to nearly 80 animals per 40 hectares of arable land, as against 40 in the United States, 25 in Egypt, 15 in China and only 6 in Japan. But the condition of this enormous cattle population is very poor because the fodder resources of the country are hardly sufficient for even half the existing number. Further, the cattle population is also increasing year by year, along with the human population. According to the Livestock Census of 1961, there were in India 226·8 million head of cattle, including 51·1 million buffaloes. This represents an increase of 10·7 per cent over the figures of the 1956 census. It is therefore obvious that the future of India's livestock cannot be satisfactory if adequate steps are not taken in good time to augment the fodder resources of the country. Insufficient fodder results in poor cattle; it not only impoverishes the farmer but also lowers national wealth and productivity. With proper feeding, Indian cows, which at present yield less than 1·36 kg of milk per day, can yield 50 per cent more milk, and buffaloes 20 per cent more. The efficiency of draught animals would also go up by as much as 60 per cent.

With an increasing cattle population, the supply of fodder for domestic animals is also getting more and more difficult every year. The areas under millets, rice and pulses have increased by less than one per cent within the past 25 years but the pressure of bovine population has increased during the same period from 74 to 98 animals per 40 hectares of arable land. This leads to a situation where the animals would not get even one-third of what they need for a maintenance ration of 4·53 kg of roughage per day plus 2·72 kg of green grass for a body weight of 227 kg.

Thus, there is an urgent need to increase our fodder resources three-fold. This increase should also be in crops other than paddy (rice), because paddy straw, which now forms the bulk of cattle roughage, is a very poor feed and needs to be supplemented with more nutritious feedstuffs. As things stand in India, crops are seldom grown specifically for fodder

purposes, except in some limited areas. In many regions of India, fodder for livestock is provided only by the various cereal straws. Grazing is poor during most months of the year except for a short period during and after the monsoons, and the available feedstuffs are not sufficient to support the existing cattle population. Pastures as they exist in other countries, such as the United States, Australia and New Zealand are very rare in India, because of the great pressure on the land here. It is seldom feasible to set apart any portion of the cultivable lands exclusively for fodder, and a dovetailing of arable farming into a system of 'mixed farming' is the only feasible method for general adoption. In mixed farming the land is utilized not only for raising food and cash crops, but also to produce enough fodder for work and dairy animals as well as for the poultry reared on the farm. A portion of the holding is given over to perennial or annual forage crops. The arable crops receive the manure obtained from the farm animals and the fodder crops receive artificial fertilizers in adequate quantities.

The fodder resources of the country can be improved by the adoption of better techniques of production, introduction of exotic types of nutritious fodders, development of grassland farming, improving the grazing grounds near forests and villages, and by a more careful preservation of surplus fodder.

A system akin to the 'ley farming' or temporary pastures adopted in England and other countries is also in vogue in a few places in India. For instance, pastures are maintained in the Kangayam tract in Madras, in the Ongole area in Andhra Pradesh and in the Bargur and Hosur areas in Mysore State. In Kangayam, sorghum is sown once in three or four years, and after the crop is harvested the land is left fallow to enable the local grasses, such as *Cenchrus ciliaris* and *C. setigerus*, to grow luxuriantly. These grasses furnish excellent forage for the well-known breed of Kangayam cattle reared in this tract. Available wasteland that had remained fallow for three or four years can be put under suitable grass-legume mixtures for six or seven years and ploughed up afterwards, to grow some cereal foodgrains for one or two years and then used again as grassland. As the land improves in fertility, the grassy spells can be reduced to four or five years.

India is virtually a subcontinent, with so much variation and overlapping in climatic and ecological regions that it is difficult to demarcate them precisely. Within each region, a good deal of variation exists due to the influence of elevation, topography, edaphic and atmospheric factors. It is, therefore, necessary to know what types of fodder crops will grow well in any particular region and also where, when and how best these types and species can be grown.

CHAPTER 1

FORAGE CROPS IN THE INDIAN AGRICULTURAL ECONOMY

DOMESTIC animals are either allowed to roam about and graze for themselves, or fed with cut grass in stalls. The term ' grass ' in the context of feeding livestock and grassland agriculture is not limited to the narrow botanical sense alone, but also includes their common associates of the legume family. ' Soiling crops ' are green forage crops that are cut and fed to stock in fresh condition.

The pasturing of animals is always cheaper and the cost of production, of both livestock and dairy produce, is the lowest in the case of pastures because no expense of growing, cutting, transporting or feeding is normally involved. In North and South Americas, in Australia and New Zealand, pastures are quite widespread and popular, because sufficient land is available for pastures over and above what is needed for growing grain and cash crops. The land is cheap and plentiful, while labour is scarce and costly, and hence any system that saves labour gets preference and popularity in these countries. Grassland farming as practised in Great Britain, Australia and New Zealand utilizes to the full the legume-grass association in herbage mixtures by the grazing animal, leading to a cycle of crop—animal—soil—crop. When such legume-grass mixtures are removed from the field for feeding as hay or silage, the stable manure seldom gets returned to the land. This leads to a heavy and progressive loss of soil nutrients which has to be restored by applying fertilizers that may often prove expensive.

North America has nearly a quarter of the arable area under pasture crops and forage crops like lucerne, maize, sorghum, swedes and mangolds. Nearly 90 per cent of the maize and oats, 50 per cent of the barley, 25 per cent of the wheat and rye, all the sorghum and an appreciable percentage of many other crops are utilized as stock-feed. In the United Kingdom, in 1963, out of 19·82 million hectares of arable land, nearly half the area was under grass and other forage crops. In India, however, out of a total cultivable area of 131·11 million hectares in 1963, less than two per cent is utilized for forage crops. This is because the population pressure on the land is much more in India than in other countries and top priority is given only to grain and cash crops, as these can furnish food for both human beings and livestock, whereas forage crops can feed only livestock. Labour, too, is more plentiful and less costly here than in Western countries, and hence the scope for setting apart areas specifically for pastures and forage crops is rather limited in India, except in a few favoured tracts and special conditions. It is, therefore, necessary to intensify our efforts towards a more efficient production of high-yielding

forage crops that would bring maximum outturn out of the minimum land.

The main difficulty in having pastures in India is the limited number of species that are suited for use as grazing legumes in a tropical climate. Conditions are, therefore, not really favourable for permanent grass-legume pastures in India, nor even for ley-farming systems of grass-legume associations.

European countries and temperate countries of the southern hemisphere like New Zealand and Australia, are fortunate in having the optimum humidity and the right legumes, such as *Trifolium repens* and other species, which thrive in those conditions. Grazing stimulates these legumes into putting forth fresh shoots, whereas in similar grass-legumes associations in tropical and even in subtropical regions of India, the legume species tend to get eradicated, rather than stimulated, by anything more than light grazing. The enormous, uncontrolled population of ill-fed cattle in India makes the position even worse, as all available grazing areas are heavily over-grazed and, hence, the trend is to grow arable legumes in separate plots alongside grasslands or cultivated grass crops.

Sometimes, when grasslands are over-grazed or burnt (as often happens) in the scrub jungles and foothills in India, unpalatable or noxious weeds gain a foothold, e.g., *Cytisus* on the Nilgiris and *Acacia*, *Prosopis juliflora* or *Cassia tora* in the semi-arid regions in the plains. In these tropical and semi-arid regions, it is not always as easy as in temperate regions to assess the effect of leguminous forage crops on soil fertility and on the yields of subsequent crops, as farmers who eke out a precarious existence on limited holdings can ill afford to spare much land for forage legumes or even for green manure legumes. In the few areas where sufficient land is available and the population pressure is less, the farmer prefers to practise ' shifting cultivation ' rather than go in for any set system of rotations.

In many cases, villagers near low hills have stripped the soil of all vegetation and all the top soil is lost by uncontrolled grazing. In the *birs* of Rajasthan, such uncontrolled grazing has led to the complete disappearance of all good grasses and fodder-yielding trees and left only a relict vegetation of *Salvadora* or *Capparis* shrubs, which are useless for forage purposes. The annual ceremonial of Vanamahotsava has also not been very successful in arresting the denudation process, mainly due to the lack of any sustained enthusiasm or provision for adequate seeds, planting material and technical advice readily available to farmers.

Steps are, however, being taken in certain areas, e.g., in the grazing lands of the Damodar Valley catchment areas, to improve grazing facilities. As the native species on these grasslands do not yield well, high-yielding grasses and legumes have been introduced and amongst these some were found to be quite promising, notably, *Cenchrus ciliaris*, *Pennisetum polystachyon*,

Urochloa mosambicensis, *Indigofera hirsuta* and *Calopogonium orthocarpum*. These species are available for utilization from the early monsoon months till the winter months. Controlled utilization of the grazing lands, along with a basal application of nitrogen at the rate of 22·4 kg per hectare and phosphorus at the rate of 44·8 kg per hectare increased the herbage yields from 22 quintals per hectare to 84 quintals per hectare.

The importance of legumes to India's agricultural and livestock economy will be appreciated better when it is noted that half the nitrogen in all legumes is derived from the air and only the other half from the soil. In the U.S.A., it is estimated that more than a million tonnes of nitrogen are ' fixed ' by legumes, from atmospheric air, which is equivalent to nearly five million tonnes of ammonium sulphate. Against this should be set off the annual loss of nitrogen from soils of the equivalent of 35 million tonnes of ammonium sulphate, less than five per cent of which could be replaced by artificial nitrogenous fertilizers. In India, the position would be even worse. Here crops are not grown specifically for fodder purposes except in certain limited areas, although maize and sorghum are widely grown and may be said to serve the purpose. Sorghum is grown as a grain-cum-fodder crop in the Punjab, Uttar Pradesh, Bihar, Rajasthan and Madhya Pradesh, Maharashtra, Gujarat, Andhra Pradesh, Madras and Mysore. Maize is also grown in many States, especially in the northern States. In the Punjab, a good deal of work has been done on fodder crops and plans have been formulated for raising crops to supply green fodder throughout the year.

In dairy farming the principle is that dairy cows must have a high quality feed and get it without too much effort or exposure to severe weather. Both hay-making and ensilage are important, because this ensures a nutritious feedstuff to farm stock all through the year.

Different species of grasses and even different varieties of the same species are capable of giving different yields of green material from the same soil; similarly, their nutritive values are also different. Leguminous plants are richer in proteins than the ordinary grasses and so the forage is always more nutritious if legumes are grown along with grasses. Young grass is more nutritious than grass cut later, for it contains a larger percentage of proteins and phosphoric acid than in the mature stages.

CHAPTER 2

CLIMATE AND SOILS

LIKE most other crops, forage crops also grow better on well-drained, fertile loamy soils than on shallow, stony or gravelly soils. Soil variations also influence their quality: where the soil is deficient in mineral ingredients, the forage crops are also likely to be deficient in mineral nutrients. Very often, the deficiency may be in calcium or phosphorus, and the animals fed exclusively on such forage may be stunted in growth and poor in production.

The rainfall and the soil moisture available in a particular area in different periods of the growing season are the factors that decide the success and value of the pasture and fodder crops grown in the particular area. In areas of heavy rainfall, as on the west coast of peninsular India, grass growth tends to be rank and coarse in quality.

India has a wide range of soils and climatic conditions, but has only three main seasons—the hot, the cold and the rainy—and these vary in degree in different States according to their geographical location and proximity to the sea or to mountain ranges. The rainfall in most regions is either too much or too little and as a result the grasses that come up after the rainy season usually dry up towards the ensuing cold season.

The paucity of nitrogen in Indian soils is so widespread that marked increases in yield result from the use of nitrogen alone on practically all crops. In most Indian soils, nitrogenous fertilizers leave hardly any residual effect and, further, soils of the same or comparable clay content and *p*H values show a lower need for lime than in temperate regions.

The whole concept of a need for fertilizers for forage crops is of recent origin even in the advanced temperate countries of the West. In India, the necessity of adequate nutrient supplies to forage crops has been recognised only during the past 25 years. In such a large country as India, it is difficult to give any easy generalised picture regarding the soils that exist in different regions; still, a general outline will be useful in a discussion of the mineral nutrition of forage crops in India.

SOIL TYPES IN INDIA

Six main soil types can be distinguished—red, black, laterite, alluvial, saline, and peaty soils.

Red soils occur in extensive areas in many parts of India, particularly in the eastern and the south-eastern regions. They are mostly light in texture, friable, quite porous and usually poor in soluble salts. They vary much in colour, depth and fertility from place to place, but are utilised

to grow a large variety of crops, both rain-fed and irrigated. Red soils are formed from the same parent rock as the black soils, but whereas these are usually formed *in situ*, the black soils are often cumulose in origin. Red soils differ from other soils in showing a neutral or slightly acidic reaction and having lower levels of calcium and phosphorus.

Black soils occur over large tracts in Maharashtra, Gujarat, Madhya Pradesh, Andhra Pradesh and certain areas in Mysore. They vary in depth from 30 cm to 610 cm and in texture from light loam to heavy clay; they crack deeply during the hot summer months. Another characteristic is the presence of '*kankar*' or calcareous nodules at some depths, in addition to the calcium carbonate distributed throughout the soil. Nitrogen is usually low, but these soils are potentially quite fertile, as moisture is the usual limiting factor. Care is needed, however, in bringing these soils under irrigation, especially the heavier types, on account of drainage difficulties and the risk of alkalinity.

Alluvial soils are to be found mostly in the Indo-Gangetic plains, namely, in Sind (now in Pakistan), the Punjab, Uttar Pradesh, Bihar, Bengal, Orissa and Assam, as well as in the deltaic areas of the Godavari and Krishna and Cauvery rivers. Alluvial soils, too, are potentially very productive, but they tend to be alkaline in many areas, through bad management of irrigation practices, e.g., in the Punjab and Sind.

Laterite soils are peculiar to tropical regions; they are porous and well-drained and found in the Deccan, Mysore, Kerala, southern portions of Maharashtra and central India, and the eastern Ghats region of Orissa and parts of Assam. Laterite soils are derived from various kinds of parent rock material, under conditions of heavy rainfall alternating with hot, dry spells. Their main characteristic is the high content of hydrated oxides of iron and aluminium and low content of manganese. They are also low in calcium, magnesium and sometimes potassium as well and are generally of low fertility, but paradoxically enough, they are agriculturally more useful for growing crops than black soils.

Saline soils are found in certain coastal regions and in deltaic areas, as well as in certain parts of the Punjab and Uttar Pradesh that had been under canal irrigation.

Peaty or marshy soils occur in certain limited locations in the coastal areas of Kerala and East Bengal (now in Pakistan) where the drainage is poor. These soils are high in organic matter. Most soils in forest regions and on the hills are also rich in organic matter; these are acidic in reaction. The Terai soils which extend along the Himalayan foothills are also rich in organic matter.

Desert soils occur in Rajasthan over large areas under arid and semi-arid climatic conditions. These are mostly sands with a high salt content and high pH values, with a low content of lime and organic matter.

Except in forest soils on the hills and in marshy soils, organic matter

is low in most Indian soils. Hence, the primary need is to rectify this nitrogen deficiency for arable as well as forage crops grown in Indian soils. Forage crops, especially, are benefited by nitrogen even more than grain and pulse crops, because it is the vegetative portion that is utilized as forage and nitrogen has the greatest effect on the shoot system. Phosphoric acid may also be necessary in many locations, more than what is realised nowadays.

A grass crop of two tonnes will remove about 90 kg. of nitrogen from the soil and higher yields will naturally remove greater quantities of nitrogen. Grasses require large quantities of nitrogen, but unlike legumes they have no power of ' fixing ' nitrogen from the atmosphere, and hence, it is always advantageous to grow legumes in association with them, so that some part of their nitrogen requirement may be secured from the legume root-nodules.

Assuming an adequate supply of phosphates and potash, the response of grasses to nitrogen will depend upon the species, the length of the growing season and the climate, especially the rainfall. Experiments have shown, however, that 11·3 kg of nitrogen can produce an extra 227–272 kg of hay and 45 kg of nitrogen will produce up to 25 quintals of additional hay per hectare.

Although nitrogen by itself is beneficial, in conjunction with phosphates the response is even greater (Table 1).

TABLE 1. RESPONSE OF GRASSES TO NITROGEN AND PHOSPHORUS
(*Telenkhari Farm, Nagpur*, 1935)

	Dry yield of grass (q/ha)	Percentage increase
No manure (control)	32·5	100
Phosphorus alone (224 kg/ha of phosphate per hectare per annum)	32·5	100
Nitrogen alone (112 kg/ha of ammonium sulphate per hectare per annum)	42·9	131·9
Nitrogen plus phosphorus (112 kg/ha of ammonium sulphate plus 224 kg/ha of superphosphate per hectare per annum)	46·4	142·2

It is clear from Table 1 that although phosphate by itself had hardly any response, it increased the yield by 42 per cent when applied along with nitrogen in the form of ammonium sulphate, which by itself had improved the yield only by 31·9 per cent over control.

On soils known to be deficient in one or more of the nutrient elements, the yields would be increased by supplying the deficient elements. For instance, at the Adartal Farm, Jabalpur (Madhya Pradesh), both the yields and the quality of grasses were improved by supplying nitrogen.

TABLE 2. EFFECT OF NITROGEN ON THE COMPOSITION OF GRASSES (1939-40)

	Protein content		Phosphorus content	
	Rhodes grass %	*Cenchrus ciliaris* %	Rhodes grass %	*Cenchrus ciliaris* %
No manure (control)	10·01	7·52	0·27	0·28
224 kg of Nitrogen per hectare as farmyard manure (F.Y.M.)	11·15	9·12	0·48	0·47
224 kg of Nitrogen per hectare as ammonium sulphate	14·30	12·18	0·32	0·29

Grasses can be made more nutritious by adequate manuring. Thus, the protein content increased from 10 per cent in the unmanured control to 14·3 per cent in Rhodes grass and from 7·52 per cent to 12·18 per cent in the case of *Cenchrus ciliaris*, as a result of supplying nitrogen at the rate of 224 kg per hectare in the form of ammonium sulphate. Similarly, the phosphorus content also showed a distinct increase in both the grasses by additional supply of nitrogen.

In the case of leguminous crops, nitrogenous fertilizers have little effect on the yields or protein content, but phosphates increase both the yield and the phosphorus content, often by as much as 20 per cent. Work at the Indian Agricultural Research Institute, New Delhi has shown that in berseem, the uptake of copper and cobalt is increased as a result of applying phosphatic fertilizers like bone-meal or superphosphate. Legumes can fix atmospheric nitrogen through bacterial activity in their root nodules, but it may be necessary to inoculate the soil with the appropriate bacterial culture when a leguminous crop is to be grown for the first time in a field. Phosphates and potash are of greater importance to legumes than nitrogen, but in India the response to phosphates and potassic manures may not be evident in all places, as some regions have already an adequate level of these elements in the soil. The degree of response will also depend on the nature of the soil: from Table 3, it is clear that the response of lucerne to phosphate applications was more clear-cut in silt loam than in fine sand.

TABLE 3. RESPONSE OF LUCERNE TO PHOSPHATE APPLICATIONS

Fertilizer treatment (kg/ha)	Yield of lucerne in kg/ha	
	Fine sand	Silt loam
O	4860	5303
56 kg/ha	5155	5819
112 kg/ha	4763	5897
224 kg/ha	4741	6143

In places where lucerne is liable to get injured by frost, additions of potash and phosphates are helpful in preventing the thinning out of lucerne by winter-killing and bacterial wilt and results in better stands and higher yields. When soils are deficient in phosphates, the grasses that grow on them remain poor in phosphorus content throughout their growth and in the ripe stage they may even fall below 0·2 per cent, whereas on good soils the phosphorus content remains at a high level.

TABLE 4. EFFECT OF SOIL FERTILITY ON THE COMPOSITION OF SPEAR GRASS (*Heteropogon contortus*)

	Stage of growth of Spear grass		
	Seedling stage %	Milk stage %	Just-ripe stage %
	(Percentages on dry basis)		
Poor soil (at Nurpur)			
Crude protein	10·12	4·43	2·89
Phosphorus	0·35	0·31	0·33
Good soil (at Nurpur)			
Crude protein	11·72	9·24	8·09
Phosphorus	0·59	0·32	0·33

(After Lander, 1942)

The feeding value of the grass, as reflected in the figures of protein and phosphorus, goes down as the grass ripens, but the decrease is less marked on a good soil than in a soil where the available phosphorus is very low. (Table 4.)

Both phosphorus and potash are important in forage plant nutrition and both must be supplied in balanced amounts for maximum growth and yields. These amounts would ordinarily be 56–112 kg per hectare per year of phosphorus plus 112–224 kg per hectare of potassium per year.

Boron deficiency is fairly widespread in legumes, especially in lucerne on light soils. The internodes get shortened near the top and lateral shoots produced give a rosette effect. In severe cases, the terminal buds die, the plants get stunted and the leaves show yellowing and reddening. Borax by itself at the rate of 22·4–44·8 kg per hectare or in borated fertilizers applied once in two or three years, should help in correcting this deficiency.

Sulphur is another element that is likely to be deficient in certain areas such as Florida; though in India there is no report of sulphur deficiency so far. Legumes need more sulphur than cereals, as they contain more protein.

Besides these elements, manganese, copper, zinc, iron and molybdenum may also be found necessary in certain soils under certain conditions,

but as a general rule they are present in adequate amounts in all normal soils, especially if they receive additions of organic manures like compost, cattle manure or green manure.

More than the actual quantities, it is the balance between the different nutrient elements that is important in maintaining a high level of forage yields.

Experiments carried out at Palghar (Bombay) in 1946-47 indicate that the best manurial treatment for the grasslands of that region (which included *Iseilema wightii*, *Ischaemum aristatum*, *Themeda cymbaria* and *Eulalia argentea*) would be 33·6 kg per hectare of nitrogen supplied at 16·8 kg as farmyard manure and 16·8 kg as ammonium sulphate, plus 44·9 kg of phosphorus in the form of superphosphate. This treatment gave 83 quintals of air-dry grass per hectare, an increase of 25 quintals or 44 per cent over unmanured plots. The same dose gave the best quality of grasses as well (Table 5).

TABLE 5. RESPONSE OF GRASSES TO FERTILIZERS—(PALGHAR, 1946-47)

Treatment	Yield (q/ha)	Protein (kg/ha)	Lime (kg/ha)	Phosphorus (kg/ha)
No manure	57·7	143·4	22·0	4·0
33·7 kg N.+45 kg/ha P.	83·3	263·2	39·5	10·0
Increase per cent	44·0	27·0	25·0	74·0

For the Terai regions in Uttar Pradesh, which are usually richer in nitrogen and poorer in phosphorus than soils further south in that State, the fertilizer treatment suggested is 11·2 kg per hectare as ammonium sulphate + 22·4 kg per hectare of phosphorus as superphosphate.

Experiments on grasslands in the Damodar Valley Corporation region seem to indicate that fertilizers can accelerate the ecological progression from inferior to superior types of grassland. This fact has been observed in the U.S.A. also, where native grasses of low nutritive value got eliminated by better grasses like Dallis grass and Bermuda grass, when the pastures were manured. Kentucky bluegrass and white clover also increase in pastures as the fertility level is improved. Thus, clover increased from 22 per cent in untreated pastures to 36 per cent of the vegetation in plots receiving lime, phosphates and potash. A single application of N alone, however, had the effect of depressing the clover population to 14 per cent and two such applications of N depressed it to six per cent of the vegetation. It is clear, therefore, that the botanical composition of forage mixtures will respond markedly to fertilizer treatments.

It is generally admitted that the fertility of Indian soils is deteriorating and that crop yields in many soils cannot be raised by fertilizing alone. Studies are in progress at the Sabour farm (Bihar) to evolve rotational

systems of five year cycles which would help in a regeneration of the fertility lost in grain farming. It is, of course, unlikely that a pasture legume analogous to the white clover of humid temperate countries would become available for Indian conditions, either for incorporation in natural grass-lands or even for special seed-mixtures for artificial reseeding, but the beneficial effects of a turf grass like *Cynodon dactylon* on the soil structure and on the nitrogen content are quite marked. The rate of improvement of soil structure was quite rapid (at Sabour) even after one-year leys. Legumes, especially of the *Phaseolus* species, were very helpful in their effect on the soil nitrogen in most places of India. A mixture of *Cynodon* and *Medicago hispida* (bur clover) would provide a very good sward for the winter months in the Bihar region and also have a good effect on the physical texture of the soil. *Cynodon dactylon* has a much better effect on soil structure than taller grasses like Napier grass or Rhodes grass. Since the scope for increasing the area under leguminous fodder crops is very limited in India, the practice of growing green manures assumes great importance for supplementing the organic fertility supplied by farmyard manure and compost.

Green manure is one of the cheapest and best sources of organic manure available to Indian farmers. It is also a very widespread practice in India, being adopted at present in the Punjab, Uttar Pradesh, Madhya Pradesh, Maharashtra and Gujarat for wheat; in Maharashtra, Mysore, Andhra Pradesh and Madras for millets; and for sugarcane, cotton, jute and vegetable crops in the several States where they are grown. It would be desirable to grow dual-purpose species like sunn-hemp or *Phaseolus trilobus* suitable either for green manuring and fodder, depending on the season and the cropping system adopted by the farmer during any particular year. Legumes for green manures are particularly helpful on light, sandy soils deficient in humus and liable to erosion. For such soils *Crotalaria juncea* and *Cyamopsis tetragonaloba* are the most suitable, while on heavier soils *Phaseolus trilobus* would be the best choice. It is a good practice to utilise the first growth of the legume for fodder and then to plough in the stubble as green manure.

CHAPTER 3

CHARACTERISTICS OF FORAGE CROPS

LEGUMES

THE three most important groups of plants from the economic point of view are the grasses, palms and pulses, i.e., Gramineae, Palmae and Leguminosae. The word legume is derived from the Latin word *legere* (to gather) because the pods have to be gathered or picked by hand, as distinct from ' reaping ' the cereal crops (Gramineae). Leguminous plants supply the major portion of the world's plant protein consumed by man either directly or indirectly through animals.

Legumes were utilized by man as early as 5,000 B.C., in the Bronze Age itself, by the Lake Dwellers of Switzerland. The Chinese cultivated soyabeans in 3,000 B.C. and the Egyptians in 3,000-2,000 B.C. The American Indians of both North and South America have grown beans along with maize from very early times. It is, however, curious that the most important and useful feature of legumes, namely, the power of their root-nodule bacteria to ' fix ' atmospheric nitrogen, was discovered only in 1875 or so. When legumes are grazed or cut and fed to cattle, nearly two-thirds of the nitrogen fixed from the atmosphere is left in the soil. Bacteria of the *Rhizobium* group get carried in dust or on the seed coat, infect the root-hairs at a very early stage of growth and stimulate the surrounding tissue to form nodules, inside which the bacteria multiply, drawing energy from the host plant. In return, the host plant gets nitrogen fixed by bacteria from the atmosphere, resulting in what is known as a symbiotic association. Recent research has revealed that fixation of atmospheric nitrogen takes place neither in the bacterial cells nor in the cell sap of the roots of the host plant, but only in the cell sap of the nodular tissue.

Legumes have thus a special significance in agriculture, in being partially independent of the soil for their nitrogen requirements as well as in their high content of proteins. Legumes are very valuable for renovating crops on poor soils, or as crops preceding cereals in crop-rotations, because instead of impoverishing the soil, they enrich it with the nitrogen fixed by the bacterial root-nodules, or by the whole plants when ploughed in as green manure. At the same time, they are, as a group, more sensitive than cereals to variations in climatic and soil conditions and have a higher water requirement than cereals. Nodulation, in particular, is quite sensitive to changes in soil reaction and may be adversely affected by excess of soluble salts, poor light or short-day conditions.

Botanically, legumes are classified under the natural order Leguminosae.

This is the third largest family of flowering plants, comprising more than 600 genera. It is subdivided into three sub-families: Mimosoideae and Caesalpinioideae, mostly tropical; and Papilionatae, largely temperate in distribution.

Leguminous plants show a great diversity in habit—trees, shrubs, herbs, xerophytes, water-plants, climbers, etc.

Stem. It is usually erect, though some are prostrate in habit and some are climbers; some climb by leaf tendrils as in the case of *Vicia*, some by stem tendrils (*Bauhinia*), some by hooks (*Caesalpinia*, *Acacia*), and some by twining (*Dolichos*).

Leaves. These are stipulate, alternate and usually compound. Stipules vary much in size, shape and function as in *Lathyrus*, *Vicia*, *Acacia*. The leaves in several species show sleep movements at night (e.g., *Enterolobium saman*); some moving upwards, some downwards, but all finally resulting in the leaflets being disposed edgewise to the sky. In *Mimosa* and *Neptunia*, the leaves are sensitive to touch and immediately assume the sleep position when touched and recover only after some time. In *Desmodium gyrans*, the lateral leaflets execute spontaneous movements in warm weather.

Inflorescence. This is mostly of the racemose type, but with many variations, ranging from simple racemes and spikes to compound panicles. Dorsiventral racemes also occur in some genera, e.g., *Dalbergia*.

The flowers are either regular and polygamous or irregular and hermaphrodite. The calyx is pentamerous, sepals more or less united with the oldest (the odd one) sepal in the anterior position. The corolla is polypetalous, alternating with sepals, with valvate aestivation in Mimosoidae, ascending-imbricate in *Caesalpinioidae* and descending-imbricate in Papilionatae. In many cases, flowers are zygomorphic; with a posterior large petal (*standard* or *vexillum*), two lateral wing petals or *alae* and two anterior petals, more or less joined to form a keel or *carina*.

Androecium. Stamens are ten, free or united into a tube; if united, the tenth stamen (or posterior one) often remains free, leaving a slit in the tube and loosely covering it. In flowers with a keel, the stamens are enclosed in it.

Gynoecium. One-carpelled, with the ventral side posterior, style long, with terminal stigma. Ovules are in two rows, alternating with one another, so as to stand in a single vertical rank, anatropous or amphitropous, erect or pendulous.

Pollination. In Papilionatae the keel encloses the essential organs and makes the flower complex. Honey is secreted by the inner sides of the stamens at their base and accumulates in the staminal tube around the base of the ovary. On either side of the base of the tenth stamen, which is free of the tube, there are two openings leading to the honey. The honey is thus concealed at some depth and only insects with a tongue

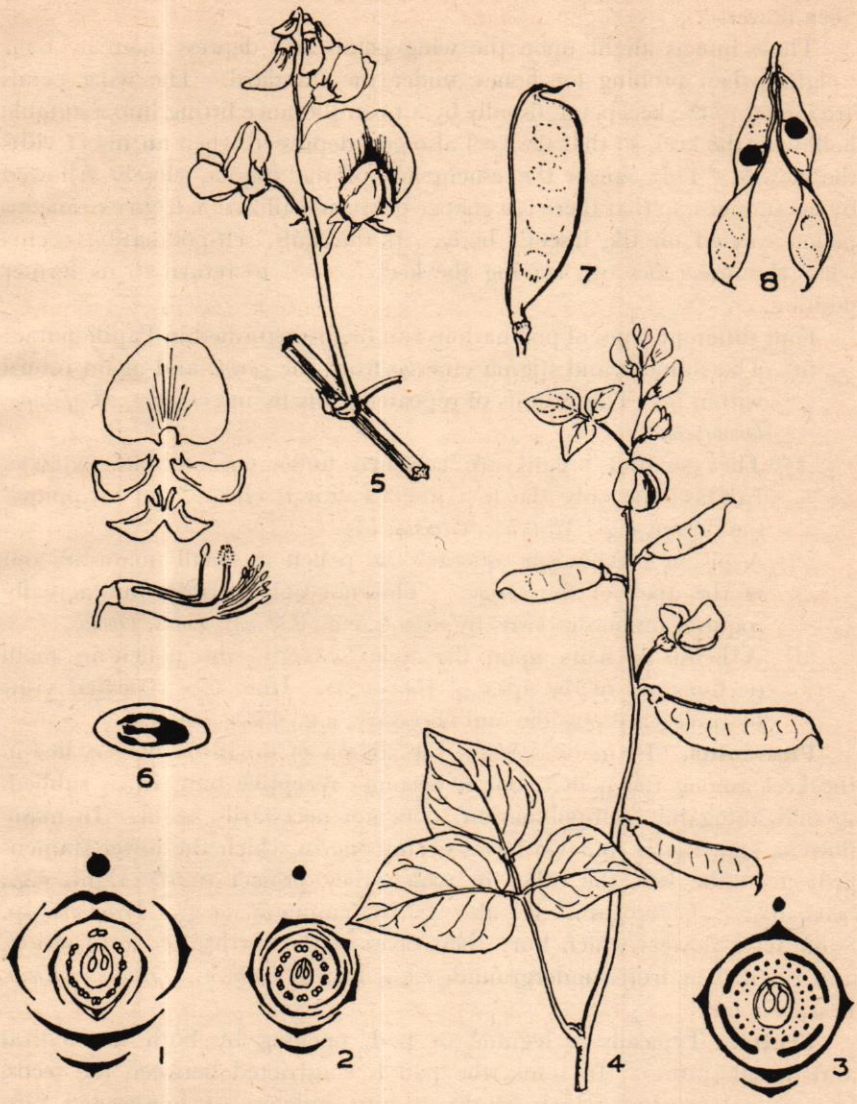


Fig. 1. *A leguminous plant*

1. Floral diagram—*Papilionatae*; 2. Floral diagram—*Caesalpinioideae*; 3. Floral diagram—*Mimosoideae*; 4. Branch of *Dolichos lablab*; 5. Flowering branch; 6. Floral parts; 7. Pod; 8. Ripe pod.

of moderate length can get at it, making the Papilionatae exclusively ' bee flowers '.

These insects alight upon the wing petals and depress them by their weight, when probing for honey under the standard. The wing petals are joined to the keel petal, usually by a protruberance fitting into a suitable hollow in the keel, so that the keel also gets depressed when an insect visits the flower. This causes the emergence of the stigma, closely followed by the stamens, so that there is a chance of cross-fertilization from extraneous pollen carried on the insect's body. If this fails, self-pollination occurs when the insect flies off, leaving the keel (*carina*) to return to its former position.

Four different types of pollinations can be distinguished in Papilionatae:

(*a*) The stamens and stigma emerge from the *carina* and again return within it. This admits of repeated visits by insects, e.g., *Trifolium*, *Onobrychis*.

(*b*) The essential organs are confined under tension and explode. In this type only the first insect's visit is effective in ' tripping ' the flower, e.g., *Medicago*, *Genista*, *Ulex*.

(*c*) A piston mechanism squeezes the pollen in small quantities out of the apex of the *carina*. This not only permits but actually requires numerous visits by insects, e.g., *Lupinus*, *Lotus*, *Ononis*.

(*d*) A brush of hairs upon the style ' sweeps ' the pollen in small portions out of the apex of the *carina*. Here too, repeated visits by insects are possible and necessary, e.g., *Vicia*, *Lathyrus*.

Phaseolus. In many species, the stigma of unvisited flowers lies in the keel among the pollen, but it becomes receptive only when rubbed, so that autogamy (self-pollination) does not necessarily occur. In many flowers, e.g., *Cassia* sp., two forms occur, one in which the lower stamens project to the left, the other in which they project to the right, e.g., *enantiostyly*. Cleistogamy is also fairly common, e.g., *Trifolium* sp. Some have flowers which bury themselves in the earth after fertilization, and ripen their fruits underground, e.g., *Arachis*, *Lathyrus*, *Trifolium*, *Vicia*, *Voandzeia*, etc.

Fruits. Typically a legume or pod, opening by both the ventral and dorsal sutures. In some, the pod is constricted between the seeds, forming a lomentum which breaks up into indehiscent, one-seeded bits, e.g., *Acacia*. Frequently the dehiscence is explosive; the valves twist spirally upwards, e.g., *Ulex*, *Cytisus*. In some, the pods are inflated, e.g., *Colutea*. In some species, the seed coats are hard enough to pass without loss of viability through the alimentary canal of grazing animals. Some have a coloured, fleshy aril on the seeds, e.g., *Acacia*, *Inga* while others have hooked pods such as (*Medicago*, *Mimosa*.)

Seeds. The seeds in legumes are ex-albuminous, usually with large reserves in the cotyledons. The seeds of many species form important

foodstuffs, e.g., *Arachis*, *Cajanus*, *Cicer*, *Dolichos*, *Glycine*, *Lathyrus*, *Lens*, *Lotus*, *Lupinus*, *Phaseolus*, *Pisum*, *Vicia*, *Voandzeia*. The pods of *Acacia*, *Ceratonia*, *Tamarindus* and *Prosopis* are also edible by cattle. A great number of legume species are valuable as fodder, e.g., *Crotalaria*, *Lotus*, *Medicago*, *Onobrychis*, *Trifolium*, *Vicia*, etc. Many species yield valuable timber, some are grown for fibre and some yield gums, resins and oils. Oil is extracted from seeds of *Arachis*, *Glycine* and *Voandzeia*.

The three main divisions of Leguminosae are:

1. *Mimosoideae* ... Flowers regular; corolla valvate, stamens numerous.
2. *Caesalpinioideae* ... Flowers zygomorphic, corolla imbricate-ascending.
3. *Papilionatae* ... Flowers zygomorphic, papilionaceous, corolla imbricate-descending.

GRASSES

All grasses belong to the family of plants known as Gramineae. This is a very large and cosmopolitan group, which includes all the cultivated cereal food crops and comprises 450 genera and more than 6,000 species, distributed in all parts of the world. Most grasses are usually herbaceous and small, but a few, such as the bamboos, often attain a height of nearly 30 metres.

In general, grasses are remarkably similar, but in details they show an immense diversity and their correct identification and classification is possible only by a study of many minute characteristics, such as the shape and size of the glumes, the number of nerves or veins on the glumes and the peculiarities of the ligules.

Grasses vary considerably in their habits, size and habitats; some are erect, some prostrate, procumbent, or decumbent, and different species show all possible gradations between an erect and prostrate habit. Some grasses are annual, while others are perennial. Some species, perennial in their native temperate habitats, behave like annuals when introduced into tropical regions. When the plant dries up after flowering and seeding in the course of a single season, it is termed an annual, but when both new shoots and older ones ending in inflorescence are found mixed in the same plant, it is termed perennial. The presence of underground rhizomes or stolons and runners is indicative of a perennial habit.

Sedges and rushes are often confused with grasses but can be differentiated from them in that the culms are not jointed, as in grasses, but are three-sided (triangular in cross section) and solid; the leaves are invariably three-ranked, whereas in grasses they are usually two-ranked. The leaf-sheaths, too, are closed and tubular in sedges, whereas they are split or 'open' with their edges overlapping, in the case of grasses.

Fig. 2. *A grass plant*

1. Adventitious roots; 2. Runner; 3. Collar; 4. Ligule; 5. Nodal hairs; 6. Inflorescence; 7. Spikelet; 8. Floret; 9. Floral parts; 10. Grain.

Stems and Roots. The stems in grasses are usually hollow and cylindrical, with cross-partitions at the nodes, except in a few species like maize, sorghum and sugarcane, where they are solid. In bamboos, the stems get very hard and woody. The nodes are often coloured reddish or purplish, or bearded with a fringe of hairs. The stems may be erect, decumbent, procumbent or prostrate; the underground stems may be short and rhizomatous as in Johnson grass, or long as in Bermuda grass. Stems that are prostrate and creep along on the soil surface, rooting at every node, are known as runners; these help in forming a continuous matted mass of shoots to make a turf or sod. The common *doob* grass (*Cynodon dactylon*) has surface runners, while in *Panicum repens*, the runners are underground. The distinction between bunchy or tufted grasses and sod-forming grasses is usually clear enough, but a great deal of variations exist.

Leaf. The leaves in grasses are generally ' two-ranked ' and alternate, though they may often get crowded or ' tufted ' at the base. The leaf consists of two parts, a flat straplike upper portion, known as the blade or *lamina* and a tubular lower portion, the ' leaf-sheath '. The margin of the leaf-sheath may be ciliate, the surface either smooth or rough or hairy. These hairs serve as protection against grazing animals. The base of the leaf sheath is often coloured purple or reddish. No petiole is present in grass leaves, except in some bamboo species. The leaf blade is generally long and narrow, but varies considerably in size from 2–8 cm to 40–120 cm in length and from 0·6–10 cm in width. The midrib is prominent in some grasses and inconspicuous in some others. The margins of the leaf blade are often minutely separate and in some species, such as in sugarcane and bamboo, they are sharp enough to draw blood if handled incautiously. At the junction of the leaf-sheath and leaf-blade on the upper side of the blade, there is a membranous outgrowth called the ligule, which is of great use in the classification and identification of different species of grasses. Sometimes, the ligule may be invisible or represented merely by a fringe of hairs.

In many grasses of dry habitats, e.g., *Sorghum*, the upper side of the leaf-blade has grooves along the length with the stomata at the base of these grooves and in dry weather, the leaf-blade rolls upwards with the collapse of the ' bulliform ' cells on the upper epidermis. The lower surface (which is covered with thick-walled cells and has no stomata) thus becomes the outer surface, thereby enclosing the stomata and checking transpiration losses. When the weather becomes more moist the leaf unrolls.

Inflorescence. The inflorescence in grasses is complex. The unit of inflorescence is not the individual flower, but a small spike of flowers termed the ' spikelet '. What appears to be a spike is really a modified raceme of spikelets (a *spiciform raceme*), consisting of a pair of spikelets, one sessile and the other pedicelled. When these spikelets are borne on

secondary, tertiary or still further subdivided branches, it is termed a panicle, which may be compact, loose, pyramidal, spreading or pendulous. Quite often various combinations of inflorescence types occur.

Structure of a Spikelet. The spikelet consists essentially of a short, central axis or 'rachilla' upon which are arranged a number of bracts or 'glumes' in two ranks. The flowers are one to five, arranged one above the other on opposite sides of the very short axis, and the whole is enclosed in one or two (or rarely more) larger membranous glumes (modified leaves). The glumes at the base of the rachis are empty. Above them stand one or more membranous boat-shaped bracts, the inferior paleae, in whose axis flowers are borne. Upon the axis of the flower, opposite the inferior palea, stands another bract, the superior palea and between these two paleae the flower is enclosed. Strictly speaking, the superior palea, being upon the same axis as the flower, is only a bracteole, but on account of the extreme shortening of the floral axis, it appears to be in the axil of the inferior palea, or even upon the main axis of the spikelet itself.

Above the superior palea, there are two small, fleshy scales, the 'lodicules', which are supposed to represent two of the three leaves of a reduced perianth. In certain species of bamboos three lodicules are present.

The flower itself has three stamens (six in rice, *Oryza sativa*) with long filaments and versatile anthers and one carpel, forming a unilocular ovary, with a basal, erect, anatropous ovule and one or two much-branched stigmas.

Most grasses flower once a year (annuals), but some specialised grasses (which spread by underground stems covering extensive areas, especially in marshy or saline places) may flower at irregular intervals. Bamboos flower at interval. of a few to many years (multiennials), after which they die off.

Grasses are all wind-pollinated and hence the flowers have no showy, coloured petals, fragrance or honey to attract insects. The fruit in grasses is a caryopsis or grain, where the single seed is fused with the pericarp of the fruit, closely adhering to the seed surface throughout. This feature of a single-seeded, dry, indehiscent fruit is a characteristic of the entire grass family.

CHAPTER 4

NUTRIENT REQUIREMENTS OF FARM ANIMALS

MAN keeps domesticated animals for various purposes. Cattle are bred for work on farms, for milk, and in most western countries, for providing meat as well. Draught cattle (bullocks) are used in India for ploughing, for pulling carts and for working indigenous water lifts like the *mhote* and the persian wheel. Bullocks are also used as beasts of burden in many regions of the world.

Cattle can be kept in good health and working condition only if they are fed properly. The food consumed by animals gets broken down in their digestive organs into simpler compounds that ultimately serve as sources of energy. Foodstuffs are used not only to build up the body but are also used to perform ' work ' and converted into various products like milk, wool and meat.

For the efficient and economic feeding of farm animals, it is essential to know the composition of foodstuffs, the changes undergone by different constituents within the body of the animals and what the animal requires for its maintenance and production.

Chemical analysis is the first step in the assessment of the nutritive value of any feeding stuff. This analysis shows the proportions of the different constituents, such as proteins, fats, carbohydrates, fibre and mineral matter. It enables us to see whether a given foodstuff is rich or poor in proteins and minerals. The limitation of chemical analysis is that it can indicate only the gross feeding potential, but little about its actual feeding utility. Hence, the second step is to feed and find out what proportion of the foodstuff consumed is digested by the animal.

In the feeding of animals two aspects have to be considered. The food that is just sufficient to maintain the health of the animal without loss or gain of weight when it is at rest, (i.e., when it does no work or produces no milk) is known as the maintenance ration. The food that is required over and above this maintenance ration for producing milk or doing work, is known as the production ration. These two aspects are usually distinguished as maintenance and production requirements.

In all living organisms, two processes are going on all the time: one is " anabolism " or building up, and the other is " katabolism " or breaking down; the two together constitute " metabolism ". To make good the loss of weight resulting from the elimination of waste products, such as urine, sweat and faeces as well as the carbon dioxide given out in respiration that takes place in the body, a certain quantity of food has to be taken in. When the quantity of food ingested is just sufficient to make up the loss due to katabolic processes, a point of balance is attained, which is

known as the maintenance requirement of the animal. This gives the energy needed for the mere continuance of normal bodily functions, such as respiration, digestion and minimum bodily movements. The quantity of food needed for this purpose depends upon the body weight of the animal.

Nutrients in feeds help generate heat needed to maintain the body temperature in the animal body, to provide the energy required for the various vital processes of breathing, circulation and digestion, etc. and also to provide material to repair the tissue breakdown that goes on continuously in the living body. The nutrients also provide the compounds and the energy required for 'growth', i.e., the increase in weight in young animals, and for milk and work production in adults.

Feeds are of two types, concentrates and roughages. Concentrates are those that contain relatively large quantities of digestible nutrients (or in other words, "net energy") in a small bulk. These concentrates are again of two types, nitrogenous concentrates, high in protein content and non-nitrogenous concentrates (otherwise known as carbonaceous concentrates) which are relatively low in protein but high in digestible carbohydrates and fats. Groundnut cake is an example of a nitrogenous concentrates, while oats and maize grain are examples of the second type of concentrates. Roughages are feeds that are relatively high in crude fibre. These roughages again are divided into high protein roughages like lucerne or clover hay, which contain 8–10 per cent or more of digestible protein and those low in protein, varying from 0 to 1·0 per cent of proteins, such as straws and green fodders like sorghum and guinea grass.

The most important ingredients in feeds are proteins, carbohydrates, fats, water, minerals and vitamins.

Proteins. Proteins form the main constituent of all organs and soft structures like muscles, tendons, etc., in the animal body. They are essential for the growth and repair of tissues and hence a continuous supply of proteins is essential. Proteins constitute about 17 per cent of the body weight of the adult animal. Milk contains about 3·5 per cent protein and hence proteins should be present in adequate amounts in the rations of lactating animals. Similarly, growth and pregnancy call for extra proteins, over and above the maintenance level.

The term protein is a collective one and includes a large number of complex organic compounds of high molecular weight that are chemically closely related but very distinct in their physiological functions. Proteins are present in all cells of living organisms and form the most important constituents (other than water) of almost all the organs of the body. Plant proteins are distinct from animal proteins and each species has its own distinctive and specific protein. In common with all organic compounds, proteins are composed of carbon, hydrogen and oxygen, but differ from fats and carbohydrates in having a fairly high percentage of nitrogen

as well. Many proteins contain sulphur and some have iron and phosphorus also.

In the analysis of foodstuffs, the proteins and non-protein nitrogenous substances are determined together, as " crude proteins ", based upon the fact that proteins contain on an average 16 per cent of nitrogen. So the amount of nitrogen is first determined in a weighed sample of the foodstuff and then multiplied by 6·25 to obtain the crude protein content in the sample. This crude protein in foodstuffs include the true proteins (composed of a number of amino-acids) and non-protein nitrogenous substances such as amides. Proteins are utilised in the animal body mainly for the production of muscle (lean meat) and to replace the physiological losses of wear and tear. They are also utilized in the formation of proteins in milk and wool.

In feedstuffs of vegetative origin, the largest amount of proteins are found in leguminous seeds and oilcakes such as cowpea (23·6 per cent) and soyabean (38·5 per cent). Oilcakes contain 21–50 per cent of protein and oilseeds 20–28 per cent. Then follow cereal by-products like rice-bran and wheat bran (10–15 per cent) and then legume hays (8–12 per cent). Cereal grains contain 9 to 12 per cent protein and fresh grasses, non-leguminous hays and straws two to seven per cent.

Fats (Lipides). This is also a collective term which indicates a group of organic substances that are insoluble in water, but soluble in ether and other organic solvents like benzene and chloroform. These lipids (lipides) include not only the true fats but also several other allied compounds such as sterols and phosphatides. These play important roles in animal metabolism; for example, ergosterol is the parent material for vitamin D. Lipides occur as essential constituents in all cells of the animal body and are thus of vital importance, even though they usually form a much smaller part of the animal's feed than proteins or carbohydrates. In a mature animal of normal condition about 20 per cent of the body weight is fat.

Fatty substances present in feedstuffs are estimated by first extracting with ether a weighed sample of the finely powdered feedstuff, evaporating the ether and weighing the ' fat ' residue. This residue or ' ether extract ' will contain not only the true fats but also some waxes, chlorophyll and some organic acids as well. Among feeding stuffs, soyabeans, linseed, groundnut and cotton seed show the highest fat content, ranging from 17 to 35 per cent; next come oilseed cakes (8 to 12 per cent) and then cereal grains (3 to 5 per cent). Non-leguminous hays and straws contain about 1–2 per cent and green grasses 0·1 to 0·2 per cent of ether extract. Chemically, fats contain C, H and O, but contain more of C and H and less of O than proteins or carbohydrates. Fats can furnish 2·25 times as much energy as the same weight of carbohydrates and, therefore, they can be regarded as ' energy concentrates '. If the extra

energy in the form of fats is supplied over and above the basic requirements of the animal, it is usually stored in the form of adipose tissue or ' depot fat ', to be drawn upon in times of need. Such adipose tissue is mostly localised under the skin as ' subcutaneous fat ' and around the intestines, kidneys and other organs. Fat is also sometimes deposited in and around muscles. Depot fat serves mainly as a reserve source of energy and insulating material to conserve body heat.

Carbohydrates. As the name indicates, carbohydrates are compounds made up of carbon, hydrogen and oxygen. The term includes not only sugars and starches but also hemicelluloses, gums and pentosans. In most feeds, the total carbohydrates are made up of a soluble portion known as soluble carbohydrates or ' nitrogen-free extract ' and an insoluble portion known as ' crude fibre '. In the analysis of feeds, the nitrogen-free extract is determined by difference and not by direct estimation. It is obtained by subtracting from 100, the sum of (Moisture + Mineral Matter+Crude Protein+Ether Extract+Crude Fibre). The nitrogen-free extract (or N.F.E.) consists mainly of carbohydrates like sugars and starches, along with small amounts of pentosans and other less important carbohydrates. Starch is, of course, the main carbohydrate found in the N-free extract in the case of grain concentrates. Sugars are found in the stems and roots of many plants, as for example, in sugarcane, sorghum and beet roots. In addition to these, the N-free extract includes also small quantities of organic acids and other substances like lignin, which are not carbohydrates.

Cereal grains contain the largest amounts of carbohydrates, (N.F.E.), ranging from 60 to 75 per cent. Next come the root crops, (on dry basis) and then cereal by-products, with 39 to 65 per cent N.F.E. Legumes, oilseeds and their products, hays and straws contain medium amounts (23 to 53 per cent); silages and green grasses contain low amounts (5 to 20 per cent), while feedstuffs of animal origin, such as bloodmeal, contain the lowest amounts.

Crude Fibre. This term includes all the insoluble forms of carbohydrates found in feeding stuffs. It is made up of cellulose, lignin and some pentosans and represents the tough fibrous parts of plants. Crude fibre is found in all plant parts, since cellulose is a constituent of every cell, but cellulose in its pure form is found only in the tender, growing parts of plants. The ' fibre ' from older parts of plants is generally associated with lignin, a substance not digested in the animal body. Hence the proportion of ' crude fibre ' found in feedstuffs varies greatly with the species, age and degree of maturity of the plants and the parts of the plant analysed. The content of crude fibre increases as the plant advances in maturity.

Crude fibre in plant material is determined as follows: after removal of the moisture and fatty material from a given sample, it is boiled for

30 minutes in 1·25 per cent sulphuric acid and then boiled for the same time with alkali of the same strength. This removes the proteins, starch and sugars and leaves as residue most of the cellulose and other complex polysaccharides along with some mineral matter. The loss on ignition of the dried residue is taken as the crude fibre content.

Crude fibre is abundant in the husks of grains and seeds, ranging from 40 to 60 per cent. Straws contain 35–45 per cent of crude fibre, while hays and dry fodders contain 20–30 per cent. Late-cut roughages contain more of fibre than early-cut ones. Cereal grains and their by-products contain low percentages of crude fibre, ranging from 2–12 per cent.

Crude fibre is considered to be the least digestible part of any feed material. Ruminants like cattle, buffaloes and sheep are able to digest about 50 per cent of it and thus utilize the nutrient to a greater degree than non-ruminants like horses and pigs.

Ash (Mineral Matter). About 13 mineral elements are essential constituents of the animal body, namely, calcium, sodium, phosphorus, potassium, magnesium, sulphur, chlorine and iron, copper, zinc, manganese, cobalt and iodine. These are present in varying amounts in different parts of the body, according to the functions they perform. Calcium, phosphorus, potassium and magnesium are present in fairly large quantities in plants.

Amongst these, calcium occurs mostly in the bones and teeth in the form of carbonates and phosphates. Magnesium is present mainly in the bones but is also widely distributed elsewhere in the body. Sulphur occurs in most protein molecules, while iron is found in haemoglobin, the red colouring matter in blood. Sodium, potassium and chlorine are present in the form of salts in various body fluids. The other five elements are present in very much smaller amounts, of the order of a few parts per million. No part of the body of plants or animals is free of mineral matter.

In the analysis of feeding stuffs 'mineral matter' or 'ash' is that part which remains after the combustion of organic substances. It is determined by igniting a weighed sample of the feedstuff until all the organic matter is burnt off and disappears. The ash consists mainly of calcium, phosphorus, potassium, magnesium, sodium, iron, etc., in the form of the oxides, sulphates, chlorides, phosphates and carbonates, but the compounds found in the ash need not necessarily be the same as those occurring in the living plant material. Ash content is high in meat scraps and tankage (15 to 60 per cent). It is found in fairly large amounts in legume hays (7 to 14 per cent); in non-leguminous hays and straws, it ranges from 4 to 10 per cent, and in green grasses, root crops and silages, it occurs in very low amounts of one to three per cent.

The minerals found in feeding stuffs serve to build up the bones in farm animals, and also the various chemical compounds present in body

fluids like blood, bile and other digestive fluids. Minerals are essential for milk production and are, therefore, of great importance for milch animals and young, growing stock.

Water. Apart from these constituents, water is also a very important component, being essential for all life processes, such as absorption of nutrients, digestion, circulation and the elimination of waste products from the animal system. Water is also the vehicle for all nutrient elements, including vitamins. The animal body needs large quantities of water for its well-being, both directly and indirectly from succulent forages. Water makes up more than 50 per cent of the body weight in animals and many tissues contain more than 70 per cent water. Animals can survive for many days without solid food, but cannot survive without water. On account of its high specific and latent heats, water helps in regulating the body temperature of the animals. Milk contains 80–87 per cent of water and hence a liberal supply of water is essential for all livestock, and especially for milch animals.

Water is universally present in all plant and animal material and even dry-looking substances, such as wood, straw, grains and starch contain two to ten per cent of moisture. The moisture content in feedstuffs varies very widely from 5 to 95 per cent depending upon the species, the stage of growth and maturity and the part of the plant examined. Thus, fresh grass contains about 80 per cent of moisture. Succulent root crops like turnips, swedes and mangels contain 90 per cent, and dry straw, seeds and grains like gram and oats (8 to 10 per cent). Too much water in feeds makes them more expensive. The keeping quality of a feed also depends on its moisture content, as in the case of hays, oilseed cakes and grain, which get spoilt soon, if too moist.

Vitamins. These are known also as 'accessory food factors' or substances and are very important for the maintenance of normal health of animals. They are usually named vitamin A, B, C, D, etc., and about a dozen of these vitamins have been known and studied so far.

Vitamin A is not present as such in plants. The carotenoids are converted into vitamin A in the animal body. Similarly, by the agency of sunlight, various sterols get converted into vitamin D.

Besides all these components of feedstuffs, their bulk is also important in rations. If too little bulk is given, the stomach remains half empty and the animal's hunger is not satisfied. If the rations are too bulky, indigestion follows. Bulk is supplied by feeding roughages like grass and straws.

Palatability is another important factor in animal nutrition, because otherwise the animal will not eat sufficient quantities of the feedstuff, resulting in impaired efficiency. Bad-smelling feeds, even if they are highly nutritious, should not be fed to livestock. Feeds may be made more palatable by adding salt or treacle or molasses and by warming

or steaming. A certain amount of variety is also necessary to get the best results from feeding, but the changes in rations should be made gradually and never abruptly.

Cost and economics are, of course, vital factors in the success or otherwise of all items in farm management and the feeding of farm animals is no exception to these principles.

THE PROCESS OF DIGESTION

The principal farm animals of India, such as cows, bullocks, buffaloes, sheep and goats, fall under the group of ruminants. These have the power of regurgitating their feed and 'chewing the cud' and have a complex, four-chambered stomach, whereas non-ruminants like horses, asses and pigs have only a single-chambered stomach, as in human beings. Ruminants can eat quickly large quantities of bulky feeds that contain much of fibre. These are subsequently regurgitated and remasticated at leisure and swallowed once again, to be digested in the stomach and intestines.

The ruminant's stomach contains four chambers, the rumen, reticulum, omasum and abomasum. The first chamber, the rumen, serves as a reservoir of food, the second as a reserve chamber for fluids, the third as a mixing and macerating chamber and the fourth as the digestion chamber. When a ruminant feeds, the more solid portions pass into the rumen and a small portion into the reticulum. The more liquid portions of the feed pass directly into the reticulum and serve to moisten later on the food material contained in the rumen. When the animal has finished feeding, it retires to a quiet spot and begins to ruminate. The solid portions are brought back into the mouth as a bolus by a contraction of the walls of the rumen and reticulum, to be chewed once again thoroughly and swallowed a second time. This time the food passes directly into the third stomach, where it gets well macerated between the corrugated walls of the omasum and it finally passes into the fourth chamber, the abomasum, where it is acted upon by the gastric juice.

In non-ruminants, the food passes directly into the stomach for gastric digestion and hence these animals need a ration that is less fibrous than what ruminants can tolerate.

Protein Digestion. Although the first step in the digestive process takes place in the stomach, real digestion takes place only in the small intestines. The walls of the stomach secrete an enzyme, pepsin, along with hydrochloric acid and these act together to break down the proteins in the foodstuff into simpler compounds, viz., peptones and polypeptides. In the intestines, the food is acted upon by several enzymes and secretions, such as bile, pancreatic juice and the intestinal juice proper. Bile is a

secretion from the liver which is stored in the gall bladder. It emulsifies fats and helps in their breakdown by lipolytic, i.e., fat-splitting enzymes. Pancreatic juice contains three enzymes, viz., amylase, which acts upon starch and other carbohydrates, trypsinogen, which acts on proteins and steapsin, which acts on fats. The intestinal juice contains four enzymes, maltase, which converts maltose into dextrose, sucrase which converts sucrose into dextrose and laevulose, lactase which converts lactose into dextrose and laevulose and a fourth enzyme, which breaks down derived proteins into simple aminoacids.

Thus, by the action of various enzymes in the body, proteins are broken down to their constituent amino-acids. These are absorbed into the blood-stream by the minute 'villi' lining the intestinal walls. The non-protein nitrogenous substances that are present in foodstuffs are relatively much simpler compounds than the true proteins and their digestion is a simpler process. The bacteria that are always present in the rumen of herbivorous animals utilize these non-protein nitrogenous substances, to multiply and perform their special function of fermentation of the carbohydrates present in the food.

Digestion of Starch and Other Carbohydrates. Starch digestion may be said to commence in the mouth of the animal when the food comes into contact with its saliva, at a temperature of nearly 40° C. In the initial stages of digestion, the starch gets converted into dextrins and later on, by the action of amylopectin in the pancreatic juice, it gets converted into maltose. Starch as well as the other carbohydrates that are normally present in fodders and feedstuffs, belong to the group known as polysaccharides. The animal system cannot utilize these polysaccharides unless they are first broken down into simple monosaccharides. This breaking down is effected mainly in the small intestines of the animal, by a group of enzymes known as invertases, that are specific, each for its own particular sugar

Digestion of Fats. Fats or lipids make up a much smaller portion of the animal diet than either proteins or carbohydrates, but they are of great importance, because certain lipids play a vital role in the secretion of milk and the deposition of fat accumulations in the animal body

Since the fats in most foodstuffs consist mainly of tri-glycerides, the products of fat digestion are mainly glycerol and fatty acids. This breakdown is brought about by the enzyme lipase present in the intestinal juice, after the lipids are first emulsified by the action of the bile. The fatty acids resulting from lipid digestion are absorbed as such and get re-formed as body fat. This body fat or depot fat in the animal body, especially in ruminants, is formed not only from the lipids present in foodstuffs but also from the carbohydrates and to a lesser extent from the proteins in the food as well.

NUTRITIVE VALUE OF FEEDSTUFFS

The purpose of feeding farm animals is to provide them with the energy necessary for maintenance and production, of work, milk, meat or wool. The capacity of different nutrients in foodstuffs to provide energy is assessed by the extent to which these nutrients are digested. The chemical composition of a foodstuff cannot by itself give a real measure of its feed value, unless we also know how much of it can be digested by the animal and become available for its bodily needs. The difference between the quantity of nutrients consumed by the animal and the quantities excreted by it in the form of dung represents the quantity of nutrients actually digested by the animal. The average percentage of each nutrient digested from the feeding stuff is termed as the ' digestion coefficient ' or ' coefficient of digestibility '.

Net Energy Concept. Chemical analysis and feeding trials will tell us how much of nutrients the foodstuff contains and how much of it is digestible, but they cannot by themselves ensure that a ration is efficient for productive purposes. Various methods have been suggested from time to time to express on a common basis, both the nutritive value of foodstuffs and the food requirements of the animal, but none of these is perfect. Since the objective in feeding nutrients to livestock is the production of energy, the real nutritive value of feeds can also be expressed in terms of the energy produced by them. And since all forms of energy are ultimately convertible into heat, it is convenient to express the energy changes in the animal body in terms of heat units or calories.

The heat required to raise the temperature of one gramme of water through 1° C. is known as a calorie, designated by the symbol ' *c* '. The amount of heat required to raise the temperature of 1,000 grammes of water through 1° C., is known as the large calorie, designated by the symbol ' *C* '. One thousand large calories are equivalent to one ' Therm '.

Measures of Energy Values. The amount of energy given out when a substance is completely burnt to its final oxidation products is known as its gross energy. Since, however, this gross energy in foodstuffs is never fully available to the animal, it cannot be regarded as a measure of the nutritive value of a feed, and so other methods have been devised to get an estimate of the relative nutritive value of different feedstuffs.

Metabolizable or Available Energy. A part of the gross energy derived from the food is lost in the waste matter excreted by the animal in the form of dung, urine, sweat and intestinal gases. The figure obtained by subtracting the energy thus lost from the gross energy derivable from the ingested feed represents the amount of energy actually available to the animal. This is known as the available or metabolizable energy.

The amount of net energy that actually becomes available to the animal for productive purposes, i.e., for work, milk, meat or wool production,

is always less than the metabolizable energy by an amount equal to the energy expended in the work of digesting the feedstuffs and in the dissipation of energy arising out of the increased metabolism which naturally follows the intake of food. These losses are grouped together under the term 'heat increment'. Therefore, the net energy derived from a feedstuff is the metabolizable energy minus the heat increment.

Starch Equivalent (S.E.). Kellner carried out a series of classical experiments on animal nutrition and by adding pure carbohydrates, proteins and fats to a basal maintenance ration, determined the relative amounts of these nutrients that were needed to produce one unit of body fat. Then he used ordinary feedstuffs in the same manner and found that the fat-producing power of these feedstuffs was less than the values obtained from pure nutrients. The difference was larger in feedstuffs containing more of 'crude fibre' and so it was clear that some part of the calculated fat-producing power was lost or expended in the actual work of digesting the feedstuffs, which increased with the fibre content.

Kellner determined the actual fat-producing power for a number of feedstuffs and worked out methods for estimating the loss of energy involved in the work of digestion, for feeds of varying fibre content. From these, he obtained a basis for expressing the fat-producing power or value of the feed in terms of the weight of starch that would be required to produce the same amount of fat as 100 kilograms of the feed. These values are, therefore, termed starch values or starch equivalents. In this system, the energy value of a feed is expressed in terms of the number of pounds of starch that are necessary to produce the same quantity of fat as 100 pounds of the feed. It has been found by experiment that one kilogram of digestible carbohydrate is equivalent to one kilogram of starch and one kilogram of digestible protein is equivalent to 0·94 kg of starch, in terms of production value. In the case of fats (ether extracts), the corresponding figure is 1·91 kg, 2·12 kg and 2·31 kg, varying with the source of fat, coarse fodder, or cereal grains and by-products, or seeds and oil-cakes. To calculate the S.E. of a feed, the percentage of each of the three digestible nutrients is multiplied by the conversion factors given above and the figures obtained are added together. A correction factor is then applied to allow for the fibre content in the roughage, because some of the fat-producing power of the feed gets spent in the work involved in the process of digestion and this work increases with an increase in the fibre-content of the feedstuff. This system is in use in European countries.

Total Digestible Nutrients. This is a useful and widely adopted measure of food energy in animal nutrition. It is derived by adding together the digestible protein, the digestible carbohydrate and the digestible fats multiplied by 2·25 (because fats contain 2·25 times as much energy as carbohydrates or proteins.)

CALCULATION OF TOTAL DIGESTIBLE NUTRIENTS FOR BAJRA GRAIN
(*Pennisetum typhoides*)

	Chemical composition	Digestible nutrients		Multiplying factor		Product
	%	%		%		%
Crude Protein	9·8	47	×	1·0	=	4·61
Ether Extract	4·6	56	×	2·25	=	5·79
Crude Fibre	—	—				
Nitrogen-free Extract	72·6	61	×	1·0	=	44·29
Total Digestible Nutrients						54·69

The total digestible nutrient contained in bajra grain is thus 54·7, i.e., 100 kg of bajra grain, when fed to animals, can furnish 54·7 kg of total digestible nutrients.

The T.D.N. values have been determined for nearly all the common feedstuffs in common use. Values for digestible protein and total digestible nutrients are the ones commonly employed nowadays in the computation of rations for farm animals, especially in the United States.

The figures for digestion coefficients can be regarded as applicable to all animals in respect of concentrates, but for roughages, the coefficients are applicable only to ruminants like cattle and sheep, but not to non-ruminants like horses and pigs.

Theoretically, the best indicators of the nutritive values of feedstuffs will be their 'net energy' values, because from the practical stock-feeding aspect, it is the net energy contained in a feed that is of use and interest. Net energy values are more accurate than total digestible nutrients because in determining the total digestible nutrients, deduction is made only for the undigested material in the faeces, whereas to derive the net energy values, the portion of the feed lost in the faeces, urine, sweat and intestinal gases and probably the heat increment, are all deducted.

	Digestible Nutrients	Net Energy
45·4 kg Timothy Hay contain	21·8 kg	43·0 Therms
45·4 kg Wheat Straw contain	16·7 kg	7·2 Therms

From the values of digestible nutrients, one would presume that wheat straw was nearly three-fourths as nutritious as Timothy hay, but from the net energy values it is clear that the straw is only one-sixth as useful as the hay in feeding value.

However, on account of the great expenditure of time, labour and, expense involved in their accurate determination, net energy values have been determined only for 17 or 18 feeding stuffs for ruminants, whereas digestible nutrients have been determined for nearly all the common feeding stuffs in use now.

Nutritive Ratio. This indicates the proportion of fuel substances, such as fats and carbohydrates, to the tissue-building proteins found in feedstuffs. It serves as an index of the balance of feedstuff and is calculated by adding the percentage of digestible fats multiplied by 2·25, to the percentages of digestible carbohydrates and crude fibre, and dividing the sum by the percentage of digestible crude protein. The nutritive ratio shows whether the feed is properly balanced in the two main ingredients, namely, the digestible nitrogenous constituent and the digestible non-nitrogenous constituents.

Young stock, breeding animals and those in milk require a ration containing a high proportion of protein and having a narrow nutritive ratio of 1 : 5 or less. For maintenance and work, the nutritive ratio may vary within wide limits, but if it is too wide, i.e., if the proportion of proteins to the carbohydrates is too low, the digestibility of the ration as a whole is lowered, which is not desirable.

The requirements of Indian livestock with regard to the main nutrients have been worked out at the Indian Veterinary Research Institute, Izatnagar.

Balanced Rations. In drawing up rations for livestock, a proper balance should be maintained between: (*a*) the digestible protein and the total digestible nutrients, and (*b*) the concentrates and the bulky roughage. The minerals and vitamins should also be in adequate quantities. Nearly three-fourths of the total dry matter consumed as feed should come from the roughage portion of the ration in the case of low yielding cows and the remainder from concentrates. The feed must be sufficiently bulky to fill the stomach of the animal but not so much as to cause discomfort or indigestion. The ration should also include enough of bulky fodder that can be consumed with relish and at the same time it should contain sufficient nutrition for maintenance and also for the desired levels of work or other production expected from the animal.

For working bullocks, the standards of nutrients required for maintenance and work are given below (Table 6).

TABLE 6. NUTRIENT REQUIREMENTS OF WORK BULLOCKS

Live weight (kg)	Normal work		Heavy work	
	Digestible crude protein (kg)	Total digestible nutrients (kg)	Digestible crude protein (kg)	Total digestible nutrients (kg)
200	0·24	2·0	0·25	2·7
300	0·33	3·1	0·42	4·0
400	0·45	4·0	0·57	4·8
500	0·56	4·9	0·71	6·4

(After Sen and Ray, 1964.)

When animals are put to heavy work and even when they are at rest, 28 gm of common salt and a mineral mixture should be supplied per head per day in the feed. The mixture is made up of finely powdered shell-meal and bone meal, sterilized and powdered fine; this is intended as a prophylactic against stiff joints and other minor ailments.

For milk production, the nutrients that are to be added to the daily maintenance allowance of the animal are given in table 7 below. In general, an animal of 450 kg live weight will require for maintenance 0·3 kg of digestible crude protein and 3·4 kg of total digestible nutrients per day.

TABLE 7. FEEDING FOR MILK PRODUCTION

Fat percentage in milk	Digestible crude protein (kg)	Total digestible nutrients (kg)
3·0	0·040	0·269
4·0	0·045	0·316
5·0	0·051	0·363
6·0	0·057	0·411
7·0	0·063	0·458
8·0	0·069	0·506
9·0	0·075	0·553
10·0	0·081	0·602
11·0	0·085	0·650

(After Sen and Ray, 1964)

In addition to the above, 2 gm of calcium and 1·4 gm of phosphorus have also to be supplied per milch animal per day for the production of one kilogramme of milk. With heavy milkers, large quantities of lime and phosphorus are secreted through the milk and this drain has to be made up in the feed, otherwise these minerals will be withdrawn from the animal's own body reserves, leading to loss of weight and condition; hence the mineral mixture (and also the salt allowance) has to be increased to 56 gm per day per milch animal.

Concentrate feeding stuffs should be fed in two instalments, half in the morning feed and half in the evening feed. The animals should have free access to clean drinking water and they should also be fed individually, otherwise the more aggressive amongst the animals will monopolize the feed and the timid ones will remain underfed. Straw and hay may be fed *ad libitum*; this can be checked up by supplying sufficient fodder to have one or two kilogrammes of it left over in the manger the next morning. If any oil-cakes are fed, they should be fresh, for old and rancid or mouldy cakes may lead to digestive disorders.

The nutrients required for growth in young animals are summarized below:

TABLE 8. NUTRIENTS REQUIRED BY GROWING ANIMALS PER HEAD PER DAY

Live weight (kg)	Digestible crude protein (kg)	Total digestible nutrients (kg)	Calcium (gm)	Phosphorus (gm)
45	0·15	0·8	7	6
70	0·22	1·3	12	10
100	0·28	1·9	13	10
150	0·35	2·6	13	12
200	0·40	3·0	13	12
300	0·47	4·0	13	12
450	0·48	5·0	12	12

(After Sen and Ray, 1964)

In the final count, nothing can be a substitute for the farmer's individual care and attention for his animals. He must know his animals just as he knows his own children and should watch over their health and well-being all the time, so that he can make the requisite changes and adjustments as and when they become necessary.

Nutritive Value of Forage Crops at Different Stages of Growth. The aim of all livestock farmers is to secure a continuous supply of a maximum output of fodder of the maximum feeding value, but this is possible only under very favourable and strictly controlled conditions. Forage crops show wide differences amongst themselves in nutritive value, i.e., in the relative percentages of proteins, fats, carbohydrates, fibre and mineral matter and in the relative digestibility of these constituents at corresponding stages of growth. Even within the same species, variations are observable at different stages of growth and in different parts of the same plant. In spite of these differences, it may be said in general that there is a progressive deterioration in the quality of forage plants with advancing maturity and the percentages of nutritive consituents diminish with ripening. This is particularly marked in the case of the more valuable constituents like proteins and minerals like calcium and phosphoric acid. Carbohydrates and fats do not show the same degree of deterioration as protein. Crude fibre shows in many cases a definite increase from the young to the ripe stages.

It has been observed in the United Kingdom that a continuous supply of rich forage comparable in nutritive value to a good concentrate, can be obtained if pasture grasses are grazed in a systematic manner and the new growth allowed to come up in a regular sequence.

The changes in nutritive value of various forage crops at different stages of maturity—young, prime and ripe—are presented in the table below.

TABLE 9. VARIATIONS IN THE NUTRITIVE VALUE OF FORAGE CROPS

Forage crop/ Stage of growth	Crude Protein	Calcium	Phosphorus	Potassium	Remarks
	(Percentages on dry matter basis)				
Anjan grass (*Cenchrus ciliaris*)					Protein content, Ca, P and K all decrease with age of grass.
Young	10·76	1·27	0·54	8·94	
Prime	9·18	0·63	0·42	3·99	
Ripe	6·28	0·77	0·39	2·56	
Chhimber (*Eleusine flagellifera*)					-do-
Young	14·75	0·93	0·60	1·67	
Prime	11·46	0·91	0·45	1·58	
Ripe	10·01	0·89	0·75	0·96	
Dub grass (*Cynodon dactylon*)					Protein, Ca and P all remain at high levels though all diminish with age.
Young	14·83	0·74	0·64	3·28	
Prime	10·24	0·64	0·55	2·83	
Ripe	8·60	0·38	0·25	2·45	
Napier grass (*Pennisetum purpureum*)					Soon becomes very fibrous and then cattle do not like it much.
Young	6·60	0·77	0·66	2·91	
Prime	6·12	0·69	0·84	3·58	
Ripe	5·92	0·71	0·51	2·81	
Oats (*Avena sativa*)					Oats are a very nutritious fodder. All constituents decrease with age.
Young	12·18	0·66	0·63	6·06	
Prime	9·63	0·53	0·60	5·33	
Ripe	5·69	0·41	0·36	2·87	
Sudan grass (*Sorghum vulgare* var. *sudanense*)					The protein, Ca and P remain reasonably good.
Young	5·92	1·13	1·14	3·33	
Prime	6·00	1·69	1·55	1·17	
Ripe	5·41	0·24	1·37	1·02	
Lucerne (*Medicago sativa*)					This forage legume also shows the same trend of nutrient decrease with advancing age.
Young	17·01	3·49	0·72	4·55	
Prime	13·31	2.48	0.38	2·21	
Ripe	11·31	1·72	0·34	3·35	

(After Lander, 1942)

CHAPTER 5

LEGUMINOUS FODDER CROPS

TRUE CLOVERS (*TRIFOLIUM* SPECIES)

Genus *Trifolium* Tourn. (L) (Leguminoseae)

A large genus of nearly 290 temperate and subtropical species, including a number of important forage legumes, such as the clovers, trefoils, shamrock and berseem. Leaves digitately trifoliolate, leaflets denticulate, stipules adnate to petiole; flowers small, white, yellow, red or purple, in dense " heads " or " crowns "; stamens 9 and 1, but not always free; style oblique, pods sessile, indehiscent, 1–2 seeded and almost enclosed within the calyx.

THE origin of the true clovers is believed to be Asia Minor, as the greatest diversity of forms is found in that region. The wild forms of clover are, however, found in all continents except Australia. The clovers are very important pasture and hay plants in Europe, the United Kingdom, the United States, Australia and New Zealand. In India, they are only of secondary importance as forage plants, with the exception of two species, *Trifolium alexandrinum* (berseem) and *T. resupinatum* (shaftal).

The clovers are annual or perennial plants that thrive in cool, moist climates and on soils where calcium, potassium and phosphorus are available at adequate levels. Many of the perennial species behave as annuals if grown in uncongenial climatic regions, since most of the clovers are long-day plants. Some species, e.g., *T. medium* and *T. ambiguum*, produce underground rootstocks. The inflorescence in all clovers is a ' head ' or ' crown '; these are really much shortened racemes, with the number of individual flowers varying from five in subterranean clover to 200 or more in white clover and red clover. The seeds also range from one to eight per pod in different species.

The floral mechanism for pollination in clovers is the simplest amongst the *Leguminoseae*. The stamens and style emerge as the keel petals are depressed by an insect alighting on the flower and return to the original position when the pressure is released. In many species the flowers are self-sterile; others are self-fertile but require the help of bees for satisfactory seed-setting. The flowers are an important source of honey in white clover; those of red clover are too long-tubed for hive bees and are, therefore, visited only by bumble bees.

The chief species of importance for forage and pastures are:

Berseem	(*Trifolium alexandrinum*)
Shaftal	(*T. resupinatum*)
White clover	(*T. repens*)

Red clover	(*T. pratense*)
Crimson clover	(*T. incarnatum*)
Alsike clover	(*T. hybridum*)
Subterranean clover	(*T. subterraneum*)

Berseem or Egyptian Clover (*Trifolium alexandrinum*)

Origin, History and Distribution. Berseem is believed to be indigenous to Egypt. It is the main forage legume of that country, and is also cultivated in Syria and Persia, where it forms the principal green forage for horses, donkeys and camels. It was introduced into India in 1904 and tried at various centres with such good results that by 1916 it was recognised as a widely adaptable and valuable addition to the forage crops of India. Berseem is now a prominent fodder legume in irrigated areas of the Punjab, Delhi, Rajasthan and Uttar Pradesh and other parts of Western and Northern India. In the adjacent areas of West Pakistan and North-West Frontier Province, too, berseem is widely grown both for fodder and green manure. In peninsular India, it is less popular than lucerne.

Description. Berseem is a low shrubby annual growing 60–90 cm high. The main, succulent stem gives off branches terminating in two or three leaves. These stems become fibrous after the flowering stage. Leaves are small, oblong and rounded at the extremities, bright green and slightly hairy, especially on the upper surface. Flower-heads are round, white. Seeds are small and vary in colour from yellow to brown.

Climate and Soils. Berseem can grow on all soils except very sandy soils, but thrives best on well-drained, medium loams, rich in lime and phosphorus. It can grow on salt-lands where few other legumes can thrive and is thus useful for reclaiming brackish and alkaline lands, but it needs plenty of water. Acid or damp soils are unsuitable for its growth. Although it tolerates low temperatures, it cannot thrive in places where snow falls, as in some places above 1,220 m. in northern India. Water is the main limiting factor for berseem as it cannot withstand drought. Twelve to fifteen irrigations may be needed for the crop between its sowing in September and the harvest in May, by which time, five to seven cuttings would have been taken from the crop. Seeds are harvested by June.

In areas where berseem is grown for the first time, prior inoculation of the soil with the appropriate *Rhizobia* bacterial culture is necessary to ensure good growth. The culture may be smeared on the seeds before sowing the seeds. Where such cultures are unavailable, soil from an old berseem field may be carted and spread on the new fields before sowing.

Cultural Practices. The land is ploughed five to six times to get a fine tilth and small-sized beds are formed. The beds are then flooded with about 5 cm of water and berseem seeds, soaked in water overnight,

are broadcast in the standing water. It is often convenient to mix an equal quantity of fine earth or soil with the seed to increase the bulk and ensure uniform sowing. A seed-rate of 22·4–27·6 kg per hectare would be sufficient. Bright yellow, plump seeds should be used, discarding all brown and immature seeds. Early sowings give better growth and higher yields, but there is a danger of damage from caterpillars; late sowings result in stunted growth and poor yields. As the water dries up in the beds, berseem seeds germinate in three to four days and as soon as they have struck root (in about a week's time) the beds should be irrigated once more.

Berseem responds well to fertilizers and needs about 67·2 kg of phosphorus (i.e., 414·4 kg of superphosphate) per hectare applied at the time of the last preparatory cultivation, while preparing the seed-bed for berseem. In soils where the phosphate level is already high, a small dose of 134·4 kg of ammonium sulphate applied at sowing time is very helpful in improving both the yields and forage quality.

In addition to these major nutrients, experiments indicate that micro-nutrients like boron, supplied as 6 to 11 kg of borax per hectare, and molybdenum, in the form of either sodium or ammonium molybdate at 1·12 kg per hectare can often increase the yields considerably.

The crop will be ready for the first cutting in 50–60 days from the date of sowing, by which time two or three further irrigations also may be needed. A total of 12 to 15 irrigations (1·37 hectare/metre of water) may be required for the entire crop duration. The plants should be cut when about 23–30 cm high; if allowed to grow taller, they get " stemmy " and go down in feeding value. Watering should be timed to be given 10 days before taking a cutting, so that re-growth can start immediately after the cut, without any further irrigation. Succeeding cuts can be taken at 35–40 day intervals. From an early-sown crop, five or six cuttings can be obtained by the middle of May.

Varieties. Amongst the several varieties introduced for trial from Egypt, two, namely Mescawi and Khadrawi, were found most successful. Mescawi grows tall and luxuriant and gives four or five cuttings and a crop of seed; Khadrawi needs one or two more irrigations, but at the same time gives one or two extra cuttings.

Rotations and Mixtures. Berseem occupies an important place in the arable crop rotations of the Punjab, Rajasthan and Uttar Pradesh. It usually follows exhausting crops like sugarcane or chillies. Some of the usual rotations are: berseem—cotton—wheat and gram (*Cicer arietinum*)—paddy—cotton. A common two-year course of rotation is:

> First year—A *rabi* crop of berseem is ploughed in and is followed by cotton, and in the second year berseem is sown again and allowed to set seed after four or five cuttings, followed by *jowar* or *bajri*.

For fodder purposes, it is more convenient to rotate berseem with fodder-jowar or maize under irrigation for several years.

With early-sown berseem, (usually the Mescawi variety), it is advantageous to grow a mixture of rape (*Brassica napus*) or oats, because the berseem will have only a few shoots when the first cutting is taken. Rape plants grow much quicker and this mixture provides a high fodder yield for the first cutting in November, when there is usually an acute scarcity of green fodder. Berseem is also very useful in that a September-sown crop gives the first cutting in November, when other *rabi* fodder crops, such as oats, peas, *methra* or *senji* have not made sufficient growth and it continues to give green forage till May, when all other *rabi* fodders are over and *kharif* fodder crops like cowpeas, *guar*, *moth* and maize are not yet ready for harvest.

Berseem is very useful in the reclamation of alkaline and saline soils. For this, the land is bunded and small beds formed, with sufficient drainage channels at suitable intervals. These beds or basins are then flooded and drained two or three times to wash away the salt accumulations, after which coarse rice or *sawan* (*Panicum crusgalli*) is sown as a trial crop. If either of these grows well, the land is sufficiently salt-free to grow berseem as a cold-weather irrigated crop. If berseem also grows well, it means the land is good enough to grow cotton.

Another use for berseem is as green manure. A hectare of berseem can add nearly 224 kg of nitrogen to the soil, which benefits the growth of succeeding crops like cotton, sugarcane or chillies. Usually the last cutting is left uncut and ploughed in, sometime in June, with the first showers of the south-west monsoon. Experiments have shown that the succeeding crops are often benefited to the extent of 45 kg of nitrogen per hectare.

Utilization. Berseem is used mainly as a nutritious green feed for livestock, but it can be utilized in other ways as well. Stock may be tethered in a berseem field to graze, after the Egyptian fashion, from October to April. Care is needed, however, to avoid over-grazing, not only to prevent the risk of " bloat " or tympanitis in the grazing animals, but also to avoid damage to the berseem crop. Bloat is more likely to occur when cattle are fed berseem in its early stage of growth, or with the early morning dew upon it. For pasturing, a bullock will need about 0·26 hectare of berseem and a cow about 0·24 hectare to keep it on green feed for four months. In the green state berseem contains about 10 per cent of total digestible nutrients and 2·2 per cent of digestible crude protein. Working bullocks can be maintained on berseem alone, along with a small quantity of dry roughage, without any need for extra concentrates at all.

As mentioned earlier, the first cutting in a berseem crop sown in September can be taken in November and the subsequent cuttings can be taken at intervals of 35 to 40 days, until mid-July. The first and

second cuttings may be rather watery. During the winter months the rate of growth slows down, but with the advent of spring, cuttings can be taken at shorter intervals, i.e., in 30 days' time. Later on in the season, the hot weather makes the yields poorer. An average crop of berseem yields about 336–448 quintals of green fodder per hectare, in five to six cuttings, from November till June.

Berseem is best fed mixed with some dry fodder, like *jowar*. It is a very palatable and nutritious feed for all livestock and stimulates milk production in dairy cows and buffaloes. Berseem can also be converted into good hay, but great care is needed to prevent loss of leaf by shedding during the drying process. Since the early cuttings are too watery, it is desirable to utilize only the later cuttings for making hay. Berseem hay contains 9·0 per cent of digestible crude protein as against 10·6 per cent of digestible crude protein in lucerne hay, but berseem is in fact, superior to lucerne hay in having a higher content of phosphorus and a better balance between calcium and phosphorus. One hundred kilogrammes of berseem hay contain a total of 50 kg of digestible nutrients, including 4 kg of digestible protein.

Seed Production. For seed production the last cutting should be taken by the end of February or early March and then the crop should be left to flower and set seed. In an early-sown crop, the fifth cutting is the one usually left for seed, but if berseem had been sown late, the fourth cut itself may have to be left for seed. If the interval is too short between the last cutting and the pod-ripening, a good part of the seeds, will remain immature. If the crop is left to set seed late in the season when hot weather and dry winds prevail, flowering and pollination by bees will be poor, with the result that seed yield is also very poor. Dry, mild weather at flowering time, from mid-May to the mid-June, is conducive to good seed production. Too vigorous a growth in plants left for seeding leads to lodging and reduces the seed yield and hence plant growth should be restricted when the crop is left for seed.

Pests and Diseases. Surface caterpillars (*Agrotis segetum*) and cotton worm (*Prodenia littoralis*) are widespread pests of berseem. These attack early-sown berseem and in bad infestations may even necessitate resowing. Delaying the sowing by a fortnight is often enough to avoid damage by these pests; another method of control is to cut and feed off the affected crop, clear all the weeds, roll the ground and then give a liberal irrigation to induce a good re-growth of the berseem crop.

The main disease in this crop is a kind of damping-off, known as the stem rot of berseem, caused by *Rhizoctonia solani* Kuhn. Plants may be attacked in all stages of growth. In seedlings the hypocotyls are affected, developing yellowish patches which in a few days turn dark brown and kill off the seedlings. No effective control is known. It is possible to prevent the disease by good drainage and cultivation. Root and brown

rots are caused by *Fusarium* species and also by *Rhizoctonia solani* in the later stages of the crop. These diseases frequently deplete the stand to a stage where it may not be profitable to retain the crop any longer.

Dodder (*Cuscuta* species) is a phanerogamic parasite infesting many plants, which sometimes damages berseem also. Dodder seeds get carried along with berseem seed and they germinate when berseem is sown. The long, tendril-like stems of the parasite wind round the berseem stems and develop suckers or ' haustoria ', which penetrate the host tissues and absorb nutrients. Having established itself on one plant the parasite gets all its nourishment from it and sends out fresh tendrils to attack other plants, ultimately resulting in poor berseem growth and yield. For controlling this pest, dodder plants should be carefully removed along with the host plants and burnt. Since cut pieces of dodder can cause fresh infections when they fall to the ground, care should be taken not to disseminate them through labourers when cutting berseem. On no account should the dodder plants be allowed to set seed, because the seeds can remain viable for long periods in the soil. Badly infested fields should be ploughed up and planted with some other non-leguminous crop. Berseem seed containing dodder seeds should be rejected and never used for sowing.

Admixture of chicory seeds is often common in berseem seed samples; this is also quite undesirable, because it causes scouring in animals when they are fed with berseem mixed with chicory plants. The proportion of chicory plants no doubt gets less after each cutting, but it is still a considerable danger and should be carefully weeded out from the berseem crop quite early in the season.

TABLE 10. ANALYSIS OF BERSEEM

	Green fodder		Silage		Hay	
	Chemical composition	*Digestible nutrients per 100 kg	Chemical composition	Digestible nutrients per 100 kg	Chemical composition	Digestible nutrients per 100 kg
	%	%	%	%	%	%
Moisture	84·9	—	76·0	—	12·7	—
Crude protein	2·8	81	2·3	31	12·8	70
Ether extract	0·4	50	0·6	47	1·4	29
Crude fibre	2·9	60	9·6	52	26·7	49
Ash	2·2	—	3·2	—	10·6	—
N-free extract	6·6	80	8·3	47	35·8	77
Calcium	0·40	—	—	—	1·81	—
Phosphorus	0·07	—	—	—	0·57	—
Potassium	0·72	—	—	—	3·40	—
Digestible crude protein	—	2·2		0·7		9·0
Total digestible nutrients	—	10·0		10·3		50·0

(After Lander, 1949.) *Syn. Digestibility Co-efficient.

Shaftal (*Trifolium resupinatum*) (Persian Clover, Peshawar Clover)

Origin, History and Distribution. As the name indicates, shaftal is a pasture and hay plant of Persia. It is also an important fodder crop of Northern and Western India and is one of the main sources of green fodder in Peshawar and adjoining areas (now forming part of W. Pakistan). It is well-suited to the colder hill regions of Northern India, but is not suited for semi-tropical conditions at low elevations. In recent years, shaftal is being grown in the United States of as a winter pasture legume and green manure.

Description. Shaftal is similar to berseem but is not so tall, and has only a single stem. Being a true winter annual, the seeds germinate in the autumn and the plants keep growing, though slowly, during the winter months as a low rosette. With the advent of spring, the growth rate is rapid and a large number of erect flowering stems develop, from which seeds are produced in summer before the plant dies. The flower heads resemble those of white clover, but unlike white clover, the plant neither creeps along the ground nor roots at the nodes. The leaflets too are more tapering at the base than in white clover. Flower heads are light purple in colour, self-pollinating and self-fertile and are borne on short peduncles, five to eight cm. long, arising from the leaf axils.

As the seed ripens, the calyx around the pods becomes inflated into a balloon-like envelope. These break off when ripe and float on wind and water, to aid in seed dispersal. The seeds are olive-green to dark-purple in colour and are difficult to distinguish from white clover seeds.

Shaftal grows best on moist, heavy soils. It is hardier than berseem, more tolerant to drought and slightly richer in protein content, but the yields are lower.

Cultural Practices. Two or three ploughings are required to prepare the land for shaftal. A dressing of ammonium sulphate to supply 22·4 kg of nitrogen and superphosphate to supply 67 kg of phosphorus per hectare at sowing time will be helpful to ensure good growth and yields. Prior inoculation of the field (or seed) with the appropriate bacterial culture is necessary when shaftal is grown for the first time in a field.

Two main varieties of shaftal are available, one early and the other late. Before sowing the crop the field is formed into beds and flooded as in the case of berseem and soaked seeds at 22–35 kg per hectare, mixed with an equal quantity of fine earth, are sown broadcast in the standing water in the beds, during the latter half of August or early September. After sowing, a light covering of dry earth is scattered on top of the seeds. The seeds strike root rapidly and a light watering should be given as soon as the field gets dry. Subsequently, the surface of the field should be kept frequently cultivated to keep down weeds and maintain a good mulch.

Rotations and Mixtures. It is often advantageous to have a light cover crop of maize or jowar previously sown in the fields intended for shaftal in order to protect the shaftal seedlings from wind and sun in the early stages. The maize (or jowar) plants are removed early in September, leaving shaftal to grow by itself afterwards. Sometimes, shaftal is sown mixed with maize, barley or mustard, to secure a heavier yield in the first cut and also a better balanced forage.

Irrigations for shaftal should never be excessive but should be given only when the plants show, by a change in the leaf colour to a darker green, the need for water. The crop grows rather slowly during December-January, but makes rapid progress in the spring months and so the waterings should be adjusted to these varying rates of growth. A total of 30 hectare cm of water (i.e., four to six irrigations) may be required for the entire crop period.

Utilization. Shaftal can be cut when the plants are about 25 cm high. If sown in September, the first cutting can be taken by the end of December. The second cutting may be ready by January or early February, the third in March and the fourth in April. In the spring, it is desirable to cut the crop as often as practicable, because delayed cuttings lead to rust infection, which weakens the stand of plants. If the crop is well-manured and irrigated, shaftal can be cut even at three-week intervals, from February to April. The last cutting is generally left uncut for seed production or otherwise ploughed in as green manure for the next crop.

Yields are variable, but about 224–336 quintals per hectare of green fodder can be expected from a good crop. Shaftal is an excellent green feed for all classes of livestock and especially for milch cows and buffaloes. For horses, mules and working bullocks, shaftal should be chopped up and fed only with some dry roughage like jowar to prevent bloat. In this respect shaftal is more liable to cause bloat than either berseem or lucerne, although as a green manure it is considered to have a better effect on soil fertility than berseem.

Shaftal is usually cut and fed green to livestock, but it is also well-suited for making hay, for which purpose it is better than either berseem or lucerne. The drying should, however, be done with great care, especially in very dry areas as in the Punjab and north-west India. The shaftal after cutting is spread out to dry for a day or two, then it is turned and allowed to dry for another day. When the material is half-dry, it is gathered into heaps and pressed down to slow down further drying. Experience is needed to judge when exactly the half-dry shaftal could be stacked. If left till too dry, the hay fails to get the slow "after-fermentation" and becomes flavourless and brittle; if stacked too soon, the final product becomes mouldy. About 20 kg of hay can be obtained from 100 kg of green shaftal.

When shaftal is used as green manure, the last cutting is left uncut to be ploughed in, but even if this is not done, the root residues contain sufficient nitrogen reserves to give a good yield in the next crop of *kharij* maize or paddy that follows.

Seed Production. Shaftal flowers by May and if left without cutting, sets profuse seed by June, so that seed production is not a problem in this crop.

Pests and Diseases. No pests or diseases have been observed so far, if shaftal is properly grown and cut regularly. If over watered, or when the foliage gets over-ripe by not being cut in time, the leaves get sometimes infected by a rust fungus.

TABLE 11. ANALYSIS OF SHAFTAL

	Chemical composition (Green forage)
	%
Moisture	85·5
Crude protein	3·1
Ether extract	0·3
Crude fibre	2·3
Ash	1·9
N-free extract	6·8
Calcium	0·36
Phosphorus	0·08
Potassium	0·58

(After Lander, 1949.)

White Clover (*Trifolium repens*)

Genus *Trifolium* L. Herbs; Leaves trifoliate, stipules adnate to the petiole. Flowers red or white, sometimes yellow or purple, in dense axillary heads, spikes or umbels. Calyx tube campanulate; Corolla adnate to the calyx tube, fading without falling off. Stamens diadelphous, filaments more or less dilated, anthers uniform. Ovary sessile or stalked, with few ovules, style filiform, stigma oblique. Pod minute, indehiscent, one to few seeded.

T. repens L (White Clover, Dutch clover)

This species is native to Europe but is now widely distributed in many countries of the temperate regions. In the United States, it is grown in pastures, but it also grows wild in lawns, meadows, roadsides and even on wastelands. It is a long-lived perennial in the northern States of the United States but in the southern States it behaves as a winter annual.

Except when grown for seed it is nearly always grown in combination with other grasses. Attempts have been made to popularize clovers in many parts of India but they have not become really popular so far. Red clover and white clover are now found growing wild in many places in the Nilgiris, at elevations of 1830–2440 metres.

White clover is a shallow-rooted, creeping herb which spreads by means of stolons rooting at the nodes. The three leaflets have serrate margins and a characteristic whitish mark in the centre. Flowers are usually white, but sometimes, pinkish and are borne in clusters. These inflorescences are numerous in the common white clover, but are few in the Lladino clover variety. Each of these heads contains 70–100 seeds when ripe. Cross-pollination is essential, as it is self-sterile.

Lladino clover is a larger type of white clover which is very popular in the United States. It is a vigorous, quick-growing perennial, nearly three times as large as ordinary white clover, in stems, leaves and inflorescences. Flowering is not as profuse as in white clover, but it is superior in palatability and protein content, with less of fibre. It is excellent for pasture mixtures, either with other legumes or with grasses and gives better pasturage than any other grass-legume mixture. Lladino clover responds well to fertilizers and withstands the competition of undesirable grasses and weeds, but it is poor in seed production and tolerance to cold. Being an aristocrat amongst pasture legumes, good management is necessary to get the best results out of it.

Red Clover (*Trifolium pratense*)

A native of Europe and West Asia, red clover was introduced into North America in 1747 and it is now the most widely-grown legume for forage and soil improvement throughout Europe and North America. It is even claimed to be the corner-stone of the grassland agriculture in the temperate countries of the Old World.

Red clover is usually grown and used as a biennial, although it is really a short-lived perennial. It is a semi-erect herb, with numerous leafy stems arising from a thick crown. The flowers are in compact clusters averaging 100 to 120 in each ' head ', rose-pink in colour, 10 mm long and 2 mm wide. The fruits are pods but bear little resemblance to other legumes, being small and breaking transversely instead of lengthwise as in other legumes. Seeds are kidney-shaped, about 2 mm long, varying in colour from yellow to deep violet. The leaves are trifoliate, with a pale mark in the middle. Stems are rather hairy. The plants are deep rooted and the roots bear numerous nodules when inoculated with the appropriate rhizobium culture. On account of its biennial nature, red clover is very useful in three or four-course rotations. The first growth is cut for hay and the next flush is left for seed or ploughed

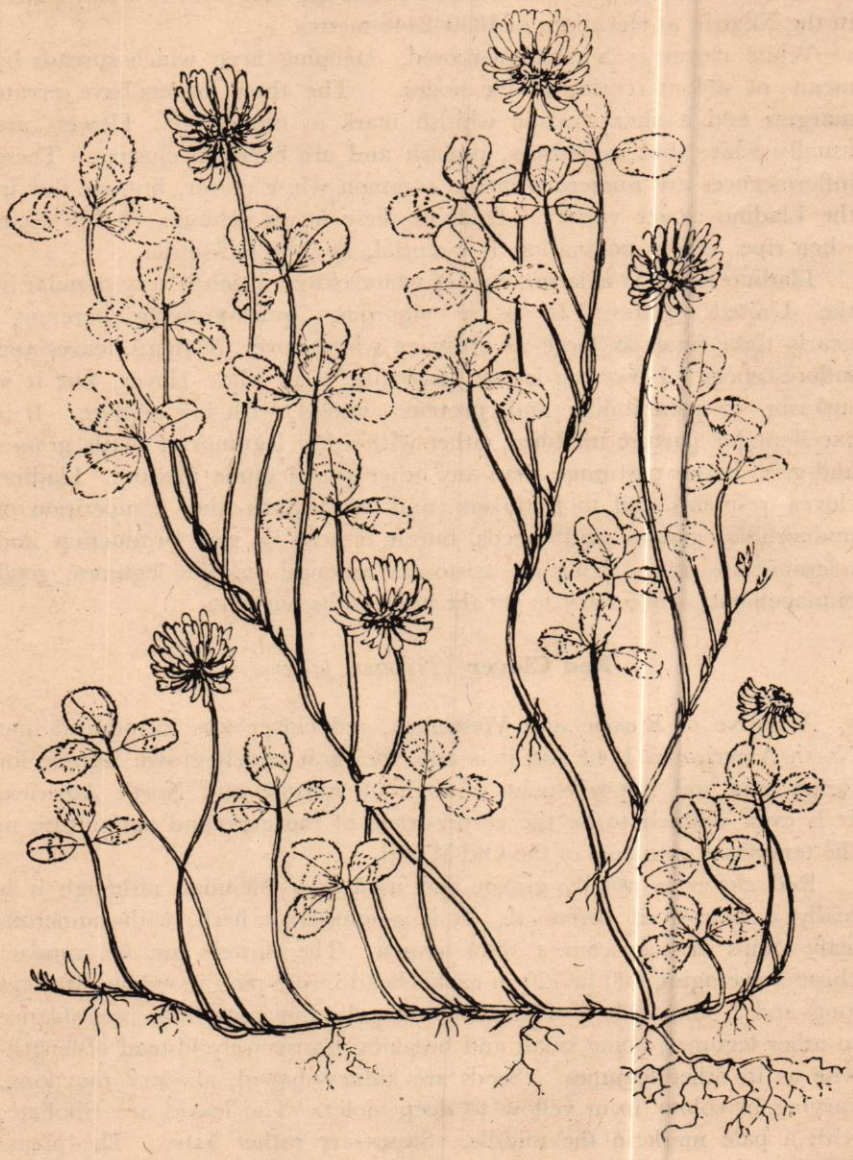


Fig. 3. White clover (*Trifolium repens*)

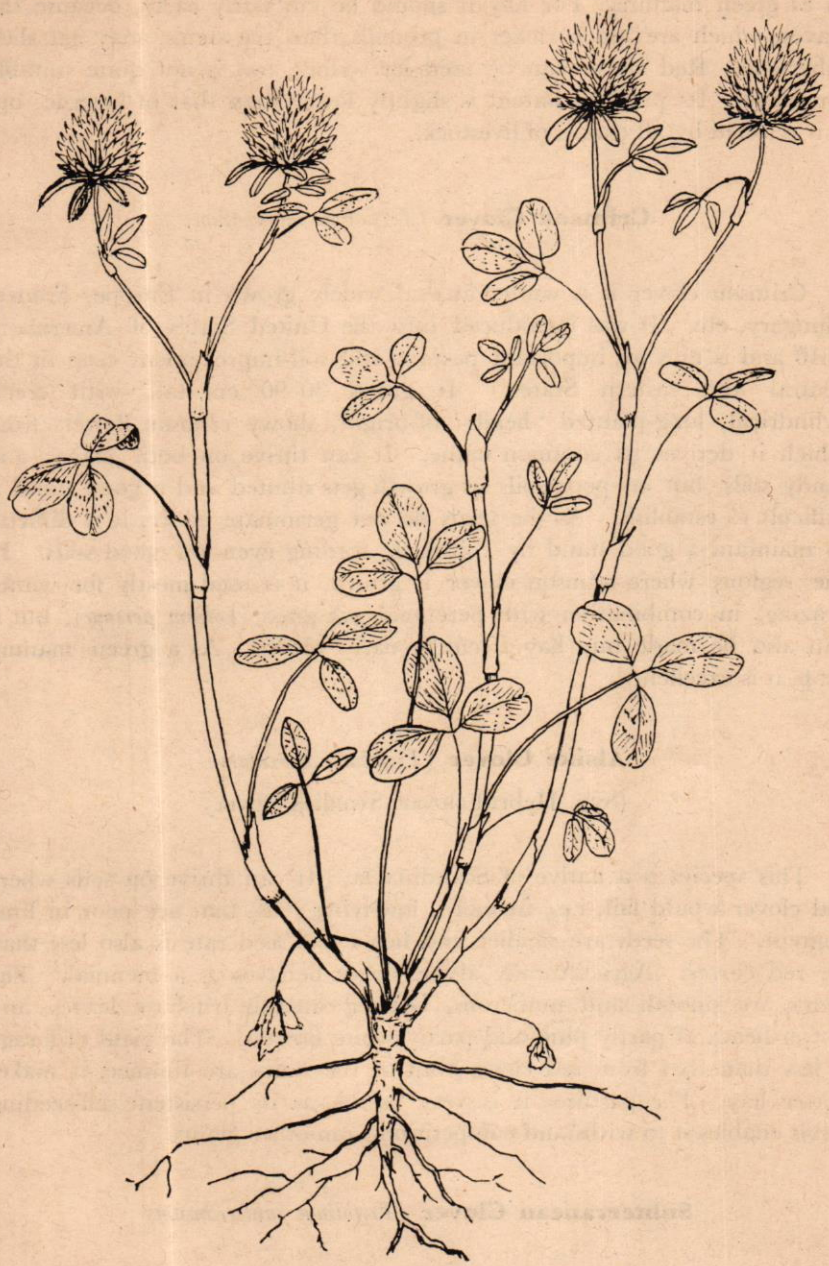


Fig. 4. Red clover (*Trifolium pratense*)

in as green manure. For hay it should be cut fairly early, because the leaves, which are much richer in proteins than the stems, may get shed otherwise. Red clover can be used for soiling, but is not quite suitable for silage. Its protein content is slightly lower than that of lucerne, but it is relished by all classes of livestock.

Crimson Clover (*Trifolium incarnatum*)

Crimson clover is a winter annual widely grown in Europe, France, Hungary, etc. It was introduced into the United States of America in 1810 and is now an important pasture and soil-improvement crop in the central and eastern States. It grows 30–90 cm tall, with erect, cylindrical, long-pointed ' heads ' of bright, showy crimson flowers from which it derives its common name. It can thrive on both clayey and sandy soils, but on poor soils its growth gets stunted and a good stand is difficult to establish. As the seeds do not germinate easily, it is difficult to maintain a good stand by volunteer seeding even on good soils. In the regions where crimson clover is grown, it is used mostly for winter grazing, in combination with perennial rye grass (*Lolium perenne*), but it can also be made into hay if cut in early bloom. As a green manure crop, it is excellent.

Alsike Clover (*Trifolium hybridum*)

(Syn. Hybrid clover, Swedish clover)

This species is a native of Scandinavia. It can thrive on soils where red clover would fail, i.e., in moist, low-lying soils, that are poor in lime content. The seeds are smaller and hence the seed rate is also less than for red clover. Agriculturally alsike clover behaves as a biennial. The stems are smooth and numerous, bearing smooth trifoliate leaves and flower-heads of partly pink and partly white flowers. The yield of forage is less than that from red clover, but as the stems are thinner, it makes better hay. For pastures it is very useful, as its persistent self-seeding habit enables it to withstand competition from other plants.

Subterranean Clover (*Trifolium subterraneum*)

The flowers in this species are of two kinds, one normal and the other going underground. Only three or four of these underground flowers develop in each inflorescence; the others form a " grapnel ": each sepal gets modified into a reflexed, hook-like structure and the stalk of the

inflorescence bends downwards and gradually forces the flower into the ground, where the fruits develop as in groundnut.

Strawberry Clover (*Trifolium fragiferum*)

This species is indigenous to Asia Minor and the Mediterranean regions, but is now widely cultivated in many other temperate countries of Europe, America and Australia. The plant is a low-growing perennial legume resembling white clover in stems, leaves and habit of creeping growth by rooting at nodes, but distinct in flowers and pods. The flower heads are round, with sometimes pointed tips, pink and white like a strawberry, giving rise to its common name. As the pod matures, the calyx around each pod becomes inflated like miniature balloons, grey to light-brown in colour and when ripe, these balloon-like capsules break off from the head and get dispersed by wind or water. The seed varies in colour from yellow to reddish-brown, flecked with darker markings.

Climate and Soils. Strawberry clover can grow under a wide range of climates, from very cold to high summer temperatures. It is also adapted to many soil types and though it thrives best on normal fertile soils, it can also come up in areas where poor drainage or alkalinity is a limiting factor for other crops.

Cultural Practices. The crop needs a firm, moist and fine seed-bed as it gets established more slowly than white clover. Seeds may either be drilled in rows or sown broadcast, at a seed rate of 4·5–5·6 kg per hectare. As the seed coat is rather hard, prior scarification is essential for good germination. The crop spreads rapidly by means of its creeping stems, so that even thin stands become quite thick by the second year.

Utilization. Strawberry clover is essentially a pasture legume, although it can also be grown for green manure, especially on alkaline soils where other legumes may not grow. Close grazing or mowing helps in stimulating its growth and eliminating sedges and other wet soil weeds that may otherwise swamp the legume. The flowers are self-fertile, unlike red and white clovers and afford good pasturage for honey bees. Flowering begins earlier in the season than in other clovers and is more profuse in thick stands. Seed production is also prolific and about 224 kg of seed may be expected from a hectare. It is best to graze the crop till June and leave the regrowth for seed production. The pods shatter very easily and hence the crop should be cut when the heads are slightly damp and the seed envelopes less brittle.

The forage is as palatable and nutritious as white clover. Pastures of strawberry clover have a greater carrying capacity than either red or white clover. In India, this legume may be found suitable for pastures in cool, humid sub-alpine regions with 152 cm of rainfall, at elevations 1,229 metres or higher.

Pests and Diseases of Clovers

Pests. Clover Leaf Weevil (*Hypera punctata*)—The greenish larvae of this weevil hatch out early in the spring and feed on clover leaves, mostly at night time. During the day they may be found clustered around the bases of the plants. From April onwards the foliage begins to look ragged on account of irregular patches being eaten away from the leaf margins.

Lesser Clover Leaf Weevil (*Hypera nigri-rostris*)—This weevil is found on Alsike clover and red clover. The larvae attack newly formed flower heads and buds in the first flush and sometimes they tunnel into the stems also.

Clover Root Borer (*Hylastinus obscurus*)—This is one of the serious pests of red clover, although the infestation occurs mainly an older plants and seldom on young plants less than a year old. The weakened plants break off at ground level.

Clover Seed Chalcid (*Bruchophagus gibbus*)—This beetle eats away the seed, leaving only the husk intact.

Control of the two weevil/pests is possible by sprays or dusts of calcium arsenate at 2·2 kg per hectare or with 5 per cent DDT at 1·1–2·2 kg per hectare in a suitable diluent, but the herbage should not be fed to dairy cows or animals meant for slaughter, to prevent tainting the milk or meat.

Diseases. Amongst the various diseases affecting clovers, the following are the most important. In most of these, however, effective control is possible only by the evolution of resistant strains of the specific clover type.

Crown and Stem Rot (*Sclerotinia trifoliorum*)—This is a soil-borne disease that is destructive to many legumes, including lucerne and lupins, but clovers are especially susceptible to it. Infection is favoured by moderate temperatures and excessive moisture and the greatest damage occurs during late autumn and early spring months.

Anthracnose (*Colletotrichum trifolii*, *Kabatiella caulivora*)—Anthracnose occurs in red clover early in summer, first as dark spots on the stems, petioles and flower stalks. These increase in both size and number and coalesce, and the resulting girdling causes the petioles and flower stalks to wilt and break off to produce a characteristic " Shepherd's Crook " appearance. Considerable defoliation also occurs and in severe cases all the tops may be killed off by late summer. The crowns and tap roots may also be affected and the forage yield is much reduced. *Colletotrichum trifolii* is favoured by high humidity and high temperatures, whereas *Kabatiella caulivora* is severe under conditions of moderate humidity and temperatures.

Powdery Mildew (*Erysiphe polygoni*)—This fungus is very common on red clover, producing a white cottony mass on the upper surface of the

leaves. In severe attacks, yields are very much reduced. Attempts are in progress in western countries to produce strains of red clover, resistant to both anthracnose and powdery mildew.

Leafspots are of widespread occurrence in clovers; these are caused both by fungi and bacteria, but they become serious only under conditions of excessive humidity.

SWEET CLOVERS (*MELILOTUS* SPP.)

Indian Clover, Senji

(*Melilotus parviflora* Desf.)

Genus *Melilotus* Juss. Annual or biennial herbs. Leaves pinnately 3-foliate, stipules adnate to the petiole. Flowers small, yellow or white, on slender axillary racemes; Calyx tube campanulate, 5 teeth, unequal. Petals deciduous, stamens 10, filaments filiform, anthers uniform. Ovary sessile or stalked, with few ovules, style incurved, stigma terminal. Pod sub-globose, or oblong, indehiscent, seeds one or few.

Origin, History and Distribution. *Senji* is a common leguminous weed in the Punjab and very similar to clover. It has been cultivated as a winter forage crop in Northern India from very early times and is still grown in certain parts of the Punjab and Uttar Pradesh for forage. All the three species, namely *M. indica*, *M. parviflora* and *M. alba* are found as cold weather weeds in fields on the Coromandel coast also. *Senji* was tried at various centres in India between 1904 and 1910, but did not prove superior to berseem or even sufficiently promising, except in Sind and in the Punjab, where it was already popular. It was not a success in peninsular India.

Description. The plant is an annual growing nearly 1·2 m high, with cylindrical, hollow stems. Leaves are trifoliate and the leaflets resemble lucerne leaflets. The midrib is reddish in young leaves but this tint disappears later on. Flowers are white or yellow. Pods are roundish and single-seeded, with a rough surface covered with a coarse network of fine ridges. The seed is small, elliptical and brownish-yellow in colour.

The white-flowered species is known as *Melilotus alba* or sweet clover in the U.S.A. and grown over considerable areas in many States. The yellow flowered variety (*M. indica*) is grown to a lesser extent in the Southern States of the United States and in Australia.

Climate and Soils. Being exclusively a winter annual, *senji* thrives best when sown as an irrigated *rabi* crop in Northern India, on rich, moist loamy soils and on alluvial land by the side of river-banks. It requires about 25 hectare cm of water in 2–3 irrigations during the crop-period.

Senji is eminently suited as a short-term forage crop or as a green

manure when sugarcane is to follow in rotation, because both berseem and shaftal may stand too long in the field and thereby curtail the preparatory cultivation for sugarcane.

Cultural Practices. Five to six ploughings will be required to prepare the land for *senji*. Application of superphosphate to supply 67 kg of phosphorus and ammonium sulphate to supply 22 kg of nitrogen per hectare before sowing will ensure good growth and yields.

Senji is sown broadcast in the standing crop of maize, a few weeks before harvesting maize, or drilled in October, using a seed rate of 45–56 kg per hectare for a pure crop. As the seeds are small, they are usually mixed with an equal weight of earth before they are sown. To help in speedy germination, the seeds should be scarified by rubbing with sand. *Senji* is often sown mixed with other crops like maize, oats or barley or Hubam clover. The last makes a very good combination, because Hubam clover can remain green throughout May and give three cuttings. *Senji* gives one good cutting of 67·2–89·6 quintals green fodder per hectare by February-March. With a *senji*-hubam clover mixture, the Hubam clover can give two more cuttings during the next three months from the same field, yielding another 134·4–168 quintals of green fodder per hectare, besides a good quantity of seed.

The right stage to cut *senji* for feeding green to livestock is when the pods are just being formed; if it is cut earlier, the risk of bloat is greater. The fodder is both palatable and highly nutritious, being richer in protein than berseem or lucerne, but the yield is very much lower and only a single cutting is possible. Being so rich in proteins, it is not quite suitable for making silage, unless mixed with other grasses or cereals like maize or jowar. It can also be cut and dried as hay, but leaf-shedding is difficult to prevent under Punjab conditions.

Pests and Diseases. Soft Root-Rot (*Phytophthora cactorum*) is a soil-borne fungus that is destructive to sweet clover during early spring in many States of the United States. Other diseases of sweet clover are : damping-off or seedling blight caused by *Pythium* species; crown and stem rot caused by *Sclerotinia trifoliorum* and stem canker (*Ascochyta caulicola*), but so far no serious diseases or pests have been reported on *senji* in India.

Hubam Clover (*Melilotus alba annua*)

This is a variety of sweet clover which was first introduced at the Indian Agricultural Research Institute, New Delhi, in 1949. It has proved a success in many parts of Northern India due to its adaptability to poor soils, high yield of nutritious green forage and utility as a hay crop and green manure. It is not suited to the climatic and soil conditions of peninsular India.

Hubam clover is sown broadcast in October-November, at 16·8–17·9 kg per hectare, just before the final levelling is done for sowing wheat. Wheat is subsequently drilled in the normal manner and harvested by the end of March. Hubam clover makes slow growth during the winter months but shoots up after March and if two irrigations are given it can remain green till June. During this period it can give two to three cuttings, averaging 90 quintals per hectare per cutting. Being rich in nitrogen, (3·5 per cent nitrogen on green basis) this clover can also serve as a very good green manure. For this purpose, it is cut for fodder once in April and irrigated and the next flush is ploughed in as green manure, before drilling maize by the second half of July.

TABLE 12 ANALYSIS OF SENJI

	Green fodder	
	Chemical composition	Digestible nutrients
	%	%
Moisture	77·8	
Crude protein	3·8	
Ether extract	0·6	
Crude fibre	5·8	
Ash	2·3	
N-free extract	9·7	
Calcium	0·48	
Phosphorus	0·11	
Potassium	0·67	
Digestible crude protein		2·4
Total Digestible Nutrients		13·2

(After Lander, 1949.)

CHAPTER 6

MEDICS (*MEDICAGO* SPECIES)

Genus *Medicago* Linn. (Leguminosae—Papilionatae)

This genus includes 65 species native to Europe, Asia and Africa. Some of them are weeds and some are useful for forage. They are mostly herbaceous annuals and perennials, erect, spreading; leaves pinnate, leaflets three, small, mostly denticulate; stipules adnate to petioles; flowers small, yellow or violet, in axillary short racemes or heads, papilionaceous; calyx teeth nearly equal, stamens diadelphous, nine and one; style beardless, stigma capitate; pod much curved, small, indehiscent, seeds one to four in pods.

Among the species in this genus, *M. sativa*, *M. lupulina* and *M. falcata* are useful fodders. *M. coronata*, *M. denticulata*, *M. hispida* and *M. tribuloides* are some of the other species that may have fodder possibilities.

Medicago sativa L. (Lucerne, American—Alfalfa, Tamil—*Kudirai masal*)

Origin, History and Distribution. Lucerne has been known since very early times, being mentioned in the Bible. It was originally a native of south-western Asia, but it is now grown practically all over the world, as it is well-adapted to warm temperate and cool sub-tropical regions. It was taken to the New World by the Spaniards and tried by the early colonists on the eastern coast of North America with indifferent success, as the land there was poor in lime, but later on, when it was taken to the Californian coast in the 1850s, it proved to be an immediate success and now lucerne is grown over six million hectares in the U.S.A. In India it was introduced some time in 1900 and has now become quite a popular and widespread forage crop which withstands the hot climate remarkably well. Lucerne is grown in India mostly under irrigation, though in temperate countries it is more usual to grow it as a rain-fed crop. In the vicinity of towns lucerne is much in demand as a green fodder for horses and in fact, its Tamil name means literally " horse-fodder ".

Description. A perennial herb, 0·6–1.6 m tall, leaves pinnately trifoliolate, the main nerves excurrent as marginal teeth. Stipules two, adnate to the petiole; flowers small, yellow, white or purple, zygomorphic, hermaphrodite, borne on short, slender axillary racemes, bracts and bracteoles minute or zero, calyx gamosepalous, campanulate, teeth five, sub-equal; corolla papilionaceous, five-petalled, petals deciduous, imbricate, the uppermost (standard) being the outermost and the other petals arranged in two opposite pairs; stamens 10, diadelphous, nine and one, the one opposite the standard petal being free, anthers two-celled; ovary free,

with one or more ovules on the ventral suture; style simple, stigma capitate; fruit a legume, spirally coiled, seed exalbuminous, testa hard, cotyledons accumbent, radicle inflexed. The characteristic kidney-shaped greenish-yellow colour and a light stripe leading from the central scar towards one end of the seed, serve to distinguish lucerne seed from the seeds of clovers and other leguminous fodder crops.

Climate and Soils. Lucerne can grow under diverse climatic conditions. Although a native of temperate regions of south-west Asia, it is now grown with success in most countries of the world, including the tropics. It can be grown even in some regions below sea level, as well as at elevations of 2,440 m.s.l. It needs a well-drained loamy soil, rich in lime and approaching neutrality in *p*H value. It cannot thrive on alkaline soils, but can be made to grow on acid soils with the aid of liberal dressings of lime. Lucerne cannot tolerate wet or damp areas, even though the crop needs copious irrigations for good growth. For optimum growth lucerne requires a well-drained sub-soil, with the water table about 0·9 m below the surface in sandy soils, below 1·2 m in loams and below 1·8 m in clayey soils. A fluctuating water table is particularly undesirable for lucerne.

Cultural Practices. When lucerne is being grown for the first time in a field, the soil should be inoculated with the appropriate culture of root nodule bacteria (*Rhizobia*).

The land should be ploughed five to six times to secure a good tilth and manured with 22.4 quintals of cattle manure plus 168 kg of super-phosphate per hectare. Ridges and furrows are then formed 45–60 cm apart and lucerne seeds are dibbled on both sides of the ridges, 15 cm inches apart, using three or four seeds per hole. Alternatively, the seeds may be sown broadcast in standing water impounded in previously made beds of suitable size. A seed rate of 7–9 kg per hectare will suffice under Indian conditions, although 11.2–16.8 kg is often used as the 'seeding rate' for alfalfa in the U.S.A. The sowing season varies from September to November. In the Punjab, the optimum period is from October to the middle of November.

Germination gaps should be filled in quickly so as to ensure a good and uniform stand later on. The first irrigation may be given 15 days after sowing and later at suitable intervals, i.e., at monthly intervals during the winter months and 10 to 15 days intervals in the hot summer months. Weedings and hoeings should be given as and when required.

Although lucerne cannot tolerate high atmospheric humidity, its water requirements are quite high, being 858 litres of water per kg of dry matter produced. The crop requires 15–18 irrigations in a year, amounting to nearly 127 hectare/cm of water.

The first cutting can be taken three months after sowing, i.e., in February from a November-sown crop. Subsequent cuttings can be

taken at intervals of 30 to 40 days. An average of 8–10 cuttings may be obtained in a year, yielding 336–448 quintals of green fodder per hectare. Higher yields of up to 784 quintals per hectare per year have also been obtained in many places with the application of liberal manuring and irrigations.

While taking periodical cuttings in lucerne, care should be taken to leave a sufficient number of shoots intact on the plants; otherwise the crop tends to die out early. In the U.S.A. and other temperate zone countries, cuttings in the autumn are discouraged, as the plants have then no chance to restore the reserve food material to the roots from the subsequent leaf growth and as a result die out due to exhaustion of the root reserves. For the same reason, the lucerne should not be cut too often in the bud stage or early bloom stage, as it may not have a sufficient interval to replenish the root reserves and as a result the crop may be very much weakened.

When a lucerne field becomes persistently weedy or appears to be getting overrun with grass, it is time to break it up and start the crop in a new field. Attempts to thicken a weak or gappy stand by subsequent inter-sowings are seldom successful and the seed is nearly always wasted. With good management and proper fertilizer schedules, however, a lucerne field can be maintained in good vigour for nearly four years.

Manuring. Lucerne has a high requirement of phosphorus, potassium, calcium and sulphur. Being a leguminous plant, it can secure its nitrogen requirements from the atmospheric air, through the agency of the nitrogen-fixing bacteria in its root-nodules. An adequate supply of phosphorus and potassium is also necessary for the proper functioning of the nodule bacteria themselves. In actual practice, lucerne responds well to farm-yard manure as well as to ammonium sulphate, especially on sandy loam soils. Being a perennial crop that stands in the field for three to four years, it is advantageous to apply every year 376 quintals of farmyard manure along with at least 134·4 kg of superphosphate per hectare. It would even be profitable to supply superphosphate every year up to 560 kg per hectare (to furnish 90 kg of phosphorus) and also ammonium sulphate to supply 22 kg of nitrogen per hectare as a side-dressing to the plants and follow it up with an irrigation. This would help to maintain good growth and yields in the second and subsequent years.

Lucerne being a heavy feeder on soil nutrients, many of the other essential elements also are likely to become deficient in certain soils. For example, boron may become deficient in leached and coarse textured soils. The leaves develop numerous pale-yellow spots similar to leaf-hopper damage, leading to the disorder known as ' lucerne yellows '. A soil dressing of 44·8–56·0 kg of borax per hectare usually suffices to remedy this disorder. Foliar sprays with a solution of 5·6 kg of copper sulphate in 455 litres of water per hectare have often helped to give forage yields nearly twice those in

unsprayed plots, by the fourth cut after spray treatment. Molybdenum sprays, (at 57 grams of sodium molybdate in 135 litres of water per hectare), are also helpful in places where calcium might be lacking. Manganese and zinc deficiencies have also been reported in lucerne from various countries, although little work has been done on this aspect in India. There is, however, one report from Sholapur (Maharashtra State) that small quantities of boron and manganese salts proved very helpful in improving lucerne yields at this station. Iron deficiency, leading to chlorosis, is fairly common on alkaline soils, particularly when the drainage is also defective, while on highly calcareous soils in areas of heavy rainfall, potassium deficiency may develop, necessitating heavy dressings with potassic fertilizers. Potash is also required in sandy areas, when lucerne is grown on the same land for several years.

Experiments have shown that placement of fertilizers helps to give 20 to 25 per cent higher yields in lucerne than when the same fertilizers are applied broadcast.

Liming the soil well in advance of sowing lucerne is very helpful in regions where the soil is acidic, as the increased yields not only pay for the lime, but makes the soil conducive to good yields for years to come.

Rotations and Mixtures. On account of its deep root system, lucerne has a beneficial effect upon soil structure and for that reason, it is a popular crop in rotations in many countries. The same is the case with mixtures; lucerne is often grown mixed with oats or other grasses like *Bromus inermis*, so that the nitrogen fixed in excess of the needs of the lucerne crop is utilized by the grass. Incidentally, such a mixture with Brome grass also prolongs the life of the lucerne as it retards the spread of wilt in lucerne.

Seed Production. Lucerne resembles clovers in being largely self-sterile, but unlike clovers, it is not pollinated by honey-bees. The specialized nature of the flowers in the genus *Medicago* makes it dependent on certain species of bumble bees and leaf cutter bees (*Megachile*). In lucerne the staminal column which encloses the pistil is itself enclosed within a boat-shaped structure called the ' keel ', made up of the two innermost petals. This column is held in a ' tense ' position and when an insect alights on the flower, the tension is released by the weight of the insect and the staminal column snaps up like a spring against the outermost petal, and thereby the pollen from the anthers sacs gets scattered. This ' tripping ' enables the female parts of the flower (style and stigma) to get dusted with pollen. The visiting insect also gets dusted with pollen, so that when it visits another flower, the stigma of that flower also gets smeared with the pollen carried on the insect's body. It is established that for satisfactory seed production, such ' tripping ' or cross-pollination by insects is essential; self-pollination being inadequate.

For seed production the crop is allowed to flower, after taking a cutting

in February. Only a light irrigation is given afterwards in order to discourage vegetative growth and encourage profuse flowering. After the flowering is complete, irrigations are withheld altogether, until all the pods ripen. Since in lucerne, the pods do not mature all at the same time, the seed grower has to harvest them when about two-thirds of the pods turn brown. The plants are cut near the base and left to ' cure ' for a few days, (i.e., for the immature seeds to dry out, and then the seeds are threshed. The seed yield is usually 280 kg per hectare, although seed yields up to 672 kg per hectare have also been recorded in the Sirsa Farm in the Punjab. Lucerne straw, after seed production, is quite dry and poor in feeding value.

In common with other hard-seeded legumes, lucerne seeds often fail to germinate uniformly, because they absorb noisture only slowly. The germination can be very much improved by ' scarification ', by rubbing the seeds on sandpaper so that moisture is absorbed more readily.

In recent years, improved high-yielding varieties of lucerne have been evolved in India, such as for example, the variety Sirsa No. 9, evolved for cultivation in the Punjab. It is capable of yielding up to 672 quintals green fodder in eight to ten cuttings per year and also 672 kg of seed per hectare.

Utilization. Lucerne can furnish green fodder for a period of three to four years from the same field. In India, lucerne is used mainly as a green forage, to be cut and fed green to cattle and other livestock. Unlike cereal fodders, lucerne remains nutritive even when harvested at a late stage maturity, but even then the percentage of protein goes down, from the early bloom stage to the late pod stage. The best stage to cut lucerne for fodder is at the ' early-bloom ' stage.

Since lucerne is a rich feed, with 15 to 20 per cent of protein on dry basis, it is to be used only in small quantities when fed to livestock. One to two kg of green lucerne are quite ample for a milch cow or working bullock per day. This should be fed along with other low-protein roughages, like cereal straws. For a small-scale farmer with four or five pairs of bullocks and three or four milch animals, lucerne need be grown only in small plots adjacent to wells.

An excess of green lucerne is apt to cause ' bloat ' in cattle. Some animals are more prone to this complaint than others and so the quantity of lucerne fed should be small to begin with; this should be increased gradually as the animals get used to it. The individual peculiarities of different animals should also be gauged and allowed for. Bloat can be avoided if the animals are first fed a half-ration of straw before feeding lucerne. Recent work in New Zealand and the U.S.A. has shown that certain vegetable oils, particularly groundnut oil and soyabean oil, are effective in reducing bloat, presumably by reducing foaming in the rumen.

Lucerne can effectively replace protein-rich concentrates like oil-cakes

for milch cows. The plants contain 15 to 20 per cent of protein on an air-dry basis in the early bloom stage, but this goes down to 12–14 per cent at the full bloom stage. The average protein content of lucerne is about 15 per cent and it is, therefore, preferable to cut lucerne at the initial or half bloom stage rather than at full bloom, when it is to be fed along with other cereal fodders to cattle. Lucerne hay is apt to be somewhat variable in quality, depending on the care with which it is prepared and handled, because the leaves, which contain nearly four-fifths of the protein in the plant, get easily shed. The hay should be prepared in dry weather, as exposure to rain at any stage of the curing process brings down the feeding value considerably. The best hay is obtained when the crop is cut at an early stage, when the protein and digestibility are both high and the fibre content low. For horses, however, hay made from a more mature crop is preferable as it is less laxative, but the method of curing is definitely more important than the stage at which the crop is cut. The protein content in lucerne hay ranges from 12 to 25 per cent and hence care is needed in balancing the ration for cows on lucerne with other cereal hays or straws.

Lucerne hay is particularly rich in calcium, amounting to nearly 1·5 per cent, but is rather poor in phosphorus which is only 0·2 per cent. It is, therefore, not well-balanced in minerals. If prepared with care the hay will retain a high percentage of carotene (vitamin A) and vitamin D.

Pests and Diseases. Leaf-hoppers of several species, aphid (*Illinoia pisi*) suck the plant sap and lead to stunted growth and yellowing of leaves. Control is rather difficult because the young, wingless hoppers hide on the underside of leaves and the adults are quite resistant to insecticidal sprays.

The alfalfa weevil (*Phytonomus posticus*) is a pest which was native to the Old World but is now a serious pest of lucerne in the United States. The adults hibernate in trash and in the spring lay a great number of eggs. The larvae that hatch out from these eggs feed on the leaves and in severe infestations cause stunted growth and reduced yields of fodder. Aldrin, Endrin or Dieldrin at 55–220 gm in 23–90 litres of water per hectare give good initial control of the larvae.

Other insects observed on lucerne are a Chalcid wasp whose larvae eat away the seed from the inside; a *Lygus* bug which damages the flowers and thereby reduces the seed-setting; army worms, aphids (*Therioaphis maculata*) and grasshoppers of several species. As baits are ineffective in a thick-sown succulent crop like lucerne, sprays or dust formulations of BHC, Chlordane or Toxaphene have to be used against these pests.

Diseases. A bacterial wilt caused by *Aplanobacter insidiosum* is the most serious disease in lucerne. Infected plants get badly stunted and show an abnormally large number of branched stems. The leaves turn a sickly green, and get misshaped with chlorotic margins. The roots

of affected plants show a brownish-yellow discoloration of the woody tissue in place of the normal white colour of healthy roots. The infection gets spread through sickles, while cuttings are taken or in manure and compost made from infected plants or by irrigation water or soil from infected to uninfected areas. The condition of the field gets worse as the crop gets older and the only remedy now possible is to grow wilt resistant varieties.

Another severe and widespread disease of lucerne is the leaf spot, caused by the fungus *Pseudopeziza medicaginis*. The spots are circular and of the size of a pinhead, ranging from dark-brown to black in colour. Diseased plants turn yellow and the leaves drop off. In bad infections the defoliation is complete, leaving the stems quite bare. In such cases, early cuttings reduce the loss of leaf to some extent, but they are also a source of fresh infection, from the infected leaves that fall among the plants.

Dodder (*Cuscuta* sp.), a phanerogamic parasite infesting many plants, sometimes damages lucerne. The seeds of *Cuscuta* get carried along with lucerne seed and germinate when the lucerne is sown. The long, tendril-like stems of the parasite wind round the lucerne stems and develop suckers or "haustoria" which penetrate the host tissues. Having established itself on one plant, the parasite gets all its nourishment from the host plant and sends out fresh tendrils to attack other plants. The final effect upon the crop is to reduce the yield considerably. At the end of the season there may be circular patches where the lucerne plants had got killed

TABLE 13 ANALYSIS OF LUCERNE

	Green fodder		Silage		Hay	
	Chemical composition	Digestibility co-efficient	Chemical composition	Digestibility co-efficient	Chemical composition	Digestibility co-efficient
	%	%	%	%	%	%
Moisture	74·6	—	46·0	—	9·6	—
Crude protein	4·6	74	10·0	—	14·7	72
Ether extract	1·0	38	2·5	—	2·0	32
Crude fibre	7·0	42	14·2	—	29·2	43
Ash	2·4	—	5·3	—	8·3	—
N-free extract	10·4	72	22·0	—	36·4	71
Calcium	0·56	—	1·19	—	2·00	—
Phosphorus	0·14	—	0·30	—	0·48	—
Potassium	0·69	—	1·46	—	2·43	—
Digestible Crude Protein	—	3·4	—	5·1	—	10·6
Total Digestible Nutrients	—	14·7	—	29·0	—	50·3

(After Lander, 1949.)

off by the parasites. Dodder seeds get mixed up with lucerne seeds and lead to fresh infections when such contaminated seeds are sown in another field.

For controlling the parasite, the dodder plants should be carefully removed along with the host plant and burnt. As cut pieces of *Cuscuta* can start fresh infections when they fall to the ground, care should be taken not to disseminate them through labourers while cutting lucerne. On no account should the dodder plants be allowed to set seed, because the seeds can live in the soil for long periods. Badly infected fields should be ploughed up and planted to some other non-leguminous crop.

Bur Clover

(*Medicago hispida*)

The group of bur clovers includes more than 35 species of *Medicago*, native to the Mediterranean region, but now grown in many other temperate countries as winter pasture legumes. But clovers are valued in the southern States of the U.S.A. as they are some of the easiest to grow among legumes, and can maintain themselves for many seasons with little or no attention for reseeding.

Bur clover is similar to clover in appearance, but the small, yellow flowers are borne in clusters of five to ten and the coiled pods are beset with short spines or ' burs '. The plant produces 10–20 or more spreading, decumbent branches near the crown, varying in length from 18 to 75 cm. Well-grown plants may contain more than 1,000 pods.

The species commonly grown in the U.S.A. are only five or six, among which the most important are the Spotted or Southern Bur clover: (*Medicago arabica*) and the Californian or Toothed Bur clover (*M. hispida*). Some varieties of the Californian bur clover have spineless pods, a desirable feature, because when sheep graze on bur clover, the burs often cling to the wool and lower the market value.

Climate and Soils. Bur clover can be grown on all types of soils, including even lime-deficient soils and poorly drained soils, but it thrives best on moist, well-drained loams rich in calcium. It can also tolerate a fair degree of alkalinity.

Cultural Practices. A firm seed-bed is essential for sowing bur clover. Sowing may be either in lines by drills or broadcasting; usually hulled seed is drilled and unhulled seed is sown broadcast. The sowing season is between August and October and about 33.6 kg of hulled seed are required for a hectare. A good proportion of the seeds is " hard " and difficult to germinate unless they are given a special pre-treatment in hot water. Prior inoculation of the seed is also necessary with the specific bacterial culture, if bur clover is sown for the first time in a field. To secure the best growth, the field should be manured with 448 kg of super-

phosphate per hectare. On very poor soils nitrogenous fertilizers also may be needed.

Utilization. Bur clover is used mostly as a pasture legume. The hay is rather rough and is seldom used. Cattle do not relish bur clover at first, but they soon acquire a taste for it. Like all protein-rich legumes, bur clover is also liable to cause bloat and so it is better to let in cattle for grazing only a few hours each day on bur clover pastures. For permanent pastures, a combination of *Cynodon dactylon* (*hariali* grass) and bur clover will be very satisfactory, because the *hariali* furnishes pasturage during the warm months and bur clover provides pasturage during the winter and spring months. Under favourable conditions bur clover will form a dense cover on the land 0·5–0·6 metres high to yield about 50–75 quintals of hay per hectare and nearly three times that weight of green forage.

For Indian conditions, Toothed Bur clover, (*Medicago hispida*) can be grown as a winter legume and cover crop to prevent soil erosion and add organic matter and fertility to the soil. It has yielded 246 quintals of forage in six cuttings under Delhi conditions. The forage is also available all through the year, except from July to September. In rice-growing areas this species can provide herbage after the harvest of paddy. If a productive strain is available for rain-fed conditions, bur clover will be very helpful in solving the legume problem in the sub-humid regions of India, with 50–100 cm of rainfall.

TABLE 14. ANALYSIS OF MEDICAGO HISPIDA

Chemical composition (On dry basis)	(Pre-flowering stage)
	%
Crude protein	18·0
Crude fibre	27·0
Ash	13·3
Calcium	1·32
Phosphorus	0·37

(I.A.R.I. Rept., 1963.)

Black Medic (*Medicago lupulina*) (Yellow Trefoil)

This species is a winter annual (or biennial) grown in many southern States of the U.S.A. as a winter legume in association with grasses. The plant is a low herb 8–40 cm in height, with small procumbent stems that

become ascending in thick stands. The leaves are hairy, 1–2 cm long and the midrib is prolonged into a minute tip or point. Flowers are yellow. The kidney-shaped pods turn black when ripe, giving the popular name of black medic. In India, this legume is found as a cold season weed in many of the Northern States.

Climate and Soils. Black medic can be grown with success on most types of soils, except on acidic soils, in sub-tropical and temperate regions. Varieties show great variation in climatic adaptations; while some can withstand cold, others can tolerate high temperatures.

Cultural Practices. A fine, firm seed-bed is essential for this legume, as the seeds are very small. Sowing may be done in the autumn months of September-October or in February-March. The seed is broadcast in autumn sowings and usually drilled in lines in the case of spring sowings. Drilling is preferable as it ensures a more even stand. The seed should not be sown more than 1·25 cm deep. A light harrowing is given when the seed is sown broadcast. The seed rate for a pure crop is 8–17 kg per hectare. Scarification of the seed is necessary to ensure good germination. The crop responds well to fertilizers and if sown in mixture with grasses, 168 kg of nitrogen and 34 kg of phosphorus per hectare may be applied in suitable forms, to ensure a good stand.

Utilization. Black medic is usually utilized only for grazing, either pure or in association with pasture grasses, or for soil improvement and is seldom cut for hay. It can propagate itself by self-seeding and can furnish grazing for two or three seasons without re-seeding. When sown in September-October, it furnishes grazing from February till May. The yield from a pure stand may be about 200–225 quintals of green herbage or 50–75 quintals of hay per hectare. Black medic plants can remain green much longer than most other winter annuals and in the Punjab they are often collected for feeding milch animals, as they are supposed to improve the colour and flavour of butter.

CHAPTER 7

CROTALARIA JUNCEA LINN.

Genus *Crotalaria* Linn. (Leguminosae)

A very large genus of over 450 species, including annuals, perennials, herbs and shrubs distributed all over the tropical and sub-tropical regions of the world. The plants are erect, leafy with much-branched, coarse stems and simple or digitate leaves. Flowers are large and showy, usually yellow; standard larger than wing petals, keel beaked and curved; stamens 10, connate; style strongly curved; fruit an inflated pod, not septate, seeds many, loose at maturity. The name is derived from Greek *Crotala*—a rattle. About 80 species occur in India, of which *C. juncea* is the commonest. A few other species have also been tried for green manure and fibre. Some species have possibilities of being useful as fodder crops and some are medicinal.

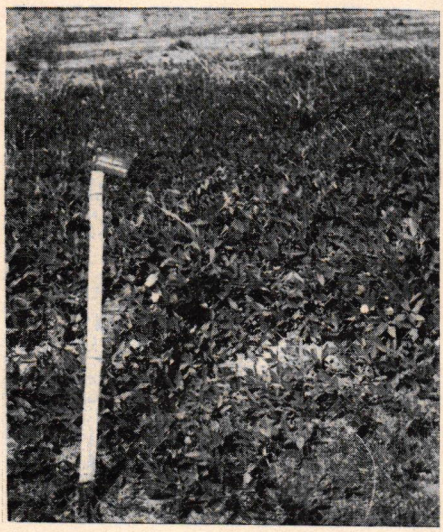
Crotalaria juncea Linn. (Sunnhemp, Sannhemp, Bombay hemp; Sanskrit—Saha; Hindi—Sunn; Bengali—Shonpat; Marathi—Tag; Tamil—Sanappu, Sanal; Telugu—Janumu; Kan.—Sanabu; Mal.—Vakku naar.)

Description. An erect shrubby annual, 1·2 to 3·0 metres in height, with simple, narrow, sub-sessile leaves and bright yellow flowers. The pods are inflated, tough-skinned and contain 5–10 flattened seeds. The plant is probably indigenous to India and is the most widely grown fibre crop in India, ranking next only to jute in importance.

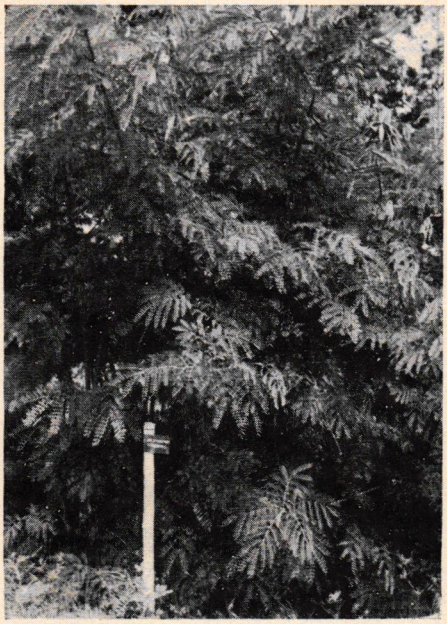
Sunnhemp is grown both as a green manure and a forage crop. It can grow on a wide variety of soils, but thrives best on light, well-drained loams. Heavy clays and water-logged or saline soils are detrimental to this crop. In South India it is grown mainly as a green manure crop, but it is also an excellent fodder, either green or dry. In the Krishna district (Andhra Pradesh) it is converted into hay and stacked in alternate layers with paddy straw to make a good, well-balanced cattle fodder.

Cultural Practices. Sunnhemp is usually sown as a *kharif* crop in June and harvested by October, although in certain parts of Maharashtra and Bengal it is often grown as a *rabi* crop, sown in October and harvested by February–March. In Madras, Andhra Pradesh and Mysore, it is grown both in the *kharif* and *rabi* seasons, the actual time of sowing varying according to local conditions.

The field is ploughed two or three times in April, soon after the summer showers and harrowed to get a good tilth. Generally no manuring is done, but a dressing of 112 to 168 kg/ha of superphosphate may be given before sowing, if the crop is intended as a green manure for the subsequent paddy crop. Seeds are usually sown broadcast and only occasionally drilled. A seed-rate of 90 kg/ha is usually for green manure, but in



Arachis marginata
A wild relative of groundnut (*Arachis hypogaea*). This spreading plant is a promising forage crop.



Desmanthes virgatus Wild.
An introduced American undershrub which can be utilized as fodder and green manure

Medicago sativa L. (Lucerne)
This is one of the best and most popular of forage legumes.

Crotalaria juncea L. (Sunnhemp)
An excellent legume, both for fodder and green manure.
(*Courtesy*: Director of Agriculture, Madras)

Cajanus cajan Spreng. (Redgram)
The leaves and shoots of this pulse crop make a good fodder.

Cyamopsis psoraloides DC. (Cluster bean)
This is grown for fodder in the Punjab and Uttar Pradesh.

Madras it may be as low as 28 kg/ha, even for green manure or fodder. As a rule, sunnhemp is not irrigated nor is any interculturing done. Being hardy, quick-growing and fairly drought-resistant, sunnhemp makes an excellent green manure and smothers all other weeds, including even stubborn species like *Saccharum spontaneum*.

The yield is about 201 q/ha of green material which under favourable conditions may go up to 336 q/ha, and supplies 67 to 112 kg of nitrogen to the soil per hectare besides substantial quantities of phosphate and potash. The yield of seed is about 448 to 672 kg per hectare.

In certain localities, as for example, in the Circars region, seed production is somewhat of a problem in sunnhemp. This is surmounted by sowing sunnhemp seeds on field-bunds and nipping off the top shoots just before the flower-buds are due to appear. Fresh buds are thereby induced to develop on the leaf axils in greater profusion and a good seed crop is secured without difficulty.

Sunnhemp can also serve as a nutritious forage, either green or as hay. The foliage and stems are non-poisonous but sometimes the seeds and pods are reported to have toxic effects and hence it is safer to remove them before feeding to cattle.

TABLE 15 ANALYSIS OF SUNNHEMP

Chemical Composition	Sunnhemp Hay	Seeds
	%	%
Moisture	64·4	8·6
Protein (Crude protein)	11·3	34·6
Ether extract	1·1	4·3
N-free extract	38·9	41·1
Crude fibre	27·4	8·1
Ash	6·4	3·3

Pests and Diseases. Among the pests of sunnhemp are the sunnhemp moth, *Utethesia pulchella* L., the caterpillars of which feed on the leaves and pods and the stem-borer, *Lespeyresia pseudonectis*. M., which bores into the top shoots of the plant.

Wilt caused by *Fusarium udun* Butler var. *crotalaria*, an anthracnose disease caused by *Colletotrichum curvatum* Bryant and Martin, are the two common and serious diseases. Wilt affects both young and old plants, causing them to dry up. Anthracnose causes considerable damage to seedlings; it can be controlled by earlier sowings and by disinfecting the seeds before sowing them or by spraying the seedlings with Bordeaux mixture or Burgundy mixture. Attempts have been made to evolve sunnhemp strains resistant to these diseases.

Other species of *Crotalaria* useful for fodder

Crotalaria alata Buch-Ham. A sub-erect under-shrub, about 60 cm in height, found in the Northern Circars (Andhra Pradesh), Assam and Kumaon Hills up to 1,525 metres. It stands cutting well and does not become woody until very late in growth. Seed production is also profuse and it can grow well under shade, but it is liable to heavy insect damage. It has been tried as a fodder crop in Sumatra, but in Queensland (Australia) it is reported to be poisonous to livestock.

C. anagyroides HB & K. This species is a native of South America which has been introduced into Malaya, Java, Ceylon and India as a green manure and cover crop in tea and coffee estates. The plant grows rapidly up to 4·2 metres in height and is also able to stand repeated prunings, yielding large quantities of green, leafy material which decomposes readily, with a high manurial value. Since it is not toxic to livestock and is also well relished by cattle it has good possibilities as a forage plant.

Crotalaria Burhi Buch-Ham. A low, slender under-shrub, common in the more arid parts of Punjab, Rajasthan and Gujarat up to 1,220 metres elevations. It is esteemed in Rajasthan as a fodder for camels.

C. medicaginea Lam. A useful perennial common all over India. Used in medicine in the Punjab under the name *gulabi*. A variety of this species, var. *luxuriana;* is common in Western Uttar Pradesh and is considered good camel fodder.

CLUSTER BEANS

(*Cyamopsis tetragonaloba* L. Taub.)

Genus *Cyamopsis* DC. (Leguminosae)

A small genus of four species of erect, tropical annuals found in Asia and Africa. Erect herbs with laterally attached hairs. Leaves pinnately 3-foliate, leaflets toothed. Flowers small, purplish, in axillary racemes, bracts caducous. Sepals connate, petals caducous; stamens monadelphous in a tubular sheath. Ovary sessile, many-ovuled, style incurved at tip, stigma capitate. Pod linear, sub-quadrangular, septate within. Seeds square, compressed.

Cyamopsis tetragonaloba Taub. (Syn. *C. psoraloides* DC; Sanskrit—Gorani, Goraksha phalini; Hindi—Guar, Guara; Tamil—Koth Avarai; Telugu—Gor Chikudu; Kannada—Gorikaya; Malayalam—Kothavara).

Origin, History and Distribution. Guar is probably indigenous to India and has been in cultivation since ancient times in most parts of the country as a vegetable. It is occasionally found growing wild also.

Description. The plant is a robust, erect annual, 91 to 182 cm high, with rather large leaflets and axillary clusters of thick, fleshy beaked

pods, 2·5 to 13 cm long, containing 5–12 seeds inside. It resembles cowpea in its wide adaptability to different soils and seasons. Its growing season is determined in North India by the length of frost-free period available and in other parts of the country by the rainfall and irrigation facilities available.

Climate and Soils. Guar grows well on medium to light types of soils, but cannot withstand water-logging or excessive moisture. Being quite drought-resistant, it is cultivated in the semi-arid " Bharani " areas of the Punjab, where rainfall is scanty and uncertain and is, in fact, the main dependable *kharif* fodder legume in this State and occupies nearly five lakhs of acres. As a green manure, *guar* can be grown in arid areas to restore the fertility of poor and depleted soils. It is even suggested that *guar* be introduced into pasture areas where there are adequate stands of grasses, as it needs very little care after sowing.

Cultural Practices. For a summer crop of guar, which follows a winter crop of cereal or vegetable, two or three ploughings are given after a preliminary irrigation and the field is brought to a fine tilth. Seeds are usually sown broadcast if the crop is intended for fodder or green manure, but are drilled 5 to 8 cm apart in furrows 45 cm apart, for a vegetable crop or seed. The furrows are best laid east to west, to ensure proper aeration of the plants, which is necessary for maximum flowering and pod development. The seed-rate varies from 11 to 39 kg per hectare, according to whether the crop is intended for seed, fodder or green manure.

Sowings are usually done in March for the summer crop in North India and in May–June or July for the rain-fed monsoon crop. The harvests are made in June–July from the summer crop and in September from the rain-fed crop, but in peninsular India, the sowings may get prolonged till September and the harvest till the next February.

Manuring. When guar is being grown on poor soils or after an exhausting crop like sugarcane, it is desirable to apply 75 to 125 quintals/ha, of farmyard manure plus 112 kg/ha of ammonium sulphate to the field, after the initial ploughings and before sowing. Application of super-phosphate to supply 45 kg of phosphorus per hectare is also recommended to ensure good yields.

For a summer crop, irrigations should be given at fortnightly intervals in early summer and at ten-day intervals later on. Normally the crop would require 20 to 25 hectare/cm of water in the course of four or five irrigations. Weeding and hoeing should be done after each irrigation. The monsoon crop does not, as a rule, need any irrigation if rains are adequate and well-distributed. If the rains are too heavy, the excess water should be drained off promptly.

As a forage crop, *guara* is often grown mixed with jowar; this makes a well-balanced, nutritious and palatable feed for cattle.

Fruiting begins in two months from sowing and in some early varieties

it may begin within 45 days after sowing. For fodder and green manure, the crop can be cut as soon as the pods begin to develop. The yield of green material is about 112 quintals/ha, and if the crop is left for seed, 5·6 to 9·9 quintals of seed per hectare may be obtained from a rain-fed crop. Under irrigation, the outturns of both seed and forage may be nearly double. The young pods form a very popular vegetable.

Both the seeds and green plants serve as nutritious feed-stuffs for cattle. The seed is a cheaper substitute for gram (*Cicer arietinum*), used as a concentrate food for bullocks.

Varieties. The numerous varieties fall into two main types; the dwarf type being popular in Uttar Pradesh, Punjab and Rajasthan and the tall type in Gujarat. Among the varieties grown in the Punjab some are smooth and sparsely branched with profuse pods; the unripe pods are used as vegetable. Others are leafy types with small pods and stiff hairs all over the plant; these are used mainly for fodder or green manure. A number of improved high-yielding varieties have also been evolved in recent years from the Sirsa Fodder Research Station and the I.A.R.I., New Delhi. For example, Pusa Sadabahar and Sirsa No. 1 and No. 2 are tall, leafy branched types suitable for fodder, green manure and as vegetable, while Pusa Mausmi and Sirsa Nos. 3, 4 and 5 are varieties with large pods and smooth, unbranched stems that are more suitable as vegetable crops.

TABLE 16. ANALYSIS OF GUARA

	Green material		Hay		Silage (Guara + wheat bhusa)	
	Chemical Composition	Digestibility Co-efficients	Chemical Composition	Digestibility Co-efficients	Chemical Composition	Digestibility Co-efficients
	%	%	%	%	%	%
Moisture	80·8	...	9·3	...	69·5	...
Crude protein	3·1	77	16·5	76	2·3	45
Ether extract	0·4	39	1·3	16	0·7	44
Crude fibre	4·4	26	19·3	45	11·2	53
Ash	3·3	...	12·4	...	5·1	...
N-free extract	8·0	70	41·2	73	11·2	58
Calcium	0·61					
Phosphorus	0·07					
Potassium	0·49					
Digestible Crude Protein		2·4		12·4		1·0
Total Digestible Nutrients		12·0		51·6		14·1

(After Lander, 1949.)

In the Gujarat-Maharashtra region, three forms are current:

(i) Pardeshi — plants 152 to 183 cm tall, pods used as vegetable.

(ii) Sotia guar — plants 2·4 to 3 metres tall, grown as green manure and also for its pods.

(iii) Deshi — plants 1·23 to 1·52 metres tall, grown mostly for seed as a rain-fed crop.

Horsegram (*Dolichos biflorus* Linn.)

Genus *Dolichos* Linn. (Leguminosae)

A genus of 50 species of annual or perennial herbs or under-shrubs, widely distributed in the tropics of both hemispheres. Leaves pinnately trifoliolate; standard is auricled and the keel petal is narrow, bent inward and upward, with the wing petals adnate to the keel petal. Style is bearded; pods are flat, usually curved or beaked. Seeds are flattened or globose. Eight species occur in India.

Dolichos biflorus Linn.; Sanskrit—Kulaththa; Hindi—Kulthi; Tamil—Kollu; Telugu—Ulavalu; Kannada—Hurali; Malayalam—Muthira.)

Origin, History and Distribution. Along with lablab (*Dolichos lablab*) horsegram is one of the most widely grown legumes in India. The important horsegram areas are: Maharashtra, Gujarat, Andhra Pradesh, Mysore and Madras; in upper India it is cultivated in Madhya Pradesh, Himachal Pradesh and the foot-hills of Uttar Pradesh, Bengal and Assam Hills.

Description. *Dolichos biflorus* is a low, spreading sub-erect annual with trifoliate leaves. The flowers and pods are borne on the lower half of the plant and are partly concealed in the foliage. The pods are narrow, flat and curved, 2·5 to 5 cm long, topped by the persistent style, containing five to six seeds, flattened ellipsoid, four to five millimetres long. The crop is self-fertile. A large number of varieties are known, varying in seed colour, (brown to black or mottled) and in duration from three to four and a half months.

Climate and Soils. Horsegram can be grown on any type of soil except very alkaline types, but thrives best on sandy loams. The crop is highly useful, for it can come up on shallow, poor soils and low rainfall areas where other crops cannot grow. On heavy soils, however, it is inferior to *val* (*Dolichos lablab*) and *chavle* (*Vigna sinensis*). Horsegram is often the first crop to be sown on newly-reclaimed areas. It is grown extensively on light, red and stony soils of peninsular India. In tracts of high rainfall as on the Kerala coast it is sown after the rainy season is over. Black-seeded types of horsegram are shorter in duration and less

vigorous than other types, but are often grown when other crops cannot be grown for want of timely rains.

Cultural Practices. The time of sowing differs in different regions. In Madras it is sown in September-November, if for seed, and in April-May, if required for green manure. In Maharashtra horsegram is sown as a kharif crop, mixed with bajra or sometimes niger and also in the *rabi* season as a second crop in rice fields. In Madhya Pradesh it is a cold weather crop and further north it is grown either as a *kharif* crop or as a catch crop after the *rabi* season. In Bengal, the sowing period is October-November if for seed, but for fodder it is sown at different intervals from June to August and even up to November. Horsegram may even follow another *rabi* crop to furnish green fodder in the hot weather months with the least expenditure of water. Sowing trials at Coimbatore have shown that horsegram does not set seed if sown from January to April; the earlier the sowing the longer is the duration of the crop. The crop is thus obviously season-bound and behaves as a short-day plant, in the Coimbatore tract. For fodder purposes three crops of horsegram can be taken in a year with irrigation, i.e., sown in June, August and November and cut by August, September/October and January.

The seed-rate is 22·4 to 28 kg per hectare in North India and 28 to 34 kg/ha in South India. The land is ploughed once or twice and seeds are sown broadcast as a rule, although in Andhra Pradesh it is drilled in rows 30 cm apart. Most of the horsegram in Western India is grown mixed with bajra; at one row of horsegram to four rows of bajra. This gives a mixed fodder of very good feeding value. The crop soon covers the ground completely and no after-cultivation is needed. Nor is the crop ever manured, except when it figures in mixtures, when horsegram also gets the treatments given to the main crop.

If cut at flowering time, horsegram makes an excellent forage for all livestock and particularly for milch animals. About 89·6 quintals/ha, is an average yield of green forage. As the crop matures (in about 4½

TABLE 17. ANALYSIS OF HORSEGRAM

Chemical Composition	Seeds
	%
Moisture	8·8
Crude protein	18·2
Ether extract	0·8
Crude fibre	4·1
Ash	5·8
N-free extract	62·3

(After R. C. Wood, 1952)

months), the leaves dry up and get partially shed; the pods change colour from light-brown and begin to shrivel; at this stage the plants are either cut with sickles or just pulled out, slightly wilted in the field and threshed by cattle-treading or by stone rollers and the seed cleaned by winnowing. The average yield of seed is 168 to 336 kg/ha, but it can go up to 672 kg/ha, under favourable conditions.

Field Bean (*Dolichos lablab*)

Genus *Dolichos* (See under *Dolichos biflorus*)

The term ' beans ' includes a number of species of Leguminosae, such as:—

Asparagus bean	—	*Dolichos sesquipedalis* L.
Bengal bean	—	*Mucuna* (*Stizolobium*) species
Bonavist bean	—	*Dolichos lablab* var. *typicus* Prain
Broad bean	—	*Vicia faba* L.
Cluster bean	—	*Cyamopsis tetragonaloba* L.
French or Haricot bean	—	*Phaseolus vulgaris* L.
Jack bean, Kidney bean	—	*Canavalia ensiformis* DC.
Lima bean	—	*Phaseolus lunatus* L.
Soya bean, Soybean	—	*Glycine soya* Sieb et Zucc.
Sword bean	—	*Canavalia ensiformis* DC.
Yam bean	—	*Dolichos lablab* L.

Dolichos lablab Linn. A perennial twining herb of Asiatic origin, generally cultivated as an annual. A few varieties are bushy or semi-erect. Leaves are trifoliate. Flowers are white, purple or reddish, borne on axillary racemes, pods are flat or inflated, linear or broad, one to five inches long, incurved, with remnants of the persistent style. Seeds globose, ovate or flattened, varying in colour from white to black.

Two varieties are commonly grown in India, one a twining annual cultivated as a garden crop, the other a bushy perennial cultivated as a field crop. In the garden variety, the longer axis of the seed is parallel to the suture of the pod, while in the field variety it is at right angles to the suture. The two are named *Dolichos lablab* var. *lignosus* and *D. lablab* var. *typicus*.

Dolichos lablab var. **typicus** Prain. (Syn. Lablab bean, Bonavist bean, Hyacinth bean, Indian butter bean; Hindi—Sem; Tamil—Avarai; Telugu—Chikkudu)

A twining herb, cultivated as an annual all over the tropical and warm temperate regions of Asia, Africa and America. It is grown in India mostly as a garden crop, trained on ' pandals ' like grape-vines. A large number of varieties are known, differing in flower colour, size, shape and texture of pods and seeds. Pods may be white, yellowish, green or purple-margined. Seeds may be white, yellow, brownish-purple or black.

Cultural practices. Pits 91 × 91 cm are dug in May-June and kept well manured. The seeds are sown in August. When the vines grow up, pandals are put up for them to spread. Frequent and copious irrigations are necessary for good growth. Flowering commences by November and pods can be gathered from December up to April. The young pods are esteemed as a vegetable all over India. Favoured types are those that have a thick, fleshy skin with good flavour and practically no fibre. The pods and seeds are also used as a cattle feed. The vines can be used for feeding cattle.

TABLE 18. ANALYSIS OF LABLAB

	Chemical composition of pods
	%
Moisture	82·4
Crude protein	4·5
Ether extract	0·1
Crude fibre	2·0
Ash	1·0
N-free extract	10·0

Dolichos lablab var. **lignosus** Prain (Syn. Australian Pea, Field bean; Hindi—Ballar; Tamil—Mochal; Telugu—Anumulu; Kannada—Avare; Malayalam—Mochakotta)

Description. A bushy, semi-erect, perennial herb, showing no tendency to climb; it is widely cultivated as an annual on drylands in peninsular India, particularly in Madras and Mysore States. It is nearly always grown in mixture with *ragi* (Mysore) or sorghum (Salem, Coimbatore) or with castor or bajra (Andhra Pradesh and Maharashtra). It is also grown as a second crop in paddy lands in certain parts of Maharashtra. The plant has a peculiar buggy smell. It is quite hardy and drought-resistant, although cold weather depresses pollination and seed-setting. It cannot thrive in water-logged places.

Cultural Practices. In the Konkan region the land is ploughed after harvest of the previous rice crop and again cross-ploughed. During the third ploughing the seeds are dropped in the plough furrows. Scarification of seeds with sand prior to sowing gives quicker germination and a better stand. Seeds are sown in June-August, usually by drills in lines. The seed-rate varies from about 56 kg per hectare when it is a pure crop, to 5·6 to 16·8 kg when grown in mixtures, usually with jowar. The pods can be harvested both in the green and the ripe stages, from October up to the next March. When the plants are fully mature, they are cut close to the ground, dried for a day or two and threshed to separate the

seeds. The haulms and leaves of the harvested plants are used as cattle fodder. In mixtures with jowar, the harvesting is done when jowar is ready, without waiting for *Dolichos* to mature. The yield is about 14·6 quintals of seed and the same weight of haulms per hectare, but as green fodder up to 145·6 quintals has been recorded from a *kharif* crop in Bihar.

Pests and diseases. The most troublesome pest on this crop is *Coptosoma cribraria* F. (stinking bug). It swarms in large numbers on the stems and pods and so far no effective control is available. In Western India the chief enemy is the hairy caterpillar, *Amsacta lactinea*. The pods are also attacked by pod-boring grubs (*Adisura atkinsonii* Moore) and aphids. The pests can be controlled by locating the egg-masses and crushing them and by two or three sprays of bleaching powder (one pound in a gallon of water) on the new flushes of flowers and pods as they appear.

Among diseases, anthracnose, dieback, root-rot and rust, and a virus disease known as Dolichos enation mosaic, are important. Diseased leaves show a mosaic of chlorotic streaks, followed by reduction of leaf-size and foliar enations on the underside of malformed flowers.

Unlike the garden bean, the field bean is valued more for its green seeds than for pods. The pods and seeds are also used as cattle feed, in addition to the vines, which make an excellent fodder when fed along with sorghum straw.

TABLE 19. ANALYSIS OF FIELD BEAN

	Hay	
	Chemical Composition	Digestibility Co-efficient
	%	%
Moisture	9·8	
Crude protein	14·8	72
Ether extract	1·4	52
Crude fibre	33·6	55
Ash	6·8	—
N-free extract	33·6	65
Digestible Crude Protein		10·7
Total Digestible Nutrients		52·6

(After Lander, 1949)

Phaseolus trilobus Ait

Genus *Phaseolus* Ait. (L.; Leguminosae)

Mostly herbs, sub-erect or twining; leaves pinnately trifoliolate, stipules subulate, persistent; leaflets entire; flowers few, colours various, in axillary

racemes; bracts and bracteoles conspicuous. Corolla exserted, keel petals coiled into a spiral beak; stamens diadelphous, anthers uniform; ovary sessile, style is conspicuously bearded down the side below the oblique stigma; pods linear or falcate, seeds smooth, hilum punctate or shortly linear, strophiole absent.

Phaseolus trilobus Ait. (Tamil—Passi payaru; Telugu—Pilli pesara).

This is a popular legume of the deltaic districts of the Northern Circars, *viz.* Krishna and Godavari, which is very useful as a fodder and green manure. It is well relished by all livestock and comes up well on all types of soils, from sandy loams to heavy black soils. Although it is an annual of some four to five months' duration, it can also serve as a pasture legume by self-sown seeds, if care is taken to get it well established before it is grazed.

Cultural Practices. Two ploughings are given before sowing, and the seeds broadcast at 16·8 to 22·4 kg per hectare in July-August, when there is sufficient moisture in the soil. Although it is seldom irrigated, one or two irrigations will improve the growth very much. Two initial cuttings can be taken, to give 134 to 157 quintals of green forage per hectare and the crop can be ploughed in as green manure afterwards. In pasture areas, two to three ploughings are given and then the seeds are broadcast at 16·8 to 22·4 kg per hectare and lightly covered. Grazing should be rotational and allowed only after the pods have set seed in the first year.

In the Godavari deltaic area it is a common practice to sow pillipesara along with other legumes from June onwards on field bunds that are kept specially wide for the purpose and to cut the legume for fodder two months later. With staggered sowings on different bunds at monthly intervals, a continuous supply of green fodder can be secured up to next February or March. In the Ongole tract, (famous for the Ongole breed

TABLE 20. ANALYSIS OF PILLIPESARA

	Hay
	Chemical Composition
	%
Moisture	10·0
Crude protein	20·2
Ether extract	1·4
Crude fibre	22·1
Ash	13·4
N-free extract	32·9

(After Wood, 1952)

of cattle), pillipesara is a common legume on the drylands, giving an average outturn of 28 quintals of green forage per hectare. Another practice that is both convenient and successful is to grow a mixed crop of maize and pillipesara in wetlands from June to September and utilise them both as green forage and silage material.

Greengram (*Phaseolus aureus* Roxb.) (Syn. P. *radiatus*; Sanskrit—Mudgaha; Hindi—Mash, Mung; Tamil—Passi payaru, Patcha payaru, Siru payaru; Telugu—Pesalu; Kannada—Hesaru; Malayalam—Cheru payaru).

This plant is indigenous to India, but it is cultivated over a smaller area in India than its allied species, *Phaseolus mungo* (blackgram). Lighter soils are sown with greengram while the heavier clayey types of soils are utilised for blackgram. Greengram prefers rather humid conditions and does best in hilly areas. Both blackgram and greengram are grown over extensive areas in North India as well as peninsular India, except in regions of heavy rainfall. Numerous varieties are known but they can be grouped into two main types, black-or green-seeded. The black-seeded types are longer in duration and are preferred for mixtures with cereals on drylands. A yellowish-green variety imported from North India is also known in Madras. Sowings are done usually after two or three ploughings, using a seed-rate of 9 to 11 kg/ha. For growing as a pure crop, the seeds are sown broadcast in the standing crop of paddy in October-November after the north-east monsoon is over. If facilities are available, one or two irrigations will prove very useful. Phosphatic manures to supply 45 to 56 kg of phosphorus per hectare will also improve

TABLE 21. ANALYSIS OF MUNG

	Mung Hay	
	Chemical Composition	Digestible Nutrients
	%	%
Moisture	9·7	
Crude protein	9·8	
Ether extract	2·2	
Crude fibre	24·0	
Ash	7·7	
N-free extract	46·6	
Digestible Crude Protein		7·4
Total Digestible Nutrients		49·3

(After Lander, 1949)

outturns. No weeding or after-cultivation is done as a rule for this crop, but in mixtures, greengram shares the cultural operations given to the principal cereal crop. Flowering takes 60 days and pod-ripening 90 days from sowing; yielding 224 to 336 kg of seed and 560 to 896 kg of bhusa per hectare. The bhusa is excellent cattle feed.

Blackgram (*Phaseolus mungo* Roxb.; Sanskrit—Mahasha; Hindi—Urid; Tamil—Ulundu; Telugu—Minumulu; Kannada—Uddu; Malayalam—Uzhunnu).

Blackgram is a short, bushy, dark-green annual. The plant is smaller and more hairy all over than its close relative, greengram. It is more drought-resistant than greengram and is grown on stiffer and more clayey soils that retain moisture longer. The seed-rate varies from 13·4 to 22·4 kg/ha for a pure crop and from 9 to 13 kg/ha. in mixtures. Blackgram is grown in association with horsegram on drylands in October and harvested by February in the Circars region of Andhra Pradesh. In the Godavari district, blackgram, cowpea, sunnhemp and pillipesara are all sown together on field-bunds in wetlands from July onwards, to furnish periodical cuttings of green fodder up to next February-March. Rain at flowering time ruins the seed-setting. The yield of gram is about 224 to 336 kg and of bhusa about 172 kg per hectare. The seed is usually black, with a white hilum scar, but greenish-seeded varieties are also grown in some places.

Dewgram (*Phaseolus aconitifolius* Jacq.; Hindi—Moth; Tamil—Nari payaru; Telugu—Mutikalu).

This plant is similar in appearance to *Phaseolus trilobus* but the leaflets are lobed more deeply. It is the most drought-resistant among all the pulse crops and is grown extensively as a rain-fed crop in many parts of India, mostly on sandy or gravelly red soils. It is usually sown as a mixture with jowar, with a seed-rate of 2·2 to 4·5 kg per hectare and up to 17 kg if sown as a pure crop. The sowing time in South India is July for pure crops, and harvesting by October; in mixtures the sowing and harvest times will depend on the principal crops in the mixture. In irrigated areas *moth* can be grown as an early fodder crop in mixture with jowar or bajra. The yield is about 16·8 quintals of green material and 108 to 336 kg/ha of grain from pure crops. The green vines serve as an excellent fodder for milch cattle and the seeds may also be mixed with cottonseed and fed as a nutritious feed for livestock.

TABLE 22. ANALYSIS OF MOTH

	Green roughage		Hay		Seed	
	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients
	%	%	%	%	%	%
Moisture	75·0		10·0		8·6	
Crude protein	3·0		16·2	67	22·6	77
Ether extract	0·4		2·4	11	0·8	75
Crude fibre	7·7		16·0	52	—	—
Ash	3·9		14·0		4·2	
N-free extract	10·0		41·4	65	63·8	87
Calcium	0·90				0·32	
Phosphorus	0·16				0·70	
Potassium	0·95				1·00	
Digestible Crude Protein				10·9		17·4
Total Digestible Nutrients				46·7		72·3

(After Lander, 1949)

Phaseolus sublobatus (Tamil—Karum payaru ; Telugu—Karu pesara).

This species is similar to greengram (*P. aureus*) and often forms a mixture with irrigated *bajra*, sown in May and harvested by July and sometimes as a mixture with sorghum or redgram. It is usual to let in cattle after harvesting the *bajra* to graze on the legume and when the next flush comes up, to plough it in as green manure. The seeds are quite nutritious, but are used for human consumption only in times of food scarcity.

These various grams form the common catchcrops of India, grown on all types of soils as and when convenient or necessary. Since most of these crops are grown on soils of poor fertility, it is seldom that they figure as pure crops. The grain is used as a pulse crop for human consumption and the *bhusa*, *i.e.*, the residue of vines, empty pods and leaves, makes an excellent cattle-feed.

Kudzu vine (*Pueraria thunbergiana*)

Genus *Pueraria* DC.

This genus includes 15 species of shrubs and herbs, native to tropical East Asia and the Pacific Isles. Leaves pinnately trifoliate, leaflets large, three, rhomboid; stipules and stipels present; flowers purplish or blue in long axillary racemes; pods long, narrow, many-sided. Seeds orbicular, hilum long.

Pueraria thunbergiana (Syn. *P. hirsuta*) Kudzu vine, Puero.

Origin, History and Distribution. A native of the East Indies, this perennial vine has become very popular in the United States for forage and soil conservation; from there it was introduced into India in 1927. It is a coarse, quick-growing perennial trailer that spreads by rooting at the nodes even on the steepest slopes and gullies. A large number of branches may be given off, some as long as 9·1 m. It is thus very useful in erosion control and being also very resistant to drought, it is well suited as a cover crop on barren wastelands unfit for cultivation as in the Chambal and Jamuna tracts. Kudzu has recently become popular in Assam and is considered promising in many other areas. The vines remain green even in severe summer. Propagation is by vegetative cuttings or ' crowns ', as it is a shy seeder.

The tangled vines make harvesting difficult, but the forage is quite nutritious and livestock gain as much live-weight from kudzu as from any other kind of forage plant. The crop should not be cut more than twice in a season or grazed until it is well established. The grazing too, should be light and rotational. Kudzu makes good hay, as the leaves do not get shed easily and also good silage, but as the green material contains only about 75 per cent moisture it should be ensiled soon after cutting. The best silage is obtained by mixing kudzu with other grasses to secure a 60 per cent moisture level at the time of ensiling.

Seed production is sometimes scanty in this vine and so rooted cuttings or crowns are more useful for propagation. Kudzu vine has no serious pests or diseases, although occasionally a root nematode may cause some damage.

Pueraria javanica. This species is similar to kudzu and is well suited as a perennial cover crop in the heavy rainfall areas of the West coast and Assam. It can serve as a pasture legume which can also be used as a cut fodder.

TABLE 23. ANALYSIS OF TROPICAL KUDZU

	Chemical Composition (on dry weight basis)
	%
Crude protein	9·2
Ether extract	1·1
Crude fibre	42·3
Ash	7·1
N-free extract	40·3
Calcium	0·53
Phosphorus	0·39
Potassium	—

(After Sen and Ray, 1964)

Pueraria phaseoloides (Tropical kudzu). This is another species that can serve as a good cover crop in coconut plantations. It can also be grown in mixture with other grasses to serve as fodder. It is susceptible to frost damage, but new shoots are put forth in the following spring from the old root stocks. This vine is raised mainly from seeds and is well adapted to the warm humid regions of India.

Methi (*Trigonella foenum-graecum* L.)

Genus *Trigonella*

This is a small group of herbs, with trifoliate leaves, which is classified as a sub-genus of *Melilotus*, along with another sub-genus *Medicago*. It is distinguished by its short floral racemes and straight pods, in contrast to the long racemes and globose pods in *Melilotus* and spirally twisted pods in *Medicago*.

Trigonella foenum-graecum L. (English—Fenugreek; Hindi—Methi, Methra; Tamil—Vendiyam; Telugu—Mentulu; Kannada—Menthiya; Malayalam—Uluva)

Origin, History and Distribution. This is a herbaceous annual indigenous to Asia, (probably India) which has been cultivated since ancient times as a pot-herb and condiment with medicinal qualities. It is also grown for fodder in many parts of India, in Egypt and adjoining countries on the Mediterranean coast.

Climate and Soils. Methi can be grown in all the climatic regions of India except the northernmost. It thrives best on well-drained, medium black soils, overlying a calcareous sub-soil of 'murum'. On lighter and poorer soils it requires the aid of irrigations, and the forage too becomes less succulent. On ill-drained soils the crop fails to tiller properly, which is essential for good yields and it is also liable to aphis attack.

Cultural practices. Methi is grown both as a rain-fed and an irrigated crop. Under irrigation the crop is naturally heavier than a rain-fed one, and even in the irrigated crops, the crop grown under well irrigation is taller and heavier than a canal-irrigated crop. Under well irrigation, methi usually follows bajra and the land remains sufficiently friable to sow methi without any further tillage or manuring. Farmyard manure (201 to 250 quintals/ha) is applied to the previous bajra crop and methi itself is sown without any cultivation or manure. Under canal-irrigation, methi follows paddy or groundnut. Here the field is ploughed twice and the seed is sown broadcast, after which the field is levelled, beds formed and immediately watered. No manuring is done, beyond the residual effect of sunnhemp applied to the previous crop. The seed-rate is 22 kg/ha for the canal crop and 34 to 39 kg/ha for the well-irrigated crop. The season for a well-irrigated crop is from

October till the end of November. Here, too, beds are formed 12·2 × 1·8 metres and the seed is broadcast at 34 to 39 kg/ha covered by a light harrowing and watered immediately. The second watering follows in a fortnight's time and the third one three weeks later. Thereafter irrigations are given at fortnightly intervals. For a fodder crop about six irrigations will be needed; if it is to be kept on for seed, two more irrigations may be required.

The nodule bacteria in methi happens to be the same as in lucerne root-nodules and hence no special inoculation of the soil or seed will be needed if methi is sown in a field previously grown with lucerne.

Rotations and Mixtures. As a garden-land crop, methi follows bajra and is followed by onions or sugarcane. Under canal-irrigation, methi follows rice or groundnut and is succeeded by sugarcane. In Egypt, methi is often grown in mixture with berseem or vetches.

Utilization. Methi is used as a pot herb or leafy vegetable when the seedlings are in the two-leaf stage of growth. It can be cut and fed green to all livestock. The first cutting can be taken in two months and continued for three or four more weeks, according to the requirements of farm animals. As a seed crop the harvest is done after 3 to 3½ months; the plants being uprooted and not cut as in other pulse crops. In Nasik and Khandesh in Maharashtra, farmers use methi fodder as the mainstay for their work cattle during the hot summer months. An acre of methi can feed seven or eight bullocks for three to four weeks. Unlike other pulses, methi is used only as green forage and hardly ever made into hay or silage. It is also useful as a green manure for sugarcane and onions.

The yield of green material would be about 89·5 quintals per hectare from a canal-irrigated crop, and about 25 per cent more from a well-

TABLE 24. ANALYSIS OF METHI

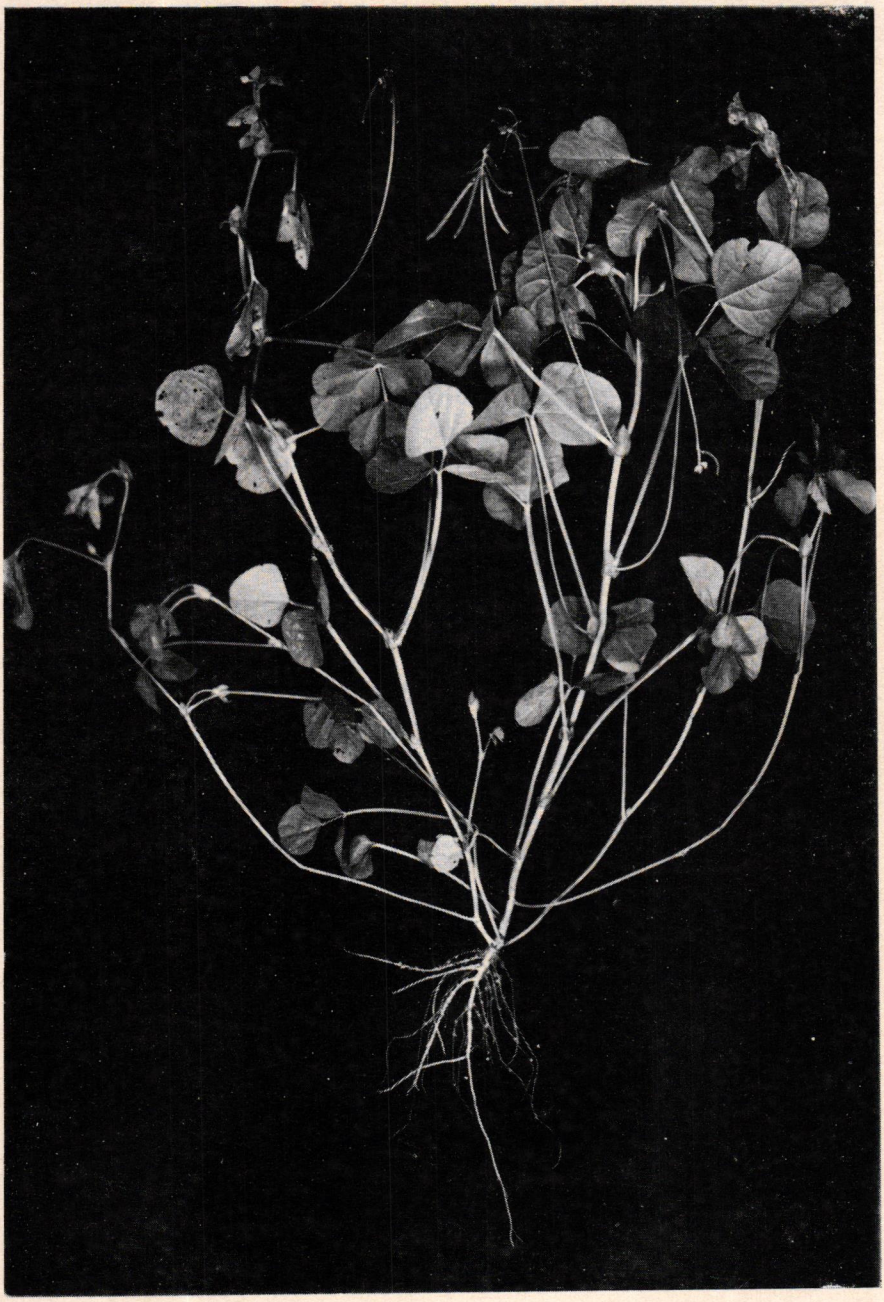
	Chemical composition
	Green material (Flowering stage)
	%
Moisture	77·3
Crude protein	3·6
Ether extract	0·5
Crude fibre	7·1
Ash	2·0
N-free extract	9·5
Calcium	0·47
Phosphorus	0·12
Potassium	0·63

(After Lander, 1949)

Glycine javanica (Soybean)

PLATE VI

Dolichos lablab L. (Field bean)
An excellent legume for growing as a mixture with sorghum, especially on drylands.



Phaseolus trilobus Ait.
(*Courtesy*: Director of Agriculture, Madras).

PLATE VIII

Brachiario mutica Stapf. (Water-grass)
A coarse, leafy grass, well-suited for damp areas.
(*Courtesy*: Director of Agriculture, Madras).

irrigated crop. The record yield in this crop is about 168 quintals per hectare, reported from California.

Pests and Diseases. The only serious pest in methi is aphis, which is apt to be severe in March-April in the case of a late-sown crop. Earlier sowings, in October-November, are free from aphid infestation.

VETCHES, PEAS and LENTILS

Vetches (*Vicia* species)

Genus *Vicia*

The genus includes nearly 150 species widely distributed all over the world in temperate and sub-tropical regions. They are annual or perennial herbs, with imparipinnate leaves and many leaflets, the rachis ending in a twisted tendril. Stipules are semi-sagittate, stipels 0. Flowers are in sub-sessile or short peduncled axillary racemes; bracts small, caducous, calyx tube campanulate, teeth unequal; corolla more or less exserted, stamens diadelphous. Ovary 2 to many ovuled. Style cylindrical, inflexed, with a dorsal tuft or ring of hairs just below the base of the stigma; stigma capitate, pod compressed, continuous within. Seeds globose or compressed.

In the closely related genus of *Lathyrus*, the tuft of hairs on the style extends over a greater length of the style. In the genus *Pisum* the stems and leaves are more soft and succulent than either *Vicia* or *Lathyrus* and the style is flattened and grooved above.

Origin, History and Distribution. Vetches are indigenous to Asia and Europe and the common vetch (*V. sativa*) finds mention in the Bible as " Tare ". They have been cultivated from very ancient times in the Old World and were introduced into America about two hundred years ago and are now very popular as winter legumes grown for soil improvement or for hay in mixtures with oats, wheat, barley or rye. In India too, vetches are grown as a winter annual, mixed with oats, in some of the States in Northern India, where the winter temperatures are sufficiently low to suit this crop. A number of varieties have recently been introduced for trials in India, from the U.S.A., Russia and Australia. They do not thrive in Peninsular India, except in isolated areas on the hills, as at Mahabaleswar or the Nilgiris. All the vetches are palatable to livestock, but for permanent pastures only varieties with hard seeds and good seeding habit are suitable.

The main cultivated species are as below:

Common Vetch	(*Vicia sativa*)
Hairy Vetch	(*V. villosa*)
Narrow-leaved Vetch	(*V. angustifolia*)
Purple Vetch	(*V. atropurpurea, V. grandiflora*)
Black Bitter Vetch	(*V. ervilia*)

Scarlet Vetch	(*V. fulgens*)
Narbonne Vetch	(*V. narbonnensis*)
Smooth Vetch	(*V. glabrescens*)
Woolly-podded Vetch	(*V. dasycarpa*)
Broad Bean	(*V. faba*)
Indian Vetch	(*Lathyrus sativus*)

Vicia faba, though belonging to the same genus as other vetches, does not go by the name of vetch, but is known as Broad-bean, Horse-bean or Windsor-bean. It is erect in habit and not viny like the other species of *Vicia*. *Vicia ervilia* does not have tendrils at the leaftips. It is not eaten by livestock and is grown mainly for green manure or soil conservation. The species *Vicia hirsuta*, known in Hindi as *chatari matari* is often found growing as a weed in cultivated fields in India. The seeds of this species can lie dormant in soils for long periods and germinate when conditions are favourable, usually by October-November. This species has fodder possibilities, as it is both palatable and nutritious to cattle. Indian Vetch belongs to another genus altogether, *Lathyrus sativus*.

Climate and Soils. Vetches thrive best in cool temperatures and are, therefore, grown only in temperate and sub-tropical regions of the world. The different species are very variable in regard to winter hardiness and are accordingly chosen to suit different climatic zones. In the northern States of the U.S.A. where the winters are fairly severe, vetches start growth in early spring months and mature by late summer or early autumn, but in the southern States, where the winters are milder, vetches make their growth in the winter and early spring months and mature by late spring or early summer. Vetches prefer well-drained soils and cannot thrive on ill-drained. They grow best on loams or sandy loams that are well supplied with lime, although they can be grown even on gravelly soils. On such poor lands they are grown mainly as a soil improver, but then they needs proper inoculation with the bacterial nodule culture to ensure good growth. It is best to mix the bacterial culture with the seeds before they are sown; carting soil from old vetch fields is apt to be uncertain and also costlier. On poor lands hairy vetch and smooth vetch are the most suitable species.

Cultural Practices. Vetches need a firm seed-bed and where they are sown in mixtures with oats, the land is prepared as for oats, giving three or four ploughings and manuring with cattle manure at 201 to 251 quintals/ha, after the second ploughing and turning it in by the subsequent ploughings. The sowing time is October-November. The seed-rate will vary according to whether it is sown as a pure crop or as a mixture with other cereals and also according to the variety of vetch grown. About 22 to 34 kg per hectare is the normal seed-rate for a pure crop of Hairy Vetch or Smooth Vetch, but for Common Vetch it will be 45 to 56 kg per hectare. Vetches are usually sown pure when intended as a green

manure and in mixtures if it is for a hay crop. Sowing in lines, by drills, is recommended, especially when mixed with oats in the proportion of three lines of oats to one of vetch. In such cases the seed-rate for vetch will be correspondingly lower. The proportion of cereal to vetch should be higher when the mixed hay is for feeding horses, than when it is intended for cattle or sheep.

Vetches make a better combination with oats than with other rabi cereals like wheat or barley, because it is easier to separate oat grains from vetch seeds than wheat or barley grains. Irrigations will be necessary at fortnightly intervals or oftener, according to the soil and weather conditions prevailing.

Utilisation. Vetches can be utilised either as green fodder or converted into hay or silage without much difficulty. For hay, it should be cut at full bloom, when the first pods are well developed, but for silage it may be done a little later. The feeding value of vetch hay is quite as good as clover or other legume hays, but the main difficulty is to retain the bright green colour in the cured hay. For permanent pastures, the variety chosen should have early maturity, profuse seeding and a long flowering period, along with hard seeds, to ensure self-seeding in the subsequent years. Common vetch seeds can lie dormant in the soil even up to five years. The yields are apt to vary considerably, but about 90 to 112 quintals of green fodder may be expected from an acre and about one-third of it as hay.

TABLE 25. ANALYSIS OF VETCH

	Green roughage		Silage	
	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients
	%	%	%	%
Moisture	79·6		69·9	
Crude protein	3·8	72	3·5	56
Ether extract	0·5	59	1·0	70
Crude fibre	5·5	44	9·8	63
Ash	2·1	—	2·4	—
N-free extract	8·5	76	13·4	67
Calcium	0·49		—	
Phosphorus	0·20		—	
Potassium	0·53		—	
Digestible Crude Protein		2·7		2·0
Total Digestible Nutrients		12·2		18·8

(After Lander, 1949)

Pests and Diseases. The Vetch Bruchid, (*Bruchus brachialis*) has been known for a long time in Asia and Europe and has since been introduced into America as well. It infests the seed and reduces seed-production very much, especially in Hairy Vetch.

Anthracnose caused by *Glomerella cingulata*, is very destructive to vetches. It is aggravated by conditions of high moisture and temperature. False anthracnose is another disease, caused by the fungus *Kabatiella caulivora*. Leaf Spot, caused by *Botrytis cinerea* and mosaic caused by several viruses, are some of the other diseases affecting vetches.

Peas (*Pisum sativum*)

Pisum and *Lathyrus* are two genera closely allied to the genus *Vicia*. In *Pisum* the stems and leaves are softer and more succulent than in either *Vicia* or *Lathyrus*. The style in *Pisum* is flattened and grooved above, whereas in *Vicia* the style is cylindrical and has a ring or tuft of hairs surrounding the style just below the base of the stigma and in *Lathyrus* the tuft of hairs on the style extends over a greater length. *Pisum sativum* is the common pea, the field pea being known as *Pisum arvense* or *P. sativum* var. *arvense*.

Peas can furnish very valuable forage and also grow well in mixtures with other crops and particularly with oats, so that peas and oats have been one of the standard mixtures for green fodder around dairy farms and cantonments, especially in north India. Peas and oats are both rabi crops and peas are believed to improve the growth of oats. The combined fodder makes a very well-balanced nutritious and palatable feed for all classes of livestock.

Origin, History and Distribution. Peas, like vetches and lentils, have been in cultivation from very early times in Europe and South-West Asia. The crop was introduced into America about two hundred years ago. In India, peas are grown in the northern States as a winter or rabi crop, usually in conjunction with oats or sometimes with wheat.

Climate and Soils. Well-manured, deep and moist soils are the best for peas. The plants grow best during the winter months in India.

Cultural Practices. Three or four ploughings will be necessary to bring the soil into the proper tilth to sow peas. The land should be well-manured with cattle manure at 201 to 251 quintals per hectare and also superphosphate to supply 45 kg/ha of phosphorus, as it responds very well to phosphates. Before sowing the seed the land should be irrigated once and after the land gets into condition, the seed is sown either broadcast or drilled in lines. If sown mixed with oats, then the pea rows will be one to every three rows of oats. The seed-rate for a pure crop is 56 to 67 kg per hectare and for a mixed crop 22 kg of peas to 67 to 90 kg of oats, according to the proportion of peas desired in the mixed forage.

The sowing should not be done too early, at least not before the end of September, but can be continued in October and till the end of November. Irrigations will be needed at ten-day intervals after the crop begins to grow, in heavy soils and at shorter intervals in lighter red soils. About 20 to 25 hectare-cm of water will be needed for the duration of the crop.

The crop can be cut for fodder in 75 days from sowing, when the oats are in the milk stage and peas are just forming pods. For feeding green as cut fodder to milch animals, it can be cut in instalments or plots can be sown at suitable intervals from October to December, to extend the forage harvest over a longer period. The yields are rather variable, but 134 to 224 quintals of green fodder may be expected from a hectare of well-manured crop. The early cuts are apt to be rather watery and so for hay or silage only the later cuts are utilised. Pea forage has a very good influence upon the quality of the milk.

Pests and Diseases. The pea aphid, (*Illinoia pisi*) is a pale green insect about an eighth of an inch long when fully grown, which sucks the sap and reduces the vigour and yield of the crop. The pea moth, (*Lespeyresia nigricana*) is another widespread pest on field pea at flowering time. It can be avoided by earlier sowings. When the produce is threshed the rubbish that is left should be burnt. The pea weevil (*Bruchus pisorum*), infests pea wherever it is grown and causes the greatest damage when the crop is left to mature till seed-setting. In a fodder crop the damage may be less serious.

Among the diseases, the following are important:

Root Knot	caused by	*Aphanomyces enteiches*
Leaf Spot	,, ,,	*Ascochyta pinodella*
Black Stem	,, ,,	*Mycosphaerella pinodes*
Leaf Blotch	,, ,,	*Septoria pisi*
Powdery Mildew	,, ,,	*Erysiphe polygoni* and

Mosaic diseases, caused by several viruses.

Indian Vetch (*Lathyrus sativus* L.)

Hindi—Kesari; Chikling Vetch

This is one of the winter legumes which may be grown as rabi crops in north India if sufficient irrigation facilities are available. Indian vetch is sometimes grown as a green fodder for cattle in the Punjab and in West Pakistan. Even the dry plants are considered as good cattle fodder in this crop. In parts of Bengal, it is sown among the transplanted rice plants soon after the rains, when the land is still sufficiently moist. The *Lathyrus* plants grow up after the rice is harvested and cattle are allowed to graze on the vetch plants. It is also usual to sow Indian vetch soon after the rains on river-banks and new silt-lands formed by the annual

TABLE 26. ANALYSIS OF FIELD PEA

	Green roughage (milk stage)		Silage		Hay		Straw	
	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestibility Co-efficients	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients
	%	%	%	%	%	%	%	%
Moisture	83·4		72·1		10·8		9·8	
Crude protein	3·6	81	3·8	—	14·9	78	6·1	53
Ether extract	0·5	54	1·2	—	3·2	50	1·6	56
Crude fibre	4·0	49	7·8	—	24·5	51	33·1	53
Ash	1·6	—	2·6	—	7·7	—	5·4	—
N-free extract	6·9	74	12·5	—	38·9	79	44·0	66
Calcium	0·39		—		1·90		2·21	
Phosphorus	0·14		—		0·50		0·23	
Potassium	0·34		—		1·24		1·30	
				Percentage Digestible Nutrients				
Digestible Crude Protein		2·9		2·9		11·6		3·2
Total Digestible Nutrients		10·6		18·0		56·9		51·8

(After Lander, 1949)

flood deposits of rivers. The crop is first allowed to be grazed and then left to ripen the seed.

Lathyrus aphaca L. This species is a cold-season weed of cultivated lands in north India. It is also found as an escape from cultivation, on the Nilgiris. The plants are often used as cattle fodder.

Lathyrus hirsutus (Rough Pea, Wild Winter Pea, Caley Pea, Singletary Pea), is a native of south-east Europe, which was introduced into the U.S.A. along with other vetches and peas. It is now grown in some States for pasture, hay and soil improvement, but it is less productive than peas or vetches. Its main advantage is that it is less exacting in its lime and soil requirements than peas, although it is also quite responsive to good soils and adequate phosphate manuring. Inoculation with its bacterial nodule culture is necessary when the crop is grown for the first time in a field. About 112 quintals of green fodder may be expected from a hectare. Some toxic effects have been reported when cattle were fed with rough pea fodder and hence the forage, green or hay, should be fed with caution, especially when it contains mature seeds.

Lentils (*Lens esculenta* Moench.)

Hindi—*Masur*)

Lentils are grown in north India as a rabi legume, sown as the first crop on newly formed alluvial lands reclaimed from river banks. The crop is usually grown as a rain-fed crop under 'Bharani' conditions, but sometimes a supplemental irrigation may be required. The seed-rate is about 28 to 39 kg/ha. The plants are often used as cattle fodder, both in the green and dry state, but it is generally considered to be rather a 'heating' feedstuff.

Cowpea (Vigna sinensis)

Genus *Vigna* Savi. (Leguminosae)

This genus includes about 60 species, mostly tropical in distribution of herbs, twining or trailing. Some species are grown for food and forage. It is distinguished from *Phaseolus* by the flowers falling off soon and by the keel petal being curved inwards, whereas it is coiled in *Phaseolus*. Bracts are caducous and cushiony, nectaries are present between the flowers. The pods are often very long. Seeds are small and of various colours, but not flat.

Vigna sinensis (Cowpea, Cherry bean, Blackeye pea (Syn. *V. catjang*, *V. unguiculata* (L) Walp.; Sanskrit—Borbataha; Hindi—Barbati, Lobia, Alsande, Chavli; Tamil—Karamani, Thatta Payaru; Telugu—Bobbarelu, Alasandulu; Kannada—Avadai; Malayalam—Kottapayaru, Mannpayaru).

Cowpea is considered as native to Central Africa, though it is claimed to be indigenous to India as well. It has been cultivated from very early

times for human consumption in the Mediterranean region by the Greeks, Romans and Spaniards.

Cowpea varieties are numerous; differing in habit from erect to prostrate, with pods inflated and nearly 91 cm long, (the Asparagus type, esteemed as a vegetable) or with small erect pods and small seeds, (the Catjang type) or the cowpea type, with pendent, medium-sized pods. The trifoliate leaves are similar to those of the garden bean (*Dolichos lablab* var. *typicus*), but vary in size from very small to very large and persist on the vines even when the pods are ripe, flowers are white or violet-fringed. Seeds are variable in size, shape and colour.

Climate and Soils. Cowpea can grow in all tropical and sub-tropical climates and on a wide range of soils, but moist medium loams with a *p*H range of 5·0 to 6·5 are the best for this crop. It can also be grown on sandy soils and heavy soils, although for such heavy soils *val*, (*Dolichos lablab* var. *lignosus*) is more suitable. It can withstand both moderate drought and heavy rains. It can also grow well under the shade of tall trees, but cannot survive cold or frost. Cowpea is not so season-bound as some other pulses and so it can be grown in any month of the year, except the hottest summer months. In fact, no other legume can grow so well under such a variety of soil and climatic conditions, with so little attention, as cowpea.

Cultural Practices. Two or three ploughings will be needed to get the seed-bed in proper condition for sowing cowpea. For an irrigated crop, beds of suitable size are formed, the seeds are sown broadcast and watered immediately after.

Cowpea is not generally manured beyond 75 to 125 q/ha of farm-yard manure applied after the second ploughing. The sowing season extends from March to the end of July in north India, where the winter temperatures are low. In Assam, Bihar and Uttar Pradesh, cowpea is sown with the onset of the S.W. monsoon in June-July. In peninsular India, the sowings are usually from October to December, but on the Kerala coast, the proper sowing season is from May till early June, to avoid being caught up in heavy rains at flowering time.

The seed-rate is 17–34 kg/ha when a seed crop is intended, but for a fodder crop or green manure, up to 101 kg/ha can be used. Three to four irrigations may also be needed for the crop, to supply its normal requirement of 8 to 10 acre-inches of water.

Mixed crops of cowpea with maize, jowar or bajra are quite common wherever cowpea is grown. The seed-rate then will be 11·2 to 16·8 kg per hectare. It is found that cowpea can improve the yield of grasses in mixtures and conversely, the grasses too, can improve the yield of the cowpea crop.

As a fodder crop, cowpea can be cut in 60 to 75 days after sowing, to yield about 90 to 120 quintals of green forage per hectare. The feeding

TABLE 27. ANALYSIS OF COWPEA

	Green		Silage		Hay		Seed	
	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients
	%	%	%	%	%	%	%	%
Moisture	83·7		79·3		9·6		11·4	
Crude protein	3·0	76	3·1	57	18·6	68	23·6	82
Ether extract	0·5	59	0·8	63	2·6	39	1·5	74
Crude fibre	3·8	60	5·9	52	23·3	47	4·1	64
Ash	2·0	—	2·3	—	11·3	—	3·5	—
N-free extract	7·0	81	8·6	73	34·6	68	55·9	93
Calcium	0·28		0·36		1·58		0·14	
Phosphorus	0·14		0·16		0·57		1·08	
Potassium	0·31		0·37		1·75		1·75	
				Percentage Digestible Nutrients				
Digestible Crude Protein		2·3		1·8		12·6		19·4
Total Digestible Nutrients		10·9		12·2		49·4		76·5

value of cowpea forage is high and quite comparable to lucerne. Cowpea is superior to soybean fodder, because although the protein content is lower in cowpea, the fibre content is also less and hence there is less of wastage by livestock in feeding cowpea fodder. A mixed crop of cowpea and jowar will be consumed by cattle with great relish with hardly any waste at all.

Cowpea is often grown as a green manure, for soil improvement. In such cases, it is usual to utilise the first growth for feeding cattle and plough in the remaining stubble as green manure. Cowpea can make good hay, as the leaves do not get easily shed. A mixed growth of cowpea with maize, jowar or bajra would make very good hay. In Assam for instance, earlier-sown crops of cowpea are cut and fed green to cattle during the rainy season; later-sown crops are cut after the rains subside, dried and stored as hay for use in the cold months.

Pests and Diseases. Aphids are often troublesome when cowpea is grown as a summer crop under irrigation. It is then best to cut and feed off the crop and when the second flush is coming up, give a light insecticidal spray early enough to suppress the aphis infestation and allow a sufficient interval between spraying and the next harvest of green material for fodder.

Hairy caterpillars (*Amsacta lactinea*), are sometimes serious pests on cowpea, especially in Gujarat. The moth lays eggs on the leaves at the beginning of the monsoon, 200 or more on each leaf and when the caterpillars hatch out much damage is done by defoliation of plants. Control is possible by means of light traps before the monsoon, to prevent the adult moths from laying eggs.

Cowpea weevils (*Callobruchus maculatus*, *Chalodermus aeneus*) damage the seed in the field and often continue to breed in the stored seed for several generations.

CHAPTER 8

MISCELLANEOUS LEGUMES

Genus *Alysicarpus* Neck. (Leguminosae)

A tropical genus of about 16 species of herbs confined to the Old World. Some of them occur in India and a few are suitable for fodder purposes. Leaves consist of one leaflet; flowers small and few, in terminal racemes; calyx deeply lobed, wing petals adnate to keel petals; stamens 9 and 1; pod is several-jointed. The name *Alysicarpus* is derived from the Greek, " chain-fruited ".

Three species, *viz.*, *A. rugosus*, *A. pubescens* and *A. longifolium* occur as annual weeds in black-soil areas, on waste lands and roadsides. They are easily propagated from seeds and are capable of good growth to serve as useful fodders in temporary pastures. They are sometimes used as fodder plants in the Deccan, both green and dry.

Alysicarpus rugosus DC. This is a tall plant often growing wild in well-drained situations in the Bundelkhand region and Bombay Deccan The plant has good powers of auto-regeneration. The fruit is ribbed.. Under cultivation it becomes less coarse and can yield up to 78·4 quintals of green material per hectare, but ordinarily cattle eat it only when the plants are young and tender. It is good for making silage.

Alysicarpus pubescens Law. This, too, is a tall plant, 60 to 91 cm tall, covered with downy hairs all over. It grows wild in well-drained locations, in many parts of Maharashtra and the Deccan peninsula. Under cultivation it is capable of yielding more abundant foliage than in nature. The plant flowers in September and fruits by November. Cattle relish it only till its flowering stage and so it is best to cut it at that stage for ensilaging.

Alysicarpus longifolium (Hindi—*Shevayara*).

This species is similar to *S. rugosus* but has neither downy hairs nor ribbed fruit. A calculated outturn of 90 quintals per hectare was obtained from trials at Poona in 1913.

Groundnut (*Arachis hypogaea* Linn.)

Genus *Arachis* Linn. (Leguminosae)

Ten species are included in this genus. They are low herbs, indigenous to Brazil and Paraguay. One of them, *A. hypogaea* is widely cultivated for its edible, oil-bearing seeds and the haulms are used for forage.

Arachis hypogaea Linn. (Groundnut, Peanut, Earthnut, Monkeynut, Gobber pea; Hindi—*Mung Phali, Vilapat Mung;* Tamil—*Nilakkadalai, Verkadalai Manilakottai* Telugu—*Verusananga;* Kannada—*Nelakadale;* Malayalam—*Nilakkadala.*

This species is indigenous to Brazil but is now cultivated in numerous countries for its edible seeds. The kernels yield a very useful oil which finds wide application in the margarine, vanaspati and soap industries.

Description. A low, herbaceous annual, 25 to 50 cm high, branched and slightly hairy; leaves paripinnate, with stipules prominent and adnate to the base of the petiole; flowers few, yellow and withering soon, after which the pedicel elongates and enters the soil, where the ovary develops into a reticulated pod or nut, containing two to three edible seeds.

Climate and Soils. Groundnut can grow on a variety of soils and climate but thrives best in regions with a temperature range of 20–35° C and an annual rainfall of 51 to 76 cm. evenly distributed during its growth period. It is not suited to regions of heavy rainfall as on the Kerala coast and Assam. Light to medium loams having a *p*H range of 5·3 to 6·6 are the best for this crop. In heavy soils the harvest of pods becomes difficult and incomplete.

Cultural Practices. Groundnut is sown as a rain-fed crop in June-July and harvested in September-December, depending upon the duration of the variety and the time of sowing. The sowings should be adjusted so as to have some rains during the time of flowering and harvest. Irrigated groundnut can be sown in February-March and even up to June-July.

TABLE 28. ANALYSIS OF GROUNDNUT

	Hay		Groundnut Cake	
	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients
	%	%	%	%
Moisture	7·5		6·0	
Crude protein	19·9	69	48·7	90
Ether extract	0·9	—	7·7	97
Crude fibre	22·7	39	6·9	10
Ash	13·7	—	5·3	—
N-free extract	35·3	64	25·4	51
Calcium	2·45		0·25	
Phosphorus	0·54		1·19	
Potassium	3·02		1·33	
				Digestible Nutrients
Digestible Crude Protein				43·8
Total Digestible Nutrients				74·1

(After Lander, 1949)

In groundnut there are two types, the bunch and the spreading types. The bunch type matures in 3–3½ months, while the spreading type takes about five months to mature. Seeds of the spreading variety need a resting period of some three months before they can germinate, whereas the bunch type is liable to germinate in the field itself, if rains continue at harvest time. Groundnut is often sown in mixtures with cereals like ragi, tenai or bajri, mainly as a sort of crop insurance, even though it is always more profitable to grow it as a pure crop.

Groundnut makes an excellent forage crop, apart from its being a recuperative crop for the soil. The haulms make a very good feed for cattle, either green or after drying. The haulms can also be ensilaged. Groundnut cake is a very nutritious feed for cattle and is also a good nitrogenous manure, containing nearly 8 per cent nitrogen.

Cajanus cajan Millsp.

Genus *Cajanus* DC.

A monotypic genus believed to be indigenous to S. Africa, but now cultivated in most tropical countries, in Asia, Africa, America, the East and West Indies, Australia and the Hawaii Islauds, for its edible seeds. The plant is an erect, bushy, perennial, pubescent shrub, growing nearly 1·5 to 2·1 metres feet in height, which in nature flowers and fruits intermittently. Leaflets are three, narrow-elliptic, 5 to 10 cm long, entire, softly pubescent on both sides, with minute resinous dots on the under-surface; flowers in axillary racemes, calyx has the upper two lobes united; keel petal obtuse and incurved; style is beardless; pod compressed, with diagonal depressions, 4 to 6 seeded.

Cajanus cajan Millsp. (Red gram, Pigeon pea ; Sanskrit—*Adhaki, Tuvarika ;* Hindi—*Arhar, Tur ;* Tamil—*Thovarai ;* Telugu—*Kandulu;* Kannada—*Togare ;* Malayalam—*Thuvara*).

Description. The plant is an erect, much-branched, perennial shrub, 12 to 24 feet tall; over 80 varieties are known in India, differing in height, habit, duration, colour, size and shape of the pods and seeds. These varieties fall into two main groups, the *arhar* group, *C. cajan* var. *bicolor* DC. and the *tur* group, *C. cajan* var. *flavus* DC. The former includes perennial types, which are late, large and bushy, with yellow flowers streaked with purple, and dark-coloured pods containing four to six seeds, while the *tur* group includes smaller plants of shorter duration, nearly all annuals with yellow flowers and plain pods containing only two to three seeds. The *arhar* types are more prevalent in Bihar, Uttar Pradesh, Bengal and Orissa, while *tur* types are grown in peninsular India. Both types are to be found in Madhya Pradesh.

Cultivation. Red gram is cultivated in all States in India, but the more important ones are: Uttar Pradesh, Madhya Pradesh, Andhra

Pradesh, Bihar, Maharashtra, Gujarat, Madras and Mysore, in that order.

Red gram is grown primarily as a mixed crop, mostly under rain-fed conditions on a wide variety of soils, from the black-cotton soils of the Deccan to the alluvial soils of the Indo-Gangetic plains. Well-drained, deep loamy soils suit this crop best. It cannot, however, thrive on lime-deficient soils. Being very deep-rooted and drought-resistant, red gram is seldom irrigated, except in the case of perennial vegetable types. It is also not very exacting in its manurial requirements and in fact, cattle manure and superphosphate make the crop liable to wilt disease.

It is grown mostly as a kharif crop, i.e., sown in June-July and harvested by February-March, in rotation with cereals and occasionally as a rabi crop, i.e., sown in October and harvested in March-April. Sowing is nearly always in lines, the spacing varying widely according to the mixtures. The seed-rate also varies widely from 1·1 to 5·6 kg/ha, in mixtures and 13·4 to 22·4 kg/ha, as a pure crop. In pure cropping, some thinning may be needed to give the bushes sufficient space to grow well, at 30 cm between plants in light soils and 60 cm apart in richer soils.

Red gram flowers by November. Pod-setting is good if no rains are received after this period and if there is a steady north-east breeze, the incidence of insect pests is also reduced.

The June-sown crop starts flowering by September. The early maturing *tur* group of varieties flower a month or two earlier than the late-maturing *arhar* group. Flowering continues even up to harvest time, but the crop is harvested when about three-fourths of the pods are mature, usually by the end of January. If kept on longer, the ripe pods dehisce and shatter the seeds.

The ripe pods are first picked off by hand and for the final harvest, the plants are cut close to the ground, usually in early mornings (to avoid shattering of ripe pods), bundled and transported to the threshing floor and stacked there on end for a few days. When the leaves and pods are nearly dry, the pods are separated by beating the plants on hard ground, flailing or vigorous shaking and seeds separated by bullock-treading. The chaff is separated from seeds by winnowing.

Early varieties yield less than late-maturing varieties, but as the crop is mostly grown in mixtures, the acre yields are highly variable (2·2 to 9 quintals per hectare). A pure crop may yield up to 20·1 quintals of seeds per hectare.

Pests and Diseases. The most serious pests of red gram are the gram caterpillar (*Heliothis obsoleta* F.), the red gram plume moth (*Exelastis atomosa* W.) and the gram pod fly (*Agromyza obtusa* M), which bore into

the pods and seeds. No effective control is known against these as yet. Other pests that may become serious at times, are the red hairy caterpillar (*Amsacta albistriga* Wlk.) and a grass hopper (*Colemania sphenaroides* Bol.). The worst disease in red gram is wilt, caused by the soil-borne fungus (*Fusarium* sp.). This is very common in the Indo-Gangetic plain. The entire plant withers and no control is known so far, except to grow wilt-resistant varieties. Green manuring acts as a check, but cattle manure and superphosphate aggravate the disease.

When grown as a perennial crop for green manure or fodder, the plants are pruned at regular intervals, and occasionally in some limited areas, even irrigated once or twice. Towards the end of the season, a closer pruning is given and the plants allowed to sprout before ploughing them in.

In certain humid regions, red gram plants can yield large quantities of green material for three to four years, which can serve as an excellent cattle fodder.

The husks and other refuse collected from the threshing floor, of leaves, immature pods and seeds and broken bits of split pulse (or *dhall*) is known as '*bhusa*' or '*chuni*'. This *bhusa* forms a very nutritious feed for milch animals. The yield ranges from 3·4 to 5·6 quintals/ha, of gram and 5·6 to 10 quintals/ha, of *bhusa* in red soil areas and up to 11 to 16·8 quintals of gram and 16·8 to 22·4 quintals of *bhusa* in the rich deltaic soils of Godavari district.

TABLE 29. ANALYSIS OF REDGRAM

	Grain		Husk	
	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients
	%	%	%	%
Moisture	8·4		8·0	
Crude protein	18·8	70	7·0	—
Ether extract	1·8	50	0·4	—
Crude fibre	—	—	—	—
Ash	6·7	—	5·7	—
N-free extract	64·3	81	42·8	—
Calcium	0·28			
Phosphorus	0·78			
Potassium	0·48			
		Digestible Nutrients		
Digestible Crude Protein		13·2		
Ttoal Digestible Nutrients		67·7		

(After Lander and Dharmani, 1944)

Calopogonium Desv.

A small genus of five species of spreading climbers indigenous to tropical America.

Calopogonium mucunoides was introduced in 1930 as a cover crop in coffee and rubber estates in India but it was not found entirely satisfactory, although it is well-suited to the Kerala coast. The plant dries up in summer, but comes up again after rains from self-sown seeds, so that *Calopogonium* can easily be grown as a rain-fed pasture crop in many places in India.

Being a plant which grows and spreads rapidly, the seeds can be sown in lines 1·2 to 1·8 metres apart during rains among other pasture grasses and lightly covered. In new pastures, these lines of *Calopogonium* can be sown after the grasses get established. It can also be propagated by planting cuttings with rooted nodes.

The crop is reported to be very successful as a cover crop in new clearings in Java, Malaya and Ceylon, yielding nearly 560 quintals of green manure per acre, which is equivalent to 12·3 quintals of ammonium sulphate per acre. It does not, however, thrive well under the shade of rubber trees and is also not liked very much by cattle. The pods become hairy when mature and hence this crop should be cut for fodder when young and still green and tender. Since it dries up during the summer months, it is liable to create fire hazards.

Cicer arietinum Linn.

Genus *Cicer* Linn. (Leguminosae)

> The genus includes about 12 species native to Western Asia, of small, low-growing annuals and perennials. Accessory buds occur in the axils of some species. Leaves pinnate, with the rachis ending in a small spiny tip (abortive tendril), margins dentate, stipules large and toothed; flowers small, few axillary or terminal; calyx deeply 5-toothed; style incurved, glabrous; pod short, turgid; seeds few and large.

Two species are found in India, of which *Cicer arietinum* is a very important pulse crop.

> **Cicer arietinum** Linn. (Bengal gram, Chick pea; Sanskrit—*Chanakaha;* Hindi—*Chana;* Tamil—*Kadalai;* Telugu—*Sanagalu;* Kanarese—*Kadale;* Malayalam—*Kadalakka*).

This is the most important pulse crop of India. It is known as Bengal gram in South India because it was being imported originally from Bengal. In north India it is known merely as gram. It is believed to have originated in West Asia but is now grown in many regions of Asia as well as in some parts of Europe, Africa, Australia and America. A number of district varieties are known, differing in seed coat colour from creamy-

white to black, in size of seeds and colour of flowers. The seeds have a characteristic shape with a broad base and a pointed " beak ", which gives it the name of chick pea. The south Indian varieties are small and yellowish-brown in colour, while '*Kabuli chana*' in north India has bold, smooth seeds, whitish in colour and rather sweet in taste.

Climate and Soils. Heavy black soils or alluviums are the best suited for Bengal gram. In north India it is grown on wheat-lands, while in south India, Bengal gram is grown on black soils and the deltaic '*lankas*' soils of Godavari and Krishna districts of Andhra Pradesh, as a cold-weather crop sown at the close of the north-east monsoon.

Cultural Practices. The land is prepared by giving the usual two or three ploughings and harrowings, after which the seeds are sown at 22 to 34 kg per hectare, either drilled in rows 20 to 25 cm apart or sown broadcast. Gram is nearly always sown only as a rain-fed crop. As it is the least responsive among pulses to fertilizers, the crop is seldom manured but a deep tilth is very useful in securing a good crop. No weeding also is usually necessary. Mixture with wheat or barley is a common and widespread practice in northern India. Gram is very sensitive to weather conditions during its growth. Rains during the growth period injure the crop, but cold, cloudless nights favour good growth and yields. Frost is also injurious to the crop; in severe frosts the seeds are killed off inside the pods.

The glandular hairs on the stems and leaves secrete malic and oxalic acids and this acid secretion is sometimes collected by spreading a muslin cloth over the plants at night, as it is considered to be useful as a stomachic.

The crop matures in 3–3½ months, when the leaves start drying up; the plants are usually pulled out early in the morning, to avoid loss of seed by shattering of pods. The plants are dried for three or four days and then threshed by cattle-treading, flailing or with stone rollers.

The yield varies from 3·4 to 5·6 quintals, to a maximum of 8·4 quintals per hectare in wetlands. The seeds are useful as a high protein pulse, not only for human beings but for cattle and other livestock as well. It is much used as a feed for horses in north India. Bengal gram *bhusa* is often not liked by animals on account of its sour taste, but it can be mixed with other feeds with advantage, as practised in Andhra Pradesh. It is curious that in the southern districts of Madras, the *bhusa* is not used for feeding cattle, but dumped into the manure pit.

Cicer soonjaricum Steph. A wiry annual, with stems finally pubescent or glabrous and linear-oblong pods about an inch in length. It grows wild in the temperate slopes of the Himalayan regions at elevations of 2,700 to 4,570 metres. The seeds are said to be eaten raw or cooked, in some parts of Ladakh. The young shoots are used as pot-herb, fresh or pickled. The plants can also serve as fodder. An aromatic vinegar is sometimes collected from the foliage.

TABEL 30. ANALYSIS OF BENGAL GRAM

	Green roughage		Hay		Bhusa		Grain		Husk	
	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients
	%	%	%	%	%	%	%	%	%	%
Moisture	63·2		10·8		9·4		8·1		8·0	
Crude protein	4·4		11·5		4·9	45	18·0	69	5·3	
Ether extract	0·7		1·3		0·6	21	4·5	84	0·8	85
Crude fibre	12·5		32·3		40·4	41	6·9		44·5	66
Ash	4·2		10·1		9·5		2·4		5·5	
N-free extract	15·0		34·0		35·2	49	60·1	90	35·9	71
Calcium	0·89		1·91		1·43		0·40			
Phosphorus	0·22		0·41		0·20		0·90			
Potassium	1·36		2·67				0·22			
							Digestible Nutrients			
Digestible Crude Protein						2·2		12·4		
Total Digestible Nutrients						34·0		79·6		59·6

(After Lander, 1949)

Soyabean (*Glycine max* Sieb. and Zucc.)

Genus *Glycine* Linn.

Herbs twining or prostrate, leaves pinnately three to seven folio-late, stipules small, stipels subulate; flowers small, in axillary racemes, calyx campanulate, corolla hardly exserted. Stamens at first monadelphous, the vexillary stamen free later on. Ovary sub-sessile, many-ovuled. Style short, stigma capitate, pod linear, septate between seeds. Seeds slightly compressed, strophiole absent.

Glycine max Sieb & Zucc. (Syn. *Glycine soya*, *G. hispida* Maxim. Syn. Soybean).

Origin, History and Distribution. Soyabean is a native of sub-tropical Central Asia and is one of the important crops of China, Japan and other Mongolian countries, since very ancient times. The plant was introduced into the United States in the 19th century and has now become very popular there for grain, oil, green manure and forage purposes. In India, it has been in cultivation in a few places on the hill-slopes of Uttar Pradesh, near Darjeeling, in Nepal and Bhuta and on the Khasi Hills.

The plant is an annual with hairy stems and slender branches that are erect in some types and semi-prostrate in others. Imported varieties have stouter stems than Indian types. Leaves vary from long, narrow, lanceolate to broad, almost orbicular.

Like maize, soyabean also needs a warm, moist, temperate to sub-tropical climate and well-drained loamy or clayey loam soils for its best growth. It is not suited to hot climates. It requires only moderate rainfall but cannot tolerate water-logging or drought. Soyabean grows well on the East coast and the central districts of peninsular India. Under irrigation it comes up very well on rich clay loams. On the Nilgiris too, it was found to grow quite well, but the crop has not become popular so far, probably because the appropriate root-nodule bacteria were lacking in the soils of the areas where it was tried, and also because the hot climate was not quite suitable for this crop.

Cultural Practices. The land is ploughed four or five times and manured with 125·4 quintals of farmyard manure per acre and brought to a fine tilth, because a well-prepared seed-bed is essential for proper germination and subsequent growth. Prior inoculation of the soil or seed with the appropriate nodule bacterial culture is necessary to ensure a good crop when soyabean is being grown for the first time in a field. It is also profitable to apply ammonium sulphate to supply 22 kg of nitrogen and superphosphate to supply 67 kg of phosphorus per hectare at sowing time. If the fertilizers are applied later on as a side-dressing, care is necessary not to place them too near the plants and damage the

young foliage. In a rain-fed crop, the manuring should be timed so as to be followed soon by a rain; in an irrigated crop, a watering should follow the side-dressing immediately.

Sowing. If irrigation facilities are available, soyabean can be sown sufficiently early, to get it established before the monsoon rains set in. Under rain-fed conditions the best time to sow is the second half of May in the Punjab region, and especially in the Kangra valley. Elsewhere on the plains in Uttar Pradesh, the first week in August would be a suitable time to sow soyabean, in rows 60 cm apart and plants 5 to 7·5 cm in the rows if rain-fed, and 2·5 to 5 cm apart in irrigated crops, because a rain-fed crop is nearly always less luxuriant than an irrigated one. The seeds should not be sown deeper than 2·5 to 5 cm, as they rot easily and this results in gappy stands and poor yields. The normal seed rate is 17 to 22 kg/ha for grain crop and 45 to 56 kg/ha, for green manure or fodder.

After-care. After sowing, two weedings may be needed, one 30 days after sowing and the next one three weeks later. Soyabean plants require good aeration for proper setting of pods and seeds, and hence the field should be kept free of weeds by timely interculturings. The short-duration " bushy " types of soyabean are easier to intercultivate than the viny, trailing types of longer duration.

Experiments have shown that soyabeans can be grown mixed with maize in alternate rows 0·3 metre apart and that it is possible thereby to increase the productivity of the maize area of nearly 1·8 lakhs of acres in the Kangra valley in the Punjab without any extra land or alteration of the normal cropping pattern of the tract.

Harvest. The crop is ready for harvest when the leaves turn yellow and begin to get shed and the pods change colour from yellow to dark-brown. Delayed harvest leads to loss of seed by shattering of pods. An August-sown crop is usually ready by the beginning of October, but for fodder, of course, the harvest can be commenced nearly a month earlier than for seed. A grain yield of 5·1 to 8·4 quintals per hectare and 9 to 14·6 quintals of *bhusa* may be expected from a grain crop and about 112 quintals to 134 quintals of green material from a forage or green manure crop.

Varieties. A number of spreading, viny and leafy varieties are available for growing as a fodder crop. The ordinary yellow-seeded local variety cultivated in Darjeeling and other places takes 145 to 160 days to mature, but several improved short-duration varieties have recently been evolved from the Punjab and the Indian Agricultural Research Institute, New Delhi. These are ready for cutting as fodder in 45 days after sowing and for seed in 70 days, and are also bushy in habit, facilitating proper inter-culture. The straw-coloured seeds are bolder than the local variety and sweet in taste, without the usual bitterness or astrin-

gency. These short-duration varieties even when sown as late as August, can mature by October and still leave the farmer ample time to prepare his land for his next rabi sowings. In the Punjab, the improved short-duration variety fits in well with the local rotation where potato follows a kharif legume.

Utilisation. The green material in soyabean forms a very nutritious forage for all classes of livestock and if mixed with maize or other grasses, it can make very good silage as well. However, cowpea is a quicker and easier crop to grow and also less fibrous, so that there is less of wastage in feeding cowpeas than soyabean fodder. In certain tracts, late varieties of soyabean may be found useful, to supply green fodder later in the season than would be possible with guara or cowpea.

As a green manure, experiments have shown that it is not really advantageous to grow soyabean for green manure in India, where other and better green manure crops are available, such as sunnhemp and *Sesbania.*

The grain can be fed as a nutritious protein supplement to farm animals, as it contains nearly 40 per cent of protein and 16 per cent of fat. Soyabean flour is sometimes used in making chappaties and is especially suitable for diabetics.

TABLE 31. ANALYSIS OF SOYABEAN

	Green		Silage		Seeds	
	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients
	%	%	%	%	%	%
Moisture	75·6		72·8		7·4	
Crude protein	4·2	77	4·2	52	38·5	90
Ether extract	1·1	53	1·5	55	16·1	77
Crude fibre	6·7	47	7·9	51	5·6	—
Ash	3·3	—	3·5	—	5·7	—
N-free extract	9·1	75	10·1	64	26·7	58
Calcium	0·41		0·31		0·53	
Phosphorus	0·20		0·10		1·64	
Potassium	0·35		0·32		—	
		Digestible Nutrients		Digestible Nutrients		Digestible Nutrients
Digestible Crude Protein		3·2		2·6		34·7
Total Digestible Nutrients		15·1		15·0		78·7

(After Lander, 1949)

Pests and Diseases. No serious pest or disease has been noted on soyabean in India, although in the U.S.A. a number of diseases, such as bacterial wilt, downy mildew and stem blight, cause much damage.

Lespedeza (Japanese clover)

Genus *Lespedeza* Michz.

> The genus includes about 125 species, mostly herbs or shurbs. Leaves pinnately three-foliate, stipules free. Flowers purple, pink, white or yellow, sometimes apetalous and cleistogamous. Calyx tube campanulate, teeth 5, subequal. Corolla exserted, stamens diadelphous; ovary sessile or stalked, 1-ovuled; style filiform, stigma capitate; pod small, compressed, 1-seeded, indehiscent, seed sub-orbicular.

Origin and Distribution. The genus *Lespedeza* includes 125 species, distributed mainly in temperate regions of Asia, Australia and North America. Most of them are perennial herbs and some are shrubby perennials, but these are of minor importance as fodder plants, except one species, *L. cuneata*, which is popularly termed Sericea lespedeza. Among the few annual species in this genus, two are of importance as fodder plants, namely, *L. striata* Hook et Arn. (Japanese clover) and *L. stipulata* (Korean lespedeza), which are grown for fodder in Japan. The former species *L. striata* has spread to North America as a fodder plant useful on acid soils with a *p*H range of 4·5 to 6·5. The Kobe lespedeza is a variety of *L. striata*. *Lespedeza sericea* Miq. is an erect undershrub that is found growing wild on the Western Ghats and Palni Hills.

The annual lespedezas are low-growing leafy plants with small three-parted leaves and blue or purplish flowers. *L. cuneata* is a tall leafy plant resembling lucerne in habit and appearance. All the lespedezas have a higher percentage of leaves than lucerne and can be grown on almost any soil, except very sandy soils. They are quite tolerant to drought and are thus suitable for locations where lucerne or berseem would fail, but they cannot withstand low temperatures so well as berseem or shaftal.

Cultural Practices. A firm seed-bed is essential for lespedeza as the seeds are very small. The sowing time is February and the seed-rate varies from 22 to 34 kg per hectare for common and Korean lespedeza to 34 to 39 kg for Kobe and 56 kg for the last-named species, however, 22 to 34 kg/ha will be sufficient if hulled seeds are used. As the seeds have a hard seedcoat, scarification is necessary to ensure good germination. Prior inoculation of the seeds with the appropriate bacterial culture is also necessary, if the crop is being sown for the first time in a field.

The fodder yield will be about 90 to 101 quintals per hectare. The crop makes excellent hay and a yield of 22·4 quintals/ha of hay can be expected from an acre of lespedeza.

In India *L. striata* was tried in Sind, Poona and Dharwar between 1909 and 1910 but was not found very promising.

Lupins (*Lupinus* species)

Genus *Lupinus* (Tourn.) L. (Leguminosae)

A genus of 70 species, mostly annuals, with some perennials and ornamental types, all native to the Mediterranean region. They have been known from very ancient times and grown widely in European countries mainly for soil improvement and sometimes for fodder. In the U.S.A. a 'Sweet' lupin variety is becoming popular as forage. In Western Australia and New Zealand lupins are often used as sheep fodder in spite of the species containing a bitter alkaloid that is toxic to other livestock. In India lupins are of little importance, except for soil improvement on the hills, such as the Nilgiris, at 1,520 to 2,130 metres elevations,

Description. Lupins are coarse, erect annuals 60 to 120 cm tall. Three main types are distinguished, yellow, blue and white-flowered. The flowers are large and conspicuous, borne on upright racemes. The leaves are palmately compound, with about seven leaflets. The pods dehisce explosively, with the valves twisting spirally. The three types are adapted to different soil types; yellow lupins grow well on poor, light soils of moderate acidity, (with the *p*H ranging from 5·0 to 6·0), blue lupins need soils of average fertility of the same *p*H range, while white lupins thrive best on soils of high fertility with a *p*H range of 5·5 to 7·0.

Cultural Practices. The seed-rate varies with the type used. White lupins being large-seeded, require nearly 1·8 quintals per hectare to ensure a close stand; blue lupins need 67 to 84 kg/ha and for yellow lupins 56–67 kg/ha will suffice. Sowing may be either by broadcasting or drills. The seeds should be first inoculated with the appropriate bacterial culture to ensure good nodulation on the roots and thereby good growth of plants.

Lupins are very useful in improving soil fertility, when ploughed in as green manure. Only the non-poisonous varieties should be used as forage to livestock. The yield of green material would range from 336 to 448 quintals per acre.

Stizolobium (Velvet Bean)

Genus *Stizolobium* (Syn. *Mucuna adans*)

Thirty-five tropical and sub-tropical species. Some have stinging hairs on the pods. *M. pruriens* DC is the cow-itch, a variety of which is the Florida velvet bean, a useful fodder. Leaflets three, broad, with bristle-like stipels and

small stipules. Flowers large, in threes, in long racemes, falling off early; standard shorter than keel petals which are curved upwards; style pubescent but not bearded; pod thick and turgid, often flattened, hairy or velvety. Seeds large. The name is derived from the Greek, " stinging pods ", alluding to the irritating hairs.

Stizolobium deeringianum Bort. (Hindi—Makhmali Sem)

This species is indigenous to South Asia but it was introduced into U.S.A. in 1850. It is now an important forage plant in the Southern States. It is a sinuous trailer which makes vigorous growth and covers the ground completely, smothering all weeds and conserving soil moisture effectively. The leaves and vines form a good roughage, while the pods and seeds have a high feeding value as a concentrated feed. For soil improvement purposes in sandy areas, velvet-bean is one of the best crops. It is cultivated in many parts of India, but thrives best under warm, moist conditions, where rainfall is sufficient or irrigation facilities are available. It is a vigorous, quick-growing annual with trifoliate leaves bearing large ovate leaflets. The flowers which in different species vary from white to dark purple, are borne in twos or threes in long, pendent clusters. Pods are of two types, one with a black, velvety pubescence and the other with whitish or grayish hairs. Seeds are three to six.

As velvet-bean prefers a warm climate, it is confined to the " cotton belt " in the Southern States of the U.S.A. It cannot thrive on cold,

TABLE 32. ANALYSIS OF VELVET BEAN

	Silage		Hay		Pods	
	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients
	%	%	%	%	%	%
Moisture	76·4		7·2		10·0	
Crude protein	4·3		16·4		18·1	74
Ether extract	1·2		3·1		4·4	80
Crude fibre	8·0		27·5		13·0	67
Ash	1·1		7·4		4·2	—
N-free extract	9·0		38·4		50·3	87
Calcium			—		0·34	
Phosphorus			0·24		0·87	
Potassium			2·20		1·44	
Digestible Crude Protein		2·7		12·3		13·4
Total Digestible Nutrients		14·0		52·0		73·8

(After Lander, 1949)

wet soils, and grows best on sandy loams. It is a new-comer to North India; the best time to sow it is July, during the monsoon rains.

Cultivation. To ensure the best results, the land should be prepared with as much care as for maize; giving two or three harrowings after ploughing, to secure a good weed-free field. Phosphatic fertilisers or cottonseed cake at 2·2 quintals per hectare can increase the seed yield by nearly 3·4 quintals over unmanured.

Seeds can be sown in alternate rows 38 to 68 cm apart, along with maize, using a seedrate of 22 to 34 kg per hectare. The seeds germinate in about a week and the crop is ready for the first cut in three to four months. The yield may be up to 224 quintals per acre. The fodder is very palatable and nutritious and its protein is highly digestible. It is also rich in calcium, phosphorus, iron and iodine and is thus an excellent fodder for all farm animals and particularly for young stock. The seeds contain some toxic alkaloids and hence are not recommended as a concentrate feed for livestock.

Stylosanthes

Genus *Stylosanthes* Swartz.

A genus of stiff under-shrubs with pinnately trifoliate leaves and small, yellow flowers borne on dense, terminal 'heads'. Pods sessile, compressed or muricate, hooked at the tip, with the persistent base of the style. Seeds compressed, lens-shaped.

S. gracilis Swartz. This legume has been reported to be highly successful as a summer forage crop in Bihar which combines very well with perennial grasses like Guinea grass and Thin Napier. It gave about

TABLE 33. ANALYSIS OF STYLOSANTHES (SPECIES)
(On dry weight basis)

	Chemical Composition
	%
Crude Protein	10·08
Ether extract	1·18
Crude fibre	38·40
Ash	8·64
N-free extract	41·70
Calcium	1·23
Phosphorus	0·43
Potassium	—

(After Sen & Ray, 1964)

41·5 quintals per hectare in the first cut within four months of sowing in September and nearly 325 quintals per hectare in the course of the next twelve months.

S. mucronata Willd. Occurs in dry localities in the Northern Circars, Deccan and Madras up to 914 metres on the hills.

S. sundaica. This is one of the few legumes that were successful in local pastures in the dryland areas of Northern Australia, especially in mixtures with *Cenchrus ciliaris* and *C. setigerus*, for which it is preferable to *S. gracilis*.

Other Leguminous plants that are useful for fodder purposes

In times of fodder scarcity in India, anything that is available, green or dry, is fed to cattle, to ward off starvation. A number of species among the Leguminosae can be used for fodder purposes.

Genus *Acacia* Wild. (Leguminosae)

A large genus of nearly 500 species of trees and shrubs distributed in dry regions in Asia, Africa and Australia. Species with phyllodineous modifications are native to Austarila, while those with pinnately compound leaves are found all over the tropics. Flowers are small, numerous, bisexual or unisexual, in stalked, globose heads or cylindrical spikes; petals are often lacking and stamens are numerous. Pod is a lomentum; seeds have arils in some species.

Twenty-two species are indigenous to India, while four other species have been introduced from Australia. The indigenous species are thorny trees or shrubs, with a few climbers, found mostly in arid, open scrub jungle vegetation. Some of the *Acacias* are useful in reclamation of waste-lands and afforestation and when conditions are favourable they can grow rapidly enough to become large trees. The main uses of Indian *Acacias* are tannin, gum, fuel and timber. The pods and leaves of some species are useful as fodder.

Acacia arabica Willd. (Babul); Sanskrit—Barburaha; Hindi—Babul; Bengali—Babul; Marathi—Babul; Tamil—Karu velum; Malayalam—Karu velum; Telugu—Nalla tumma; Kannada—Jali gobli.

Babul is a thorny, evergreen tree of moderate size, with a rough, black trunk. The spines are straight and sharp and occur in pairs below the petioles, being modified stipules. The yellow, globose, sweet-scented flowers are put forth in June-September. The pods are 7·5 to 15 cm. long and about 1·2 cm. broad, with 8 to 12 seeds in each. The largest tracts of babul are found in Sind (now in Pakistan) and in Madhya Pradesh and on the alluvial loams of the Punjab and Uttar Pradesh. In the extreme

north of India it is rare, as it cannot withstand severe frosts. It is somewhat less abundant in the southern States of India, although babul trees are found also in Ceylon and Burma.

Babul seeds collected from goat and sheep pens are found to germinate better than seeds shelled from pods, as a result of their passing through the alimentary canal of these ruminants, because the seed coat becomes more permeable to water after the action of digestive fluids. Similarly, coffee seeds gathered from jackal droppings on the Nilgiris are said to have a better germination capacity. Ridge sowings are desirable for successful afforestation with babul seeds. The seedlings require plenty of moisture and sunlight and a friable soil, free of weeds or grasses. Under favourable conditions the seedlings can grow up to 1·8 metres within a year or two.

The most serious pests of babul are the beetles, *Coelasterna scabrate* Fabr. and *Psiloptera fastuosa* Fabr. The former is a destructive root borer, while the latter strips off the bark from the younger branches and shoots.

Uses. The pods of babul are a nutritious feed for grazing cattle and sheep and hence this species can be planted as shade plants in grasslands and pastures. A well-grown tree can yield nearly 1·8 quintals of pods a year.

TABLE 34. ANALYSIS OF BABUL

(Pods on dry weight basis)

	%
Crude Protein	15·8
Ether extract	0·8
Crude fibre	12·4
Ash	15·5
N-free extract	65·5

Acacia leucophloca Willd.; Hindi—Safed kikar; Tamil—Vel velam; Telugu—Tella tuma; Kannada—Bili jali; Malayalam—Pattacharaya maram.

A moderate-sized tree, with smooth, light-yellowish or whitish bark, which is reddish on the inside. The tree is gnarled and the branches are armed with long, straight, whitish spines, 2·5 to 5 cm long. The pods and seeds are used for fodder in the same manner as in *Acacia arabica.*

Acacia jacquemontii Benth.

This is a thorny shrub with fragrant yellow flowers found in the plains of Sind, Rajasthan and North Gujarat, extending as far south as Ceylon in the drier regions. The branches of this species also can be lopped for fodder.

Acacia latronum Willd. (Tamil—Kar odei; Telugu—Paki tuma)

A gregarious, thorny shrub found in the drier parts of peninsular India. The plants are browsed by goats, in spite of the formidable thorns.

Acacia planifrons Wight & Arn. (Umbrella Thorn; Tamil—Kodai maram; Telugu—Godugu tuma).

A small, gregarious tree with a flat, umbrella-like crown, found in the Deccan region of peninsular India.

Acacia senegal Willd.

A small, thorny tree of Sind, south-east Punjab and Rajasthan, which is also abundant in the Sudan, central Africa and Senegal, growing under the most adverse conditions of heat and moisture. This tree yields the true 'gum arabic' of commerce. The foliage is readily browsed by goats and camels.

Albizzia species

Genus *Albizzia* Durazz. (Leguminosae) (Syn. *Albizia*)

A genus of about 50 species, distributed in the warm regions of the world, of which 12 species occur in India. These are mostly trees, some of which yield good timber, while others are grown as shade trees in avenues and tea estates.

Leaves alternate, often deciduous, bipinnate; flowers in globose heads or cylindrical spikes; corolla segments partly connate at the base; pods large, strap-shaped, dry and non-septate.

Albizzia amara Boivin.

This is a medium-sized tree with pinkish-white flowers and yellow, pubescent young shoots, which is common in the Deccan and Carnatic up to 910 metres elevations. It can be grown on roadsides and waste-lands; propagation is by seeds. The leaves are liked by cattle. In certain parts of Salem district in Madras, cattle are fed exclusively on these leaves and are known as " Thurinji-thazhai-maadu ", i.e., cattle reared on leaves of *Albizzia amara*.

Albizzia lebbeck Benth. (Woman's tongue tree)

A large, erect, deciduous tree with brownish-gray bark and umbrella-shaped crown, large white flowers and very long, greenish stamens; the

pods are characteristic and remain on the tree even when dry. This species is well suited for all localities up to 1,220 metres elevations and its abundant foliage is relished by all livestock.

Albizzia marginata Merr.

A tall, deciduous tree with white flowers and pink filaments, found in all hill forests of the Northern Circars and the Western Ghats up to 1,220 metres elevations. It is sometimes planted as a shade tree for coffee. The foliage is well relished by cattle.

Aibizzia odoratissima Benth.

This species is similar to *A. lebbeck*, but the foliage is dark green and drooping and the sweet-scented white flowers have yellow anthers. The leaves and twigs of this species are also lopped for fodder.

Albizzia stipulata Boiv.

A large, deciduous tree with a flat-topped crown, which prefers moist localities; the leaves can be lopped for fodder.

Alhagi camelorum Fisch. (Leguminosae; Camel-thorn, Persian Manna plant).

The genus Alhagi is a small one, of three species of thorny shrubs distributed in western Asia and the Mediterranean regions. *A. camelorum* is a low-growing, spiny shrub, 60 to 91 cm tall, which is common in Sind, Gujarat, Punjab and Uttar Pradesh; the plant serves as fodder for camels in these regions.

Genus *Bauhinia* Linn. (Leguminosae)

A large genus of tropical plants including trees, shrubs and climbers; 150–200 species in both the eastern and western hemispheres. Leaves broad, usually two-cleft, with the midrib prolonged into a short awn-like bristle between the leaflets; flowers variously coloured, five unequal petals, often narrowed to a claw; stamens 10, sometimes reduced even to one; pod long, dehiscent or indehiscent. About 40 species occur in India.

B. malabarica Roxb.

A medium-sized bushy tree with deciduous foliage distributed in Assam, Bengal and South India. The leaves and young branches are said to be a good fodder for cattle.

B. purpurea Linn.

A small ever-green tree with abundant foliage of large leaves and pink flowers. The leaves are eaten by cattle and the flower-buds can be used as a pot-herb. Propagation is by seeds.

B. variegata Linn. (Hindi—Kachnar).

A medium-sized tree often grown for its beautiful flowers that bloom in the hot season; found in the sub-Himalayan tracts from Indus eastwards, in dry areas. The leaves and buds can serve as good fodder for cattle.

Butea Roxb.

Trees or large shrubs; leaves pinnately three-foliolate, leaflets large; flowers large, showy, in dense fascicles; pod an oblong follicle; flat-based, wing-like and indehiscent, the tip splitting round the single apical seed; seed obovate, compressed.

Butea frondosa (Koen.) Roxb. (Syn. *B. monosperma*; Hindi—Dhak, Palas; Tamil—Porasu; Telugu—Modugu; Malayalam—Palasin samatha.

A deciduous tree with showy, orange-red flowers set in velvety calyces. The large leaflets are broadly ovate and coriaceous. Found in all districts in open country and deciduous forests, particularly in black soils. Propagation is by seeds. It can be planted in avenues and tank bunds for its plentiful leaves, which are readily eaten by cattle.

Canavalia DC. (Leguminosae)

A tropical genus of about 48 species of annuals and perennials. Erect or robust, twining herbs; leaflets three, coriaceous; flowers large, in axillary racemes; calyx two-lipped; standard orbicular, keel incurved; stamens 10, monadelphous or one partly free; style incurved, beardless; pod large, woody, flat; seeds large, flat. Two species are cultivated, for their edible pods and seeds.

Canavalia ensiformis Linn. DC. (Jack bean, Sword bean, Sabre bean, Horse bean; Hindi—Kadsambal, Bara sem.; Tamil—Vellai thambattai; Telugu—Thumbetten kaya.

This species is native to the West Indies and is grown to a limited extent in India. The plant is drought-resistant and immune to most pests and diseases. It is a bushy, semi-erect, climbing plant with large pink or white flowers and sword-shaped pods 20 to 40 cm long and 2·5 cm broad, each containing 1–12 white seeds with long, brown hilum. An outturn of 251 to 502 quintals of green material and 13·4 quintals of seeds

can be expected from a hectare. It is cultivated usually as a vegetable in gardens and on house-tops. It can be quite useful as a green manure, but its utility as a forage plant is somewhat doubtful, as it is reported to be unpalatable as well as indigestible.

Canavalia gladiata (Jacq.) DC. (Syn. *C. ensiformis* Baker non DC.; Sword bean; Hindi—Lal Kadsambal; Tamil—Segappu Thambattai; Telugu—Yerra Tamme).

A large, quick-growing perennial climber, widely cultivated throughout East Asia. It is used as a cover crop, forage and vegetable. Some semi-erect varieties are also known. It bears large, white or pinkish flowers and sword-shaped pods 20 to 30 cm long and 2·5 to 3·8 cm broad, which are more curved and prominently ridged than *C. ensiformis*. The seeds are blackish and strongly compressed, with the hilum extending over the length of the seed. The green pods are used as vegetable in many countries of Eastern Asia.

Genus *Cassia* Linn.

A very large genus of more than 400 species, including herbs. shrubs and trees, of which about 20 species occur in India. Many are medicinal, while some provide tanning material. Leaves paripinnate, sometimes reduced; flowers solitary or racemose, calyx teeth equal, longer than tube, corolla of five nearly equal, spreading petals; stamens 10, some abortive; pods flattened or terete, partitioned cross-wise and many-seeded.

Cassia tora Linn. (Hindi—Chakunda; Tamil—Thagarai; Telugu—Tanipu)

A common herbaceous annual found all over India on waste-lands soon after rains, with small, yellow flowers and long, curved pods 15 to 23 cm long and 6 mm broad, with numerous dark, rhombohedral seeds which give a blue dye. The seeds can be used as a protein-rich feed for livestock, if introduced into their feed gradually.

TABLE 35. ANALYSIS OF CASSIA TORA SEEDS
(Chemical composition on dry basis)

	%
Crude protein	21·1
Ether extract	7·8
Crude fibre	13·2
Ash	6·6
N-free extract	51·3
Calcium	1·22
Phosphorus	1·62

Although the green plants are avoided by cattle on account of their rank smell, they are consumed when ensiled; which also helps to solve the problem of a good fodder during the summer months. *Cassia tora* plants come up in large number during the monsoon season on roadsides and waste-lands, start flowering in mid-July, fruit in September-October and then dry up. The plants should be ensiled before they flower, in pits $6{\cdot}1 \times 4{\cdot}6 \times 1{\cdot}5$ metres one of which can provide enough silage to feed a pair of bullocks, one cow and a calf for eight months in the year.

Centrosema pubescens (Centro)

This species was an introduction into India for trial as a cover crop in tea and coffee estates. Unlike *Calopogonium* which is an annual, this plant is a perennial which spreads quickly. It is, therefore, a very useful fodder plant, well suited to the west coast of peninsular India. It takes about four months to get established, but once established, it keeps on growing and needs little attention later on.

Ceratonia siliqua Linn. (Locust bean, Carob tree, St. John's bread, Algaroba)

The genus is a monotypic one, native to southern Europe on the Mediterranean coast. The plant was introduced into India and is now naturalised in the Punjab and a few other places. It is a small tree with thick, evergreen crown, paripinnate leaves and broad, leathery leaflets, small flowers borne on short racemes, unisexual or bisexual. Petals are absent, stamens five, pod is compressed, elongate, indehiscent and filled with a sweet edible pulp between the numerous, shiny brown seeds.

A full-grown tree yields nearly 6·7 quintals of fruits; these are useful in preparing cattle feeds, as the pods are rich in sugars and the seeds in protein; the seeds form about 10 per cent of the pod weight.

TABLE 36. ANALYSIS OF CERATONIA PODS

	%
Moisture	8·9
Crude protein	17·1
Ether extract	2·4
Crude fibre	7·6
Ash	2·9
N-free extract	61·1

NOTE: Analysis data given without specific citations are from the 'Wealth of India', C.S.I.R. Publications, New Delhi, 1958 to 1962 (Vols. I to VI).

Genus *Desmodium* Desc.

A large genus of nearly 180 species of annual or parennial herbs or shrubs, distributed in the tropical and sub-tropical regions of Africa, Australia and the New World. The genus can be distinguished from *Lespedza* by the presence of stipels on the leaflets and the many-jointed pods that break apart. Name is derived from Greek *Desmo-dium*, a chain, alluding to the jointed nature of the pods. Thirty-eight species are found in India, some of which have been tried as fodders and green manure plants. Many species are medicinal.

Desmodium diffusum DC.

A herb growing 30 to 60 cm tall, found on the plains and up to 1,220 metres elevations in Bengal, Bihar, Orissa and the Vindhyan regions. It is useful as fodder. It has also been tried as a green manure and experiments show that it can bring about a greater improvement in black soils and a higher level of nitrogen, as compared with sunnhemp on equal nitrogen weight basis.

D, tortuosum DC. (Beggar weed)

An erect annual herb, 1·8 to 2·4 metres tall, which has been introduced from Central America for trials as a forage plant in India. At the Pusa Farm it gave only 46·7 quintals per acre of green material, but it may be useful for keeping light sandy soils in cultivation.

TABLE 37. ANALYSIS OF DESMODIUM TORTUOSUM

	Green material	Hay
	%	%
Moisture	72·9	10·0
Digestible Crude protein	3·2	11·1
Total Digestible Nutrients	14·3	49·2

It is reported to be as good as or even better than lucerne as a protein supplement in poultry feeding.

D. triflorum DC. (Hindi—Kudaliya; Tamil—Siru pulladi; Telugu—Muntamandu)

A trailing, much-branched perennial herb found on the plains and up to 2,130 metres elevations in most parts of India. It resembles clover in forming a " matted " growth at ground level and is well-suited for dry, rocky situations for erosion control. It has been tried as a green

manure in coconut gardens and as a cover crop in rubber estates, but was not found suitable, as the matted roots hinder soil aeration. It may, however, be useful for fodder purposes, even though the yield is only moderate.

TABLE 38. ANALYSIS OF DESMODIUM TRIFLORUM

	%
Crude protein	14·5
Ether extract	4·1
Crude fibre	33·5
N-free extract	40·0

Other species of *Desmodium* that may be useful for fodder are *D. gyrans* DC (Semaphore plant), *D. parviflorum* DC, *D. pulchellum* Benth., *D. tilaefolium* G.Don. and *D. umbellatum* DC. The last species is particularly favoured by horses.

Dichrostachys Wight & Arn.

A genus of small trees and shrubs found in tropical regions of the Old World.

Dichrostachys cinerea Wight & Arn.

Occurs in India, as a thorny, small-sized tree common in scrub-jungles of the north, central and south India; it is useful as a cover plant in semi-arid regions. The leaves can be used for fodder.

Genus Enterolobium Mart. (Syn., *Pithecellobium, Pithecolobium*)

A tropical genus of about 125 species of Asia and America. Name is derived from Greek, *Pithecello-bium* " monkey ear-ring " alluding to the coiled pods; pods rarely straight, dehiscent or indehiscent; seeds compressed, often arillate.

Enterolobium saman Prain; the Rain Tree (Syn. *Pithecolobium saman, Pithecellobium saman, Samanea saman* Merrill; Bengali—Belati siris; Tamil—Thoongumoonji maram; Telugu—Nidra ganneru.

A large deciduous tree, 18·2 to 24·3 metres tall, with a short bole and broad, spreading crown, leaves bipinnate, leaflets ovate-oblong, oblique, 2·5 to 3·8 cm long, shiny above aud downy on the under surface, folding and drooping at night-time and on approach of rain. This species is an introduction from South America and is often grown as an avenue tree

and also for shade in coffee and vanilla gardens in Madagascar, as well as a support for pepper vines. In Indonesia and Uganda it serves as a shade tree for nutmeg and coffee but is considered unsuitable for tea.

Flowers solitary, pinkish, grouped in globose heads, 5 cm in diameter. Pods sessile, indehiscent, 15 to 20 cm long and 1·2 to 2·5 cm broad, flattened or sub-terets, with 10–12 seeds embedded in a sweetish pulp.

Propagation is by seeds or cuttings. The tree grows best in warm, moist regions and attains a large size, killing out all grasses and other vegetation beneath its shady crown. In drier regions it tends to branch low and remain small. It withstands lopping and can be maintained at any desired height by judicious pruning.

The foliage and pods are esteemed as a good fodder for livestock. A yield of 13·4 quintals of green leaves can be secured from a five-year old tree. The loppings can also be used as green manure, as they contain 3·25 per cent nitrogen on a dry-weight basis.

TABLE 39. ANALYSIS OF RAIN TREE

	Chemical Composition		
	Green leaves	Pods	Seeds
	%	%	%
Moisture	47·8	15·3	7·6
Crude protein	10·2	12·7	28·6
Ether extract	2·1	2·1	4·3
Crude fibre	15·7	11·4	14·0
Ash	2·0	3·2	3·5
N-free extract	22·2	55·3	42·0

The pods are particularly useful as a rich and palatable feed for cattle and horses, like carob beans (*Ceratonia*), as they contain a sugary pulp. The pods ripen in April-May when other fodders are scarce; they can also be dried and stored for future use. A well-grown tree can furnish about 2·7 quintals of pods in a season, which is almost as good as high quality hay or concentrates in feeding value. When used for feeding, the seeds should be crushed and mixed with the rest of the pods.

Erythrina Linn.

A genus of 50 species of trees and shrubs, usually thorny, distributed in tropical and sub-tropical regions. Eight species are indigenous to India and ten others have been introduced from other countries for growing as shade or support trees, for green manure or for their showy flowers as ornamental plants. The flowers are large and showy, the standard has a long stalk-like base, wing

petals often absent, stamens are mona- or diadelphous, style is incurved and beardless, fruit is a long, two-valved pod, constricted between the seeds.

Erythrina variegata Linn. var. *orientalis* Merrill (Syn. *Erythrina indica*; Indian Coral Tree; Hindi—Dadap; Tamil—Kalyana murukku).

A medium-sized, quick-growing tree, with smooth bark peeling off in papery flakes. The branchlets are armed with conical dark prickles up to the fourth year. Leaves are trifoliate, leaflets 10 to 15 cm long and 10 to 13 cm broad; flowers large, coral-red, in dense racemes. Pods are torulose, 15 to 30 cm long, with 5–12 smooth oblong seeds, red, brown or dark purple. Propagation is by seeds or cuttings. Branches of 7·5 cm diameter strike root readily when planted as 1·8 metres long stumps. For sowing seeds, the ripe pods are collected in June and the seeds extracted and sown 10 to 15 cm apart, in nurseries. The seedlings grow 10 to 15 cm tall by the first year when they can be planted out. The plant is well suited for live fences and as standards for pepper, betel, grapevines, jasmine and other climbing plants.

The leaves and young shoots can be used as cattle fodder and sometimes even as a pot herb. Nearly 203 quintals of green foliage can be secured as loppings from 40 trees of six years growth, to form a good green manure. The green leaves mixed with rice straw in the ratio of 1 : 3 form a nutritious feed for cattle.

TABLE 40. ANALYSIS OF DADAP

	Leaves
	Chemical Composition (on air dry basis)
	%
Moisture	6·9
Crude protein	16·8
Ether extract	5·4
Crude fibre	22·5
Ash	11·3
N-free extract	37·1

Hardwickia binata Roxb. (Tamil—Acha maram, Kattudugu; Telugu—Yepi; Kannada—Kamra).

This is a large tree bearing abundant foliage, which thrives in most localities and soils. It can be planted on tank bunds and waste-land and when full-grown can be lopped occasionally for fodder.

Indigofera teysmannii

This is a quick-growing shrub which can produce a fair quantity of green leafy material in five to six months. Although the plant is usually grown only for green manure, it can also serve for fodder, as it can withstand lopping.

Leucaena glauca Benth.

This is a small tree commonly found in dry tracts. Leaves are bipinnate, leaflets small and in many pairs; flowers white, in close heads, non-papilionaceous; stamens 10, exserted; ovary stalked and many-ovuled. Pod is stalked, flat and without any cross-walls between seeds, seeds six to ten in number. Propagation is by seed. Seedlings are raised in nurseries and planted out later on. The foliage is relished by cattle, sheep and goats, but is likely to prove toxic to non-ruminants like horses, pigs and asses, causing loss of hair and infertility. The leaves can be used to supplement lucerne hay in poultry feeding and the seeds as a concentrate for dairy animals. In Hawaii the leaves are pressed into cakes and used as a nutritious cattle-feed.

TABLE 41. ANALYSIS OF LEUCAENA GLAUCA

	Chemical Composition
	Green roughage
	%
Moisture	70·6
Crude Protein	5·3
Ether extract	0·6
Crude Fibre	9·7
Ash	1·8
N-free extract	12·0
Digestible Crude Protein	3·9
Total Digestible Nutrients	17·5

(From " Wealth of India," 1962)

Mucuna species (Velvet beans). *Mucuna pruriens* is promising as a fodder in Bengal on account of its quick growth and heavy foliage, but as the pods when mature have irritating hairs the forage should be fed when still young and green.

Pongamia glabra Vent. (Tamil—Pungam; Telugu—Kunugu; Malayalam—Ungumaram)

A medium-sized tree which is found all over India on roadsides and waste-lands. The leaves are eaten by cattle, though not very readily. Propagation is by seeds.

Prosopis juliflora Linn. (Mesquite)

This is a quick-growing hedge plant, where the leaves are not eaten by cattle but the pods are relished; these can serve as a nutritious feed when other feeds are not available.

Sesbania grandiflora pers.

A very common shrub in vegetable gardens and betel vine gardens. The leaves are readily eaten by cattle and are believed to increase milk flow in milch animals. Propagation is very easy by seeds and the species can be recommended for growing on paddy field bunds.

CHAPTER 9

CEREAL FODDER CROPS

MAIZE

Genus *Zea* Linn. (Gramineæ)

This is a monotypic genus, containing *Zea mays*, Indian corn or maize. The plant is a robust annual, monoecious, with terminal panicles of staminate racemes (tassels) and short-peduncled, axillary, pistillate, 8 to many-rowed spikes (ears) enclosed in numerous spathes (husks).

Zea mays L. (Maize, American-Indian corn, Corn; Hindi—Makka; Tamil—Makka cholam; Telugu—Makka jonnalu; Kannada—Makka jola)

MAIZE is one of the most important economic plants of the world, serving as food for man and forage for cattle. Its origin is in Mexico and it has been cultivated from pre-historic times by the aboriginal people of America. Even now it is the most important food and forage crop in the New World. In India its cultivation is more recent, but both its area and production are steadily increasing. In 1960–61 maize was grown over 4·35 million hectares. Major areas for maize are mainly in the northern and central parts of India, along the upper and middle Gangetic plain, in the States of Uttar Pradesh, Bihar, Rajasthan, Punjab and Madhya Pradesh.

Description. Maize is almost an ideal forage crop, as it is quick-growing, high-yielding, palatable and nutritious. It can be cut for fodder within two months after sowing and unlike sorghum, there is no risk of prussic-acid poisoning by feeding young plants, although it is not quite so hardy or so widely adaptable to soil and climatic conditions as sorghum. Unlike sorghum, which tends to rush to flower and give smaller outturns when sown from September to February, the yields from maize remain fairly uniform all through the year.

Climate and Soils. Maize thrives best in warm climates, where the day temperatures are fairly high and night temperatures not too low. Heavy rains and dry, hot winds are both unfavourable for maize. Cold spells retard its growth and reduce the yields; frost is also very injurious. In India, the rainfall in maize-growing areas ranges from 38 to 64 cm, in the North-west plains of Rajasthan to nearly 203 cm on the hills of Darjeeling and Kalimpong. During the crop season, the temperatures range from 27 to 35°C. in Rajasthan and Indo-Gangetic plains, down to 10 to 30°C. in the sub-montane Himalayan regions.

Seasons. Maize is grown mostly as a *kharif* crop in West Bengal, Bihar, Uttar Pradesh, Punjab, Rajasthan, Gujarat and Madhya Pradesh.

It is sown with the monsoon rains from the fourth week of June to the beginning of July and harvested by September or early in October. In South India maize makes the best growth between September and February, when sorghum makes only slow growth. Since the yields from maize tend to remain uniform all through the year, unlike sorghum which rushes to flower when sown between September to January, maize is preferred to sorghum as a fodder crop during these months.

Very early-maturing maize varieties are grown during the summer months in river valleys in April and harvested in 70 days, before the onset of the south-west monsoon. In hilly regions maize is planted from March to May; here the varieties mature in 110 to 130 days' time and are harvested in August or September. In Andhra Pradesh and Maharashtra maize is grown within the *kharif* season as a rain-fed crop from June to September and also in the *rabi* season as an irrigated crop from November to March.

Rotations. In the Indo-Gangetic plains the usual rotations are *kharif* crops like maize-jowar-cotton or bajra, followed by *rabi* crops like wheat-barley-mustard-linseed or potatoes. Other rotations are:

(*a*) Two-year rotations: (1) Maize-berseem-jowar-peas
(2) Maize-potatoes-tobacco
(3) Maize-Bengal gram-cotton-peas

(*b*) Three-year rotations: (1) Green manure (Senji)-sugarcane-maize
(2) Maize-potatoes-sugarcane-wheat

Cultural Practices. PREPARATION OF SEED-BED. Two or three ploughings are given to prepare the seed-bed. As most of the red-soils become very hard and the black soils of peninsular India crack deeply in the dry season, many farmers have to wait for the first monsoon showers to soften the land and then give two or three harrowings before sowing maize. In hilly areas hand-hoeing is often the only way to prepare the land for maize.

Maize is usually dibbled in rows behind the plough at a depth of 5 cm, at a seed-rate of 13·4 to 18 kg per hectare for a grain crop and 28 to 34 kg for a fodder crop. In irrigated crops a spacing of 60 cm between rows and 25 to 30 cm plants in the row is adopted for a grain crop. In South India it is usual to broadcast fodder maize at 67 to 90 kg per acre.

MANURING. To ensure high yields in maize, liberal manuring is necessary. Maize is very responsive to both nitrogen and phosphorus and it is good practice to apply 45 to 57 kg of nitrogen and 22 to 45 kg of phosphorus in the form of ammonium sulphate and superphosphate. The fertilizers should be applied in divided doses, half prior to sowing and the other half as a top dressing after the first weeding and again when plants are 90 cm tall. Superphosphate may also be broadcast before the final seed-bed is prepared and worked into the soil by means of a harrow. If a leguminous green manure precedes maize, all the superphos-

phate may be applied to the green manure. Placement of fertilisers in the furrows is found more useful to the crop than broadcasting them.

Maize requires a total of 63·5 hectare/cm of water, supplied in six to eight irrigations, depending upon the duration of the variety grown. The first weeding is given when the crop is 20 to 25 cm high and a second when it is about 60 cm high. For hoeing, bullock-drawn harrows are more convenient when the crop is sown in rows, but in hilly regions hand-hoeing is the only way.

HARVEST. As a fodder crop, it is important to cut maize at the right stage, when the cobs are just being formed, because the feeding value goes down rapidly thereafter. In parts of Maharashtra, maize is dibbled in rows 60 to 90 cm apart when sown for fodder. A fortnight before cutting the plants, maize is again dibbled in rows between the standing rows of maize plants and this " inter-sowing " is repeated five or six times to secure green forage all through the year from the same land.

The yield varies according to the fertility of the soil, the season and type of management, from 157 to 280 quintals of green fodder per acre. The grain yield too, ranges likewise, from 6·7 to 9 quintals per acre. Maize is eminently suited for silage, as it is rich in carbohydrates, which promote vigorous activity of lactic acid organisms and thereby keep down undesirable organisms that give rise to putrefactive odours in silage. The nutritive value of maize silage is enhanced by adding legumes like cowpea or lucerne when filling up the silo pits. Unlike other grasses or legumes, maize requires no previous wilting or any preservative before it is pitted. The best stage to cut maize for silage is the " glazing " stage, when the ears contain about 50 per cent moisture and the leaves and stalks contain 70–75 per cent moisture.

The consumption of maize as a food grain is quite high in India, though perhaps not on the same scale as in America. In some parts of India, maize is the staple diet in the winter months, in the form of flour for making unleavened bread. In parts of Bihar, Bengal and Rajasthan, crushed or ground maize is cooked and eaten as a porridge, with milk or curds. It is also mixed with pulses and vegetables, while at certain seasons (August-September) the roasted green cobs are very popular as a tasty snack.

Pests and Diseases. The most important pests of maize are the following:

(1) Stem borer (*Chilo simplex*): This is widespread and quite severe in the plains of Northern India. The young caterpillars bore into the culms of seedlings and kill the growing plants and cause great damage in certain seasons.

(2) Maize ear worm (*Heliothis* species): The caterpillars of this moth are found in all maize growing areas. Grasshoppers (*Hieroglyphus nigrorepletus* and other species) and bill bugs (*Calandra* spp.) are two of the other major pests of maize. Sprays with some of the modern pesticide

formulations are effective if done in time, but the stemborer is difficult to eliminate.

DISEASES: The worst diseases are:

(1) Leafblight (*Helminthosporium turcicum* and *H. maydis*).

This disease is very serious in the hilly regions of the North and in South India.

(2) Rust (*Puccinia sorghii*) is another disease which is prevalent in the northern hilly regions and in South India.

(3) Stalk and ear rot (*Erwinia carotovora*) occurs wherever maize is grown but is most serious in the Tarai regions of the Himalayan slopes.

(4) Downy mildew (*Sclerospora philippinensis*) is also widespread in the northern plains. Effective control of these diseases is possible only by the evolution of resistant strains.

Sorghum (*Sorghum vulgare* Pers)

Genus *Sorghum* Moench. (Gramineae)

Tall or moderately tall, annual or perennial grasses, native to Africa and Asia, with long, flat laminae and terminal inflorescences of one to five-jointed racemes. Spikelets in pairs, one sessile and fertile, the other sterile and pedicellate, but well developed, usually staminate. Glumes sub-equal, often coriaceous. Lemmas hyaline, lower as long as the glumes or nearly so, empty; upper oblong, two-toothed, mucronate or awned from the sinus, paleas sometimes present, including a bi-sexual floret. Lodicules 2, rather large. Stamens 3, styles 2, free. Grain obovate or linear-oblong in wild species, globose in cultivated ones, free; embryo half as long or more, grain colours various, white, yellow, red or brown.

Young plants contain a cyanogenetic glucoside in sufficient quantities to cause prussic acid poisoning in grazing livestock.

Sorghum vulgare Pers. (The Great Millet, Sorgo; Hindi—Jowar; Tamil—Cholam; Telugu—Jonnalu; Kannada—Jola; Malayalam—Cholam)

Origin, History and Distribution. Next to wheat and rice, sorghum is the most important cereal crop of the world, covering an area of over 32 million hectares. It has been in cultivation since very ancient times in all regions of the tropics where rainfall is low and uncertain. Sorghum is almost unique in its ability to grow over a very wide range of climatic and soil conditions, particularly in climates too hot and too dry for most other cereals. Sorghum is believed to be indigenous to Africa, although both India and China have been claimed to be the home of at least certain varieties of sorghum.

The name sorghum is derived from the Italian '*Sorgo*', meaning 'rising above', to denote its tallness as compared to other cereal crops.

TABLE 42. ANALYSIS OF MAIZE

	Green		Silage		Hay		Straw		Grain	
	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nurrients
	%	%	%	%	%	%	%	%	%	%
Moisture	76·0		71·7		9·5		7·2		8·1	
Crude protein	2·0	59	2·3	58	5·9	46	4·7		9·7	75
Ether extract	0·6	74	0·9	80	0·6	32	1·5		3·0	82
Crude fibre	5·6	63	6·9	65	26·2	73	28·0		2·1	—
Ash	1·3	—	1·7	—	11·3	—	5·3		1·7	—
N-free extract	14·5	73	16·5	75	46·5	61	53·3		75·4	76
Calcium	0·08		0·11		0·43		—		0·46	
Phosphorus	0·11		0·14		0·30		—		0·84	
Potassium	0·45		0·34		0·86		—		0·30	
Digestible Crude Protein		1·2		1·3		2·7		1·0		5·4
Total Digestible Nutrients		16·3		18·7		50·6		39·9		70·5

(After Lander, 1949)

It is the largest as well as the most important amongst the group of cereals known as millets and is hence also known as the Great Millet. Being well adapted to arid and semi-arid conditions it is grown extensively in regions of low rainfall in America, Manchuria and Australia. In India, sorghum is grown over about 17·4 million hectares, mainly in the States of Madhya Pradesh, Maharashtra, Gujarat, Andhra Pradesh, Uttar Pradesh, Madras and Mysore and to a lesser extent in Rajasthan, Bihar and the Punjab. In Bengal, jowar is grown to some extent in Murshidabad, Nadiad, Malda and Rajsahi districts. Regions of heavy rainfall such as the West Coast of peninsular India and Assam grow very little sorghum.

Climate and Soils. Sorghum is a crop that thrives in tropical climates with a temperature range of 25 to 35°C. It is not suited to high elevations of 1,220 metres and above, nor to areas where the minimum temperatures go below 15°C. It is pre-eminently a crop for semi-arid regions in tropical and sub-tropical zones, where moisture is a limiting factor for crop-growth. Being more often a rain-fed than an irrigated crop, it is better suited to the heavier soils that are retentive of moisture than for light soils, although it is capable of growth on almost any soil, red or black, light or heavy, except on very sandy soils. Its greatest vigour and height is attained on the deep alluvial soils of the Godavari deltaic areas or " lankas ", i.e., the islands formed on the river-bed of the Godavari river. Under irrigation sorghum can be grown in all months of the year, although in actual practice, it is sown mainly in two seasons, December-January and March-April. As a fodder crop it is convenient to grow it in staggered sowings in different months for cutting and feeding as green forage. Sorghum as a rain-fed crop is usually sown from June till August as a South-west monsoon crop in the region north of the Vindhyas, but in peninsular India, it can be sown both in the S.W. and in the N.E. monsoon seasons. These are termed, for convenience, as early and late sowings. The early sowings on drylands are sown with the commencement of the south-west monsoon rains in light red soils and late sowings in September with the north-east monsoon rains, in heavier black-soils. The actual sowing times are determined in any locality by the nature of the soil, the duration of the variety and the distribution of the rainfall in that locality. The aim is to get the crop to flower at a time when there are no rains and have the harvest in clear weather.

Cultural Practices. On drylands two to four ploughings are given with the help of summer showers; if no summer rains are received to soften the land, it is ploughed after the receipt of the regular south-west monsoon rains; the seed sown broadcast and covered by ploughing and levelling. Garden lands can be ploughed as soon as the previous crop is harvested and in case the residual moisture is insufficient, a light irrigation is given to facilitate ploughing. Here too, two to four ploughings may be required to get the land into the proper tilth. In the Deccan red soils

are ploughed once or twice and then worked with blade harrows; on black soils, as in Cuddapah, Kurnool, Bellary and Sholapur district, the blade-harrow alone is worked two to four times and ploughing is done only once in two or three years with a heavy plough drawn by two or three pairs of bullocks. Recent experiments indicate that ploughing confers no special advantage in the Deccan black soils. Sorghum requires a firm seed-bed, but a fine tilth is not so essential as for some other crops and so ploughing in these black soils is not really economical.

MANURING. In regions of low rainfall, sorghum is seldom manured. In regions of medium rainfall, i.e. with 76 to 90 cm per year, 50 to 75 quintals of farmyard manure are applied and covered by means of blade-harrows. Sheep-penning and carting tank silt are also prevalent in some areas in peninsular India. In irrigated fields, manuring will be advantageous, especially in the form of 176 to 250 quintals of farmyard manure plus ammonium sulphate to supply 22 to 34 kg of nitrogen, and phosphorus at 11 to 22 kg per hectare in the form of superphosphate to ensure high yields and maintain the soil fertility at a high level.

ROTATIONS AND MIXTURES. Sorghum being such a widely adaptable crop, it figures in most of the dryland rotations of the various regions in India where it is grown. Thus, a three-year rotation of sorghum/cotton/groundnut is prevalent in the Ceded Districts of the Deccan, while in the ' lankas ' of Godavari, sorghum is followed by tobacco or chillies. The main principle in the rotations that are in vogue in different States where sorghum is grown is that a pulse crop should follow sorghum whenever possible. In Salem and Coimbatore districts a common dryland rotation is sorghum/bengal gram/cotton. Another rotation is groundnut sown in April-May to be followed by fodder sorghum sown with the onset of the North-East monsoon. Further south, on the light black soils of Madura, Ramanathapuram and Tirunelveli districts, fodder sorghum is often grown year after year as a rain-fed crop, but this is rather an unusual practice.

The commonest mixture with sorghum is lablab (*Dolichos lablab* var. *lignosus*) or cowpea, although other legumes are also sown in mixture with sorghum such as pillipesara, dewgram and even groundnut, in different parts of the country. Especially for a fodder crop, a mixed crop of sorghum and lablab is an excellent combination, which gives a very nutritious and palatable fodder for all classes of livestock.

SOWING. As a grain crop, sorghum is sown in lines by bullock-drawn drills, especially in the low-rainfall regions of the Deccan and Central India. Broadcasting is also done in many places but it takes more seed, and as the seeds are laid at different depths, when they are covered later on by a plough or blade harrow, the seeds do not germinate uniformly. For a fodder crop, however, especially when irrigated, broadcasting is both sufficient and convenient, as the seed-rate is usually much higher and it is not essential to conserve the seed so carefully.

The seed-rate for a grain crop is from 13 to 22 kg per hectare, for a fodder crop, 56 to 67 kg/ha may be used. Higher seed-rates are used on light soils and regions of low rainfall, where the crop cannot cover the ground fully. In the south of Madras, a very high seed-rate of 90 to 112 kg/ha is used for sorghum, to secure a fine and thin-stalked fodder.

AFTER-CARE. Thinning may be necessary for an irrigated grain crop, but rain-fed crops are not usually thinned, nor is it needed for a fodder crop. Inter-cultivation with blade harrows is done for rain-fed sorghum in the Deccan region, first when the plants are about a month old and a second time three weeks later. Irrigated crops are hoed twice before the plants flower; during the second hoeing the plants are also slightly earthed up.

IRRIGATION. A total of five to seven irrigations, to supply about 50 hectare/cm of water will be needed for an irrigated crop of sorghum. A fodder crop will naturally require more liberal irrigations than a grain crop, because frequent irrigations stimulate shoot-growth rather than grain production.

HARVEST. In grain crops, sorghum is harvested when the grain becomes hard. The straw from a rain-fed crop is quite palatable and nutritious as a cattle-feed, but the straw from irrigated sorghum is apt to be too thick and coarse, and rather poor in feeding value. As a fodder crop, sorghum is harvested when the earheads are fully emerged and the grain is in the milk or early dough stages. Care is necessary not to cut sorghum for feeding animals before it flowers, as otherwise there is a risk of cattle poisoning by the cyanogenetic glucoside contained in the young plants. The risk of poisoning is particularly great in young plants exposed to drought, when they are in a semi-wilted condition. For this reason sorghum is not recommended for pastures. Immature plants from a ratoon crop of sorghum are more poisonous than those from a seedling crop.

Another drawback in sorghum is its depressant " after-effect " upon the succeeding crop, usually cotton, which may show as much as 15 per cent reduction in yield than when it follows bajri. This depressant effect may be overcome by growing a leguminous crop, either as a mixture along with sorghum or following it. Experiments have shown that *Tephrosia purpurea* (wild indigo) was more effective in overcoming the bad after-effect of sorghum than any of the other legumes tried. Wild indigo should be ploughed in as green manure, before the next cotton crop is sown.

Yield. From rain-fed crops about 3·4 to 4·7 quintals/hectare of grain and 9 to 16·8 quintals of straw may be expected, according to the variety, the fertility of the soil and the rainfall distribution. From an irrigated crop 16·8 to 22·4 quintals of grain and 224 to 280 quintals of straw can be expected. As a fodder crop under irrigation, the yield will be 426 quintals of green fodder per hectare, although up to 42·6 q/ha have been recorded with liberal manuring and irrigation.

Utilisation. In India sorghum is mainly a food grain for people in arid and semi-arid regions and fodder for their cattle. In Africa sorghums are grown for food, fodder and also for brewing beer for the grains. In the United States and Australia, sorghum is used not only as grain feed for livestock and poultry, but also for syrup making and for making brooms from special long-panicled varieties of " broom-corn " bred for the purpose.

Sorghum can make excellent silage. The feed value of a hectare of sorghum is about 50 per cent higher when fed in the form of silage than when fed as fodder, as shown by feeding experiments. In spite of this, however, only a very small portion of the sorghum grown is coverted into silage even in the United States, where it is grown in the semi-arid regions of the " Corn Belt ". Sorghum silage is considered superior to maize silage in many respects and another advantage is that sorghum plants that fail to set seed on account of drought can also be converted into good silage, as the silage involves no risk of prussic acid poisoning. Silage made from mature sorghum keeps better; silage from immature plants often becomes too acid. Sorghum silage takes longer to ferment than most other crops, perhaps because the protein is lower than in other crops, which limits the activity of the fermenting bacteria. The addition of small quantities of urea speeds up the fermentation process and also improves the palatability, carotene content and general feeding value of the silage.

Varieties. Varieties in sorghum are very numerous, even in India itself. These are mostly local adaptations evolved through centuries of cultivation for the agro-climatic requirements of different regions and tracts where sorghum is being grown. Many of these are highly season-bound; for example, the variety Periamanjal cholam which is very popular in the districts of Salem and Coimbatore as a long-duration rain-fed crop between July to December, is quite unsuited for growing in any other season or area. The variety Tellajonna is a white-grained, compact-panicled type that is very well adapted to the arid districts of Bellary and Anantapur with 50 cm of rainfall, but does not set seed in other regions. It is sown in August-September and harvested by January-February. The plants are of medium height and leafy, with sweet and juicy stems, and make a good fodder for the cattle of the tract. Patcha Jonna is a yellow-grained variety of four months' duration that is adapted to the Nandyal valley in Andhra Pradesh where the rainfall is higher. The plants grow nearly 2·1 metres tall and being leafy as well as sweet-stalked, make very good fodder, while the yellow grain is much esteemed for making " jonna rotties " or chappaties.

Irungu cholam is a very popular fodder crop in the rain-fed black soils of Tirunelveli, Ramanathapuram and Madurai districts of Madras State. The glumes in this variety are black, red or brown in colour and enclose the grain completely. The grain is of poor quality, but the fodder is excellent, as the crop is sown very thick, using a seed-rate of 90–112

kg 87/ha and the crowded plants grow very thin and fine-stalked, so that cattle eat it with great relish and little waste.

Sorghum varieties that are adapted to areas of fairly heavy rainfall (of 100 to 115 cm) are usually of poor quality as fodder, as for example, Talaivirichan cholam, which is grown for grain in the districts of Chittoor and North Arcot in Madras State. The stalks of this variety are so dry and pithy that they are not relished at all by cattle.

In Maharashtra a number of major varieties are grown, both for grain and fodder. *Nilwa* jowar is a leafy type which is well adapted to the Deccan tract, where it is grown on black soils as a rain-fed crop. It is more drought-resistant and heavier yielding than *Sundhia* jowar, but is nearly a month longer in duration and unless sown thick, using 90 to 110 kg of seed per hectare, the stalks are apt to get thick and coarse. It is not also suitable for sowing after August. For late sowings the variety *Utavli* is better suited. This variety when sown in August can yield by October, nearly 414 quintals of green fodder. *Hundi* is another variety suitable for growing under irrigation both in March and in the cold weather, in the Sholapur district, while *Kalbondi* is a similar short-duration variety adapted to Ahmednagar area. In Gujarat, the *Sundhia* jowar is a popular variety which is adapted to a wide range of soil and climatic conditions. It can grow on almost any fairly fertile soil, both as a rain-fed and as an irrigated crop. In north Gujarat it is the favourite fodder crop and is usually grown under irrigation, but in certain parts of north Maharashtra it is also grown as a kharif crop under rain-fed conditions. *Dudhia* jowar is another variety that is popular in Gujarat, though it is now gradually yielding place to Sundhia, as it is somewhat coarser.

In recent years improved high-yielding strains are being evolved from many centres in India; for example, two new jowars are available for Madhya Pradesh, named Gwalior 82 and Gwalior 304. Both are tall and vigorous types, and especially suited for light sandy and clayey loams in Gwalior, Bhind and adjoining districts and are capable of giving higher outturns of both grain and straw than the local types, within a shorter period, of 110 days from sowing. Similarly, Co 11 is a new variety evolved at Coimbatore from the Patcha jonnas of Nandyal. It combines a good yield potential for grain, a short duration of 105 days and straw with a high content of 40 per cent of sweet juice in the culms. Under rain-fed conditions in soils of only average fertility, it can yield 33·6 quintals of dry fodder per acre, while under irrigation it can yield about 224 quintals/hectare of green fodder per acre within 75 days after sowing. There is, of course, great scope for further improvement in the yield and forage quality in sorghums, by breeding for taller and quicker-growing types and for resistance to the various diseases that lower the nutritive value by defoliating the plants.

Pests and Diseases. The stem borer (*Chilo simplex*) is a very common

and widespread pest on sorghum. The young caterpillars attach themselves to the seedlings and bore into the culms, killing the upper leaves and the growing point. Control is difficult, as the pest is inside the plant and the most practical method is to pull out the affected plants and burn them. The sorghum earhead bug (*Calocoris angustatus*) is another pest which is found in most sorghum fields. The adults and nymphs suck the sap from developing grains and thereby render the earheads undersized, chaffy and unfit for human consumption. The pest can be controlled by dusting with a 2 per cent DDT or BHC formulation during the milky stage of the crop. Grasshoppers and hairy caterpillars are sometimes found on the young crop, but seldom on any serious scale.

Among diseases, covered smut or grain smut (*Sphacelotheca sorghii*) is the most common and destructive. It is found wherever sorghum is grown and especially on crops sown during the colder months. The grains are replaced by short, dirty, grey sacs filled with a black powdery mass of the fungal spores. Being a seed-borne disease it can be effectively controlled by treating the seed before sowing with sulphur dust at 28 gm per 6·8 kg of seed, or with any of the modern fungicide dust formulations such as Thiram, Chloranil or Dichlone, which are more efficient and also non-toxic to humans.

Loose Smut (*Sphacelotheca cruenta*) is less widespread than Covered Smut but is still common enough in sorghum fields. Affected plants are very much stunted, with many tillers, and produce little or no grain. The forage value of the plants is reduced, and the affected earheads show numerous proliferated spikelets with hypertrophied glumes that resemble miniature plants. Seed treatment with fungicide dusts is effective in controlling this disease also.

Head Smut (*Sphacelotheca reiliana*, syn. *Sorosporium reilianum*) is a sporadic disease found in all districts where sorghum is grown. As a rule, only a few plants are affected, but in some seasons and areas, it may cause serious loss of crop. At flowering time the inflorescence within the boot is completely changed into a large, whitish gall or " sorus ". These sori are often large, 5×10 cm and irregularly oval and on rupturing are seen to be full of black, powdery spores. Since this disease is soil-borne and not seed-borne, the only way to keep it in check is to uproot and destroy affected plants before the spores get scattered. Long Smut (*Tolyposporium ehrenbergii*) is a disease in which a varying number of grains on the earhead are changed into spore-sacs of the fungus, into elongate cylindrical structures about 12 mm long and 6 mm in diameter, with a thick, light-yellowish membrane enclosing a solid mass of spores inside and also eight to ten long, dark-brown filaments, which represent the vascular bundles of the

ovary. The infection in this disease is air-borne and so the control lies in a suitable adjustment of the sowing dates. Usually earlier sowings are able to escape the infection.

In addition to these, other diseases like the leaf blight (*Helminthosporium turcicum*), anthracnose (*Collectotrichum graminicola*) and bacterial blights attack sorghum wherever it is grown as a rain-fed crop and take a steady toll every season. Certain other diseases such as the downy mildew (*Sclerospora sorghi*) are very common in some areas and seasons but not in others. For instance, *Sclerospora sorghi* is very common in South India. The upper leaves in young plants become yellow and turn brown; in older plants the lower surface shows a white downy growth of the fungus mycelium. Earheads are not formed and so the yields are very much reduced. This disease is believed to be soil-borne and control consists in the removal and burning of infected plants before they dry up.

Striga is a pest on sorghum in many parts of the world and especially in Asia and Africa. It is a phanerogamic parasite (*Striga lutea* and *Striga hermontheca*), the minute seeds of which lie dormant in the soil and sprout along with sorghum seeds or other cereal crops and establish haustorial connection underground with the root-system of the cereal host plants. In severe infections the entire crop assumes a scorched appearance and yields are much reduced. Timely spray treatment with some of the recent selective herbicides such as 2, 4-D will help in controlling this parasite

TABLE 43. ANALYSIS OF SORGHUM

	Green (Milk stage)		Hay		Straw (Dry basis)	
	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients
	%	%	%	%	%	%
Moisture	67·0		9·0			
Crude protein	1·1		4·9		5·6	32
Ether extract	0·5		1·5	37	1·5	38
Crude fibre	11·5		34·0	58	28·9	74
Ash	2·9		9·2		8·7	
N-free extract	17·0		41·4	62	55·3	50
Calcium	0·22		0·61		0·43	
Phosphorus	0·09		0·56		0·32	
Potassium	0·80		2·24		—	
Digestible Crude Protein				—		1·05
Total Digestible Nutrients				46·6		50·8

(After Lander, 1949; Sen & Ray, 1964)

on sorghum. Effective control is, however, possible in most of these diseases only by the evolution of resistant strains.

THE LESSER MILLETS AS FODDERS

The name millets is applied to a group of cultivated annuals belonging to several genera in Gramineae. They are used for both grain and fodder purposes and have the common feature of being able to come up on land that is too poor and too dry for other crops. They are hence very useful as " catch-crops " or emergency crops on land which for various reasons could not be got under a crop earlier in the year. These millets have the desirable feature of being quick-growing and coming to harvest within three or four months after sowing. They can thus fit in well into various rotation systems. As forage crops they are palatable to stock and have a high feeding value and can be utilised for hay or silage even when badly lodged.

In Africa, China, India, Korea and Japan and in Russia these millets are grown extensively for food. In the United States only the ' broom corn ' is grown for grain, the other varieties are grown for only fodder purposes. In China, broom corn (*Sorghum nervosum*) and foxtail millet (*Setaria italica*) are most common. In India, sorghum, the spike or bulrush millet, finger millet, foxtail millet, little millet, proso millet and barnyard millet are all grown for grain as well as for fodder. In Korea and Japan, considerable Proso millet (*Panicum miliaceum*) and foxtail millet (*Setaria italica*) are grown. Japan also grows barnyard millet (*Echinochloa frumentacea*) over large areas. In Russia, especially in the South-east regions, much Proso millet and Broom corn are grown. In the U.S.A., the foxtail millet is important for forage purposes, but the importance of millets has declined during the last ten to fifteen years.

Bajra

Pennisetum typhoides Stapf & Hubb. (Pearl millet, Spike millet, Bulrush millet; Hindi—Bajra, Bajri; Tamil—Cumbu; Telugu—Sajja; Kannada—Sajje.)

Description. Erect, annual culms, one to many, robust, often 1·8 to 2·4 metres tall, densely villous below the panicle, laminae flat, 91 to 122 cm. long and 2·5 to 5 cm, wide, panicle stiff, spike-like and very dense, varying in length from 10 cm. to 91 cm. spikelets short-pedicelled, two in a fascicle, 3–5 mm. long, obovate, turgid. The grain at maturity protrudes from the hairy-margined lemma and palea.

This millet is usually grown only for grain, but can also serve as a quick-growing forage crop under irrigation, which is nearly equal to sorghum as a green fodder. Unlike sorghum, there is no risk of prussic acid poisoning and cumbu can be cut and fed even before flowering.

Another advantage is that it can give a second cutting after a first cut is taken when the crop is 2½ to 3 months old. Under favourable conditions, several cuttings can be taken in the course of a year, giving a heavy tonnage of green fodder. As early as 1879, it was found to yield at the Saidapet Farm, 168 q/ha. of green forage within 75 days of sowing. For the Kerala Coast, cumbu is better suited than sorghum.

TABLE 44. ANALYSIS OF BAJRA

	Green roughage		Grain	
	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients
	%	%	%	%
Moisture	78·4		12·5	
Crude protein	1·5	62	8·3	87
Ether extract	0·3	67	4·1	64
Crude fibre	6·9	60	1·1	3
Ash	2·4	—	1·97	—
N-free extract	10·5	69	72·0	90
Calcium	0·15			
Phosphorus	0·07			
Potassium	0·73			
Digestible Crude Protein		0·9		
Total Digestible Nutrients		12·8		

(After Lander, 1949; Mukherjee and Parthasarathy, 1948.)

Ragi

Eleusine Gaertn (*Gramineae*). (From Greek *Eleusis*, the town where Demeter, the Earth goddess, was worshipped.)

A small genus of annual or perennial grasses, distributed all over the tropical and subtropical regions of the world. Four species occur in India, of which *Eleusine coracana* is cultivated as food grain and a few others used for fodder.

Eleusine coracana Gaertn. (Finger millet; Sanskrit—Rajika; Hindi—Mandua; Tamil—Ragi, Kelvaragu; Telugu—Ragulu; Kannada—Ragi; Malayalam—Muthari.)

E. coracana is considered to be a cultigen of the wild species *E. indica*, a species that was native to India (or Africa) but which is now occurring throughout the warm regions of the world. It differs from *E. indica* only in its stouter habit and broader spikes.

Eleusine coracana is an erect, tufted, annual grass, 60–122 cm. tall, with tillering culms laterally flattened, bearing a whorl of digitately incurved

Fig. 5. *Pennisetum typhoides*

1. —Plant (×1/10); 2., 2a. —Spikelets (×10); 3. —Grain (×10).

spikes, 13 to 15 cm. and 1·2 cm. broad; spikelets numerous, 70 to 100, arranged alternately on the rachis, each spikelet contains four to seven seeds, 1–2 mm diameter, nearly globose, varying in colour from dark brown to creamy white.

Ragi is a popular crop in India, East Africa and Somaliland where it is the staple food of a large section of the population. The grain is also used for malting and brewing. In India ragi is grown over 2 to 2·4 million hectares on a wide variety of soils. It tolerates salinity better than other cereals. The yield varies from 5·6 to 7·8 q/ha of grain and 11·2 to 22·4 q of straw from rain-fed crops and up to 51.5 q of grain and 89·6 q of straw from irrigated crops. Though the straw by itself is only an indifferent fodder, it improves on ensilage and is then well-relished by cattle.

In the Punjab, ragi is grown mainly for fodder purposes, yielding about 134 q green forage per acre in three cuttings. Ragi straw is a nutritious fodder and may be fed green or as hay. The growing plant is considered quite nutritious as growing oats, but once the grain ripens, the straw loses its fodder value. Ragi straw from irrigated crops is tough and fibrous and makes poor fodder, but it improves on stacking, as fermentation occurs and makes it less tough and more palatable. Rain-fed ragi straw is, however, of good quality and is readily consumed by cattle. In Mysore it is an important fodder, being rated as even superior to sorghum straw.

The green straw is suitable for making silage, which is sweet-smelling and consumed by cattle without any wastage.

TABLE 45. ANALYSIS OF RAGI

	Silage		Straw	
	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients
	%	%	%	%
Moisture	7·30			
Crude protein	4·3	8	3·7	6
Ether extract	1·3	44	0·9	41
Crude fibre	8·1	69	35·9	69
Ash	4·1	—	8·1	—
N-free extract	9·2	52	51·4	58
Calcium			1·11	
Phosphorus			0·16	
Potassium			1·50	
Digestible Crude Protein				1·22
Total Digestible Nutrients				18·7

(After Lander, 1949.)

Setaria italica Beauv.

Genus *Setaria* Beauv.

Annual or perennial grasses with narrow terminal panicles, either dense and spike-like or loose and open. Spikelets awnless, but subtended by one or more bristles (sterile branches and branchlets); first glume broad, less than half of the length of the spikelet, 3–5 nerved; second glume and sterile lemma equal, several-nerved; fertile lemma coriaceous-indurate, smooth or transversely rugose.

Setaria italica Beauv. (Italian millet, Foxtail millet, German millet; Hindi—Kangoone; Tamil—Tenai; Telugu—Korra; Kannada—Navane; Malayalam—Thena.)

Foxtail millet was cultivated in China as early as 2,700 B.C. and was introduced into Europe much later, although seeds of this millet have been found in early remains such as those of the Swiss lake-dwellers of the Stone Age. In America this species is used for hay, while in India it is a crop of the poorer soils and drier regions, cultivated from very early times.

An erect annual, growing to a height of 102 to 114 cm., with slender culms. The leaves are flat and extend well up to the top of the culms. The inflorescence is a terminal, cylindrical panicle, often arching towards the tip; in some varieties they are drooping, loose and open. There are one to four bristles at the base of each spikelet, these give the ' foxtail ' look to the panicle. The seeds are small, convex and enclosed in the hard inner glume and its palea. The hulls are of various colours in different varieties, from creamy-white to orange-red and even purple. A large number of varieties are grown in different countries and are known by various names such as German millet, common millet, Italian millet, Hungarian millet, Siberian or Kursk millet. Some have very short durations and can be cut for hay in 45 days from sowing date.

Climate and Soils. Foxtail millet can thrive only in places where warm weather prevails during its growing period. It does not grow well at high elevations or cool regions. Although its water-requirement is low, the plant has no power of recovery after a spell of drought and its so-called drought-resistance is in fact an escape from drought by means of a short growing season. It thrives best on rich, loamy soils, even though it is often sown as a catch-crop in poor soils.

The seed-rate varies from 6·7 to 9 kg/ha in drill-sown crops in Andhra Pradesh to 9·6 to 10·1 kg in parts of North America; the usual quantity is 11 to 17 kg per hectare. Covering of the sown seed is done by means of a spike-tooth or blade harrow. Foxtail millet is free of any serious pest or disease, except occasional rust on the leaves which is seldom serious and sporadic infestation by cinch-bugs.

About 78 to 90 q/ha of hay may be obtained from an irrigated forage crop cut at the flowering stage. As a soiling crop it is not so good as sorghum or bajra; the latter has the advantage of larger yield and a second growth. In feeding value too, it is usually ranked as inferior to other grasses, even though the chemical analysis shows it to be the equal of Johnson grass. For pasture purposes, millets in general are not suitable and foxtail millet is specially unsuitable.

Setaria straw is thin-stemmed and liked by cattle, but in South India, it is not usually fed to milch animals, as it is believed to reduce milk flow and to induce cows in calf to abort. Setaria hay is also regarded in some tracts as injurious to horses, if fed exclusively.

TABLE 46. ANALYSIS OF SETARIA (*S. intermedia*)

	Chemical Composition (on dry basis)
	%
Crude Protein	11·96
Ether extract	2·25
Crude fibre	33·35
Ash	14·82
N-free extract	37·52
Calcium	0·49
Phosphorus	0·29
Potassium	—

(After Sen and Ray, 1964.)

Panicum miliaceum L.

Genus *Panicum*

Annuals or perennials of various habit, distributed in warm regions of the world. Inflorescence an open or compact panicle. Spikelets somewhat compressed dorsiventrally, glumes two, unequal, the first often minute, the second equalling the sterile lemma, fertile lemma chartaceous-indurate, typically obtuse, with margins inrolled over the enclosed palea of the same texture.

Panicum miliaceum (Proso millet, Hog millet, Broomcorn millet; Hindi—Barri; Tamil—Panivaragu; Telugu—Varigalu; Kannada—Baragu.)

This is a popular catch-crop and cereal food-grain in many parts of the world in the tropics as well as sub-tropical regions. It is probably native to Central Asia. The inflorescence is a much-branched panicle, but there are no bristles as in *Setaria*. The seeds may be creamy white,

yellow, red or black. The grain serves as the poor man's standby and famine reserve. It is, however, rich in protein and equal to wheat in nutritive value. The yield is 2·2 to 5·6 q/ha grain from rain-fed crops with the straw yield more or less equal to grain. Under irrigation they may be 11 to 17 quintals per hectare. The straw is considered a good fodder. In North America it is grown as a forage crop and the grain is used as a feed for pigs and poultry. The hay is not, however, so good as foxtail millet, being less leafy and more fibrous, the yield too is small, being only 25 to 38 q/ha.

Panicum miliare (Little millet; Hindi—Savan; Tamil—Samai; Telugu—Samulu.)

This is another small-grain millet of poor soils and marginal lands. The grain is a famine reserve. The straw is thin-stemmed and liked by cattle, but is not very nutritious; in North India it is rated so low that it is usually consigned to the manure pit. On the Nilgiris it is quite popular, both as a grain crop and as green manure.

Genus *Echinochloa* Beauv. (Gramineae)

Annual or perennial grasses, often tall, coarse and succulent, distributed throughout the warmer regions of the world. Culms robust, often flattened, leaves linear, flat. Inflorescence is a crowded panicle of loosely arranged spiciform branches, rachis triquetrous. Grain broadly elliptic, plano-convex.

All the species are eaten by livestock, but many grow in situations where their utilisation is difficult. Several forms are cultivated in tropical Asia and Africa as food crops of the poor. Three species occur in India.

Echinochloa colona Link (Syn. *Panicum colonum* Linn.; Hindi—Swank, Jharua; Tamil—Varsanum pillu; Telugu—Otha gaddi).

A tufted annual, growing 60 to 90 cm tall, with flat glabrous leaves, found all over India up to 1,830 metres elevations, in moist situations. Being quick-growing and succulent, it is useful as a fodder grass, relished by cattle at all stages of growth. Its nutritive value is higher when in grain. It grows abundantly in the ' tarai ' region and eastern districts of Uttar Pradesh. In the Nainital area, stock owners actually prefer this grass to other grasses in the market, as they consider it good for stimulating milk yields in milch buffaloes and for fattening cattle. In the Nagla State Farm, it was able to give three cuttings between July and September, yielding over 336 quintals per hectare. Another advantage in this succulent grass is that it need not be chaffed, even for feeding calves. The hay can be stored for five to six years and is considered to improve the condition of cattle. The grain is eaten by poor people in times of famine.

TABLE 47. ANALYSIS OF SWANK

Chemical Composition	Hay
	%
Moisture	11·1
Crude protein	5·6
Ether extract	1·1
Crude fibre	36·3
Ash	7·2
N-free extract	38·7
Calcium	0·30
Phosphorus	0·19
Potassium	1·78

(After Lander, 1949)

Echinochloa crusgalli Beauv. (Syn. *Panicum crusgalli* Linn.; Barnyard millet, Japanese millet; Hindi—Sanwak; Tamil—Oothu pillu; Telugu—Pedda wundu; Kannada—Kaadu dabbai hullu).

This species is taller than *E. colona*, growing to a height of 91 to 122 cm. with flat linear leaves and smooth, ovoid grain. It is found throughout India in moist places and is sometimes cultivated as cattle fodder. It is suitable for silage but not for hay. It is grown in North Gujarat on light soils in February-March to be fed green to cattle. The crop can be cut in 60-70 days after sowing and yields from 34 to 78 q/ha of dry fodder (about three times as much, when green).

The grass has been recommended for reclamation of saline and alkaline soils in Egypt. The grain is sometimes consumed as famine food.

Echinochloa frumentaceum Link. (Syn. *Panicum frumentaceum* Roxb.; Hindi—Sanwa; Tamil—Kudiraivalu pillu; Telugu—Bontha shama oodalu; Kannada—Savai).

This species is taller and more robust than *E. colona*, with dense, somewhat corymbose panicles, broad leaves, large spikelets and smooth, shiny seeds, rounded at the base and sharp at the apex. It is cultivated as a rain-fed crop in many places in India and on the Himalayan slopes up to 1,980 metres. The straw makes good fodder. As a food crop it is one of the lesser millets and of only limited importance, but it is one of the quickest-growing of all plants and so it is suited for growing as a catch-crop or for fodder in rough jungle lands, light soils and in water-logged areas. In China and Japan it is said to be grown as a substitute crop when the rice crop fails.

This species was once advertised by seedsmen in the U.S.A. as a " billion dollar " grass for forage. Although it did have some forage

value, it was found to need much moisture to yield well and was also too succulent for hay-making, though suitable for ensilage. In Japan it is used for feeding dairy cows. The straw is considered inferior to even ragi and paddy straw in Madras and Mysore.

Cultural Practices. The seeds are sown broadcast in June-July, at 9 to 11 kg. per hectare or else drilled in rows 30 cm. apart, in which case 7 to 9 kg. per hectare would suffice. No irrigation or manuring is given. Harvest is by September-October, yielding 6·7 to 9 q of grain and 90 to 111 q of straw per hectare. In the Punjab the crop is sometimes ploughed in as green manure. The grain is eaten mostly by the poorer classes, but sometimes it is brewed for beer and also used as a feed for caged birds.

TABLE 48. ANALYSIS OF ECHINOCHLOA FRUMENTACEUM

Chemical Composition	Dry Roughage	Grain
	%	%
Moisture	11·1	11·9
Crude protein	5·6	6·2
Ether extract	1·1	2·2
Crude fibre	36·3	9·8
Ash	7·2	4·4
N-free extract	38·7	65·5
Calcium	0·30	0·02
Phosphorus	0·19	0·28
Potassium	1·73	—

Echinochloa stagnina Beauv. (Syn. *Panicum crusgalli* Linn.) *P. stagninum* Retz; Hindi—Dul; Telugu—Bontha oodu; Kannada—Kaadu dabbai hullu).

A perennial or annual, 91 to 120 cm tall, with soft, succulent culms and flat leaves marked with purple bands, found in all wet situations in India, often partly submerged, distributed in most parts, from sea-level to 910 metres. The grass is regarded as a good fodder, both green and as hay, as the culms are rich in sugars, (sucrose 10 per cent and reducing sugars 7 per cent). The grain serves as famine food and the straw is used for thatching.

Oats (*Avena sativa* Linn.)

Genus *Avena* L.

Low or moderately tall annuals or perennials with narrow or open, usually few-flowered panicles of large spikelets. The most important species is

Avena sativa, the oats of temperate countries, which is often cultivated as a fodder crop.

Avena sativa Linn.

Origin, History and Distribution. Oats ranks next to wheat and barley in importance as a food crop of the temperate regions and has been cultivated from ancient times in most countries of the West. In India oats are cultivated mainly in the Punjab and Uttar Pradesh, where it ranks next to wheat and barley as a food crop, on account of its longer duration.

Description. The plant is an erect annual, with lax, effuse panicles and long grains; glabrous or hairy at the apex, enclosed within the lemma and palea, which are often awned.

Climate and Soils. Like wheat and barley, oats are grown mainly in temperate regions and cool sub-tropical places. It grows well on most soil types, except on very sandy or alkaline soils. Where the sub-soil is sandy and pervious, it can grow even on slightly alkaline lands. Oats require the same soil and climate as wheat, but mature later and need more water. In India, oats are grown wherever horse-breeding is practised, as it furnishes a highly sustaining forage during the winter months. In places where the water facilities are not sufficient to grow berseem, oats are a good substitute.

Cultural Practices. Oats require a well-prepared and firm seed-bed for good germination. Usually two ploughings are given in medium loams, followed by two harrowings, but on heavy clays that are inclined to be cloddy, two more ploughings may be needed and sometimes a clod-crusher as well, before the harrowings can be given. The land is given an initial soaking irrigation before the final harrowing to get a smooth surface, otherwise the germination is likely to be defective. Oats needs a fertile soil and also responds well to fertilisers. Whenever oats follows a leguminous crop in the regular rotations, the yield is higher than when it follows a non-leguminous crop and in such a case it is necessary to apply ammonium sulphate to supply 45 kg. of nitrogen and superphosphate to supply 22 kg. of phosphorus per acre to the field before sowing the crop. Oats can be sown from October till December. For forage purposes, 67 to 112 kg/ha. are drilled in rows; for a seed crop about 45 to 67 kg/ha. can be used. In order to secure a continuous supply of green fodder from January till April, it is better to have the sowings staggered at fortnightly intervals, from October till December.

A mixture of peas (*Pisum sativum*) if sown along with oats, enhances the feeding value of the fodder and this is a common practice in many places. Four or five light irrigations, at monthly or three-week intervals, will be required during the growth period.

There are many varieties in oats, but all are of high feed value, if cut at the flowering stage or soon after. Broad-leaved varieties give a higher forage yield, but narrow-leaved varieties are more esteemed, particularly for horses and milch cattle.

Utilisation. Two cuttings are possible from a well-grown field of oats. The first cutting may come to 168 to 224 q of green fodder per ha and the second, about 90 q. Often the first cut alone is utilised as fodder and the crop is then left for seed, but in that case, the maturity is delayed and the grain yield is also lower than normal. A normal grain yield is from 11 to 13 q/ha and the straw yield about 34 to 39 q/ha.

Oats fodder can also be dried and stored as hay. The bhusa left after threshing out the grain is also useful as a dry fodder. The green forage is well relished by all livestock, being sweet and nourishing and it is esteemed as of special value for dairy animals because it reduces the cost of feeding concentrates and cattle can be maintained in good condition on oats at a time of the year when fodder supply is both scarce and costly.

Pests and Diseases. As one of the four main cereal crops of temperate regions, many of the pests and diseases on oats are the same as those found on wheat, barley and rye.

Among the important diseases on oats, root rots are caused by *Helminthosporium victoriae*, *H. avenae*, *H. sativum*, *Colletotrichum graminicola*, *Pythium* spp., *Fusarium graminarium*, *Rhizoctonia solani*, take-all disease, (*Ophiobolus graminis*). These root diseases are rather insidious and have no spectacular symptoms. Infected plants may often reach maturity, although the vigour and yield are much less than normal. The general symptoms are, discoloration of roots and bases of culms, yellowing and bleaching of foliage, and premature death of adult plants. Many of these root-disease pathogens also attack the upper parts of the plants and cause head and seed blights, foliage lesions and rotting of the nodes.

Colletotrichum graminicola is one of the major diseases of oats. The fungus produces a cushion-like outgrowth at the base of the stem near the surface of the soil. In *Pythium* root-rot the symptoms are reddish-brown lesions on the roots and loss of green colour on the lower leaves. Take-all disease on oats is liable to occur on non-acid soils and is severe on alkaline soils.

Control measures for these root diseases are difficult and apart from adopting good farming practices like proper crop-rotations, summer fallows and timely sowings, the breeding of resistant varieties is the only effective method of control. Seeds should not be sown too deep, but only just deep enough to provide adequate moisture for germination.

Among the leaf diseases, the rusts are the most important and cause as much as 80 per cent losses of yield. They are found wherever oats are grown. Stem rust is caused by *Puccinia graminis avenae* and crown rust by *P. coronata avenae*. In stem rust the pustules occur near the neck

of the plants and are longer and darker (brick-red) in colour, whereas in crown rust the pustules are circular in shape and orange in colour. These pustules spread and often coalesce, rupture the epidermis and release myriads of spores to get wafted by wind and spread and the disease to other plants. Crown rust (syn. leaf rust or orange rust) occurs mostly on the leaves, although it is found sometimes on the leaf-sheaths, culms and panicles as well. This is the most destructive disease of oats and attacks many other grasses also. Warm moist weather favours crown rust development. In dense stands as in fodder oats, moisture from rain and dew is held longer on the plants and this favours the spread of the disease.

Control of rust is possible by the use of resistant varieties, eradication of alternate hosts like barberry and buckthorn and by dusting the crop with fungicides. In practice it is difficult, because the dusting has to be done before any rust symptoms appear on the leaves. Septoria blight caused by *Septoria avenae* is common on oats and other cereals and grasses. The lesions on the leaves are irregular in shape, size and colour. The leaf and culm tissue surrounding the lesions turn straw-coloured. Golden-brown pycnidia form beneath the leaf surface with an opening to the surface to release the spores.

Smuts on oats were among the first cereal diseases to attract the attention of early workers on plant diseases. The loss of yield from smuts may be as much as 30 per cent. The smut spores germinate when the oat seed germinates and grows inside the seedling, eventually to form spores in the transformed oat spikelets.

Loose smut on oats is caused by the fungus *Ustilago avenae*. It destroys all the floral parts, including the glumes so that the spores are quickly scattered in the field itself, leaving behind only a denuded panicle skeleton. In the covered smut (*Ustilago kolleri*) the spores are produced inside balls enclosed by the glumes. The infected oat panicles ripen early, but the spore balls remain intact, until broken in harvesting. Then the spores get distributed over the surface of the healthy seeds.

Control is relatively easier and more effective in smuts than in other diseases of oats. Seed treatment by organo-mercuric fungicides like Arasan, Spergon, Dow 9-B and Dithane, at the rate of 2 gm. per kg. of seed would effectively prevent smut infection.

Teosinte (*Euchlaena mexicana* Schrad.)

Genus *Euchlaena* Schrad. (Gramineae)

A small genus of annual or perennial grasses, native to Central America, of which one species, *Euchlaena mexicana*, has been introduced into India as a fodder plant.

TABLE 49. ANALYSIS OF OATS

	Green roughage		Silage		Hay		Straw		Grain	
	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients
	%	%	%	%	%	%	%	%	%	%
Moisture	83·8		72·1		7·0		10·4		8·9	
Crude protein	1·6	72	2·3	65	5·2	47	4·0	22	12·0	78
Ether extract	0·4	50	0·8	61	1·6	74	2·3	33	4·7	88
Crude fibre	4·3	76	11·1	77	33·4	65	36·1	59	10·6	38
Ash	1·8	—	2·6	—	7·8	—	6·0	—	3·6	—
N-free extract	8·1	79	11·1	61	45·0	64	41·2	49	60·2	81
Calcium	0·17				0·43		0·50		0·13	
Phosphorus	0·19				0·35		3·00		0·76	
Potassium	1·14				2·27		2·00		0·48	
Digestible Crude Protein		1·2		1·5		2·5		0·9		9·4
Total Digestible Nutrients		11·4		17·7		55·6		44·1		71·5

(After Lander, 1949.)

Fig. 6. *Euchlaena mexicana*

1. —Plant, much reduced (×1/12); 2. —Pistillate inflorescence; 3. —Pistillate inflorescence with some bracts removed; 4. —Dorsal view of fertile spikelet, showing first glume; 5. —Lateral view of fertile spikelet.

Euchlaena mexicana Schrad. (Syn. *E. luxuriana* Dur. & Aschers; Hindi—Makchari, Makhya bajra).

Origin, History and Distribution. This plant is a wild relative of maize and is a native of Central America. It is a tall, leafy, succulent annual, growing to a height of 1·8 to 3·6 m in large clumps with numerous basal-branching tillers. The leaves are smooth and broadly linear, about 90 cm long and 5 to 7·5 cm broad. It was first introduced to India in 1881 at the Saidapet Farm near Madras and has since then become a popular forage crop in many parts of the country. In the Punjab it is recommended for growing as a green fodder in the fodder-scarce months of May–June and October–November.

The plants are monoecious, like maize, with the male inflorescence in a terminal " tassel " and the female flowers in small " ears " at the leaf axils. The plant hybridizes easily with maize, but unlike maize, it is unaffected by any serious pests or diseases. The seeds are about 8 mm long, somewhat angular and vary in colour from dark-brown to creamy white.

Climate and Soils. Being a tropical species, teosinte can be grown in warm, humid regions with an annual rainfall of 101 cm and more; in drier regions it needs irrigation to supplement the seasonal rains. Like maize, teosinte too, needs a rich, well-drained loamy soil for its best growth. On poor soils liberal manuring will be necessary.

Cultural Practices. It is usually grown in the *kharif* season, the seeds being sown from March up to August, either broadcast or drilled in rows 46 cm apart. A seed-rate of 22 to 45 kg/ha is usual, but in Maharashtra and Gujarat, a lower seed-rate of 16.8 kg/ha is preferred. Early sowings in March provide two cuttings by June; later sowings in July provide a heavy single cut by October. In either case, teosinte furnishes green fodder in periods when other green fodder is usually scarce.

One interculture should be given when the plants are 23 to 30 cm tall, to keep down weeds. Teosinte requires more water than maize, and four to five irrigations would be found necessary during the growing period.

Manuring with 125 to 200 quintals of farmyard manure or compost or 112 kg/ha of ammonium sulphate or mixed fertilisers would be helpful in ensuring profitable returns. The first cutting can be taken in 3 to $3\frac{1}{2}$ months after sowing and one more cutting can be taken at intervals of six or seven weeks. The yields range from 179 to 448 q/ha under irrigation and 168 to 224 q under rain-fed conditions.

When grown for seed, the crop is harvested in November and allowed to dry for a week before threshing. The grain yield is about 6·7 to 13·4 q/ha. The dry straw can be fed to bullocks and the grain (or seed) itself can be used in the form of flour in cattle rations to a limited extent.

Utilisation. Teosinte is used mostly as a green fodder, though it is reported to make both good silage and hay. To improve the quality and quantity of the forage, it is desirable to grow teosinte in mixture with cowpeas, velvet-bean or soybeans. Compared to maize or sorghum, teosinte fodder is rather coarse, but it is well relished by cattle.

TABLE 50. ANALYSIS OF TEOSINTE

	Green fodder		Hay	
	Chemical Composition	Digestibility Co-efficients	Chemical Composition	Digestibility Co-efficients
	%	%	%	%
Moisture	78·7		10·6	
Crude protein	1·7		9·1	
Ether extract	0·5		1·9	
Crude fibre	6·7		26·4	
Ash	2·0		10·3	
N-free extract	10·4		41·7	
Calcium	0·34		—	
Phosphorus	0·09		0·39	
Potassium	0·25		1·06	
Digestible Crude Protein		1·0		4·7
Total Digestible Nutrients		13·7		54·9

(After Lander, 1949.)

CHAPTER 10

PERENNIAL CULTIVATED GRASSES

Para Grass (*Brachiaria mutica* Stapf.)

Genus *Brachiaria* Griseb (Gramineae)

A large genus formerly grouped with *Panicum*, comprising about 100 species of annual and perennial grasses distributed in tropical and sub-tropical regions. About 15 species are found in India, of which six are fodder grasses.

Brachiaria mutica Stapf. (Syn. *Panicum muticum* Forsk, *Panicum purpurascens* Raddi; buffalo grass, Para grass, Mauritius grass, water grass).

Origin, History and Distribution. This grass is indigenous to Brazil, but has now been introduced in many other warm countries as it grows well on all soils and not only withstands water-logged conditions but can actually thrive therein. It is well-suited for wet-land areas where other grasses will not thrive. This grass was introduced into India probably in 1894 in Poona, but although it was found quite promising there, its fodder possibilities have been recognised only in recent years. It is now grown in the Aarey Milk Colony in Bombay, Bangalore, Quilon in Kerala State, and many other places in India.

A coarse-looking perennial grass, spreading rapidly by surface runners which root profusely at the nodes and bear erect, leafy culms growing up to 1·8 metres in height. Stems rhizomatous with ascending branches; culms hollow, succulent and glabrous with hairy nodes. The leaf-blades are dark-green in colour, 30 cm long and 1 to 2 cm broad. The inflorescence is an open panicle about 15 cm long.

The grass prefers a warm, humid climate and moist situations. It grows well on field bunds, banks of canals and on soils too wet for normal farm crops, but being sensitive to cold it makes no growth during the winter months in the sub-tropical regions of India. The grass can be grown on sandy soils also, provided the water supply is sufficient.

Cultural Practices. The grass can be established in the same manner as Napier grass, but the ridges should be closer, i.e., about 60 cm apart for planting the slips. Since seed-setting is poor in this grass, propagation is almost exclusively by planting slips, in a well-prepared level field, with plots of 10 cents area and the irrigation channels laid out carefully. Thin, straggling shoots of the grass are used as planting material cut into lengths of 30 to 45 cm, each with two or three nodes and these slips are planted

13 cm apart in the row, leaving the two ends sticking up and irrigated immediately after planting. Under irrigation the planting is best done in March, but as a rain-fed crop it should be planted at the beginning of the monsoon months. Rain-fed crops are possible with this grass only in regions of high and well-distributed rainfall, where the soil would remain moist for a number of months in the year.

In the initial stages of growth the plant sends out surface runners which root at the nodes and erect shoots are produced only after the field is completely covered by these surface runners, so that the first cutting in this grass is apt to be rather delayed.

Being a water-loving grass, liberal irrigations at fairly close intervals are necessary, both for establishing the stand and for profitable returns. The intervals between irrigations should be adjusted so as to keep the land always moist. Liberal manuring is also necessary to secure the maximum yields from this grass. Sullage water or cattle-shed washings are ideal for this crop. A basal dose of 376 to 502 quintals/ha of farm-yard manure, compost or sludge, followed by a top-dressing of 168 kg/ha of ammonium sulphate or a complete manure mixture after every two or three cuttings, would ensure a steady level of high fodder yields.

The crop is ready for the first cut in three months after planting and subsequent cuttings can be taken at intervals of 30–35 days. Para grass was reported to have yielded 339 quintals/ha of green fodder per acre at the Government Farm at Poona as early as 1894; at the Central Farm, Coimbatore, the grass has given 784 quintals/ha per acre in nine cuttings in a year. At Bangalore, under sewage farm conditions an outturn of 2,755 quintals per hectare was recorded, while at the Aarey Milk Colony in Bombay a record yield of over 2,755 quintals per hectare per year was realised from irrigations with cattle-washings.

Utilisation. The grass is best fitted for feeding green to livestock. Cattle do not eat this grass too readily to begin with, and mature culms are often rejected. It should, therefore, be cut and fed when it is young and not too old. Grass cut with the morning dew on, is also apt to be rejected by cattle. The hay is also rather coarse. Its nutritive value is somewhat low, with a protein content of only 6 per cent and low values of 0·76 per cent for calcium and 0·49 per cent for phosphorus.

The nutritive value of the forage can be improved if the grass is grown in mixture with velvet beans or *Centrosema pubescens*, as practised in Guam and Australia. Under Delhi conditions, *Brachiaria* fields were improved by sowing *Vicia sativa* during the winter months. The grass can also be used with success for reclaiming newly-cleared low-lying areas, as in Guam. Recent trials in India have shown that saline lands could also be reclaimed by growing this grass under irrigation. In other countries the grass is

Fig. 7. *Brachiaria mutica*

1. —Plant (×-): 2. —Inflorescence; 3. —Two views of spikelet (×10); 4. Floret (×10): 5. —Grain (×10).

used variously for soiling, hay and pasture, but in India it is used mainly for soiling purposes and cut when the plants are 122 cm tall. It can stand moderate grazing; in Florida and Guam, a stocking rate of one or two animals per acre for nine to ten months is recommended.

TABLE 51.

ANALYSIS OF *Brachiaria mutica*

	Chemical Composition (On dry basis)
	%
Crude protein	6·9
Ether extract	1·0
Crude fibre	33·3
Ash	15·2
N-free extract	43·6
Calcium	0·32
Phosphorus	0·35
Potassium	—

(After Sen and Ray, 1964.)

Brachiaria paspaloides (Presl .)Hubb. (Syn. *Panicum ambiguum* Trin.; crab-grass; Hindi—Takvi).

An annual grass 60 to 120 cm tall, found on plains and at low elevations on the hills, after the monsoon rains. It is found all over India, Burma and Ceylon, both on light and heavy soils. It is a good fodder grass, for feeding green or as hay and also makes a good turf. The hay yield is about 50 quintals per hectare and being soft, it is relished well by cattle. It is said to improve milk flow in cows and buffaloes.

TABLE 52.

ANALYSIS OF TAKVI

	Chemical Composition Mature grass
	%
Moisture	69·1
Crude protein	1·1
Ether extract	—
Crude fibre	10·2
Ash	4·0
N-free extract	13·7

Brachiaria ramosa Stapf. (Syn. *Panicum ramosum* Linn.; Tamil—Pala pul, Arisi pillu; Telugu—Anda korra; Kannada—Bennaki hullu; Malayalam—Chama pothaval).

An erect or sub-erect annual or perennial grass, growing 60 to 91 cm in height and found in the plains all over India. In certain parts of Mysore and Madras it is cultivated for its grain which is rated by some as superior to *Panicum miliare*. The flour is usually mixed with ragi flour and consumed as gruel or as flat cakes. As a catch crop it is sown between August and October and harvested by the end of December, yielding about 3-4 quintals of grain and 5·6 quintals of straw, which is well relished by cattle.

Rhodes grass (*Chloris gayana* Kunth.)

Genus *Chloris* Sw. (Gramineae)

A genus of about 85 species of tufted perennials or annuals, with flat or folded, scabrous leaf-blades and two to many feathery and sometimes showy spikes at the tip of the terminal inflorescences; confined to the warmer regions of the world. Several species are useful as fodder grasses.

Chloris gayana Kunth (Rhodes grass).

Origin, History and Distribution. This perennial grass from South Africa gets its name from the famous Cecil Rhodes who popularised it in his estate near Cape Town. It was introduced in 1802 into the United States. It is a fine-stemmed, leafy perennial grass with culms growing 0·9 to 1·2 metres tall, with long, stout, leafy stolons, wiry and compressed internodes, and leaf-blades 3–5 mm wide, tapering to a fine-pointed tip. The spreading, digitate spikes of the inflorescence number 10 to 15, 5 to 10 cm long; spikelets crowded, straw-coloured when ripe; lemma 3 mm long, hispid on the margin near the tip, shortly two-awned, the awns 1 to 5 mm long. Seeds are produced in abundance. Some strains of Rhodes grass are stoloniferous, reaching lengths of 60 to 122 cm and rooting at the nodes, though it does not become a persistent weed like Hariali or Johnson grass.

Climate and Soil. The grass can tolerate drought and low temperatures and can grow well in both tropical and sub-tropical parts of India, although it comes up best in warm, moist regions and low-lying areas. In the United States, this grass is cultivated for forage in North Carolina and Florida and has escaped into fields and waste places. In India it grows best on light loams. Stiff clays and soils prone to water-logging are not suitable, though it can tolerate a fair degree of salinity. It is reported to grow well in soils too alkaline for lucerne or cotton. At the Hosur farm, it was tried in 1920 and found to be remarkably drought-resistant, with an average annual yield of 121 quintals per hectare.

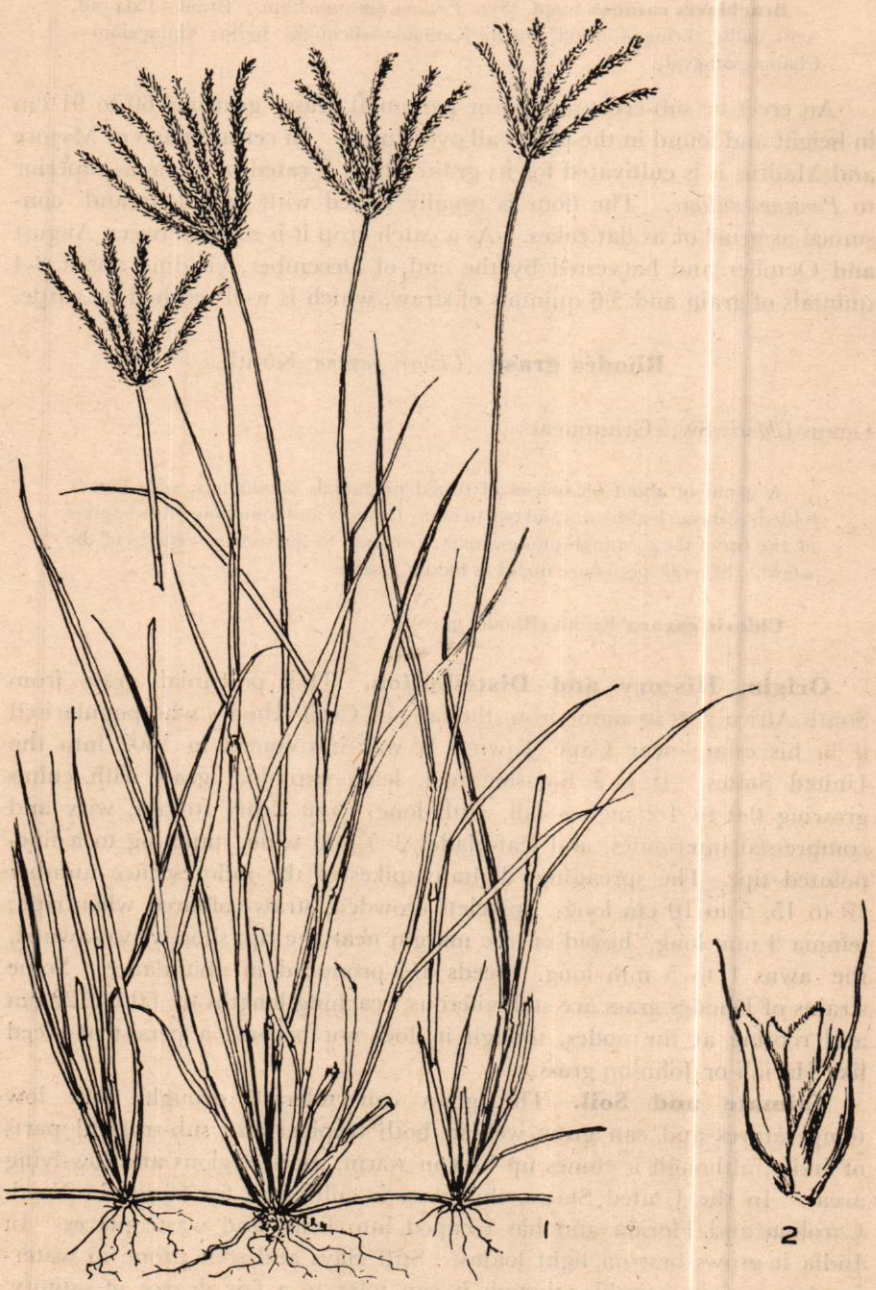


Fig. 8. Rhodes grass (*Chloris gayana*).
1. Plant ($\times\frac{1}{2}$); 2. —Spikelet ($\times 10$).

Cultural Practices. Rhodes grass can be established from seeds or rooted cuttings. The former method is cheaper, provided good quality seed is available. For establishing the grass from seed the land is prepared well to obtain a fine and firm seed-bed. When there is sufficient moisture in the soil, a rain-fed crop may need a seed-rate of 4·5 to 8 kg/ha of seed per acre for broadcasting, but in regions of heavy rainfall or under irrigation 11 to 13 kg/ha may be advisable. As the seed is small, it is desirable to mix it with five or six times its volume of fine soil to ensure uniform distribution. After sowing, the field should be lightly worked with a brush harrow. If the seed is sown in furrows they can be set by being lightly walked over soon after the seed is sown. Under normal conditions germination will be complete in a week or ten days.

In the vegetative method of propagation, rooted cuttings are planted in rows two feet apart, and immediately irrigated. About 24,700 cuttings would be required to plant a hectare. Planting can be done any time during the year, but February plantings are found to be the best in the Punjab. For a rain-fed crop, sowing should be done with the commencement of the monsoon. Delayed sowings result in poor germination.

Interculture once or twice after sowing or planting is necessary to keep down weeds. When line-sowing is done, weeding within the sown lines should be delayed until the sown crop can be easily distinguished from self-sown seeds. Thinning is necessary to leave the plants at a distance of 45 to 60 cm. The crop should be irrigated at two to three-week intervals, depending on the season.

MANURING. Rhodes grass responds well to manuring. A basal dressing of 125 to 200 quintals/hectare of farm-yard manure, compost or sludge and a second application of 2·2 quintals/hectare ammonium sulphate or fertilizer mixture after the first cutting will help maintain high yields.

Utilisation. The seed-sown crop will be ready for the first cut in three months' time, while from a vegetatively raised crop, it can be taken in two months. Subsequent cuttings are taken at monthly intervals. In the subtropical parts of India, 7–8 cuttings are possible, while 12 cuttings can be taken in a year in the warmer regions of peninsular India. The yield will be about 370 quintals per hectare from irrigated crops in a year and about 175 quintals/hectare from rainfed crops. From fields irrigated with sullage water or stable washings, yields exceeding 1,756 quintals per acre have been recorded. In Bangalore 1,254 quintals per hectare has been obtained in one year.

On account of its quick-growing, aggressive habit the grass tends to get too crowded and hence it is necessary to open up the land once a year, preferably late in the cold season, in order to maintain a proper stand and high yields for a number of years.

Nutritive Value. The grass is leafy and palatable and also fairly nutritious, containing 5 per cent. protein with a balanced content of

calcium (0·5 per cent,.) and phosphorus (0·4 per cent). Although it is suitable for pasture, hay or for soiling, like most other introduced grasses in India, Rhodes grass is used chiefly as a soiling crop. The crop is cut just before flowering, when its nutritive value is the highest.

At Bangalore this grass was found to withstand trampling and provided grazing till September, after which it could be utilized for making hay. In Australia, Rhodes grass leys are popular in rotation with cotton. To improve the quality of the forage the grass is grown along with lucerne. This has the advantage of maintaining a continuous supply of fodder, the Rhodes grass supplying fodder in the summer months and the lucerne in the winter months. Such lucerne-Rhodes grass leys are beneficial for the subsequent crops and can be recommended for adoption, wherever possible, in India as well.

Seed Production. When a seed crop is desired, no cutting is taken after July. The seeds mature by October-November, but seed collection is somewhat difficult as the spikes do not all mature at the same time. Bulk harvest is possible as the seeds do not shed easily, but the best method is hand-picking, to ensure good quality seed. About 112 kg/ha of unhusked seed per acre can be considered as a good yield.

Though the grass is quite suitable both for hay and silage, it is not much used for these because other species are available, giving higher yields. In the rabi season the yield from Rhodes grass is much less than from Guinea grass. The grass is liked by livestock, but remount authorities do not consider it good for horses, as it causes skin troubles.

TABLE 53.

ANALYSIS OF RHODES GRASS

	Green		Hay	
	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients
	%	%	%	%
Moisture	66·3		9·1	
Crude protein	2·9		6·4	
Ether extract	0·7		1·2	
Crude fibre	10·6		29·3	
Ash	2·6		9·1	
N-free extract	16·9		44·9	
Calcium	0·42		0·42	
Phosphorus	0·23		0·23	
Potassium	0·86		—	
Digestible Crude Protein		1·4		3·1
Total Digestible Nutrients		13·7		53·0

(After Lander, 1949) (Kehar, Ray and Negi, 1949)

Other Species of Chloris

Chloris incompleta Roth. (Syn. *C. Roxburgii* Edgew.); Hindi—*Bamna, Mathania*; Telugu—*Kanthari gaddi;* Kannada—*Melamala hullu.*

This perennial grass is found all over India on a wide variety of soils. It is a good fodder, if cut before it flowers.

TABLE 54.

ANALYSIS OF CHLORIS INCOMPLETA

	Chemical Composition (on air-dry basis)
	%
Moisture	8·4
Crude protein	5·5
Ether extract	1·2
Crude fibre	33·5
Ash	6·4
N-free extract	45·0

Chloriss inflata Link. (Syn. *C. barbata* Sw.); Hindi—Choti jargi, Gandi; Tamil—Kodai pillo, Sevvarugu pillu; Telugu—Uppu gaddi; Kannada—Hennu manchada, Kalu hullu,

A tufted perennial common in all parts of India, Burma and Ceylon; from sea level to 610 metres elevations. Though it can grow on all soils

TABLE 55.

ANALYSIS OF CHLORIS INFLATA

	Hay	
	Chemical Composition (on dry weight basis)	Digestible Nutrients
	%	%
Crude protein	6·0	42
Ether extract	1·4	61
Crude fibre	30·9	62
Ash	11·9	
N-free extract	49·8	49
Calcium	0·74	
Phosphorus	0·15	
Potassium	—	

(After Sen and Ray, 1964)

Fig. 9. *Chloris bournei*

1. Plant; 2. Leaf with ligule; 3. Spikelet, showing (*a*) first, (*b*) second, (*c*) third, (*d*) fourth and (*e*) sixth glumes (×10); 4. and 5. Third glume and its palea; 6. and 7. Fourth glume and its palea; 8. Fifth glume; 9. Stamens, ovary and lodicules; 10. Grain.

it thrives best on sandy soils and is one of the few species that can grow on alkaline soils. The culms when chewed have a saltish taste. It is a good fodder grass if cut before flowering, but cattle do not relish it in the later stages. It is also not good for silage or hay, because the loss of weight on drying is considerable.

Chloris tenella Koenig ex Roxb.

This is a slender grass common in Madras, Madhya Pradesh and Rajasthan and is considered a good fodder.

Chloris virgata Sw. (Syn. *C. tetrastachya* Hack.)

This is another perennial grass found in the drier regions of North-western, Central and South India. It is often the only vegetation found on the saline tracts of North-western India. The grass is considered to be a nutritious fodder.

Guinea Grass (*Panicum maximum* Jacq.)

Genus *Panicum* Linn.

This is a very large genus of more than 500 species, distributed in tropical and warm temperate regions throughout the world. They are annuals or perennials of various habit. Inflorescence open or compact panicles, rarely racemes; spikelets compressed dorsiventrally, glumes 2, herbaceous, unequal, first glume often minute, the second equal to the sterile lemma; fertile lemma chartate-indurate, typically obtuse, margins enclosing palea of same texture; grain free within the tightly closed lemma and palea. Many Panicums are important, though subsidiary, cereal crops, while others are important fodder grasses.

Panicum maximum Jacq. (Guinea Grass).

Origin, History and Distribution. This grass is a native of tropical Africa but has now spread to many other countries, like Australia, the Philippines and the southern States of the U.S.A. It was introduced into India in 1793 in some military farms and is thus the oldest amongst the introduced grasses. It has now become very popular and is being grown in many parts of India. It is the main grass cultivated in many sewage farms of municipalities, *e.g.*, Dacca, Kanpur, Madurai and Coimbatore.

Description. The grass is a tall, densely tufted perennial, with numerous shoots arising from short, stout rhizomes. A full-grown plant attains a height of 1·8 to 2·7 metres under favourable conditions. Culms

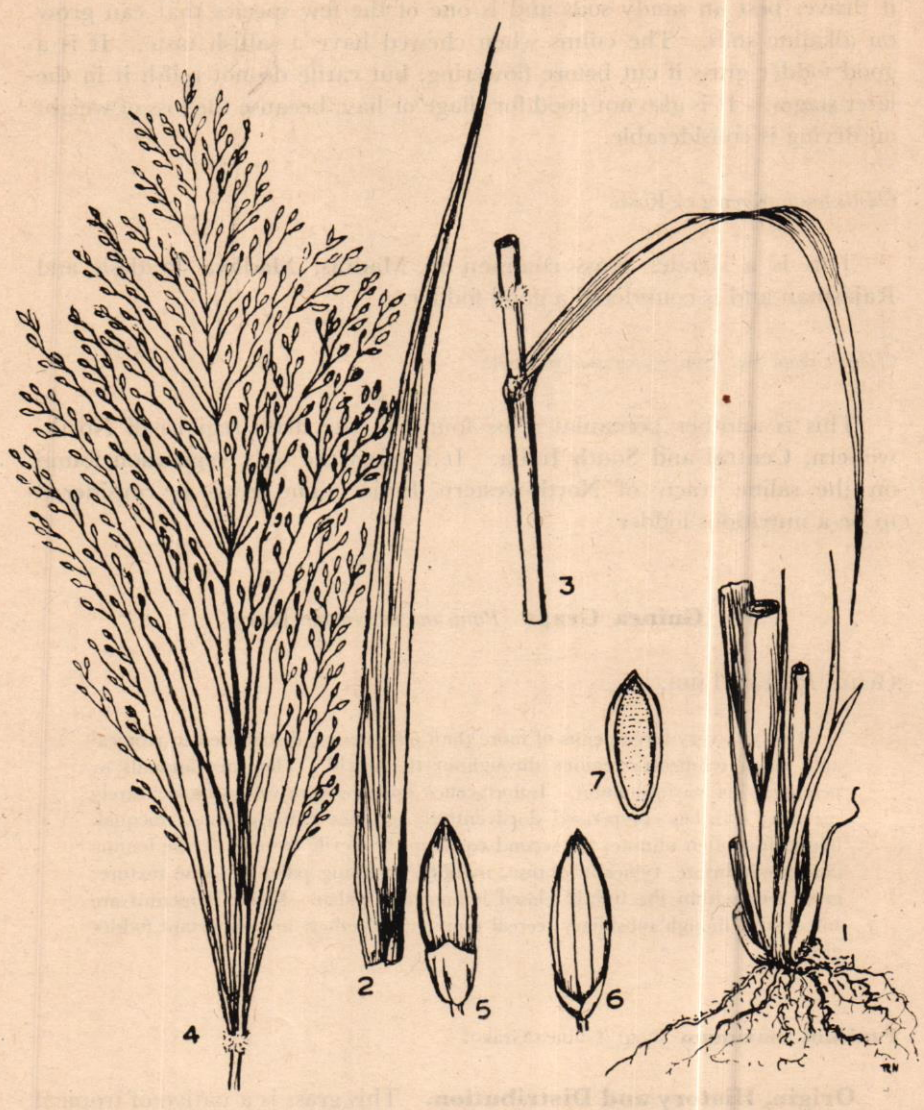


Fig. 10. Guinea grass (*Panicum maximum* Jacq.)

1. Plant with roots; 2, 3. Leaf; 4. Inflorescence; 5, 6. Spikelet, two views; 7. Floret.

are erect, glabrous, nodes densely hairy, leaf-sheaths also pubescent; leaf-blades are about 60 cm long and 2·5 to 3·8 cm broad and light green in colour. The inflorescence is an open panicle, about 30 cm long and 10 to 13 cm across, much divided, with long, stiff branches and whorls; spikelets small, grain transversely rugose. The grass can get distributed through animal agency, as bits of culms are able to grow even after passing through the alimentary canal of ruminants.

Climate and Soils. The grass thrives best in warm, moist climates; under favourable conditions it remains green and productive all the year round. In the absence of adequate moisture the grass goes dry and dormant, but resumes its growth with the beginning of the monsoon rains. It can grow well under rain-fed conditions, *e.g.*, at Hosur and on the Kerala coast (Nileshwar), but then it remains productive only for five to six months. In places where the winters are fairly severe, as in North India, the grass remains dormant from November to February and revives only by the next spring, with the help of irrigations.

The grass can grow on almost all types of soils except water-logged ones, but thrives best on fertile, well-drained, medium loam soils. On light sandy soils, heavy manuring is necessary to secure good yields. It can also thrive on sullage water and can be grown along field bunds and sides of water channels. Guinea grass can thrive in shade and so it can be grown as an intercrop in orchards and plantations.

Cultural Practices. Although seed formation is quite good in this grass, collecting the seeds is rather difficult as they do not ripen all at the same time and further, the mature seeds get easily shed. The grass is, therefore, propagated mainly by vegetative means, through planting rooted slips.

The land is prepared well by giving two or three ploughings, followed by three or four harrowings. To obtain rooted slips a whole clump is dug up with the roots to a depth of one foot and divided into several parts. These divided slips are then used for planting, usually after " topping " the foliage to minimise transpiration. The slips are planted 91 to 122 cm apart between rows and between plants. About 12,350 slips will be required to plant one hectare.

For a rainfed crop, the planting should be done at the beginning of the monsoon, preferably on a drizzly day. Under irrigation, planting can be done any time of the year, although in North India this is done usually from the middle of February till the middle of August. Plantings later than August are apt to prove failures, with the approach of winter. Liberal irrigation immediately after planting is necessary. Interculture once or twice during the period of establishment is also needed, to keep down weeds.

MANURING. The grass responds well to manuring. To ensure high yields, in addition to a basal dose of farmyard manure, compost or sludge,

it is desirable to give top-dressings of ammonium sulphate in two doses to supply 168 to 224 kg/ha, the first in February and the second at the commencement of the monsoon. In Madras, 500 quintals/ha of farmyard manure are recommended as a basal dose, followed by a top-dressing of 250 quintals compost and 112 kg/ha of ammonium sulphate after every two cuttings. In Maharashtra 125 to 200 quintals of farmyard manure per acre before the rains and a top-dressing of at least 125 quintals per acre of farmyard manure after every fourth cutting, are recommended.

Fodder Yield. The first cutting can be taken six to eight weeks after planting, depending upon the fertility of the soil. The average production is about 448 to 672 quintals per hectare in 5–6 cuttings per year. Under sewage irrigation a yield of nearly 2,258 quintals per hectare in twelve cuttings per annum has been recorded at the sewage farm, Madurai in Madras State.

For maintaining the yields at high levels, one or two intercultures should be given each year. The yield, however, declines with age and it is advisable to replant the field with fresh slips every fifth year in peninsular India and once in three years in North India. The replanting can be done in the standing field of Guinea grass, in between the rows and the old plants removed after the new plants get established. The fodder supply can thus be maintained at an uniform level.

Guinea grass makes a good fodder and compares well with maize and jowar fodders. It is liked by all classes of livestock and is also nutritious, with a protein content of 5 to 8 per cent, depending upon the stage at which it is cut. Both calcium and phosphorus are also well balanced.

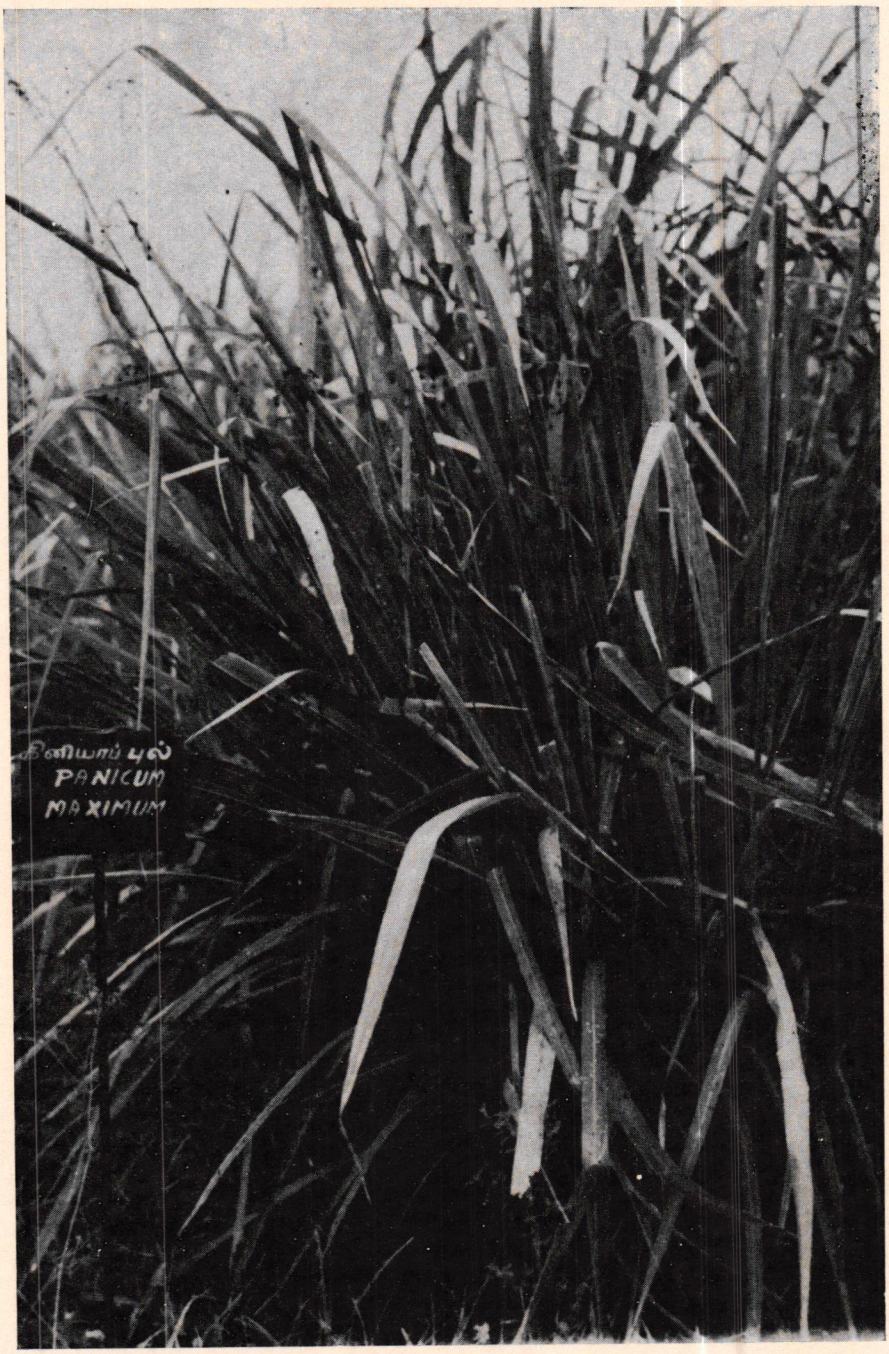
Utilisation. Although Guinea grass can be used both for grazing and soiling in India it is invariably used only as a soiling crop. It is best to cut the grass when it is 60 to 90 cm tall, when the fodder is most nutritious and palatable, but for economic reasons, it is desirable to cut it when 122 to 152 cm tall. Unlike Napier grass it does not become coarse even if left to grow to this height, but still it is preferable to cut it before flowering, as otherwise livestock may reject the coarser stems.

The grass can be grown along water-channels where, besides giving additional fodder, it serves also to protect the bunds against erosion and infestation by weeds. In Western India, Guinea grass grows very well under the shade of mango trees. Cattle can be turned out on Guinea grass pasture when the plants attain a height of three feet. After the crop is grazed off, the grass is cut back to 10 to 15 cm. Guinea grass can also be utilised for making silage.

Rotational Harvest. Since perennial forage crops are harvested in small quantities for the daily feeding of livestock, the harvesting schedule is adjusted so that successive cuttings are taken at intervals that are in accordance with the number of cuttings that can be taken from the crop in one year. Thus a Guinea grass field gives ten cuttings in a year, with

Chloris gayana Kunth. (Rhodes grass)
A leafy, palatable forage grass, introduced from Africa.

PLATE X



Panicum maximum Jacq. (Guinea grass)

Panicum maximum Jacq.
An African species which is now the most popular fodder grass in India.

Pennisetum purpureum (Napier grass)
(*Courtesy*: Director of Agriculture, Madras.)

PLATE XII

Panicum antidotale Retz.
An Australian drought-resistant grass.
A hardy perennial, suitable for semi-arid situations
(*Courtesy*: Director of Agriculture, Madras)

an interval of 35–40 days between cuttings and so it is convenient to divide the field into 36 plots and harvest one plot each day in a regular sequence.

TABLE 56.

ANALYSIS OF GUINEA GRASS

	Green grass		Hay	
	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients
	%	%	%	%
Moisture	74·9		11·8	
Crude protein	1·3	59	6·7	54
Ether extract	0·4	42	1·1	33
Crude fibre	9·1	58	33·6	64
Ash	3·1	—	14·1	—
N-free extract	11·2	60	32·7	49
Calcium	0·19		2·45	
Phosphorus	0·16		0·54	
Potassium	0·81		1·07	
Digestible Crude Protein		0·8		3·6
Total Digestible Nutrients		13·2		27·9

(After Lander, 1949)

Blue Panic Grass (*Panicum antidotale* Retz.)

(Australian drought-resistant grass, Blue Panic grass; Hindi—Gift, Parwari, Ghamar)

Origin, History and Distribution. Although this grass grows wild in Rajasthan and the North-western regions of India, its fodder value was first recognised in Australia, from where seeds were obtained for trial at Coimbatore in 1938. Since then it has been recognised as a very drought-resistant grass well-suited for arid and semi-arid regions. In Rajasthan it can grow in places with less than 13 cm. of rainfall per annum, usually in association with xerophytic shrubs like *Capparis aphylla*. Roth. The grass is now found distributed in most districts of the Carnatic and the hill regions of the Nilgiris and Shevaroys.

The plant is an erect, deep-rooted, thin-stemmed perennial, growing to a height of 122 to 152 cm, with smooth and solid culms and thickened nodes looking like miniature bamboos, on account of which it is popularly known as *bansi* in some localities. It grows into large, dense tufts of a blue-green colour, with leaves about 45 cm and 1·2 cm wide, with acuminate tips. The ligule is short and jagged. The panicles are terminal, loose and pyramidal, branches fascicled, slender, spreading and drooping

spikelets laxly crowded on branchlets, ovoid, acute, glabrous, strongly nerved.

Climate and Soils. Being both drought and cold-resistant, the grass can be grown on the plains as well as on the hills. It is recommended for all dry regions, as it withstands drought better than many other grasses and can remain green even when all other plants dry up. The grass grows well on all soils, from light sandy to heavy clays and can also tolerates a fair degree of soil salinity.

Cultural Practices. The land is ploughed two or three times and the seeds sown broadcast or drilled in furrows 45 cm. apart, 4 to 7 kg/ha seed-rate, as soon as monsoon rains are received. Line sowing is preferable, as it facilitates inter-culturing later on. As the seeds are very small, they should be mixed with three or four times the weight of soil and after sowing they should be " firmed in " by lightly walking on the furrow lines. The grass can also be established by planting rooted slips in rows 60 cm apart, or by planting seedlings raised in separate nursery beds. The best time for planting is at the commencement of the monsoon rains, but if irrigation facilities are available, planting can be done any time from March onwards. Interculture is helpful in keeping down weeds. When grown under irrigation, watering is required at monthly intervals.

The grass responds well to manuring, although it is seldom manured. A basal dose of 125 to 250 quintals of cattle-manure at the time of preparatory cultivation and annual top dressings of ammonium sulphate at 168 kg per hectare, would meet all the normal requirements of this grass.

The first cutting can be taken four months after sowing and subsequently once in two months. Under irrigation, with adequate manuring, cuttings can be taken even at fortnightly intervals. The yield is about 224 quintals of green fodder per acre per year in four to six cuttings under rainfed conditions. With sewage irrigation, yields of over 1,505 quintals have been recorded.

Cattle relish this grass when young but if allowed to get too ripe, it becomes too stemmy and the foliage gets scanty. The grass contains 7·5 per cent protein with a satisfactory balance of calcium and phosphorus.

Utilisation. Blue Panic is recommended as a cut fodder, but it can also be used as a pasture grass, as it shows remarkable recovery after cutting. In Texas, the grass is used for grazing cattle. In India sheep grazed on Blue Panic grass did not show much gain in weight under the conditions at Jodhpur, although it was the earliest pasture to get ready in the spring season.

Seeding is profuse in this grass, but as the mature seeds get easily shed, it is desirable to collect the seeds periodically by hand. For seed production, the crop should be grown in rows 91 cm apart, with 60 cm between plants in rows. About 112 kg of clean seed can be collected from a hectare of *Panicum antidotale*.

TABLE 57.

ANALYSIS OF BLUE PANIC GRASS

	Chemical Composition (On dry weight basis)
	%
Crude protein	7·3
Ether extract	1·2
Crude fibre	40·5
Ash	7·9
N-free extract	43·1
Calcium	0·39
Phosphorus	0·09
Potassium	1·62

(After Sen and Ray, 1964)

Napier grass (*Pennisetum purpureum* Schum.)

Genus *Pennisetum* L. Rich. (Gramineae)

This is a fairly large genus of annuals and perennials, consisting of 50 tropical and sub-tropical species, distributed in Asia, Africa, Southern Europe and America. Leaves flat; inflorescence is a spike-like panicle, spikelets solitary or in groups of two or three, surrounded by an involucre of bristles (sterile branchlets). The name is derived from Latin *Penna*, a feather and *seta*, a bristle, alluding to the bristles on the inflorescence.

Pennisetum purpureum. Schum. (Napier grass, Elephant grass)

Origin, History and Distribution. This is a vigorous, hardy, high-yielding perennial grass native to South Africa which derives its name from Col. Napier, who first drew the attention of the Rhodesian Department of Agriculture in 1909 to the fodder value of this grass. In its native habitat it grows to a height of 3 to 3·6 metres and even elephants roaming inside the ' forest ' of this species are hidden from view, hence the grass is also known as elephant grass. It was tried first in the Transvaal in 1910 and in 1913 it was introduced into America by the United States Department of Agriculture. It proved a success in Florida, California, Puerto Rico and Hawaii. In India it was introduced in 1912 from the South African Department of Agriculture. It is now widely recognised as a valuable fodder grass.

Description. Napier grass is a tall, robust perennial, similar in habit to sugarcane, growing from creeping rhizomes in clumps of 20 to 30

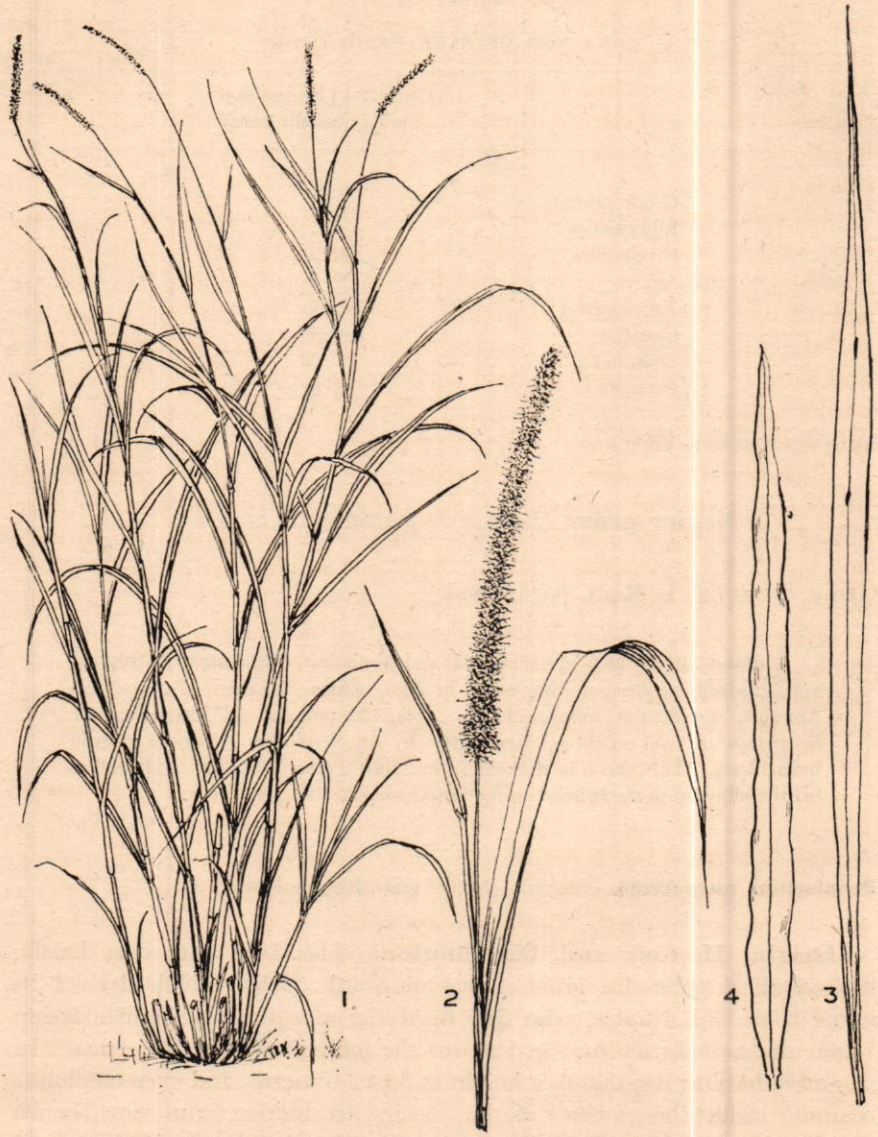


Fig. 11. *Pennisetum purpureum.*
1. Plant (×1/15) ; 2. Inflorescence ; 3. Leaf ; 4. Leaf of *P. typhoides*.

culms, each about 2·5 cm in diameter. The leaves are dull green and 60 to 91 cm long and about 2·5 cm broad. The ligule is a narrow rim of small white hairs. The inflorescence is an erect, golden yellow spike, 12·5 to 25 cm. long and about 2·5 cm thick, densely set with deciduous spikelets. Each spikelet is surrounded by an involucre of bristles of varying lengths, usually 5–8 mm long, with one or two much longer than the others (10–20 mm).

Climate and Soils. The grass can grow on a wide variety of soil types and moisture variations, but cannot survive in water-logged fields. The best yields are secured from well-drained, fertile loams that have an adequate level of lime. Although it prefers a warm climate, it can also withstand low temperatures in subtropical regions better than guinea grass and can be recommended for cultivation in northern India. Unlike guinea grass, it does not produce viable seeds and hence it has to be propagated only vegetatively by planting slips or setts.

Cultural Practices. For planting a new field, the clumps are dug up and separated into rooted slips, each bearing a live, healthy bud. The field is prepared by ploughing four to six times, manuring and forming 90 ridges and furrows cm apart. The rooted slips are planted about 60 cm apart in these furrows and covered with soil. The first irrigation, in this method, is given only after the sprouting is complete.

Another method is to cut the culms into setts or pieces as in the case of sugarcane, each with three nodes and plant these setts in the same manner as before, but at an angle of 45 degrees, so that the nodes are buried in the soil just enough to cover the second node or joint, the third joint being left above the ground level. About 12,350 setts will be required to planta hectare. In this case the field can be irrigated immediately after planting. Young setts grow much better than older material, especially during dry season plantings. The best time to plant this grass in North India is from February onwards, under irrigation and from June to August for a rain-fed crop. In South India the plantings can be done any time in the year if irrigation facilities are available.

Two or three interculturings may be necessary to keep down weeds while the grass is getting established. Irrigations will be needed at fortnightly intervals and also soon after each cutting, except during rainy spells.

Being a heavy yielder, Napier grass requires liberal manuring, with 125 to 250 quintals/hectare of farmyard manure before planting and top dressings of ammonium sulphate in two doses, once in February and again in July, to supply 2·24 quintals of nitrogen per ha. The grass comes up very well under sewage farm conditions and in that case no extra manuring will be necessary.

The first cutting can be taken from a newly-planted crop after three months and subsequent cuttings at six to eight week intervals. An average

yield is 560 to 896 quintals of green fodder per acre per annum, which is nearly twice that from guinea grass and four times as much as from fodder sorghum. Under favourable conditions of manuring and irrigation, over 1,505 quintals per acre have been recorded.

Renovation. Interculture twice a year helps to maintain good growth and yields. A field of Napier grass continues to supply green fodder for several years, although the yields tend to go down after the third or fourth year. It is, therefore, necessary to replant the grass in a fresh field after three years in North India and after the fourth year in peninsular India.

Nutritive value. Napier grass is nutritious and contains 5–7 per cent protein, with both calcium and phosphorus in proper balance and in adequate quantities. It is also palatable to livestock. They make good gains in live-weight and so Napier grass is recommended in the United States for fatting animals for the market. In Uganda, rotational grazing experiments with *Pennisetum purpureum* and *Chloris gayana* showed that bullocks got a steady, linear live-weight increase with *P. purpureum*, whereas *C. gayana* produced a higher initial gain, which declined afterwards, from June to November. Although by analysis it shows a higher moisture content than Guinea grass, in practical feeding the serrate leaf-margins cause mouth-sores in cattle, so that they cannot consume this grass in sufficient quantities, for heavy work or milk production. Hence Guinea grass is on the whole a better fodder, though Napier grass is the heavier yielder. The fodder also tends to get coarse, if left too long in the field and then the thick, woody basal culms are rejected by cattle. It should, therefore, be cut and fed when young, as late cuts lead to much waste of fodder.

Although in other countries cattle are allowed to graze on this grass, in India it is utilised only as a soiling crop. The nutritive value of the grass is improved by growing velvet beans or cowpeas in the same field. A combination of a perennial legume like Kudzu vine with Napier grass can be recommended for wider adoption in warm, humid localities.

For hay-making this grass is somewhat too coarse, but it can be used for making silage and for rotational grazing. To obtain the maximum feeding value it should be grazed when the grass is 91 to 122 cm tall. For a proper adjustment of rotational grazing on a continuous basis, four or five fields may be required.

Napier grass is considered useful as a soil-restoring crop in Uganda and in Ceylon, as experiments have shown that the grass leaves the soil richer in organic matter and with a better texture. On this account this grass figures prominently in crop rotations in Uganda. The fields are " rested " under Napier grass for three years, which is then followed by three years of arable farming.

TABLE 58.

ANALYSIS OF NAPIER GRASS

	Green grass		Hay	
	Chemical Composition	Digestibile Nutrients	Chemical Composition	Digestibile Nutrients
	%	%	%	%
Moisture	77·8		10·9	
Crude protein	1·0	63	8·2	
Ether extrabt	0·5	69	1·8	
Crude fibre	7·4	63	34·0	
Ash	3·1	—	10·5	
N-free extract	10·2	65	34·6	
Calcium	0·17			
Phosphorus	0·16			
Potassium	0·97			
Digestible Crude Protein		0·6		3·3
Total Digestible Nutrients		12·7		44·1

(After Lander, 1949)

Giant Napier Grass

In recent years a number of interspecific hybrids have been secured between Napier grass (*Pennisetum purpureum*) and bajra (*P. typhoides*) in the Agricultural Research Institutes at New Delhi and Coimbatore. Some of these have shown great promise as perennial fodder grasses, being quite tall, vigorous and capable of yielding much higher outturns of less fibrous and more palatable green forage than Napier grass, or bajra. For example, from one such hybrid at Coimbatore, a yield of 1,680 quintals/hactares of green fodder was obtained in a year from eight cuttings. As the hybrid was sterile, propagation is by planting setts, like sugarcane. Regeneration and growth were also rapid in this hybrid.

A similar hybrid evolved from the Indian Agricultural Research Institute, New Delhi, in 1961 and named Pusa Giant Napier grass, is even more promising, as it yielded 2,835 quintals of green fodder per acre, *i.e.*, nearly two and a half times as much as Napier grass grown under identical conditions. Here, too, propagation is by planting rooted slips or stem cuttings. The land is ploughed twice in January-February and manured with 25·2 quintals of cattle manure per hectare and levelled by discing and planking. Planting may be done any time except the winter months if irrigation is available, but it is best done in February or early in March. Rooted slips or stem cuttings having at least two nodes on them, are planted in rows 60 cm apart, with the same spacing between the plants in the rows. About 24,700 slips may be needed to

plant 9 hectare, and so a small " nursery " area should be left uncut in a previous crop, to furnish planting material. The field should be irrigated immediately after planting and subsequent irrigations given at two-week intervals until the plants get well established, after which the frequency can be adjusted according to the rainfall and other weather conditions prevailing.

Being such a heavy feeder, this hybrid should be liberally manured with ammonium sulphate to supply 168 to 224 kg of nitrogen per acre, preferably in four split doses once in three months, fifteen days after each cutting. The first cutting will be ready in May from a crop planted in February and subsequent cuttings may be taken at intervals of 45–50 days, except in the winter months when growth is slowed down and cuttings are somewhat delayed, in the northern States of Punjab and Uttar Pradesh. This slowing down of growth does not occur in the warmer regions further south.

When cutting the crop for forage, a fairly long stubble of 13 to 15 cm has to be left, to avoid damaging the growing points near the base of the plants. A field of Giant Napier Grass can be kept on like Napier grass, for about three years in the same field before replanting becomes necessary.

Apart from higher yields, this hybrid is superior to Napier grass in fodder quality as well. It contains 25 per cent more of protein and 12 per cent more of sugars than Napier grass, the leaves are larger and greener, with less serrated leaf margins and softer leaf-sheaths, so that it is definitely more palatable. It is also more juicy and succulent at all stages of growth and less fibrous, so that there is less of wastage in feeding it and the cuttings too, can be delayed longer than Napier grass, without detriment to its feeding value. Yet another advantage in this new hybrid

TABLE 59.

ANALYSIS OF GIANT NAPIER GRASS

	Chemical Composition (On dry weight basis)
	%
Crude protein	10·2
Ether extract	2·1
Crude fibre	30·5
Ash	16·2
N-free extract	41·0
Calcium	0·46
Phosphorus	0·37
Potassium	—

(After Sen and Ray, 1964)

is its utility in crop rotations, as it can add more of root residues and organic matter to the soil than Napier grass.

The hybrid has also shown great adaptability to soils and climates and has grown well in almost all the places it had been tried, *viz.*, in Rajasthan, Uttar Pradesh, Bihar, West Bengal, the Punjab and Maharashtra.

Thin Napier Grass (*Pennisetum polystachyon* Sch.)

Thin Napier first came into prominence at the Hebbal Farm in Bangalore in the forties, as a very drought-resistant grass and has since been recognised as a species that is well suited to semi-arid regions in India.

It is an erect, thin-stemmed perennial growing 1·5 to 1·8 metres in height. The culms are thin and erect. Leaves are small and pointed. The inflorescence is a spike-like raceme and resembles that of Napier grass.

Climate and Soils. The grass can grow under a variety of climatic conditions, on alkaline soils in semi-arid regions and also on acidic soils in regions of high rainfall. Sandy loams are, however, preferred by the grass. It is well suited for the high rainfall conditions of the Kerala coast.

Cultural Practices. Since the grass is a profuse seeder, it is propagated mainly from seeds. The preparation of the land is similar to other seed-sown grasses. Seeds are either broadcast or drilled in lines 15–22 cm, apart, on a well-prepared, moist seed-bed at 3·4 to 4·5 kg per hectare. It can also be established by planting seedlings raised in the nursery or through rooted slips. Seedlings are started on raised beds and the seedlings transplanted later on at 75 × 75 cm spacing. The rows are 75 cm apart, running along the contour and the seedlings are set in the bottom of the furrows, 50 to 75 cm apart. On soils of moderate fertility it is desirable to apply a basal dose of 125 to 200 quintals of farmyard manure and subsequently annual top-dressings with 158 kg of ammonium sulphate or fertilizer mixture. Interculturing and weeding will be needed until the plants get well established.

The crop is ready for cutting in about three months, when the flower heads are just emerging. After the flowering stage, it soon becomes low in feeding value and may even become unpalatable. A good crop of thin Napier gives over 336 quintals of green fodder per hectare in about three or four cuttings per year.

The grass is fairly palatable to livestock, but being less leafy, it is rather inferior to other fodder grasses. The nutritive value is, however, good, with about 8 per cent protein on dry basis and a well-balanced calcium and phosphorus content.

Utilisation. The grass is recommended for cutting and feeding green to cattle. It is also good for hay, being thin-stemmed. For hay it is usually cut after the monsoon rains subside.

The grass produces abundant seed and can get established by self-seeding. It is worth introduction in high rainfall areas and acidic soils, to supplant the coarse, less nutritive grasses that form the natural vegetation in such areas.

TABLE 60.

ANALYSIS OF THIN NAPIER GRASS

	Chemical Composition (On dry basis)
	%
Crude protein	11·2
Ether extract	2·6
Crude fibre	28·4
Ash	16·3
N-free extract	41·5
Calcium	0·31
Phosphorus	0·18
Potassium	—

(After Sen and Ray, 1964.)

Pennisetum squamulatum

This is a grass which has recently been introduced from East Africa into India. It has shown great tolerance to heat and cold, in addition to high yield potential. Unlike other grasses which remain dormant during certain months of the year, *Pennisetum squamulatum* showed no adverse effects even in summer temperatures of 40–45°C. and near-freezing temperatures in winter. It can also tolerate shade and is very useful both for fodder and soil conservation purposes in the tropical and sub-tropical regions of India.

The grass can be propagated either by broadcasting the seed or if seed is in short supply, by planting out the seedlings raised in a nursery or by planting rooted slips from a prior stand of the grass. The best time to sow is with the first showers of the south-west monsoon. The seed should not be sown more than half an inch deep. When sowing seeds, it is best to use uncleaned seed, with the appendages intact, as they are then not so liable to get washed away. For transplanting, the nursery should be raised by the middle of May to mid-June. A preliminary watering is given to the nursery beds two weeks before sowing the seeds, in order to eliminate any weeds that may come up and then seeds of *P. squamulatum* are sown in lines 5 to 7·5 cm apart, covered with fine soil and lightly " firmed in ". The beds are then covered with gunny bags

to ensure better germination and watered regularly with a rose-can till the seedlings grow 15 cm high, when they are transplanted at 30 cm by 30 cm. spacing, by the beginning of the south-west monsoon.

The grass can serve both as a pasture and fodder crop. With a July planting, the plants attain a height of 91 to 122 cm by September, but it is best to leave it ungrazed until next February, for a good stand to get established. In subsequent years, the pasture should not be grazed during the winter months below one foot of stubble. Once the grass is well established, a field can be kept on for four or five years before replanting becomes necessary. As a cut fodder, the first cutting can be taken in October and the second by next February and a total annual yield of nearly 672 quintals/hectares can be expected. The grass can also be converted into good hay. It contains 10·5 per cent protein, nearly double that of other local grasses and is quite a nutritious fodder.

Sudan Grass (*Sorghum vulgare*, var. *sudanense*)

Origin, History and Distribution. Although Sudan grass is claimed to have been grown in Egypt from very early times, the value of this grass was first noted in the Sudan only in 1909. It was also introduced into the United States from its African home at about the same time, in the search for a forage plant to replace Johnson grass which had become a noxious weed in many of the southern States. In 1909, C. V. Piper of the United States Department of Agriculture got eight ounces of seed from the Director of Agriculture, Khartoum, and part of this seed was sown in Texas. Here it proved so successful that it soon spread to many of the south-western States. It was introduced into India in 1920 and has now proved a valuable addition to the introduced fodder grasses in the country.

Sudan grass is a quick-growing, drought-resistant annual, which can be very useful for hay, silage or pastures. Under favourable conditions it can be cut or grazed several times without damage. In appearance it is similar to Johnson grass. A full-grown plant may attain a height of nearly 3 metres but ordinarily a broadcast crop grows 91 to 152 cm tall, while in rows it may be somewhat taller, 1·8 to 2·4 metres in height, with culms about 1 2 cm thick. The leafblades are about 60 cm long, but broader and more numerous than Johnson grass and as a result this plant can make a better hay crop. Tillers are numerous. The plant has no persistent rootstock like Johnson grass and hence it does not become a pernicious weed. The root-system is quite deep and extensive. The inflorescence is a loose panicle about 30 cm long and similar to that of Johnson grass, but larger and more open. The glumes are awned and purple at the flowering stage. The grain fades to a pale yellow when ripe and the awns get broken off in threshing.

Climate and Soils. Like all sorghums, Sudan grass thrives best in a warm climate and is a crop of semi-arid, tropical and sub-tropical regions. It cannot tolerate frost, but can grow on all soils from heavy clays to light sands, provided they are well-drained. It grows best on rich, medium-textured loamy soils. Alkaline soils as well as wet soils in cold regions are not suitable for Sudan grass. It can withstand drought quite as well as sorghum, but experiments have shown that it needs more water to produce one pound of dry matter than maize, sorghum or other millet crops. Its main value is as an early summer fodder.

Cultural Practices. Sudan grass is propagated exclusively by seed. An improved selection from Sirsa (Punjab) has proved superior to other introduced varieties and is recommended for general use in India. To prepare the land for sowing, two or three ploughings and two harrowings will be needed. A rather firm seed bed is also necessary, as the seeds are small. The seed-rate is about 11·2 to 34 kg per hectare; the lower seed-rate is preferable, because the profuse tillering habit levels up all differences between thin and thick sowings. The seeds should be sown about 2·5 cm. deep in the soil. A basal dressing of 125 to 250 quintals of farmyard manure, compost or sludge, plus 168 kg of ammonium sulphate or manure mixture would be very helpful to improve the yields by nearly 70 per cent. When sown broadcast the seeds should be covered by a brush or tooth harrow. Where irrigation facilities are available, Sudan grass can be sown from March onwards, but as a rainfed crop it is sown in June–July, after the commencement of the monsoon. One interculture when the plants are about 25 to 30 cm tall, helps to remove weeds and gives the plants a better start.

Utilisation. The crop becomes ready for the first cut in about eight to nine weeks after sowing. Care is however necessary to feed it to cattle only after flowering, to avoid the risk of prussic acid poisoning. Subsequent cuts may be taken at intervals of six weeks, yielding about 336 to 445 quintals of green fodder per acre in four to six cuttings in a year. Under favourable conditions yields of even 560 quintals per hectare have been recorded. Sudan grass is well suited for use as fodder, as it is quite palatable to all classes of livestock. As the leaves are retained well, it makes good hay, which is well relished by cattle, sheep and horses. It has also another advantage in not being damaged by standing in the field beyond the stage of maturity. Analysis and feeding trials indicate that Sudan grass is equal to any other non-leguminous forage, but the best results are secured only when the grass is fed in conjunction with other forages. Since it is so easily made into hay, Sudan grass has only a limited use as silage, the silage is also somewhat inferior to maize or sorghum silage. In places of good rainfall Sudan grass can be grown mixed with cowpeas, velvet-beans or cluster-beans. In the United States, this grass has been found very good for pasture. In Australia, the milk

yield of cows was greater when pastured on Sudan grass than when they were pastured on Dallis grass (*Paspalum dilatatum*).

Prussic Acid Poisoning. Sudan grass is less poisonous than the cultivated grain sorghums in the young stages, but all the same, it should not be fed before it flowers, nor when the plants are damaged by drought or frost. A remedy for accidental poisoning by this grass is a mixture of sodium thiosulphate and sodium nitrite; this can save the animal if administered in time by a veterinarian.

Nutritive Value. The best time to harvest Sudan grass is after the first heads appear, up to the milk stage, but it retains its nutritive value over a considerable period.

The highest yield of quality hay is secured by cutting the crop at the ' heads emerged ' stage. The gain in weight per day in cattle fed on Sudan grass is the same as with sorghum.

Seed Production. Sudan grass produces seed in abundance, but as it intercrosses freely with ordinary sorghums, it should be grown for seed only at some distance from sorghum fields. In the Punjab where Sudan grass is grown extensively, the ratoon crop is usually left for seed. The seeds are best collected in April-May, when there is no grain sorghum in the field. The panicles alone are gathered as and when they ripen; the yield is about 2·2 to 4·5 quintals/hectares.

TABLE 61.

ANALYSIS OF SUDAN GRASS

	Green grass		Silage		Hay	
	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients
	%	%	%	%	%	%
Moisture	74·3		73·9		10·8	
Crude protein	2·0	72	2·2		8·8	49
Ether extract	0·6	72	0·9		1·6	52
Crude fibre	8·5	76	8·8		27·9	64
Ash	1·8	—	2·4		8·0	—
N-free extract	12·8	69	11·8		42·9	67
Calcium	0·20					
Phosphorus	0·14					
Potassium	0·52					
Digestible Crude Protein		1·4		1·2		4·3
Total Digestible Nutrients		17·7		15·1		48·5

(After Lander, 1949)

Diseases. Three bacterial diseases are somewhat serious in this crop: the bacterial spot disease, bacterial streak and the stripe disease. *Helminthosporium turcicum*, which causes leaf blight in maize, attacks Sudan grass also. Anthracnose (*Colletotrichum graminicola*) and the covered smut of sorghum are also found sometimes on this plant. Control is possible only by the use of resistant varieties.

CHAPTER 11

INDIGENOUS GRASSES

Apluda L.

Apluda L. This is a genus of annual and perennial grasses, often geniculate and rooting at the nodes. Leaves flat, sometimes petioled. Panicles compound, leafy, with clustering branches, each branch subtended by a spathe. Spikelets in threes at the tip of branchlets, embraced by a boat-like bract.

Apluda aristata Linn. (Hindi—Gururna; Tamil—Manda pillu, Kodi pillu; Kannada—Akku hullu).

A very variable species, found in all districts of peninsular India, from sea level to 2,130 m.

Apluda mutica Linn. (Syn. *Apluda varia* Hack.; Hindi—Banjura, Tachula).

A glaucous perennial, growing 1·5 to 2·1 m tall, culms smooth and solid with flexuous branches. Leaf-sheaths often thinly hairy, blades 10 to 38 cm long, base narrowed and sometimes petioled, upper leaves small; ligule short, rounded. Inflorescence is a terminal leafy panicle of simple racemes, with each branchlet enclosed in a peduncled spathe.

TABLE 62.

ANALYSIS OF BANJURA

	Green grass (Second cut)
	Chemical Composition (On dry basis)
	%
Crude protein	4·6
Ether extract	1·2
Crude fibre	33·6
Ash	19·9
N-free extract	40·7
Calcium	0·30
Phosphorus	0·29
Potassium	0·90

(After Sen and Ray, 1964)

Spikelets are in threes, one sessile and bisexual and two pedicelled and male. In Uttar Pradesh this grass is used for mixing with other more palatable grasses, to add bulk.

Arundo Linn.

Genus of tall, reed-like perennials with broad leaves and large, plume-like panicles. Three species occur in India, but they are of little fodder value.

Bothriochloa Kuntze.

A small genus of perennial grasses, found in tropical regions in Asia, Africa and Australia.

Bothriochloa intermedia (R.Br.) A. Camus.

This species is found in most places in India, along with *B. pertusa*. It is a tall grass, growing nearly 2·1 m tall. It is easily established from rooted slips, but cattle relish it only in the young stages. The yield is about 50 q/ha of hay per year.

Bothriochloa pertusa Willd. A. Camus (Syn. *Andropogon pertusus* Willd.; sour grass, pitted blue-grass; Hindi—Choti jergi, Sandur, Phalwan; Tamil—Chinna karai pillu; Telugu—Janu gaddi, Turri gaddi).

A short, perennial grass 25 to 30 cm. tall, found all over India and especially in Uttar Pradesh. Culms erect or ascending, nodes bearded with spreading hairs, internodes smooth and shiny. The purplish inflorescences have an aromatic smell when bruised. Racemes 2 to 8, arranged

TABLE 63.

ANALYSIS OF BOTHRIOCHLOA SPECIES

	Chemical Composition (On dry weight basis)	
	B. intermedia	*B. pertusa*
	%	%
Crude protein	3·9	6·0
Ether extract	1·3	1·4
Crude fibre	38·9	33·2
Ash	9·5	11·7
N-free extract	46·4	47·7
Calcium	0·41	0·62
Phosphorus	0·21	0·40
Potassium	0·98	...

(After Sen and Ray, 1964) (Wealth of India, 1962)

Pennisetum purpureum Schum (Napier grass)
A vigorous, high-yielding perennial grass well-suited for sewage farms.
(*Photo*: P. M. Dabadghao)

PLATE XIV

Pennisetum merkeri

Bajra Napier grass hybrid
A quick-growing hybrid of great potentialities as a fodder grass.

Pennisetum polystachyon Sch.
A drought resistant fodder grass
recommended for semi-arid regions

PLATE XVI

Pennisetum polystachyon Sch. (Thin Napier grass)

more or less digitately on tips of peduncles; spikelets in pairs, one sessile and awned, the other awnless and pedicelled. The lower glume of the spikelet has a deep pit at the back, about the middle of the glume. This grass closely resembles *Dichanthium annulatum*, but can be distinguished by this pit on the back of the lower glume of the spikelet.

The grass is rated as a good fodder, both for grazing and stacking, as it grows quickly and stands cutting well. The yield of hay is also good, being nearly 60 per cent of the fresh weight. The grass is suitable for lawns, as it sends out when cut or grazed, numerous creeping shoots rooting at the nodes, just like hariali.

Brachiaria ramosa (Staph.) (Syn. *Panicum ramosum* Linn.; Tamil—Arisi pillu; Telugu—Eduri gaddi; Kannada—Kadu baragu hullu).

This grass is found in almost all districts in South India, from the sea level to 6,000 feet and can serve as a fairly good fodder.

TABLE 64.

ANALYSIS OF BRACHIARIA RAMOSA

	Chemical Composition (On dry basis)
	%
Crude protein	9·4
Ether extract	0·8
Crude fibre	28·6
Ash	17·3
N-free extract	43·9
Calcium	0·45
Phosphorus	0·35
Potassium	—

(After Sen and Ray, 1964)

Kolukattai grass (*Cenchrus ciliaris*)

Genus *Cenchrus* Linn (Gramineae)

A tropical and sub-tropical genus of 35 species, of which a few are important as fodder grasses. The spikelets are surrounded by an involucre of sterile bracts, which in some species become hard and prickly, surrounding the fruit and aiding dispersal by animals.

Cenchrus ciliaris Linn. (Syn. *Pennisetum cenchroides* Rich., *Pennisetum ciliare* Link.; Hindi—Anjan, Dhaman baiba, Kusa; Tamil—Kolukattai pillu: Telugu—Kusa).

Origin, History and Distribution. An indigenous, perennial, tufted pasture grass 15 to 41 cm in height, erect or decumbent, common on the plains, particularly in dry areas. Culms erect, or gently bent from the rootstocks, 20 to 45 cm high. Leaf-sheath smooth or hairy near collar, ligule narrow, ciliate, membranous, leaf blade linear, 10 to 25 cm long and 3 to 6 mm wide, glabrous or hairy, tip acuminate. Inflorescence a dense cylindrical raceme 2 to 10 cm long and 8 to 15 mm wide, pale or purplish, rachis rough. Spikelets are surrounded by an involucre of spreading bristles (sterile branchlets). It is cultivated in the Punjab as well as in south India for fodder, as it is drought resistant and stands cutting well. Although it can yield a fair crop even with poor rainfall it can give much better yields with liberal moisture, either as rain or by irrigation, in well-drained soils.

This grass is the dominant pasture grass of the Kangayam area in Madras State, where the well-known Kangayam breed of cattle is bred. A closely similar grass, *Cenchrus setigerus* (Black kolukattai), where the involucre of spikelets are coloured blackish-purple, (whereas they are straw-coloured in *C. ciliaris*), is also found growing in the same tract. Both the species are eaten readily by cattle and are highly nutritious. They can be fed green or as hay. Feeding these grasses to milch animals is said to improve milk yield and also produce a sleek, glossy coat indicative of health and well-being. The yield is about 224 q/ha per annum from *C. ciliaris* and about 168 to 224 q/ha from *C. setigerus*.

The grass is also cultivated in the arid and semi-arid parts of north-west India, where a number of well-known cattle and sheep breeds are bred. It is one of the principal grasses of the Hariana and Tharparkar tract. *Cenchrus ciliaris* was accidentally introduced many years back into the semi-arid tracts of Australia, probably through seeds contained in camel saddles. It has now spread extensively in that country and forms the staple grass for the flourishing sheep and cattle-rearing industry in Australia.

Description. *Anjan* is a perennial, rhizomatous grass growing to a height of 1·2 to 1·5 m under favourable conditions. The habit of growth varies considerably; rosette, decumbent and geniculately ascending forms being the most common. The leaves are dull green in colour. The inflorescence is a raceme of loosely arranged spikes arranged on a zigzag rachis about 7·5 to 10 cm long. The spikes are surrounded by an involucre of sterile spikelets modified into bristles. Light-brown inflorescences are quite common, especially in the desert forms.

Climate and soils. Although it is found growing in the medium rainfall regions of the northern plains, its best development takes place in the semi-arid regions of the north and south. It comes up best on calcareous red soils. It can be grown under irrigation on light soils, but cannot thrive on clayey soils or on laterite soils deficient in lime. Some

recent strains are reported to grow well on neutral or even slightly acidic soils.

Cultural Practices. As the grass produces abundant seed which is easily collected, it is propagated as a rule only by seed. The land is ploughed well and the seeds sown broadcast at 4·5 to 6·7 kg per hectare just before the monsoon rains. If the fields are irrigable, sowings can be done in any season. Unhusked seed is mixed with four or five times its volume of soil and sown in plough furrows 45 cm apart. After sowing, the furrows are lightly walked over to set the seeds at about 12 mm depth. On an adequately moist seed-bed germination starts within three or four days. For a planted crop seedlings can be raised in a nursery as for ragi, using 0·68 kg for every cent of nursery area. Seedlings raised in three cents will plant one acre. These seedlings grow about 20 to 22 cm in three weeks. They are then transplanted 30 cm apart on the sides of ridges which may be 45 to 60 cm apart.

For raising a pasture, seeds are sown with early rains, at 18–33 kg per hectare. Manuring prior to sowing helps to secure a better and quicker stand. Ammonium sulphate or superphosphate at the rate of 112 kg per hectare followed by an annual top-dressing of 112 kg/ha ammonium sulphate is a good manurial schedule.

A system akin to the ley-farming in England is prevalent in the Kangayam tract using *C. ciliaris* as the pasture grass. Once in three or four years, the land is given a light ploughing and sorghum is sown broadcast. After this sorghum is harvested, the land is left fallow for three or four years, when the local grasses *C. ciliaris* and *C. setigerus* take root and make luxuriant growth. This is left to grow and serve as pasture for the

TABLE 65.

ANALYSIS OF ANJAN GRASS

	Chemical Composition (On dry basis)		
	Young	Prime	Ripe
	%	%	%
Crude protein	11·4	6·2	9·1
Ether extract	1·9	1·5	1·6
Crude fibre	27·2	34·4	29·2
Ash	18·1	13·3	15·9
N-free extract	41·4	44·6	44·2
Calcium	0·50	0·48	0·43
Phosphorus	0·37	0·27	0·28
Potassium	3·41	2·52	2·27

(After Sen and Ray, 1964)

well-known Kangayam breed of cattle of this tract and at the end of the period, the land is sown with sorghum once again.

The first cutting can be taken in 3–3½ months after sowing, but it is desirable to delay the first cut till seed formation, to allow the grass to get established better. The delay also allows some of the seeds to get shed, to fill up gaps during the next growing season. Subsequent cuttings can be taken at 50–60 day intervals. Under irrigation 12 cuttings are possible in a year. The grass tillers well and develops a tussocky sward in about six months' time. A well-established rain-fed crop of *Cenchrus ciliaris* gives 90 to 112 quintals of green fodder per annum even in arid tracts with less than 30 cm of annual rainfall. In regions receiving 38 to 76 cm of rainfall, the yield would be 224 to 280 q/ha per annum.

Nutritive Value. Both *Cenchrus ciliaris* and *C. setigerus* rank very high among the indigenous grasses. The protein content is about 11 per cent in the young grass, with a well-balanced ratio of calcium to phosphorus.

Anjan grass is relished by all classes of livestock. Palatability trials carried out at the Central Arid Zone Research Institute, Jodhpur, showed that the grass is relished even at the dead-ripe stage, more than other grasses.

TABLE 66.

COMPOSITION OF ANJAN HAY

	Digestible Nutrients per cent		
	Young	Prime	Ripe
	%	%	%
Crude protein	11·2	5·5	3·0
Ether extract	0·3	0·5	0·2
N-free extract	47·6	49·6	49·5

(After Sen, I.C.A.R. Misc. Bull No. 25, 1946)

Utilisation. Although mostly used as a cut fodder, the grass is also well suited for grazing. A newly established pasture should be grazed only lightly during the first year and that too, after the seeds mature, to ensure a good stand for the next year. The pasture can be ploughed up after three to five years. The stocking rate for cattle is one adult animal for two acres and three sheep to an acre of *Cenchrus ciliaris* in tracts where the rainfall is adequate. In Australia, *Cenchrus* pastures are utilised for off-season grazing. Since the grass retains its nutritive value even when ripe, it makes very good hay and also silage.

TABLE 67.

ANALYSIS OF ANJAN HAY

	Hay	
	Chemical Composition	Digestible Nutrients
	%	%
Moisture	9·8	—
Crude protein	5·2	48
Ether extract	1·3	43
Crude fibre	33·1	62
Ash	10·8	—
N-free extract	39·8	59
Calcium	0·39	—
Phosphorus	0·38	—
Potassium	1·89	—
		—
		—
Digestible Crude Protein		11·2
Total Digestible Nutrients		48·8

(After Lander, 1949)

For seed purposes it is desirable to sow the grass in lines 0·9 m apart and intercultivate between the lines, to avoid overcrowding through self-seeding. The crop is ready for seed collection by October-November, depending upon the season. Seed collection is easier in this species than in many other grasses, as the mature seed is retained for a long time without being shed. Handpicking is the best method for gathering reliable seed, although bulk harvest may be more economical. Mechanical harvesters attached to jeeps are used in Australia for harvesting *Cenchrus* seed. A well-established field of *Cenchrus ciliaris* yields about 90 kg of seed per hectare.

Cenchrus setigerus Vahl (Syn. *C. biflorus* Roxb.), (Black Kolukkattai) grass and *Cenchrus barbatus* Schum. (Syn. *C. catharticus* Delile) are two species that are common in the semi-arid regions of Rajasthan, north-western India and some parts of Madras. *Cenchrus setigerus* yielded 123 q/ha of green fodder in one cutting under rain-fed conditions at Coimbatore.

Strains of *C. ciliaris* and *C. setigerus* have been evolved at the Indian Agricultural Research Institute, New Delhi, that are specially suited for arid and semi-arid regions like Rajasthan and alpine and sub-alpine regions of the Himalayan slopes. These strains are capable of giving higher yields of forage in a year than the existing types. Some of them

are also stoloniferous and on account of their greater soil-binding efficiency are particularly suited for soil conservation and erosion control.

Pusa Giant *Anjan* is a hybrid between clones of *C. ciliaris* from Rajasthan and *Pennisetum ciliare* from the United States. It yields twice as much forage as the parent species. The forage is also softer and more succulent than the existing types and the maximum growth is produced during the spring and hot season, when green fodder is very scarce.

Cenchrus glaucus (Blou Buffel grass). This is a deep-rooted, perennial grass which is easily established from seed and from rooted slips. Erect, slender, leafy culms grow to a height of 60–121 cm, from a tussocky base. The basal leaves are short and few in number, but the upper leaves which are borne on the ends of most culms and branches are long and narrow, with pointed tips and a bluish-green, glaucous appearance. The inflorescences are slender, 2·5 to 10 cm long, with long bristles and are relatively few in each clump, which may contain as many as 100 tillers.

This grass was introduced a few years ago at the Agricultural Research Institute, Coimbatore and proved very promising. It is well adapted for a wide range of soil types and can be grown both as a rain-fed and an irrigated crop. The yield is about 112 q/ha per year in four or five cuttings as a rain-fed crop and over 560 q/ha under irrigation. The maximum yield recorded was 717 q/ha. The forage is both palatable and nutritious. Blou Buffel is one of the leafiest of all grasses and has a leaf-stem ratio of 16: 9 as against 8: 9 in *Cenchrus ciliaris* and *C. setigerus*.

Seed-setting in this species is about 90 per cent, but the germination is rather low, being only 39 per cent. Manuring at 125 q of farmyard manure plus 170 kg of ammonium sulphate per hectare once a year ensured high yields throughout the year. For its consistent high yields and quality, this grass is being multiplied in forest areas in Chingleput district, for popularising among the farmers of Madras State.

Cenchrus pennisetiformis Rochst and Steud (Syn. *P. cenchroides* var *echinoides* Hook).

This species is considered to be a hybrid between *Cenchrus ciliaris* and *C. setigerus* and differs very little from *C. ciliaris*.

Hariali Grass (*Cynodon dactylon*)

Genus *Cynodon* Rich. (Gramineae)

This is a cosmopolitan genus of 11 species, of creeping perennial grasses, found in all the tropical and sub-tropical countries of the world. They are useful as pasture grasses and soil binders for erosion control. The spikes are digitate, with single-flowered spikelets.

Cynodon dactylon Pers.; Hariali grass, Bahama grass, Bermuda grass, Doob grass, Dhub grass, Devil's grass, Dog's-tooth grass; Sanskrit—Durva, Haritali; Hindi—Dhub, Hariali; Tamil—Arugam pillu, Hariali; Telugu—Garicha gaddi, Harvali; Kannada—Garika hullu, Kudi garike).

Origin, History and Distribution. This species is distributed in almost all the tropical and sub-tropical countries of the world, from sea level up to 2,130 m. elevations. It is a very hardy, ubiquitous, creeping perennial grass, rooting at the nodes and forming spreading mats on the surface of the ground. It was originally a native of India, and was introduced into the United States early in the nineteenth century by way of the Bahama Islands—hence its name Bahama grass. The name Devil's grass is indicative of its habit of becoming a troublesome weed of cultivated lands, which is extremely difficult to eradicate. It is, however, one of the best grasses for pasture and soil-conservation purposes and as a turf grass for lawns, air fields and golf courses. It is one of the important pasture grasses in the southern States of the U.S., where it is considered unrivalled as a palatable, nutritious, cheap and dependable winter feed for cattle. A number of improved varieties have also been selected in the U.S.A., of which the best is " Coastal Bermuda grass ", which is taller and leafier, with better yields than ordinary types. Hariali grass is superior to all other herbages in India in palatability, nutritive value and yielding ability.

Description. The plant is a much-branched, leafy perennial with numerous runners and stolons; these underground parts are pale-white, hard and covered with small, scaly leaves. When these stolons are cut each bit can become a separate plant.

Culms are variable in length from 3–30 cm, leaves short, variably linear or lanceolate, soft, flat, with acuminate tips. Ligule is a conspicuous ring of white hairs. Spikes 2–8, slender, 2–5 cm, long, digitately arranged on the summit of the erect peduncle. Spikelets one-flowered, awnless, laterally compressed, sessile, arranged on one side of the rachis, 3 mm, long; glumes narrow, acute, lemmas broad and ciliate on the keel; fruit (caryopsis) free. *Cynodon* means dog-tooth, probably in allusion to the tooth-like sheaths on the stolons. *Dactylon* refers to the *dactyls* or finger-like spikes on the inflorescence.

Climate and Soils. Hariali can grow as far north as 40 degrees north latitude and on practically all soils. It thrives best, however, on the heavier silt and clay soils, not subject to water-logging or flooding. It is resistant to both drought and salinity (on coastal areas) and alkaline soils. Very few grasses are so responsive to fertilizers as hariali, especially to nitrogen and also to extra moisture.

Cultural Practices. Although the grass can be raised from seed, it is usually propagated by planting slips or rooted cuttings. The germination

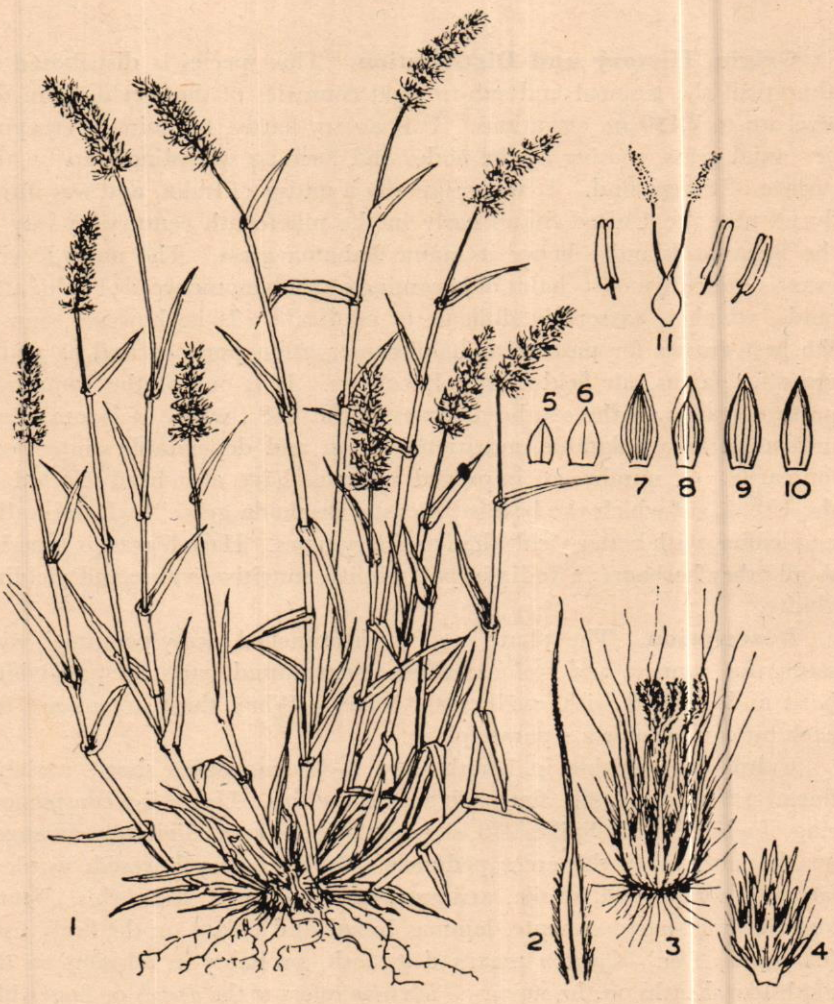


Fig. 12. *Cenchrus setigerus*

1. Plant (×1/3); 2. Bristle (×10); 3. Spikelets, with their involucels; 4. Involucel; 5. First glume; 6. Second glume; 7. Third glume; 8. Palea of third glume; 9. Fourth glume; 10. Ovary and stamens.

Fig. 13. Blou Buffel (*Cenchrus glaucus*)
1. Plant (×1/5); 2. Leaf; 3. Inflorescences.

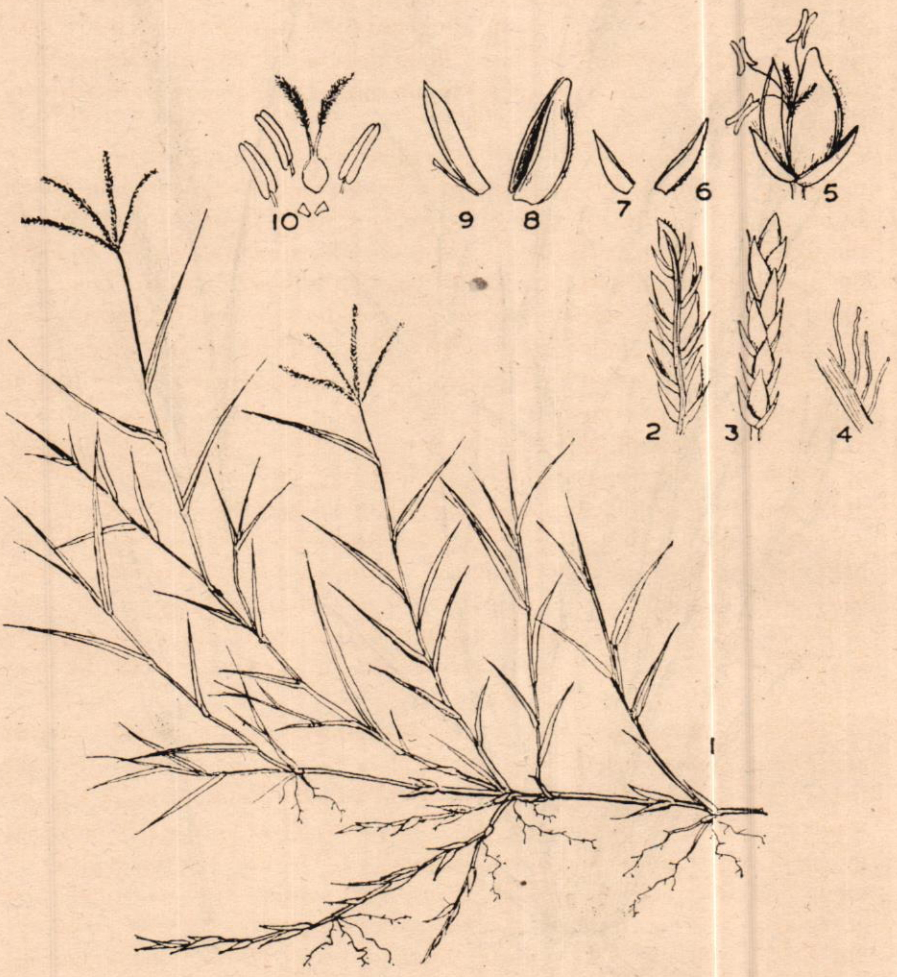


Fig. 14. Hariali grass (*Cynodon dactylon*)

1. Plant; 2. Portion of spike, back view; 3. Portion of spike, front view; 4. Hairs on margin and keel of third glume; 5. Spikelet; 6. First glume; 7. Second glume; 8. Third glume; 9. Palea of third glume and rachilla; 10. Ovary, stamens and lodicules.

of the seed is slow and uneven, and the seedlings too, are lacking in vigour and often get smothered by other grasses. The propagation is, therefore, mostly by planting rooted slips. The common method is to prepare the land by two or three ploughings and plant the slips in plough furrows 30 to 60 cm apart. Freshly dug out Hariali root-stocks, which are kept moist, should be used for planting. Planting is best done in drizzly weather, as the slips strike root better. After planting, the slips are pressed in by the feet.

As a rain-fed crop the grass is planted at the commencement of the monsoon, but under irrigation it may be planted after March in North India and practically any time of the year in South India. In sandy soils, the slips should be planted 10 to 13 cm, deep in rows, taking care to leave the tips above the ground surface. If the soil is sufficiently moist at planting time, no watering is needed, but to prevent the soil from drying out and to ensure intimate contact between the slips and the moist soil, the field may be lightly rolled after planting. The subsequent irrigations should be given at weekly intervals.

Side dressings with a nitrogenous fertilizer such as ammonium sulphate or sodium nitrate are very useful in hastening the establishment of the grass, but along with fertilizers, the field should also be cultivated at suitable intervals, in order to keep down weeds, otherwise the fertilizers will only help the weeds to smother the grass. With adequate manuring, a high level of production can be maintained over a number of years. A dose of 112 to 135 kg of ammonium sulphate or sodium nitrate or a complete fertilizer mixture at 224 kg per hectare early in the season would be very helpful.

Normally the grass is ready for the first cutting in three to four months after planting and subsequent cuttings can be taken at 60–70 day intervals, to give 4–5 cuttings in a year. The yield will be about 18 to 22·4 q per acre per cutting from rain-fed crops and about two and a half times as much, under irrigation and liberal manuring. The hay, when it is properly made and stored, keeps well for nearly two years. For pasturing, close grazing to 10 to 15 cm, ensures a nutritious forage, but the total yields are apt to get reduced. To ensure the best results from grazing, hariali pastures should be reinforced by growing a legume also. In the U.S.A., white clover or lespedeza is recommended for this purpose.

Utilisation. The grass is readily eaten by all types of livestock and is very nutritious. It is also very useful as a soil-binder for erosion control on embankments, etc., and for lawns and turfs.

Since the grass, once established, is very difficult to eradicate, it often becomes a serious weed on cultivated land, where its network of runners and stolons starves out all other crops and makes the field unfit for cultivation. Deep ploughing and digging out the plants with crowbars and spades during the hot summer months and exposing the dug-up plants

to the atmosphere is effective, but very expensive and not always satisfactory. Growing a thick-sown smother crop like wheat or fodder sorghum may be tried. Some of the recent herbicide chemicals will be helpful in small areas. Ploughing, followed by a well-shading crop like *Calopogonium* may also keep the weed in check.

Hariali grass is one of the most nutritious among the grasses. It is higher in protein and lower in crude fibre than either Johnson grass or Timothy hay. In the U.S.A., this grass has been found to be quite equal to Timothy hay for milk production. Cattle made better gains in weight on Cynodon grass than on any other grass. The protein content of this grass at various stages of growth follows the general pattern found in all grasses, decreasing from about 11 per cent in the young stage to about 7 per cent in the mature stage.

TABLE 68.

ANALYSIS OF HARIALI GRASS

	Green grass (On dry matter basis)		Hay (On dry matter basis)	
	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients
	%	%	%	%
Crude protein	10·4	59	11·1	54
Ether extract	1·8	21	1·4	27
Crude fibre	28·2	—	18·4	54
Ash	11·8	—	12·5	—
N-free extract	47·8	76	56·6	46
Calcium	0·77	—	—	—
Phosphorus	0·59	—	—	—
Potassium	2·08	—	—	—
Digestible Crude Protein		6·0		5·9
Total Digestible Nutrients		42·6		38·7

(After Sen and Ray, 1964)

Giant Star Grass

(*Cynodon plectostachyus* Pilger)

Origin, History and Distribution. This grass is a native of Africa, from where seeds were obtained in 1940 for trials at Coimbatore and the Vivekananda Laboratory at Almora. It is now recognised as a useful addition to our cultivated grasses. It is a perennial with long, branching runners which root at the nodes and put forth dense, erect shoots often reaching a height of 60–91 cm. In general growth it resembles the common Doob grass (*Cynodon dactylon*), but can be distinguished by its longer

runners, more vigorous growth and longer digitate spikes. On account of its ability to strike root at each node, it is a very useful grass for soil-binding purposes.

TABLE 69.

ANALYSIS OF CYNODON DACTYLON

(In comparison with other fodders, on dry matter basis)

	Cynodon dactylon	Cenchrus ciliaris	Andropogon pertusus	Oats	Jowar	Bajra
	%	%	%	%	%	%
Crude protein	21·9	10·1	6·1	7·6	4·3	10·6
Ether extract	2·7	1·6	1·4	2·0	1·5	2·1
Crude fibre	18·6	29·5	33·2	34·9	29·6	27·9
Ash	12·6	18·2	11·7	10·2	9·1	9·2
N-free extract	44·2	40·6	47·6	45·3	55·5	50·2
Calcium	0·81	0·60	0·62	0·51	0·66	0·73
Phosphorus	0·82	0·67	0·40	0·50	0·17	0·50

(After Lander, 1949.)

Climate and Soils. The grass grows well both on the plains and on the hills, up to 1,830 m elevations and on all types of well-drained soils.

Cultural Practices. The land is ploughed two or three times to bring it into condition before planting the slips 45 cm apart each way. As a rain-fed crop it is best to plant the grass at the commencement of the monsoon, but under irrigation planting can be done in any month. After planting, weekly irrigations may be necessary. Generally, no manuring is done, but like Hariali this species is also quite responsive to nitrogenous fertilisers.

A five-year old pasture of Star grass was supplied with three levels of ammonium sulphate, (0, 112 and 224 kg per acre), in conjunction with adequate phosphates at the start of the rains in November. The first cutting could be taken three months after the first-dressing and the second cut was also ready by the next four weeks. All the dressings showed larger returns but the earlier cuts showed the largest benefits. Under favourable conditions an irrigated crop will yield about 672 kg per hectare per year over three cuttings.

The tender grass is reported to be somewhat toxic, as it contains in all plant parts a low percentage of hydrocyanic acid, 0·012 per cent in the leaves and 0·001 per cent in the culms. Although this is too low to have any lethal effect on livestock, it is nevertheless safer to feed the grass only after it flowers.

On account of its rapid and vigorous growth, it is very useful in controlling soil erosion on bunds and embankments. This grass has been used as a soil binder on the mile-long earthen dam in the Lower Bhavani Project in Coimbatore district.

Nutritive Value. The grass is quite nutritious, with about 10 per cent protein and a well-balanced calcium: phosphorus ratio. It is also rich in digestive protein, and feeding trials indicate that the hay by itself can serve as an adequate maintenance ration.

TABLE 70.

ANALYSIS OF GIANT STAR GRAS

	Chemical Composition (On dry basis)	
	Green	Hay
	%	%
Crude protein	9·4	6·4
Ether extract	0·9	0·6
Crude fibre	30·4	35·6
Ash	11·2	6·8
N-free extract	48·1	50·6
Calcium	0·75	0·31
Phosphorus	0·33	0·37
Potassium	—	—

(After Sen and Ray, 1964)

Marvel Grass
(*Dichanthium annulatum*)

Genus *Dichanthium* Willemet (Gramineae)

A small genus of perennial grasses, rarely annuals, distributed in all tropical regions. Six species occur in India, of which two are of importance as fodder grasses.

Dichanthium annulatum (Syn. *Andropogon annulatum* Fors); Hindi—Apang.

This is one of the best-known grasses of India; its fodder value was first recognised in Poona. It is an erect, tufted, fine-stemmed, perennial grass favouring moist situations; the habit varies from erect to procumbent. A full-grown plant may attain a height of nearly 1·2 m. The culms are purplish-red or bluish in colour, with a distinct ring of whitish hairs at the nodes. Leaves are bluish-green and are variable in length from 23 to

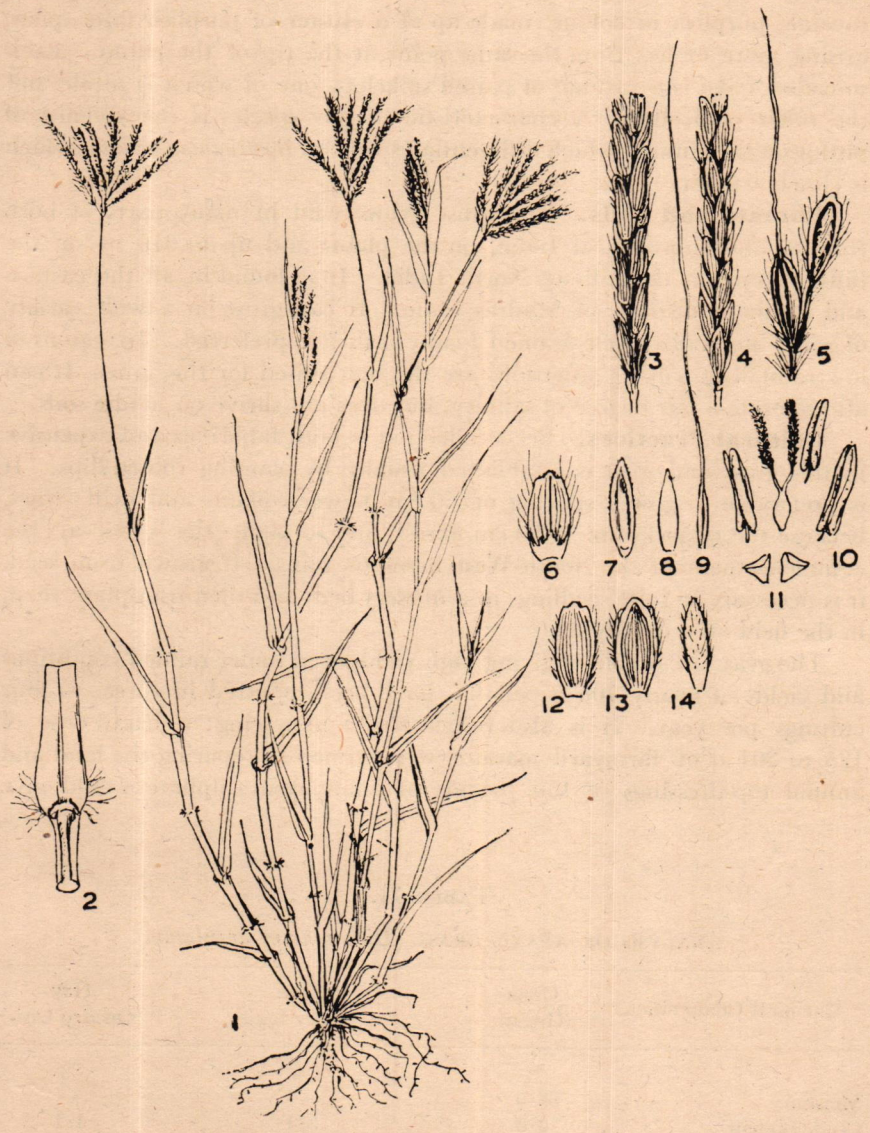


Fig. 15. *Dichanthium annulatum*

1. Plant ($\times\frac{1}{2}$); 2. Leaf base and ligule; 3, 4. Front and back views of spikes; 5. Sessile and pedicelled spikelets; 6–9. First, second, third and fourth glumes of sessile spikelet; 10. Ovary and stamens; 11. Lodicules; 12–14. First, second, third glumes of pedicelled spikelet.

45 cm., with a distinct yellowish midrib. The inflorescence is a compound raceme, purplish in colour, made up of a cluster of purplish false spikes arising more or less from the same point at the tip of the culms. Each so-called spike is a raceme of paired spikelets, one of which is sessile and the other pedicelled. A characteristic of this species is the absence of pitting on the glumes, which differentiates it from *Bothriochloa pertusa*, which is closely similar.

Climate and Soils. The grass grows wild in many parts of both tropical and sub-tropical India, on the plains and up to 910 m on the hills, except on the hills of North India. It is found in all the eastern and southern districts of Madras State. It can grow on a wide variety of soils, but moist, well-drained loamy soils are preferred. In regions of low rainfall, low-lying situations are the best suited for this grass. It can also tolerate a fair degree of salinity, but does not thrive on acidic soils.

Cultural Practices. Seed collection is both laborious and expensive in this grass and so it is established usually by planting rooted slips. It is preferable to give a spacing of 60 cm between plants and drill rows, because the tussocks are 30-80 cm across, and to plant the grass at the commencement of the South-West monsoon rains. If grown from seed, it is necessary to raise seedlings in a nursery beds and then transplant them in the field on a drizzly day.

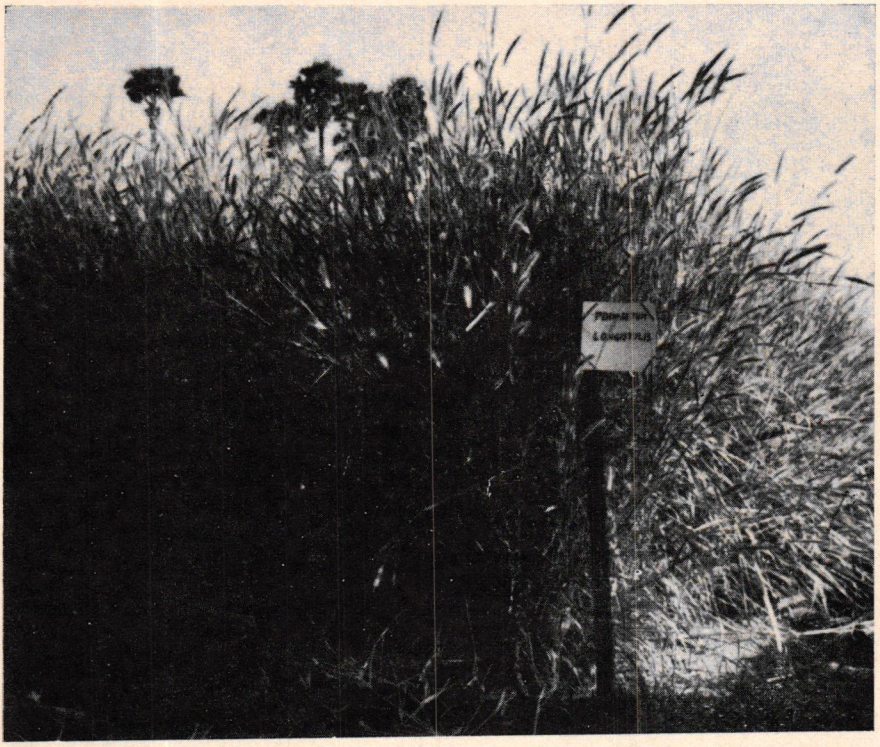
The grass is capable of giving high yields even under rainfed conditions and yields of nearly 706 q per ha have been reported in three to four cuttings per year. It is also responsive to manuring; a basal dose of 125 to 201 q of farmyard manure at the time of preparing the land and annual top-dressings of 150 pounds of ammonium sulphate would give

TABLE 71.

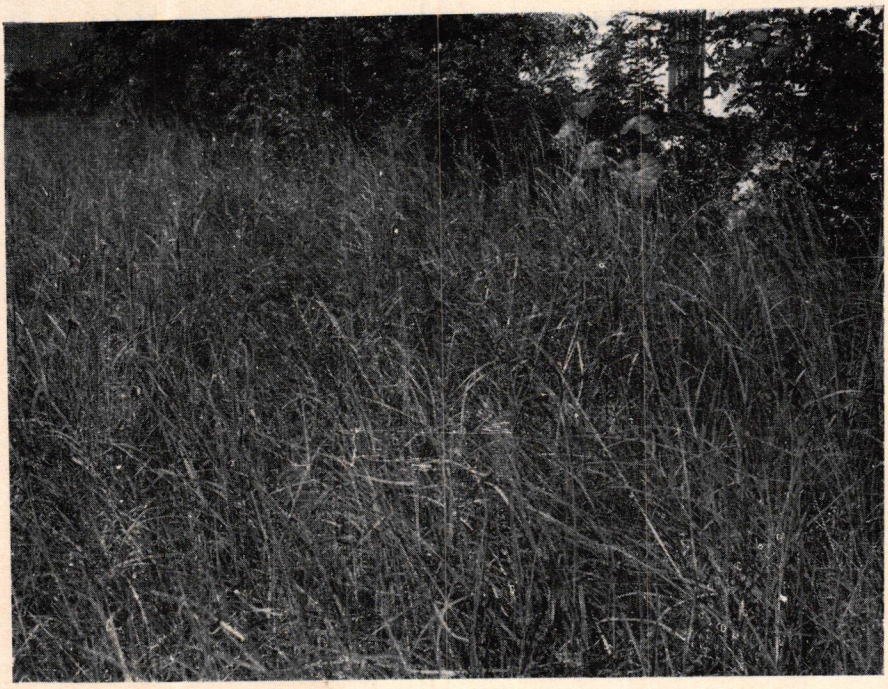
ANALYSIS OF APANG GRASS (*Dichanthium annulatum*)

Chemical Composition	Grass (Green)	Grass (On dry basis)	Hay (On dry basis)
	%	%	%
Moisture	66·0	—	—
Crude protein	2·2	3·1	4·1
Ether extract	1·7	1·1	1·0
Crude fibre	11·6	35·2	29·9
Ash	3·7	10·0	10·6
N-free extract	14·8	50·6	44·4
Calcium	—	0·44	0·41
Phosphorus	—	0·14	0·11
Potassium	—	1·00	0·90

(After Sen and Ray, 1964)



Pennisetum longistylis



Cenchrus glaucus (Blou-buffel)
One of the leafiest of all forage grasses.
(*Courtesy*: Director of Agriculture, Madras).

PLATE XVIII

Cenchrus ciliaris L. (Kolukettai grass)
(*Courtesy*: Director of Agriculture, Madras).

Ophiuros exaltatus O. Ktz.
A coarse, erect grass, useful as fodder when young and for thatching, when mature.

Eragrostis superba
The genus *Eragrostis* includes the love grasses, some of which are useful as a vegetative cover on eroded sites.

Heteropogon contortus Beauv. (Spear grass)

profitable returns. It is considered one of the best grasses in India for forage, as pasture, hay or as a soiling crop. The protein content of the grass is not high, being only 5–7 per cent, but this is more than made up by its palatability. Cattle seek out this grass in mixed pastures and graze on it first, even in preference to Anjan grass (*Cenchrus ciliaris*). It does not, however, fit in well in mixtures, as it crowds out all other vegetation. In dry regions, as at the Arid Zone Research Institute, Jodhpur, sheep did not show good response to this grass, but cattle and especially horses showed very good responses to feeding on this grass. The grass is largely used for hay-making in many parts of the country and this appears to be its best use.

Dichanthium caricosum A. Camus (Syn. *Andropogon caricosus* Linn,; (Hindi - Kartak, Khel)

An erect, perennial tufted grass, 30 to 60 cm tall, found throughout the plains and on low hills up to 914 m, but less common than *D. annulatum*. It is not found on the Kerala coast, as it prefers dry, sandy habitats. The yield is about 89·6 q of green forage per hectare.

Elyonurus hirsutus (Sewan Grass)

Genus *Elyonurus* Humb. and Bonpl. (Gramineae)

Erect, moderately tall, perennial grasses with solitary spikelike, often woolly racemes. These are important grazing grasses on the plains and savannas of tropical America, distributed from Texas down to the Argentine in South America.

The spikelets are borne in pairs along the rachis; the joints and pedicels are short, thickened and parallel; sessile spikelet perfect, appressed to the concave side of pedicels; pedicellate spikelet staminate; both awnless, the pair falling off with a joint of the rachis.

The name is derived from the Greek *elusein*, (to roll) and *oure*, (tail), in allusion to the cylindrical inflorescence.

Elyonurus hirsutus (Sewan grass)

Origin, History and Distribution. This is a common grass of the Rajasthan desert, where it occurs on sandy areas and arid tracts with 10-13 cm of rainfall. It is widely distributed in other arid parts of the world also, viz., Pakistan, Iran, Arabia and Africa. Its forage value is being now recognised in Western Rajasthan.

Description. Sewan grass is an erect, tussocky perennial, often attaining a spread of 2·4 to 2·7 m and a height of 1·2 to 1·5 m., is characterised by numerous yellowish-green tillers, often 200 or more in number. In natural growths the grass is somewhat variable in habit,

ranging from erect to procumbent and some types are more leafy than others, the leaves are 30 to 45 cm long, tapering to a fine-drawn out point. The inflorescence is cylindrical in shape, 13 to 15 cm long, pale-yellow when fresh and turning whitish when mature.

Climate and Soils. The grass prefers sandy soils and does not thrive on heavy soils. Being essentially a grass of arid regions, it is well suited to Rajasthan and the Punjab. It can be established by seeds or by planting slips. The field is ploughed twice and planked once and harrowed once with a toothed harrow. If virgin land is to be sown with Sewan grass, two or three ploughings, two harrowings and a final levelling will be necessary. If the area is extensive, the land can be opened up with furrows 1·2 to 1·5 m apart, leaving it to be covered by the grass itself later on. Sowing is done in July-August with the monsoon rains after making shallow furrows 60 cm. apart on the moist seed-bed and sowing the unhusked seed at the rate of 4·5 to 6·7 kg per hectare. After sowing, the furrows are lightly walked over, to set the seeds 12 mm deep into the soil. The grass can also be established by planting rooted slips 45 to 60 cm apart, between rows and between plants. It is desirable to top the plants at planting time to reduce transpiration.

One or two interculturings will be helpful in conserving soil moisture and keeping down weeds. Under rain-fed conditions Sewan grass yields about 112 q of green fodder per hectare in four to five cuttings in a year.

Utilisation. The forage is well relished by all livestock and is quite nutritious, with 9 per cent protein and high calcium, although the phosphorus content is low. The grass can be used as a pasture, hay or soiling crop. As a pasture grass, its carrying capacity is greater than *Anjan*

TABLE 72.

ANALYSIS OF ELYONURUS HIRSUTUS

	Chemical Composition of Hay (On dry basis) (Post-flowering stage)
	%
Crude protein	5·9
Ether extract	0·3
Crude fibre	38·0
Ash	11·0
N-free extract	44·8
Calcium	1·09
Phosphorus	0·06
Potassium	—

(After Sen and Ray, 1964)

Fig. 16. *Elyonurus tripsacoides*
1. Plant (×½): 2. Inflorescence (×1); 3. Spikelet, with rachis joint (×8).

grass (*Cenchrus ciliaris*). At the Arid Zone Research Institute, Jodhpur, this grass had a carrying capacity of 4·5 sheep per acre on a year-long basis as against 2·5 sheep per acre of *Anjan* grass. In view of the widely variable rainfall conditions, a carrying capacity of 3 sheep per acre is recommended for Rajasthan.

Being a perennial, Sewan grass can continue to provide grazing for a number of years, provided a stubble height of at least 10 cm is left and no grazing is allowed in the first year. The land is given an interculture once or twice in a year, to help in the conservation of soil moisture and a uniform distribution of cattle droppings.

Abundant seed is produced in the grass and a well-established stand can give about 280 kg of seed per hectare. For a seed-crop, the grass is planted in rows 90 cm feet apart. Two seed crops can be secured in a year, once in the autumn and again in the next spring.

Eragrostis species

Genus *Eragrostis* Beauv. (Love grass)

Includes 250 species, distributed mainly in temperate regions.

A large group of annual and perennial grasses of various habit, with open or contracted panicles. Spikelets few or many-flowered, the florets closely imbricate, the rachilla disarticulating about the glumes and between the florets.

The name is derived from Greek *eros*, love and *agrostis*, a kind of grass. Although the genus includes numerous species, few of them have much fodder value. *E. intermedia* is reported to furnish grazing on the wastelands of Arizona and New Mexico. Some species native to South Africa are very drought-resistant. Among these, *E. curvula* and *E. lehmaniana* are known in India. These are useful as vegetative cover on eroded sites.

Eragrostis curvula (Schrad.) Nees. (Weeping lovegrass)

A densely tufted, tall erect grass, leaf-sheath narrow, lower part densely hairy, blades have long drawn-out fine tips. Panicles 20–30 cm long, branches solitary or in pairs, ascending, densely hairy at base. Spikelets are 7–11 flowered, 7–10 mm long, lemmas 2·5 mm. long, prominently nerved.

Trials carried out with this species and *E. lehmanniana* have shown that they can be grown successfully in many parts of India on loamy soils that are neutral or even slightly alkaline in reaction, but neither of them can survive desert conditions, unless irrigation is provided. The grasses can be established by seeds and can yield about 280 q/ha of green fodder in a year under favourable conditions of irrigation and manuring. The forage is rather coarse, although love-grass pastures have been found to have a high carrying capacity and are also useful for erosion control. For instance *E. trichodes* (sand lovegrass), which is found in 10 central Great

Plains States from Illinois and Colorado to Texas is known as the "ice-cream grass", on account of its palatability.

E. abyssinica (Kacq.) Link. (Teff. grass).

This species is a native of South Africa, where the seed is used for food. In 1913 it was introduced from Kew into the United States. In India, it was introduced in 1934 for trial at the Central Farm, Coimbatore.

It is a tufted, quick-growing perennial, resistant to heat and drought and is a heavy seed-producer. It thrives best on sandy loams and cannot tolerate wet soils. It is also responsive to fertilizers, especially cattle manure and other nitrogenous fertilizers.

As the seeds are very small, they should not be covered too deep, nor sown too thick, otherwise the growth will be too crowded and stunted. Mowing the grass encourages good growth; if planted in rows, inter-cultivation will be needed only in the first year. The grass makes a good pasture and can be combined with some legumes. The hay yield may vary from 25 to 100 q per hectare. The grass is also good for erosion control.

TABLE 73.

ANALYSIS OF ERAGROSTIS CURVULA

	Chemical Composition (On dry basis)
	%
Crude protein	5·2
Ether extract	1·7
Crude fibre	36·4
Ash	11·1
N-free extract	45·6
Calcium	0·35
Phosphorus	0·31
Potassium	—

(After Sen and Ray, 1964)

Heteropogon contortus Beauv. (Spear Grass)

Genus *Heteropogon* Pers.

Annual or perennial, often robust grasses with flat leaf-blades and solitary terminal racemes; rachis slender, lower part bearing the pairs of staminate spikelets is continuous, while the remainder disarticulates obliquely at the base of each joint. The fertile lemma is narrow and extends into a strong, bent and twisted brown awn or 'spear'.

Heteropogon contortus Beauv.; Hindi—Kusal, Kumeria, Parwa; Tamil—Oosi pillu; Telugu—Pandu mullu gaddi; Kannada—Sankari hullu.

A densely tufted perennial grass 91 to 152 cm. tall, erect or decumbent, leafy mainly at base. Leaves up to 60 cm. long, 3–7 mm. broad, firm, linear, often hairy from bulbous bases. Racemes terminal, erect or bent, 4–8 cm long with prominent dark-brown awns which are jointly twisted together to form a bundle, especially in the older inflorescences. Sessile spikelet 7 mm long, almost hidden by the imbricate pedicelled spikelet. Awns 3–12 cm long, usually twisted together.

Speargrass is an indigenous forest grass which is found practically all over the world and in India in all semi-dry areas up to an elevation of 1950 m. It is the dominant grass wherever grasslands are subject to periodic burning, as in most of the dry, deciduous forests of Madhya Pradesh, Bihar, Orissa, North-East Punjab, Rajasthan, Gujarat, Maharashtra, Andhra Pradesh, Mysore and Madras. In Madras it covers extensive areas in Salem and adjoining districts, dominating and even suppressing other grasses, especially on poor rocky soils.

It is a quick-growing hardy grass, growing to a height of 60 to 121 cm. It should be cut and fed to cattle before the flowering stage, otherwise the sharp awns or spears make it unpalatable. Cattle do eat it,

TABLE 74.

ANALYSIS OF SPEAR GRASS

	Green (Prime)		Hay (On dry weight basis)		Silage	
	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients
	%	%	%	%	%	%
Crude protein	3·9	—	7·0	16	6·6	26
Ether extract	1·1	—	1·4	43	1·7	40
Crude fibre	31·3	—	34·5	57	32·6	69
Ash	8·0	—	9·2	—	15·5	—
N-free extract	55·7	—	47·9	47	43·6	62
Calcium	0·61	—	0·34	—	—	—
Phosphorus	0·07	—	0·13	—	—	—
Potassium	0·77	—	1·02	—	—	—
Digestible Crude Protein	—	—	—	0·8	—	0·5
Total Digestible Nutrients	—	—	—	40·3	—	15·1

(After Sen and Ray, 1964)

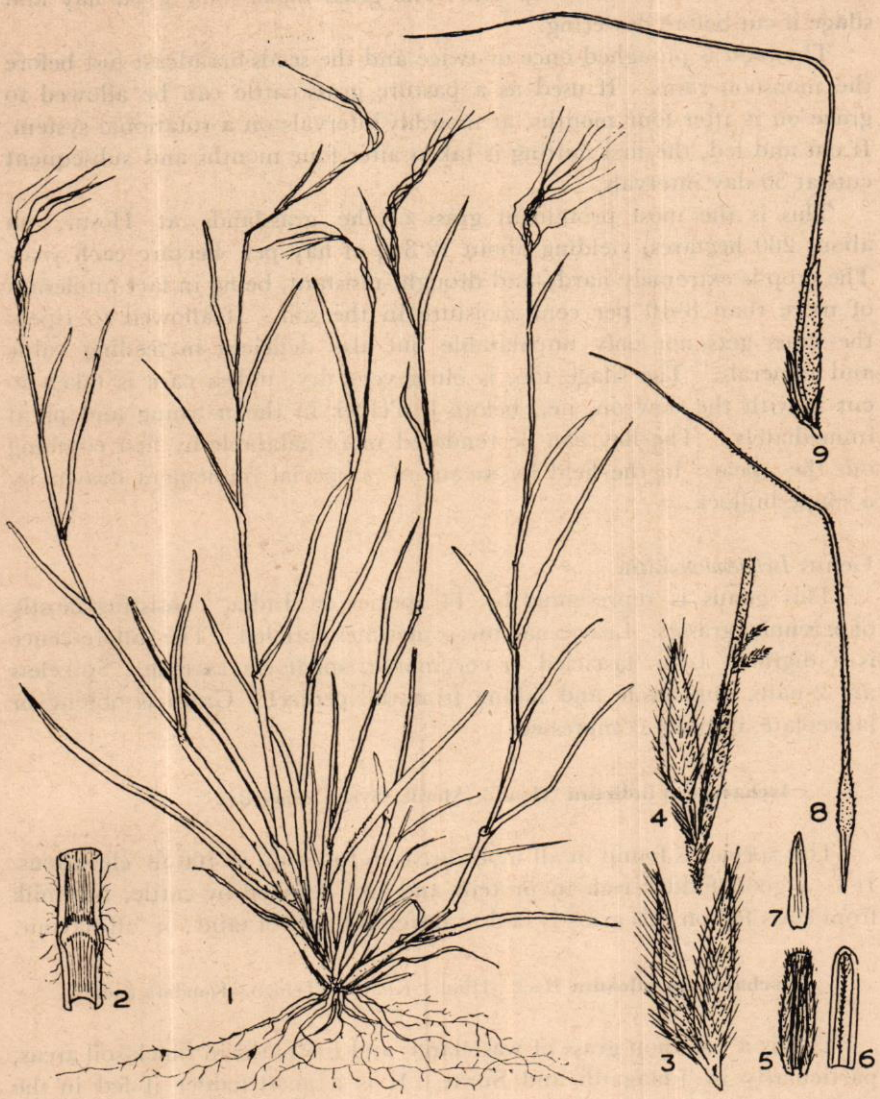


Fig. 17. *Heteropogon contortus* Beauv.

1. Plant ($\times\frac{1}{4}$); 2. Leaf-sheath and ligule; 3, 4. Lower and upper pair of sessile and pedicelled spikelets; 5, 6, 7, 8. First, second, third and fourth glumes of sessile spikelets; 9. Ovary.

however, after the awns drop off. The grass makes very good hay and silage if cut before flowering.

The land is ploughed once or twice and the seeds broadcast just before the monsoon rains. If used as a pasture grass cattle can be allowed to graze on it after four months, at monthly intervals on a rotational system. If cut and fed, the first cutting is taken after four months and subsequent cuts at 50 day intervals.

This is the most prominent grass of the grasslands at Hosur, on about 280 hectares, yielding about 12·3 q of hay per hectare each year. The crop is extremely hardy and drought-resistant, being in fact intolerant of more than 8–10 per cent moisture in the soil. If allowed to ripen, the grass gets not only unpalatable but also deficient in feeding value and minerals. The silage too, is often very dry, unless care is taken to cut it with the dew on, i.e., before 8 o'clock in the morning and pit it immediately. The hay can be rendered more palatable by first combing out the spears in the field by means of a special implement drawn by a single bullock.

Genus *Ischaemum* Linn.

This genus is represented by 14 species in India, consisting mostly of perennial grasses. Leaves narrow, sometimes petioled. The inflorescence is a digitate, twin, fascicled or corymbose, spiciform raceme. Spikelets are 2-nate, one sessile and falling from the pedicel. Grain is oblong or lanceolate, dorsally compressed.

Ischaemum indicum (Houff.) (Morill. (Syn. *I. ciliare* Retc.).

This species is found in all moist areas in India up to 760 m elevations. It is a good fodder rich in protein and well-relished by cattle, but milk from cows fed on this grass is said to develop a sort of taint or off-flavour.

Ischaemum pilosum Hack. (Hindi—Khevdo; Telugu—Kundara gaddi).

This is a common grass of wastelands and footpaths in black-soil areas, particularly in Junagadh and Surat. It is a good fodder if fed in the young stage.

Ischaemum rugosum Salisb. (Gujarati—Gandaru; Tamil—Kadukken pillu).

This species is also a good fodder grass, and when it is fed in conjunction with *Iseilema prostratum* it is reputed to improve the milk yield of cows and buffaloes. In Gujarat State nearly 50 per cent of the grassy cover is composed of *Pseudanthistiria*; *heteroclita* Hk.f. and *Themeda triandra*. *Ischaemum rugosum* and *Iseilema prostratum* (L) And. form only 20 per cent of

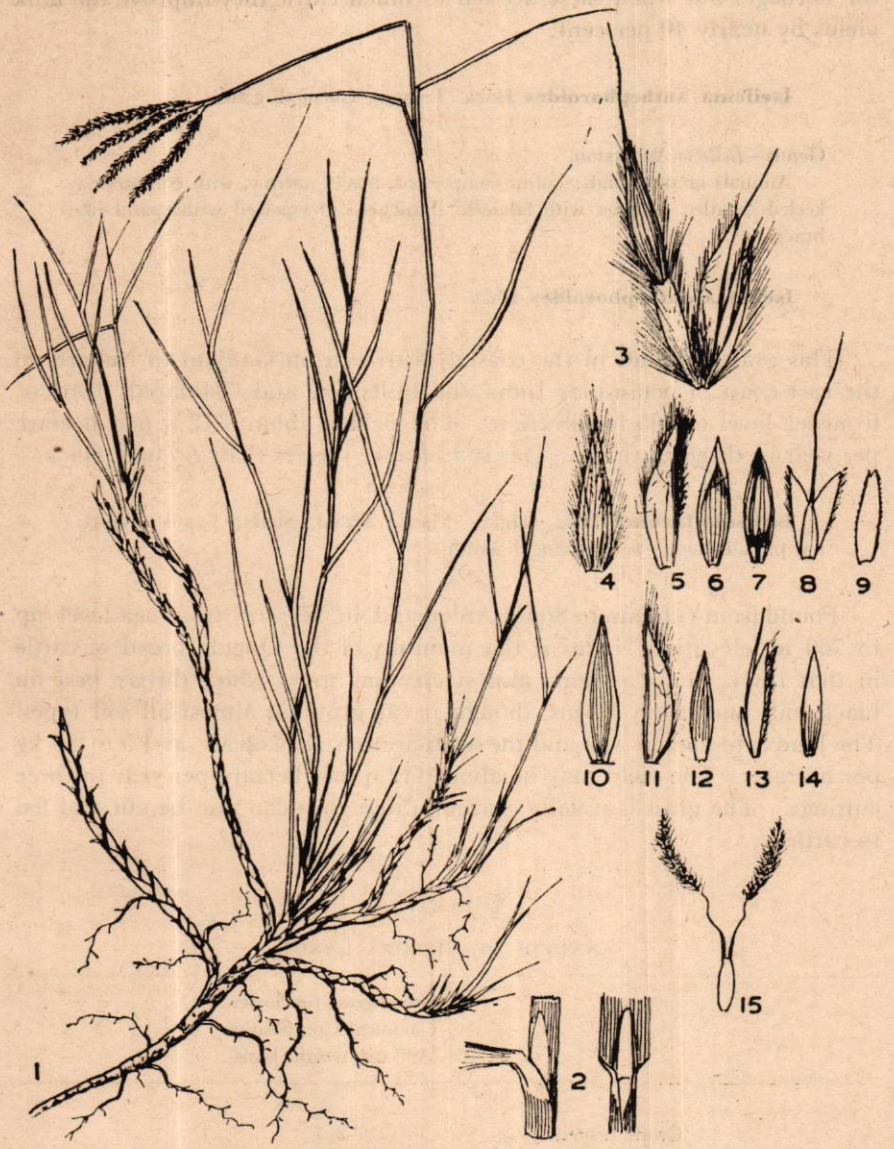


Fig. 18. *Ischaemum pilosum* Hack.

1. Plant ($\times\frac{1}{4}$); 2. Ligules ($\times 2$); 3. Sessile and pedicelled spikelets; 4, 5, 6. 1st, 2nd and 3rd glume; 7, 8, 9. Palea, 4th glume and palea of sessile spikelet; 10, 11. 1st and 2nd glume of; 12, 13. 3rd and 4th glume; 14. Palea; 15. Ovary.

the herbage, but when these are fed to milch cattle they improve the milk yields by nearly 40 per cent.

Iseilema anthephoroides Hack (Telugu—Chengali gaddi).

Genus—*Iseilema* Andersson.

Annuals or perennials; culms compressed, leaves narrow, with compressed, keeled sheaths; panicles with fascicled branches, interspersed with spathe-like bracts.

Iseilema anthephoroides Hack.

This grass is found in the coastal districts from Ganjam to Nellore on the east coast of peninsular India and in Bellary and Cuddapah districts, from sea level to 305 m elevation. The yield is about 112 q per hectare per year in three cuttings. This is a hardier species than *I. laxum* Hack.

Iseilema laxum Hack. (Hindi—Masel, Musel, Shata; Tamil—Tengai nar pul; Telugu—Yerra chengali gaddi).

Found from Ganjam to South Arcot and in Mysore, from sea-level up to 760 m elevation. This is the mainstay of the Ongole breed of cattle in that tract. It is a short, almost creeping grass which thrives best on black soils and heavy loams, though it can grow on almost all soil types. The land is ploughed well and the seeds are sown broadcast at 4·5 to 6·7 kg per hectare. The yield may be about 112 q per hectare per year in three cuttings. The grass is usually grazed, although it can also be cut and fed to cattle.

TABLE 75.

ANALYSIS OF ISEILEMA LAXUM

	Green grass (in flower) Chemical Composition (On dry weight basis)
	%
Crude protein	3·7
Ether extract	1·0
Crude fibre	38·8
Ash	9·8
N-free extract	46·7
Calcium	0·36
Phosphorus	0·07
Potassium	0·72

(After Sen and Ray, 1964)

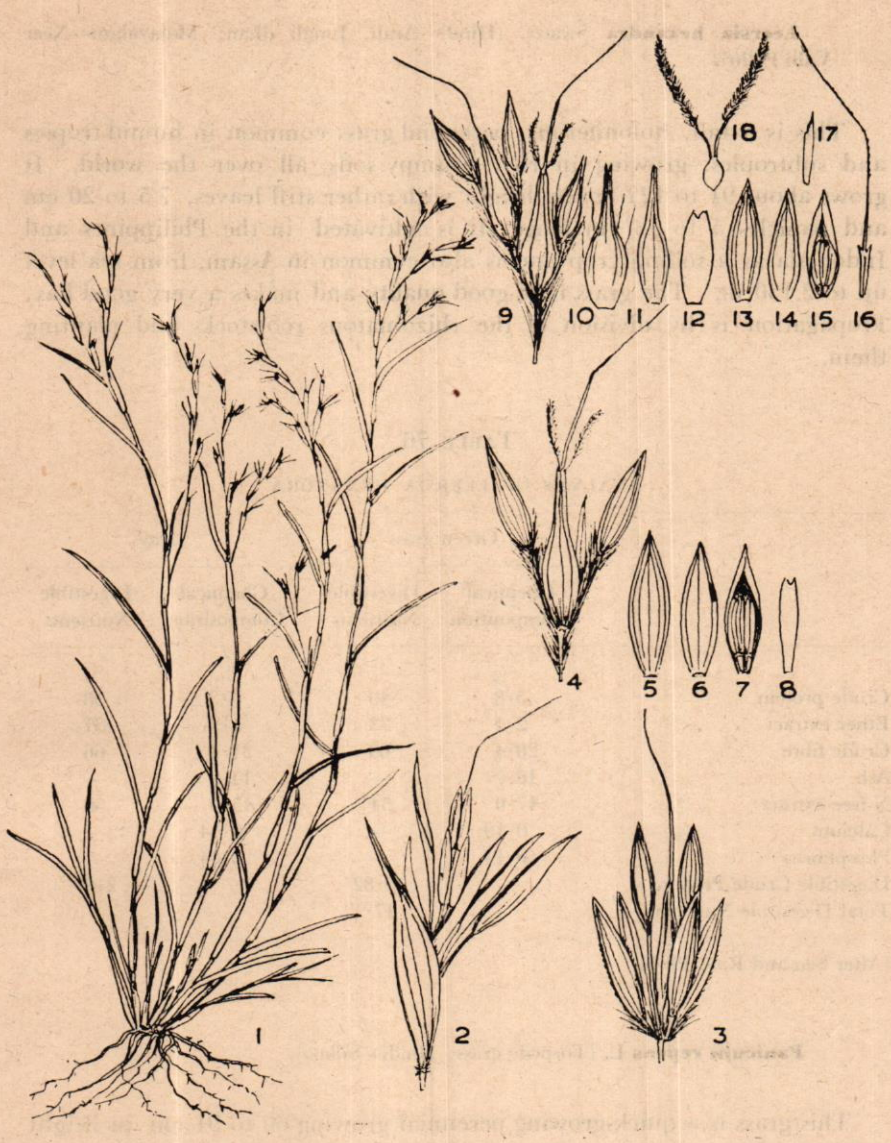


Fig. 19. *Iseilema laxum*

1. Plant (×1/3) 2. Cluster of spikelets, with spathes; 3. Cluster of involucral spikelets and three inner spikelets; 4. Inner spikelets consisting of one sessile female or bisexual and 2 pedicelled, male spikelets; 5, 6. First, second of involucral spikelet; 7, 8. 3rd glume and palea of involucral spikelet; 9. Inner spikelets of 2 pedicelled male and 2 bisexual spikelets; 10–13. First, 2nd, 3rd and 4th glume of sessile spikelets; 14–16. First, 2nd and 3rd glumes of the inner pedicelled spikelets; 17. Palea of the inner pedicelled spikelets 18. Ovary and stigma.

Leersia hexandra Swarts. (Hindi—Arali, Jungli dhan; Malayalam—Neer Valli Pullu).

This is a tall, stoloniferous, perennial grass common in humid tropics and subtropics, growing in rich swampy soils, all over the world. It grows about 91 to 122 cm in height with rather stiff leaves, 7·5 to 20 cm and panicles 5 to 13 cm long. It is cultivated in the Philippines and Indonesia as a soiling crop and is also common in Assam, from sea level up to 2,130 m. The grass is of good quality and makes a very good hay. Propagation is by division of the rhizomatous rootstocks and planting them.

TABLE 76.

ANALYSIS OF LEERSIA HEXANDRA

	Green grass		Hay	
	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients
	%	%	%	%
Crude protein	5·8	40	6·3	38
Ether extract	2·1	23	1·5	31
Crude fibre	28·4	63	31·4	66
Ash	16·7	—	14·9	—
N-free extract	47·0	54	45·9	50
Calcium	0·19	—	0·14	—
Phosphorus	0·14	—	0·14	—
Digestible Crude Protein		0·82		2·00
Total Digestible Nutrients		17·1		—

(After Sen and Ray, 1964)

Panicum repens L. (Torpedo grass; Hindi—Silkoo).

This grass is a quick-growing perennial growing 60 to 91 cm in height and spreading by long creeping rhizomes. It is widely distributed in the tropics and sub-tropics all over the world, especially on sandy soils near river banks and sea coasts. It is highly resistant to flooding and drought, as the rhizomes can survive long dry spells. The grass is very palatable and can serve as a good pasture grass under irrigation, and can stand close grazing well, but often it is liable to become a very troublesome weed, almost impossible to eradicate, in ditches and water channels. Propagation is by planting the rootstocks, as the grass seldom sets seed.

TABLE 77.

ANALYSIS OF PANICUM REPENS

	Chemical Composition (On dry basis)
	%
Crude protein	8·5
Ether extract	3·2
Crude fibre	27·4
Ash	12·7
N-free extract	48·2
Calcium	0·63
Phosphorus	0·29

(After Sen and Ray, 1964)

Pennisetum orientale Rich.

This is a rhizomatous, deep-rooted perennial, native to North Africa and found extending eastwards up to India. It attains a height of 91 to 122 cm and the culms spread out at the base to form tussocks. It is a useful pasture grass for rich, moist soils but can also withstand drought and remain green throughout the year. The herbage is palatable and nutritious. Propagation is by seed or by planting rooted slips.

TABLE 78.

ANALYSIS OF PENNISETUM ORIENTALE

	Chemical Composition (On dry basis)
	%
Crude protein	8·2
Ether extract	3·2
Crude fibre	27·8
Ash	16·1
N-free extract	44·7
Calcium	0·59
Phosphorus	0·37

(After Sen and Ray, 1964)

Sehima nervosum

Genus *Sehima* Forsk.

Annual or perennial, erect, tufted grasses. Leaves convolute when young; inflorescence solitary, often much curved; rachis jointed fragile; spikelets compressed; one sessile, the other pedicelled.

Sehima nervosum Stapf. (Hindi—Pavna, Sheda, Suckal; Tamil—Kara itti, Vennai pillu; Telugu—Nendra gaddi; Kannada—Sinnaishadai hullu.

A short, clumpy grass with abundant soft foliage and numerous tillers, growing up to 91 cm in height. It is generally found wild in forests, at low elevations under partial shade and is distributed in all districts of Madras from sea level up to 1,830 m elevation; but not found on the west coast (Kerala). Branches erect, four-noded, the upper two are exserted. Leaves 15 to 35 cm long, 2·5 to 5 cm wide, sheath tight, thinly hairy from tubercled-bases hairs; ligules a line of stiff hairs. Leaf blade linear. Racemes solitary, 7·5 to 13 cm long, erect or slightly flexed. Sessile spikelets linear-lanceolate. Both sessile and pedicelled spikelets are awned; the awns are slender and twisted at the base. It can be grown also as a cultivated grass; as a rain-fed crop in places with 50 to 75 cm of rainfall. It is somewhat difficult to establish first, in a new locality, but once established it can stand cutting well. The grass is well relished by cattle.

The land is ploughed well and seeds broadcast at 11 to 13 kg per hectare. No manuring is given as a rule, but the grass can respond well to nitrogenous manures. The first cutting can be taken in 3½ months. The grass can be either grazed or cut and fed. The yield is 112 to 157 q per hectare of green fodder in four cuttings per year.

TABLE 79.

ANALYSIS OF SEHIMA NERVOSUM

	Chemical Composition (On dry weight basis)
	%
Crude protein	4·9
Ether extract	0·8
Crude fibre	40·3
Ash	11·9
N-free extract	42·1
Calcium	0·32
Phosphorus	0·15
Potassium	—

(After Sen and Ray, 1964)

Johnson Grass (*Sorghum halepense* Pers.)

Origin, History and Distribution. Johnson grass is a native of the Mediterranean coast of Asia. It was introduced from Turkey into the United States in 1830 when a planter named Colonel William Johnson sowed some seeds on his lands on the banks of the Alabama river. Here

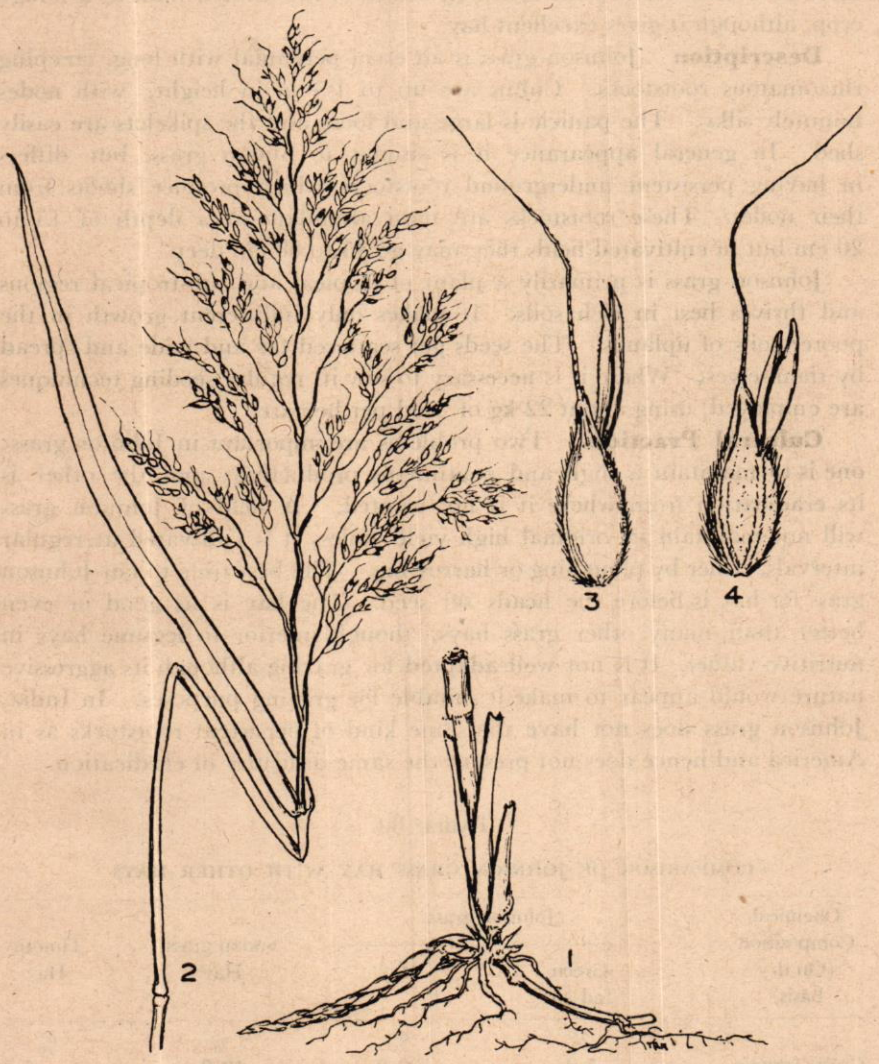


Fig. 20. *Sorghum halepense* (Johnson Grass)
1. Rootstock; 2. Inflorescence; 3, 4. Two views of spikelet.

it grew very well and soon spread to many other States, being known as Johnson grass thereafter. At the present day, however, this is regarded more as a bad weed in the southern States of the U.S.A. than as a forage crop, although it gives excellent hay.

Description Johnson grass is an erect perennial with long, creeping rhizomatous rootstocks. Culms are up to 1·5 m in height, with nodes minutely silky. The panicle is large and loose and the spikelets are easily shed. In general appearance it is similar to Sudan grass, but differs in having persistent underground rootstocks which produce shoots from their nodes. These rootstocks are most abundant at a depth of 15 to 20 cm but in cultivated fields they may go 45 to 60 cm deep.

Johnson grass is primarily a plant of tropical and sub-tropical regions and thrives best in rich soils. It makes only indifferent growth in the poorer soils of uplands. The seeds get scattered far and wide and spread by themselves. Where it is necessary to sow it, regular seeding techniques are employed, using about 22 kg of seed per hectare.

Cultural Practices. Two problems are important in Johnson grass; one is to maintain a high and continuous productivity and the other is its eradication from where it is not wanted. A field of Johnson grass will not maintain its original high yield unless it is cultivated at regular intervals, either by ploughing or harrowing. The best time to cut Johnson grass for hay is before the heads set seed. The hay is as good or even better than many other grass hays, though inferior to legume hays in nutritive value. It is not well adapted for grazing although its aggressive nature would appear to make it suitable for grazing purposes. In India, Johnson grass does not have the same kind of persistent rootstocks as in America and hence does not present the same difficulty in eradication.

TABLE 80.

COMPARISON OF JOHNSON GRASS HAY WITH OTHER HAYS

Chemical Composition (On dry basis)	Johnson grass		Sudan grass Hay	Timothy Hay
	Green 2nd cut	Hay		
	%	%	%	%
Crude protein	5·1	9·0	10·2	6·2
Ether extract	1·5	3·0	1·8	3·1
Crude fibre	36·4	32·6	29·5	32·3
Ash	9·4	7·7	8·6	6·2
N-free extract	47·6	47·7	49·9	52·2
Calcium	0·31	—	—	—
Phosphorus	0·26	—	—	—
Potassium	—	—	—	—

(After Sen and Ray, 1964)

Heteropogon contortus Beauv.
A quick-growing hardy grass, which makes good hay if cut before flowering.

Sehima nervosum Stapf
A short, clumpy grass, with soft foliage, well-relished by cattle.

Panicum antidotale Retz.
(An Australian drought-resistant grass)
A good fodder grass, when young.

Sorghum halepense Pers. (Johnson grass)
A good fodder and hay grass.

PLATE XXIV

Pennisetum pedicellatum Trin. (Deenbandu grass)
A fodder grass of good promise.
(*Photo*: P. M. Dabadghao)

CHAPTER 12

INTRODUCED GRASSES

Bothriochloa insculpta. This grass is indigenous to Brazil. It was introduced for trials at the Indian Agricultural Research Institute, New Delhi, in 1950 and was found to be a vigorous, quick-growing perennial, suitable for warm, moist locations. It forms a dense mat by sending long runners rooting at the nodes and will, therefore, be useful in erosion control and soil conservation. Propagation is by planting stem cuttings. In nutritive value the grass compares favourably with Rhodes grass.

TABLE 81.

ANALYSIS OF BOTHRIOCHLOA SP.

	Flowering stage Chemical composition (On dry basis)
	%
Moisture	70·9
Crude protein	6·1
Ash	10·8
Calcium	0·54
Phosphorus	0·14

Brachiaria brizantha (Signal grass)

This species is native to East Africa, but was introduced from Australia for trials at the Indian Agricultural Research Institute, New Delhi, in 1950. It is a tufted, semi-erect, drought-resistant perennial, with sharp-pointed, deep-green leaves, 22–30 cm long, which remain green much

TABLE 82.

ANALYSIS OF BRACHIARIA BRIZANTHA

	Flowering stage Chemical composition (On dry basis)
	%
Moisture	74·6
Crude protein	9·8
Ash	12·3
Calcium	0·48
Phosphorus	0·24

longer than other grasses, up to May-June. It thrives best on loamy soils and is propagated by planting rooted slips. Under irrigation it yielded 201 q per hectare of green fodder in three cuttings in a year. Under rain-fed conditions only one or two cuttings are possible, as its recovery after cutting is rather poor. The grass would be suitable for the warm-humid coastal tracts of India.

Dactylis Linn.

A monotypic genus of perennial tufted grasses with flat leaves and fascicled, glomerate spikelets. Native to temperate regions of Asia and Europe, the grass is now naturalised in many countries. Name of genus is derived from Greek *dactylos* (finger), from the stiff branches of the panicle.

Dactylis glomerata Linn. (Orchard grass, in the U.S.A.; Cocksfoot grass in England.)

Cocksfoot grass is an esteemed fodder grass in temperate countries and numerous varieties have been evolved, both in the United States of America and England, some suited for hay and some for grazing. In India the grass is found in the Punjab and north-west Himalayas from Kashmir to Kumaon at 2,400 to 3,000 m, elevations as well as in Assam and the Nilgiris at 2,100 to 2,400 m, as an escape from cultivation.

The grass grows on all soils but thrives best on clay loams. On account of its deep-rooted nature it is useful for erosion control and has the additional good feature of growing well in the shade of trees. Propagation is by planting slips. It produces a continuous growth of young leaves and can thus withstand heavy grazing in pastures. For hay it should be cut at full bloom, as otherwise it gets " stemmy " in the later stages. The forage is both abundant in quantity and excellent in quality and is well relished by all classes of livestock.

TABLE 83.

ANALYSIS OF DACTYLIS GLOMERATA

Chemical Composition	Green grass	Hay
	%	%
Moisture	67·0	12·6
Crude protein	3·1	11·4
Ether extract	1·3	3·3
Crude fibre	10·1	17·3
Ash	2·9	7·9
N-free extract	15·6	47·5

Fig. 21. *Dactylis glomerata* L.
1. Plant (×½); 2. Spikelet (×5); 3. Floret (×5).

A leaf smut caused by *Entyloma crastophilum* and *E. dactylidis* has been noted affecting this grass on the Nilgiris.

Festuca elatior (Meadow Fescue)

The genus *Festuca* is a large one, including more than a hundred species of annual or perennial grasses, native to Europe and other temperate countries of the world. Many of them are important pasture grasses in Europe, but in the U.S.A. they are of lesser importance. In India the Fescue grasses may be found suitable for the cool, humid regions at elevations of 1,200 m and more, with a rainfall of 100 cm.

Festuca elatior (Meadow Fescue) is a hardy, short-lived perennial, growing 38 to 75 cm high, with succulent bright-green leaves, which remain green throughout the growing season. The grass is best suited to heavy moist soils and cool locations. The growth is rather slow in the early stages, but it can remain longer in pastures than other grasses and furnish good grazing even till the autumn months. The hay is of very good quality, but the yield is less than from other grasses, like Timothy.

Festuca arundinacea (Tall Fescue) is similar to Meadow Fescue, but is taller, (91 to 122 cm) and coarser. As it has a deeper root-system which can penetrate even stiff subsoils, it is longer-lived than *F. elatior*. Like Meadow Fescue, this species also prefers moist, heavy soils and can tolerate a fair degree of alkalinity. On fertile soils Tall Fescue can out-yield Meadow Fescue both in forage and seed production.

TABLE 84.

ANALYSIS OF FESTUCA SP.

Chemical composition	(On dry basis)
	%
Crude protein	8·9
Ether extract	4·2
Crude fibre	24·0
Ash	9·2
N-free extract	53·7
Calcium	0·39
Phosphorus	0·33

(After Sen and Ray, 1964)

Lolium perenne (Perennial rye-grass)

Genus *Lolium* L.

Annual or perennial grasses of temperate and subtropical regions, with flat leaf-blades and slender, usually flat spikelike inflorescences. Spikelets several-

flowered, solitary, placed edgewise to the continuous rachis, one edge fitting to the alternate concavities, the rachilla disarticulating above the glumes and between the florets; glumes two in the terminal spikelet, the lower glume suppressed; upper persistent, rigid, many-nerved; lemmas rounded at the back, 5–7 nerved, sometimes awned.

Lolium perenne L.

Origin, History and Distribution. A native of temperate Asia and North Africa, perennial or English rye-grass was the first meadow grass to be cultivated in the seventeenth century in England and in Europe as a distinct species. With *L. multiflorum* (Italian rye-grass), it is the most important of European forage grasses. The rye-grasses are of great importance in the U.S.A. also, as winter forage in the southern States.

Climate and Soils. Rye-grass is essentially a grass of temperate regions, although it can be grown with success in sub-tropical regions as a winter forage with the help of irrigation. Under such conditions it does not retain its perennial habit but dies out in summer. On the Nilgiris it has been grown successfully as a pasture grass for sheep, the winter rainfall in this region being favourable for its growth. In the temperate and alpine regions of Northern India, it is an excellent species for pastures, especially on soils of medium to high fertility.

Cultural Practices. Propagation of perennial rye-grass is solely by seed, drilled in rows 45 cm apart. A seed-rate of 22 to 28 kg per ha is common in western countries. In India it should be sown on a fine seed-bed, in October on the plains and in March-April in the temperate northern areas. The grass grows into leafy rosettes 60 to 91 cm in height, with long, narrow leaves, deep green with a shining lustre. The grass is ready for the first cutting in about three months from sowing. Under irrigation, three cuttings are possible on the plains, before the grass dries up in April-May.

Lolium perenne is very leafy, palatable and nutritious, with a high protein content. As a pasture grass it should be grazed fairly heavily, to keep the herbage tender and succulent for a longer period. Where the growth gets too rank, partial grazing, after first cutting the heavy growth for hay-making, is recommended. Liberal top-dressings of ammonium sulphate ensure high yields of forage.

In the United Kingdom and other temperate countries, this grass is nearly always grown mixed with white clover, liberally manured with superphosphate, which helps the clover to fix atmospheric nitrogen better, which in turn is useful to the grass. Perennial rye-grass-clover leys are popular in the United Kingdom, as they help to build up soil-fertility and later on enable the cultivation of arable crops, like potatoes.

TABLE 85.

ANALYSIS OF LOLIUM PERENNE AND L. MULTIFLORUM

	Lolium perenne		Lolium multiflorum	
	Chemical composition	Digestible nutrients	Chemical composition	Digestible nutrients
	%	%	%	%
Moisture	73·4		72·9	
Crude protein	3·0		3·1	
Ether extract	1·3		1·3	
Crude fibre	6·7		6·8	
Ash	2·4		2·5	
N-free extract	13·2		13·4	
Calcium	0·18		—	
Phosphorus	0·16		0·20	
Potassium	0·61		0·75	
Digestible Crude Protein		1·4		1·5
Total Digestible Nutrients		15·5		15·7
(After Mirchandani and Dabadghao, 1949)			(Lander, 1949)	

Lolium multiflorum Lam. (Italian rye-grass).

This grass differs from *Lolium perenne* in being more robust, with cyliudrical culms instead of flattened ones as in *L. perenne*, larger spikelets and awned lemmas. The spikelets are 10–20 flowered, 1·5 to 2·5 cm long, lemmas 7–8 mm long and the upper ones are awned. It is a cool-season, bunchy annual grass which grows to a height of 60 to 90 cm.

Italian rye-grass is a native of southern Europe, Asia Minor and North Africa; it is adapted to a wide range of soils and gives a good temporary pasture and also gives two cuttings during the growing season, to make excellent hay. Adequate manuring with nitrogen and phosphates is, however, essential to secure good yields from this grass.

Lolium perenne X L. multiflorum (Short-rotation rye grass).

Perennial rye grass intercrosses readily with Italian rye grass and natural hybrids are common wherever both these species are grown. New Zealand H.I. Rye grass is a hybrid strain developed from natural hybrids of this type. The hybrid is more persistent than *L. multiflorum* and is better suited for short-term grazing leys of two to three years' duration. It is very palatable, has a long growing season and makes good growth even during the winter months. It is sometimes included in long-term or permanent pastures, to increase the production of green herbage in

Fig. 22. *Lolium multiflorum*

1. Plant (×½); 2. Spikelet (×5); 3. Floret (×5); 4. Inflorescence of *Lolium perenne* (×½).

the first two seasons. In India it may be suitable in cool humid regions, of 1,220 m elevation and 152 cm rainfall.

TABLE 86.

ANALYSIS OF LOLIUM HYBRIDUM

(*L. perenne* × *L. multiflorum*)

	Pre-flowering stage Chemical composition (On dry basis)
	%
Moisture	81·5
Crude protein	20·0
Crude fibre	19·1
Ash	10·6
Calcium	0·55
Phosphorus	0·35

(I.A.R.I. Report, 1963)

Paspalum dilatatum Poir. (Dallis grass)

Genus *Paspalum* Linn.

A very large genus of over 400 species, mostly natives of Brazil. Several species furnish good pasturage and are found in meadows. The inflorescence is a spike-like raceme solitary, paired or several, on a common axis. Spikelets are secund, two-seriate, nearly sessile, orbicular or oblong ovate.

Paspalum dilatatum Poir.

This species is native to South America. It was introduced into the United States about 1875 from Argentina, and is now one of the valuable pasture grasses in the southern States of the U.S.A. It was originally known as ' water grass ' and is now known as Dallis grass, after A.T. Dallis of Georgia, who grew it extensively at one time. In India it is occasionally found growing wild.

The grass is a tufted, bunchy perennial, leafy at the base, ascending or erect from a decumbent base, and attaining a height of 60 to 152 cm. The inflorescence is spreading, bearing 3–5 racemes each 3–5 mm long and fringed with long silky hairs on the spikelets. It is found on low-lying land, from dry prairie to marshy meadows. For vigorous growth it needs a fertile and moist soil. It is more tolerant than *hariali* to excess of moisture and can be grown in marshy localities. The decumbent stems root at

Fig. 23. *Paspalum dilatatum*

1. Plant ($\times\frac{1}{2}$); 2. Inflorescence; 3. Front view of spikelet ($\times 10$); 4. Back view of spikelet ($\times 10$); 5. Floret ($\times 10$).

the nodes, when they come in contact with moist soil. Being a perennial with a deep root-system, this grass is not injured by persistent grazing and the herbage is renewed rapidly and hence pastures of Bermuda grass (*hariali*) are benefited by including this grass also. If continuous grazing is not possible, it is necessary to mow the grass at intervals. Shading weakens the grass more than grazing or mowing.

TABLE 87.

ANALYSIS OF PASPALUM DILATATUM

	Flowering Stage—Chemical composition (On dry basis)
	%
Crude protein	6·7
Crude fibre	40·9
Calcium	0·27
Phosphorus	0·14

(I.A.R.I. Report, 1963)

Paspalum notatum Flugge (Bahia grass).

This is a low-growing perennial, introduced from Brazil. It spreads by short, stout runners and by seed. The runners give rise to an extensive root-system at the nodes to form a dense, tough sod even on sandy soils subject to periodic droughts. The grass can grow well on poorly drained, moist or even swampy soils and on account of its ability to form dense sods it is well suited for erosion control and pastures in the humid sections and coastal regions of India, although it takes some time to get well established.

Seeds are sown 1·2 to 2·5 cm deep, at 11–12 kg seed-rate. Germination is rather slow on account of a tough waxy coat and so scarification by a sulphuric acid dip would improve germination.

Paspalum scrobiculatum Linn. (Kodo millet; Hindi—Kodo; Tamil—Varagu; Telugu—Arika, Kannada—Harak hullu).

This is a low-growing annual, which is grown on very poor soils as a catch crop to serve as famine food and foodgrain for poorer classes. It is found in all districts, from sea level to 2,130 m and sometimes grows wild. The wild form is smaller and more slender. The grain is sometimes poisonous. The straw makes poor fodder.

Pennisetum clandestinum Hochst. ex. Chiov. (*Kikuyu* grass).

This is a perennial, rhizomatous and stoloniferous grass, which forms a dense mat on the ground by means of its numerous stolons and short internodes. Leaves are short, 5 to 10 cm long, flat, glabrous or slightly hairy, midrib prominent on the underside, leafsheath closely imbricate. Ligule is reduced to a densely hairy rim. The inflorescence is also reduced to two or four spikelets and is enclosed in the uppermost leafsheath. Spikelets are surrounded by an involucre of short bristles. Stamens have long filaments, 2–3 mm long, style is thread-like, 3 mm long, simple or bifid and finely plumose.

Origin, History and Distribution. Kikuyu grass is a native of South Africa. In 1919 it was introduced in the North-West Frontier Province of undivided India. In 1921 the grass was introduced for a second time, from Australia into the Wellington Military Farm on the Nilgiris and now it has spread all over the Nilgiris and become an aggressive weed of potato fields in many localities on the hills. Kikuyu grass is being grown on the Shillong hills with success.

Climate and Soils. The grass thrives best in a cool, moist climate, at elevations of 1,220 m and more, but during the cold months it remains dormant as it is somewhat sensitive to frost. Rich loamy soils, somewhat acidic in reaction, are the best for this grass. It does not thrive on alkaline soils. It is not suited to the climatic conditions prevalent on the plains of India.

Cultural Practices. The grass sets very little seed and is therefore, propagated exclusively by planting root stocks or rooted runners, 90 cm apart on well-prepared land. The best time to plant is with the commencement of the South-West monsoon. A basal dressing of 125 to 200 q/ha of farmyard manure and subsequent annual dressings with 1·7 q/ha of ammonium sulphate would ensure good yields of forage.

The grass spreads rapidly by means of both surface and subterranean stolons and covers the land completely in a single season and attains a height of nearly 90 cm within 3 to 3½ months of planting. The first cutting can be taken in three months and subsequent cuttings at six-week intervals. Yields of over 336 q per hectare have been recorded. Old stands of Kikuyu grass tend to get too crowded and require to be opened up once in two years, in order to maintain fodder production at high levels.

Utilisation. The grass is well-relished by all kinds of livestock and is very nutritious, with over 12 per cent protein and a fairly narrow nutritive ratio. It is, therefore, a very good feed for dairly cattle. Being a spreading type the grass is well-suited for pasture purposes. At the cattle-breeding station, Shillong, dairy animals are let out on Kikuyu grass pasture. On the Nilgiris it is used as a soiling crop.

The aggressive, spreading growth and the soil-binding ability of the underground runners make this grass very useful for soil conservation on the hills, but care is necessary to keep it in proper check and prevent it from encroaching into cultivated fields, as its eradication is extremely difficult.

Pennisetum pedicellatum Trin. (Deenabandhu grass)

Genus *Pennisetum* L., Rich. (Gramineae)

Annual or perennial grasses distributed throughout the tropics and sub-tropical regions of the world, often branched, but with usually flat leaf-blades and dense spikelike panicles. Spikelets solitary or in groups of three, surrounded by an involucre of bristles (sterile branchlets); these are not united except at the very base, often plumose, falling away attached to the spikelets; first glume shorter than spikelet, sometimes minute or absent; second glume equal to or shorter than the sterile lemma; fertile glume chartaceous, smooth with thin margins, enclosing the palea.

The name is derived from the Latin *penna*, feather and *seta*, bristle, alluding to the plumose bristles in some species. The Pearl Millet, (*P. typhoides*) is an important cereal food crop of tropical Asia and Africa and *P. purpureum* (Napier grass), is a well-known fodder grass.

Pennisetum pedicellatum Trin.

This species is yet another grass that has come into prominence in recent years. Although it had been growing wild in the Chota Nagpur and Gaya districts of Bihar as well as in some parts of peninsular India, such as Ganjam in Orissa State, its fodder value was first recognised in Africa and in Australia, from where seeds were obtained for trials at the Indian Agricultural Research Institute, New Delhi, in 1950. Since then trials carried out in different parts of the country have shown the fodder possibilities of this grass and it has been named as ' Deenanath ' in Bihar and as ' Deenabandhu grass ', i.e., friend of the poor, later on from Jodhpur. A large number of useful ecotypes have also been isolated at Ranchi, from the seed samples obtained from Nigeria.

Description. The plant is an erect grass with numerous tillers. The shiny glabrous culms are tinged reddish-purple at their bases. The leaves are fairly broad, about 45 cm long and vary in colour from light to dark green. The inflorescence is a spikelike panicle, 15 to 20 cm long, with a purplish tinge when young, which turns whitish on maturity. Seeds are small, shiny and are produced in large numbers.

Climate and Soils. The grass is adapted to warm habitats, but trials have shown that it can be grown with success in the northern States of India, both as a rain-fed and an irrigated crop. It thrives best on fertile loamy soils, but with adequate manuring it can also be grown on sandy soils. It is a grass that can tolerate both slightly acidic and alkaline soils.

In Bihar, in the Ranchi and Chota Nagpur regions, a rainfall of 127 cm is received between June and September; but after that the weather becomes very dry. *Pennisetum pedicellatum* is able to germinate quickly and also utilise the rainfall to the best advantage by producing a rapid growth of forage with a high ratio of shoot to roots and also a large quantity of seeds before dry weather sets in. No other grass was found to make such a rapid growth on the poor soils of the uplands of Chota Nagpur.

The grass is established exclusively by seed, which is either broadcast or drilled in lines 45 cm apart, on a well-prepared moist seed-bed at the rate of 1 to 2·2 kg per hectare, soon after the commencement of the monsoon rains.

The first cutting can be taken from this grass in about 3½ months after sowing and under favourable conditions three cuttings giving about 336 q/ha. of green forage can be obtained. Yields up to 450 q/ha. in three cuttings have been reported from Bihar under medium to high rainfall conditions.

The grass is palatable to all classes of livestock and is fairly nutritious. It is used mainly as a cut fodder, but can also serve as a pasture grass, as its regeneration from self-sown seed is excellent.

TABLE 88.

ANALYSIS OF PENNISETUM PEDICELLATUM

	Chemical Composition (On dry basis)
	%
Crude protein	7·4
Ether extract	2·8
Crude fibre	22·2
Ash	18·6
N-free extract	49·0
Calcium	0·42
Phosphorus	0·41
Potassium	—

(After Sen and Ray, 1964)

Phalaris tuberosa (Harding Grass)

Genus *Phalaris* L. (Canary grasses)

Annuals or perennials with numerous flat leaves and narrow, spikelike panicles. Spikelets usually compressed laterally, with terminal perfect floret and two sterile lemmas below, the rachilla disarticulating above the glumes; glumes equal, boat-shaped, often winged on the keel, sterile lemmas reduced

to two or rarely one, minute scales; fertile lemma coriaceous, shorter than the glumes, enclosing the faintly two-nerved palea.

Phalaris canariensis L. (Reed Canary grass)

This resembles *P. minor* in many respects and has a high yield potential as a forage crop.

Phalaris minor (Chidia bajra)

Origin, History and Distribution. This grass first attracted attention in 1948 in India at the Indian Agricultural Research Institute, New Delhi, where it was found growing in association with oats. The local name ' Chidia bajra ' finds a parallel in the common English name of Canary grass, from canary birds being fed on seeds of *Phalaris canariensis*.

Description. The grass resembles in the young stages an oat plant from which it is distinguishable by the purple colour at the base of the culms. It is procumbent in habit and forms a rosette of tillers, but when sown thick it can assume an erect habit and attain a height of nearly 122 cm. The leaves are 48 cm long and about 1·2 to 2·5 cm broad. The inflorescence is an ovate-oblong panicle 2–5 cm long, consisting of closely imbricate spikelets. Glumes are 4–6 mm long. The outer glume has a variegated appearance, with a white margin and inner, broad green stripes. Seed (i.e., caryopsis) is lens-shaped, resembling sesamum seeds, but grey in colour, smooth and shiny.

Cultural Practices. Like most other grasses, *P.minor* needs a well-prepared seed-bed. The seed is broadcast at 13 to 16 kg/ha. After the seeds are sown, they are covered by a desi plough or spring harrow. For line-sowing by drills 9 to 11 kg/ha of seed would be needed. The grass is responsive to manuring; 179 kg of ammonium sulphate per hectare being quite helpful. In places where the winter rainfall is sufficient, no irrigation is needed. When once established, the grass has a special ability to regenerate itself from self-sown seed, in subsequent years.

The crop is ready for harvest in 3½ months when the plants are in flower. A second cutting can be secured if the first cut is taken a fortnight before the plants flower. The yield will be about 179 q/ha of green forage.

The forage compares favourably with oats and is well-relished by cattle. Its nutritive value is also high, with a protein content of 14 per cent in the young stage and 12 per cent at the flowering stage. The calcium and phosphorus contents too, are well-balanced, being 0·72 per cent and 0·55 per cent respectively.

The leafy, succulent and nutritious fodder from this species makes it a promising fodder crop for the winter months. It would make a good

mixture with either *Melilotus parviflora* (Senji) or vetches, giving an average outturn of over 179 q per hectare, of a balanced forage.

TABLE 89.

ANALYSIS OF PHALARIS MINOR

(CHIDIA BAJRA)

	Chemical Composition of young grass (On dry weight basis)
	%
Crude protein	13·9
Ether extract	5·2
Crude fibre	9·9
Ash	19·7
N-free extract	51·3
Calcium	0·51
Phosphorus	0·24
Potassium	—

(After Sen and Ray, 1964)

Phalaris tuberosa (Harding grass).

Like the other Canary grasses *P. tuberosa* is also a native of the Mediterranean region. Its forage value was first recognised in Australia and seeds were obtained from that country for trial at the Indian Agricultural Research Institute, New Delhi. Harding grass thrives best in cool, humid regions with adequate winter rainfall. It has proved quite a success on the Nilgiris (2,130 m elevation) and it would be equally successful in the temperate hill-slopes of North India. It is reported to set seed well on the Nilgiris, but on the plains very little seed is set, because seed development synchronises with high summer temperatures. Although it can grow well on both light and heavy soils, its best performance is obtained from soils of high fertility. The grass is able to retain its perennial habit even on the plains, unlike *Lolium perenne*. The forage is relished by all classes of livestock and is also nutritious, containing 13 per cent of protein on dry basis.

Phleum pratense L. (Timothy)

This is a short-term perennial, native to Europe and temperate Asia, which is now grown in many countries as a valuable pasture grass, usually in association with red clover and Alsike clover. The culms grow to a height of 45 to 60 cm, tufted or ascending from a bent base; the basal

nodes are very short and bulbous. The grass is adapted to a cool, moist. temperate climate and thrives best on heavy moist (or even wet) soils, It cannot stand drought but can tolerate cold very well and is one of the few species that can be grown in the Arctic Circle. It is one of the most esteemed pasture grasses of temperate regions and is grown widely in Europe, America, Australia and New Zealand. In India, it may be found suitable for cool, humid regions of 152 cm. rainfall and 1,300 m elevations.

It makes excellent hay and for that purpose it is usually grown mixed with red clover or Alsike clover, or lucerne, in three to four-year leys. It combines well with Orchard grass on drier soils and with Fescues on wet soils, and starts growth very early in the spring. Liberal manuring with phosphatic fertilizers and when grown pure, with nitrogenous fertilizers also, will ensure high yields.

Establishment is both easy and rapid. The seed rate is 6·8 to 5·4 kg per hectare if grown mixed with clovers.

Utilisation. For hay this grass should be cut at early bloom stage, if delayed longer, the quality goes down without any appreciable increase in yield. Early cutting stimulates the growth of clovers also.

Poa pratensis (Kentucky Blue grass)

Genus *Poa:* Annuals or perennial grasses, native to temperate regions. Leaves flat or convolute; Panicle usually lax, rarely spiciform. Spikelets laterally compressed, 2–6 flowered, rhachilla jointed at the base and between the lemmas.

Poa pratensis (Kentucky Blue grass)

This is one of the important pasture grasses of Europe and America, grown nearly always in association with white clover. It is a sod-forming perennial, growing 30 to 60 cm high, with an extensive finely branched root-system, numerous tillers and shiny, dark-green leaves that have a characteristic boat-shaped tip. The inflorescence is a pyramid-shaped panicle 5 to 20 cm long, with branches arranged in whorls of three to five.

The grass grows well only on soils of high fertility, rich in lime and having a *p*H range of 5·8 to 8·2. Two or three dressings with nitrogenous fertilizers will be necessary during the growing season and phosphate applications are also helpful. In India this grass is suggested as suitable for the cool, humid sections of the country, at elevations of 1,220 m and above, and a rainfall of 152 cm.

Poa annua (Annual Meadow grass) and *Poa trivialis* (Rough Meadow grass) are often found at elevations of 1,220 to 2,130 m, on the hills in many parts of India, as escapes from previous introductions.

Fig. 24. *Phalaris canariensis*

1. Plant ($\times\frac{1}{2}$); 2. Inflorescence; 3. Spikelet ($\times 10$); 4. Floret ($\times 10$); 5. *Phalaris minor*—plant; 6. *Phalaris minor*—inflorescence; 7. *Phaalaris minor*—spikelet glumes ($\times 10$); 8. *Phalaris minor*—floret ($\times 10$); 9. *Phalaris tuberosa* spikelet ($\times 10$); 10. Floret ($\times 10$).

Setaria sphacelata (Kazungula grass)

Genus *Setaria* Beauv. (Gramineae)

Annual or perennial grasses, with narrow, dense, terminal panicles, which are sometimes open and loose. Spikelets are subtended by one or several bristles (sterile branchlets) falling free from the bristles, awnless; first glume broad, 3–5 nerved, second glume and sterile lemma equal, several nerved, fertile lemma coriaceous-indurate, smooth or transversely rugose. The name *Setaria* is derived from Latin *seta*, a bristle, alluding to the numerous bristles on the inflorescence.

Setaria sphacelata

This species is perhaps the most recent introduction amongst the high-yielding grasses obtained from other countries. It is a native of Africa and was first introduced in 1950 for trials at the Indian Agricultural Research Institute, New Delhi.

The grass is an erect perennial with flattened culms arising from stout rhizomes, growing to a height of 1·2 to 1·5 m. The leaf-blades are flat, rather lax, 30 to 45 cm long and 6 to 12 mm wide. The inflorescence is a compressed panicle about 15 cm long, appearing as a dense, cylindrical spike, orange to purple in colour.

Climate and Soils. Although its origin suggests its adaptation to tropical environments, its pronounced winter-hardiness makes it suitable for sub-tropical tracts as well. It has been reported to grow well at Almora at an elevation of 1,500 m, indicating its adaptability to cool situations. Like other *Setarias* this species also can be grown on light soils, although it thrives best on fertile loams. It is suitable for growing as a rain-fed crop in regions receiving a rainfall of 152 cm. or more per year.

Cultural Practices. The grass produces a fair quantity of seed, but it is generally established by vegetative means, through planting of rooted slips. Under irrigation, the grass is planted from February onwards, but as a rain-fed crop it should be planted at the commencement of the south-west monsoon. A basal dressing of 125 to 200 q ha of farmyard manure, compost or sludge and a top-dressing of ammonium sulphate to supply 44 to 56 kg. of nitrogen per hectare after every two cuts would help to ensure high yields. The first cutting will be ready in three months from sowing (or planting), and subsequent cuttings may be taken at six to eight weeks intervals. The yield will be about 896 q per hectare in seven cuttings per year, from an irrigated crop.

The forage is very leafy and palatable, with a fairly high nutritive value. The grass can be used equally well for soiling, hay or grazing and is particularly useful because of its good winter growth, which ensures a continuous supply of forage throughout the year.

Sorghum almum Parodi (Columbus grass)

This species is a robust perennial growing up to 3·8 to 4 m. in height. It spreads by means of short, stout rhizomes. It is native to Argentina and originated probably as a natural hybrid between *Sorghum halepense* and another species of *Sorghum* and is adapted to a wide variety of soils in the tropics and sub-tropics, in regions with summer rainfall. The grass resembles Johnson grass, but is taller and has broader leaves, larger spikes and seeds. The grass can resist drought very well and under favourable conditions can also make rapid growth to give high yields of palatable forage. If the tops get killed off by frost in the winter, fresh growths are put forth from the rhizomes in the next spring. It is one of the important fodder grasses grown in central Argentina and has recently been introduced with success into South Africa, in areas of less than 50 cm of rainfall. In New South Wales it gave good results both in dryland and irrigated conditions.

Establishment of this grass is by seed, either sown broadcast or drilled in rows 91 cm apart. The seed rate is 13·4 to 28·2 kg/ha. Stands of this grass normally persist for five to six years but when required it can be eradicated easily by ploughing up the rhizomes during dry weather.

Sporobolus diander Beauv (Hindi—Chidia ki dana)

TABLE 90.

ANALYSIS OF SPOROBOLUS SP.

	Hay	
	Chemical composition	Digestible Nutrients
	%	%
Moisture	8·5	—
Crude protein	6·1	42
Ether extract	1·0	50
Crude fibre	30·0	—
Ash	4·8	—
N-free extract	49·6	73
Calcium	0·30	—
Phosphorus	0·33	—
Digestible Crude Protein		2·6
Total Digestible Nutrients		39·6

(After Kehar, Ray and Negi, 1949)

Annual or perennial, culms 25–30 cm tall, smooth, glabrous. Leaves narrow 15–25 mm wide, sheaths smooth, ribbed, ligule a rim of hairs. Inflorescence a panicle 10–18 cm long, pyramidal, spreading outwardly when mature. Branches naked at base and bearing racemosely arranged, crowded, minute spikelets at their apices. Spikelets are spindle-shaped, 1·5 mm long, one-flowered; grain is sub-truncate. This grass is a good fodder for cattle.

Tricholaena rosea Nees (Natal Grass)

Genus *Tricholaena* Schrad.

Perennial or annual grasses with rather open panicles of silky spikelets. Spikelets on short pedicels; first glume minute, villous; second glume and sterile lemma equal and covered with silken hairs; fertile lemma shorter than spikelet, smooth, boat-shaped, obtuse, with thin margins enclosing the margins of the palea. Name is derived from Greek *Thrix* (trich-)—hair and *chlaina*—cloak, alluding to the silky spikelets.

Tricholaena rosea Nees.

This grass is reported to grow wild in many parts of peninsular India on sandy soils and slightly acidic soils. It is a native of Africa and was introduced for trial at Poona as a pasture grass, but has gained prominence only in recent years as an aggressive species that spreads rapidly through self-sown seed. The plant is of medium height, with conspicuous purple inflorescences which turn white on ripening. It is easily propagated either by broadcasting the seed or drilling it in rows 46 cm apart. Trials

TABLE 91.

ANALYSIS OF TRICHOLAENA ROSEA

	Chemical composition (On dry basis) Hay
	%
Crude protein	5·6
Ether extract	1·4
Crude fibre	41·6
Ash	8·0
N-free extract	43·4
Calcium	0·34
Phosphorus	0·11
Potassium	1·63

(After Sen and Ray, 1964)

Fig. 25. *Tricholaena rosea*
1. Plant ($\times\frac{1}{2}$); 2. Inflorescence; 3. Spikelet ($\times 10$); 4. Floret ($\times 10$).

at Dharwar have shown that it can be established on wind-swept hill-tops if the rows are disposed at right angles to the direction of the prevailing winds.

Description. Annual, culms slender, about 91 cm tall, leaf-blades flat, 2–5 mm wide; panicle rosy purple, 10–15 cm long, branches on slender flexuous or recurved pedicels, spikelets 5 mm long. Cultivated as a meadow grass in sandy soils of Texas and Florida, naturalised from South Africa (Natal).

Tripsacum Linn. (Gama grass)

Genus *Tripsacum* Linn.

This is a genus of robust perennials, with broad flat leaf blades and monoecious, terminal and axillary inflorescences of 1–3 spikes; the pistillate part below breaking up into bony seed-like joints, the staminate, above on the same rachis; deciduous as a whole. The genus is of interest as a wild relative of maize.

Tripsacum dactyloides L. (Eastern Gama grass).

This is a native of tropical America, widely distributed from Florida to Mexico and Brazil as well as the West Indies, as a warm season perennial that grows in large clumps from 30 to 122 cm in diameter. It spreads by thick, (1·2 to 2·5 cm) long, pointed rhizomes giving rise to culms 0·91 to 2·74 m tall. The leaf blades are smooth, 45 to 60 cm long and 1·2 to 3·8 cm wide. The inflorescence consists of 1 to 3 spikes, 22 to 25 cm long with the female (pistillate) part below and the staminate (male) part above. The seeds are somewhat sunken in the hollow depressions in the joints of the lower one-fourth of the spike. When mature the seed-bearing portions break off at the joints with each part containing one seed.

The grass grows on a variety of soils in low-lying, moist areas. It is a good forage grass, palatable and nutritious and readily eaten by all classes of livestock, but cannot survive close grazing. Being a heavy producer of green fodder it is suitable for cultivation in the same manner as Guinea grass and Napier grass under liberal irrigation with sullage water or stable washings.

Urochloa mosambicensis

Genus *Urochloa* Beauv.

Annuals or perennial grasses; leaves flat, inflorescence of sessile or sub-sessile racemes on a common triquetrous axis with straight or zigzag keel on the

Fig. 26. *Tripsacum dactyloides*
1. Rootstock; 2a, 2b. Leaves; 3. Inflorescence; 4. Spikelet.

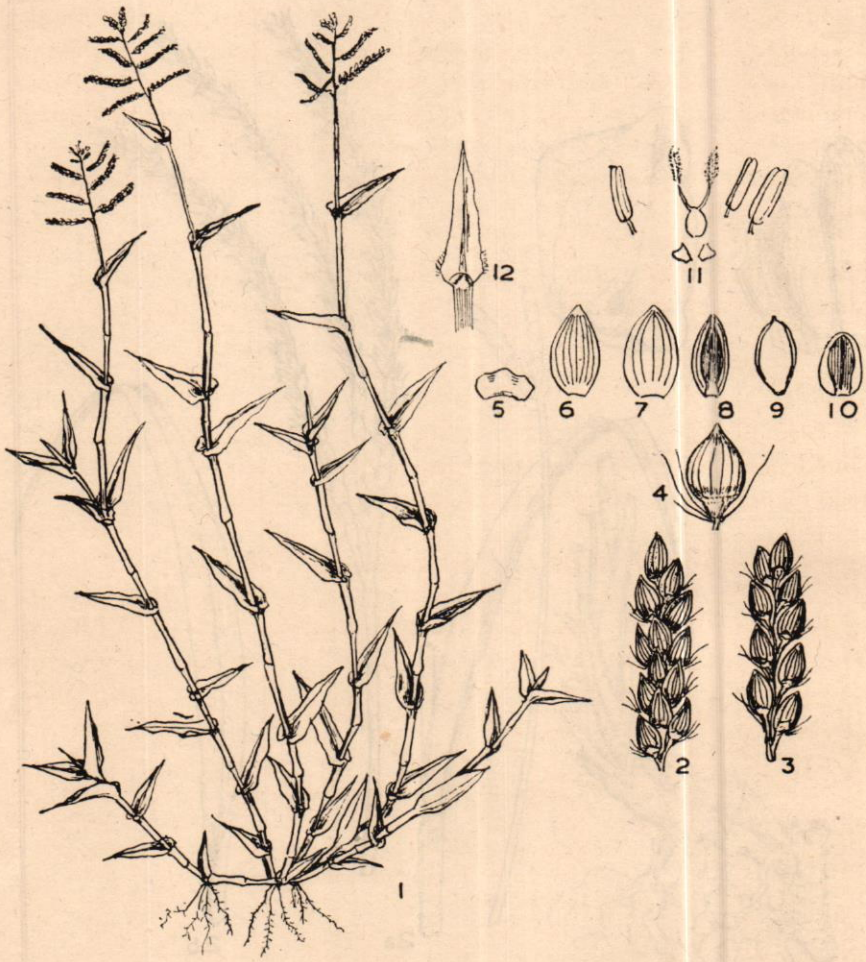


Fig. 27. *Urochloa reptans*

1. Plant (×1/3); 2, 3. Front and back views of spike; 4. Spikelet; 5, 6. First and second glumes; 7. 8. Third glume and palea; 9. 10. Fourth glume and palea; 11. Ovary, stamens and lodicules; 12. Leaf with ligule.

shorter face. Spikelets broadly ovate to lanceolate, more or less flattened, convex side turned towards the axis.

Urochloa mosambicensis

The grass was introduced from Australia in 1950 for trial at the Indian Agricultural Research Institute, New Delhi, and was found quite promising, both under rain-fed and irrigated conditions. It is a quick-growing, semi-erect grass, growing to a height of 60 to 91 cm and spreading through runners rooting at the nodes. It is reported to be both drought-resistant and winter-hardy and trials have shown that it can tolerate both alkaline and acidic soils.

The grass is propagated either from seed or by planting rooted slips. It yields about 224 q/ha of green fodder which is very palatable and can serve as a pasture grass as well as for soil conservation purposes.

U. panicoides Beauv. (Syn. *Panicum javanicum* Hook. f. non. Poir).

The grass is found in all districts of Madras, except on the heavy rainfall areas of the Kerala coast, from sea level up to 910 m. It is a good fodder grass. The grain is eaten in times of famine.

U. reptans Stapf. (Syn. *Panicum prostratum* Lamk.)

Found in all districts except the wettest, from the plains up to 1,820 m. A good fodder, much liked by cattle. The grain is eaten in times of scarcity.

TABLE 92.

ANALYSIS OF UROCHLOA SPECIES

	Chemical composition (On dry weight basis)		
	U. mosambicensis (first cut)	*U. pullulans*	*U. stolonifera*
	%	%	%
Crude protein	11·0	5·8	9·8
Ether extract	1·9	1·4	—
Crude fibre	23·4	33·3	
Ash	28·1	13·2	—
N-free extract	35·6	46·3	—
Calcium	0·54	0·51	0·40
Phosphorus	0·41	0·31	0·28
Potassium	2·80	—	—

(After Sen and Ray, 1964)

U. setigera Stapf. (Syn. *Panicum setigerum* Retz.)

Found in most districts of the southern peninsula from Krishna to Tirunelveli, from sea level up to 610 m elevations.

Urochloa stolonifera Stapf. (Creeping liver-seed grass).

This species is a native of East Africa. It was introduced to India in 1950 from Australia for trials at the I.A.R.I., New Delhi. It is a low growing, prostrate perennial, which can come up well under rain-fed conditions to form a dense sod, by means of numerous runners rooting at the nodes. The grass shows good growth even in the spring and pre-monsoon months and being self-seeding in habit, it can be very useful, both for grazing and for soil conservation in sub-humid sections of India, of 300 to 910 m elevations and 50 to 101 cm rainfall.

CHAPTER 13

OTHER MISCELLANEOUS GRASSES

Alopecurus Linn. (Foxtail)

Low or moderately tall, perennials, rarely annuals with flat leaf-blades and soft, dense spike-like panicles. Genus includes about 25 species, native to temperate Asia and Europe, of which six are recorded in India.

A. geniculatus Linn. (March Foxtail).
A. myosuroides Huds. (Slender Foxtail).
A. pratensis Linn. (Meadow Foxtail).

These three species are found mostly in the Himalayan and Khasia tracts. They are palatable and nutritious grasses, but are not found in sufficient abundance to be of much importance.

Andropogon Linn.

Genus includes 100 species, mostly in the tropics. Formerly many other species were included in this genus such as *Cymbopogon*, *Dichanthium*, *Sorghum*, *Vetiveria*, etc. *A. ascinidis* C.B. Clark is a common grass in Burma; it is eaten by cattle only when young.

TABLE 93.

ANALYSIS OF ARISTIDA SPP.

	Chemical composition (On dry weight basis)	
	A. depressa	*A. funiculata*
	%	%
Crude protein	2·3	2·4
Ether extract	1·5	1·1
Crude fibre	42·3	33·2
Ash	4·9	9·5
N-free extract	49·0	53·8
Calcium	0·35	0·80
Phosphorus	0·05	0·27
Potassium	0·32	—

(After Sen and Ray, 1964)

A. pumilus Roxb. is a gregarious species, about 60 cm tall, distributed in most places, from dry soils to moist areas. It is considered a good fodder, as cattle relish it.

Aristida Linn. Genus of nearly 160 species, of annual or perennial, slender, tufted grasses with narrow, convolute leaf-blades and narrow panicles. The ripe fruits of many species in this genus are troublesome to livestock on account of the sharp, pointed callus, terminating in a trifid awn. They are distributed in temperate and subtropical regions; about 12 species are found in India. The fodder value of these grasses is rather limited, as they are all low-growing plants with scanty foliage.

A few species like *Aristida adscensionis* Linn, *A. funiculata* Trin. & Rupr. and *A. hysterix* Linn. are palatable when young.

Axonopus affinis

Genus *Axonopus* Beauv.

Stoloniferous or tufted perennials, rarely annuals, with usually flat or folded, abruptly rounded leafblades and slender spike-like racemes, digitate or racemose along the main axis. Natives of Central America and the West Indies.

Axonopus affinis

This is a perennial creeping grass which makes a dense sod, distinguished by its compressed, two-edged creeping stems which root at each joint and by its blunt-tipped leaf-blades. The slender peduncles grow 30 to 60 cm high and bear usually three branches, each with numerous brownish-grey, oblong seeds. As it has no underground stems it never becomes a pest in cultivated fields. It is well adapted to sandy soils where the moisture is maintained near the surface most of the year, but does not grow well in swampy localities. The usual seed-rate is 5·6 to 11·2 kg per hectare, but it gets easily spread by natural seeding. It makes a valuable grass for permanent pastures and for fire-breaks in forests and for lawns and turfs, but its aggressive habit makes it difficult to maintain a legume along with it in pastures. Because of its low fertility requirements and prolific seeding habit it is a common grass of permanent pastures in Florida.

Bamboo (*Arundinaria*, *Cephalostachyum*, *Dendrocalamus*, etc.).

Bamboos are useful as fodder, especially when other forage is scarce and near forest areas. Cattle and horses relish it when young; it is one of the favourite forages of elephants and wild buffalo in the forests.

Fig. 28. *Alopecurus pratensis*

1. Plant ($\times\frac{1}{2}$); 2. Inflorescence; 3. Glumes ($\times 10$); 4. Floret ($\times 10$); 5. *A. geniculatus*; 6. Glumes ($\times 10$); 7. Floret ($\times 10$).

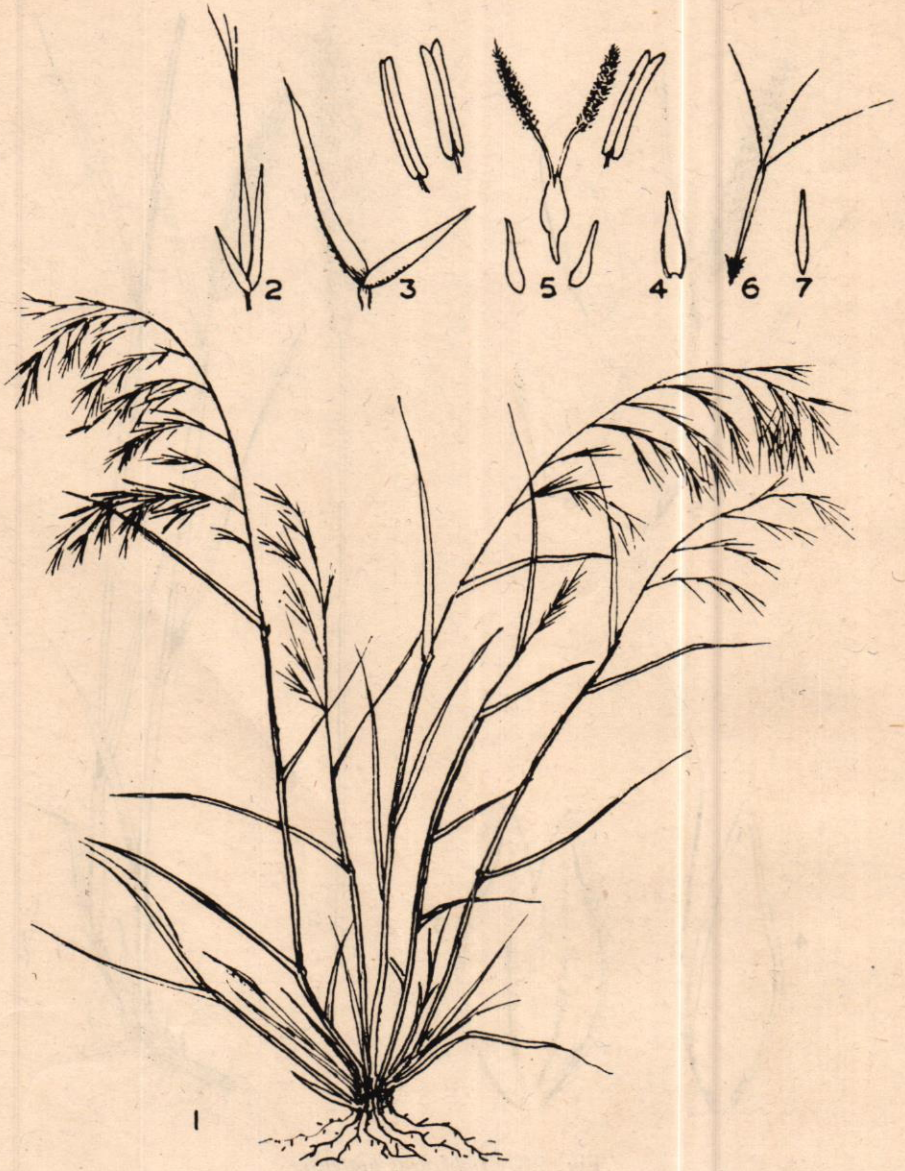


Fig. 29. *Aristida adscensionis*

1. Plant (×1/3); 2. Spikelet (×10); 3. First and second glumes; 4. Palea; 5. Lodicules, ovary and stamens; 6. Third glume, with awns; 7. Grain.

Fig. 30. *Axonopus compressus*
1. Plant ($\times\frac{1}{2}$); 2. Spikelet ($\times 10$); 3. Floret ($\times 10$).

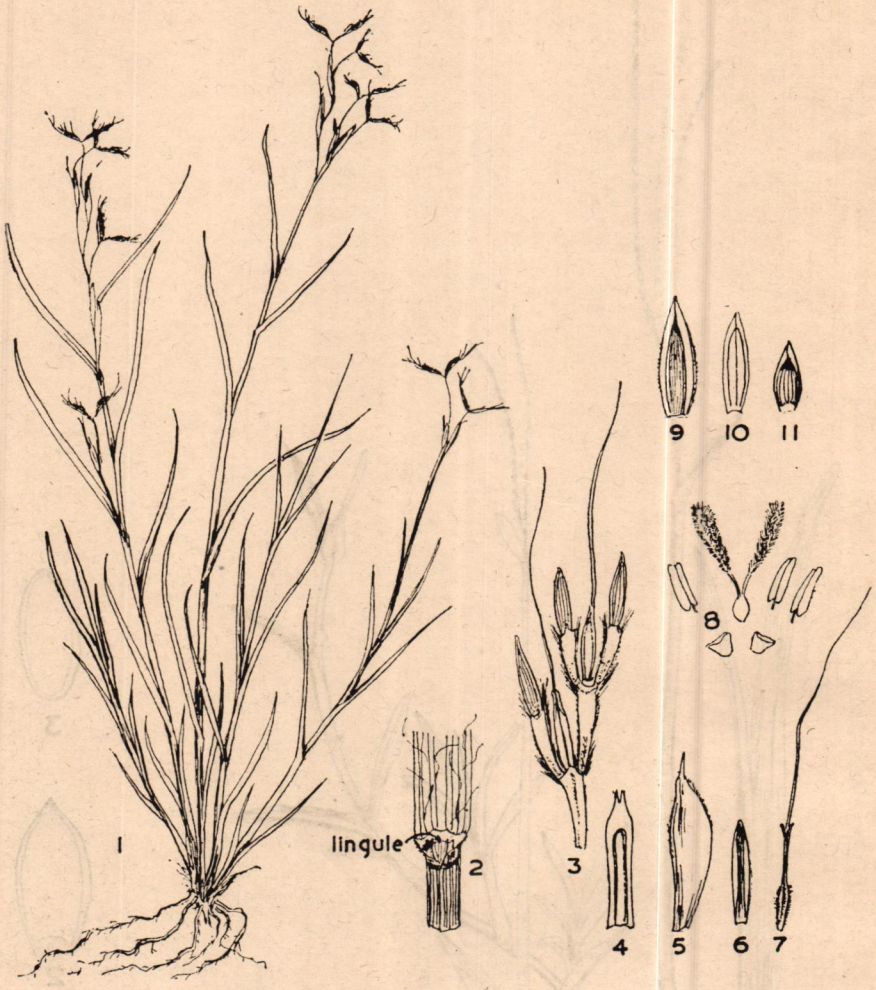


Fig. 31. *Andropogon pumilus*

1. Plant ($\times\frac{1}{2}$); 2. Leaf-blade and ligule; 3. Portion of spike; 4, 5, 6, 7. First, second, third and fourth glumes of sessile spikelet; 8. Ovary, stamens and lodicules; 9. First glume of the pedicelled spikelet; 10. Second glume of the pedicelled spikelet; 11. Third glume of the pedicelled spikelet. The third glume has three stamens.

Setaria sphacelata (Kazungula grass)
A recent promising introduction from Africa.

PLATE XXVI

Tricholaena rosea Ness. (Natal grass)
Native of Africa, this grass has gained prominence in recent years in India.

(*Photo*: P. M. Dabadghao)

Fig. 63. *Urochloa* species

PLATE XXVIII

Apluda species
In Uttar Pradesh, *Apluda mutica* Linn. is often mixed with more palatable grasses to add bulk to the grass bundles.

Bromus Linn. (Brome grass).

A large genus of nearly 100 species distributed in temperate regions and at higher altitudes in the tropics. About 10 species occur in India, on the Himalayan and other mountainous tracts, among which *B. asper*, *B. inermis* and *B. catharticus* are good fodder grasses.

Bromus catharticus Vahl. (Syn. *B. unioloides* HB and K).

This grass is a native of South America which was introduced some years back into India. It is now found growing wild near Darjeeling and on the Nilgiris. It is grown as a winter forage grass in the U.S.A., although it is reported to have a laxative effect on livestock.

Centotheca Desv.

This genus includes five species of tall perennials, distributed in tropical Asia, Africa and Australia.

Centotheca lappacea Desv.

This species occurs on the Khasi, Sikkim and Himalayan tracts, in Central India, Andamans and Ceylon. The plant has a woody rootstock and rect culms, 30 to 122 cm tall, and is a good fodder grass.

Chionachne R.Br.

Genus of seven species, distributed in India and Malaya. Some of them are useful for fodder.

Chionachne koenigii Spreng. (Syn. *Coiz koenigii* Spreng, *Polytocha barbata* Stapf.).

TABLE 94.

ANALYSIS OF CHIONACHNE KOENIGII

	Chemical composition (on dry weight basis)
	%
Crude protein	7·3
Ether extract	1·4
Crude fibre	34·6
Ash	11·7
N-free extract	45·0
Calcium	0·37
Phosphorus	0·27
Potassium	—

(After Sen and Ray, 1964)

A robust perennial grass found all over India, in damp localities and on hillsides but its fodder value is rather low on account of the stiff hairs on the leaf-sheaths and blades. The hard fruits are used as rosary beads and resemble Job's-tears (*Coix lachryma*).

Chionachne semiteres (Syn. *Polytocha semiteres* Benth).

This grass was tried at Coimbatore in 1942 and it yielded under rainfed-conditions 170 q. of green fodder per hectare in one cutting.

Chrysopogon Trin.

This tropical genus includes 32 species, of which a few are useful as fodder.

Chrysopogon asciculatus Trin. (Hindi—*Surwala, Lampa*; Telugu—*Puttli gaddi*).

A small, creeping, rhizomatous perennial, with erect culms 30–60 cm tall, distributed in many places on the plains and low hills of India as a weed in damp and over-grazed areas. It can withstand heavy grazing, but cattle eat it only when nothing else is available, as the long, sharp callus of the spikelets cause mouth-sores in cattle.

Chrysopogon gryllus Trin.

A perennial grass growing to a height of 1·8 m., distributed in dry, stony and inhospitable situations on the Himalayan slopes, Sikkim and Khasi hills, up to 2,740 m. It is reported to be a good fodder grass in Australia, but the young plants contain a cyanogenetic glucoside, as in sorghum.

Chrysopogon lancearlus (Hook. f.) (Syn. *Andropogon lancearius*) Hook. f.

TABLE 95.

ANALYSIS OF CHRYSOPOGON LANCEARIUS

	Chemical composition (On dry basis)
	%
Crude protein	4·7
Crude fibre	27·6
Ash	16·3

(I.A.R.I. Rept., 1913.)

A perennial grass growing nearly 1·8 m. tall, distributed in shady places as well as rocky places in many parts of India. It is considered to be a good fodder grass.

Chrysopogon montanus Trin. (Syn. *Andropogon monticola* Schult. Hindi—*Goria, Guria*).

A highly variable, tufted perennial growing nearly 1·8 m tall, with leaves 91 cm long, distributed throughout India, especially in hilly areas up to 1,830 m. It can thrive on shallow, stony or sandy soils with little or no water-holding capacity. It is very resistant to drought and is found on the plains and lower ranges of hills of northern India. Culms slender, glabrous; leaf-sheaths keeled, glabrous, ligule a row with scabrous margins, upper leaves 7.5 to 10 cm long. Panicles 5 to 13 cm long, with several whorls of flexuous branches, bearing groups of spikelets at their apices. Spikelets in groups of three, one sessile, bisexual, awned, in the centre with two lateral, awnless, pedicelled spikelets. Propagation is by seed or by rooted slips. If cut before flowering, the grass makes good fodder, yielding about 125 q/ha of green fodder in five cuttings from January to July. Well-established pastures can also be raised in three years' time if grazing is avoided during the first year. The grass is not suitable for hay or silage, as it contains a high percentage of moisture. It can, however, serve as a soil binder.

TABLE 96.

ANALYSIS OF CHRYSOPOGON MONTANUS

	Chemical composition (On dry weight basis)
	%
Crude protein	4·6
Ether extract	1·2
Crude fibre	36·7
Ash	8·7
N-free extract	48·8
Calcium	0·36
Phosphorus	0·18
Potassium	0·95

(After Sen and Ray, 1964.)

Chrysopogon orientalis A. Camus (Syn. *Andropogon wightianus* Steud. Telugu—Karappa gaddi).

A perennial grass of variable habit, common in peninsular India, from Cuddapah southwards and up to 2,130 m on the Nilgiris.

TABLE 97.

ANALYSIS OF CHRYSOPOGON ORIENTALIS

	Chemical composition of hay (On dry basis)
	%
Moisture	7·8
Crude protein	4·5
Ether extract	1·1
Crude fibre	35·6
Ash	8·4
N-free extract	42·6

Cymbopogon Spreng (Oilgrass, Lemon grass).

An old-world tropical genus of some 80 species of which 12 occur in India. Most of them are robust, aromatic perennials and some species yield essential oils of great commercial value, like citronella oil, that are used in the soap and perfumery industries. A few of them have fodder value.

Cymbopogon citratus Stapf. (West Indian lemon grass).

This species is being grown in Florida for oil. The residue left after distillation of the oil, when mixed with 35 per cent cane molasses and a small quantity of protein concentrates forms a useful cattle feed.

Cymbopogon gidarba Haines (Syn. *Andropogon gidarba* Bach-ham ex.) Wall.

This grass is found in Bihar and the Himalayan hill-slopes and is reported to be a good fodder.

Cymbopogon jwarancusa Schult. (Syn. *Andropogon jwarancusa* Jones *A. laniger* Duthie non Desf.).

A highly aromatic, tall species, growing up to 1·82 m in height, with leaves 60 cm long and 5 cm broad, found in the Himalayan slopes from Kashmir to Assam, ascending up to 5,485 m and extending from the plains of the north-west up to Bombay. As a fodder, however, it is of only limited value, and is eaten by cattle only when no other grass is available.

Cymbopogon polyneuros Stapf. (Syn. *Andropogon schoenanthus* Linn.) *var.* Hack.

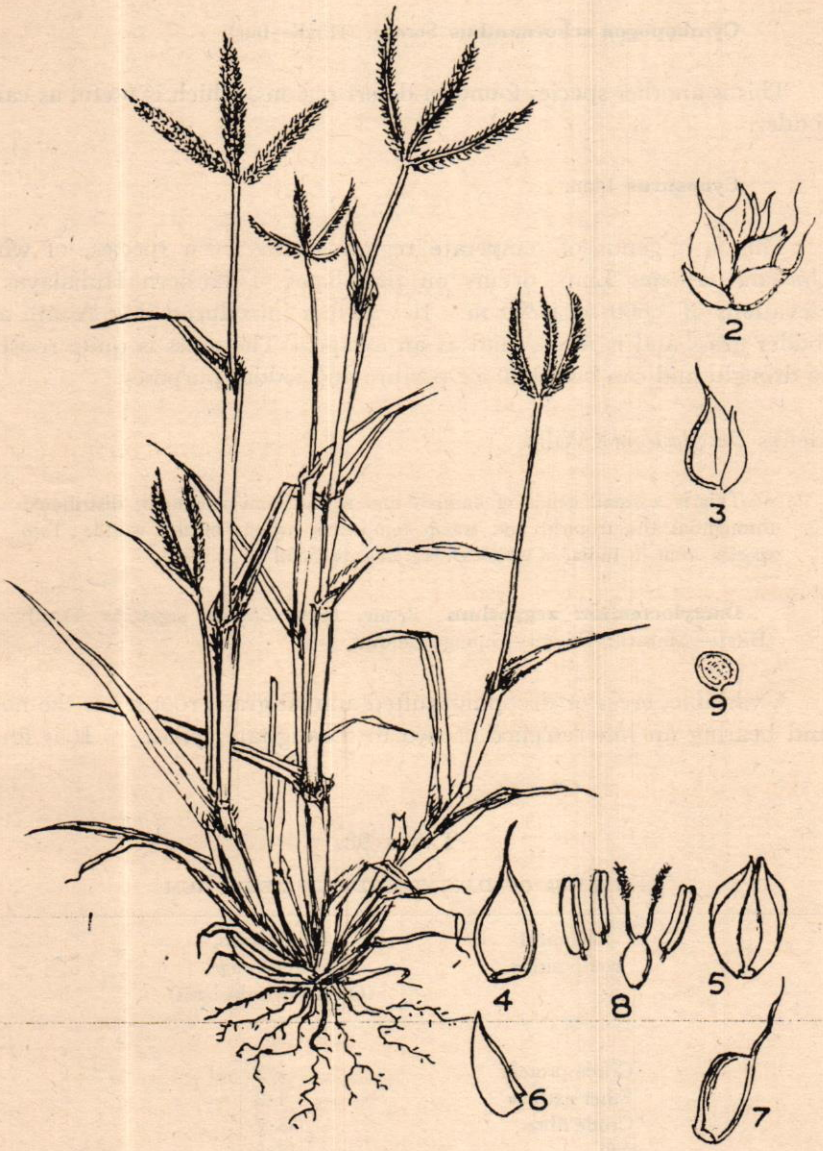


Fig. 32. *Dactyloctenium aegyptium*

1. Plant ($\times\frac{1}{2}$); 2. Spikelet ($\times 5$); 3. Floret ($\times 5$); 4. First glume; 5. Second glume; 6. Third glume; 7. Palea of third glume; 8. Ovary and anthers; 9. Grain.

This species occurs in the south-western region of India and in Ceylon. It is sometimes used as fodder for horses.

Cymbopogon schoenanthus Soreng. (Hindi—Bur).

This is another species found in desert regions, which is useful as camel fodder.

Cynosurus Linn.

This is a genus of temperate regions, with seven species, of which *Cynosurus cristatus* Linn. occurs on the slopes of Western Himalayas at elevations of 3,600 to 4,200 m. It was first introduced into Assam as a fodder grass and is now found as an escape. The grass is quite resistant to drought and can be useful for pasture and fodder purposes.

Genus *Dactyloctenium* Willd.

This is a small genus of annuals and a few semi-perennials, distributed throughout the tropical and warm temperate regions of the world. Two species occur in India, of which *D. aegyptium* is useful for fodder.

Dactyloctenium aegyptium Beauv. (Syn. *Eleusine aegyptium* Desf.) (Hindi—Makara; Telugu—Gunuga gaddi).

A variable, erect or drooping, tufted annual grass, rooting at the nodes and bearing an inflorescence of two to six digitate spikes. It is found

TABLE 98.

ANALYSIS OF DACTYLOCTENIUM AEGYPTIUM

Chemical composition	Green grass, at milk stage (On dry weight basis)
	%
Crude protein	7·3
Ether extract	1·2
Crude fibre	33·7
Ash	12·5
N-free extract	45·3
Calcium	0·91
Phosphorus	0·70
Potassium	3·75

(After Sen and Ray, 1964)

in all places up to 910 m feet elevations, and often becomes a weed in cultivated fields. Although it can be used as fodder, its fodder value is below average and the yield too, is less than 45 q per hectare. In New South Wales, it is reported to have contained cyanogenetic glucosides. The reddish, rugose and sub-globose grain is consumed in times of scarcity in India and Africa.

Dactyloctenium indicum Boiss. (Syn. *Eleusine indica* Duthie, *E. aristata* Ebrenb. ex. Boiss.).

This is a slender perennial grass found on sandy soils in North India, which is considered to be useful as fodder.

Danthonia DC

Genus: A genus of perennial, rarely annual grasses distributed in the tropics and temperate regions of the world, particularly in South Africa and Australia. Several species are important in Australian grasslands as they thrive even on poor soils and extremes of temperature and rainfall and provide nutritious fodder for the greater part of the year; plants are tufted, low or moderately tall, with few-flowered, open or spikelike panicles of rather large spikelets.

Danthonia jacquemonti Bor. (Syn. *D. cachemyriana*).

A capitate perennial, 30 to 75 cm tall, found on the slopes of the Himalayas from Garhwal to Assam and Sikkim at elevations of 3,000 to 4,270 m. It is considered to be a good fodder grass.

Deschampsia Beauv.

Genus: A small genus of tufted perennial grasses, low or moderately tall, with shining pale or purplish spikelets in narrow or open panicles. Found in temperate regions of the Northern hemisphere. Two species occur in India.

Deschampsia caespitosa Beauv. (Tufted hair grass).

This species is a densely tufted ornamental grass, 30 to 91 cm tall, found in the Himalayas from Kashmir to Bhutan at elevations of 3,000 to 4,880 m. It is useful as a coarse fodder, but should be cut before it flowers, as the protein content decreases from 8.54 per cent at panicle emergence to 5.5 per cent at the fully flowered stage.

Desmostachya Stapf.

A monotypic genus of tufted perennial grasses distributed in Africa and India.

Desmostachya bipinnata Stapf. (Syn. *Eragrostis cynosuroides* Beauv.) Sanskrit—Dharbha kusa; Hindi—Dab, Durva, Dhabodo; Telugu—Darbha, Kusa darbha).

A tall, tufted perennial grass growing 60 to 152 cm. tall, with stout stolons enclosed in shiny leafsheaths, found in the plains in Gujarat and also other States in India. It flourishes both in dry situations, forming large tussocks in sandy desert areas, and in low-lying areas and even water-logged places. It flowers during rains. Cattle do not eat this grass, although buffaloes may eat it in its young stages.

TABLE 99.

ANALYSIS OF DHABODO

	Chemical composition (On dry weight basis)
	%
Crude protein	4·5
Ether extract	2·1
Crude fibre	33·3
Ash	9·0
N-free extract	51·1
Calcium	0·32
Phosphorus	0·27

(After Sen and Ray, 1964)

Diectomis Kunth

A monotypic genus. *D. fastigata* HB & H (Syn. *Andropogon fastigatus* Sw.) is an erect perennial 30 to 60 cm tall, found in Bihar and Orissa on hilly and stony ground; not found in the coastal areas. It is said to be a good fodder, when young.

Digitaria Haller (Crab grass)

This is a large genus of annual or perennial, often weedy grasses, with narrow, flat and flaccid leaves, erect to prostrate in habit, with slender, digitate spikes on a short axis. Name is derived from Latin *digitus*, a finger, alluding to the finger-like branches of the inflorescence. The nomenclature is somewhat confused by the inclusion of species from other genera, such as *Panicum*,

Paspalum and *Axonopus*. About 20 species are found in India, both on the hills and in the plains and about ten of them are important as fodder plants. *Digitaria* species are widely distributed in India and often become weeds in lawns and cultivated fields. Some species grow in semi-arid situations and a few thrive on the hills. Some species are useful as fodder grasses in the U.S.A. yielding up to 50 q/ha. of hay, but though they can form a fine growth, they start late and die off early in autumn.

Digitaria adscendans (HB. & K.) Henr. (Syn. *D. marginata* Link.; Hindi—*Takri takra;* Tamil—*Arisi pillu, Akki pillu;* Kannada—*Henna akkibu hullu*).

This species has more elongated spikelets than the highly variable species growing in Central Europe and other temperate regions. This grass is found in all districts in Madras from sea level up to 2,130 m. It makes a good fodder if cut at the stage when the first-formed heads are just maturing.

TABLE 100.

ANALYSIS OF D. ADSCENDANS

	Chemical composition of hay (On dry weight basis)
	%
Crude protein	14·5
Ether extract	2·2
Crude fibre	28·0
Ash	11·3
N-free extract	44·0
Calcium	0·82
Phosphorus	0·46

In general, the young plants are rich in proteins and mineral constituents. Carbohydrates, fibre and ether extractives remain practically constant in all stages and the calcium content actually increases with maturity.

Digitaria longiflora Pers. (Syn. *Paspalum longiflorum* Retz.; Tamil—*Valari pillu*).

This grass is found in all districts in Madras from sea level up to 1,830 m. In the U.S.A. Crab grass is considered a troublesome weed and is often sought to be controlled by spraying weedicide chemicals.

Other species of *Digitaria* of fodder value are: *D. bicornis* (Lam.) Roem & Schult., *D. corymbosa* (Roxb.) Merill, *D. cryciata* (Nees) A. Camus, *D. griffithii* (Arn.) Henr., (Western Ghats), *D. jubata* (Griseb) Henr.,

D. pruriens (Trin.) Busc., and *D. wallichiana* (Wight & Arn) (Nilgiris and Palni Hills, 1,220 to 2,130 m.).

Digitaria marginata Link. var. *fimbriata* Stapf. (Tamil—Arisi pillu, Chatta pillu; Telugu—Peddootla gaddi; Kannada—Henna akkibu hullu).

This grass is about 60 cm tall and is found in all districts of Madras up to 2,130 m elevations. It is considered as one of the good fodder grasses.

TABLE 101.

ANALYSIS OF DIGITARIA SPECIES

	Chemical composition (On dry weight basis)	
	D. longiflora	*D. marginata*
	%	%
Crude protein	5·9	7·1
Ether extract	0·8	1·2
Crude fibre	24·6	33·6
Ash	22·4	13·2
N-free extract	46·3	44·9
Calcium	0·51	0·67
Phosphorus	0·22	0·29

(After Sen and Ray, 1964)

Dimeria R.Br.

A large genus of annual or perennial grasses occurring in Asia and Australia. Fifteen species are found in India, of which *D. ornithopoda* Trin. a slender, tufted annual, is found throughout the country. It is only an inferior fodder.

Dinebra Jacq.

A small genus of annual leafy grasses, distributed throughout tropical Asia and Africa.

Dinebra retroflexa Panz. (Syn. *D. arabica* Jacq.; Telugu—*Wadate toka gaddi*).

This is the only species occurring in India. A low, erect tufted annual, 30 to 91 cm tall, growing as a common weed in cultivated fields in Madhya

Pradesh, Western India and the Central and Southern districts of Madras, from sea level to 910 m. It thrives on heavy clayey and black soils. The yield is about 28 q of green fodder per hectare, which is excellent for milch cattle. It is not, however, suitable for ensilage or for hay.

TABLE 102.

ANALYSIS OF DINEBRA RETROFLEXA

Chemical composition—	Green
	%
Moisture	69·9
Crude protein	1·6
Ether extract	0·9
Crude fibre	6·3
Ash	2·3
N-free extract	19·0

Diplachene Beauv.

A small genus of tall, tufted perennial grasses, widely distributed in the tropics of both hemispheres. In India, however, only a single species, *D. fusca*, is recorded.

Diplachne fusea (Linn.) Beauv. (Tamil—Nandi pillu).

A tufted grass, with narrow, flat leaves, found in the upper Gangetic plains, Bengal and Orissa and also in the districts of Krishna and Anantapur

TABLE 103.

COMPARISON OF CHHIMBAR WITH HARIALI GRASS

Chemical composition	*Chhimbar* (Green roughage)	*Hariali* (Green)
	%	%
Moisture	63·1	50·8
Crude protein	4·3	4·7
Ether extract	0·6	0·9
Crude fibre	12·9	12·5
Ash	4·6	5·2
N-free extract	14·5	25·9
Calcium	0·40	0·43
Phosphorus	0·56	0·27
Potassium	0·23	1·15

(After Lander, 1949)

in Andhra Pradesh, Tirunelveli in Madras and on the Kerala coast. The culms are about 152 cm in height, with leaves 45 cm long and panicles 10 to 30 cm long. The margins of the lemmas and paleas are hairy. It thrives in moist locations and saline soils. As a fodder it is an inferior grass, although buffaloes may eat it in the young stage.

Eleusine flagellifera (Hindi—Chhimbar, Ghantil).

This is a very useful fodder grass in Northern India. It thrives best on sandy soils, where *Cynodon dactylon* would fail to make good growth. The grass spreads by means of runners, just like *hariali* and in the young stages it is quite nutritious and compares favourably with *hariali* grass.

Enteropogom monostachys K. Sch. (Tamil—*Kannai pul*).

This grass is found in many places in peninsular India from Cuddapah southwards, from sea level up to 610 m elevations, except on the Kerala coast. It is a tall, slender grass common in dry forest areas. As it can be grown with ease and is also quite nutritious, it is worth introducing in forest areas where it is now absent. Cattle relish the grass well. The yield is about 1,681 q per hectare in four cuttings in the course of a year.

Eremopogon faveolatus Stapf. (Hindi—*Mur jhaims*).

This is a slender perennial grass about 60 cm tall, which can yield up to 134 q/ha. of green forage in three cuts in a year.

Erianthus Michx. (Plume grasses).

A genus of giant perennial grasses, native to tropical and warm temperate regions; about 11 species occur in India. They are reed-like plants with elongated flat leaf-blades and terminal, oblong, densely silky panicles. Species of *Erianthus* are believed to be wild relatives of the cultivated sugarcane, *Saccharum officinarum.*

Erianthus longisetosus Anders ex Benth.

A tall, perennial grass growing up to 4·5 to 6 m in height, with leaves 60 to 91 cm. long and 2·5 to 3·8 cm broad, found at elevations of 300 to 1,830 m from Nepal to Assam, usually in moist but not water-logged situations. The leaves resemble maize leaves and are eaten by wild herbivores and also used as cattle fodder by ranchers and wood-cutters on the Assam hills. It is well-relished by cattle and can be fed at any stage of growth. The grass can also be converted into hay or silage.

The hay is not very palatable but the silage is consumed readily enough. In nutritive value the grass compares favourably with many cultivated grasses and feeding experiments have shown that late-cut tops as well as the early-cut plants have almost the same digestibility co-efficients.

TABLE 104.

ANALYSIS OF ERIANTHUS LONGISETOSUS

	Early growth (Cut in May)		Late growth (Tops cut in December, when lower parts were brown)	
	Chemical composition	Digestibility co-efficients	Chemical composition	Digestibility co-efficients
	%	%	%	%
Crude protein	8·0	52	7·5	52
Ether extract	2·3	33	2·4	27
Crude fibre	35·0	63	32·2	66
Ash	9·2	—	9·1	—
N-free extract	45·5	65	48·8	60
Calcium	0·21	—	0·20	—
Phosphorus	0·16	—	0·10	—

(After Sen and Ray, 1964)

Erianthus ravennae Beauv. (Ravenna grass, Plume grass; Hindi—Dolser, Dolu).

A tall, perennial grass with smooth culms growing nearly 6 m tall, with leaves 91 to 152 cm long and 2·5 to 3·8 cm broad, found in the western Himalayan regions, from the upper Gangetic plains to the Punjab and extending westwards up to the Mediterranean coast. Although buffaloes can eat this grass when the plants are young, it is not of much fodder value.

Themeda Forsk.

This is a genus of coarse, annual or perennial grasses, with erect or ascending culms, 1·8 to 2·7 m tall, and very narrow, leaves. The inflorescence is leafy and somewhat bent when ripe, in solitary, short racemes, subtended by the spathes, crowded in paniculate or glomerate fascicles. The bract leaves have a row of tubercle-based hairs on each side below the margin.

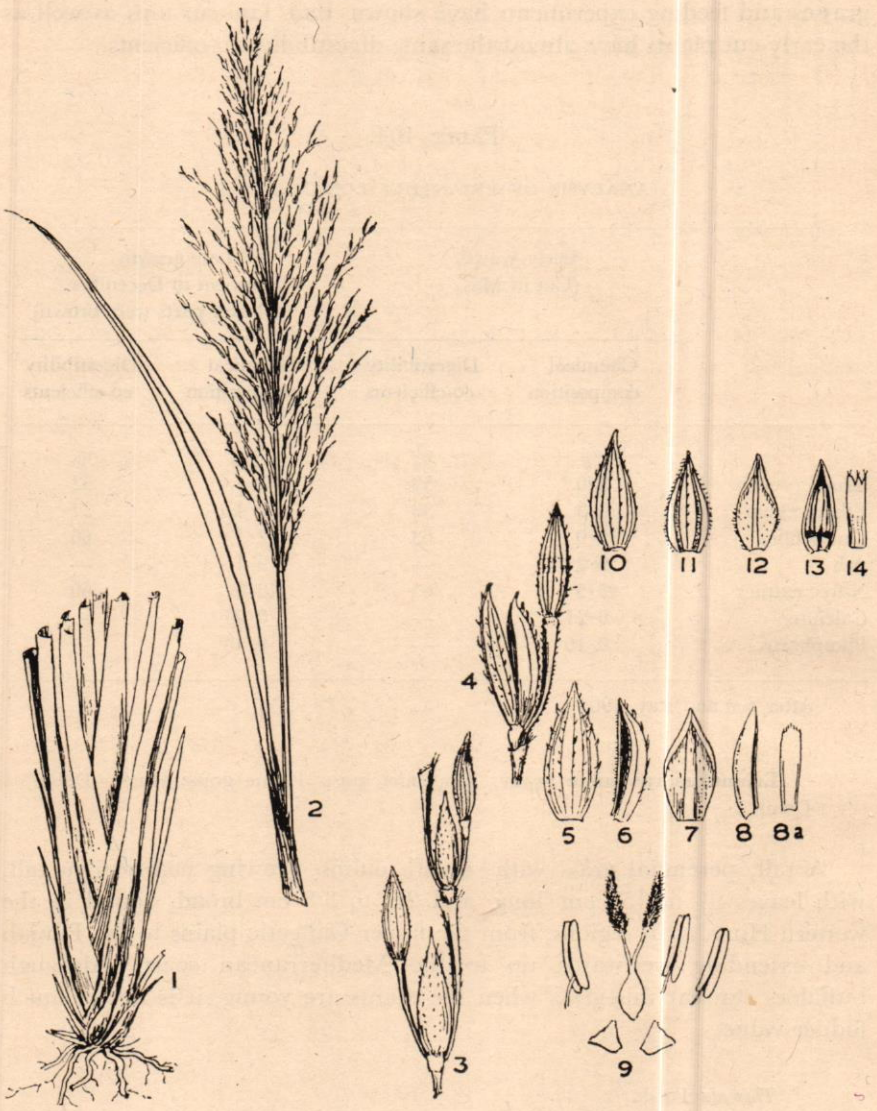


Fig. 33. *Vetiveria zizanoides*

1. Plant base ($\times\frac{1}{2}$); 2. Inflorescence ($\times\frac{1}{2}$); 3. Portion of a branch; 4. Sessile and pedicelled spikelets; 5, 6, 7, 8, 8a. First, 2nd, 3rd and 4th glume and palea of 4th glume of sessile spikelet; 9. Ovary, stamens and lodicules; 10, 11 and 12. First, 2nd 3rd glumes of pedicelled spikelet; 13 and 14. 4th glume and palea of pedicelled spikelet.

Themeda triandra Forsk. Forsk.

This species is common on the slopes of the Himalayas, which is palatable to cattle in the young stages. Other species of *Themeda*, viz. *T. arundinacea* Ridley, *T. caudata* Dur. et Jack, *T. quadrivalis* Ktze and *T. anathera* Hack. are also found growing gregariously in the Terai region of the Himalayas, but they are not good fodders.

Vetiveria zizanoides Nash (Hindi—Khas khas, Panni).

A densely tufted perennial grass with aromatic, branching rootstocks. Culms smooth, glabrous, 91 to 152 cm tall, sheaths compressed, leaves 30 to 91 cm long, usually glabrous, pale green in colour. Panicle oblong, erect, about 30 cm long. The grass is a fair fodder when young, but becomes coarse and fibrous after flowering.

CHAPTER 14

MISCELLANEOUS FODDER PLANTS, INCLUDING SHRUBS AND TREES

In times of fodder scarcity, almost anything edible, green or dry, is fed to cattle in India, to ward off starvation. A number of species are useful for this purpose; some of them are also cultivated, while others are utilised wherever available in times of fodder scarcity. Many trees are lopped for fodder, especially near jungle areas, as for instance, *Dalbergia*, *Ficus* and *Zizyphus* species.

Artemesia Linn. (Compositae).

This is a large genus of small herbs, of 280 species distributed in the northern hemisphere, especially in arid and semi-arid regions. About 34 species are found in India, on the north-western Himalayan slopes. Several species yield essential oils, some of which are medicinal. *A. maritima* is found in Kashmir and was formerly used for extraction of the vermifuge drug santonin. Some species are useful as fodder for the cattle and sheep in these regions.

Artocarpus Forst. (Moraceae).

A genus of evergreen or deciduous trees with nearly 100 species distributed throughout India. Among these, *Artocarpus chaplasha*, *A.*

TABLE 105.

ANALYSIS OF SALTBUSH

	Green material	
	Chemical composition	Digestible nutrients
	%	%
Moisture	75·7	—
Crude Protein	3·9	—
Ether Extract	0·3	—
Crude Fibre	4·2	—
Ash	5·1	—
N-free extract	10·8	—
Digestible Crude Protein	—	2·9
Total Digestible Nutrients	—	9·8

(After Lander, 1949)

Themeda triandra Forsk.
A coarse species, eaten by cattle only when young.

PLATE XXX

Erianthus ravennae Beauv. (Plume grass)
A tall, perennial grass, palatable only when young.

Atriplex vesicaria (Australian salt-bush)
Salt-bushes are useful as emergency fodders in arid or alkaline areas.

PLATE XXXII

Pennisetum rupelli

hirsuta and *A. lakoocha* are useful for timber. *A. communis* (Breadfruit tree), *A. altilis* and *A. integer* (Jackfruit) can be utilised as fodder trees as the leaves are relished by cattle.

Atriplex Linn. (Chenopodiaceae) (Australian Saltbush).

This is a large genus of nearly 180 species distributed in both tropical and subtropical regions, chiefly in arid and alkaline areas. Five species occur in India. These plants are all highly drought-resistant and can grow under very severe conditions. A few species like *Atriplex mummularia* Lindl. can serve as fodder plants, others like *A. repens* and *A. hortensis* are also useful as pot-herbs.

Betula utilis D. Don (Betulaceae) (Syn. *B. Bhojpatra* Wall; Himalayan Silver Birch).

The genus *Betula* includes 38 species, mostly timber trees growing in temperate regions. The wood of the Himalayan silver birch is used for building purposes. The leaves can be used for fodder.

Genus *Brassica*

Amongst the Crucifereae the genus *Brassica* includes a large number of species that are important as crops, viz. cabbage, cauliflower, Brussels sprouts, Choumoellier, radish, rape, mustard, rai, sarson and garden cress. Of these, a few can be grown as fodder crops, e.g., rape and Choumoellier.

Rape (*Brassica campestris* var. *toria* Duthie and Fuller).

This species is one of the major oil-seed crops in India, being grown in large areas in the Punjab, Uttar Pradesh, Bihar, Madhya Pradesh, Rajasthan, West Bengal, Orissa and Assam. It is sometimes cultivated as a fodder crop. Experiments have shown that for fodder purposes, *B. campestris* var. *dichotoma* Watt was the best amongst all the *Brassica* species. Another species that is useful both as a fodder and as a vegetable is the Indian mustard, (*Brassica juncea* var. *napus*) or *rai*.

Toria is usually grown as a pure crop, but *rai* and *sarson* are generally grown mixed with wheat, barley or gram.

Rape is very useful for feeding sheep and is ideal for fattening swine and cattle. It is easy to grow, vigorous and adaptable to various soils and climates and is also quite responsive to manuring and good cultivation. It is a winter annual herb, 45 to 152 cm high. The leaves are auricled and stem-clasping, lyrate in shape, sometimes hairy or with a waxy bloom.

The inflorescence is a corymbose raceme; the flowers are very variable in size. Sepals are sub-erect, the inner pair being larger than the outer pair of sepals. Petals four, separate or overlapping according to different varieties, narrow or broad, the colour may range from deep yellow to cream or white. Stamens are tetradynamous. Ovary is hypogynous, syncarpous with parietal placentation. The fruit is a siliqua, a " pod " two-loculed owing to the presence of a false septum extending from placenta to placenta. The seeds are yellow or brown, usually smooth, rarely rough or finely rogose.

Climate and Soils. The Brassicas thrive best on rich loamy soils and a cool climate, but they are liable to get damaged by frost. For rape, black loams are the best.

Cultural Practices. Rape needs a perfect tilth to grow well. Two or three ploughings will be needed, followed by harrowing and levelling. Manuring is also necessary, to supply 22 to 34 kg of nitrogen per hectare. Seeds may be sown broadcast or drilled in rows. The seed-rate is 5·5 kg. per hectare. Rape is a biennial like beets and seeds should be obtained from reliable sources, under a guarantee of germination. About three irrigations, to supply 25.4 hectare cm of water, will be needed by the crop.

Rape is often grown in mixture with berseem and sometimes with shaftal as well. The rape plants grow quicker and increase the bulk of the first cutting of the legume by November and also furnish a better balanced forage.

Utilisation. When rape is cut for fodder, care should be taken to leave a long stubble of 10 to 13 cm, otherwise no second or third cuts will be possible. Sometimes, only two cuts are taken for fodder and the third is left for seed production. Being a succulent feed, great care should be taken to avoid bloat. A little maize or barley or mixed dry grass should be included to balance the ration and bring the nutritive ratio to 1 : 5·5. Cattle should not be led into a rape field when they are very hungry or on dewy mornings. The yield may be about 168 to 224 q per hectare.

Pests and Diseases. The mustard sawfly (*Athalia proxima* Klug.) is often a serious pest on cruciferous crops. The larvae defoliate the plants and cause much damage and reduction of yields. Control is by hand-picking or by spraying lead arsenate once a week at 1·1 kg per 560 litres of water per acre. The interspace between rows can be ploughed up so that the pupae may be exposed, to be picked off by birds.

Another serious pest of cruciferous crops grown in India in the winter months is the Mustard Aphid (*Lipaphis erysimi* Kaltenback). Cloudy moist weather encourages pest multiplication. The aphids cover the entire plant, sucking the sap and reducing the vigour and ultimately the

yield of the plants. Control is possible by dusting with 1 to 4 per cent nicotine or rotenone (0·5 to 0·76 per cent) at 16·8 to 22·4 kg/ha, pruning off infested shoots and destroying the aphids.

The painted bug (*Bagrada cruciferarum* Kirk) is a polyphagous insect, so control is rather difficult. Clean cultivation may be helpful and dusting with 0·1 to 0·25 per cent BHC under expert supervision may also be effective. The flea beetle (*Phyllotreta cruciferae* Goeze) cuts holes in the leaves and causes much damage sometimes. Here too, dusting with BHC will be helpful. The cabbage butterfly (*Pieris brassicae* L.) causes a certain amount of damage by the yellowish larvae defoliating the leaves: it may be controlled by sprays of 0·12 per cent DDT.

Among diseases Alternaria blight [*Alternaria brassicae* (Berk) Sacc.] is one of the most widespread and destructive. It attacks cabbage, cauliflower, turnip, radish, sarson, toria, rai and rape. Small brown spots appear on the plant and these spread to cover the entire plant. In severe attacks the plant withers and sets no fruit. The yield and oil content are very much reduced. Control is possible by spraying Bordeaux mixture (4: 4: 50), but it may not be economical. The search for resistant strains is in progress. White rust [*Albugo candida* (Pers) Kuntz.] is another widespread disease on cruciferous crops. Creamy yellow pustules form on the floral parts, but the total damage is usually not serious enough to call for control measures. In downy mildew (*Peronospora brassicae* Gaumann) light-green lesions develop on the leaves; these coalesce and in severe cases the leaf dries up. Spraying with Perenox (0·25 per cent) from December onwards or with Bordeaux mixture (4: 4: 50) will control the disease. Rotation with non-cruciferous crops will be desirable. In powdery mildew (*Erysiphe polygoni* DC) white floury patches develop on both sides of the leaves, but the damage to growth and yield is not very serious. Dusting with sulphur dust is recommended as a control measure for this disease.

Choumoellier (*Brassica oleracea* var. *acephala*, Cabbage broccoli).

Another cruciferous plant that can serve as a fodder for livestock is Choumoellier or Cabbage Broccoli. This is widely grown in Australia and New Zealand as a forage crop for dairy cattle and sheep. The plant resembles cabbage in the early stages but forms no heads and grows up to 1·2 to 1.5 metres in height. In New South Wales it is reported to be a popular crop in areas of moderate rainfall, where the summers are apt to be dry. In cooler areas it can supply green fodder for many months of the year. Choumoellier was tried in 1951–52 at the College of Agriculture, Sabour, from seed obtained from New Zealand, with a view to find

out whether it could serve as a simpler and cheaper substitute for berseem, which requires liberal irrigations and careful cultivation to give good results. The seed bed was prepared carefully, as usual for small-seeded crops like mustard and the seeds were sown in October at 2·2 kg per hectare on ridges 45 cm apart. Later on the plants were thinned to leave 30 cm of space between plants. The crop could be cut for fodder in February, and supplied green forage until the middle of March. The plants remained green till May, but the lower parts of the stems became too woody, although the upper parts were still palatable to livestock. A calculated outturn of 190 q and 224 q per hectare was obtained from the two types of Choumoellier that were under trial. Feeding trials indicated that Choumoellier was in no way inferior to berseem as a green feed for milch cows. Under Indian conditions seed production is likely to be a real problem with this crop, but it was clear that it could serve as a very palatable and nutritious green fodder for dairy stock from February to March, at a lower cost than berseem.

TABLE 106.

ANALYSIS OF CRUCIFEROUS FODDER CROPS

Chemical composition	Sarson	Giant Type Choumoellier (On dry basis)	Cabbage
	%	%	%
Moisture	87·1	—	—
Crude protein	1·4	17·7	18·8
Ether extract	0·4	—	3·6
Crude fibre	2·6	—	10·8
Ash	2·4	16·9	23·9
N-free extract	6·1	—	42·9
Calcium	0·45	4·43	—
Phosphorus	0·10	0·41	—
Potassium	0·36	—	—
	(After Lander, 1949)	(Mukerjee and Mahanta, 1953-54)	(Sen and Ray, 1964)

Buchanania lenxan Spreng. (Anacardiaceae).

This genus includes 20 species of trees and shrubs distributed in tropical Asia, Australia and the Pacific islands. Among these, six species are found in India.

Buchanania lenzan (Syn. *B. latifolia* Roxb.; Hindi—*piyar, chironji, charoli*) is a medium-sized tree with dark grey bark resembling crocodile skin. The leaves are reported to be used for fodder in parts of Maharashtra

and the Punjab. The fruits are eaten by hill tribes and the kernels are sometimes used in making sweetmeats.

Canna edulis (Queensland arrow-root; Cannaceae)

Both the tops and tubers of this species can be used as stock-feed. Another species *C. orientalis* Rosc., (Hindi—*sabba jaya*, Tamil—*kal vazhai*), which is widely grown as an ornamental plant in parks and gardens, is also useful, as the stalks when boiled with some pepper and rice-water, serve as an antidote for the toxic effects produced by eating poisonous plants.

Cardus nutans Linn. (Compositae).

This plant is distributed in the western Himalayan region from Kashmir to Simla at elevations of 1,830 to 3,660 m and can serve as a good fodder for camels.

Carex baceans Nees (Cyperaceae).

The genus *Carex* is a very large one including 1,500 species of grass-like perennial sedges, growing mainly in temperate regions. In the tropics they occur chiefly in mountainous areas. *Carex baccans* occurs in Sikkim and Assam and in Kerala on hilly tracts. The plant may be used as emergency fodder, but the foliage is very harsh.

Celtis australis Linn. (Ulmaceae; Nettlewood)

This is a medium-sized deciduous tree, which grows wild on the Khasi Hills and Himalayas, up to 2,440 m elevations. It can grow on both swampy and dry situations and is not very exacting in its requirements. The leaves can be used for fodder. The leaves of another species, *C sinensis* pers. found in Assam can also be used for fodder.

Carthamus tinctorius L. (Compositae)

The genus *Carthamus* includes 36 species distributed in Asia, Africa and the Mediterranean region. Three species occur in India, of which *C. tinctorius* is of economic importance as one of the oilseed crops of India. *C. lanatus* L. (Saffron Thistle) is a herb found in Kashmir between 1,520 to 2,130 feet elevations. The seeds yield a pale yellow oil similar to the oil expressed from *C. tinctorius* seeds.

Carthamus oxycantha Bieb. (Wild safflower)

This is a medium-sized herb growing wild in the arid tracts of north-west India, in the Punjab, Uttar Pradesh and Baluchistan (now in Pakistan). It is often a troublesome weed in cultivated fields during May-June. The plants are said to be useful for fodder but they are eaten by animals only in the young stages; when mature they are hardly touched, unless the thorns are first bruised by beating the plants with sticks. It is richer than ordinary cereal straws in digestible protein and may perhaps be useful as a supplement to cereal straws in feeding cattle.

C. tinctorius Linn. (Hindi—*Kusum*)

Green safflower plants can serve as a succulent fodder yielding nearly 448 q/ha of green forage which is well relished by cattle, if cut before flowering. Safflower hay, if cut and cured before flowering is reported to be almost equal to lucerne in feeding value. In the young stages the seedlings can be used as a pot-herb or salad. It is also made into silage with the aid of fermenting agents and fed with success to hogs in Germany.

TABLE 107.

ANALYSIS OF SAFFLOWER

Chemical composition	Safflower leaves	*Methi* leaves (*Trigonella foenum-graecum*)
	%	%
Moisture	86·0	77·0
Crude protein (on dry basis)	28·1	16·2
Ether extract	6·1	4·8
Crude fibre	9·1	11·5
Ash	12·1	11·4
N-free extract	44·6	56·1

It will be clear that safflower compares well with other leafy forage plants.

Coix lachryma-jobi Linn. (Gramineae) (Syn. *C. lachryma* Linn.; Sanskrit—Jargadi; Hindi—Sankru; Tamil—Net pavalam).

The green foliage of this plant may be used as fodder for cattle, horses and elephants and can also be ensiled. The dry leaves are useful for thatching purposes.

Eichhornia crassipes Solms (Pontederiaceae; Syn. *E. speciosa* Kunth)

(Water hyacinth, Lilac Devil; Hindi—Kachuri para; Bengali—Kachura pana; Tamil—Akasa thamarai; Telugu—Pisachi thamara; Malayalam—Kola vazha).

The genus *Eichhornia* is a small genus of aquatic plants native to South America, of which one species, *E. crassipes* has now become a widespread weed throughout the tropics, in water-ways and tanks.

This species is an aquatic perennial native to South America, partly rooting and partly floating in shallow water, with numerous long fibrous roots, short leafy stems and showy lilac flowers. The leaves are paddle-shaped with rounded tips and borne in rosettes, swollen and spongy in the middle, to enable the plant to float on water. The inflorescence is an erect, spicate raceme 15 to 50 cm long, bearing 5-35 flowers, two-lipped and funnel-shaped, mauve, lilac or violet-blue in colour, 2·5 to 3·8 cm long. On withering, the peduncle bends over to push the flowers under water.

The plant is very resistant to drought and can even grow as a land plant, but is sensitive to frost and saline water. It gets propagated by the creeping stolons that get readily separated. Rooted plants are also easily separated and get washed away, to form separate colonies. The floating plants when they reach shallow water send down roots into the mud below. Birds also help in the dispersal of this weed, as the young rosettes get entangled in their legs and claws. The seeds fall and settle down in the bottom of the pond and can retain their viability for a long time.

In the course of the numerous attempts that have been made to control water hyacinth, attempts have also been made to utilise it as a fodder. In China and Malaya, it is sometimes used for feeding pigs; the plant is actually cultivated in ponds as pig fodder and the piggery washings are led into the ponds to fertilizers the water hyacinth plants.

The plants are eaten by cattle and horses but they are inferior to common fodders, both in palatability and feeding value. In South India (Tirunelveli district), water hyacinth has been used as a forage for buffaloes at 6·8 kg a day and it was found that the milk yield was increased by nearly 15 per cent, but the milk was too watery and the butter poor in flavour and consistency. The average yield of green fodder may be as much as 1,505 q/ha per year. Water hyacinth is richer than Guinea grass or Napier grass in lime and magnesia but poorer in phosphates. In digestible nutrients it is superior to rice straw and quite comparable to Guinea grass, but on account of its high potash content it upsets the mineral metabolism of the animal and cannot be used as a regular fodder

for any length of time, although it may be used in moderate quantities in combination with other concentrated feeds in short interrupted spells.

TABLE 108.

ANALYSIS OF WATER HYACINTH

	Chemical Composition	Digestible Nutrients
	%	%
Moisture	79·3	
Crude protein	1·3	
Ether extract	0·3	
Crude fibre	4·8	
Ash	3·2	
N-free extract	11·1	
Calcium	3·50	
Phosphorus	0·36	
Potassium	5·00	
Digestible Crude Protein		—
Total Digestible Nutrients		41·3

(After Lander 1949)

Ficus bengalensis Linn. (Moraceus) Banyan tree

This is a large tree with profuse leathery leaves which is commonly grown in avenues and roadsides in almost all parts of India. Propagation is by seeds. The leaves can be used as green fodder. Another species is *Ficus religiosa* Linn., the *peepul* tree, which is also very common all over India in avenues and roadsides. The profuse, acuminate-tipped leaves are readily eaten by cattle. Propagation is by seeds or stumps.

Niger (*Guizotia abyssinica* Cass; Compositae; Hindi—Ram til, Sarguja).

Niger is an African plant which is grown as an oilseed in the Deccan and Carnatic regions. It is a stout herb growing nearly 90 cm in height, with conspicuous yellow flowers. The plants can be cut for fodder at the flowering stage, particularly for feeding sheep. In some parts of the Deccan, Niger is grown as a border crop around cereal crops that are exposed to cattle tresspass, because cattle do not care to eat the niger plants nor stray through the niger belt to feed on the more palatable cereals inside the field.

Niger can be made into good silage, which is quite as nutritious as silage from maize or cowpea.

TABLE 109.

ANALYSIS OF NIGER

	Chemical Composition		
	Niger Silage	Maize Silage	Cowpea Silage
	%	%	%
Moisture	69·6	71·7	79·3
Crude protein	3·9	2·3	3·1
Ether extract	3·3	0·9	0·8
Crude fibre	7·3	6·9	5·9
Ash	3·5	1·7	2·3
N-free extract	12·4	16·5	8·6

Sunflower (*Helianthus annuus*; Compositae)

Sunflower is a tall, single-stemmed, quick-growing annual with large cordate-ovate leaves 10 to 15 cm across and large, showy flower-heads which are often 25 to 30 cm in diameter. It is a plant which can grow in almost all parts of the world, in the tropics as well as in temperate regions. It is grown in Russia and America as an oilseed crop, for green manure and for fodder purposes. Sunflower was first tried in India at the Chintala-devi Farm in Andhra Pradesh in 1924 and was being grown for many years as a regular silage crop at Hosur, in Mysore State and Hissar in the Punjab.

Sunflower can come up on all types of soils, except laterite soils and water-logged soils and can be sown practically all the year round, except during June, July and August, when the monsoon rains might hamper germination of the seeds. The optimum seed-rate for this crop is 33 kg per hectare for fodder and 16·5 kg/ha for seed. The first irrigation should be delayed as long as possible, so that the plants might develop a deep root system, but subsequent irrigations may be given as and when necessary. No weeding will be needed for this crop, as sunflower smothers all weeds. The crop can be cut for fodder in 60—120 days according to the time of the year, but the maximum yields are obtained when it is cut at the soft milk stage of the seeds, when they contain about 2·5 per cent proteins. Sunflower can serve as a maintenance fodder which compares very favourably with many other green fodders and grasses. In later stages the stems become too fibrous. For silage, sunflower should be cut when the seeds are well-formed but not hardened. If cut earlier, the crop may be too succulent and may have to be dried for a day or two before it is ensiled. In any case it is preferable to leave the cut plants in the field for a day before they are packed in the silo, otherwise they

may be too moist and succulent. The crop is not suitable for preparing hay. An average outturn of 168 q of green fodder may be expected from hectare, though at Hosur it gave for many years an average of nearly 336 q/ha and at Hissar sunflower had yielded as much as 414 q/ha of green fodder. As a seed crop about 4·5 to 5·6 q/ha may be expected. Sunflower is an exhausting crop and should be followed by a legume or the field should be manured adequately before sowing the next crop. Cattle eat the green fodder with relish and the silage too, is both nutritious and palatable to livestock.

TABLE 110.

ANALYSIS OF SUNFLOWER

	Green material (Pre-flowering stage)		Silage	
	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients
	%	%	%	%
Moisture	79·1	—	77·8	—
Crude protein	2·5	72	2·1	50
Ether extract	0·7	44	1·0	74
Crude fibre	5·0	20	6·8	49
Ash	3·2	—	2·3	—
N-free extract	9·5	79	10·0	66
Calcium	0·52	—	0·39	—
Phosphorus	0·11	—	0·04	—
Potassium	0·89	—	0·65	—
Digestible Crude Protein		1·8		1·1
Total Digestible Nutrients		10·7		12·6

(After Lander, 1949)

Kochia brevifolia (Chenopodiaceae)

This plant was found very useful for colonising bare salt-lands in west Australia and converting those lands into productive fodder areas. The yields were of course, dependent on the rainfall received, but the potential dry matter production was not less than 2·2 to 3·4 q per hectare. *Kochia brevifolia* had a protein content of 14–30 per cent and it was also more persistent in adverse seasons than even *Atriplex mummularia*. The best results in grazing trials with salt-tolerant species were obtained on pastures of *Kochia brevifolia* at heavy rates of stocking and *Atriplex mummularia* at moderate rates.

Mangifera indica L. (Anacardiaceae)

The mango tree is one of the commonest trees in India. The profuse foliage of dark-green lanceolate leaves is well-relished by cattle.

Opuntia species (Cactaceae; Prickly pear)

The genus *Opuntia* Mill. includes a number of xerophytic shrubs with woody stems and fleshy joints, often flattened and set with hirsute, spiny tubercles. The leaves are small, scale-like and deciduous on the young joints; on the older, they are represented by spines. Flowers are lateral, showy, yellow, orange or red. The fruit is a pear-shaped, fleshy tubercled berry.

About four species occur in India, mostly found in arid and semi-arid tracts of peninsular India. Prickly pear has been used as an emergency fodder for cattle during times of famine in the past. Before feeding it to animals, the spines have first to be burnt or singed off by using a burner. Animals have to be fed small quantities at first until they get used to the feed. In the beginning there is some diuresis and loss of weight, but the animals regain weight later on. The feed has to be supplemented by other less succulent dry feeds, (about 1·4 kg of straw or dry grass) and 0·45 kg of cotton-seed per day. Spineless cacti can also be fed to cattle, but they are seldom available in times of need, as they are liable to get grazed off by stray cattle.

TABLE 111.

ANALYSIS OF PRICKLY-PEAR

	On wet basis	On dry basis
	%	%
Moisture	90·7	—
Crude protein	0·7	7·0
Ether extract	—	1·5
Crude fibre	—	21·6
Ash	—	22·7
N-free extract	—	47·2

(After K. C. Sen, 1953)

Spergula arvensis L. (Caryophyllaceae); Spurry

Spurry is a plant of temperate regions which has now become a very troublesome weed on the Nilgiris, in potato fields. The axillary shoots

do not lengthen their internodes so that the leaves appear tufted". Flowers are in cymes. The plants are sometimes used as fodder for hill cattle.

Saccharum species

Genus *Saccharum* Linn.

Erect, tall, perennial grasses, with mostly solid culms and narrow leaves, often rolled up when dry. The inflorescence is a large, showy, terminal panicle of racemes set on a fragile, articulate rachis. About four species occur in India, of which *S. officinarum* is widely cultivated for sugar manufacture.

Saccharum officinarum Linn. (Sugarcane; Hindi—Eekh)

Sugarcane is cultivated in most parts of India, *gur* and sugar are made from the sweet sap expressed by crushing the 'canes'. The tops and young leaves can be used for feeding cattle both in the green state and after ensiling. Silage made from sugarcane tops and molasses has an appetising smell and cattle relish it, consuming up to 9 kg a day.

S. spontaneum Linn. (Hindi—Kans)

Kans grass is found growing wild throughout India on the plains and in the Terai region, near river banks and swampy areas. It is remarkably drought-resistant and is usually 91 to 183 cm tall, but can grow up to 3 m in height under favourable conditions. Propagation is by seed and by means of underground spreading roots from the nodes. In the green state Kans grass is quite as nutritious as cultivated fodders and even when dry it is comparable in feeding value with wheat and rice straw. If supplemented with 225 to 454 gm of oil-cakes or other protein-rich concentrates, Kans grass can safely be recommended as a normal cattle feed, particularly for buffaloes.

S. barberii (*Desi* sugarcane; Hindi—*Katha*)

This was once being grown in the Punjab by farmers for use as fodder during periods of fodder scarcity. The plant tillers profusely and can withstand drought, flooding and frost better than many other plants. It contains nearly 20 pounds of total digestible nutrients per 100 pounds

of material and can serve as a maintenance fodder for cattle if supplemented by other protein-rich concentrates.

TABLE 112.

ANALYSIS OF SACCHARUM SPECIES

	Sugarcane tops (green)		Kans (on dry basis)	
	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients
	%	%	%	%
Moisture	64·9	—	—	—
Crude protein	1·3	49	5·3	59
Ether extract	0·5	32	1·4	60
Crude fibre	12·4	62	34·8	76
Ash	2·9	—	7·9	—
N-free extract	18·0	64	50·6	61
Calcium	0·45	—	0·59	—
Phosphorus	0·32	—	0·67	—
Potassium	0·71	—	—	—
Digestible Crude Protein		0·6		3·1
Total Digestible Nutrients		19·3		—

(After Lander, 1949) (Kehar, 1948)

Syzigium jambolanum DC. (Myrtaceae; Hindi—Jamun)

This is a large evergreen tree with abundant drooping foliage and dark purple, edible fruits. Propagation is by seeds. The leaves are readily eaten by cattle.

Zizyphus jujuba Lamk. (Rhamnaceae; Indian cherry; Hindi—*Ber*).

This thorny tree grows wild on wastelands and forests; the edible fruit are sometimes collected and sold in bazaars. The leaves can be used for feeding cattle. Propagation is by seeds.

TABLE 113.

MISCELLANEOUS FODDER PLANTS

Species	Natural Order	Herb, Shrub or Tree	Part of plant useful as fodder
Acacia arabica Willd	Leguminosae (Mimosoideae)	Tree	Pods suitable for growing in paddocks.
A. leucophloea Willd	,,	,,	,, ,,
A. planifrons W. & A.	,,	,,	Pods, suitable for sandy areas
Adina cordifolia Hk. f.	Rubiaceae	,,	Leaves
Aegle marmelos Corr.	Rutaceae	,,	,,
Anogeissus latifolia Wall.	Combretaceae	,,	,,
Artocarpus heterophyllus	Moraceae	,,	,,
Balanites Roxburgii	Simarubaceae	,,	Leaves sparingly eaten
Bassia longifolia L.	Sapotaceae	,, (evergreen)	Flowers and seeds
B. latifolia Roxb.	,,	Tree (deciduous)	Flowers and seeds sparingly eaten
Bauhinia malabarica Roxb.	Caesalpinioideae	Tree	Leaves
B. purpurea Linn.	,,	,,	Leaves sparingly eaten
Boerhaavia diffusa L.	Nyctaginaceae	Herb	Whole plant
Bridelia retusa Spr.	Euphorbiaceae	Tree	Leaves
Capparis zeylanica L.	Capparidaceae	Shrub	Leaves and fruits
Cassia fistula L.	Caesalpinioideae	Tree	Leaves
C. siamea Lamk.	,,	,,	,,
Cedrela toona Roxb.	Meliaceae	,,	,,
Commelina benghalensis	Commelinaceae	Herb	Whole plant
C. diffusa Burm. f.	,,	,,	,,
Convolvulus arvensis l.	Convolvulaceae	,,	,,
Cordia obliqua Willd.	Boraginaceae	Tree	Leaves and fruits
Cyanotis axillaris L. R. & S.	Commelinaceae	Herb	Whole plant
C. cristata L. D. Don.	,,	,,	,,
Desmanthes virgatus W. & A.	Mimosoideae	Shrub	Leaves
Digera arvensis Forsk.	Amarantaceae	Herb	Whole plant
Elaeodendron glaucum Pers.	Celastraceae	Tree	Leaves
Erythrina indica Lam.	Leguminosae	,,	,,
Erythroxylon monogynum Roxb.	Linaceae	,,	Leaves greedily eaten
Feronia limonia Corr.	Rutaceae	,,	Leaves
Ficus bengalensis L.	Moraceae	,,	,,
F. glomerata Roxb.	,,	,,	,,
F. infectoria Roxb.	,,	,,	,,
F. retusa L.	,,	,,	,,
Flacourtia sepiaria	Bixaceae	Spinous shrub	,,
Garuga pinnata Roxb.	Burseraceae	Tree	,,
Grewia oppositifolia	Tiliaceae	,,	,,
G. tiliaefolia Vahl.	,,	,,	,,
Guazuma tomentosa Kunth	Sterculiaceae	,,	,,
Hardwickia binata Roxb.	Caesalpinioideae	,,	,,

TABLE 113.—(*contd.*)

Species	Natural Order	Herb, Shrub or Tree	Part of plant useful as fodder
Helicteres isora L.	Sterculiaceae	,, (deciduous)	Leaves greedily eaten
Holoptelia integrifolia Planch.	Ulmaceae	Tree	Leaves
Hymenodictyon excelsum (Roxb.) Wall.	Rubiaceae	,,	,,
Ipomoea pes-tigrides L.	Convolvulaceae	Herb	Whole plant
I. sepiaria Koen.	,,	,,	,,
Kydia calycina Roxb.	Malvaceae	Tree	Leaves
Melia azadirachta L.	Meliaceae	,,	Leaves sparingly eaten
Michelia champaca L.	Magnoliaceae	,,	Leaves
Mitragyna parvifolia (Roxb.) Kunth.	Rubiaceae	,,	,,
Moringa pterygosperma Gaert.	Moringaceae	Tree	Leaves and flowers
Odina wodier Roxb.	Anacardiaceae	,,	Leaves
Prosopis juliflora L.	Mimosoideae	,,	Pods
P. spicigera L.	,,	,,	,,
Randia brandisi Gamble	Rubiaceae	,,	Leaves
Salix tetrasperma Roxb.	Salicaceae	,,	Leaves readily eaten
Schleichera oleosa (Lour.) Merrill.	Sapindaceae	,,	Leaves and twigs
Sesbania grandiflora Pers.	Leguminosae	Large shrub	Leaves
Spondias mangifera Willd.	Anacardiaceae	Tree	,,
Tamarindus indicus L.	Caesalpinioideae	,,	Young leaves eaten
Terminalia bellerica Roxb.	Combretaceae	,,	Leaves
T. catappa L.	,,	,,	,,
T. paniculata Roth.	,,	,,	,,
T. tomentosa W. & A.	,,	,,	,,
Thespesia populnea Cav.	Malvaceae	,,	Leaves sparingly eaten
Wrightia tinctoria R. Br.	Apocynaceae	,,	Leaves

CHAPTER 15

ROOT CROPS USEFUL IN FEEDING ANIMALS (Beets, Carrots, Mangolds, Swedes, Turnips, Potatoes and Sweet Potatoes)

These root crops can be grouped under 'succulent' feeds, for they contain nearly 80 per cent moisture. They are very popular feeding stuffs in western countries, as they are quite palatable and on account of the low fibre content are easily digested by all livestock. Root crops are very low in protein and should, therefore, be regarded as a counterpart of leguminous crops with their high protein and low carbohydrate content. These root crops are, however, seldom used in India, except in a few government farms in North India. They are apt to cause scour in livestock, especially if the freshly harvested roots are fed, and hence turnips, swedes and mangolds are all allowed to wilt for a few days before feeding to animals. This storage induces a mild fermentation which increases the sugar content a little and converts the nitrates and amides present in fresh tubers into proteins, thereby helping to increase the low protein content. Another disadvantage of these root crops, especially turnips and swedes, is the taint imparted to milk if the roots are fed before milking the animals.

Turnips (*Brassica ropa* Linn. ; Hindi—Salgam)

Both white and yellow varieties are found in turnips, as well as various hybrids. The white varieties are more watery and contain only 7–8 per cent of dry matter, against 8–9 per cent in yellow varieties. The protein content in both is about one per cent. Turnips are fed entire to cattle and sheep.

Swedes (*Brassica napobrassica* Mill ; Syn. *Brassica campestris;* Rutabagas)

These are similar to turnips in appearance but the tubers are larger and denser, with yellow-white flesh, a higher dry matter content of 9 per cent, a better feeding value and storage life. Swedes thrive best in light sandy soils well-supplied with N, P, K and Ca; they cannot grow well even if any one of these elements is deficient, particularly phosphorus. Sheep and pigs relish swedes very well. In cattle the risk of tainted milk can be avoided by feeding the root crop only after milking the animals. The average yield in both swedes and turnips is about 280 to 336 q per hectare; the crop matures in 100 days.

Beets (*Beta* Linn. ; Chenopodiaceae)

A genus of biennials, including six species of succulent herbs,

with swollen roots containing sugar, found mainly in the Western Europe and Mediterranean region. The beet-roots of cultivation are several forms of *Beta vulgaris* Linn., derived from the wild sea-beet, *B. maritima* Linn., a native of the coastal parts of the Mediterranean region and adjacent countries. Sugar beet is extensively cultivated in temperate regions for sugar manufacture. Other species of importance are Swiss chard, (*B. vulgaris* var. *cicla* Linn.) a foliage beet which is a very good vegetable and pot-herb, cultivated in the summer in Europe and North America. In North India, *B. vulgaris* var. *benghalensis* is often grown as a pot-herb. The mangels (*B. vulgaris* var. *crassa*), are derived from Chard and are used as cattle feed in European countries. In the sugarbeet (*B. vulgaris* var. *rapa* L.) the tops and the pulp that remain after sugar extraction are used as stockfeed. The dry pulp has been recently recognised as a very good source of vitamin C. Beet molasses are used for sweetening other insipid animal feeds and for preparing alcohol.

Mangolds (*Beta vulgaris* Linn.) Mangels, Mangel wurzels

This is a crop which is very responsive to N, K, P, fertilizers and capable of yielding more than 784 q per hectare. Mangolds grow better in heavier soils and grow higher above ground level than swedes or turnips. The dry matter content is about 10 per cent. Mangolds are easily digestible, and make a better feedstuff than swedes or turnips, as they do not taint the milk and contain about one per cent digestible protein and 7 per cent total digestible nutrients, but fresh tubers are apt to cause scour. Rams and wethers fed on mangolds for extended periods are apt to develop urinary calculi.

Beets (*Beta vulgaris* Linn. ; Garden beet ; Hindi—(Chumander)
Beta vulgaris var. *rapa ;* Sugar beet

Beets are little used in India as a cattle feed except in a few places in North India. It can be grown with success in the Peshawar valley, from early October to April. The average yields are 241 to 444 q. per hectare, with a range of sugar content of 12·9 to 14·3 per cent. Beets are well relished by all classes of livestock. Pigs in particular relish beets very much, but it is believed that when fed for long spells to male animals their breeding capacity is impaired.

Beet tops or crowns are available in the vicinity of sugar factories. They contain little sugar and may be fed either fresh or after wilting for a few days or after conversion into silage The silage is less laxative than fresh plant tops, but even that should be fed only in small quantities of not more than 13·6 kg. per day to cattle or 1·4 kg. a day for sheep. Non-ruminants like horses and pigs should be fed even smaller quantities, as their single-chambered stomachs do not have the same capacity as ruminants to ferment and digest the high content of oxalic acid that is present

TABLE 114.

ANALYSIS OF FORAGE ROOT CROPS

	Beets (Tops)		Carrots (Roots)		Mangels (Roots)		Turnips (Tops)	
	Chemical Composition	Digestibility Co-efficients	Chemical Composition	Digestibility Co-efficients	Chemical Composition	Digestibility Co-efficients	Chemical Composition	Digestibility Co-efficients
	%	%	%	%	%	%	%	%
Moisture	88·6	—	88·1	—	90·6	—	85·0	—
Crude protein	2·6	74	1·2	68	1·4	70	2·8	79
Ether extract	0·3	55	0·2	40	0·1	—	0·4	66
Crude fibre	1·2	70	1·1	94	0·8	78	1·5	86
Ash	2·0	—	1·2	—	1·0	—	3·0	—
N-free extract	5·3	80	8·2	92	6·1	94	7·3	93
Calcium	0·21	—	0·08	—	0·01	—	0·55	—
Phosphorus	0·09	—	0·14	—	0·07	—	0·18	—
Potassium	0·64	—	0·48	—	0·43	—	0·55	—
		Digestible Nutrients		Digestible Nutrients		Digestible Nutrients		Digestible Nutrients
Digestible Crude Protein		1·9		0·8		1·0		2·2
Total Digestible Nutrients		7·4		9·6		7·3		10·9

(After Lander, 1949)

in beet tops. One way of neutralising this toxic effect of oxalic acid is to sprinkle powdered chalk on the tops and leave them to wilt and ferment for a few days before feeding them.

Carrots (*Daucus carota* var. *sativa* DC.)

Carrots are rich in carotene—the precursor of vitamin A—and are superior to all other root crops both in palatability and feeding value. The tubers contain 12 per cent dry matter, of which one per cent is protein, one per cent is fibre and 9 per cent carbohydrates. 3·15 kg of carrots are equivalent to 0·45 kg of oats in feeding value. All types of livestock relish carrots very well and sick horses will often eat carrots even when they refuse all other feeds, but some farmers believe that carrots should not be fed to brood mares a few weeks before foaling time.

Both the tops and roots can be used as cattle feed, either fresh or after ensiling. In some regions the white variety of carrots is preferred as a feed for dairy cattle and horses. Carrot leaves form a very good poultry feed; they are low in fat but rich in calcium and other minerals and hence carrot pomace, i.e., the residue left after pressing out the carrot juice, is a good feed for cattle. The yield of root is about 175 to 450 q per hectare and sometimes goes up to 500 q/ha.

Carrot pomace is a palatable feed and is useful in increasing the vitamin A content in eggs in poultry and milk and butter fat in dairy animals. In western countries the leaf wastes are converted on a commercial scale into a meal for feeding livestock.

TABLE 115.

ANALYSIS OF CARROTS

Chemical Composition	Roots	Leaf-wastes	Pomace
	%	%	%
Moisture	90·0	83·3	10·1
Crude protein	0·3	5·1	7·7
Ether extract	0·1	0·5	0·8
Crude fibre	0·7	2·8	15·6
N-free extract	8·9	8·3	65·8
Calcium	—	—	0·34
Phosphorus	—	—	0·11

Potatoes (*Solanum tuberosum* Linn.) ; Hindi—Alu

Ordinarily potatoes are too expensive to be used as a cattle-feed, but in times of glut the small-sized ' chats ' can be fed to cattle. The tubers are richer in protein (2·2 per cent) than any other root crop and 0·45 kg of potatoes is equivalent to 0·9 kg of swedes or mangolds, but even then the

low protein content should be counter-balanced by adding legumes or oil-cakes to the rations when potatoes form any part of the stock-feed. These tubers have also a laxative effect on stock when newly added to the rations and this should be prevented by the addition of 'binding' ingredients in the ration like cotton-seed cake. The tubers are consumed with greater relish if boiled with some salt before they are fed. Immature tubers and sprouts from stored tubers contain a poisonous alkaloid 'solanin', and these should therefore be carefully removed before stored tubers are fed to stock.

TABLE 116.

ANALYSIS OF POTATOES

	Potatoes (Tubers)	
	Chemical composition	Digestible Nutrients
	%	%
Moisture	78·8	—
Crude protein	2·2	51
Ether extract	0·1	—
Crude fibre	0·4	—
Ash	1·1	—
N-free extract	17·4	90
Calcium	0·01	—
Phosphorus	0·11	—
Potassium	0·54	—
Digestible Crude Protein		1·1
Total Digestible Nutrients		17·3

(After Lander, 1949)

Ipomoea batatas Poir

Genus *Ipomoea* Linn. (Convolvulaceae)

A large genus of prostrate or twining herbs, rarely shrubby or erect; leaves alternate, entire or lobed or divided, flowers axillary, solitary or in cymes; calyx has five unequal ovate or linear sepals; corolla campanulate, slightly lobed; stamens five, filaments often dilated at base, unequal anthers straight or contorted, pollen grains spinulose; ovary two-celled, ovules 4, style filiform, stigma capitate; fruit is a 4–6 valved capsule, seeds 4–6, glabrous or velvety, cotyledons crumpled, bilobed. About 24 species occur in India, some are persistent weeds, e.g., *Convolvulus arvensis* (Bindweed) in garden-lands.

TABLE 117.

ANALYSIS OF IPOMOEA SPECIES

	Ipomoea batatas (Sweet potatoes)				Ipomoea pes-tigrides (On dry basis)			
	Tubers		Dried vines		Green roughage		Hay	
	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients
	%	%	%	%	%	%	%	%
Moisture	68·5		9·3		—	—	—	—
Crude protein	1·6		12·6		12·3	72	13·6	57
Ether extract	0·4		3·3		3·0	59	3·5	68
Crude fibre	1·9		19·1		26·2	52	27·0	57
Ash	1·2		10·2		10·3	—	11·9	—
N-free extract	26·4		45·5		48·2	78	44·0	42
Calcium	0·04		—		0·92	—	1·48	—
Phosphorus	0·14		—		0·48	—	0·34	—
Potassium	0·46		—		—	—	—	—
Digestible Crude Protein		0·8		8·9		1·4		7·0
Total Digestible Nutrients		26·7		51·7		10·3		45·0

('Wealth of India' 1962)

Ipomoea batatas Poir. (Sweet potato).

Although this species is grown chiefly for its edible tubers, the vines are useful as fodder and considered good for milch cattle.

Sweet potato is grown usually under irrigation, on ridges 60 to 75 cm apart, preferably on red loams. The vines are cut into pieces about 50 to 91 cm long and planted on the sides of ridges. The crop comes to harvest in about four months and apart from the tubers nearly 450 q of vines may also be expected from a hectare. Some varieties yield much more foliage than others and these leafy types may well be used for fodder purposes. When grown specially for fodder, up to 780 q/ha can be expected in three to four cuttings. The vines are nearly as nutritious as lucerne in feeding value and are believed to increase milk yield. They can also be ensiled, to give a product comparable to maize silage. The tubers can be fed to cattle.

Ipomoea pes-tigrides Linn.

This species occurs in all districts of Madras and Andhra Pradesh, especially in the drier places, on hedges and bushes. It is a hairy climber with white or pink flowers and leaves cut to about 1·2 cm from the top of the petiole, in a rounded sinus.

The plant grows in abundance during the rainy season and can remain green for nearly four months. The vines furnish a good feed for cattle, both green and as hay, comparable to legume fodders in nutritive value.

Ipomoea sepiaria Koen. This species is a twining perennial with villous stems. The leaves are variable and flowers are pink with purple tube, the peduncle and pedicels are often thickened in fruit. The plant is found in nearly all districts on hedges and near tanks, especially near the coast.

These two species can be utilised as emergency fodders.

CHAPTER 16

CROP RESIDUES USEFUL FOR FEEDING PURPOSES

(*a*) Bulky roughages

Straws. The portion of a crop that is left after the grains are threshed out, is known as straw. All straws are usually poor in feeding value, with little protein, fat and minerals and rich only in fibre. The main utility of straws is their low cost and abundance, so that they serve as bulk roughages for ruminants. They are not suitable for dairy cattle or sheep nor for non-ruminants like horses, mules or pigs. In actual practice, however, cereal straws form the main subsistence for the majority of Indian cattle.

Barley straw. Barley, oats and wheat straw are more common in North India than in peninsular India, being crops of temperate and sub-tropical regions. Barley straw is superior to wheat straw and nearly equal in feeding value to oats straw.

Jowar straw. Compared to rice and wheat straw, jowar straw has a better feeding value. Unlike rice straw, which is uniformly poor, irrespective of the variety, sorghum straw varies in feeding value from very good to very poor, according to the variety and the conditions under which the crop is grown.

Some varieties such as the ' Irungu cholam ' of the southern districts of Madras are grown exclusively for fodder, as a rain-fed crop in black soil areas and sown very thick to make the stalks thin. The grain yield is just sufficient to recoup the seed sown, but the straw is eaten with great relish by cattle. Sweet sorghums (*Sorghum vulgare* var. *cernuum*), have juicy stalks and the straw is of high quality. Similarly in the ' Tella jonna ' variety which is popular in the districts of Anantapur, Bellary and parts of Kurnool, the culms are sweet and juicy in the fresh state and the straw is leafy, so that it makes a good fodder. In the central districts of Salem and Coimbatore in Madras State a tall, leafy yellow-grained variety known as Periamanjal cholam (*Sorghum vulgare* var. *durra*) is the predominant type on dryland areas; here too, the straw is quite leafy and makes a good dry fodder for cattle. There is also a practice of growing this variety in mixture with field bean (*Dolichos lablab* var. *lignosus* Prain) and both are harvested at the same time so that the lablab vines enhance the feeding value of the sorghum straw.

On the other hand certain varieties such as the Talaivirichan cholam (*S. vulgare* var. *Roxburghii*) that are popular as rain-fed crop on the hill-slopes of North Arcot and Chittoor districts in Madras, possess very dry and pithy stalks and the straw is therefore of very poor quality. Sorghum

grown under irrigation generally gives a straw of poor feeding value, as the stalks get too thick and coarse.

Straws of the Lesser Millets. In contrast to sorghum straw, the straws of other millet crops such as bajra, Kodo millet and barnyard millet are generally of poor quality. Bajra straw in particular is extremely pithy, has a very low feeding value and is seldom fed to cattle, except in times of extreme scarcity. It is ordinarily used only for thatching or as fuel.

Ragi (*Eleusine coracana* Gaert.). This is an important cereal crop in Mysore, Madras, Maharashtra, Bihar, Andhra Pradesh and Orissa. Irrigated crops yield about 34 to 56 q/ha of dry straw while rain-fed crops yield 11·2 to 17 q/ha. The latter has a fair feeding value, but straw from irrigated ragi is a poor quality roughage.

Among the other millets, the Italian or foxtail millet (*Setaria italica* Beauv.) gives a thin and leafy straw which is liked by cattle, but it is not fed to cows, as it is believed to reduce the milk yield and also increase the risk of abortion in pregnant animals.

In the little millet (*Panicum miliare* Lamk.) the average yield of straw is only 7·8 to 11·2 q per hectare and is also poor in quality, although cattle eat it readily on account of its thin and leafy nature. The Proso millet (*Panicum miliaeum* Linn.) is very variable in yield of both grain and straw, ranging from 2·8 to 5·6 q. in rain-fed and 11·2 to 17 q/ha in irrigated crops. The straw yield is nearly the same as the grain yield in this millet and is considered to be a good fodder. In the Barnyard millet, (*Echinochloa frumentacea* Link.) the yield of straw may go up to 17 q/ha in rain-fed crops, but its feeding value is very low. The Kodo millet (*Paspalum scrobiculatum* Linn.) also yields about 11·2 to 13 q of straw but it is so poor a fodder that it is generally consigned only to the manure pit.

In maize, the normal yield of straw is about 22·4 to 34 q/ha from rain-fed and 45 to 67 q from irrigated crops. If this straw can be fed in the semi-green state after removing the cobs, it makes a good fodder.

Oats (*Avena sativa* L.). Oat straw contains less of silica and is hence softer and more easily digested than wheat or rice straw. It is one of the best amongst the cereal straws and is perhaps the only straw that is suitable for feeding horses, but being costlier and less readily available, it is used only to a limited extent as a roughage for cattle, in Northern India.

Rice (*Oryza sativa* L.). This is the staple roughage of Indian cattle and in many cases forms the only fodder for the majority of Indian live-stock, particularly in the eastern and southern States where rice is the major food crop. Rice varieties run into hundreds, but the straw is uniformly poor as a cattle feed, on account of its high content of crude fibre and silica and very low content of protein, calcium and phosphoric acid. Dairy cattle and work animals soon begin to lose condition if fed

exclusively on rice straw, although some of the hardy hill cattle can subsist for fairly long periods.

TABLE 118.

ANALYSIS OF RICE STRAW

	Chemical composition	Digestibility co-efficients
	%	%
Moisture	7·5	—
Crude protein	3·9	22
Ether extract	1·4	23
Crude fibre	33·5	59
Ash	14·5	—
N-free extract	39·2	46
Calcium	0·27	—
Phosphorus	0·16	—
Potassium	1·47	—
Digestible Crude Protein		0·9
Total Digestible Nutrients		37·9

(After Lander, 1949)

Because of its low content of digestible protein, total digestible nutrients and very wide nutritive ratio, rice straw should be fed only in combination with green forages like lucerne or green maize and protein-rich concentrates like groundnut cake or cotton-seed cake.

The feeding value of rice straw can be improved by the addition of a legume such as sunnhemp hay. In the districts of Krishna and Godavari in Andhra Pradesh, sunnhemp is sown in rice fields about a week before the rice-crop is harvested. The residual moisture in the soil enables the legume to make good growth in two months' time. The paddy plants are usually stacked for two months after harvest on account of labour scarcity for threshing the crop, so that when the rice is threshed and the straw becomes available, the sunnhemp also is cut at the flowering stage and stacked with the rice straw in alternate layers.

Wheat (*Triticum* sp.). Wheat straw is similar to rice straw in its high content of silica. Although it is the most abundant roughage in northern India, available over a larger area than either oats or barley, it is a very poor fodder and can be fed only in conjunction with other green forages and concentrated feedstuffs like oilcakes. In South India, on the Nilgiris, wheat straw is usually left in the field itself or burnt as fuel.

(*b*) Concentrates

Oil-cakes. These are the residues left over after the oil is extracted from oilseeds. This extraction is effected by various methods, by the

TABLE 119.

ANALYSIS OF CEREAL STRAWS

	Wheat		Barley		Oats		Ragi	
	Chemical Composition	Digestibility Co-efficients	Chemical Composition	Digestibility Co-efficients	Chemical Composition	Digestibility Co-efficients	Chemical Composition	Digestibility Co-efficients
	%	%	%	%	%	%	%	%
Moisture	8·0	—	10·0	—	10·4	—	7·5	—
Crude protein	3·8	20	3·7	25	4·0	22	3·4	6
Ether extract	1·5	55	1·6	39	2·3	33	0·9	41
Crude fibre	35·7	40	37·7	54	36·1	59	33·2	69
Ash	8·2	—	6·0	—	6·0	—	7·5	—
N-free extract	42·8	46	41·0	53	41·2	49	47·5	58
Calcium	0·31	—	0·45	—	0·50	—	1·03	—
Phosphorus	0·16	—	0·20	—	0·30	—	0·15	—
Potassium	0·96	—	1·52	—	2·00	—	1·38	—
		Digestible Nutrients		Digestible Nutrients		Digestible Nutrients		Digestible Nutrients
Digistible Crude Protein		0·8		0·9		0·9		0·2
Total Digestible Nutrients		35·7		44·5		44·1		39·0

(After Lander, 1949)

traditional village '*ghanies*' worked by bullock power, as well as by more modern methods like hydraulic or screw type expellers or by "solvent extraction" by the use of chemical solvents. *Ghani* cakes contain nearly 6–7 per cent more oil than expeller or solvent extracted cakes. The major oilseeds that furnish edible oil-cakes suitable for cattle feed are groundnut, coconut, sesamum, cotton-seed, rape-seed and linseed. The residues are known as cakes when they are in the form of slabs or lumps and as meal when they are marketed (as in the case of expeller or solvent extraction residues), in the form of a coarse powder. Oil-cakes are all rich in protein and total digestible nutrients and are thus very useful for making up a balanced ration for different classes of livestock. There is a fairly wide range of nutrients in different oil-cakes to choose from while computing rations for livestock, but the ultimate deciding factors are more likely to be their cost and availability rather than their actual nutritive value.

Coconut Cake. Coconut cake is the residue left after extracting the oil from 'copra', the dried kernel of the coconut palm (*Cocos nucifera* Linn.). Good quality coconut cake is light-brown in colour, with an agreeable smell and contains about 8 per cent oil. Although the protein in coconut cake is lower in biological value than that in groundnut cake it is easier to digest and helps to improve the milk yield in dairy cattle as well as give a 'firmer' butter. Dairy cows may be fed 1 to 1·4 kg per day, while for fattening animals it may form up to half the total concentrates given. Coconut cake should be soaked in water to soften it before feeding to livestock. For fattening pigs, too, coconut cake is very useful, as it helps to produce a firm body fat.

Cotton-seed Cake. Cotton-seed cake is of two kinds, one when the whole seed is crushed without removing the fuzzy seed-coat and the other when the adhering fuzz and seed-coat are first removed prior to heating and crushing the 'decorticated' kernels. Decorticated cotton-seed cake has a lower fibre content and higher protein. In Western countries such as the United States, cotton-seed cake is almost invariably of the decorticated type, but in India this has only in recent years been taking the place of the traditional practice of feeding whole cotton-seed to cattle.

Feeding trials have shown that 1·4 to 2·7 kg per day of cotton-seed cake can be safely fed to a 360 kg milch animal giving 9 kg or more of milk per day, provided sufficient green forage is also fed to guard against vitamin A deficiency. Cotton-seed cake has a phosphorus content, up to 1·2 per cent, but is low in calcium and deficient in vitamins A and D. Its main advantage is that it helps to produce a hard body fat in pigs and in fattening cattle and also helps in giving a hard butter. Its disadvantage is that it contains a toxic alkaloid 'gossypol', which is harmful to pigs and growing calves, although adult cattle are unharmed. Hence for

calves and also for horses, cotton-seed cake should not form more than one-tenth of the total concentrates included in the ration.

Cotton-seed as such is somewhat more popular as a cattle feed in India than cotton-seed cake. The American varieties of cotton have bigger seeds with more fuzz than *desi* varieties and on that account are cheaper in the market than *desi* cotton-seeds. This may be regarded as an advantage, as American cotton-seed is richer in protein and fat content than *desi* seeds.

Groundnut Cake. Groundnut (*Arachis hypogaea*) is ordinarily decorticated before oil extraction. The decorticated cake contains nearly 48 per cent protein and 7–8 per cent oil left as residue. In groundnut cakes from expellers, the cake may have a charred and burnt odour and darker colour on account of the friction and heat generated during oil extraction. In un-decorticated cake the fibre content is much higher and the protein correspondingly lower.

Groundnut cake is a very rich feed, particularly suitable for dairy cows and buffaloes, but it should be fed only gradually in full quantity. For milch animals up to 1·4 to 1·8 kg a day may be given, depending on the weight and size of the animal and its milk yield, as well as on the nature of the rest of the ration. For growing calves and other young livestock, groundnut cake may be fed along with other soft foods. The cake should be stored in a dry place, as otherwise it soon gets mouldy and rancid, which may lead to digestive troubles in livestock.

Linseed Cake (*Linum usitatissimum*). Linseed is the seed of the flax plant and is an important oilseed in North India. The cake is the residue left after extracting the oil from the seeds in various ways similar to those adopted for other oilseeds. Good quality linseed cake is brown in colou and contains about 36 per cent of protein and 3 per cent oil, but in India it is not used as a cattle-feed to the same extent it is used in other countries. Linseed cake is a useful feed for young stock, for it is easily digestible and has a laxative effect which helps to counteract the effect of other constituents in the ration that are likely to be constipating. Apart from its being a valuable protein supplement for all classes of livestock, no other feed will bring these animals into good condition so readily as linseed cake.

Linseed cake meal is the cake finely ground, but it should be distinguished from linseed meal, which refers to the whole seed ground to a meal. This is higher in oil content and is used only for sick animals and constipated calves.

Palm Kernel Cake. This is a by-product of the red oil palm of Africa and the East Indies, which is hardly known at all in India and seldom used as a cattle-feed. It is rather variable in fibre and oil content and animals may take some time to get used to its taste and appearance.

Rape Seed Cake. There is considerable confusion in the terms rapeseed, mustard, toria and sarson. Sarson or rapeseed, refers to *Brassica*

TABLE 120.

ANALYSIS OF OIL-SEED CAKES

	Coconut-cake		Cotton-seed cake		Groundnut cake		Linseed cake		Sarson cake	
	Chemical Composition	Digestibility Co-efficients	Chemical Composition	Digestibility Co-efficients	Chemical Composition	Digestibility Co-efficients	Chemical Composition	Digestibility Co-efficients	Chemical Composition	Digestibility Co-efficients
	%	%	%	%	%	%	%	%	%	%
Moisture	11·4	—	5·7	—	6·0	—	5·6	—	6·4	—
Crude protein	21·2	79	36·3	80	48·7	90	28·9	86	29·6	91
Ether extract	8·0	92	8·7	82	7·7	97	4·2	80	12·8	91
Crude Fibre	11·5	63	5·9	46	6·9	10	9·1	—	10·2	—
Ash	5·5	—	7·7	—	5·3	—	9·4	—	8·9	—
N-free extract	42·4	82	35·7	42	25·4	51	42·8	95	32·1	68
Calcium	0·36	—	0·30	—	0·25	—	0·69	—	1·30	—
Phosphorus	0·66	—	1·40	—	1·19	—	1·62	—	2·15	—
Potassium	—	—	1·63	—	1·33	—	1·30	—	—	—
		Digestible Nutrients		Digestible Nutrients		Digestible Nutrients		Digestible Nutrients		Digestible Nutrients
Digestible Crude Protein		16·8		29·0		43·8		24·9		26·9
Total Digestible Nutrients		82·0		63·8		74·1		82·6		81·6

(After Wood, 1962; Lander, 1949)

campestis var. *sarson*, whereas the real Indian rape is *Brassica napus* var. *dichotoma*. The oil cakes that are used as cattle-feed are only those from sarson and toria, both of which are cold-weather crops in the North Indian states of Punjab, Uttar Pradesh, Bihar, Bengal and Orissa. The oil from both is used for cooking and lighting purposes. The seeds of mustard (*Brassica juncea*) are used mainly as a condiment. The oil of this species is very pungent and little used as an edible oil and the cake too is very pungent-smelling and unpalatable to cattle.

Sesamum Cake (*Sesamum indicum* Linn.). Sesamum cake is the residue left after the oil is extracted from the seeds of *Sesamum indicum*, the gingelly plant. The oil is valuable for culinary and medicinal purposes. The cake contains over 40 per cent of high-grade protein, nearly equal to cotton-seed cake, as well as a high content of calcium and phosphorus. It is also believed to stimulate milk flow, but if too much is given the butter gets very soft. For the same reason it should not be fed in large quantities to fattening pigs, as the body fat gets too soft.

Soybean Cake and Meal (*Glycine max* Zieb & Zucc.). Soybeans are not grown to any appreciable extent anywhere in India, so neither the cake nor the meal is a common feed for Indian cattle, but in the United States, it is a very popular feed-stuff. Soybean cake differs from other oil-cakes in having very little starch, but nearly double the protein and ten times the fat content in other oil-cakes. The protein content in soybean cake is about 38 per cent, but it is highly digestible. The calcium and phosphorus contents are, however, quite low and the cake contains hardly any vitamins, and so these deficiencies should be kept in mind and made up by other constituents in the ration. Soybean meal differs from the cake in having a higher protein and lower oil content. This is true of most other oil-cakes as well, because the meals are derived from solvent

TABLE 121.

ANALYSIS OF SOYBEAN CAKE

	Chemical Composition	Digestible Nutrients
	%	%
Moisture	7·4	—
Crude protein	38·5	—
Ether extract	16·1	—
Crude fibre	5·6	—
Ash	5·7	—
N-free extract	26·7	—
Digestible Crude Protein	—	34·7
Total Digestible Nutrients	—	78·8

extraction processes where the extraction is much more complete, than in expeller processes where the residue is left in the form of cakes or slabs.

Soybean cake is available in two forms, the cooked and the uncooked. Cooked cake results from the hydraulic or expeller process and has a light brown colour and nutty taste, while uncooked cake has a raw, beany taste and lighter colour. For pigs and poultry the cooked cake is of greater value. Being a very rich feed, not more than 0·9 to 1·8 kg a day should be fed to dairy cattle, while for horses the daily quantity should be even less, not more than 225 to 454 gm a day when at hard work. Since soybean cakes and meals have a laxative effect, they are best used in conjunction with un-decorticated cotton-seed, cake which has a binding effect on the bowels.

(*c*) Grains and Seeds

Cotton-seed. Feeding experiments at Lyallpur have shown that cotton-seed may be fed to bullocks at hard work up to 1·4 kg a day per 450 kg of live weight of animal, supplemented by 0·45 kg of bran and 6·8 kg of *bhusa*. Cotton-seed is best fed after kibbling.

Linseed. Linseed is useful more as an invalid feed for sick animals than as a regular feedstuff. It may be given after boiling or steaming the crushed seeds. Cattle do not consume more than 1 kg a day, as the mucilaginous linseed depresses their appetite for hay and other bulky fodders.

Soybeans. As mentioned earlier, soybean is seldom used as a cattle feed in India. It is nevertheless a very nutritious feedstuff containing a high-quality protein that equals animal protein in biological value. It is also rich in calcium (0·53 per cent) and phosphorus (1·64 per cent), but is deficient in vitamins A and D. Care is, however, needed not to feed too much of soygean or for extended periods, as it is liable to cause digestive disturbances.

Sunflower. This is another seed which figures as a feedstuff for farm stock in other countries, but not in India. The seeds are quite nutritious with about 18 per cent of protein and easily digestible as well.

Gram (*Cicer arietinum*). In North India gram is fed to horses, buffaloes and bullocks at work, at 1·4 to 1·8 kg a day and to mules and milch cows at 0·9 to 1·4 kg per day. The protein content of gram is about 20 per cent, digestible protein 14 per cent and the total digestible nutrients 77 per cent, while the lime (0·7 per cent) and phosphorus (0·6 per cent) contents are well balanced, so that on the whole, gram constitutes a very useful feedstuff for all animals.

Redgram (*Cajanus cajan*) **and Guara** (*Cyamopsis tetragonaloba*) are other pulse grains that may be fed to all livestock, except to horses. Guara

can serve as a cheaper substitute for gram or arhar, but is less digestible than arhar and also less palatable. It should not be fed more than 0·5 to 1 kg a day to cattle.

Muttar (Matri) (*Pisum sativumh*); **(Indian field-pea).** This is another protein-rich pulse which may be fed to all classes of livestock, including horses. The total protein content is 23 per cent and the digestible protein is 18 per cent. Since the total digestible nutrients (62 per cent) are lower than in gram (80 per cent), *muttar* can be used in slightly larger quantities as a substitute for gram.

Indian Field Bean (*Dolichos lablab*) **and Moth** (*Phaseolus aconitifolius*). These are two *kharif* pulses having nearly the same protein content (23 per cent). Moth has 17 percent digestible protein, while *Dolichos lablab* has 18 per cent. The total digestible nutrients too, are nearly equal in these two pulses and so either of them may be fed up to 1·4 kg a day to horses, in the absence of gram or peas. Beans should be fed only after being coarsely ground, as the seed-coat is rather tough. In the form of ground meal, beans make a very good feed for fattening pigs and can also serve as a milk substitute for young calves.

CEREAL GRAINS

Most of the cereal grains are more or less similar in use and feeding value, for fattening pigs, cattle and sheep. They should be fed to animals only after being coarsely ground, except sheep, which can masticate much more thoroughly.

Barley (*Hordeum vulgare*)

Foreign varieties of barley are bred mainly for malting and in these the digestible carbohydrates are higher than in oats and the protein content less, but Indian barley contains 6–7 per cent digestible protein as against 9·4 per cent for oats. Hence, these hard barleys are better as a stockfeed than malting barleys.

Dried Brewer's Grains

In western countries brewers' grains left as a residue after malting for beer are usually dried before they are sold, as the wet grains are difficult to transport and moreover tend to taint the milk just as swedes and turnips do. These dried grains contain about 26 per cent protein, 6·7 per cent fat, 14·8 per cent fibre and 42·8 per cent N-free extract and can be used for fattening sheep and as a 50 per cent substitute for oats in horse rations. Its ' binding ' property should be counter-balanced by the inclusion of linseed cake or soybean meal in the ration.

TABLE 122.

ANALYSIS OF PULSES AND OTHER SEEDS

	Gram		Moth		Redgram		Cotton-seed	
	Chemical Composition	Digestibility Co-efficients	Chemical Composition	Digestibility Co-efficients	Chemical Composition	Digestibility Co-efficients	Chemical Composition	Digestibility Co-efficients
	%	%	%	%	%	%	%	%
Moisture	8·1	—	8·6	—	8·4	—	6·8	—
Crude protein	18·0	69	22·6	77	18·8	70	14·4	58
Ether extract	4·5	84	0·8	75	1·8	50	17·6	89
Crude fibre	6·9	—	—	—	—	—	21·7	66
Ash	2·4	—	4·2	—	6·7	—	4·7	—
N-free extract	60·1	90	63·8	87	64·3	81	34·8	51
Calcium	0·40	—	0·32	—	0·28	—	0·44	—
Phosphorus	0·90	—	0·70	—	0·78	—	1·20	—
Potassium	0·22	—	1·00	—	0·48	—	1·01	—
		Percentage Digestible Nutrients		Percentage Digestible Nutrients		Percentage Digestible Nutrients		Percentage Digestible Nutrients
Digestible Crude Protein		12·4		17·4		13·2		8·4
Total Digestible Nutrients		79·6		72·3		67·7		73·0

(After Lander, 1949)

Maize

Maize is used extensively in the United States as a feed for livestock. The grains contain 76 per cent starch, 3 per cent fat and 9·7 per cent protein but as maize protein is deficient in two essential amino-acids, tryptophane and tyrosin, maize should be supplemented by other protein-rich legumes, fodders or oilcakes. The calcium content is also very low in maize grains and hence the other ingredients in the ration should be chosen to counter-balance the deficiencies of maize.

Millets

The major millets, jowar and bajra are commonly grown in the drier parts of India as food crops of the poor, but they can also serve as feedstuffs for poultry and other animals, except horses. Being hard to masticate, they should be kibbled (i.e., soaked and then rough-ground), before they are fed to animals; for poultry the grains may be fed as such.

Oats (*Avena sativa*)

This grain is peculiar in that its composition varies according to the proportion of husk that is left. Some varieties show as much as 35 per cent husk, while other smaller-grained varieties show less than 20 per cent. Indian oats contain less of protein than foreign varieties. Oats make a more balanced feed than any other cereal grain, with the highest contents of calcium and phosphorus, but its high fibre content makes it less digestible than maize or wheat. It is the best cereal grain feed for horses and is equally useful for other animals. Stored oats are generally preferable, because fresh grain causes colic indigestion. Bruising or coarse-grinding the grain is also desirable, but this should be done only prior to feeding, for crushed grains develop a musty odour on keeping. Sprouted oats are believed (on inadequate evidence) to overcome sterility in heifers and dairy cows.

Rice

Rice is hardly ever fed to farm stock, although it is an item in the feed of domesticated elephants in parts of Madras and Assam and is sometimes fed to riding horses in Sind.

Wheat

In contrast to oats and barley, wheat grains are naked in most varieties and have thus a lower content of crude fibre, but are not as a rule fed to cattle, except when damaged grain is available at cheap rates. Wheat should not be more than 50 per cent of the total concentrates, otherwise it leads to digestive disorders. Being a hard grain it is best to feed it after a coarse grinding, but it should not also be ground too fine, as it then forms a sticky mass in the animals' mouths.

TABLE 123. ANALYSIS OF CEREAL GRAINS

	Jowar	Rice	Wheat	Oats	Barley	Maize	Bajra
	%	%	%	%	%	%	%
Moisture	10·0	11·4	8·5	8·9	8·1	8·1	9·6
Crude protein	9·8	8·3	9·6	12·0	9·3	9·7	13·8
Ether extract	4·6	1·8	1·7	4·7	2·7	3·0	2·3
Crude fibre	1·5	8·8	1·7	10·6	6·3	2·0	0·8
Ash	3·0	5·0	1·7	3·6	2·5	1·7	2·5
N-free extract	71·1	64·7	76·8	60·2	71·1	75·5	71·0
Digestible Crude Protein	4·6	6·3	5·8	9·4	6·7	5·4	6·6
Total Digestible Nutrients	54·3	59·1	84·0	71·5	70·8	70·5	73·7

(After Lander, 1949)

Bran

Bran is the term used for the powdery product obtained from the milling of cereal grains, especially wheat and rice. It consists of the outer seed-coat and underlying layers containing much of the proteins and vitamins and also part of the endosperm of the grain when the milling is carried to the point of polishing the grain to secure a white product. Bran is a useful feedstuff which can be fed to all classes of farm-stock, including poultry. It helps to prevent digestive troubles that might arise from feeding other heavy concentrates. Bran is best fed in the form of a mash made by adding a little salt and sufficient boiling water to a bucket of bran and stirring it to form a thick gruel. About 0·9 to 1·4 kg of this mash is sufficient for cattle and horses and smaller quantities for smaller animals.

Bran is usually available in the market in two or three kinds, depending on the size of the particles. For instance, in wheat bran, the coarsest part of the grain removed during nilling is known as 'broad bran' and a finer-sized fraction as 'medium bran'. Both these contain much of crude fibre and are poor in nutritive value. Bran proper is a fine, brownish, fluffy powder which contains up to 11 per cent protein, though ordinarily it is somewhat lower, with a digestible protein of 7 and total digestible nutrients of 71 kg per 100 kg of wheat bran. The phosphorus and magnesium content in bran is high but it is low in calcium, so that this deficiency will have to be made up in the ration by the addition of

TABLE 124. ANALYSIS OF RICE AND WHEAT BRAN

	Rice Bran		Wheat Bran	
	Chemical Composition	Digestibility Co-efficients	Chemical Composition	Digestibility Co-efficients
	%	%	%	%
Moisture	11·0	—	11·0	—
Crude protein	9·3	—	11·5	77
Ether extract	11·6	—	4·4	84
Crude fibre	13·1	—	12·2	—
Ash	19·7	—	6·8	—
N-free extract	35·3	—	54·1	82
Calcium	0·19	—	0·23	—
Phosphorus	5·45	—	2·00	—
Potassium	0·17	—	1·30	—
		Digestible Nutrients		Digestible Nutrients
Digestible Crude Protein		6·1		8·9
Total Digestible Nutrients		54·5		62·0

(After Lander, 1949)

a mineral mixture or steamed bonemeal. Wheat bran when fed as a mash has a laxative effect, especially for horses, but when fed dry it has a binding effect on the bowels. Rice bran is similar to wheat bran in its uses and composition, but shows a higher content of fat and lower protein, although this lower content is set off by the higher biological value of rice protein as compared to wheat proteins. Both wheat and rice bran contain the ' germ ', which is rich in oil and is one of the richest sources of the anti-sterility vitamin E.

Bhusa

The refuse collected from the threshing floor after threshing pulse crops like redgram, bengal gram, etc., is commonly known as *bhusa*. It consists of the leaves, immature pods and seeds and the empty shells of pods and is available as an inexpensive by-product which is quite useful for feeding cattle. It is also fairly nutritious, as would be clear from the composition of some legume bhusas given below.

TABLE 125. ANALYSIS OF LEGUME BHUSAS

	Redgram bhusa	Bengal gram bhusa	Green gram bhusa	Lablab bhusa
Moisture	8·8	8·4	13·3	9·9
Crude protein	11·0	3·6	10·9	13·4
Ether extract	4·4	2·3	2·5	3·7
Crude fibre	19·2	26·7	18·7	16·2
Ash	11·9	13·1	14·3	13·8
N-free extract	44·7	45·9	40·3	43·0

(After Wood, 1952)

Bengal gram bhusa is a nutritious feedstuff, but on account of its sour taste, it is not readily consumed by cattle. It is therefore mixed with other feeds and fed to cattle in Andhra Pradesh. In many parts of Madras, however, it is usually consigned to the compost pit. When groundnut is harvested, nearly 7·8 to 11·2 q of haulms are left after the pods are picked out from the plants. These haulms may go up to nearly 22·4 to 33·6 q per hectare from an irrigated crop and make a good fodder for cattle. Horsegram, cowpeas and lablab are other pulse crops, the haulms of which can serve in a similar fashion as fodder for cattle.

CHAPTER 17

THE STORAGE AND PRESERVATION OF FORAGE CROPS

Surplus fodder can be preserved for later use in two ways, as hay and as silage. The preservation of fodder is somewhat more difficult than cereal grains and pulses, on account of their bulky and perishable nature. In India, especially, the growth of grasses and legumes is limited to the monsoon season and the surplus is seldom large enough to need preservation, except in some isolated localities. In most places, therefore, the main bulky feeds for livestock in India consist only of the crop residues left after threshing the grain from cereals and pulse crops. Straw from cereals like paddy and wheat and millets like sorghum and ragi, make up the main fodder for cattle in most parts of India, the residues from leguminous crops such as redgram, Bengal gram and horsegram, etc., made up of the leaves, bits of stems, empty pods, husk and broken seeds, is called ' bhusa ' and is used as cattle feed to a small extent.

Hay. Hay is any forage crop cut before it is dead ripe and dried for storage. It is more nutritious and palatable than straw, because the entire crop is cut before maturity and dried. High quality hay is made from fine-stemmed legumes and grasses, cut at the right stage of growth and dried in such a way as not to lose any of the nutrients. It is leafy, pliable, green in colour and free from mould, weeds and dust and has a pleasant, characteristic smell and aroma. When it is made from a mixed herbage of grasses and legumes, the hay is also high in nutritive value.

Although any grass or legume that is fit to be fed to livestock can be converted into hay by proper drying, certain species are better suited for the purpose than others. Forage plants that are best suited for haymaking are thin-stemmed and leafy and remain sufficiently nutritious and palatable after drying. *Hariali* (*Cynodon dactylon*) for example, is rated as one of the best grasses for hay, being quite as good as Timothy hay in Western countries. Oats, maize and sorghum are other cereal crops that can be made into very good hay, but maize and sorghum are made into silage more often than hay. Among other grasses, *Cenchrus ciliaris* makes excellent hay and *Dichanthium annulatum*, *Echinochloa colonum*, *Eleusine flagellifera*, *Pennisetum squamulatum* and *Setaria sphacelata* are all well-suited for making hay. *Cenchrus ciliaris* should be cut for hay at the end of the south-west monsoon, after taking a first cutting for green feeding, when half the flower heads have emerged. If it is cut only once, at the end of the monsoon, the grass becomes too coarse, when the heads mature and the quality of the hay become poor. Some species are abundant in certain seasons and areas and are converted into hay mainly as a stand-by against future scarcity, even though they may not be of high quality. For example,

spear grass, (*Heteropogon contortus*) is often abundant near many forest areas after the rains, but unless this grass is cut early enough, the sharp-pointed ' spears ' or awns on the inflorescences make the hay unpalatable to livestock. Orchard grass, (*Dactylis glomerata*) should be cut at or before the full bloom stage, otherwise the hay becomes too ' stemmy ', but smooth Brome grass, (*Bromus inermis*), remains palatable even if the cutting is delayed till after the full bloom stage. Timothy grass (*Phleum pratense*) should be cut for hay before the full bloom stage, as analysis indicates that early-cut Timothy hay contains 3·2 times as much digestible protein and 1·25 times as much metabolizable energy as late-cut Timothy hay. Many other grasses too, have to be cut at early or full bloom if the hay is to be sufficiently palatable and nutritious. Thus Thin Napier grass, Sudan grass and Johnson grass can make fairly good hay only if they are cut at early flowering stage, before the heads set seed.

Some grasses are used only as green fodders and seldom, if ever, converted into hay; as for example, Guinea grass. *Paspalum dilatatum* can also make very good hay, but it is grown mostly as a pasture grass. Some species lose so much moisture on drying that it is not worth while making hay out of them, e.g., *Echinochloa frumentacea*, *Chrysopogon montanus* and *Chloris inflata*. Certain other species are too coarse to be made into hay, such as Teosinte, *Brachiaria mutica* and *Erianthus longisetosus*, while a species like *Setaria italico*, though it makes good hay, is not used, as it is believed to be injurious to horses.

Legume hays are even more useful in feeding livestock than grass hays, as they contain more protein. In Western countries a large variety of legumes are converted into hays, usually in mixtures with other grasses. Thus Timothy-Clover hay is one of the mainstays of livestock farming in the United States of America. In India, hay-making is practised mainly in remount depots and military farms, as for example at Hosur, Kirkee, Meerut and also in the vicinity of large dairy farms. Apart from grasses, lucerne, berseem, shaftal, senji, guar and peas are available for conversion into hay in North India, and lablab, cowpea, guar, horsegram and pillipesara in the Southern States. In legumes the main difficulty is to avoid loss of leaf through shedding during the drying and curing process. Since the leaves constitute nearly half the green material and contain 75 per cent of the protein, loss of leaf will reduce the feeding value of the hay very much indeed. Nearly all the legumes are liable to loss of leaf during the drying process, but shaftal and senji are more prone to it than others. Lablab and pillipesara are less liable to leaf-shedding than many legumes, but cowpea is the best in this respect as it can be dried with very little loss of leaf. Methi (*Trigonella foenum-graecum*) is an exception among fodder legumes in that it is seldom made into hay.

In legumes the stage at which they are cut for hay is even more important than in grasses, in determining the quality of the hay. With

advancing maturity of the plants, the hay made therefrom shows a decrease in protein, calcium, carotene content, green colour and grade of hay and an increase of lignin, i.e., the fibre content. Clovers should in general be cut for hay in early bloom or just before full bloom, to secure the maximum protein content in the hay, because in clovers the protein content declines rapidly from the " heading out " stage to full bloom. Red clover should be cut when half the plants are in bloom and the cutting completed by the time all the plants are in bloom. Alsike clover and Lladino clover have a continuous growth habit and so they give the highest yields of hay if cut when the majority of the flowers have turned brown. In the case of lucerne, which stands on the same land for nearly four years, the last cutting of the year (usually in the autumn), has to be left uncut to proceed to maturity, in order to build up the root reserves for the next year's growth and hence for making hay only the second or third cuts are used, when the plants are in the half-bloom stage. The first cutting and sometimes even the second cutting are often too watery and are used only as green feed. Berseem, although it makes very nutritious hay, is usually cut and fed green, on account of the difficulty of preventing loss of leaf by shedding during the drying process. Shaftal is cut for hay at its full bloom stage; when prepared well, this hay is superior to lucerne hay, although the dryage may be as much as 80 per cent of the green weight. In many cases a compromise has to be made in cutting plants for hay, because the yield from early cuts is smaller than from late cuts,even though the protein. content and quality of the hay may be much higher than from the late cuts.

For making hay, the herbage reserved for the purpose is left to grow till the flowering stage without allowing any grazing and then cut in bright weather, usually by machines, in the more advanced countries of the West, Australia and New Zealand and dried without delay. Some workers claim significant increases in dry matter and carbohydrate content when herbage is cut for hay late in the afternoon, but in practice hay-cutting is done mostly in the morning and the afternoon is utilised for bringing the cut material to the drying place. The mown material is laid out in rows called ' windrows ' on one side of the mower. The windrows are periodically shaken out and reformed, to secure uniform drying, otherwise the plants on the outside would get too bleached and dry, while the inner ones would remain moist and green. Rainy weather at the time of making hay is most undesirable, as it ruins the product. In India hay is made sometime in September-October, after the S.W. monsoon rains are over and the sun is sufficiently bright to dry the plants in the swathe in a day or two.

When the leaves are dry and before the stems get dry, the partially dry material is made up into small heaps or ' cocks ' and left on the meadow for a few days, until the leaves become pliable once again by re-absorbing

moisture from the stems. Care should be taken not to leave the material longer in the cocks than necessary, as otherwise the leaves would get dry once again and drop off during the subsequent handling. It is easier to cure a mixture of grasses and legumes than either of them separately, as the grasses aid in aeration and a quicker drying of the legumes. All operations in hay-making are aimed at avoiding as far as possible the loss of leaves, since they form the most valuable part of the hay. Finally the hay is carted off to its permanent storage site and covered with straw or coarse grass. When cured under ideal conditions hay has a high feeding value and vitamin D content. Even in storage, care is needed to avoid excessive heating up, because the sugar content, carotene, and protein digestibility are all reduced by over-heating. Since hay is the main forage of livestock in temperate countries during the winter months when cattle have to be stalled indoors and the sunlight is not very bright, the carotene content in the feed is quite important, especially for milch animals. If the hay is too wet when stored, there will be over-heating and charred areas in the hay. Sometimes, the heating may continue to a stage of spontaneous combustion even, leading to serious loss of both hay and place of storage. Common salt is added sometimes to hay as it is believed that salting reduces the danger of overheating in storage. Though this is not realised in practice, salt, when used in moderation, improves the palatability of stored hay, although it does not prevent spontaneous combustion, bacterial fermentation or mould development in the stored hay.

When hay is cured in the open field, a loss of about 10 per cent in the feeding value is inevitable; under adverse conditions it may range all the way up to 90 or even 100 per cent. In wet weather, leaching, bleaching and leaf-shedding may account for losses up to 40–60 per cent and hence any method which reduces the curing time and ' leaf-shattering ' will also minimise the losses in feeding value. If the hay is too moist at stacking time, fermentation sets in with rise of temperature and the overall loss of dry matter and nutrients may be anything from 15 to 50 per cent.

Many gaps still remain in our knowledge of the changes that take place during the ' curing ' of hay. Apart from the obvious loss of moisture, which varies in rate and degree with the weather conditions, many other chemical changes also occur. Even after the plants are cut they continue to respire for some time, before the leaves get wilted, and there may even be a slight gain due to photosynthetic activity in the leaves. Besides loss of moisture there is also a loss of dry matter content on account of respiration from the plant material and loss of carbon dioxide, ranging from 7 to 20 per cent of the fresh weight. The protein content may also decrease on account of enzyme activity within the plant tissues. In carbohydrates the polysaccharides get reduced to simpler sugars and the simple sugars are built up into more complex forms. Often these ' drying'

losses increase when the material gets too dry and the leaves get detached in the handling. Legumes are more liable to such 'leaf-shattering' than grasses, because the moisture is lost more easily from the leaves than from the coarser stems. In lucerne for instance, the leaves contain nearly three-fourths of the protein and 90 per cent of the carotene in the entire plant and hence leaf-shattering would reduce the feeding value of the hay considerably.

The weather affects the curing of hay in many ways. Even one or two heavy dews may be enough to lower the grade of the hay very much. Hay that is rained upon may lose up to 50 per cent of the digestible protein content. A shower on freshly cut unwilted plant-material would cause less damage than the same rain on hay that is almost fully cured. Light showers will delay the curing and bleach out the green colour; if these are followed by sunny spells, the loss of green colour is still further aggravated. Such sun-bleached hay is not only less palatable, but is also less nutritious.

Crushing of the stalks and stems in the plant material is claimed to hasten the drying process. With the same end of securing a greater control over the drying process, artificial drying of hay material is recommended by some authorities in the West, as the exposure time in the field is very much reduced and the losses due to weathering are correspondingly reduced. Hay can be artificially dried either long or chopped short, but the moisture content should be brought down to 40–50 per cent in the field before the hay is dried artificially. This has recently been developed further and to avoid the risks of making hay in the open, methods of making 'dried grass' have been evolved in recent years, mainly as a result of war-time shortages in England during the Second World War when her

TABLE 126. COMPOSITION OF HAYS

	Crude Protein	Crude Fibre	N-free Extract
	%	%	%
Grass Hays			
Hariali Hay	6·8	24·2	56·0
Marvel grass Hay	5·2	38·5	44·5
Rhodes grass Hay	12·7	27·3	45·8
Spear grass Hay	5·6	38·2	46·0
Legume Hays			
Berseem Hay	14·7	30·6	41·0
Cowpea Hay	15·3	34·8	35·4
Guara Hay	25·2	13·8	43·6

(After Sen and Ray, 1964)

imports of oil-cakes for cattle feed were all severely curtailed. Fresh grass is chopped up into small bits and passed between rollers to crush the stems and culms and dried in special chambers at 200° to 250° C for a short time. The moisture in the material is expelled in a short time without any appreciable loss of nutrients or dry matter and almost all the goodness of the green grass is retained in the dry product. The cost of this operation is of course higher than in field-curing, but it is advantageous as ' dried grass ' from young herbage contains 9 to 16 per cent of protein and can serve as an effective substitute for concentrated feeds and is much superior to ordinary hay.

The quality of hay as well as its composition is subject to wide variations, depending upon the type of herbage, its age and the conditions under which it was made, as would be evident from table 126.

It may be noted that one sample has a very low protein content of only 5·2 per cent, while another hay, from Rhodes grass, has 12·7 per cent protein, which compares well with some legume hays and cotton seed. When hay is made in a proper manner, at the proper stage of growth, it can be quite nutritious and can even replace concentrate feedstuffs to a large extent.

CHAPTER 18

SILAGE

Silage is the term used for the product formed when any green plant material is put where it can ferment in the absence of air. In this process of fermentation the silage develops acids; these acids preserve the nutrient substances in the plant material. This fermentation occurs during the first two or three months; after that the silage remains practically unchanged for another 12 to 18 months.

The process of making silage is known as ensiling. Any green forage crop that will keep in storage without too much loss of nutrients can be made into silage. In humid regions subject to frequent rains, silage is much easier to make than hay. Nutrient losses which may be as high as 20 to 30 per cent in hay-making are only 10 to 15 per cent in silage, i.e., the loss of nutrients is very much less than when crops are cured as dry forage. Very coarse-stemmed or woody forage crops that are apt to be rejected by livestock if fed as hay, will be fully edible when made into silage. The awns and thorns in some species may be rendered quite innocuous through ensiling. Weed seeds die off in the silo. Ensiling preserves succulent forage more economically than any other method and it is possible to recover by ensilage, more of the crop grown on an acre of land than is possible with ordinary hay-making procedures. Ensiling provides supplementary feeding when pastures are inadequate on account of drought or frost. It also gives a greater flexibility than hay-making, because hay can be made only when the sun shines, but silage can be made whenever it is convenient to the farmer.

Crops Suitable for Silage. There are as many kinds of silage as there are crops and crop mixtures. Maize is the most common crop for silage in the United States, because " corn silage " is not only very palatable, easy to make and preserve in good condition for several years, but more food material can be obtained from an acre of corn as silage than from an acre of almost any other crop. Sorghum, both the sweet and non-sweet types, and Sudan grass are also well suited for silage. Amongst other kinds of silage, the commonest and probably the best is a mixture of grasses and legumes. Grasses or mixtures of grasses and clovers that are ordinarily used for hay or pasturage can make good silage. When properly made, grass silage is not only palatable and highly nutritious, but it has also an agreeable smell and high carotene content. Butter made from cows fed on grass silage high in carotene content has almost the same colour as butter from cows grazing on green grass. Forage legumes including lucerne, cowpea, sunnhemp, clovers, pillipesara and soyabeans can all be utilised to make silage.

The yield of silage from an acre of forage crop will be roughly three times as much as when it is made into hay because of the moisture retained in the silage. If a farmer intends to make silage as a regular practice, he should raise some of the more succulent and easily harvested kinds of forage crops such as lucerne, maize, etc., in their optimum combinations and favourable conditions. Cereal crops like sorghum or ragi should be harvested for silage between their flowering and milk stages. If harvested later, the leaves and stems would have turned brown and the carotene content of the silage will be low. Silage from green material that was too wet at pitting may have a high carotene content, but it would be rather rank and ' cold ' and cattle may not relish it much. ' High temperature ' silages, which are formed when the crop material is too dry and mature when put into the silo may be palatable, but they will be low in carotene and feeding value. The best silages are moist to the touch, soft but not slimy, and fragrant in their own characteristic way. The kinds of crops affect the quality of the silage, but the condition of the crops affects the quality even more.

Miscellaneous crops and by-products such as sugarcane tops, Napier grass, beet-root tops, sweet potato vines, peas and bean vines, surplus fruits and vegetables and distillers' grains can all be used for making silage, with fair to good success.

Silage was popularised in America in 1917, when lucerne was successfully ensiled at the Kansas Agricultural Experiment Station. Later on it was reocgnised that the addition of other materials rich in carbohydrates kept the silage good for longer periods. The use of germinated maize and molasses were later improvements. The A.I.V. method was discovered by A.I. Virtanen in 1925, when he recommended the addition of equal quantities of dilute sulphuric and hydrochloric acids to the green fodder when ensiling. More recently, the use of phosphoric acid has been suggested, either by itself or in mixture with other acids. In 1950, sulphur dioxide was tried with success as a preservative in Pennsylvania and in 1952 workers at the same station used sodium metabisulphite with success.

Methods of Making Silage. The principle in making silage is to keep the green fodder material tightly packed in impervious containers, excluding air as much as possible. The crop should be harvested at the right stage of growth. If the crop is too succulent (as when it is cut young), it is preferable to allow it to get slightly wilted to reduce the moisture content before ensiling it, as this makes a better silage. The material is chopped up and packed into the ' silos ' with suitable machinery. These ' silos ' may be either pits or cement towers; towers are more common in the U.S.A., Europe and Australia and they are 9·1 m or more in height and 3 to 4·5 m in diameter. Side-doors are provided in these towers at different heights for convenient removal of silage. Green fodder is chaffed

and put into the silos, ' blown ' into them) by the use of suitable blowers and elevator-shutes and trampled down to the proper degree, as it is being filled. With unwilted material the length of chaffed bits should be 1·9 to 2·5 cm.; with wilted material the length may be set according to the nature of the material and the experience of the region. Sealing the silo is important, to minimise the spoilage. One method is to tramp the top thoroughly for about an hour daily for four or five days and after the top is well tramped down, silage caps or covers should be put in place immediately. Another way of sealing the top is to lay down a layer of sawdust or waste material to a depth of 15 to 22 cm and wet it with a water hose.

Ensilage has been tried in earthen pits and trenches. The pits are dug 2·4 to 3 m deep, 1·8 to 2·4 m wide and of variable lengths, in high level locations, where the water-table is more than 3·7 m below the surface. One cubic metre of space is provided for 400 kg of fodder. Small-size pit or trench silos are made wider at the top than at the bottom, as this shape helps the silage to pack tightly against the sides as it settles. It also prevents the sides from caving in. The slope of the side walls is determined by the type of soil; the lighter and more friable soils require a greater slope. The depth is governed by the ground-water level and the required cross-sectional area. The soil removed from the trench is generally piled along its sides to increase the depth and also provide bunds to lead the drainage water away from the silo. Fodder does not, however, pack so well in these pits as in tower silos and hence a little more space should be provided in pits than in tower silos. Coarse straw is used for lining the bottom and sides of the pit and also for covering the top over the green material. The chopped fodder is spread out uniformly and trampled well as each layer is laid. Filling is done up to 0·9 to 1·2 m above ground level and the top is made rounded like a dome to allow rain water to drain off easily, then covered with straw and finally sealed up with a thick layer of clayey soil. The pit is also banked all round with earth, to prevent rain-water seeping in. The material sinks on settling and the cracks that form on the earthen cover are plastered over with wet mud from time to time, to exclude air.

Changes During Fermentation. When green crops are cut up and packed in air-tight silo pits or towers, fermentation occurs to convert it into silage. Plant respiration continues for a short time after the material is packed in and enzymes, aerobic bacteria, yeasts and moulds become active until all the oxygen in the packed material is used up. The respiration also uses up some of the carbohydrates in the plant material, giving off carbon dioxide, with a rise of temperature to about 27 to 38° C., particularly in the early stages of the fermentation process. As the temperature goes up, bacteria that are always present on the surface of the material become active and use up the carbohydrates and produce carbon dioxide,

and organic acids like lactic, acetic and butyric acids and small quantities of alcohol. Two main types of fermentation may take place, namely butyric acid and lactic acid types. When the fodder contains 65 to 75 per cent moisture and sufficient sugar in the plant-juices, anaerobic lactic-acid bacteria become active, to produce eventually a good, clean-smelling silage of high quality. If the acidity rises to about one per cent at the start itself, the silage will be of good quality, as the lactic acid checks the activity of undesirable organisms. It is thus essential that the forage used as silage material should contain a high percentage of carbohydrates. If the forage is too rich in proteinaceous substances, the butyric acid type of fermentation will predominate.

This butyric acid fermentation is also anaerobic, but the bacteria involved are of the *Clostridium* group and butyric acid is one of the main products of this fermentation. Butyric acid has a sharp, disagreeable odour and the silage is not relished by stock. The anaerobic organisms favour the activity of some enzymes that break down the proteins in the plant material to produce compounds with a putrefactive smell and these make the silage unpalatable to livestock. Too much aeration is also undesirable, as it promotes the activity of moulds, which spoil the silage and make it unpalatable.

Storing the plant material at a moisture content of 65 to 75 per cent excluding air and encouraging a rise of temperature to 30 to 38° C., are, the three conditions for success in silage making. When it is not possible to secure these optimum conditions, it is helpful to add some preservatives or ' silage conditioners '. When the legume and grass material is too succulent, the addition of adequate amounts of preservatives helps in securing good quality silage. Molasses and salt are usually added at the rate of one kg per 1,000 kg of green material, but molasses can be increased up to 10 kg per 1,000 kg of material, without any adverse effect on silage.

Preservatives are of three kinds: substances like molasses, cereal grains, citrus pulp or beet pulp that act not only as preservatives but also add to the feeding value of the silage; and chemical additives such as sodium metabisulphite, which modify the fermentation process and reduce the smell. Preservatives may thus have a three-fold role: adding extra carbohydrates, lowering the *p*H value of the silage material and inhibiting the action of the butyric acid type of bacteria. Wilting the green material to a moisture content of 65 per cent is also effective in bringing down the butyric acid, but it is difficult to adjust the moisture exactly to the level desired; either it becomes too dry and the exclusion of air is not complete, or it still remains too wet and the object of preventing butyric fermentation is not achieved.

The best method of adding preservatives is still a problem to be solved by further research. Chemical additives like sodium metabisulphite

and sulphur dioxide do sometimes improve the palatability and smell, but the extra cost may or may not be worthwhile, as it is found that the greatest loss of dry matter occurs in silage made with preservatives and the least with wilted silage. The proper degree of wilting is, of course, very difficult to achieve and in rainy weather it may not be feasible at all.

To sum up, silage of good quality can be made by several methods, each of which has its own advantages and disadvantages and there is thus a good deal of scope for improving the techniques available for ensilage.

The following quantities of preservatives are recommended per quintal of green material, for making high quality silage:

Silage material	*Preservatives and/or additives*
Grasses alone	2·7 to 3·6 kg/q of molasses or 4·5 to 6·8 kg/q of kibbled cereal grains or 4·5 kg/q of citrus or beet pulp.
Legumes and grasses	3·6 kg of molasses or 6·8 to 9·0 kg/q of kibbled cereal grains or 4·5 kg/q of citrus or beet pulp.
Legumes alone	3·6 to 4·5 kg/q of molasses or 6·8 to 11·3 kg of kibbled cereal grains or 6·8 kg/q of citrus or beet pulp.

Of the chemical preservatives, the most effective is sodium metabisulphite, at the rate of 400 gm to a quintal of green material.

Losses of Nutrients in Silage. When high moisture legumes and grasses are ensiled, the lower layers which are pressed by the weight of the material above exude plant juices. This drainage loss may often be quite considerable in tower silos; nutrients lost in seepage from a 100-tonne silo may equal the nutrients contained in 7.2 q of hay and about 3 to 10 per cent of the green material put into the silo, depending upon the succulence of the material.

There is a loss of carbohydrates as a result of respiration and fermentation, amounting to nearly one-third of what is present in the original green material. The end-products are carbon dioxide and organic acids. A certain extent of rotting and spoilage is inevitable at the top, however carefully the silo may be sealed; this spoilt layer itself acts as a second seal and protects the lower layers from spoilage. Spoilage occurs in earthen silo pits also and may amount to 25 to 35 per cent depending on the size of the silo pit; in smaller pits the loss is greater. If the sides are lined with cement or other impervious material, this loss can be kept down to 5 to 10 per cent.

The proteinaceous material in the pitted forage gets broken down into amino-acids and simpler compounds. Carotene is also broken down to some extent, especially when the temperature rises too much during fermentation leading to a loss of vitamin C of 50 per cent and more. A

loss of dry matter occurs up to 5–10 per cent even when silage is made under ideal conditions. This loss is considerable in earthen pits and may be as much as 50 per cent in small pits; 30–35 per cent due to spoilage and 15–20 per cent due to respiration and fermentation.

Characteristics of Good Silage. Good silage has a 'clean' odour without any objectionable after-smell, as well as a pleasing taste, without any mould, sliminess or mushy rot. The body of the silage is uniform in colour and moisture content. A dark-brown colour indicates excessive heating and if the colour is black the silage is useless and rotten.

Green, fruity silage is the most palatable and nutritious type; this can be produced only under very careful management, from crops that are cut at the right stage, with a dry matter content of 20–25 per cent. Sorghum and maize cut at the milk stage and ensiled the same day with careful packing and control of temperature to keep it below 35° C. gives an olive-green silage with a pleasant smell, neither sour nor sweet, but fresh and fruity, which is readily consumed by cattle.

Sour Silage. This is produced when the fodder is tender, with less than 20 per cent of dry matter; the material gets readily compacted and the temperature does not rise above 35° C., but the silage has a sour smell characteristic of butyric acid which makes it unacceptable to livestock.

When crops are fully ripe at the time of ensiling and also wilted, the porous nature of the material makes it difficult to exclude air completely. This leads to the development of moulds and a considerable rise of temperature and results in a musty silage which is rejected by cattle. Such over-ripe materials should be moistened with water at the time of filling the silos or mixed with other tender, succulent material, at least in the top layers, so that the top portion could be compacted thoroughly and air excluded completely.

In spite of a certain amount of inevitable losses, the conversion of forage material into silage involves the smallest losses of nutrients. Field-cured hay involves three to four times as much loss as in silage making. Barn-curing with artificial heat preserves the maximum dry matter in hay, wilted silage comes next, this is followed by barn-curing without artificial heat and field-cured hay comes last. From the milk-production aspect too, the increases over field-cured hay are of the following order: barn-cured hay with artificial heat, 16 per cent, wilted silage, 12 per cent, and barn-cured hay without heat, 8 per cent.

Improvements in Ensiling Procedures. In the A.I.V. process developed in Finland, dilute sulphuric acid and hydrochloric acids are sprayed on the chaffed fodder at the time of filling the silo, to reduce the *p*H value from the original 6 or 6.3 to 3 or 4. This suppresses bacterial activity and fermentation and the material gets converted into silage without too much damage. A recent improvement is the use of dilute phosphoric acid in place of sulphuric and hydrochloric acids. The addi-

TABLE 127. COMPOSITION OF SILAGE FROM DIFFERENT CROPS

	Berseem		Red clover		Guara and wheat bhusa		Sorghum and cowpeas	
	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients	Chemical Composition	Digestible Nutrients
	%	%	%	%	%	%	%	%
Moisture	76·0	—	75·6	—	69·5	—	67·7	—
Crude protein	2·3	81	3·9	51	2·3	45	2·4	54
Ether extract	0·6	47	1·3	62	0·7	44	1·0	58
Crude fibre	9·6	52	6·7	49	11·2	53	8·5	49
Ash	3·2	—	2·1	—	5·1	—	2·2	—
N-free extract	8·3	47	10·4	61	11·2	58	18·2	64
Calcium	—	—	0·59	—	—	—	0·14	—
Phosphorus	—	—	0·16	—	—	—	0·04	—
Potassium	—	—	0·64	—	—	—	0·30	—
Digestible Crude Protein		1·9		2·0		1·0		1·3
Total Digestible Nutrients		10·3		13·4		14·1		10·5

(After Lander, 1949)

tion of molasses up to 1–2 per cent of the weight of green material is also helpful, in the case of leguminous fodders that are low in carbohydrates and which may putrefy without such an ameliorant.

Silage Making in India. Although several attempts have been made in various places in India to conserve forage material by ensilage, certain practical difficulties impose limitations on its wider adoption. The small size of the average Indian farm makes it difficult, if not impossible, to set apart areas for fodder production and ensilage. Cement silos of the western type are the most efficient, but their initial cost is beyond the means of most farmers in India and it is also rare to have 900 to 1,100 q of forage material in a single farm in India to fill up these tower silos. Further, a daily consumption of at least a two-inch layer of silage is imperative, when once a silo pit is opened, to prevent the silage from getting spoilt and going to waste; this means a minimum of ten animals will have to be fed with silage each day, whereas the average farmer seldom has more than two or three pairs of work-bullocks. Silage when made in small pits involves too much waste of forage materials. However, in certain circumstances silage-making may be the sole method of fodder-conservation; thus ragi in the central districts of Madras, viz., Salem and Coimbatore, comes to harvest in the rainy season, in October and much of the green straw cannot be dried in some years. Even if weather conditions are favourable, ragi straw makes an indifferent fodder which is not relished by cattle, whereas if it is converted into silage it is consumed with relish on account of its pleasant taste and flavour. This has been tried with success by some farmers in Madras State.

When silage is fed to livestock it is desirable to feed also some dry hay or straw with the silage. It may be necessary, when animals are fed silage for the first time, to feed it in small quantities, as some animals do not relish it at first. The quantity can be increased later on and the quantity of hay or straw decreased correspondingly.

The composition of silage made from different crops is given in Table 127.

TABLE 128. SILAGE FROM DIFFERENT MATERIALS IN COMPARISON WITH MAIZE SILAGE

Chemical Composition	Maize	*Cenchrus ciliaris*	Oats
	%	%	%
Crude protein	7·9	10·0	8·1
Ether extract	1·1	1·2	3·0
Crude fibre	24·6	35·3	39·8
Ash	11·3	10·9	9·5
N-free extract	55·1	42·6	39·6

(After Sen and Ray, 1964)

Silage from grasses and small grains show a higher content of proteins and fat than maize silage; this is evident in Table 128.

Advantages of Silage. Silage can be made all the year round and can utilise plant material that might be inedible in their dry state or after damage by rains. Even weeds and surplus grasses that become plentiful after rains can be ensiled, to be fed to stock when green fodder is unavailable. Less of storage space is needed for silage than for hay. Silage contains 230 kg of dry matter per cubic metre as against 66 kg per cubic metre in hay. Silos are also less expensive to construct than hay barns and fire hazards are virtually non-existent.

The disadvantage of silage is that more labour is needed, adding to the cost of feeding farm animals. Preservatives like molasses or sodium metabisulphite add still further to the cost. Silage can seldom be used as the sole ration, unless it has the right combination of high protein legume, low protein grasses and cereal crops.

Dairy cows can be fed 3 kg of maize silage per 100 kg live weight, together with the usual concentrates and hay feed. Dairy animals can consume 4·5 to 6·8 kg per day, while beef cattle can consume 13·6 to 18 kg. per day. For feeding 10 animals at 13·6 kg of silage per day for 300 days, a tower silo should be $3 \times 6{\cdot}7$ m. A silo to hold less than 250 q would be impracticable, but it should not also be so large that less than 7·5 to 10 cm are removed daily, to keep ahead of spoilage.

CHAPTER 19

GRASSLANDS IN INDIA AND THEIR ECOLOGY

It is estimated that about 90 per cent of the livestock population in India subsists on natural grasses that are available inside and outside forests. According to the land utilisation statistics of 1951–52, of a total area of 320 million hectares of the Indian Union, 8·8 million hectares are classified as grazing lands, i.e., as permanent pastures and meadows. In addition to this, 43 million hectares of culturable and non-culturable lands also serve as grazing grounds for Indian livestock. Grasslands are thus very important as feeding grounds for the livestock of the country and deserve to be developed along proper lines. Improperly managed grasslands not only fail in their primary function of feeding livestock, but also aggravate soil erosion and deplete the national soil wealth.

A grassland is defined as a natural land surface which is covered mainly by members of the grass family of plants. The characteristics of a grass plant have been described in Chapter 4. In the popular sense, however, the term ' grass ' includes all plants that are grazed by livestock and in this chapter the term grassland is used in this broader sense of all plants that are grazed by livestock.

Ecology of Grasslands

Scientific management of grasslands is based upon ecological principles. Ecology is defined as the science which deals with the inter-relations of plants with their environment. Plant ecology seeks to find out the laws governing the development of vegetation in different habitats and environments. This knowledge can be utilised to make natural resources serve the requirements of livestock nutrition in an efficient way.

In the development of natural vegetation, there is a close relationship between the soil and the vegetation that grows upon it. Soil is the end-product of the action of both the climate and the vegetation upon the parent rock-material and all soils develop ultimately into a ' climax soil type ' which is in equilibrium with the climate and other environmental factors. At each stage of soil formation and development, there is a corresponding stage of vegetational development. This development, if left undisturbed, ends in either a forest climax or grassland climax depending on the climatic conditions. The final type of vegetation is termed as a ' climax ' in ecological nomenclature. Grassland can thus be a climatic climax or sub-climax and may also arise as a result of disturbances in the forest climax.

Ecological Status of Indian Grasslands

As pointed out by R. O. Whyte, climax grassland in its true equivalent to the steppes, pampas and savannahs in other countries, appears to be absent in India, although grassland is common enough as an interim stage in the ecological succession and may sometimes be even stable as a preclimax under the influence of repeated burnings and regrowths of grasses and other vegetation. In India grassland may also be found as an edaphic climax on wet soils. Grasslands in India generally represent secondary series and wherever they are relatively stable, they constitute a biotic climax maintained under the influence of fire and grazing in varying intensities and combinations.

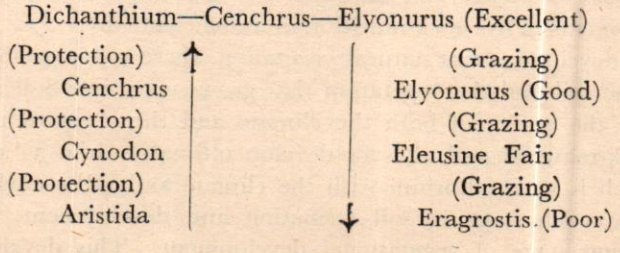
Grassland Covers in India

For a proper management of grasslands it is necessary to know something about the ecology of Indian grasslands. Five main types have been recognised, as outlined below.

1. Dichanthium—Cenchrus—Elyonurus Cover

This type is met with in the north-west arid and semi-arid regions between 23° N. and 60–80° E. comprising the plains of Punjab, Rajasthan, Uttar Pradesh and North Gujarat, on soils that are alluvial or sandy-loam in texture. The main species found in this region are perennials like *Dichanthium annulatum*, *Cenchrus ciliaris*, *C. setigerus*, *Elyonurus hirsutus*, *Eleusine flagellifera*, *Cynodon dactylon*, *Sporobolus pallidus* and *Panicum antidotale*, all of which are valuable forage grasses. However, even well-developed grasslands deteriorate if grazed too long and too heavily. The stages in the deterioration process and the progress of development if grazing is prevented are shown in the figure below.

Progressive and regressive stages in the succession of Dichanthium—Cenchrus—Elyonurus cover



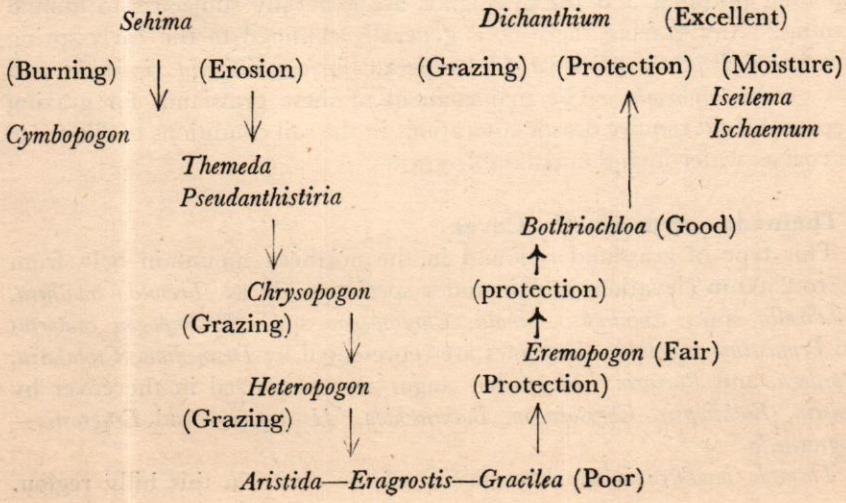
In the management of grassland of this type the objective should be to maintain a proper balance of *Dichanthium* and *Cenchrus* species in tracts receiving less than 20 inches and more than 10 inches of rainfall. Below ten inches the objective should be to have a stand of *Elyonurus hirsutus*. *Cynodon* represents the last stage of resistance of the perennial cover and

hence when this stage is reached, the grazing should be stopped, to enable the grassland to recoup itself. At the *Aristida-Eragrostis* stage the grassland will be too poor to support any grazing and a complete closure for four to five years becomes imperative to allow the succession to attain the ' fair ' condition represented by *Cynodon dactylon* and *Eleusine flagellifera.*

2. Sehima—Dichanthium cover

This cover occurs all over tropical India below the Tropic of Cancer, comprising the Deccan plateau and extending from south Rajasthan, south Uttar Pradesh, Madhya Pradesh to Bihar and parts of West Bengal. The tracts are characterised by undulating hills with valleys intervening. All types of red and black-soils are associated with this cover, including laterite soils also. Species of perennial grasses that are distinctive to this region are *Sehima nervosum, Chrysopogon montanus, Themeda triandra, Eremopogon foveolatus, Heteropogon contortus* and *Cymbopogon* spp.; while annual grasses in these areas are represented by *Themeda quadrivalvis, Apluda aristata, Pseudanthistiria* spp.; *Diectomis fastigiata* and *Schyzachyrium* spp. On deep soils in the valley portions or on plateaux, the grasses in order of their importance are: *Dichanthium annulatum, Bothriochloa pertusa, Eremopogon foveolatus* and *Cynodon dactylon.* In moist situations, *Dichanthium caricosum, Iseilema laxum, I. Wightii* and *Ischaemum aristatum* occur. On grasslands that have got badly overgrazed and deteriorated, annual species alone occur, such as *Aristida* spp. *Gracilea royaliana, Eragrostis* spp., *Chloris* spp., *Alleteropsis cimicina, Andropogon pumilus, Urochloa panicoidea* and the annual form of *Heteropogon contortus.* The best among these for forage are *Sehima, Dichanthium, Chrysopogon, Iseilema* and *Ischaemum.*

The progressive and regressive stages in the plant succession of this type are given below.



Ecological management. *Sehima nervosum* and *Dichanthium annulatum* are the typical species, on gravelly and well-developed soils, respectively. Since *Sehima nervosum* occurs in hilly situations, adequate soil conservation measures are necessary in any plan of management for this grass. In the improvement of degraded *Sehima* grasslands through reseeding, preference should be given to species like *Chrysopogon montanus* and *Eremopogon foveolatus* which are easily raised from seed, unlike *Sehima nervosum*. In the coastal, high rainfall mountain belt, where the succession often gets arrested at the *Themeda-Pseudanthistiria* stage, probably due to leaching away of soil nutrients, contour furrowing, along with adequate manuring would be necessary. *Sehima* grass land quickly degenerates into inferior *Cymbopogon* cover as a result of burning and hence this practice should be discouraged in tracts receiving rainfall below 30 inches. In regions of high rainfall, where tree species are likely to encroach on the grasslands, occasional burning may not be too harmful.

Dichanthium, Iseilema and *Ischaemum aristatum* grass-lands are best utilised for hay purposes; for grazing, the post-monsoon period is the safest. Several pasture legumes are also associated in this *Sehima* cover, such as *Atylosia scaraboeoides, Desmodium diffusum, Alysicarpus rugosus, A. longifolius, Heylandia latabrosa* and *Indigofera glandulosa.*

3. Phragmites—Saccharum Cover

This type of cover occurs on the eastern humid portions of the lowland plains of the Ganges and Brahmaputra river basins, especially on low-lying, ill-drained land or in situations where the water-table is high. The type is characterised by tall, coarse species of reedy grasses typified by *Phragmites karka, Saccharum* spp., *Imperata cylindrica, Desmostachya bipinnata, Vetiveria zizanoides* and *Narenga porphyrocoma.* These grasses are useful only for thatching purposes and the grasslands are generally subjected to annual burning. Any grazing there is, is generally confined to the early spring growths of *Imperata cylindrica* (depauperate form) *Vetiveria zizanoides* and *Desmostachya bipinnata.* The management of these grasslands for grazing purposes would require drastic alterations in the soil conditions to eliminate the coarse, water-loving unpalatable grasses.

4. Themeda—Arundinella Cover

This type of grassland is found in the northern mountain belt, from 450 to 2500 m elevations and includes species such as *Themeda anathera, Arundinella* spp., *Eulaliopsis binata, Chrysopogon* spp., *Heteropogon contortus* and *Pennisetum orientale.* Legumes are represented by *Desmodium, Crotalaria, Lespedeza,* and *Pueraria.* Degraded stages are recognized in the cover by *Dimeria, Eulaliopsis, Chrysopogon, Bothriochloa, Heteropogon* and *Eragrostis—Eragrostiella.*

Themeda anathera is the key species of the cover in this hilly region.

Measures designed for soil conservation are essential for the proper management of this type of cover and the present practice of mowing the grass for hay appears to be the best practice under the circumstances. Light grazing during the monsoon months and moderate grazing later on, followed by cutting the grass for hay once in three to four years would be a good balance between the demands of livestock and the requirements of the grassland.

5. Temperate and Alpine Cover

This type of cover is met with mostly on the hills of the Himalayan region in the north and the Nilgiris in the south of India. It is characterised by the presence of species like *Agrostis*, *Calamagrostis*, *Festuca*, *Muhlenbergia*, *Phleum*, *Poa*, *Bromus*, *Holcus*, *Dactylis*, *Oryzopsis*, etc., together with pasture legumes like white and red clovers, medicks and vetches, all species that are typical of grassland cover in temperate lands.

CHAPTER 20

GRASSLAND IMPROVEMENT

The main objective in the managements of grasslands is to secure the maximum production of livestock without any detriment to the productivity of the grasslands. It is, therefore, essential to see that the grassland under consideration is kept at its peak level of productivity for as long as possible. Decline of herbage productivity may be due to a variety of causes such as bad drainage or lack of sufficient plant nutrients in the soil. It is easy enough to recognise physical defects like bad drainage in soils by the presence of species that are typical of swampy locations, such as *Cyperus* spp., wild rice, *Coix lachryma-jobi*, *Panicum repens* and *Ischaemum rugosum*. The methods to be adopted for the improvement of such areas will be mainly mechanical, designed to remove excess of water from the soil. Nutrient and physiological defects may be caused by the lack of any one or more of the essential plant nutrients. Continued removal of the grass cover and the consequent leaching may deplete the soil of plant nutrients so much that they become limiting factors in the growth of vegetation. In such cases the productivity of the grassland can be restored only by the use of fertilizers to supply the deficient elements. The majority of grasslands will as a rule be benefited by applications of nitrogenous and phosphatic fertilizers.

Weed Control. Both herbaceous and shrubby weeds are found to invade deteriorated grasslands. To eradicate these and remove their competition for soil moisture and plant nutrients there are various ways such as cutting, digging out, burning or the use of weedicide chemicals. These weedicide chemicals have become very popular in recent years and for small areas they are quite effective, although their cost may prove a serious handicap, especially in India, where manual labour is still very much less expensive than what it is in Western countries.

Burning of Grasslands. Setting fire to the dry vegetation in order to encourage new growths after the next monsoon rains, is a widespread practice in many parts of India. It is a convenient method of removing unutilized herbage residues of the previous year so that a new growth of vegetation may develop unhindered and become available to grazing animals. It is also helpful in eradicating undesirable weeds and shrubby growths that may compete with desirable grasses and legumes. Burning is also helpful in encouraging an early spring growth of grasses and discouraging the encroachment of jungle growths. Since burning is a process antagonistic to the process of natural succession, both primary and secondary, it has to be practised with very great care. In humid, high rainfall areas, burning may not be very harmful, but in arid and semi-arid

regions burning is definitely harmful. We have as yet very little detailed knowledge on the effect of burning on plant succession in grasslands, but it is likely that burning may result in favouring certain species over others and thereby lead to a plant succession which may or may not be favourable from the grazing point of view. For example, in the *Sehima—Dichanthium* type of grassland, burning leads to a dominance of the *Cymbopogon* species which are worthless from the grazing point of view, but in the *Phragmites—Saccharum* type, burning results in bringing about a reduced form of *Imperata cylindrica*, which is useful for forage purposes.

Closure of Grasslands. Elimination of the grazing factor, which is directly responsible for the deterioration of grasslands, induces a progressive succession. It can therefore serve as a very effective method of improving degraded grasslands. Closure for a few years will be effective when the remnants of better species are still scattered in the area, to serve as seed sources. Four or five years of closure may be necessary, but if the deterioration has already proceeded to the " poor " condition when only annual species of grasses are left to grow, then the regeneration even under closure may be much slower.

Reseeding. On highly degraded grasslands, the surest and quickest way of regeneration is by re-seeding, but the topography of the land will be an important consideration in undertaking the reseeding operation. On level lands the operation is fairly easy and effective; such conditions are met with in the *Dichanthium-Cenchrus-Elyonurus* type of grasslands. On undulating sites, as under the *Sehima—Dichanthium* or *Themeda-Arundinella* types of grassland, soil conservation measures are essential before reseeding is taken up. Sufficient preliminary information should also be gathered on the choice of species to be sown, the quality of the seed, preparation of the soil, moisture conditions and the method of reseeding, if the reseeding programme is to be successful.

In arid and semi-arid parts of India, where the vegetation is of the *Dichanthium-Cenchrus-Elyonurus* type, re-seeding can be done successfully, with *Cenchrus ciliaris*, *C. setigerus*, *Elyonurus hirsutus* and *Panicum antidotale*, as the seed of these species is usually of good quality and able to germinate in two or three days after sowing, if the soil is sufficiently moist.

In peninsular India, where the grassland cover is of the *Sehima-Dichanthium* type, soil conservation measures are necessary before a desirable species like *Sehima nervosum* can be established on the degraded grass-lands. In such cases it is preferable to use for reseeding a species which is one step lower in the successional level, such as *Chrysopogon montanus* or *Eremopogon foveolatus*. The method of reseeding is a subject on which much information is not yet available in India. Re-seeding can be done on level land and in rows 54 cm apart, but this spacing can be increased if necessary, depending on the quantity of seed available, the urgency of regeneration and other factors. On grass-lands in arid regions where

there is wind erosion, it would be a wise policy to re-seed in strips at right angles to the direction of the wind. Normally it is easier to secure a good stand if re-seeding is done after the monsoon sets in, but sometimes dry sowings before the monsoon can also be done, as at the Arid Zone Research Institute, Jodhpur. After sowing, the soil is given a light harrowing. On undulating land it is preferable to sow the seed along the contour furrows, to reduce the risk of erosion. The success of re-seeding also depends upon the after-care. The grazing during the first year of seeding should be very light and allowed only after the grass has set seed. From the second year onwards, moderate grazing can be allowed.

Soil and Water Conservation on Grasslands. The proper conservation of both water and soil is an integral part of all good grassland management systems. When properly grazed, eroding forces are kept in check and the grassland is in balance with erosive factors and no special conservation measure would be needed, but when grasslands have been mismanaged by neglect and overgrazing for many years, soil and water conservation measures become essential for any improvement plan.

On degraded grassland, especially on slopy ground, the first measure of improvement would be to prevent any further erosion of the soil. Where the erosion has already progressed to the stage of gully formation, dams will have to be put across the gully channels; a number of small check dams being more effective than a few large ones. Terraces or ridges are useful in high rainfall regions in diverting water from the slopes to the channels with a minimum of soil loss from the grasslands. Small terraces are both more economical and efficient when put up in the form of contour ridges, but contour furrows may often be still better on grasslands, besides being cheaper than terraces. Such contour furrows will not, however, be suitable for soils that are loose and sandy or on rough land that is too steep.

In arid and semi-arid regions, the main object in the improvement programme will be to conserve as much of the rainwater as possible on the grasslands, to favour the growth of grasses. Harrowing, contour-furrowing or pitting are some of the measures that help in conserving soil-moisture. In recent years " water-spreading " has assumed some importance in improving the productivity of grasslands. This consists in diverting water from natural water-courses to adjacent slopes by putting up small dams to lead the water out in the desired direction.

Grazing management. The greatest single factor which causes deterioration of grasslands is over-grazing. Just like human beings, grazing animals too, have their likes and dislikes and certain grasses are preferred while certain others are avoided. On account of this selective grazing habit, desirable species tend to get depleted in grasslands much faster than other species that are not so palatable. In most perennial grasses, new shoots are produced by utilizing the reserve food-material that is

stored in the underground parts and before the new growths are in a position to build up food reserves by their own photosynthetic activity, there is a stage in the life-history of the perennial plant when the food reserves are at their minimum. When the plant produces food material in excess of its growth requirements, the surplus is translocated into storage organs; at the commencement of the next growing season this surplus is utilized for the production of new shoots. Under grazing conditions these fresh shoots get removed by the grazing animals and the plant never gets a chance to build up any reserves of food material. There is thus a continuous drain on the food reserves of the plant, so that at the next growing period, the plant has to start with greatly depleted food reserves. If this over-grazing continues, the food reserves get exhausted soon and the plant becomes weaker and weaker and ultimately dies. Hence in grasslands, it is essential to allow the plants to build up their food reserves before the forage is utilised for grazing purposes. In the case of annual plants, which can continue to exist only through seed formation and germination of that seed each year, the correct management of grasslands dominated by annuals is to cut it for forage only after the seed-formation stage.

The object of scientific grassland management, as mentioned before, is to maintain the grassland in the highest state of herbage production and at the same time to satisfy the forage requirements of the grazing animal as well as maintain the fertility of the soil unimpaired. In any plan of grazing management, therefore, the main principles are to utilise the grass at a time when the growth and reproduction are the least interfered with and to utilise the grass when it is most palatable and nutritious. Grasses in general are most palatable and nutritious at the young stage, but grazing at this stage is harmful to the plants. The palatability and nutritive value decrease with the maturity of the plant and when the grass is consumed only at the late stage, the grazing animal is at a disadvantage, because of the lower nutritive value. Thus the requirements of the grassland and those of the grazing stock are somewhat antagonistic and good pasture management consists in effecting a satisfactory compromise between these divergent needs.

Systems of Grazing. Since a smaller number of well-fed animals is always better than a large number of half-starved ones, a strict control of the number of animals let in for grazing is the first principle of all grazing systems. In fixing the number of animals, the carrying capacity of the grassland should be taken into consideration; this is defined as the number of animals that can graze in a unit area without overgrazing or undergrazing in an average season. It is also expressed in terms of the number of acres needed per animal in an average season.

As mentioned already, continuous grazing is an important cause of grassland deterioration, apart from early grazing and overgrazing. Al-

though the harmful effects may be reduced when the number of animals is reduced in continuous grazing, the effect is a cumulative one and may eventually result in the elimination of the most palatable species. To avoid this risk, the grazing must be stopped at some stage or other, i.e., in grassland terminology, the grazing has to be ' deferred '. Since it will seldom be possible to stop grazing over the entire area, when no other alternative areas are available, the practical method is to defer grazing in a part of the grassland and to allow grazing in the other parts in a " rotational " system.

Controlled Continuous Grazing. In most parts of India the prevalent practice is to allow uncontrolled, continuous grazing; as a result of which grasslands soon get depleted of all the desirable species, leaving only weak and stunted specimens of undesirable species. Controlled grazing, even if it is continuous, can mitigate this effect to a great extent. The grazing is stopped when a certain minimum number of preferred plants are still left, with sufficient seed stock. When managed on these lines, the system would permit a progressive development of the grassland area.

Deferred Grazing. This system consists in delaying grazing in a part of the grassland area until after seed-maturity, in order to give a chance for the herbage to make sufficient growth and accumulate sufficient reserve food material to maintain the vigour of the plants and produce new shoots next year from the seeds that are shed. This system is applicable where perennial grasses are predominant. In practice, the grassland is divided into three compartments. One compartment is completely closed to grazing during the growing season, while the animals are allowed to graze in the other two compartments alternately. Grazing is allowed in the ' closed ' compartment later on, before the herbage becomes too old and unpalatable. Grazing at this stage helps in the dispersal of seeds and their placement in the soil, thus favouring good germination. Grazing in the other two compartments gives the benefit of early growth to the grazing animals, while the alternation of grazing in the two plots enables the plants to recoup their vigour after each grazing. The grass in the ' deferred ' plot, though less nutritious, makes up for it by its greater quantity. Each year one compartment is deferred in this manner, so that in three years, each compartment gets an adequate period of rest, during which the plants could recoup their vigour.

In deteriorated grasslands, where the perennial grasses are in a badly weakened condition, grazing can be deferred for two years in each compartment or even longer, until the desired improvement is seen.

Rotational Grazing. Rotational grazing consists in allowing the grazing animals into different sub-units of the grassland area in rotation at suitable intervals during the grazing season, so as to bring about uniform grazing without making it too close. The quick change-over from one compartment to another provides the advantage of giving the animals a

nutritive, young herbage and at the same time provides a period of rest during the growing season. The disadvantage in this method is that it gives no chance for seed-formation.

Hohenheim System. An improved system of rotational grazing is the Hohenheim system, developed in Germany during the First World War, to produce sufficient milk without any need to feed concentrates to milch cattle. It consists of dividing the pasture into several equal-sized plots or paddocks and applying large quantities of nitrogenous fertilizers in these paddocks. The dairy cattle are separated into three groups, high, medium and poor milkers and are let into the paddocks in rotation, so that the best milkers will get the youngest and most nutritious grazing.

Deferred and Rotational Grazing. This system is suitable for grasslands where annual species predominate and where seeding of the perennial species is desired to maintain the density of the grass cover. The grassland is divided into three compartments and grazing is allowed in rotation, so that each compartment is grazed for one-third of the grazing season and protected afterwards, until the seeds mature. By the time the animals are let into the third compartment, the seeds would have matured and got shed and when the animals come back to the first and second compartments the seeds in those would also have ripened and got shed. In the second year, the third compartment is grazed as the second and the second compartment is grazed as the first in the rotation. In subsequent years, the same order is followed for each compartment in rotation, so that in three years the grasses in each compartment would have produced enough seed with the partial protection afforded to the grasses.

Assuming a growing period of three months, from July to September, the plan of grazing in this system will be:

	July	August	September
First year	I	II	III
Second year	II	III	I
Third year	III	I	II

Other Aids in Pasture Management. Placing rock salt in different places in the grassland helps in bringing about a more uniform graying and also, water supplies when properly placed will help in equalising the grazing over the entire grassland area.

CHAPTER 21

THE BREEDING OF FORAGE CROPS

The two main groups of forage crops are grasses and legumes. Compared to what has been achieved in the breeding of high-yielding strains of food and cash crops such as wheat, rice, cotton and sugarcane, very little has been done to improve the yield and quality of forage crops, even in the advanced countries of the West and as far as India is concerned, it is even less. In India, it is not easy to increase the area under even food crops to any appreciable extent. Increasing the area under forage crops is even more difficult and so the only method is to increase the yield per acre and the quality of the existing grasses and legumes.

Breeding improved varieties in forage crops is more difficult than in cultivated crops, on account of the diversity of species involved and the peculiarities in pollination and seed-setting and the special difficulties in maintaining the identity of strains. For instance, most forage crop are cross-pollinated, making it difficult to preserve the purity of types; many species are self-sterile, and so it is not easy to inbreed them. In many species of grasses, the floral parts are so small that artificial hybridization is very difficult. Some grasses are also poor seed producers and a few species are apomictic, i.e., the seed is set without fertilization. Further, forage crops are usually grown in mixtures, where the potentialities cannot be judged accurately and improved strains may not show the same performance under different systems of grazing management. Yet another drawback is the lack of any large collection of germ plasm material in forage crops, upon which breeding programmes can be planned out.

Before embarking upon a programme of forage crop improvement it is essential to define the problem and objectives aimed at in specific terms. An intensive study is necessary of the breeding behaviour of different forage species, their methods of reproduction, the effects of inbreeding and the nature of sterility. It is also necessary to recognise the characters that determine the economic value of grasses and legumes as forage crops.

For grasses the following characteristics are important and should receive attention in any breeding programme of improvement: 1. Yield of digestible nutrients and their distribution. 2. Persistence. 3. Ease of reproduction 4. Ease of management, and 5. Palatability.

Yield. In assessing the yield of a forage crop, both the quantity and its quality are important. The quantity is the resultant effect of soil fertility, the nature of the species, its growth habit, vigour and aggressiveness, the stage of maturity at cutting time, irrigation, drainage, manuring and other items of management, response to seasonal variations in day-

length and temperature and the incidence of pests and diseases. The quality of herbage, i.e., the relative levels and proportions of proteins, fat, fibre, carbohydrates, minerals and vitamins, is influenced by the nature of the species, the stage of growth when it is cut or grazed, the lodging and the incidence of pests and diseases. The distribution of yield over the season depends on the growth cycle of the particular species, its habit of growth, the fertilizer treatments and the frequency and height of clipping. The persistence of the herbage is also influenced by the vigour and growth habit of the species and its tolerance of drought and temperature variations. Lack of persistence in perennial species (grasses mainly), may be due to diseases, insect attack, drought, too high or too low temperatures, unfavourable soil conditions or defoliation from excessive grazing or clippings. Persistence can be increased by methods other than breeding. For example, the introduction of the 'Ladak' variety of lucerne from the northern limits of India (*Medicago media*), made it possible to grow alfalfa successfully in Canada and the northern States of the U.S.A. It is nevertheless desirable to keep this characteristic in view when breeding for improved forage crops.

The factors associated with reproduction are the growth habit, the abundance or otherwise of seed production, seed-shedding or shattering, and environmental factors such as day-length, temperature and moisture and soil fertility variations. High forage yields often go with poor seed production and it may be necessary to make a compromise between these features in deciding which culture should be increased. Many grasses and legumes are grown in mixtures and their yield under such competitive conditions should be tested while selecting under improved types. A high degree of seedling vigour is another desirable characteristic, as this helps in the quick establishment of a good stand.

Palatability is a quality that is difficult to define in precise terms, as it is the end result of numerous variables of both the plant and the feeding animal. Palatability is not closely linked with nutritive value, but it affects the intake of adequate quantities of forage by grazing animals. In determining palatability, leafiness and succulence are important as also the hairiness of leaves and stems and the degree of their harshness. In developing sweet clover strains a low level of coumarin is aimed at, otherwise this organic compound impairs the palatability of sweet clover. Breeding for more leafy types is a direct way of improving forage quality, as the leaves are richer in proteins, calcium and carotene and lower in fibre content than the stems. The nutritive value of forage may be improved by selecting strains with a higher content of proteins, minerals and vitamins, but care is needed to see that an increase in one constituent is not accompanied by a decrease in another. In breeding for improved forage quality it is necessary though not easy, to develop techniques for comparing the actual feeding value and palatability of strains when con-

sumed by various classes of livestock, as such comparisons require extensive grazing and feeding trials over a number of seasons.

Based upon the above considerations, the objectives in forage crop improvement may be defined as below:

(i) Ability to grow well and quickly, both independently and in association with legumes (in the case of grasses).
(ii) Resistance to pests and diseases, drought and frost.
(iii) Suitable growth-habit, e.g., short, tussocky types of grasses for grazing and tall types for hay production.
(iv) Prolific seeding and in non-seeding types, ease of vegetative reproduction.
(v) Elimination or at least reduction of undesirable characteristics, such as cyanogenetic glucosides in sorghum and Sudan grass, coumarin in sweet clover, stemminess in grasses or dry, pithy culms, presence of awns (as in spear-grass) and leaf-shedding when mature.

Since some form of progeny testing is indispensable in all breeding work for isolating high-yielding genotypes, proper records should be kept of all factors influencing the phenotypic expression of all the genotypes studied.

Disease and Insect Resistance. Forage crops are subject to a large number of diseases: such as smuts (head smut, leaf smut), rusts (stem, leaf, stripe and crown rusts), leaf scald, brown spots, root-rots, crown rot and pre-emergence rot, "blind seed" disease, bacterial leaf-disease, ergot and root-knot nematodes. Apart from reduction of yields, these diseases also lower the quality of the forage; for instance, lucerne damaged by leaf hoppers contained only 105 milligrammes of carotene per kilogramme of leaves, against 262 milligrammes in leaves from normal plants (Johnson 1936). Damaged leaves are also poorer in protein content. Sudan grass anthracnose (*Colletotrichum graminicola*), has the effect of decreasing the protein and fat content in the leaves while the lignin content is increased.

Suitable Growth Habit. Detailed information on growth, persistence and aggressiveness should be collected at an early stage of the breeding programme. Both in legumes and in grasses, wide variations exist in height, erectness, habit of growth, leafiness, tillering and rate of growth, persistence and aggressiveness. Certain species can tolerate defoliation, trampling and overgrazing, while others die off under such conditions. Since forage crops are usually grown in mixtures, improved strains must be sufficiently aggressive to compete with weeds and with the other species of forage plants. Some grasses, however, may be too aggressive and may reduce the stand of the associated legume, thereby lowering the nutritive value of the forage mixture.

Often natural selection may itself evolve ecotypes that are more persistent

than the original type; for example, *Dactylis glomerata* in Great Britain, in fields that had been heavily overgrazed for a period of years, produced a dwarfy, leafy type which persisted under heavy grazing (Stapledon 1928).

Seed Production. In many grasses, high yield of green forage is associated with poor seeding ability; in such cases vegetative propagation can solve the difficulty, by planting stolons, rhizomes, by division of crowns or stem cuttings. Vegetative propagation is useful to the forage crop-breeder, for evaluating superior plants, establishing clones, propagating strains that produce little seed and for maintaining the original plants used in evolving improved strains.

Elimination of Undesirable Characteristics. The leaves of young sorghum plants contain a cyanogenetic glucoside, " durrin ", which on hydrolysis in the presence of an enzyme, releases hydrocyanic acid and this is liable to cause fatalities in animals grazing or fed on young sorghum. It has, however, been noted that certain types of sorghum show a lower content of this glucoside and that this character is controlled by more than one gene. Recently low prussic acid varieties of sorghum as well as Sudan grass have been developed and distributed in the U.S.A. (Hogg and Ahlgren, 1943).

Chemical Composition. There is normally little correlation between protein content and morphological features, but it is desirable to breed new varieties that are richer in protein, especially when the varieties are to be grown on poor soils. The carbohydrates and lignin content of forage crops also deserve careful study.

Palatability. The relation between palatability and nutritive value is not well established, as animals can make good gains in live weight even on some unpalatable forage species, e.g., on *Eragrostis curvula*. In assessing palatability a distinction must be made between the avidity with which the forage is consumed and the proportion of the forage consumed by the animal. Differences in palatability may exist even within the same species, e.g., between *Sorghum Roxburghii* and *Sorghum cernuum* and hence full information must be gathered from preliminary tests on acceptance and palatability before starting breeding work.

Breeding Procedures. The methods to be adopted for improving any crop plant would obviously depend on the mode of reproduction of the species under reference. Most perennial species of grasses and legumes are cross-pollinated, while most of the annual species are largely self-pollinated. It is, however, convenient to group them as below:

(1) Largely cross-pollinated:	*Pennisetum typhoides*, *P. purpureum*, *Sorghum halepense*, *Cynodon* sp., Lucerne, Clovers
(2) Largely self-pollinated:	Sudan grass, *Eragrostis curvula* *Lespedeza* sp., *Vicia* sp.
(3) Largely apomictic:	*Panicum maximum*, *Paspalum dilatatum*

(4) Largely dioecious: *Poa arachnifera*
(5) Sterile: *Digitaria procumbens*

Breeding methods normally adopted are of three types:

(1) Designed for normally self-fertilised species, e.g., controlled hybridization, back-crossing and selection. Varieties are developed by multiplying superior individual plants selected from advanced inbred generations, in F_5, F_6, and F_7.

(2) Methods designed for naturally cross-fertilised species which are normally propagated from seed. These include individual plant selection, inbreeding, hybridisation and recurrent selection.

(3) Methods designed for species that are normally apomictic and/or male-sterile or female-sterile. The methods are similar to those adopted for normally self-fertilised species, viz., hybridization, followed by individual plant selection where sexuality exists to some extent. Where sexuality is absent, individual plant selections are made from a wide collection, followed by comparison of clonal lines. The same method can be adopted wherever it is advantageous to multiply a strain vegetatively, even if it is seed-propagated.

In all the three methods listed above, the methods of selecting and evaluating individual plants and individual selection are the same.

Selection of Species. For any locality we have first to choose the species that would be suitable and useful. Preliminary tests and observations have to be made on the persistence, heat and cold tolerance, leafiness, seed-setting and seasonal peculiarities and yield potentials. These tests may be carried out in drill-rows or suitably replicated plots, preferably at two levels of soil fertility and two or more systems of management, e.g., to simulate grazing and clipping.

Source Nurseries. These should be as comprehensive as possible and made up of domestic collections, foreign introductions, named varieties and experimental cultures and strains.

For carrying out observations and collecting records on the variability of these collections, the species should be planted with spacings of 0·6 to 1·2 m. between and within rows. Certain species of grasses like Bermuda grass may need wider spacings of 2·4 to 3 m. The population should be at least 12,500 and may go up to 25,000 per hectare.

For assessing the aggressiveness of grasses, a controlled competition technique is recommended. This consists in planting a variety of grasses and legumes in such a manner that each plant is subject to the same amount of competition from other selections of the same species and from other associated species.

Clonal Evaluation. In the case of grasses it is often easier to increase the selected cultures vegetatively. This multiplication may be done by space-planted clones and the clones may also be tested in different localities and habitats, as there is a fairly close correlation between the yield poten-

tial of the parent clones and the progeny clones. Clonal evaluation is *not* a substitute for progeny testing, but is only a preliminary test which helps to reduce the size and expense of subsequent progeny tests. For vegetatively propagated species, however, it is the only method.

Apomictic Species. Apomixis is a term used to denote a type of reproductive process that does not involve the union of egg and pollen nuclei, although pollination may be necessary to fertilize the polar nuclei before the seed can develop. Apomictic progenies show remarkable uniformity in respect of maternal characters. Apomixis may be of two kinds; vegetative apomixis and apomixis with seed formation, the latter is termed agamospermy. Vegetative apomixis occurs when as a result of sexual sterility, mere vegetative reproduction substitutes for sexual reproduction. Such vegetative apomixis is noticeable in many species of *Panicum*, *Poa*, *Avena*, *Bromus* and *Phleum*. Agamospermy in grasses is again of two kinds: " apospory " which occurs when the embryo asc develops by mitotic division from an unreduced cell, and diplospory, when meiosis (reduction division) is initiated in macrospore mother cells. The chromosome number is not reduced in these, due to incomplete synapsis.

In the absence of fertilisation, seed-formation may occur through " parthenogenesis " and " pseudogamy ". In parthenogensis, the egg-cell divides and develops into an embryo without the aid of pollination, as for example in *Pennisetum villosum* R.Br. and P. *rupelli* Steud. In pseudogamy, pollination is required for seed formation. The initiation of the endosperm depends on the union of a male nucleus with the polar nuclei of the embryo-sac. In this case a " pre-embryo " may be formed prior to anthesis, but no seed is formed unless pollination is effected. Apomictic reproduction is surmised, on account of the uniform nature of the progeny in them, in certain strains of *Paspalum dilatatum* and *Poa* species. In *Panicum maximum*, *Pennisetum ciliare* and *Cenchrus setigerus*, the reproduction is apospory followed by pseudogamy.

Where it is known that the species under study is an apomictic one, e.g., as in *Poa pratensis*, the promising selections are tested through progeny tests to find out the frequency of aberrant plants, after which the highly apomictic selections are evaluated in separate plots, from seed or tillers.

Apomixis has certain advantages. Plants exhibiting high apomixis need not be isolated in breeding nurseries. Vigorous heterozygous genotypes can be maintained without fear of segregation of characters when the seed is distributed to growers.

Ecotype Selection. When species are grown for several years in the same region or locality, the types that survive and give the best yields are obviously those that are best adapted to the local conditions. Genotypes that are not so well adapted will tend to die out. This is the basis of ecotype selection. Well-adapted types that emerge from this kind of

' natural selection ', as the best suited to the particular locality are known as ' ecotypes '. New strains may be selected from such ecotypes after testing them in the areas where they are required to be developed, under the same systems of cultivation or grazing management as are prevalent in these areas. Such ecotypes get differentiated more readily from heterozygous populations of cross-pollinated crops, where the genotypes are heterozygous. The procedure in selecting ecotypes is essentially the same as that for selection of strains, although limitations of seed may sometimes make it necessary to make the plantings alternate with checkrows of the standard variety in place of replications.

Varieties Developed From Introduction. Many new varieties can be secured merely as introductions from other parts of the world. For example, lucerne was originally a native of south-western Asia, but it has now become a very important forage legume, not only in the U.S.A. but in many other countries. Other examples are: berseem, imported from Egypt into India, cowpea, a native of India which is now a popular forage plant in the southern States of the U.S.A., Guinea grass and Napier grass, that have now spread to many parts of the world from their original habitats in tropical Africa.

Mass Selection. This method is one of the oldest in crop-improvement and has been helpful in developing several new varieties in the past, although it is now considered rather old-fashioned. In fact, many of the forage grasses now in cultivation are the result of mass selection.

Procedure. An extensive collection is gathered and grown in ' source ' nurseries as rows or plots under suitable agronomic conditions. Seed from promising plants is gathered and bulked to be grown for two or more seasons. Such ' mass ' samples are easier to handle and have the advantage of larger populations and simulating field conditions. In the case of grasses, clippings can be taken for assessment of yield potentials for one or two seasons before the bulk sample is left for seed, either for continuing the tests or multiplying the seed for distribution.

The advantages of mass selection are that it is simple, inexpensive and in a new tract it is also quite effective in making higher yielding ' strains ' available to the cultivator within a short time. The success of the method depends, of course, on the maintenance of a high level of selection pressure by the breeder.

Varieties Developed by Selection. Many self-pollinated forage crops, including soybeans and lespedeza were introduced from China and Korea into America; amongst these a new variety of lespedeza, Rowan, was developed in the U.S.A. by simple selection, as resistant to root-knot nematode (McKee and Pieters, 1937).

Repeated Mass Selection. Seed harvested from well-grown, vigorous plants is bulked and sown in the next season and the same process is continued for several years. With open-pollinated maize, continuous mass

selection progressively changes characters like plant height and leaf length, but not the yield. In lucerne, the variety Grimm 451 was developed in Canada by mass selection, keeping winter-hardiness as the primary consideration.

Maternal Line Selection. This is a modification of the mass selection method. When plants are screened on the basis of the performance of progenies and the identity of the maternal line is maintained, then the procedure is termed " maternal line selection ". The progenies may be (*a*) open pollinated progeny (without any restriction on the pollen source), (*b*) top-cross (selections interplanted with a common pollen source) and (*c*) polycross (pollen restricted to plants that have certain characters in common). In open-pollination progeny tests, the seed of each selection is limited and the number of selections is also large; this makes it necessary to have only simple designs, such as unreplicated row plots inter-planted with check varieties at frequent intervals. The evaluation is also not as thorough in these plots as from solid-seeded plots, but the expectation of isolating plants with high yield potential is fairly high in this method.

Top-crossing. Top-crossing is effected by inter-planting clones of the type that is to be improved, side by side with a standard variety or an experimental " synthetic " strain. The pollen-supplying " tester " is planted in alternate solid-seeded rows to ensure an adequate supply of pollen. The selections are propagated vegetatively in separate nurseries to provide material for five or more single-plant replicates and furnish sufficient seed for planting solid-seeded replicated plots. In some programmes the individual plants are top-crossed with a series of superior phenotypes. The maternal parents are isolated by using paper bags and the pollen collected from the group of paternal plants is applied with a brush or pollen gun.

Polycross techniques are based on the principle of random pollination where each of the original selections included has an equal opportunity of being pollinated and of itself pollinating any of the others. Each clone is also randomised within each block and the blocks are replicated from 10 to 30 times, depending on the number of selections. The procedure will be most effective if all the selections included in the source nursery flower at the same time or at least approximately so, so that it would increase the percentage of crossing.

When properly designed and carried out, polycross nurseries have the following advantages:

(*a*) Random or near-random pollination among plants selected for common characteristics, such as maturity, disease-resistance, seeding habit, growth-habit, etc.

(*b*) A good chance to study replicated clones.

(*c*) Production of ample seed for progeny testing.

Polycross blocks provide good facilities to practise recurrent selection within progenies. Good combining clones selected on the basis of top-cross or open-pollination progeny performance are grouped in polycross blocks and re-selection is done from the resulting progenies.

Recurrent Selection. This term was first used with reference to maize breeding, but it is applicable to many other crops, including forage crops. Hull (1945) used the term ' recurrent selection ' for maize, when the first generation inbred lines were recombined according to the performance of the parental lines crossed on a homozygous line. The procedure is then repeated in the bulked F_1 population resulting from crosses among selected inbred lines.

Recurrent selection has been found more effective than the older method of inbreeding and selection in modifying the oil content in maize. The size of the polycross nurseries and the number of selections that should be handled, will be determined by the specific nature of the improvement that is to be effected, the space available and the intrinsic differences among species. Recurrent selection can be practised within polycross progenies of demonstrated superiority in the preliminary yield tests.

In each new series of advanced polycross nurseries, the same number of clones should be included as were included in the first crossing blocks. These series will represent three classes, namely (*a*) clones from the original source nursery, retained on the basis of their performance in two progeny tests, (*b*) clones included in the second cycle source nursery and evaluated in one progeny test, and (*c*) clones selected within superior polycross progenies. One or more polycross nurseries can be confined to selections made from outstanding polycross progenies in order to measure the progress and effectiveness of recurrent selection. Complete pedigrees should be maintained in all these procedures.

Hybridization. The inter-crossing of different types in order to secure increased variability within populations is a common procedure in plant breeding. In breeding perennial grasses, the emphasis has so far been on some form of maternal line selection, due to the fact that cross-fertilised grass species often show considerable selfing depression and self-incompatibility. Single crosses can serve to secure desirable recombinations of specific characters or to secure an increased frequency of desirable genes. Differences are sometimes seen between the progenies of reciprocal crosses, due to differences in the vigour of the selfed offspring of different parents. To overcome the difficulty of obtaining sufficient seed from single crosses, a number of plants are bagged or a number of clones arranged in pairs, in small isolated crossing blocks.

Economic characters are sought to be improved by inter-crossing selected plants and practising recurrent selection within maternal lines. In this inter-crossing, various systems have been suggested, such as diallel

crosses, (all combinations of single crosses) and cyclic crosses, (1×2, 2×3, 3×4, etc.). Diallel crossing is no doubt a sound method, but it limits the size of populations and is also expensive.

In breeding for disease resistance, the value of resistant or semi-resistant types can be assessed by making single crosses and comparing the F_1 progenies with the parental types. One practical difficulty that may be encountered is the difference in the flowering and maturing dates of different ecotypes, but this can be overcome by adjusting the sowing dates and making the crosses under controlled conditions in the greenhouse. For combining desirable economic characters that are mostly quantitative in nature, the most promising method is to make single crosses and then practise recurrent selection after back-crossing.

Interspecific and Intergeneric Hybridization

Very often a saturation point is reached in the scope for improvement by selection from inbred or hybrid progenies in a given species. In such cases interspecific and intergeneric hybridization offer a method of breaking the barrier that may block crop improvement by standard procedures. Numerous problems will arise in this line of study also, such as sterility and incompatibility, but as a tool in the elucidation of cyto-taxonomic problems and for the phylogenetic classification of species, the method offers great scope.

As examples of interspecific hybridizatoin, *Paspalum dilatatum* was crossed with *P. malacophyllum* to isolate fertile segregates that were immune to ergot. *Sorghum halepense* was crossed with other sorghums and some of the progenies were found very promising as forage plants. Perennial Napier grass (*Pennisetum purpureum*) and annual Pearl millet, (*P. typhoides*) hybridize readily and though the hybrids are sterile, some of them have shown great possibilities as fodder crops. Coastal Bermuda grass is an interspecific hybrid which arose by chance and although it is sterile and needs vegetative propagation, its marked superiority over the ordinary Bermuda grass has made it very popular in the southern States of the U.S.A.

Crosses between species and genera may also help to transfer desirable features from an agronomically undesirable species to one which is already valuable from an agricultural standpoint. Hybrids made between species that differ in chromosome number are more likely to be successful if the species with the larger chromosome number is used as the pollen parent. Failure to hybridize may sometimes be overcome by first doubling the chromosome number of the low chromosome parent. Induction of polyploidy is the most effective way of securing fertile plants from sterile hybrids. Sometimes, when the F_1 hybrids are partially sterile, selection for fertile plants in the F_2 generation may prove effective. In the absence of chromosome pairing in the F_1 hybrids, induced polyploidy might make them

fertile, but if there is a high degree of chromosome pairing in the undoubled F_1 itself, the chances are the allopolyploids might not be useful. Hybrids between types having different ecological preferences are likely to show a broad adaptation, but in general, both the parents should have a range of adaptation that is suited to the requirements of the locality where the new type is to be used.

Synthetic Varieties. These are developed by combining into a composite strain either individual plants or different strains themselves, by crossing them and replanting the seed of subsequent generations. The aim of this method is to develop a variety made up of a sufficiently wide range of genotypes to maintain the vigour for a number of seasons, yet sufficiently homozygous for the particular character that is desired and which is used as a basis for selection. This is a commonly used method in forage crop breeding. (Jenkins, 1931.)

Synthetic varieties may be either multiple strain varieties or multiple-plant varieties. In developing multiple-strain varieties the individual strains that are to be used should be randomised within each replication and these replications should also be sufficient to avoid non-random pollination. The experimental synthetics should be carried to the Syn_2 or Syn_3 generation before they are put under comparative yield trials or distributed for regional testing. The Syn_2 seed is produced from the Syn_1 by planting under isolation equal quantities of Syn_1 seed from each clone. The selections that constitute these multiple-plant strains may be self-incompatible without much detriment to the success of the method; this is an advantage over the single-plant strains where a minimum self-fertility is essential for the success of the method. In most synthetic varieties of forage grasses there would be several advanced generations of multiple-heterozygous-clone varieties that are usually mixtures of F_1 and F_2 crosses. Such multiple-plant strains are not affected by inbreeding defects, but may often show a lack of uniformity.

An example of a multiple-strain synthetic is 'Ranger' alfalfa which was a blend of five strains, three from Turkestan, and one each from Ladakh and Cossack. These five strains were wilt-resistant, inbred lines, that were each out-crossed with other lines and then multiplied. (Tysdal, 1940.)

The actual performance of a synthetic strain is influenced more by the combining ability of the parent lines than by the actual number of lines that had gone into its development. This has been proved in the case of maize. Similarly in lucerne, the highest yielding synthetics were secured from clones of high combining ability. It is also necessary that the experimental synthetics should be taken to Syn_3 and Syn_4 generations before their performance is assessed on any extensive scale. For instance, the Syn_1 generation of a 2-clone combination in lucerne showed a higher yield that of a multiple-clone synthetic, but in the Syn_3 and Syn_4 genera-

tions there was hardly any difference between the yields of the 2-clone and multiple-clone synthetics.

Multiple-plant Synthetics. A large number of plants are grown and the best amongst them selected for superior characteristics. These superior phenotypes are then crossed and the progeny tested for combining ability by suitable procedures. The performance of these progenies will form the basis for choosing the parents that would constitute the synthetic strain. The cross progeny is multiplied by open pollination for a limited number of generations, generally four or five. Here too, the original plants that figured in the cross are maintained so that the synthetic strain could be reconstituted whenever necessary.

The minimum number of plants that should be used in developing a synthetic variety to avoid the risk of loss of vigour in advanced generations would depend upon the species and on the pedigree of the parent clones. Thus if we have 12 clones, all promising and looking alike in a progeny test, but with 3 or 4 of them outstandingly promising, then these 3 or 4 should be included in one experimental synthetic and all the 12 in another. Based on the performance in this Syn_1 as well as in the subsequent synthetic generations, the composition of both the sets of synthetics may be changed as needed later on.

Procedures for Developing Synthetic Strains

(*a*) *Multiple strain synthetic* (for wilt resistance)

Strains			
A	B	C	D

Steps

1. Selfed.
2. Each strain is crossed with one or more wilt-resistant lines.
3. The progeny in each is tested for wilt-resistance.
4. Seed of selected resistant progenies is increased separately and combined and multiplied by open pollination to produce a multi-strain synthetic variety.

(b) Multi-plant Synthetic

Steps

1. *Source Nursery.*—Several thousand plants are collected from many sources and grown in a " source nursery ". Superior plants may be inbred for one or more generations, to fix desirable characters.
2. From the source nursery, a few, i.e., 100 or 200 superior clonal lines are isolated and screened to pick out the best and most vigorous clones.

3. A limited number (10–30) of superior clones are growr in a separated nursery and the seed resulting from polycross pollination is harvested and bulked by clones.
4. Seed from these polycrosses is grown in performance tests and the clones are judged for merit.
5. On the basis of this polycross progeny performance, 4–10 of the original clones are selected to be combined into a synthetic. The clones are grown in an isolated area and random inter-pollination is permitted.
6. Seed is harvested from each clone and bulked to grow the Syn_1 generation (This Syn_1 may, if desired, be used as a source nursery to start a new selection cycle).

   Open-pollinated seed from Syn_1 is harvested to form and grown Syn_2 and succeeding generations of the synthetic variety, for sale to farmers.

The exact procedures may have to be varied, to suit different forage crops and conditions (Poehlman, 1959).

Propagation of Breeding Material. Among forage crops, grasses have the advantage that they can be maintained by vegetative means whenever valuable germ-plasm has to be preserved. The tillers may be separated and planted in pots or in small plots. Establishment is easier and losses can be reduced if the tillers are first rooted in water, immersing them in about one inch of water and changing the water two or three times a day. Tillers from the same plant may be kept together by a string or elastic band. The tillers may be planted out when new roots grow about half an inch long. If the species is a stoloniferous one, the stolons or bits of stolons may be planted directly in the field or in pots in the green house.

Seed Propagation. When only a limited quantity of seed is available, it should be sown in petri dishes in finely sifted sterile soil, to make it easier to keep them at optimum temperatures. In many crops, seed from newly harvested plants shows poor germination on account of dormancy. Dormancy exists in varying degrees in many species of forage plants and often special treatments may be necessary to break the dormancy, such as alternation of temperatures, keeping the moistened seed at higher or lower temperature levels, scarification or pre-soaking in chemical solutions like potassium nitrate. An allied aspect is the loss of viability in storage; which in some species may be quite rapid.

Planting. For growing grasses in greenhouses, clay pots of suitable sizes are convenient. Two to four tillers, seedlings or germinated seeds can be grown in a six-inch pot. After planting, the soil around the plants should be 'firmed' in by hand. The soil or pot mixture should be one with adequate plant-nutrients and proper and timely plant-protection measures should be taken as and when needed in the course of plant growth.

Induction of Flowering. In the course of hybridization work it may be necessary to adjust the flowering time of the species and varieties intended for use as parents of crosses, so as to synchronise the flowering periods. This is done by suitable modifications of the day-lengths and temperature. It is of course essential to have the requisite background information regarding the photoperiodic and thermoperiodic responses of the species and varieties under reference as their behaviour would differ according as they are grown in temperate or tropical conditions and according to whether they are long-day or short-day plants.

Isolation and Hybridization. When forage crops that are naturally cross-fertilised are involved in breeding programmes, they have to be grown in ' spatial isolation ' to produce sufficient quantities of self-fertilised seed. Similar spatial isolation will be useful in producing synthetic strains and in preserving the purity of the strains that are already released. The main difficulty would be one of securing the requisite field or greenhouse space. The correct isolation distance will obviously depend on the species, on the flowering and maturity periods of different cultures and on the number of plants in each isolation block. This question again, is one that should be determined by preliminary tests before the breeding programme is actually started.

Isolation by bagging. " Bagging " or covering the inflorescences by cloth or paper bags or by other means is necessary to prevent contamination by extraneous pollen. Cotton fabrics, waterproof or plastic bags have been used by various workers; the size and shape of the bags will naturally depend on the nature of the inflorescence in the species under study. Wire or bamboo stakes are used to support the bags and it is desirable to leave some airholes for ventilation if the bags are to be tied up at the bottom of the inflorescences. The flag-leaf in grasses should be clipped off to prevent excess of humidity inside the bags and tents. Ordinarily bagging has no adverse effect on the seed-setting. When the number of plants to be crossed is large it would be desirable to have separate small greenhouses in place of bags or tents. These houses are closed when pollination is to be effected and the panicles swayed about by means of cords or strings from the outside.

Emasculation

In any programme of breeding, preliminary studies should be carried out on the anthesis and floral peculiarities of the species under study. In species with hermaphrodite flowers, emasculation will be necessary in making crosses. Here, too, a clear knowledge of the floral peculiarities is needed to decide upon the best method of emasculation. Dense, compact inflorescences will have to be thinned, by removing the topmost and lowermost spikes in grasses. The anthers are removed by means of fine-pointed

forceps. The use of a magnifying glass will be necessary in most cases. The anthers should be removed one or two days before they are due to dehisce; although it is easier to remove them when they are full-sized, the danger of contamination is then greater.

Bulk Emasculation

Hand emasculation is a slow process and not always successful, especially when the spikelets are small, as in *Cynodon* and *Phalaris* sp. and in such cases bulk emasculation by the " hot-water " method is convenient for many plants. The method is based on the fact that the thermal death-point of pollen is slightly lower than that for the ovary. The panicles are dipped for about five minutes in water at 45–55°C; both the temperature and the duration of dipping differ in different species and these have to be determined by preliminary tests. Treated panicles should be allowed to dry before they are bagged again. Although the method looks simple, a number of points need attention to avoid erratic results; the florets should be of the correct age, the time of the day is also important and for many species this hot-water treatment is more effective and less injurious at midday than in the morning or evening. The thickness of the glumes and the compactness of the panicle are the other points that need consideration and careful preliminary tests are essential before this method is used on any extensive scale.

The contact method or mutual pollination is the simplest and quickest method for crossing plants. Inflorescences of nearly the same age are bagged together, taking care that no flowers or spikelets have opened. The method can be adopted both in the field and in the greenhouse, although it is naturally more convenient in the greenhouse.

Pollination of emasculated spikelets is done in several ways; by means of bags, pollen guns or simply by brushing the stigmas of the maternal parents with detached panicles of the male parent. In any method, it is always preferable to make a second pollination, to ensure success.

Harvesting

The seeds from crossed plants are harvested when the culms turn brown (in grasses) and in the case of seeds that get easily shed, the panicles are left in the bag itself to dry. Under certain conditions even the immature seed can be harvested and used for germination. In sorghum it has been found that the seed can germinate even if gathered at the milk stage.

Threshing

For small experimental samples of seed, individual hand-threshing is the most reliable method.

Breeding Work on Forage Crops in India

In India, the study of forage crops and legumes has been taken up since 1925, starting in the form of introduction of new species from other countries like the United Kingdom and the U.S.A. Work on the improvement of grasses and legumes has been in progress at several centres, in the Punjab and Mysore from 1925, the Indian Agricultural Research Institute, New Delhi, from 1953, the College of Agriculture, Nagpur, from 1954 and the Agricultural Research Institute, Coimbatore, since 1956.

In the Punjab, which leads all other Indian States in its acreage under fodder crops, fodder improvement work started in 1925, first at Lyallpur and then at Sirsa from 1934. The work is mainly on breeding and agronomic aspects such as the effect of fertilizers, time and method of sowing, irrigation and other cultural practices. The crops dealt with are cultivated grasses like Guinea grass, Napier grass and Rhodes grass and pasture grasses like *Cynodon dactylon*, *Cenchrus ciliaris*, *Dichanthium annulatum* and *Eleusine flagellifera*. In addition to these, a few hill grasses are also under study at Palanpur in Gujarat. There is a keen demand for improved seeds of both grasses and legumes from the forage improvement centres in this State.

Dharwar College of Agriculture (Mysore)

A large collection of forage grasses and legumes was built up in 1945 by Sir William Jenkins and tested at three centres in the former Bombay State; this is now concentrated at one centre, Dharwar, since 1948. The work at this centre includes acclimatisation of superior exotic and indigenous forage crops, the improvement of indigenous forage grasses and legumes and studies on the establishment of balanced pastures and swards.

At the Indian Agricultural Research Institute, New Delhi, breeding work on pasture plants began in 1953, starting with *Cenchrus ciliaris* and *C. setigerus* for increased growth and earlier spring growth and on *Chrysopogon montanus*, *Chloris gayana* for increased vigour and yield and on *Pueraria* species for better winter hardiness. Before starting work on the breeding aspects preliminary information was gathered on the fertility aspects and the extent of the inter-fertility and sterility of different species. While *Cenchrus ciliaris*, *Pennisetum orientale* and other species were all self-fertile, *Chrysopogon montanus* did not set any seed when bagged; this needs further study. It is programmed at this centre to adopt the polycross technique for the evaluation of selections from cross-fertilized species, to serve as the basic material for the multiplication of improved strains of forage crops.

At the College of Agriculture, Nagpur (Maharashtra) the main objectives in forage research are to isolate high-yielding grass strains possessing palatability and nutritive value, with better root-systems and tillering capacity to withstand cattle-trampling and capacity to compete with other natural, undesirable grasses and to improve the drought resistance

of the desirable species. In legumes too, the objectives are to evolve high yielding forage types suitable or mixtures and double-cropping. The hybridization work is also intended for the isolation of *kharif* and *rabi* sorghums that can serve as green fodder or as dual-purpose crops for both grain and fodder.

At the Agricultural Research Institute, Coimbatore, the main objectives of fodder research are:

(1) Maintenance and study of grasses and legumes that are collected from different sources,
(2) Study of their characteristics and fodder values,
(3) The drought-resistance or otherwise of the various species,
(4) Study of the response to fertilizers of five major grasses and lucerne,
(5) Yield evaluation tests on 12 important fodder grasses,
(6) Experiments with annual legumes in rotation with sorghum and cotton.

BIBLIOGRAPHY

AGRAWAL, S. C. and REGE, N. D. 1961. Plant Introduction. *Gosamvardhan*, **8,** 7–10.

AIYADURAI, S. G. 1950. Thin Napier grass, a useful fodder for semi-dry tracts. *Madras Agric. Jour.*, **37,** 335–8.

ARAKERI, H. R., CHALAM, G. V. and DONAHUE, R. L. 1959. "Soil Management in India." Asia Publishing House, pp. 576.

AYYANGAR, G. N. R. 1935. Juiciness and Sweetness in Sorghum stalks. *Madras Agric. Jour.*, **23,** 350–2.

AYYANGAR, G. N. R. AYYAR, M. A. S., RAO, V. P. and NAMBIAR, A. K. 1936. Mendelian Segregations in Juiciness and Sweetness in Sorghum Stalks. *Madras Agric. Jour.*, **24,** 247–8.

BALWANI, T. L. 1962. What you feed your cattle. *Ind. Fmg.*, **12,** p. 9.

BAPAT, G. M. 1942. Dry Napier grass, *Ind. Fmg.*, **3,** 590–1.

BARUCHA, F. R. 1938. The problem of grassland improvement in India. *Curr. Sci.*, **6** (2), 600–1.

BERGER, J. 1962. *Maize Production and the Manuring of Maize.* Centre d'Etude de l'Azote, Geneva.

BINGEFURS, S. 1959. Practical experience of Tetraploid Clovers, in Sweden. *Genetics & Agric.*, **11,** 173–80.

BLATTER, E. and MCCANN, C. 1935. "The Bombay Grasses", I.C.A.R. Monographs, No. 5, pp. 322.

BOR, N. L. 1938. The vegetation of the Nilgiris, *Ind. Forester*, **64,** 600–9.

——— 1960. "Grasses of Burma, Ceylon, India and Pakistan", Pergammon Press, London.

BROWN, W. R. 1924. Kikuyu grass, *Agric. Jour. India*, **19,** 32–5.

BULL, S. and CARROLL, W. E. 1949. *Principles of Feeding Farm Animals*, Interstate Printers & Publ, Ill, U.S.A.

BURNS, W. 1939. The botanical side of the grassland problem in India, *Agric. & Livestock, India*, **9,** 389–94.

BUTTERWORTH, M. H. 1961. Studies on Pangola grass at the Imp. Coll. Trop. Agric., Trinidad, *Trop. Agric. (Trin.)*, **38,** 305–310.

CHANDRASEKHARAN, S. N., PARTHASARATHY, S. V. and DANIEL SUNDARA RAJ 1948. Fodder grasses of Madras, *Madras Agric. Jour.*, **35**, 389–394.

CHATTERJEE, I. B. 1938. Can water hyacinth be used as a cattle-feed? *Agric. Livestock, India*, **8**, 547–553.

CHATURVEDI, M. D. 1948. The role of leaf fodders in Uttar Pradesh, *U.P. Forest Dept. Bull.* No. **19**, 9.

CHAVAN, A. R. and MEHTA, A. R. 1955. Studies on the grasses of Gujarat, I., *Jour. M.S. Univ., Baroda*, **4**, 97–102.

——— and ——— 1955. *Ibid*-II, Grasses of Baroda and its environs, *Jour. M.S. Univ., Baroda*, **7**, 67–83.

COMMONWEALTH AGRIC. BUREAU 1947. The use and misuse of shrubs and trees as fodder, *Joint Publ.* No. **10**, 231.

DABADGHAO, P. M. 1960. Types of grass covers of India and their management, *Proc. of the 8th Internat. Grassland Congress*, 1960.

DAS GUPTA, N. C. 1947. A survey of the fodder requirements of livestock in Uttar Pradesh, *Ind. J. Vet. Sci.* **17**, 34.

——— 1957. Jharua grass, *Ind. Fmg.* **7**, 34.

DATTA, D. and GOSSIP, F. G. 1931. Fodder crops in Bengal, *Agric. & Livestock, India*, **1**, 266–273.

DHARMANI, L. C., LAHORA, K. S. and AKBAR ALI, N. 1947. Some digestibility trials on Indian feeding stuffs—XIII. Desi sugarcane, *Ind. J. Vet. Sci. & Anim. Husb.*, **17**, 261.

DUTHIE, J. F. 1898. Food and Fodder for Cattle *Dict. Econ. Prod. India*, Vol. III.

FINNEY, D. J. and PANIKKAR, M. R. 1953. Experimental tests of mixed farming in India, *Ind. Jour. Agric. Sci.*, **23**, 269–281.

FOSTER, W. H. and MUNDY, E. J. 1961. Forage species in North Nigeria, *Trop. Agric. (Trin.)*, **38**, (*4*), 311-318.

FRANDSON, H. N. 1940. Some breeding experiments with Timothy, *Imp. Agric. Bur., Joint Publ. No.* **3**, pp. 92.

FYSON, P. F. 1915. *The Flora of Nilgiris and Palni Hilltops*; Govt. Press, Madras, pp. 475.

GANDHI, R. T. and DABADGHAO, P. M. 1956. Hubam Clover *Ind. Fmg.* **6**, p. 14.

GANGULI, B. D. and RELWANI, L. L. 1954. Berseem, *Ind. Fmg.* **4**, p. 28.

GIDDENS, U. 1959. Nitrogen applications to new and established stands of Alfalfa, *Agron. Jour.*, **51**, 574.

GOVT. OF BOMBAY 1914. The Fodder Problem of the Bombay Presidency.

GOVT. OF MADRAS 1946. A quantitative study of the fodder and grazing resources of the Madras Province.

———— 1946. *Fodder and Grazing Atlas of the Madras Province*; Central Survey Office, Madras.

HALL, M. 1948. 500 varieties of Herbage and Fodder Plants, *C.A.B. Pasture and Field Crops*, Bull. No. **39**.

HALNAN, E. T. and GARNER, F. H. 1946. "The Principles and Practice of feeding Farm Animals," Longmans Green & Co., London.

HARBANS Singh 1964. "Problem of Cattle Development in India," Bharat Krishak Samaj Year-Book, p. 439.

HARLAN, J. R. 1950. The breeding of Side-oats Grama in partially isolated populations, *Agron. Jour.*, **42**, 20–24.

HELBERG, A. *et. al* 1959. Investigations on different ensiling additives; Ref. *Herbage Abstr.*, **30**, (1960), 560.

HENRICHS, D. H. and KNOWLES, R. P. 1950. Studies of combining ability in Brome grass and Crested Wheat-grass, *Sci. Agric.*, **30**, 275–302.

HITCHCOCK, A. S. 1935. *Manual of the grasses of the United States*, U.S.D.A., Misc. Pub. No. 200.

HOGG, P. G. and AHLGREN, H. L. 1943. Environmental Breeding and Inheritance studies of hydrocyanic acid in *Sorghum vulgare* var. *Sudanense*, *Jour. Agric. Res.*, **67**, 195–210.

HUGHES, H. D., HEATH, M. E. and METCALFE, D. S. 1951. "The Science of Grassland Agriculture." Iowa State College Press, Ames, Iowa.

HULL, F. H. 1945. Recurrent selection for specific combining ability in corn, *Jour. Amer. Soc. Agron.*, **37**, 134–145.

ISAAC, I. and LLOYD, A. T. E. 1959. Lucerne Wilt, *Ann. Appl. Biol.*, **47**, 673–684.

JENKIN, T. J. 1931. The method and technique of selection, breeding and strain-building in grasses, *Imp. Bur. Plant Genetics*: *Herbage Plants, Bull. No.* 3, 5–34.

JOACHIM, A. W. R. and KANDIAH, S. 1944. The effect of Napier grass fallow on the soil composition and structure, *Trop. Agriculturist*, **100**, 75–81.

JOHNSON, H. W. 1936. The effect of leaf-hopper yellowing upon the carotene content of alfalfa, *Phytopathology*, **26**, 1061–63.

JOSHI, A. B. and PATIL, B. D. 1960. Grasses that defy drought, *Ind. Fmg.*, 10, 25–27.

KAPADIA, G. A. 1945. Notes on some grasses from Junagadh, *Jour. Bom. Nat. Hist. Soc.*, **45**, 259.

KEHAR, N. D. 1948. Investigations of Famine Rations: *Saccharum spontaneum*, *Ind. Jour. Vet. Sci. & Animal Husb.*, **18**, 211.

KEHAR, N. D., RAY, S. C. and NEGI, S. S. 1949. Digestibility and nutritive value of *Usar* grass hay, *Ind. Jour. Vet. Sci. Anim. Husb.* **19**, 137.

KELBNY, G. P. 1959. Report on the development of legume crops, *F.A.O.Report* No. 1094, pp. 48.

KRISHNASWAMI, N. and RAMAN, V. S. 1949. Notes on an amphidiploid of the hybrid of *Pennisetum typhoides* and *P. purpureum*, *Curr. Sci.*, **18**, 15–16.

KUMAR, L. S. S. 1946. Better Utilisation of forest grassland in Bombay Province, *Ind. Forester*, **72**, 162–4.

LANDER, P. E. 1942. *I.C.A.R. Misc. Bull.* No. 16, pp. 113.

———— and DHARMANI, L. C. 1944. Digestibility Trials on Indian Feeding stuffs, *Ind. Jour. Vet. Sci. & Anim. Husb.*, **14**, 13.

LANDER, P. E. 1949. "The Feeding of Farm Animals in India," Macmillan & Co. Ltd., p. 492.

LEA, J. D. and PASSMORE, R. G. 1958. Grazing periods and bullock growth-rates on Elephant grass and Rhodes grass; *Progress Rept. Emp. Cotton Growing Corpn.*, Ref. *Herbage Abs.* **30**, No. 435.

MALIK, H. C. 1953. Production of Teosinte fodder in relation to water supply and application of fertilisers; *Punjab Farmer*, **5** (*2*), 20–21.

MANN, H. H. 1921. Fodder Crops of Western India; *Bull. No.* 100, *Bombay Dept. Agriculture.*

MAYNARD, L. A. 1951. "Animal Nutrition"; McGraw Hill Book Co., N.York.

MCKEE, R. and PIETERS, A. J. 1937. "Breeding miscellaneous Forage and Cover-crop Legumes," Year Book of Agric. U.S.D.A., 999–1031.

MILLER, T. B. 1961. Studies on the nutrition of Zebu cattle in N. Nigeria, *Emp. Jour. Exper. Agric.*, **29**, 230.

MIRCHANDANI, T. J. and DABADGHAO, P. M. 1949. *Science and Culture*, **14**, 433.

MIRCHANDANI, P. M. and SINGH, B. 1958. Renovation of grazing lands in the Damodar catchment; *Jour. Soil Water Conservation of India*, **7**, 14–18.

MOLLISON, J. 1893. Agricultural Ledger No. 18.

MORRISON, F. B. 1936. "Feeds and Feeding"; Morrison Publ. Co., N.Y.

MUKHERJEE, R. and PARTHASARATHY, D. 1948. The digestible nutrients of certain cereal grains; *Ind. Jour. Vet. Sci. & Animal Husbandry*, **18**, 41.

MUKERJEE, S. K. and MAHANTA, G. C. 1953–1954. Evaluation of Choumoellier as a Rabi fodder crop for Bihar; *Proc. Bihar Acad. Agric. Sci.*, **2 & 3**, pp. 31–37.

MURARI, T. 1932. The nutritive value of Kolukkattai grass dried artificially; *Agric. Livestock, India*, **2**, 380–382.

MUSTAFA, A. M. 1930. Cultivation of berseem in the N.W. Frontier Province; *Agric. Jour. India*, **25**, 138–142.

NAIDU, K. J. V. R. 1932. "Fodder Crops in India," Ananda Press, Madras.

NAIR, P. D. and SAGREIYA, K. P. 1944. *The fodder and grazing position in the Central Provinces and suggestions for its improvement*; Govt. Press, Nagpur, p. 51.

NANDA, P. C. and KHERA, R. C. 1959. Grasses can reclaim *usar* soils and provide fodder too; *Ind. Fmg.* **9** (*5*), 7–8.

NARSINGH DASS 1965. Sweet Sudan grass; *Ind. Fmg.*, **15**, p. 12.

PAL, B. P. and SINGH, H. 1948. Exploration of new fodder crops, in addition to improving the existing ones; *Proc. 7th Meeting Crops & Soils Wing, Bd. Agric. & Anim. Husb. of India*, 391–96.

PATIL, B. D. 1964. Pusa Giant Napier Grass; *Bharat Krishak Samaj Year Book*; p. 469.

———— and GHOSH, R. 1962. The grass that shrugs off drought and cold, *Ind. Fmg.*, **12**, p. 11.

PATTERSON, D. D. 1933. The influence of time of cutting on the growth, yield and composition of typical fodder grasses; *Jour. Agric. Sci.*, **23**, 615–41.

POEHLMAN, J. M. 1959. "Breeding Field Crops," Henry Holt and Company Inc., N.Y.

PURI, G. S. 1961. Grasslands of Western India; *Gosamvardhan*, **8**, 16–21.

RAHEJA, P. C. and OBRAL, S. R. 1953. Why practise mixed farming? *Indian Fmg.*, **3**, 20–21, 30–31.

——— 1956. Your Crops; *Ind. Fmg.* **6**, p. 17.

——— *et. al.* 1959. Crop response to micro-nutrients under Indian conditions; *Ind. Jour. Agron.* **3**, 254–63.

RAMASOMAYAJULU, M. V. 1953. Watergrass, a suitable fodder for the Araku valley; *Madras Agric. Jour.*, **40**, 426.

RAMIAH, P. V. 1932. Studies on South Indian pastures: I. Seasonal variations in the mineral and nitrogen content of spear-grass; *Ind. Jour. Vet. Sci.*, **3**, 65–84.

——— 1941. Detailed Report of the Animal Nutrition Scheme, Madras; I.C.A.R. Pub., 1940–41.

RANGACHARI, K. and MUDALIAR, C. T. 1921. *A Handbook of some South Indian Grasses*; Govt. Press, Madras.

RANGASWAMI AYYANGAR, G. N. and NARAYANAN, T. R. 1940. Fodder Crops in the Madras Presidency; *Madras Agric. Jour.*, **28**, 2–14.

RAO, K. V. 1959. Need for pasture development in Bellary district, *Jour. Soil Water Conserv. India*, **7**, 91–98.

REGE, N. D. and SRINIVASAN, V. 1956. Grasses that stabilise the soil; *Ind. Fmg.*, **6**, (7), 39–41.

ROACH, W. A. and DEL BEYERS, C. P. 1959. Copper and molybdenum deficiencies in winter rainfall areas; *Fmg. in S. Africa*, **35**, 13–14.

ROTH, V. D. 1959. Alfalfa seed-treatment for spotted aphid control in S. Arizona; *Jour. Econ. Entom.*, **52**, 654–8.

ROWNTREE, J. B. 1940. Grazing versus Burning as an aid to *Sal* regeneration; *Ind. For.* **66**, 645–53.

SAINI, H. R. 1937. *Fodder Crops of the Punjab*; Supdt. Govt. Printing Press, Lahore, p. 54.

——— and MALLICK, H. C. 1947. Varieties of lucerne for cultivation in the Punjab; *Ind. Jour. Agric. Sci.* **17**, 94–100.

SAYER, W. 1934. Berseem as green fodder, hay and silage; *Agric. Livestock, India*, **4**, 21–28.

SEN, BOSHI 1942. Giant Star-grass; *Ind. Fmg.*, **3**, 421–4.

SEN, K. C. 1953. *Animal Nutrition Research in India*; Animal Husbandry Manuals, I.C.A.R., Macmillan & Co., p. 370.

——— and RAY, S. N. 1964. *Nutritive values of Indian cattle feeds and the feeding of animals*; I.C.A.R. Bull. No. 25, New Delhi, p. 133.

SEN, S. K. and PREMNATH 1962. *Handbook of Animal Husbandry*; I.C.A.R. Pub., New Delhi.

SHEPHERD, W. 1959. Effects of chemical desiccants on the speed of curing hay; *Jour. Austral. Inst. Agric. Sci.*, **25**, 218–21.

SHIVA RAO, B. and CHANDRASEKHARAN, S. N. 1947. A note on the pasture value of Giant Star grass; *Ind. Fmg.*, **68**, 121.

SIKKA, L. C. 1947. An estimate of the food requirements of milch and other cattle in India; *Ind. Jour. Vet. Sci. & Anim. Husb.*, **17**, 29.

SPRAGUE, G. F. 1955. "Corn and Corn Improvement"; Academic Press Inc., N.Y.

SRINIVASAN, V. and VENKATRAMAN, K. 1962. Co 11. Jowar; *Ind. Fmg.*, **12**.

STAPLEDON, R. G. 1928. Cocksfoot grass: Ecotypes in relation to the Biotic factor; *Jour. Ecol.*, **16**, 71–104.

STEWART, A. B. 1947. *Report on the Soil Fertility Investigations in India with special reference to manuring*; Manager of Publications, New Delhi.

SUBBIAH MUDALIAR, V. T. 1955. "Common Cultivated Crops of South India"; Amudha Nilayam, Madras, p. 606.

SUNDARA RAJ, D. D. and BALASUBRAMANIAN, G. 1959. "Guide to the Economic Plants of South India"; Amudha Nilayam, Madras.

TADULINGAM, C. and NARAYANA, G. V. 1932. "A Handbook of some South Indian weeds"; Govt. Press, Madras, p. 356.

TARR, S. A. J. 1962. "Diseases of Sorghum"; Commonwealth Mycol. Inst., Kew, U.K., p. 380.

TISDAL, H. M. 1940. The History and Performance of the new Alfalfa strain A-136 (Ranger); *Ann. Rept. Internat. Crop Improvement Assoc.*, **22**, 44–52.

UNITED STATES DEPT. AGRICULTURE 1953. "Year Book of Agriculture", 1953; Plant Diseases.

WATTS, G. 1892. "A Dictionary of the Economic Products of India"; Supdt. Govt. Press, Calcutta; p. 594.

WEALTH OF INDIA 1958–1963. Manager of Publications, New Delhi.

WHEELER, W. A. 1950. "Forage and Pasture Crops, a Handbook"; D. Van Nostrand Company, Inc. N.Y., p. 752.

WHYTE, R. O. 1953. The Agronomy of Fodder Production in India; *Jour. Soil Water Conservation, India*, 1, 20–3.

———— 1955. Grasslands in Soil Conservation; *Jour. Soil Water Conservation, India*, **3**, 70–71.

———— 1964. *The Grassland and Fodder Resources of India*; I.C.A.R. Scientific Monographs, No. 22, New Delhi.

————, NILLSON-LEISSNER, G. and TRUMBLE, H. C. 1953. "Legumes in Agriculture"; F.A.O. Agric. Studies, No. 21.

WHYTE, R. O. 1958. Plant Exploration, Collection and Introduction; F.A.O. Agric. Studies, No. 41.

———— 1959. "Grasses in Agriculture" F.A.O. Agric. Studies No. 42.

———— 1959. "Grassland and Fodder Development in Asia and the Far East"; F.A.O. Meeting on Dairy Problems, New Delhi, Dec. 1959, 14–21.

WOOD, R. C. 1952. "A Notebook of Agricultural Facts and Figures"; Govt. Press, Madras, p. 459.

WOODMAN, H. E. 1945. "The Composition and Nutritive Values of Feeding-stuffs"; Min. Agric. H. M. Stationery Office, London, Bull. No. 124.

WRIGHT, N. C. 1937. "Report on the Development of the Cattle and Dairy Industries in India"; Manager of Publications, New Delhi, p. 184.

YADAV, J. S. P. 1960. Soils of the Dry Zones of India; *Indian Forester*, **86**, 274–295.

YEGNA NARAYANA AYYAR, A. K. 1949. Mixed Cropping in India; *Jour. Agric. Sci.*, **19**, 439.

———— 1950. "Field Crops of India"; Bangalore Press, p. 686.

ZALESKI, A. 1959. Effect of germination and seedrates on the Establishment, Mortality and Yield, Dry matter and Protein in Lucerne; *Jour. Agric. Sci.*, **54**, 260.

APPENDIX I

Popular and Scientific Names of Grasses and Legumes

African millet	*Eleusine coracana* Gaertn.
Alaska onion grass	*Melica subulata* (Griseb), Scribn.
Alfagrass	*Stipa tenacissima* L.
Alkali grass	*Puccinellia* Parl. species.
Annual Bluegrass	*Poa annua* L.
Aparejo grass	*Muhlenbergia utilis* (Ton.) Hitchc.
Arctic Bluegrass	*Poa arctica* L.
Australian chess (grass)	*Bromus arenarius* Labill.
Bahia grass	*Paspalum notatum* Flugge.
Barnyard grass	*Echinochloa crusgalli* (L) Beauv.
Bermuda grass	*Cynodon dactylon* Pers.
Basket grass	*Oplismenus hirtellus* (*Panicum variegatum*).
Beach grass	*Ammophila* species.
Beard grass	*Andropogon* species.
Blou Buffel	*Cenchrus glaucus.*
Blue grass (31 spp.)	*Poa* species; *Dichanthium* species also.
Buffalo grass	*Buchloe dactyloides* Nutt.
Bent grass	*Agrostis* L. species.
Big Bluegrass	*Poa ampla* Merr.
Billion dollar grass	*Echinochloa crusgalli* var. *frumentacea.*
Blue stem	*Agropyron smithii* Rydb.
Bottle brush	*Hystrix patula* Moench.
Bristle grass	*Setaria* species.
Brome grass	*Bromus* L. species.
Broomcorn millet	*Panicum miliaceum* L.
Bunch grass	*Sporobolus airoides* (Torr.) Toit.
Bur Bristle-grass	*Setaria verticillata* (L) Beauv.
Canary grass	*Phalaris* L. species
Cocksfoot	*Dactylis glomerata* L.
Colonial Bent grass	*Agrostis tenuis* Sibth.
Columbus grass	*Sorghum almum*
Couch grass	*Agropyron repens*
Crested Wheat grass	*Agropyron desertorum*
Carpet grass	*Axonopus compressus* (Swartz) Beauv.
Catchfly grass	*Leersia lenticularis* Michx.
Centipede grass	*Eremochloa ophiuroides*
Citronella grass	*Cymbopogon* species
Cloud grass	*Agrostis nebulosa*
Cord grass	*Spartina* species
Coracan millet	*Eleusine coracana* Gaertn.
Corn	*Zea mays* L.
Crab grass	*Digitaria* species
Crested Dogtail	*Cynosurus cristatus* L.

Crinkle awn	*Trichopogon montufari* (HBK.) Nees.
Cup grass	*Eriochloa* (HBK.) species
Cut grass	*Leersia oryzoides* (L) Swartz.
Dallis grass	*Paspalum dilatatum* Poir.
Darnel	*Lolium temulentum* L.
Deer grass	*Muhlenbergia rigens* (Benth) Hitchc.
Desert needle grass	*Stipa speciosa* Trin. & Rupr.
Domestic ryegrass	*Lolium multiflorum* L.
Downy oatgrass	*Danthonia sericea* Nutt.
Dune grass	*Elymus mollis* Trin.
Durra	*Sorghum durra*
Eastern manna grass	*Glyceria septentrionalis* Hitchc.
Elephant grass	*Pennisetum purpureum.*
Elliott beard grass	*Andropogon elliotti* Chapm.
English bluegrass	*Festuca elatior* L.
English ryegrass	*Lolium perenne* L. (Perennial ryegrass)
Esparto	*Stipa tenacissima* L.
False buffalo grass	*Munroa squarrosa* (Nutt.) Torr.
Feather finger grass	*Chloris virgata* Swartz.
Feather-top	*Pennisetum villosum* R.Br.
Fescue (Blue fescue)	*Festuca ovina* var. *glacica*
Feterita	*Sorghum* species
Finger grass	*Chloris* species
Finger millet	*Eleusine coracana* Gaertn.
Fluff grass	*Triodia pulchella* HBK.
Fountain grass	*Pennisetum rupelli* Stapf.
Fowl bluegrass	*Poa palustris* L.
Fowl manna grass	*Glyceria striata* (Lam. Hitchc.)
Foxtail	*Alopecurus* L. species
Fragrant grasses	*Anthoxanthum odoratum* L., *Cymbopogon nardus* (L.) Rendle, *C. citratus*, *Heteropogon melanocarpus* (E11.) Benth., *Hierochloe antarctica* (Labill) R.Br. *Vetivaria zizanoides* (L.) Nash
Gama grass	*Tripsacum dactyloides* L.
Giant Setaria	*Setaria splendida*
Giant Star grass	*Cynodon plectostachyum*
Green Panic, Guinea grass	*Panicum maximum* Jacq.
Guatemala grass	*Tripsacum laxum* var. *trichoglume*
Geyser onion grass	*Melica geyseri* Munro
Goat grass	*Aegilops* species
Golden top	*Lamarckia aurea* (L.), Muench.
Grama grass	*Bouteloua* Lag. species
Green Bristle-grass	*Setaria viridis* (L) Beauv.

Hair fescue	*Festuca capillata* Lamk.
Hair grass	*Deschampsia* Beauv. species
Hard fescue	*Festuca ovina* var. *duriuscula* (L) Koch
Hardin grass	*Phalaris tuberosa* (Hack.), Hitchc.
Herdsgrass	*Phleum pratense* L. (Timothy)
Himalayan fairy grass	*Miscanthus nepalensis* (Trin.), Hack.
Holy grass	*Hierochloa antarctica* (Labill.) R.Br.
Howell blue-grass	*Poa Howellii* Vasey & Scribn.
Hungarian brome-grass	*Bromus catharticus* Vahl.
Idahoe red-top	*Agrostis idahoensis*
Idahoe fescue	*Festuca idahoensis* Nash
Indian love-grass	*Eragrostis pilosa* (L) Beauv.
Indian corn (Maize)	*Zea mays* L.
Indian grass	*Sorghastrum nutans* (L) Nash
Inland blue-grass	*Poa interior* Rydb.
Italian millet	*Setaria italica* (L) Beauv.
Italian ryegrass	*Lolium multiflorum* Lam.
Japanese chess	*Bromus japonicus* Thunb.
Japanese lawngrass	*Zoysia japonica* Steud.
Japanese millet	*Echinochloa crusgalli* var. *frumentaceum*
Johnson grass	*Sorghum halepense* (L) Pers.
Jaragua	*Hyparrhenia rufa* (Nees) Stapf.
Job's tears	*Coix lachryma-jobi* (L).
June grass	*Koeleria cristata* (L) Pers.
Jungle rice	*Echinochloa colonum* (L) Link.
Kafir	*Sorghum cafforum.*
Kaoliang	*Sorghum nervosum*
Kentucky b luegrass	*Poa pratensis*
Khas-khas, (Khus-khus)	(Vetiver) *Vetiveria zizanoides* (L) Nash.
Knot grass	*Paspalum distichum* L.
Knot-root bristlegrass	*Setaria geniculata* (Lamk.) Beauv.
Kolukattai grass	*Cenchrus ciliaris* L.
Korean lawn grass	*Zoysia japonica* Steud.
Korean velvet grass Mascarene grass	*Zoysia tenuifolia* Willd.
Lemon grass	*Citronella citratus* (DC) Stapf
Lace-grass	*Eragrostis capillaris* (L) Nees
Love-grass	*Eragrostis* Beauv. species
Maiden cane	*Panicum hemitomom* Schult.
Maize	*Zea mays* L.
Malojilla	*Eriochloa polystachya* HBK.
Manilla grass	*Zoysia matrella* (L) Merr.
Manna grass	*Glyceria* R.Br. species

Meadow fescue	*Festuca pratensis* L.
Marram (European beach-grass)	*Ammophila arenaria* (L), Link.
Mascarene grass	*Zoysia tenuifolia* Willd.
Mat grama	*Bouteloua simplex* Leg.
Melic grass	*Melica* L. species.
Mesquite grass	*Hilaria belangeri* (Steud.), Nash.
Mexican love-grass	*Eragrostis mexicana* (Hornem) Hitchc.
Mexican teosinte	*Euchlaena perennis*
Millet, African	*Eleusine coracana* Gaertn.
Millet, Broomcorn	*Panicum miliaceum* L.
-do- Browntop	*Panicum fasciculatum* Swartz.
-do- Coracan (finger millet)	*Eleusine coracana* Gaertn.
-do- Italian	*Setaria italica* Beauv.
-do- Japanese	*Echinochloa crusgalli* var. *frumentacea* (Roxb.) Wight.
-do- Pearl	*Pennisetum typhoides* Stapf. et Hubb.
-do- Proso	*Panicum miliaceum* L.
-do- Texas	*Panicum texanum* Buckl.
Milo	*Sorghum* species.
Miracle wheat	*Triticum turgidum*
Molasses grass	*Melinis minutiflora* Beauv. (Efwatkala grass).
Mountain bunch grass	*Festuca viridula Vasey* (Green-leaf fescue)
Mountain hair grass	*Deschampsia atropurpurea* (Wahl.) Scheele.
Mouse barley	*Hordeum murinum* L.
Mummy wheat	*Triticum turgidum* (Miracle wheat)
Mutton grass	*Poa fendleriana* (Steud) Vasey.
Mutton long tongue	*Poa longiligula* Scrib. & Willd.
Natal grass	*Tricholaena rosea* Nees.
Napier grass	*Pennisetum purpureum* Schumach.
Naid grass	*Cymbopogon nardus* L. (Citronella grass).
Narrow plume grass	*Erianthus strictus* Baldw.
Needle and thread	*Stipa comata* Trin. & Rupr.
Needle grass	*Stipa* L. species.
Nevada blue grass	*Poa nevadensis* Vasey.
New Mexican blue grass	*Poa occidentalis* Vasey.
New Mexican feather grass	*Stipa neo-mexicana* (Thurb.) Scrib.
New Mexican muhly	*Muhlenbergia pauciflora* Buckl.
Nit grass	*Gastridium ventricosum* (Gowan) Schinz. & Thell.
Oat grass	*Danthonia* species.
Wild oats	*Avena fatua* L.
Onion grass	*Melica* species (typically *Melica bulbosa* Geyer).
Oil grass	*Cymbopogon* species
Orchard grass	*Dactylis* L. species.
Palm grass	*Setaria palmifolia* (Willd.) Stapf.
Pampas grass	*Cortaderia* Stapf. species.
Pangola grass	*Digitaria decumbens.*
Perennial rye grass	*Lolium perenne* L.
Purple onion-grass	*Melica spectabilis* Scribn,

Pappus grass	*Pappophorum* Schreb. species.
Para grass	*Panicum purpurascens* Raddi.
Patterson blue grass	*Poa pattersoni* Vasey.
Pearl millet	*Pennisetum typhoides* Stapf. & Hubb.
Peruvian winter grass	*Phalaris stenoptera*
Pine grass	*Calamgrostis rubescens* Buckl.
Plume grass	*Erianthus* species.
Porcupine grass	*Stipa spartea* Trin.
Purple top	*Triodia flava* (L) Smyth.
Rabbit foot grass	*Polypogon monspeliensis* (L) Desg.
Ragi	*Eleusine coracana* Gaertn.
Rattlesnake chess Rattle-snake grass	*Bromus brizaeformis* Fisch. & May.
Ravenna grass	*Erianthus ravennae* (L) Beauv.
Rescue grass	*Bromus catharticus* Vahl.
Red fescue	*Festuca rubra*
Red top	*Agrostis gigantea*
Rhodes grass	*Chloris gayana* Kunth.
Reed grass	*Calamagrostis* Adans. species.
Ribbon grass	*Phalaris arundinacea* var. *picta* L.
Rice grass	*Oryzopsis* Michx.
Ring grass	*Muhlenbergia torreyi* (Kunth.) Hitchc.
Rye grass	*Lolium* species.
Salt grass, desert	*Distichlis stricta* (Torr.) Rydb.
Satin tail	*Imperata hookeri* Rupr.
Scratch grass	*Muhlenbergia asperifolia* (Nees & Mey.) Parodi.
Semaphore grass	*Pleuropogon* R.Br. species.
Shallu	*Sorghum* species.
Short-hair	*Clamagrostis breweri* Thurb.
Sickle grass	*Pholiurus incurvus* (L) Schinz. & Thell.
Sleepy grass	*Stipa robusta* Scribn.
Smut grass	*Sporobolus poiretii* (Roem. & Schult.) Hitchc.
Snail clover	*Medicago scutellata*
Sorgho Sorghum	*Sorghum* species.
Sour grass	*Trichachne insularis* (L) Nees.
Spider grass	*Aristida ternipes* Cav.
Sprangle top	*Leptochloa* Beauv. species.
Spreading wheat grass	*Agropyron scribneri* Vasey.
Squirrel-tail	*Sitanion* Raf. species.
Stink grass	*Eragrostis cilianensis* (All.) Link.
Sudan grass	*Sorghum sudanense.*
Sugarcane	*Saccharum officinarum*
Sweet grass (Seneca grass, Holy grass, Vanilla grass)	*Hierochloe odorata* (L) Beauv.
Switch grass	*Panicum virgatum* L.
Sacaton	*Sporobolus wrightii* Munro
Saint Augustine grass	*Stenotaphrum secundatum* (Walt.

Smooth Brome grass	*Bromus inermis* Leyss.
Spear grass	*Heteropogon contortus* Beauv.
Tall fescue	*Festuca arundinacea.*
Tanglehead (Spear grass)	*Heteropogon contortus* (L) Beauv.
Tares	*Lolium temulentum* L.
Teff-grass	*Eragrostis abyssinica* (Jacq.) Link.
Thin grass	*Agrostis diegoensis* Vasey.
Tibisee	*Lasiacis divaricata* (L) Hitchc.
Tickle grass	*Agrostis hiemalis* (Walt) B.S.P.
Timothy	*Phleum* L. species.
Tobosa grass	*Hilaria mutica* (Buckl) Benth.
Toothache grass	*Ctenium aromaticum* (Walt) Wood.
Tuber oatgrass	*Arrhenatherum elatius* var. *Bulbosum.* (Wild.) Spenner.
Tumble grass	*Schedonnardus paniculatus* (Nutt.) Trel.
Tunis grass	*Sorghum virgatum* (Hack) Stapf.
Turkey foot	*Andropogon hallii* Hack.
Usar grass	*Sporobolus arabicus*
Uva grass	*Gynerium sagittatum* (Mubl) Beauv.
Vasey grass	*Paspalum urvillei* Steud.
Venezuela grass	*Melinis minutiflora.*
Vernal grass	*Anthoxanthum* L. species.
Vetiver	*Vetiveria zizanoides* (L) Nash.
Washington bent (Creeping bent)	*Agrostis palustris* Huds.
Water grass	*Brachiaria mutica.*
Weak manna grass	*Glyceria pauciflora* Presl.
Wedge grass	*Sphenopholis* Scribn. species.
Weeping lovegrass	*Eragrostis curvula.*
White spear grass	*Aristida leptopoda*
Wild rice	*Zizania* L. species.
Wire grass	*Cynodon dactylon* Pers.
Witch grass	*Panicum capillare* L.
Wolf tail	*Lycurus phleoides* HBK.
Woodblue grass	*Poa nemoralis* L.
Wooton three-awn	*Aristida pansa* Woot & Stand
Yabila grass	*Panicum queenslandicum*
Yellow bristle grass	*Setaria lutescens* (Weigel) F.T. Hubb.
Zawadke alkali grass	*Puccinellia nuttalliana* (Schult.) Hitchc.

APPENDIX II

GLOSSARY

Abortive	Imperfectly developed.
Accrescent	Increasing with age.
Accumbent	Lying against.
Acuminate	Gradually tapering to a sharp point.
Acute	Sharp-pointed but less tapering than acuminate.
Achene	A small, hard, dry indehiscent one-seeded fruit.
Actinomorphic	Symmetrical in several planes.
Adelphous	Of stamens united into one or more bundles.
Adnate	Attached by the whole length.
Adventitious	Arising irregularly.
Aestivation	The manner in which the parts of a flower are arranged and folded in the bud.
Aggregate	Collected or bunched together, as in the inflorescences of many species of *Andropogon*.
Albumen	The nutritive material stored in the seed *outside* the embryo.
Alveola	A surface cavity.
Amphitropous	Said of an ovule curved to bring the two ends near to each other.
Amplexicaul	Stem-clasping as in the bases of some leaves or petioles.
Anastomosing	When veins meet to form a net.
Anatropous	Said of an ovule inverted on its funicle, so that the opening is close to the hilum and the chalaza at the other end.
Androecium	The male parts of a flower.
Androgynous	Male and female flowers, in the same inflorescence.
Annular	In the form of a ring.
Annual	Completing its life cycle in one year.
Anther	That part of the stamen which contains the pollen.
Anthesis	The period during which a flower is open.
Anthocarp	A false fruit formed by the fusion of the whole or a part of the flower with the fruit itself.
Antrorse	Directed forwards or upwards; opposed to retrorse.
Apicula	A short, sharp, but not *rigid* point.
Appressed	Lying against an organ; the branches of an inflorescence may be appressed to the main axis.
Areole	A space marked out in any way; a small cell or cavity.
Aril or arillus	An appendage arising from the hilum and covering partly or wholly the seed, as in the mace of the nutmeg.
Arista	A bristlelike appendage, common in grasses.
Armed	Provided with spines or thorns.
Ascending	Sloping upward.
Articulate	Jointed.
Attenuate	Narrowed, tapering.
Auricle	Ear-shaped appendage or lobe.
Awn	A bristle-like outgrowth, longer than an *arista*; in grasses the awn is usually a continuation

	of the midnerve of the glume or lemma.
Axil	The upper angle formed between the axis and any organ arising from it, as that between a stem and a leaf on it.
Axile	Belonging to the *axis*.
Axillary	Situated in an *axil*.
Axis	An imaginary line around which organs are developed.
Baccate	Berry-like
Barbed	Furnished with retrorse projections as in the spines of *Cenchrus*.
Barbellate	Provided with short, stiff hairs; especially if retrorse.
Beak	A hard point or projection, usually in seeds or fruits.
Bearded	Furnished with long, stiff hairs.
Berry	A pulpy fruit with immersed seeds.
Biconvex	Convex or bulging outwards on both sides.
Bifid	Two lobed or cleft into two, as in the tips of glumes.
Blade	The part of a leaf above its stalk or sheath.
Bract	The reduced leaves of the inflorescence or upper part of a shoot.
Bracteole	A small bract, often on the petiole or immediately below or on the calyx.
Branch	A lateral stem.
Branchlet	A branch of the second or higher order in much-branched panicles, the main branches from the axis are branches of the first order, the branchlets from these branches of the second order, and so on.
Bristle	A stiff, slender, appendage; an awn is a kind of bristle. In grasses the term is applied to the modified branchlets at the base of the spikelets, as in *Setaria* and allied genera.
Bulb	A subterranean bud with fleshy scales as in the onion. Most of the so-called bulbs in grasses are *corms*.
Bulbil	A small, usually axillary bulb.
Bullate	Puckered; a surface with portions which are convex on one side and concave on the other.
Caducous	Falling off early.
Caespitose (Cespitose)	Tufted, as in many grasses.
Callus	An abnormally thickened part; in grasses an extension of the flowering bract below its point of insertion adhering to the axis of the spikelet.
Calycine	Resembling a calyx in texture, herbaceous.
Calyx	The outermost series of the parts of a flower.
Campanulate	Bell-shaped.
Campylotropous	Said of an ovule curved by unilateral growth so that the true apex is brought near the hilum.
Cancellate	Latticed.
Canescent	Becoming grey or hoary, gray - pubescent or hairy.
Capillary	So slender as to be hair-like.
Capitate	In a globular head-like cluster.
Capsule	A dry dehiscent fruit.
Carinate	Keeled; said of glumes, lemmas and other parts

	when flattened laterally with a sharp keel.
Carpel	Single modified leaf, forming an ovary or part of it and bearing the ovules.
Carpophyll	Carpel, but used specially when the carpel is open and the ovules are exposed.
Cartilaginous	Tough and elastic, like the rind of an apple.
Caruncle	Protruberance near the attachment of a seed.
Caryopsis	Grain or fruit in grasses, where the seed-coat is fused with the pericarp of the fruit.
Catkin	Spike of unisexual, apetalous flowers, solitary or twin in the axils of bracts.
Caudate	With a tail-like tip.
Caudicle	A small tail-like organ.
Caulescent	Having an obvious, though not large stem.
Cauline	Pertaining to or arising from the stem.
Centrifugal	Developing from the centre outwards.
Centripetal	Developing from the outside towards the centre.
Chalaza	That part of the ovule or seed where the nucleus is nearest the integuments.
Chartaceous	Papery.
Chlorophyll	The green colouring matter of plants.
-cidal	Suffix denoting dehiscence, e.g. *septicidal*-splitting along the septum, *loculicidal*-splitting down the middle of the carpel.
Cilia	Marginal hairs.
Cinereous	Somewhat ashy in tint.
Circinnate	Coiled.
Cladode	A branch or single internode simulating a leaf.
Cladophyll	A branch assuming the form and function of a leaf.
Clavate	Club-shaped.
Claw	The narrowed base of an organ, especially of a petal.
Cleistogamous	Flowers that are fertilized within the unopened flower, e.g. as in Subterranean Clover.
Coccus	One part of a lobed fruit becoming more or less detached from the rest and usually derived from a single carpel.
Collar	The area on the outer side of a leaf at the junction of the leaf-sheath and blade.
Collateral	Placed side by side at the same level,
Columella	A persistent axis around which the carpels of some fruits are arranged.
Column	The fusion of stamens or of style and stamens, to form a solid body.
Coma	The tuft of hairs at the end of some seeds.
Compact	Said of close-set flowers on the inflorescence.
Compressed	Flattened laterally.
Commisure	The face of adherance, of two carpels.
Complicate	Folded lengthwise upon itself.
Compound	Formed of similar parts grouped in a whole.
Conduplicate	Folded together lengthwise.
Confluent	Blended or merged into one.
Connate	United to one another.
Connective	The portion of a stamen, distinct from the filament, which connects the lobes of an anther.
Continuous	Said of a rachis or other organs, which do not articulate.
Contracted	Short and densely set, as in an inflorescence, the opposite of open or spreading.

Convex	Bulging or rounded outwards.
Convolute	Rolled longitudinally, mostly in leaf-blades, one edge being inside and the other outside.
Cordate	Heart-shaped.
Coriaceous	Leathery.
Corm	A bulb-like fleshy stem or base of stem.
Corniculate	Bearing one or more little horns.
Corolla	The interior series of the perianth.
Corolline	Resembling petals in texture.
Corona	An inner appendage to the corolla, shaped like a coronet or a more or less interrupted appendage to the stamens.
Corymb	A centripetal inflorescence where the outer branches or pedicels arise at different levels but grow longer to form a flat-topped cluster.
Costate	Ribbed.
Cotyledon	The leaf or pair of leaves inside the seed.
Crenate	Toothed, with rounded teeth.
Cristate	Crested.
Crown	The persistent base of a tufted perennial herbaceous grass.
Culm	Jointed stem of grasses.
Cuneate	Wedge-shaped, with the narrow part below.
Cupule	A small cup.
Cuspidate	Tipped with a short, sharp, rigid point.
Cymbiform	Boat-shaped.
Cyme	A centrifugal inflorescence on which the secondary or lateral branches continue to grow and extend beyond the main axis.
Cystolith	A mineral concretion in the cell of a leaf.
Deciduous	Falling off, not persistent.
Declinate	Bent or curved downward or forward.
Decompound	Repeatedly branched or divided or compound.
Decumbent	Curved upward from a horizontal or inclined base, said of stems or culms.
Decurrent	Prolonged downwards from the base.
Decussate	In pairs alternately at right angles.
Definite	Not numerous, said of stamens not exceeding five.
Dehiscent	Splitting into definite parts.
Deltoid	Shaped like an equilateral triangle.
Dense	Said of inflorescences in which the spikelets are crowded—the opposite of open or loose.
Dentate	Sharply toothed, with teeth not pointing forward.
Depauperate	Reduced or undeveloped, said of stunted or dwarfed plant specimens.
Dichasium	A centrifugal inflorescence in which all the axes end in flowers below which lateral opposite branchlets arise.
Dichotomous	Forked.
Diclinous	Unisexual with the stamens and pistils in separate flowers.
Didymous	In equal pairs or connected halves.
Didynamous	In two unequal pairs.
Diffuse	Open or much branched, said of panicles.
Digitate	Spreading like the fingers of a hand.
Dimidiate	One half wanting or rudimentary.
Dimorphous	Occurring in two different forms.

Dioecious The two sexes segregated on different plants.

Disc Development of the torus within the calyx and under or outside the pistil.

Distichous Arranged in two vertical rows.

Divaricate Widely and stiffly divergent as the branches of certain open panicles.

Dorsal Relating to the back of an organ.

Dorsiventral With a distinct upper and lower surface.

Drepaniform Sickle-shaped.

Drooping Erect to spreading at base, but inclining downward above, as the branches of a panicle.

Drupe A fruit with a more or less succulent flesh, enclosing a single one or many-celled stone.

Echinate Set with spines or prickles.

Effuse Loose and wide-spreading.

Ellipsoid Said of the shape of panicles, fruits or spikelets.

Elliptic Shaped like an ellipse, said of leaf-blades and other flat surfaces.

Elongate With the length many times the breadth.

Emarginate Deeply notched at the apex.

Embryo Incipient new plant within the seed.

Endocarp The inner layer of the wall of a fertilized ovary or fruit.

Ensiform Sword-shaped.

Epicarp The external layer of the wall of a fertilized ovary or fruit.

Equitant Folded over, as if astride, said of leaves when in vertical rows, with the bases of the outer leaves ensheathing the bases of the inner.

Erose Eroded, appearing torn or frayed.

Excurrent Running beyond; the midrib is excurrent from the lemma as an awn, in many grasses.

Exocarp Outer layer of a pericarp.

Exserted Protruded or protruding.

Extrorse Directed outwards, often referring to the opening of anthers.

Falcate Sickle-shaped.

-farious A suffix denoting parts, e.g. bifarious- in two parts.

Fascicle A close cluster or bundle.

Fastigiate With branches all clustered and erect.

Fenestrate Pierced with holes.

-ferous Suffix meaning bearing, e.g., Floriferous-bearing flowers.

Ferrugineous Rust-coloured.

Fibrillose Furnished with fibres.

-fid Cleft, e.g. bifid-cleft into two.

Filament Any thread-like body, especially the stalk of an anther.

Filiform Thread-shaped.

Fimbriate Fringed.

Fistular Hollow throughout the length.

Flabellate Fan-shaped.

Flaccid Flabby, limp.

Flagellum Whip-like appendage.

Flexuous Bent alternately in opposite directions.

Floccose, Flocculent Bearing or covered with locks of soft woolly hairs.

Floret The lemma and palea with included flower-parts (pistil and stamens).

Folded Conduplicate, said of leaf-blades.

Foliaceous	Of the shape and texture of a leaf.
Follicle	Fruit of a single carpel, opening by a ventral suture to which the seeds are attached.
Fovea, Foveola	A pit or depression.
-fragal	A suffix indicating breaking or splitting.
Fucoid	Resembling seaweed.
Fugacious	Rapidly falling off, soon perishing.
Fulvous	Tawny.
Funicle	The stalk present in many ovules and seeds.
Furcate	Forked.
Furfuraceous	Covered with bran-like scales or powder.
Fuscous	Dusky, greyish-brown.
Fusiform	Spindle-shaped, thick in the middle and tapering at both hands.
Galeate	Helmet-shaped.
Gamo-	Prefix indicating union, e.g. gamopetalous, petals united by their edges into one piece.
Geminate	In pairs.
Geniculate	Bent abruptly, like a knee.
Gibbous	Swollen on one side, humped.
Glabrous	Without any kind of hairs.
Glabrescent	With deciduous hairs, becoming glabrous.
Glaucous	Sea-green or bluish-green.
Gland	A protruberance or depression, usually minute, that secretes or appears to secrete a fluid.
Glochidiate	Bearing barbed bristles.
Glomerate	Collected in heads.
Glumaceous	Resembling the outer empty floral bracts of grasses.
Glumes	The pair of bracts at the base of a spikelet.
Gonophore	An elongation of the axis of a flower bearing the stamens and carpels.
-gonous	A suffix indicating an angled body, e.g. three-angled.
Gregarious	Growing in groups or masses.
Gynoecium	The entire female part of a flower.
Gynandrous	The stamens adnate to or borne on the pistil.
Gynobasic	Applied to a style arising from the base of the carpels.
Gynophore	An elongation of the axis, forming a stalk to the ovary.
Hastate	Shaped like a halberd, with two acute basal lobes turned outwards.
Helicoid	Coiled like a shell, applied to an inflorescence with all the flowers on one side.
Herbaceous	Thin in texture and green in colour.
Hermaphrodite	With both male and female organs in the same flower.
Heterogamous	Bearing two kinds of flowers, sexually dissimilar.
Heteromorphous	Not uniform in structure.
Hilum	The scar left on a seed at the former point of attachment.
Hirsute	Bearing long, tolerably distinct hairs.
Hispid	With rough or bristly hairs.
Homogamous	Bearing only one kind of flower.
Hyaline	Thin and transparent or translucent.
Hygroscopic	Apt to swell on application of water and shrink on drying.
Hypocarp	An enlargment of the pedicel below the fruit.

Hypocrateriform Salver-shaped.

Hypogynous Free from, but inserted below the pistil.

Imbricate Overlapping like the tiles on a roof.

Imparipinnate Pinnate with an odd terminal member.

Imperfect Where certain parts usually present are not developed, e.g. when one sex is absent in a flower.

Incumbent Resting or leaning upon.

Indumentum A covering such as of hairs.

Induplicate With the edges folded inwards.

Indurated Hardened.

Inflated Puffed up, bladder-like.

Inflexed Turned in at the margins, said of glumes and lemmas in species of grasses.

Inflorescence The flowering part of a plant.

Innovation A new-formed shoot.

Integument The covering of an organ or body.

Intercalated Interposed.

Internerves The space between the nerves, in glumes and lemmas.

Internode The portion of an axis between two adjacent nodes.

Interpetiolar Between two opposite petioles.

Interrupted Said of inflorescences whose continuity is broken by gaps.

Intrapetiolar Within the petiole, i.e. between it and the stem.

Introrse Directed inwards, usually referring to the opening of anthers.

Involucel An inner wrapping.

Involucre A ring of free or more or less united bracts, surrounding several, (rarely one) flowers of their supports.

Involute Rolled in from both margins, so that the upper side is within.

Irregular Symmetrical only on one side of a median plane.

Isomerous Having the members of successive series in equal numbers.

Joint The node of a grass culm, the internode of an articulate rachis.

Keel The sharp fold resembling the keel of a boat, at the back of a compressed sheath, blade or glume or lemma.

Labiate Lipped; divided at the apex into (usually) a two-lipped shape.

Lacerate Torn at the edges or irregularly cleft, as in some ligules.

Laciniate Irregularly cut into narrow lobes.

Lacunose A surface covered with depressions or perforated with holes.

Lamella A thin plate.

Lamina The blade of a leaf.

Lanate Woolly, clothed with long, tangled hairs.

Lanceolate Shaped like a lance-head, tapering at both ends, the broadest part below the middle.

Laterally (compressed) Flattened from the sides, as in many glumes and spikelets.

Lax Loose.

Leaf The lateral organ of a stem in grass, consisting of sheath and blade.

Legume A one-celled, two-valved dehiscent fruit.

Lemma	The bract of a spikelet above the pair of glumes.
Lenticel	Corky spots (lens-shaped), on young bark.
Lenticular	Shaped like a biconvex lens.
Lepidote	Beset with small scurfy scales.
Lignified	Converted into wood.
Ligule	A strap-shaped thin appendage on the inside of a leaf at the junction of sheath and blade.
Linear	Long and narrow with parallel sides.
Lineolate	Marked with fine lines.
Lobe	Any division of an organ, especially a rounded division or projection.
Locule	Cell.
Lomentum	A legume constricted between the seeds and falling apart when mature, at the constriction between the seeds.
Loose	Open, said of panicles.
Lorate	Strap-shaped.
Lunate	Crescent or halfmoon-shaped.
Lyrate	Pinnatifid with the terminal lobe large and rounded and the lower lobes small.
Macropodal	Long-footed or long-stalked.
Marcescent	Remaining attached after withering.
Membranaceous	Thin, like a membrane.
Mericarp	A portion of a fruit which splits away and simulates a perfect fruit.
-merous	A suffix used in combination to denote the number of the parts, e.g. pentamerous-in fives.
Mesocarp	The middle layer of a pericarps.
Mitriform	Mitre-shaped.
Moniliform	Resembling a string of beads.
Monoecious	With the male and female parts in different flowers but on the same individual plant.
Mucous	Slimy.
Mucro	A sharp, short terminal excrescence, longer than an *apicula* but shorter than a *cusp*.
Muricate	Rough, with short hard, tubercular excrescences.
Muticous	Blunt, without any apical excrescence.
-nate	A suffix used in combination to indicate the number of parts, e.g. ternate—in threes.
Navicular	Boat-shaped, especially used for the tips of leaf-blades shaped like the bow of a canoe.
Nectary	An organ in which nectar is secreted, sometimes applied to any anomalous part of a flower, such as a spurred petal.
Nerve	The vascular veins mostly longitudinal) o leaf-blades, glumes and lemmas.
Nodding	Inclined somewhat from the vertical, said of some panicles.
Nodose	Knobby.
Nut	A hard, dry, indehiscent one-seeded fruit; also often applied to a similar single part of a many-called fruit.
Ob-	A prefix used to denote the opposite of the term, e.g. obovate.
Oblate	Spherical but flattened at the poles.
Oblong	Longer than wide, with parallel sides.

Obsolete — Almost wanting; applied to organs usually present.

Obtuse — Rounded at the apex—contrast with acute.

Ochrea — A tubular stipule or pair of combined stipules.

-oid — A suffix denoting similarity to the term prefixed, e.g. petaloid, resembling petals.

Olivaceous — Olive-coloured.

Open — Loose, said of panicles.

Operculum — A lip or cover which separates by transverse dehiscence.

Orbicular — Circular in outline.

Orthotropous — An ovule with a straight axis, the chalaza close to the hilum and the orifice at the opposite end.

Oval — Broadly elliptic.

Ovary — That part of the pistil which contains the ovules.

Ovate — The shape of a longitudinal section of an egg, broadest below the middle.

Ovoid — An egg-shaped solid.

Ovule — The incipient embryo before fertilization.

Palate — The prominent lower lip of certain corollas; the throat of certain two-lipped corollas.

Palea — Chaffy or hyaline scale present in the inflorescence of some plants. Scale (i.e. bract) of a grass floret.

Palmate — Diverging like the widely spreading fingers of a hand.

Panduriform — Fiddle-shaped.

Pancile — A much-branched inflorescence with a main axis and subdivided branches.

Papilla — A minute nipple-shaped projection.

Papillose — Bearing stiff hairs arising from papillae.

Pappus — Tufts of hairs on some achenes or fruits.

Parietal — Borne on the wall.

Paripinnate — Pinnate with an equal number of members on each side of the axis and no odd terminal one, as in leaves of *Arachis hypogaea*.

-partite — A suffix denoting division deeper than to the middle.

Patent — Spreading.

Pectinate — Pinnately cut in narrow segments, set close like the teeth of a comb.

Pedate — Palmately divided with the lateral divisions two-cleft.

Pedicel — The stalk of a single flower.

Peduncle — The common stalk of two or many flowers of a complete inflorescence.

Peltate — Shield-shaped, said of leaves of which the petiole is attached to the lower surface of the blade and not at the margin.

Pendent — Hanging down.

Penicillate — Shaped like an artist's brush, with a terminal tuft of hairs.

Pennate — Divisions or incisions resembling the arrangement of a feather.

Perennial — Lasting more than one year.

Perfect — An organ or flower in which all the normal parts are present.

Pergamentaceous. — Parchment-like.

Perianth — The floral envelopes of one or two series, i,e. calyx and corolla, more commonly used

	when the two series are not differentiated or only one of them is present.
Pericarp	The walls of a fertilized ovary.
Perigynous	Said of the floral parts other than the pistil, when they are inserted above the level of the base of the ovary, but not above the ovary.
Perisperm	The nutritive tissue outside the embryo-sac which remains in the seed until absorbed.
Persistent	Remaining attached until the part bearing it is wholly matured.
Perulate	Furnished with protective scales.
Petal	A single member of a corolla.
Petiole	The stalk of a leaf.
Phyllode	A petiole assuming the form and function of a leaf.
Pilose	Hairy, with long, soft, distinct hairs.
Pinnate	Organs or leaflets arranged on either side of a common axis, as in a feather.
Pisiform	Pea-shaped.
Pistil	The complete female part of a flower.
Pistillode	A rudimentary pistil.
Pitted	Marked with small depressions or pits.
Placenta	The part of the ovary that bears the ovules.
Plano-convex	Flat on one side and convex on the other.
Plicate	Folded into plaits, usually lengthwise.
Plumbeous	Lead-coloured or greenish drab.
Plumule	The primary leaf-bud of an embryo.
Pollen	The powdery, granular or waxy fertilizing bodies, produced in the anthers.
Pollinia	A pollen mass, especially in orchids.
Polliniferous	Bearing or containing pollen.
Poly-	A prefix indicating the presence of many of the affixed objects.
Polygamous	With both bisexual and unisexual flowers on the same or on different individual plants.
Posticous	On the back part, next to the axis.
Procumbent	Lying along the ground.
Proliferous	Bearing progeny as offshoots.
Pruinose	With a waxy-powdery secretion; bloom.
Puberulous	Slightly hairy, with very short hairs.
Pubescent	Clothed with soft, downy hairs.
Puberulent	Diminutive of pubescent.
Pulvinus	An enlargement close to the insertion of a leaf or the swollen base of the petiole.
Punctate	Marked with dots, depressions or glands.
Pungent	Ending with a sharp (rigid) point, having a sharp taste or smell.
Pustulate	Pimply as though blistered, but not as definitely roughened as papillose.
Pustulose	
Putamen	The shell of a nut, the hardened endocarp of a stone-fruit.
Pyramidal	Pyramid-shaped, applied to panicles.
Pyrene	A nut-let, one of the small stones of a drupe or similar fruit.
Pyriform	Pear-shaped, obovoid with attenuate base.
Quadrate	Squared.
Raceme	A centripetal inflorescence in which the

axis is long, as well as the pedicels of flowers.

Racemose — Adjective of raceme.

Radiant — When the flowers on the outer rim of an umbel are larger than the inner.

Radical — Arising from the root or its crown.

Radicle — The rudimentary root of the embryo.

Ramulus — Branchlet.

Raphe — The ridge formed by the adherent funicle along the sides of some ovules.

Raphides — Needle-shaped crystals inside plant cells.

Receptacle — That part of the axis that bears one or more organs or flowers.

Regular — Symmetrical in several planes.

Reniform — Kidney shaped.

Repand — With wavy margins, but less than if sinuate.

Replicate — Folded so that the upper part comes against the lower.

Resupinate — Upside down or appearing so.

Reticulate — Resembling a network, net-like.

Retinaculum — A horny curved funicle of many *Acanthaceae*.

Retrorse — Pointing backward.

Retuse — A shallow notch in an obtuse apex.

Revolute — Turned down or rolled backward from both edges, said usually of leaf-blades.

Racheola or Rachilla — A secondary axis in the inflorescence of grasses.

Rhachis or Rachis — The axis of an inflorescence or of a compound leaf.

Rhizome — An underground stem; rootstock.

Rosette — A cluster of spreading or radiating basal leaves.

Rostellum — A small beak.

Rostrate — Beaked with slender tip.

Rosulate — With leaves clustered into a rosette.

Rotate — Wheel-shaped, said of a gamopetalous corolla with a short tube and spreading limbs.

Rufous — Reddish.

Rugose — Wrinkled, thrown into folds.

Ruminate — Said of a testa when the testa projects as points or plates into the albumen.

Runcinate — Incised with the teeth or lobes directed backwards.

Saccate — Bag-shaped or sac-shaped, as in the second glume of *Sacciolapis*.

Sagittate — Arrow-head shaped, with the base enlarged into two straight acute lobes.

Samara — An indehiscent winged fruit, or winged parts of a dehiscing fruit.

Saprophytic — Feeding on decayed organic matter, such as humus.

Sarmentose — Producing long and lithe runners.

Scabrid — Covered with small, hard hairs or points and feeling rough.

Scabrous — Very scabrid.

Scandent — Climbing.

Scape — Leafless or almost one-leaved floral axis or peduncle, arising directly from the root.

Scapigerous — Scape-bearing.

Scarious — Thin, dry, membranous, not green.

Scorpioid — Said of an inflorescence with flowers in two ranks and the axis coiled like the tail of a scorpion.

Scrobiculate — Pitted.

-sect — Suffix used to denote division of an organ

	to its base or nearly so, into the number of parts stated in the prefix.
Secondary	Subordinate, said of branches arising from primary branches.
Secund	With the parts or members all directed to one side.
Sepal	Single member of a calyx
Septum	Any kind of partition or interior wall.
Serrate	With forward-pointing, short, marginal teeth.
Serrulate	Minutely serrate.
Sessile	Without stalk, said of leaf blades, spikelets or other organs.
Seta	A bristle or long, stiff, needle-like hair.
Setaceous	Bristle-like, said especially of slender teeth alternate to an awn.
Sheath	The lower part of a leaf that encloses the stem.
Sigmoid	Like the letter 'S', with a double curve in opposite directions.
Siliqua	A fruit with two valves falling away from a frame on which the seeds are attached and across which a false partition is formed.
Sinuous	With a deeply waved margin.
Sinus	A recess or re-entering angle.
Smooth	Not rough to touch, cf. glabrous- without hairs, but which may be rough to the touch.
Spadix	A flower spike with a fleshy axis.
Spathe	A modified bract, enclosing or subtending a flower cluster or complete inflorescence.
Spatheole	A small secondary spathe on a partial inflorescence.
Spathulate	Narrowly oblong with the end expanded and broadened, as in a chemist's spatula.
Sphacelate	Dark and withered, as though dead.
Spiciform	Spike-like.
Spicule	A diminutive or secondary spike.
Spike	An inflorescence with sessile flowers on a usually elongate axis.
Spikelet	The unit of inflorescence in grasses, consisting of two glumes and one or more florets. A cluster of one or more flowers each in the axil of one or a pair of bracts and subtended by two (or rarely one) empty bracts.
Spinulose	Bearing small spines.
Spur	A hollow or sometimes solid extension of some part of a flower.
Squarrose	With numerous outstanding processes, spreading or recurved at the tip, said of the tips of some lemmas.
Stamen	The floral organ bearing the anther and pollen.
Staminode	A sterile or abortive stamen without pollen.
Stellate	With parts radiating like the points of a conventional star.
Sterile	Barren, devoid of one or other of the sexual parts.
Stigma	That part of the pistil which receives the pollen.
Stipe	The stalk or support of an ovary or carpel.
Stipella	The stipule of a leaflet.
Stipitate	Stalked.
Stipule	One of a pair of appendages borne on each side of the base of the leaves or petioles in many plants.

Stolon	A sucker, or any basal branch that is disposed to form roots.
Stoloniferous	Bearing stolons.
Stoma	An aperture in the epidermis of leaves and young branches.
Stramineous	Straw-coloured.
Striate	Marked with longitudinal parallel fine lines.
Strict	Stiffly upright.
Strigose	Beset with sharp-pointed, appressed, straight stiff hairs.
Strobilate	Resembling the cone of conifers; and inflorescence largely made up of imbricating scales.
Strophiole	An appendage to the hilum of some seeds.
Style	That part of the pistil between the carpel and the stigma.
Sub-	A prefix to denote somewhat slightly or in a lesser degree, e.g. sub-acute=somewhat acute.
Subtend	To be below, as a bract subtends a branch in its axil.
Subulate	Awl-shaped, slender, terete and tapering to a sharp tip.
Succulent	Soft and juicy.
Suffruticose	With the base of the stem woody.
Sulcate	Grooved or furrowed; said chiefly of stems, leaf-sheaths and slender leaf-blades.
Suture	A junction or seam of union; line of opening.
Synandrium	Where the stamens are united throughout.
Syncarpium	A multiple or fleshy aggregate fruit.
Syncarpous	Composed of one or more united carpels.
Syngenoecious	With the anthers united and the filaments free.
Tabescent	With a wasted or shrivelled look.
Tawny	Pale brown, dirty yellow.
Teeth	Pointed lobes or divisions.
Tegmen	The inner coat of a seed.
Tepal	A division of a perianth, usually employed when there is no distinction between the two series.
Terete	Cylindrical or circular in cross-section.
Tessellate	Chequered.
Testa	The outer coat of a seed.
Thallus	A vegetative body, without differentiation into stem and leaf.
Thecous	Celled.
Thyrse	A close-set panicle.
Tigellus	A miniature or initial stem.
Torulose	More or less cylindric, but with alternate swellings and constrictions.
Torus	That part of a flower on which its parts are inserted.
Trabeculate	Cross-barred.
Translucent	Allowing light to pass through.
Trichotomous	An axis successively 3-forked.
Trifid	Divided into three parts, like the awns of *Aristida* species.
Trigonous	Three-angled.
Triquetrous	Three-edged with salient angles.
Truncate	As though cut off at the tip.
Tuber	A short, thickened subterranean branch beset with buds; the swollen end of a root attached to the upper end of a rootstock.
Tuberculate	Furnished with small projections.
Tumid	Swollen, inflated.
Turbinate	Top-shaped.
Turgid	Swollen, but not with air.

Umbel	An inflorescence in which a cluster of pedicels springs from the same point.
Umbilicus	A vascular strand by which some seeds are attached.
Umbonate	Embossed in the centre.
Uncinate	Hooked.
Unguiculate	Contracted at the base into a claw.
Unilateral	One-sided or turned to one side.
Unisexual	Said of flowers containing only stamens or only pistils.
Urceolate	Shaped like an urn or pitcher.
Utricle	A membranous sac or bladder-like appendage.
Vaginate	Sheathed or sheathing.
Valvate	Opening by valves; or the several parts of an organ which meet exactly without overlap.
Vascular	Relating to or furnished with vessels.
Venose	Having veins.
Ventral	The side towards the axis.
Ventricose	Belly-like, swollen or inflated on one side.
Vermiculiform	Shaped like a small worm.
Vermiform	Worm-shaped.
Verrucose	Warty.
Versatile	Turning freely on its support; said of anthers attached above the base and swinging freely on the acute tip of the filament.
Verticillate	Arranged in verticels or in a ring around the axis.
Vexillary	Pertaining to the anterior or posterior modified petal of some flowers, e.g., as in the *Papilionatae*.
Villous	Pubescent, with long, soft hairs.
Virgate	Wand-shaped, straight, erect.
Viscid or Viscous	Sticky or clammy, owing to an exudation.
Viviparous	Germinating or sprouting from seed or bud while still attached to the parent plant.
Web	The cluster of soft, slender hairs at the base of the floret, as in certain species of *Poa*.
Whorl	A cluster of several branches around the axis of an inflorescence.
Wing	A thin border or projection or fringe, e.g., the thin borders on the rachis of certain species of *Digitaria*.
Xerophytic	Adapted to arid habitats.
Zygomorphic	Symmetrical on either side of one median plant only.

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