

**NITROGEN MANAGEMENT STUDIES WITH GRASS AND
LEGUME INTRODUCTION IN NATURAL GRASSLAND
UNDER MID-HILL CONDITIONS**

THESIS

BY

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Submitted to



**HIMACHAL PRADESH KRISHI VISHVA VIDYALAYA
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**In partial fulfilment of the requirements
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**DOCTOR OF PHILOSOPHY
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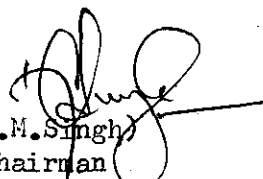

(Mohd Hussain Shah)

C E R T I F I C A T E

This is to certify that the thesis entitled, " Nitrogen Management Studies with Grass and Legume Introduction in Natural Grassland Under Mid-hill Conditions" submitted in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy (Agronomy and Agrometeorology) of Himachal Pradesh Krishi Vishva Vidyalaya, Palampur is the bonafide research work carried out by Shri Mohd Hussain Shah son of Shri Ghulam Nabi Shah under my supervision and that no part of this thesis has been submitted for any other degree.

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Palampur
November 24, 1982.


(C.M. Singh)
Chairman
Advisory Committee

**DEDICATED TO MY WIFE
“ SHAHNAZ”**

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INTRODUCTION

1. INTRODUCTION

The Himalayas represent a diverse assemblage of ecological areas which are associated with a variety of forest types (Champion and Seth, 1960). A prominent ecological entity in these forest types is the natural grasslands. These may be short or vast stretches of flat or undulated lands covered with various botanical mixtures, grasses being the dominant ones. While the alpine pastures are very old in age, other grassy patches seem to be of recent origin having come into being due to biotic interferences, mostly the human (Singh and Sexena, 1978). Since long the vast cattle population presently around 237 million (Bhattacharya, 1976) in these Himalayas have sustained on these grasslands and have been supplying the much needed animal protein and other livestock products to the human population. The area and the botanical composition have not changed much during all this time but the grazing pressure has been increasing every year with the increase in cattle population. Consequently, these grasslands have been depleted and damaged to such an extent that if allowed to remain in present state, even the sustenance of the existing cattle population may not be possible. This fact has already started showing its signs by way of weak and unproductive cattle in most of the Himalayan regions.

Himachal Pradesh with an area of 11.9 lakh hectares under natural grasslands and pastures out of the total geographical area of 55.68 lakh hectares, is not exception to hill agriculture (Anon., 1980). The livestock population of the state is 47.95 lakh. This population is being reared in two systems viz., migratory and sedentary. The migratory system includes usage of grasslands at lower altitudes for hay and

winter grazing while during summer the livestock mostly sheep, migrate to alpine pastures for grazing. The sedentary system avails of the local low altitude grasslands for year round sustenance. The denuded and depleted conditions of the grasslands make them inadequate for sustaining the need of livestock population resulting in poor livestock health and inturn the productivity. A survey of the grasslands in Himachal Pradesh suggests that besides over grazing, another important factor for their deterioration is the absence of a suitable legume component and presence of inferior and unproductive species of grasses (Singh et al., 1975). Besides, lack of other management practices viz., fertilization, irrigation, control of obnoxious species and regulated grazing can also be held responsible for poor herbage production. In state like Himachal Pradesh where only limited land is available for arable farming, the scope of the cultivable fodder is out of question and therefore, it is of utmost importance to ensure the productivity of the natural grasslands of the state to meet the fodder needs of the huge livestock population. It is out of question to increase the fodder production through further increase in area under cultivable fodders. Limited irrigation facilities in Himachal Pradesh (16.61%) further limit the scope of cultivable fodder crops.

The importance of growing a suitable grass-legume mixture in pastures and grasslands is not a new concept but it was for the first time in 1681 that Jhon Worlidge recommended that clover and rye grass should be sown together as a means of improving the soil and furnishing animals with a superior herbage (Wilson, 1940). However, the benefits of growing grass-

legume mixtures were not appreciated till the peculiar nature of the nitrogen nutrition of legumes was resolved. Legumes have their special significance as they not only meet out their nitrogen requirement from the atmosphere but also help the other species growing in association. The amount of nitrogen fixed by legumes is quite variable but the level may be as high as 400-500kg N per hectare per annum as estimated in New Zealand (Sears, 1960) in rye grass/white clover pasture. This practice assumes more importance in our country due to the increasing prices of the fertilizers every year and poor purchasing power of farmers especially in Himachal Pradesh. Besides improving the herbage production, the introduction of legumes markedly change the chemical and botanical composition of a pasture (Trumble and Strong, 1937). The benefits of a grass-legume mixture though well known but may summarily be described as follows (after Ahlgren, 1956):

1. The productive period of the field is prolonged and when legumes thin out, the grasses often take over.
2. Grasses tend to prevent winter heaving of legumes by providing a protective vegetation mulch of aftermath.
3. Good mixtures yield nearly as well as straight legumes and usually out yield pure stands of grass.
4. Legumes grown with grass have an effect similar to that of fertilizing the grass with nitrogen. Growth, vigour and protein content of the grass are increased by this favourable association.
5. Erosion damages are decreased by the denser soil coverage provided and encroachment by weed is reduced to minimum.

Similarly, grasses and legumes in natural grasslands whether introduced or natural require judicious use of fertilizers. One of the most prominent factors responsible for low production of grasslands is the lack of adequate fertilization. The efficacy and utility of fertilizers on the production and quality of grasslands have been reported by several workers in the country (Dabadghao et al., 1965, Bahl et al., 1970, Erasmus, 1970, and Shankarnarayan et al., 1973). Most tropical grasses have a capacity for high photosynthetic rates (Ludlow and Charles, 1980) and high dry matter production per unit area in response to nitrogen fertilization. Nitrogen content of grasses is relatively low unless nitrogen was applied in excess of the requirements for maximum growth. The efficiency of dry matter production relative to applied nitrogen and nitrogen recovery in tops could both be improved substantially when adequate quantities of fertilizer nitrogen are added. Nitrogen rather than soil moisture, is the primary limiting factor to grass growth under natural rainfall (Henzel and Strik, 1963).

Fertilization of grasslands also affect the quality of produce through the changes in the botanical and chemical composition of the plants. Grass and legume mixtures grown with adequate N and P fertilizers increased the digestibility of the forage significantly through the beneficial effect on protein, mineral matter and cell content of plants (Minson, 1960). Fertilizer nitrogen not only increases the protein content of grass but the digestibility of protein also. Nitrogen fertilization may increase or decrease the dry matter digestibility by a decrease or increase, respectively, in the level of lignin encrusting the cell wall

(Minson, 1975). Another dynamic role of fertilizer nitrogen is the change in voluntary intake, considered to be the most important character from the quality point of view.

However, high cost, scarcity and huge requirements warrant judicious use of nitrogen. Therefore, it was felt necessary to find out optimum requirement of nitrogen for the natural grasslands introduced with improved grass species and legumes or both. The present investigation entitled " Nitrogen management studies with grass and legume introductions in natural grassland under mid-hill conditions" was initiated with the following main objectives:

1. to study the impact of grass/legume introduction on the production potential and quality of natural grasslands in Kangra Valley,
2. to work out the nitrogen requirement and best method of its application for natural grasslands introduced with grass/legume,
3. to work out the nutritive value of grass/legume mixture obtained from different treatments, and
4. to study the relative economics of grass/legume introduction and nitrogen fertilization in natural grasslands.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The grasslands of the world are characterized by the presence of a great variety of grass and legume species which are responsible for all the available animal production. Although the man must have been aware of the benefits of grasslands right from the time when he had a transition from nomadic hunting life to a settled life and went on using these grasslands without much attention to their improvement. The grasslands have in the past been regarded as a constant natural source and little has been done to supplement their output by way of improvement, fertilizer application or proper use of these grasslands. Nineteenth century marked the beginning of a new era in the grassland research. A well planned and comprehensive research was initiated in this century on all aspects of pastures and cultivated forages, though the first agricultural experiment station for research on pasture and grasslands was established in England in 1843 (Barnard and Frankel, 1964).

Improvement of the existing grasslands by introducing grass-legume mixtures has been one of the subjects widely worked out and discussed. It is very difficult to say when farmer first became aware of the virtue and value of associating legumes with grasses for pasturage but it certainly was a discovery of great importance and consequence. Sir Richard Weston is considered to be a pioneer in legume introduction (Barnard and Frankel, 1964). He first introduced red clover in pastures of England in 1613. Ever since the research on grassland improvement by way of legume introduction has advanced many fold.

Indian farmers have not been much different from their counterparts in other parts of the world. They too used the natural

resources indiscriminately. It is not certain when the Indian farmers realized the importance of grasslands as a tremendous source of energy for livestock rearing. But it is certain that farmers from hill regions must have been first to realise the importance of grasslands through the age old migratory system of grazing in hills.

At present various programmes of grassland improvement have been started by legume introduction or renovation of the depleted grasslands by sowing of a compatible grass-legume mixture. The important work prior to the present study on grass-legume mixtures has covered several aspects and has been done in different parts of the country as well as the world. Their perusal for the present study assumes great importance, so the same are reviewed in this chapter.

2.1 Introduction of species in natural grasslands

The experience of advanced farms has shown that by carrying out the whole complex of measures for the improvement of meadow lands (clearing of shrubbery and tree shoots, surface drainage, destruction of weeds, sowing of herbaceous plants, application of fertilizers) their yield can be increased three fold or more (Larin, 1962). It has also been observed that sowing of grasslands with productive and suitable species with little disturbance to the existing vegetation can enhance the productivity of a grassland. The diversity by the agro-climatic conditions as that of Himachal Pradesh, complicates the identification of suitable forage species for introduction. Forage yield, seedling vigour, growth rhythm, winter hardiness, high and low temperature tolerance, drought

resistance and maturity time are some of the most important characters of a forage species which have to be considered before its introduction in a particular region.

A general ~~survey~~ of the grasslands of Himachal Pradesh at an altitude of 2360m and below suggests that the grass cover is of Themeda arundinella type (Singh et al., 1975) and most of the plant species are tropical or sub-tropical in nature. The legume content is very low and the available total biomass is below the standards. This gave an indication that the species to be introduced should be of tropical or subtropical habitat, productive and should be able to grow in a symbiotic relationship as grass and legume component of a pasture. Singh (1971-76) evaluated the suitability of tropical and temperate grasses and legumes for introduction under mid-hill conditions of Palampur. It was found that the temperate species although initially established were eliminated within two years. Besides, their performance as compared to tropical and sub-tropical species was poor. Setaria sphacelata and Desmodium uncinatum two highly productive tropical species were evaluated for their introduction in the mid-hills of Himachal Pradesh and both of them were found to be highly suitable. The suitability of Setaria as a productive forage species and its introduction into the grasslands of various tropical regions has also been observed and advocated by other workers in different parts of the world (Ostrowski, 1977; Jateno, 1978, Kobayashi, 1978; Smith, 1979, Thomas et al., 1979, Luck, 1979, Winter, 1979, Anning, 1980; Davies, 1980; Ludlow, 1980, and Thomas et al., 1980).

Introduction of Desmodium as a single component or legume component of a mixed pasture system too has been found suitable by many workers (Humphrey, 1978; Hutton, 1978, Gutteredge, 1979; Rajani, 1979, Kitamura and Nishimura, 1980 and Ludlow, 1980).

Builer and Bathurst (1956) have observed that the botanical composition of a pasture undergoes tremendous change with legume introduction when grass and legume are sown together in a soil having low nitrogen, in the first year legume dominates the sward. This is because in the first year, the legume is not efficient enough to fix adequate atmospheric nitrogen and provide it to the grass. Trumble and Donald (1938) and, Anderson and McLachlan (1951) in their studies found that in subsequent years nitrogen from prior legume growth is available to grass and enhances the competition of grass with legumes. Harris (1968) advocated the introduction of grass-legume mixture for a sustained and productive herbage. In both the components, he studied the differences in various attributes like peak growth, capacity for utilization of horizontal space, leaf orientation and its light interception, rooting depths and water utilization pattern. Due to the differences in all these attributes, Harris (1968) stressed the importance of their utility for sustained herbage production. Sowing of compatible and productive grass-legume mixture on pastures having inferior and less productive species was recommended by Levy (1968). He further emphasized that it will not only enhance the production potential but also prolong the period of availability of green forages.

Anderson (1949) investigated the influence of plant nutrients on symbiotic nitrogen fixation and found that a compatible grass-legume mixture is ideal for adequate nitrogen fixation. Cowling and Lockyer (1965) studied the difference in growth and herbage production of grasses with fertilizer nitrogen and association with white clover. He found that most of the grasses performed better when grown alongwith clover. He also found that this practice is far economical. The studies of Singh and Katoch (1975) showed that introduction of Pennisetum purpureum and P. typhoides in the natural grassland of Kangra Valley not only increased the herbage yield significantly over the local grasses but also provided green forage during the months when the existing grasses were dormant. Sood (1981) reported that the introduction of Siratro in natural grassland of Kangra Valley increased the green as well as dry fodder yield over no introduction during all the three years of the experimentation. He also emphasized on the ability of this crop to utilize atmospheric nitrogen, which would not only meet its own nitrogen requirement but also benefit the associated grass especially in the second year. Nitrogen fixation by perennial legume is reported to be higher in the second year compared to the establishment year due to better nodule development (Morrison, 1966). Prasad (1980) in his studies observed that introduction of A. gayanus and B. brizantha gave significantly higher average yield than the local grasses. There was no significant difference in the yield of these two grasses in the first year. In the second year, B. brizantha gave higher yield but in the third year A. gayanus produced higher yield than B. brizantha. Their studies further revealed that herbage yield did

not increase enough due to poor establishment in the first year. In the second year, however, herbage yield increased significantly. The interaction effect of the introduction of grasses and legumes was found to be significant.

Rees (1972) studied the persistence and seasonal distribution of growth of 134 tropical and temperate grasses and legumes without irrigation over four years in a high rainfall area in South Eastern Queensland. Most tropical grasses were capable of high summer dry matter production but Setaria sphacelata and Panicum coloratum appeared to be most suitable owing to the combining persistence with production. Setaria sphacelata persisted better and gave higher winter dry matter yields. It survived even when no nitrogen was applied in winter.

Silver leaf Desmodium and Cooper glycine were the most persistent species of the 31 tropical legumes tested and silver leaf and green leaf Desmodium were the highest yielding. Chauhan and Faroda (1979) also advocated the role of mixed pastures of Cenchrus species and Dolichos lablab in 1:1 ratio for increasing the production of high quality forage from pastures.

Chauhan and Faroda (1974) while comparing the compatibility of various legumes like Macroptilium atropurpureum, Dolichos lablab, Clitoria ternatea and Atylosia scarabaeodes with Cenchrus ciliaris and Cenchrus satigerus found that grass-legume mixtures were much better than grasses alone in qualitative characters. They further found a higher degree of in-vitro dry matter digestibility value in grass legume mixtures since these contain more crude protein and less fibre. Prashad and Mukherjee (1980) found that grass-legume mixture increased the palatability

and feed value of herbage. They found an increased amount of crude protein in grasses when grown along with legumes. Lima (1972), on introduction of Siratiro in a grass dominated pasture, found that the crude protein of herbage increased by 30 per cent, while its fibre content decreased by 10 per cent, thereby increasing its digestibility. Gruber (1972) reported that a compatible grass-legume mixture increased the crude protein content, calcium, phosphorus and magnesium contents of the herbage.

Minson et al.(1964) observed that in-vitro dry matter digestibility between species differed significantly even at the same physiological stage of growth. Perennial rye grass and meadow fescue were found to be more digestible at all times of growth than cocksfoot and tall fescue. Apart from species differences, grazing management is another important factor which influences quality components and dry matter digestibility of forages. Hutton (1962) found that dry matter digestibility was medium in the sward which was intermittently grazed than the one which was continuously stocked. The digestibility of grasses is considerably influenced by the stage of growth. It reaches to peak just prior to ear emergence and then declines rapidly (Minson,1960). It has been generally assumed that leaf/stem ratio influences the digestibility. The species with more proportion of leaves are more digestible than that having higher proportion of stems. However, Dent (1963), and Minson et al.,(1964) found certain stemmy varieties of grasses to be at least as digestible as leafy varieties. It is only when stems are allowed to mature that they lead to a marked reduction

in digestibility. The digestibility of tropical grasses is in general 13 units lower than that of temperate species. This difference is closely associated with climatic differences, digestibility being depressed by higher temperatures. The temperature effects were, however, not observed in case of tropical legumes (Minson and Mcloed, 1970).

It is an established fact that the intake of legumes is higher than that of grasses (Reid et al., 1966; Vansoest, 1965). At 55 per cent digestibility, the intake of the tropical legume Glycine wightii was more than twice that of tropical grass Setaria sphacelata (Milford and Minson, 1965a). Ingalls et al. (1965) concluded that 70 per cent of the variation in production potential (animal output) can be accounted for in terms of differences in voluntary intake, compared with 30 per cent by difference in digestibility. Sood (1981) reported higher in-vitro dry matter digestibility of grass-legume mixture which was ascribed to higher crude protein and cell content which are most easily available to the animals rumen microflora and also the adverse effect of increased lignin content is nullified by increased crude protein and cell contents. Vansoest and Jones (1968) have also reported that the effect of lignin on digestibility is wiped out when forages are having higher protein and cell contents.

In some of the recent grassland improvement projects undertaken in various parts of the world, the importance of grass-legume mixtures has once again been established. Hutton (1978), Humphrey (1978), Falvey and Andrews (1979), Rajani (1979) and Anning (1980) have reported that grass-legume mixtures have been substantially economical and productive

in most of these projects. The grasslands in India in general and Himachal Pradesh in particular are in highly degraded conditions because of many factors such as absence of productive grass species, lack of legume component, lack of fertilization, over and above heavy pressure of grazing. However, in light of literature cited above, there seem to be great scope of enhancing the production potential and quality of existing grasslands of the state following introduction of more productive grass-legume species.

2.2. Methods of introduction

There are two systems of introducing desirable plant species to develop a productive pasture, that of establishing a new pasture by ploughing the soil and then seeding, and improving the natural pasture with minimum damage to the existing vegetation and soil. The first system which has also been described as a 'radical system' by Larin (1962) has its own disadvantages which become all the more pronounced on slopy lands as that in Himalayan mid-hills. The slopy pastures if ploughed can result in tremendous soil erosion and ultimately in loss of top soil. Larin (1962) found that the improvement of the existing pastures only by introduction of better species and fertilization can increase the yield upto 100 per cent. Reicosky et al. (1977) reported that the benefits of pasture renovation includes higher productivity of better quality feed, less soil loss and conservation of nitrogen fertilizers. But, inspite of its benefits this system is nevertheless difficult. The existing vegetation poses a problem for sowing and the subsequent competition for light, moisture, nutrients and space is all the more tough for introduced

species. The mid-hill grasslands in Himachal Pradesh are dominated by shrubby plants and tussock forming perennial grasses. The eradication of these plants is a must for establishment of the introduced species as suggested by Derbin (1948) and Astrakhov (1951). The suppression of existing vegetation can be done by grazing, burning or herbicide application.

Herbicides have assumed a considerable importance in eradicating the undesired plant species as observed by Mayers and Triplett (1974), Cook (1980) and Sood (1981). Besides their proven advantages, herbicides are yet beyond the reach of an average farmer of India and especially of Himachal Pradesh. The availability of herbicides, technical knowhow about their use and economics further make their use limited.

Burning of the existing vegetation is a cheaper and old practice in India but there exists a great diversity of opinion about its desirability. By and large, the practice of grassland burning has now come to be regarded as necessary 'evil' as an attempt to eliminate introduced problems by management system as serious as those created by accidental fires. Saner (1956) and Stewart (1956) stated that probably the most ancient and important influence of man on vegetation has been through the use of fire. Saner (1956) further pointed out that fire is not a destructive exploitation, since a protective cover of plants is maintained, moisture penetration is unimpaired and possibly loss of moisture through evaporation is reduced. Andrews (1920) and Cooper (1960) have observed that protection from fire especially when associated with grazing by domestic animals, often causes the development of dense, woody

communities and a reduction in the grass component. Acocks (1953), Heady (1960) and Rattray (1960) reported that over much of the tropical continent of Africa, fire is important in controlling the density of the tree population and many grasslands have developed under the influence of frequent burnings. Bartlett (1956) reported that in tropical regions, clearing and burning of forest is practised by native tribes to provide areas for cultivation and in time, tropical grasslands may replace the original forests and maintained by frequent burnings. Harshels (1977) observed that burning range or pasture helps in controlling the undesired species of grasses. The grass establishment in native grassland was better in burnt plot which was due to elimination of existing vegetation and consequently less competition (Cooper, 1960). Partridge (1973) introduced Stylo in a pasture after burning the existing vegetation. He found that the production potential of an introduced grass-legume mixture was much better in a burnt pasture. West (1965) advocated the economy of burning the pastures. He felt this to be the easiest and cheapest method for improvement in a shrub dominated grassland. The burning may not affect much the grass cover but old shrubby vegetation is eradicated. Tiedmann and Klock (1974) reported that sowing a legume after burning the native grassland increased the herbage yield and provided a good vegetative cover due to better establishment of legume. Leslie (1979) advocated the use of controlled burning in rangeland management in South Dakota. Such burning killed Pinus ponderosa seedlings, increased prairie grass production and prevented the occurrence of uncontrolled fires. Best conditions for burning were 0-70°F air temperature, 30-60 per cent relative

humidity and less than 12 miles per hour wind speed. Ralphs and Busby (1979) reported that burning almost completely eliminated Artemisia tridentata. Herbage yield increased by 1.6 to 5.8 times the yield before burning. Burning was cheap and effective means of controlling A. tridentata when adequate safety precautions were taken.

The influences of burning on the apical bud behaviour and carbohydrate reserves stored in the root resulting in fast and vigorous growth of grasses, was observed by Vinod Shanker (1978). However, as a result of burning, reduction in organic matter and moderate increase in pH of grassland soils generally occur, but very little effect on nutrient level of the soil is reported. Uresk (1976) found that the community of grasses yielded 21 per cent more total live herbage than the unburnt, due to the stimulation of growth, which was reflected in increased plant height and better tillering capacity of grasses. Harrington (1974) observed that burning stimulated shooting and flowering earlier than unburnt treatments. However, Harrington (1974) reported that burning increased the herbage yield at the cost of quality of the produce because burning increased the proportion of undesired species in the sward. Sood (1981) observed that introduction of Siratro after burning the existing vegetation also resulted in similar green and dry fodder yield as that of plots treated with herbicides.

In view of the literature cited above, it is clear that burning a grassland before introduction of grass or legume leads to an increase in herbage yield and better utilization of grasslands. Besides, burning has been found by many workers as most economical and easiest method to

eradicate the existing vegetation. This also helps in stimulation of vegetative growth and influences the behaviour of apical bud that results in good growth and vigour of grasses. However, as a management tool, burning needs to be employed cautiously and sparingly. Effect of burning on the soil, biology of the grasses, standardization of season, frequency of burning and evaluation of grazing -burning rotation systems for grassland management are the areas of research which require further attention.

2.3. Nitrogen management

One of the most prominent factors responsible for low production of grasslands is the lack of adequate fertilization. The efficacy and utility of fertilizers on the production and quality of grasslands have been reported by several workers in the country and abroad (Bahl et al., 1970; Eramus, 1970; Shankernarayan et al., 1973; Singh et al., 1975, and Sood, 1981). Fodder production from natural grasslands in the state of Himachal Pradesh could be increased two to three times of the present level if adequate doses of fertilizers are applied (Dogra et al., 1975).

2.3.1. Effect of nitrogen levels

Among major effects of nitrogen on the crop, increased meristematic activity and induced vegetative growth are more apparent and most important from the view point of herbage production. The nitrogen application also influences the tillering, leaf area and thus, the overall vegetative growth of plants. Most of the grass species respond well to nitrogen (Lewis and Lang, 1970; Cowling et al., 1972; Magoon and Dabadghao, 1973 and Dhiman and Chauhan, 1980). Bradshaw et al. (1964) demonstrated

that the response of grasses to nitrogen is well pronounced and the differences among commonly cultivated species are small and inconsistent. On the other hand, the legumes in general, show little response to fertilizer N but in certain conditions like acid soils, when the supply of nitrogen from nodules is inadequate, the legume crop efficiently utilizes the N from applied fertilizer (Garwood et al., 1972). The application of nitrogen on pure grass pastures has shown considerable increase in production as observed by Shankernarayan et al. (1973). Their studies showed that 60 kg N/ha was adequate to obtain best herbage yield from the grasslands of Bundel Khand region of India. Mukherjee et al. (1976) obtained 127 to 153 quintals dry matter per hectare with the application of 60-120 kg N/ha from the grasslands of West Bengal. These grasslands without fertilization yielded only 35 q dry matter per hectare. Mannteje and Shaw (1972); Narwal et al. (1977), Ravi Kumar et al. (1979) and Dwivedi et al. (1980) have also found that considerable increase in productivity of natural grasslands can be obtained by nitrogen fertilization.

In a grass-legume sward, the response to nitrogen depends upon many factors like the forage species present, botanical composition, availability of other nutrients, harvest management, and moisture regimes etc. Kresge (1964) observed that legume component is able to fix or change into usable form, sufficient atmospheric nitrogen. Meyers (1945) ascertained that the grasses are benefited six times in association with legumes. The fact has been supplemented by Lusk (1967); Neathery (1969) and Wagner (1973). This nitrogen fixed by legume component, besides being

used by legume itself, can be utilized by grass component also, especially when it is fixed in enough quantity (Walker, 1954). Elaser and Kimbrough (1968) and Hutton (1970) admitted the fact that a proper grass-legume association can provide enough nitrogen for worldwide improvement of grasslands but they felt that the association must be supplemented with fertilizer nitrogen. Morrison (1966) has attributed the low productivity of some high altitude pasture to inadequate nitrogen supply. He felt that the grass-legume sward can produce enough herbage if nitrogen fertilizer is applied. The application of nitrogen in a grass-legume sward needs very careful observation about its responses from the component species.

Davies et al., (1960); Carter (1966) and Trempleton and Taylor (1966) have observed that increased levels of nitrogen in a grass-legume pasture stimulate and enhance the grass growth and suppress the emergence and yield of clovers. Ravi Kumar et al. (1979) on the basis of their three years experiment with nitrogen on Cenchrus ciliaris and Heteropogon contortus grassland, reported that dry forage yield increased with increasing levels of nitrogen. Application of 90 kg N/ha produced the highest yield during all the three years. Narwal et al. (1977) also observed increase in green and dry fodder yields with increasing levels of nitrogen. Application of nitrogen showed a significant response upto 120 kg N/ha resulting in dry matter yield increase to the tune of 102 per cent over 30 kg N/ha. Results from the field experiment conducted on a representative grassland located at an altitude of 1300m at Palampur, Himachal Pradesh with Heteropogon contortus, Arundinella nepalensis, Chrysopogon montanus and Chrysopogon gryllus as prominent species revealed

that the dry matter yield was significantly influenced by nitrogen levels and yield increased significantly upto 40 kg N/ha (Singh et al., 1975). Magoon and Dabadghao (1973) reported that most of the grasslands in tropics suffer from the deficiency of nitrogen whereas, with application of N, there was great improvement in the condition of the grassland. Their studies at Indian Grassland and Fodder Research Institute, Jhansi on three important grass communities namely Sehima, Iseilema and Heteropogon have shown that the application of 40-60 kg N/ha, the production could be raised from 20 to 25 q/ha of hay over unfertilized grassland. Singh (1973) in his studies at Indian Agricultural Research Institute, New Delhi found that for obtaining the maximum green fodder yield, Setaria grass needs heavy fertilization. Sood (1981) reported that increase in the levels of nitrogen from 60 to 120 kg N/ha brought about significant increase in plant height, green as well as dry fodder yield in all the three years of the study. He further observed that increase in nitrogen level from 60 to 120 kg N/ha significantly reduced the legume component in the grass sward.

Ravi Kumar et al. (1979) while conducting an experiment at Indian Grassland and Fodder Research Institute, Jhansi on the effect of nitrogen on the quality of Cenchrus ciliaris and Heteropogon contortus reported that crude protein content increased significantly with successive increase in the levels of nitrogen. The increase in crude protein was from 4 per cent in control to 9.8 per cent when 90 kg N/ha was applied representing an increase of 143 per cent. Singh et al. (1975) while conducting experiment on representative grassland at an altitude of 1300m at Palampur, Himachal Pradesh reported that nitrogen levels

positively influenced the per cent crude protein in forage significantly in both the years of experimentation. The highest percentage of crude protein in 1973 was obtained at 160 kg N/ha which was significantly higher than the one obtained under rest of N levels. However in 1974, crude protein increased significantly with N application upto 80 kg N/ha only. Minson (1975) reported that application of nitrogen increased the protein content and also the digestibility of grasses. He further observed that tropical grasses were 13 per cent less digestible than temperate grasses, and this might be the cause of lower level of production of cattle grazing tropical pastures. The increase in crude protein content of forages due to N application has been reported by several workers (Sherwood et al., 1967; Bahl et al., 1970, Rai et al., 1979; Dwivedi et al., 1980). Newman and Smith (1972) found that the application of high doses of nitrogen to a grass-legume mixture only increased the grass content and there was no significant effect on the crude protein content of the herbage. Wagner and Oltjen (1973) found that the crude protein of grasses increased when they were grown in association with legume. On a Setaria pasture, nitrogen fertilizer had little effect on the gain per animal but considerably increased the gain per hectare (Mcilroy, 1962). Fertilizer nitrogen increased the protein content of grass and the digestibility of the protein. Despite this increase the average effect on dry matter digestibility was negligible (Minson, 1975). He further reported that nitrogen fertilization sometimes increase the dry matter digestibility while at the other time decrease the digestibility. This increase or decrease in digestibility is caused by a decrease or increase, respectively in the level of lignin encrusting the cell wall. However,

why these changes are sometimes negative and at other time positive is not very well known. Fertilizer N will cause changes in voluntary intake in the same direction as the changes in dry matter digestibility provided the diets are not deficient in protein (i.e. $< 7\%$).

Sood (1981) reported that the quality of the herbage produced from the plots fertilized with 120 kg N/ha was significantly better than the plots fertilized with 60 kg N/ha as indicated by in-vitro dry matter digestibility at harvest. This has been ascribed to comparatively higher crude protein content and lower cellulose, silica and lignin content. Crude protein content of plants had significant positive correlation with invitro dry matter digestibility of the herbage.

2.3.2. Effect of methods of N application

Singh (1973) recommended the application of 100kg P_2O_5 and 80 kg N/ha before planting Setaria grass. He further recommended second and third application of nitrogen at the rate of 60kg N/ha, each to be applied after first and third cut. The splitting of nitrogenous fertilizer has also been recommended by Henzel (1974) under rainfed conditions. Nitrogen should not be given in less than 4 applications per year and most effective number seems to be six. Dhiman and Chauhan (1980) in a trial with natural Themeda anathera/Heteropogon contortus grasslands in the Kuly Valley of Himachal Pradesh found that application of 50kgN/ha as urea at different times and by different methods gave herbage yields of 4.66 to 5.37 t/ha compared with 4.22 t/ha without nitrogen. Application of urea in pre- or post monsoon season gave similar yields. Foliar

application of nitrogen in split dressings at 10 days interval in any season gave average yields of 5.37 t/ha compared with 4.84 t/ha for 50 per cent N applied to the soil and the remainder in 2 foliar dressings and 4.66 t/ha for the full nitrogen rate applied to the soil.

2.4. Economic aspect of grassland improvement

The economics of the grass-legume pasturage has been studied by various research workers and the reports available indicate that the system is quite economic under proper management. Rajbans (1967) found a grass-legume mixture to earn highest net returns as compared to pure grass or legume crop. Similar observations have been made by Crowder et al. (1974). Katoch et al. (1975) calculated the economics of grass-legume mixture and found that without proper management this practice can be very uneconomical. They recommended that application of N and P must be made in a combination, since the application of one of these does not affect the yield much. Ravi Kumar and Shankernarayan (1980) worked out a net profit of Rs.482.16/ha with the application of 120kgN+30kg P_2O_5 /ha to a pasture followed by 120kgN + 60kg P_2O_5 (Rs.429.12) per hectare and 90kg N+60kg P_2O_5 /ha (Rs.421.92/ha). On an average, net profit increased with increasing levels of nitrogen, however, the case was reverse with phosphorus application. Rai et al. (1979) claimed that application of 60kgN/ha earned maximum net profit of Rs.514.20/ha over that of control (Rs.389.85/ha). The profit decreased with the increasing levels of nitrogen.

Sood (1981) reported the highest net profit with $N_{120}P_{60}$ fertilizer combination which was on account of relatively low cost of production in this treatment. He further observed that the per cent saving in form of cost of production in $N_{120}P_{60}$ over $N_{120}P_{120}$ was 24.7, 31.6 and 16.9 for the year 1978 and 1980 and combinedly for over two years (1978 and 1979), respectively.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

A field experiment in natural grassland (Ghasni) situated in Kangra Valley was undertaken to achieve the objectives laid down in the previous chapter. The details of materials used and the methods employed during the course of the investigation are described in this chapter.

3.1. Experimental site

The present study was undertaken in natural grassland (locally known as "ghasni") located in the experimental area of Himachal Pradesh Krishi Vishva Vidyalaya, Palampur, during Kharif seasons of 1980 and 1981. Palampur is situated at 32.6°N latitude and 76.3°E longitude at an elevation of 1300 metres above mean sea level.

The experimental site selected was a typical representative of the mid-hill grasslands of the state. The condition of this grassland was completely deteriorated due to over-grazing and indiscriminate cutting of grasses. During the course of investigation the site was not disturbed in respect of its slope. The slope was measured with the help of dumpy level. Since the experimental field exhibited varied topography and differences in slope, the whole site was tentatively divided in 4 near homogenous blocks which later on were used as replications to ensure more homogeneity within the replication. In general, the slope worked out 7.9 to 9.7 per cent. The direction of the slope was North to South and blocks were made across the direction of slope. Table 3.1 contains the data on the slope of site measured in each replication of the experiment.

Table 3.1. Slope of the site measured in each replication of the experiment

<u>Replication</u>	<u>Per cent slope</u>
1	7.9
2	9.7
3	9.1
4	9.2
Mean	8.9

3.2. Existing vegetation

The varied topography of the site provided diverse ecological habitats for the plant life. The undulated topography included some shallow depressions in which the water accumulated during monsoons and the species pertaining to semi-aquatic group were also noticed in such pockets. The area was infested with bushes namely Lantana camara and Zizyphus jujuba which were removed to expose the ground canopy. The species present before start of the experiment on the basis of composite samples taken from entire site are given below:

1. Imperata cylindrica (L)
2. Heteropogon contortus (P.Beauv.)
3. Chrysopogon fulvus (Trin.)
4. Arundinella nepalensis (Trin.)
5. Paspalum dilatatum (Poir.)
6. Setaria glauca (P.Beauv.)
7. Saccharum bengalense (Linn.)
8. Sorghum halepense (Pers.)

9. Flemangia fruticlosa

10. Ipomea carnea (Jacq.)

11. Desmodium triflorum (D.C.)

Heteropogon contortus, Chrysopogon fulvus and Setaria glauca, were the dominant grass species in the experimental site. Other grass species were eratically distributed and the legume component was almost absent from the site except that rare presence of Desmodium sp.

3.3. Soil Characteristics

For soil characterization, soil samples from individual replications were drawn from two depths (0-15 and 15-30 cm). The results of analyses and methods used for the determination of soil properties have been presented in Table 3.2. The results of soil analysis evidently indicated that soil of the experimental site at the initiation of the experiment was clay loam in texture with acidic soil reaction. It was medium with respect to organic carbon and available K while low in available N and available P.

3.4. Weather conditions

Climatically, Palampur comes in sub-temperate humid zone (Verma, 1979) with high rainfall ranging from 2000-2500 mm per annum. Almost 80 per cent of this is received during June to September while rest is distributed in remaining months.

The meteorological observations recorded at the Meteorological Observatory of Department of Agronomy and Agrometeorology, Himachal Pradesh Krishi Vishva Vidyalaya, Palampur, have been appended in Appendices I and II and illustrated graphically in Figure 3.1.

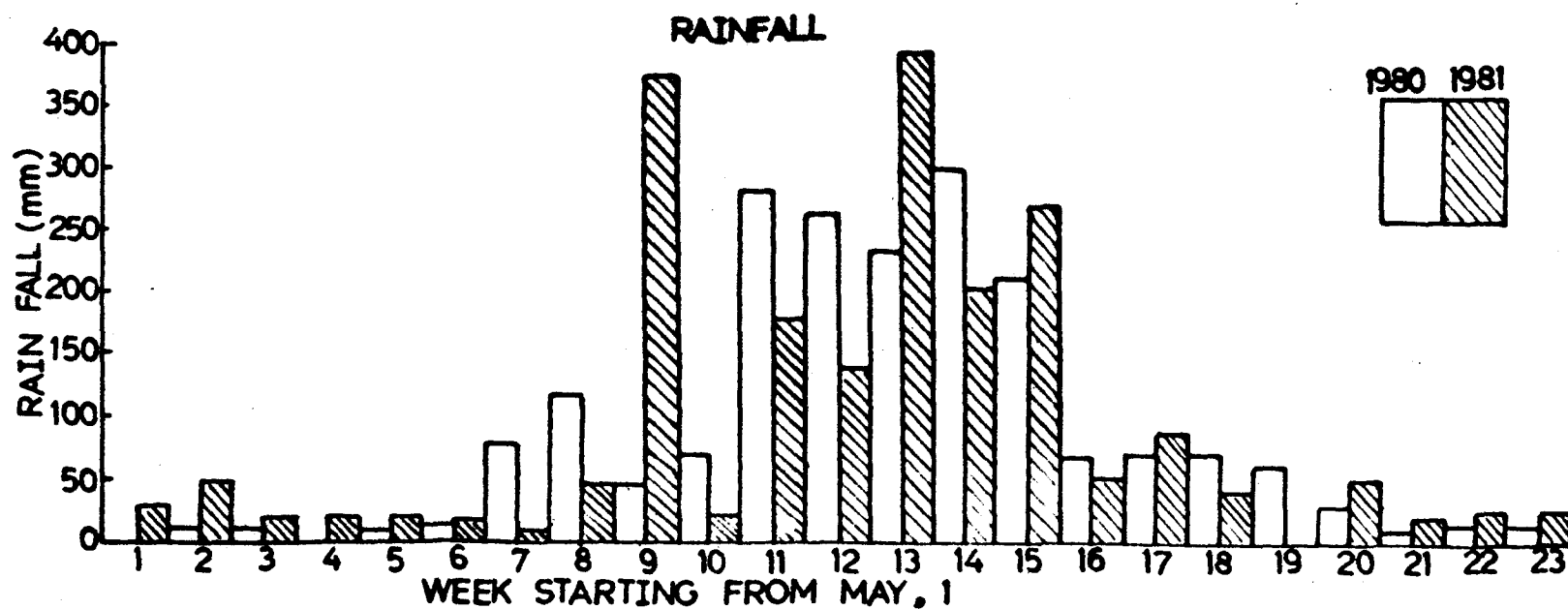
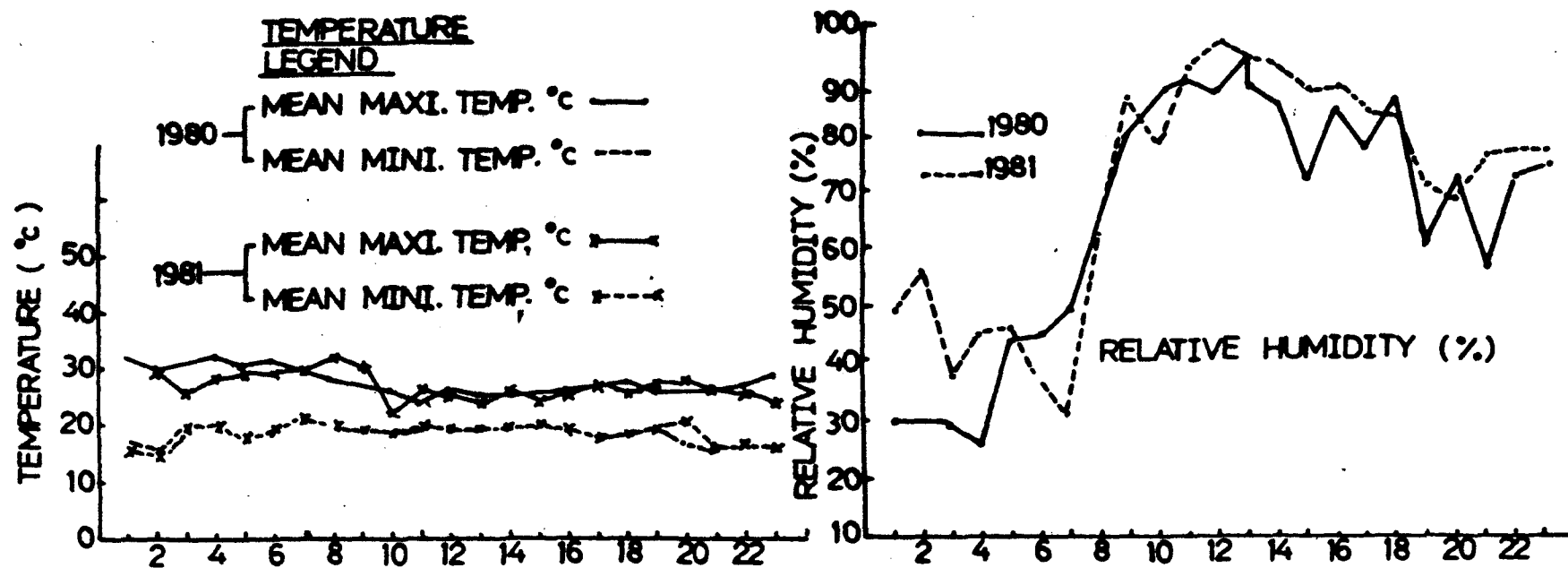


FIG.31: MEAN WEEKLY WEATHER DATA FOR 1980 & 1981

Table 3.2. Mechanical and chemical analyses of soil

Particulars	Depth (cm)		Method employed
	0-15	15-30	
<u>A. Mechanical analysis</u>			
Sand (%)	40.5	40.0	International Pipette
Silt (%)	30.5	30.5	method (Piper, 1966).
Clay (%)	29.0	29.5	
Texture	Clay loam	Clay loam	
<u>B. Chemical analysis</u>			
Organic carbon(%)	0.96	0.70	Walkley and Black's Rapid titration method (Piper, 1966).
pH (1:2.5 Soil water suspension)	5.7	5.6	Glass Electrode pH meter (Jackson, 1967).
Available nitrogen (kg/ha)	198	181	Alkaline permanganate method (Subbiah and Asija, 1956).
Available phosphorus(P)8.5 (kg/ha)		8.8	Olsen's method (Olsen et al., 1954).
Available potassium(K)253 (kg/ha)		252	Extraction with normal neutral ammonium acetate and flame photometric determination (Merwin and Peech, 1950).

Mean maximum temperature during the crop seasons 1980 and 1981 ranged from 24.8 to 28.7°C and 22.4 to 32.5°C, respectively. Whereas the mean minimum temperature during the corresponding years ranged from 16.3 to 19.6°C and 15.7 to 21.4°C, respectively. The total rainfall received during crop seasons 1980 and 1981 was 1144.6 mm and 1927.4 mm, respectively. The average relative humidity ranged from 56.0 to 94.2 per cent and 31.3 to 96.3 per cent, respectively.

3.5 Experimental details

3.5.1. Treatments: There were 32 treatment combinations comprising of 4 introduction, 4 levels of nitrogen and two methods of nitrogen application. The details of each are given below:

A. Grass and legume introductions : 4

- T₁ - Introduction of grass alone (Setaria sphacelata)
- T₂ - Introduction of legume alone (Desmodium uncinatum)
- T₃ - Introduction of grass plus legume (1:1 ratio).
- T₄ - No introduction (Control)

B. Nitrogen levels : 4

- N₀ - No nitrogen
- N₁ - 30 kg N/ha
- N₂ - 60 kg N/ha
- N₃ - 90 kg N/ha

C. Methods of nitrogen application : 2

- M₁ - 1/2 at planting + 1/2 at 25 days after planting in first year, while 1/2 at the time of regeneration + 1/2 at 25 days after regeneration in second year.

M_2 - $1/3$ at planting + $1/3$ at 25 days after planting + $1/3$ at 50 days after planting in first year while $1/3$ at the time of regeneration + $1/3$ at 25 days after regeneration + $1/3$ at 50 days after regeneration in second year.

3.5.2. Layout : The experiment was laid out in split-split plot design with four replications. Grass and legume introductions were kept in main plots and the nitrogen fertilizer treatments in sub-plots, while the methods of nitrogen application were in sub-sub plots. The introduction of Setaria and Desmodium was done in first year only. The layout remained unchanged in second year. The experiment was conducted in natural condition without disturbing the soil and modifying the slope to represent the true natural grassland conditions. The plots were demarcated by narrow furrows in order to avoid the run off of fertilizers and water from one plot to another. The layout plan has been shown in Fig.3.2. The gross plot size was 7m x 2.7 m, accomodating 6 rows each of Setaria and Desmodium when introduced alone at a row distance of 45cm and 3 each in case when both were introduced alternately with 45cm inter and 50cm intra row spacings. The net plot harvested to determine the yield was 3x1.7m.

3.5.3 Burning of existing vegetation: In order to eliminate the initial competition from the existing vegetation, the vegetative cover was burnt before start of the experiment. The controlled fire was confined only to the experimental area. The dried litter on the surface served the purpose of burning material. Burning was done on July 19, 1980.

3.5.4. Application of fertilizers: Nitrogen was applied through urea(46% N) in two and three equal splits as per treatments while entire quantity of

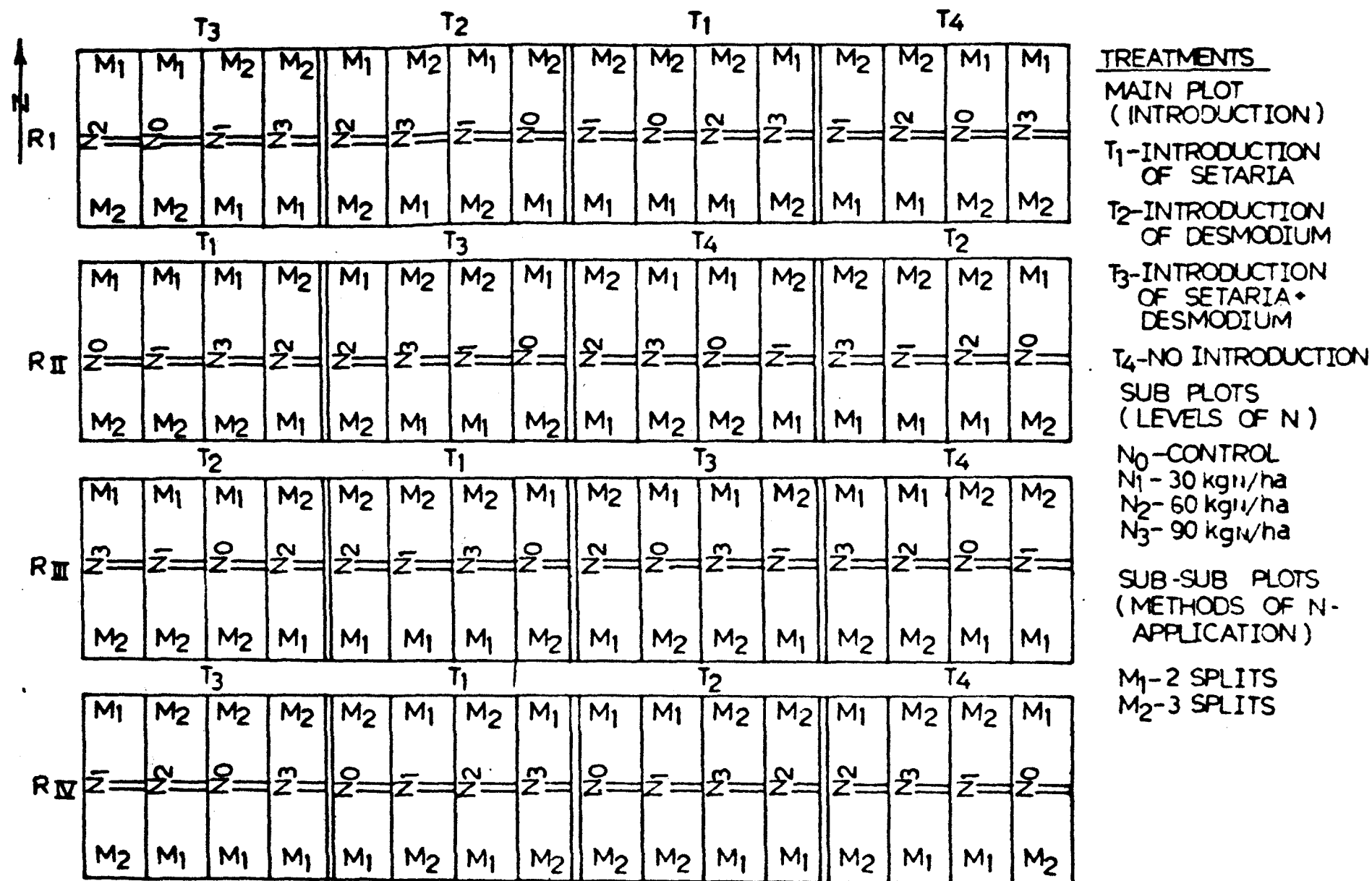


FIG.32: PLAN OF LAY-OUT OF EXPERIMENT DURING KHARIF 1980 & 1981

80 kg P_2O_5 (through single superphosphate, 16% P_2O_5) and 60 kg K_2O (through muriate of potash, 60% K_2O) were applied as broadcast at the time of planting in first year. The first split of nitrogen as per treatment was administered at the time of the introduction as broadcast and its remaining splits were top dressed 25 and 50 days after the introduction of grass and legume. No phosphorus and potash was applied during 1981.

3.5.5. Planting of grass/legume seedlings: Seedlings of both Setaria and Desmodium were obtained from the Economic Botanist (Fodder Crops) Himachal Pradesh Krishi Vishva Vidyalaya, Palampur. The seedlings were planted about 4-5cm deep in soil by making a hole with the help of a peg and covering the same after planting the seedlings without disturbing the soil.

3.6 Cultural operations

The various cultural operations performed during the growing seasons are given in Table 3.3.

Table 3.3. Cultural operations carried out during Kharif, 1980-and 1981.

Particulars	Dates	
	1980	1981
1. Destruction of shrubbery and tree shoots	14.7.80 to 16.7.80	-
2. Layout of experiment	17.7.80	-
3. Burning of plots	19.7.80	-
4. Fertilizer application		
a. 1/2 and 1/3 nitrogen and full phosphorus and potash as per treatments	20.7.80	1.5.81
b. 1/2 and 1/3 nitrogen application	14.8.80	25.5.81
c. 1/3 nitrogen application	9.9.80	20.6.81
5. Planting of <u>Setaria</u> and <u>Desmodium</u>	20.7.80	-
6. Harvesting	4.10.80	10.9.81

3.7. Observations recorded

3.7.1. Growth and development studies: The data pertaining to growth and development studies were recorded at 25, 50, 75 days after introduction of grass/legume in 1980 and 25, 50, 75, 100, 125 and 130 days from the date of regeneration in 1981 i.e. from May 1st, 1981.

a. Plant height: Three plants each from introduced grass/legume and indigenous grass (mixed species) were selected randomly and labelled in the observational plot. Height of these plants was recorded at 25 days interval from the date of plantation in the first year and from the initiation of regeneration in the following year till harvest and then averaged out. The plant height was taken from the base to the highest tip of the plant.

b. Green and dry weight: The samples were taken with the help of a quadrat measuring 0.5m x 0.5m from the observational area at the intervals at which plant height was measured. The scheme of sampling is shown in Fig. 3.3. After cutting the herbage from the ground level, the same was allowed to remain for sometime to facilitate the evaporation of the adhered water, if any, and weighed to record the green weight. The total green weight was then converted into kg/m^2 .

From the harvested green samples, a small quantity of representative sample of 200g and entire quantity for those where the sample size was small, were taken to determine the dry weight. The samples were air dried for 3-4 days, then dried at 70°C in a forced air draft oven for three days. Data on dry weight were recorded when samples attained constant weight. The recorded dry weight was converted into dry weight kg/m^2 .

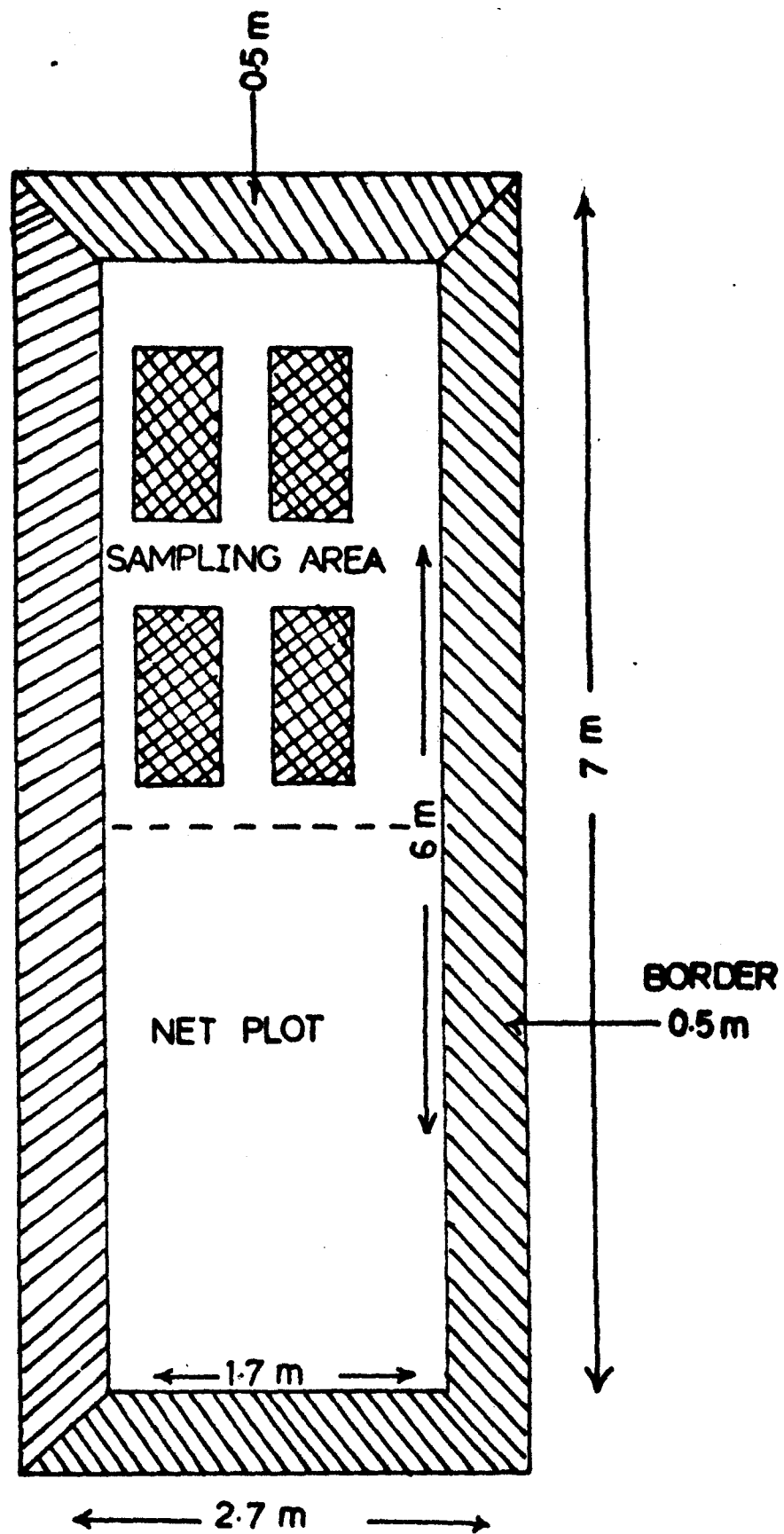


FIG. 33: PLAN OF SAMPLING SCHEME

c. Per cent establishment: The number of introduced grass/legume seedlings per plot were counted before the final harvest in each year and their establishment per cent was worked out as given below:

$$\text{Per cent establishment} = \frac{\text{No. of plants at harvest}}{\text{Total No. introduced}} \times 100$$

3.8. Harvesting:

When the introduced grass attained about 20 per cent flowering, the harvesting was done. It was observed in both the years of experimentation that legume did not flower by the time introduced grass had attained 20 per cent flowering. Most of the indigenous grass species at this stage were in full bloom.

3.8.1. Green fodder yield: The produce from the net plot (3m x 1.7m) was weighed and expressed in quintals per hectare.

3.8.2. Dry fodder yield: The green herbage after harvest was sun dried and representative samples from the same were finally oven dried to record the dry matter which was expressed in quintals per hectare.

3.9. Chemical analysis

3.9.1. Plant analysis: Plants, sampled for the determination of green and dry weight at different stages of growth, were ground in a electric grinder using 2 mm sieve and analysed for total nitrogen employing Kjeldahl method (A.O.A.C., 1960). The uptake values (g/m^2) were determined using the per cent values and multiplying these with corresponding dry weights per square metre and dividing by 100.

3.9.2. Quality evaluation: Plant samples at harvest were qualitatively evaluated for the characters such as cell wall and cell constituents, crude

protein, calcium, phosphorus and in-vitro dry matter digestibility.

The methods employed for estimation of these are given below:

- a. Neutral detergent fibre(NDF): It was determined by the method of Van Soest and Wince (1968).
- b. Acid detergent fibre (ADF): For its estimation, Modified Acid Detergent Fibre(MADF) method was followed as described by Goering & Van Soest (1967).
- c. Hemi-cellulose: It was calculated by finding out the difference between NDF and ADF (Van Soest and Moore, 1965).
- d. Lignin: It was estimated as loss in weight of samples for ADF determination after oxidation with $KMnO_4$ and was expressed in percentage.
- e. Cellulose: It was calculated by ashing lignin residues and calculating the loss in weight and expressed as cellulose content in per cent.
- f. Total ash: A weighed quantity of sample (5g) in a tared vitrosil silica basin was incinerated and muffled at $550^{\circ}C$ for three hours. The net weight of total ash was expressed on percentage basis.
- g. Silica (SiO_2): The ash was treated with HBr (48%) and the residue obtained was expressed in per cent of total ash as silica content.
- h. Acid insoluble ash: The ashed sample was quantitatively transferred on a filter paper (Whatman No.40) with the help of distilled water. The sample was washed 25 times with dilute HCL and filtered. The filter paper along with the residue was muffled at $550^{\circ}C$ for three hours. The net weight of the acid insoluble ash was expressed on percentage basis.
- i. Crude protein: Estimated by multiplying per cent nitrogen values by 6.25.

j. Cell contents: Neutral detergent solubles or cell contents were calculated by subtracting the per cent NDF from 100 as suggested by Von Soest and Moore (1965).

k. Phosphorus: Phosphorus content was determined by Vanado-Molybdate Phosphoric Yellow Colour method (A.O.A.C., 1960), n, 1960).

l. Calcium: Calcium was determined by precipitating it as calcium oxalate (Piper, 1966).

The overall basic scheme of the analysis of the above fractions has been given in Table 3.4.

Table 3.4. Basic scheme for forage analysis

Fraction	Reagents	Treatment	Yield
Neutral Detergent Fibre (NDF)	Sodium lauryl sulphate EDTA pH 7.0	Boil one hour	Total plant cell wall (CWC)
Acid Detergent Fibre (ADF)	Cetyle trimethyle ammonium bromide in 1N H_2SO_4	Boil one hour	Ligno Cellulose
Lignin	$KMNO_4$, pH 3.0	1½ hour at 20°C	Lignin as loss in weight by oxidation
Cellulose	None	Ash residue from loss in weight lignin step.	
Silica(SiO_2)	Conc. HBr(48%)	Treat ash drop wise one hour at 25°C	Residue in silica
Hemi-cellulose	None	Calculated as NDF - ADF	-

3.9.3. In-vitro dry matter digestibility (IVDMD): The in-vitro dry matter digestibility was determined by the technique developed by Tilley and Terry (1963) and modified by Goering and Vansoest (1969).

3.10. Economic studies:

The economics of individual treatment was worked out for the year 1980 and 1981 separately and also combinedly for both the years. The objective of working out the combined economics for 1980 and 1981 was to have more valid comparison^{of}/treatments. Since 1980 was the year of establishment and phosphorus and potash were applied only in this year their residual effects were bound to be operative in subsequent year also. The cost of the produce has been estimated on the basis of rates collected from the Department of Animal Husbandry from their office at Palampur and current fertilizer rates were obtained from the records of the Department of Agronomy and Agrometeorology, Himachal Pradesh Krishi Vishva Vidyalaya, Palampur.

3.11. Statistical analysis

All the data pertaining to the present investigation were subjected to statistical analysis by the method described by Cochran and Cox (1963). The statistical significance of various effects was tested at 5 per cent probability level. The requisite transformation for percentage data were not needed to apply as the values did not cross the critical limits of 30-70 per cent. Simple Correlation Coefficients were worked out between dry fodder yield and nitrogen content, and nitrogen uptake, and between in-vitro dry matter digestibility and various cell wall components and cell contents.

EXPERIMENTAL RESULTS

4. EXPERIMENTAL RESULTS

The treatment effects on various characters recorded during two years of experimentation (Kharif, 1980 and 1981) have been described in this chapter and presented with the help of data tables and diagrammes. The analyses of variance tables have been given in the Appendix section. The pattern followed for description of treatment effects includes the effect of each factor under study on growth and development, progressive fresh and dry weight accumulation, herbage yield, nutrient accumulation and quality parameters.

4.1. Effect of grass and legume introduction

4.1.1. Establishment of introduced grass and legume

The data on per cent establishment of Setaria grass and Desmodium introduced as per treatments are given in Table 4.1. The per cent establishment was worked out as ratio of the established plants counted at harvest to the total number planted and multiplied with 100. In second year, this per cent based on the number of plants regenerating in May 1981, thus being survival percentage rather than establishment percentage in true sense.

In 1980, the year of introduction, various treatments of introduction did not influence the per cent establishment significantly either that of Setaria or Desmodium, that is to say, whether these species were introduced alone or in combination (alternate rows) established with same efficacy. In second year, the survival of Setaria and Desmodium after harvest and passing through winter season was also same whether introduced alone or in combination (Table 4.1). The corresponding analyses of variance for the year 1980-1981 are appended in Appendix III.

Table 4.1. Effect of grass and legume introduction on growth, development, yield and nutrient accumulation

Character	Year	Grass and legume introduction				SEm _±	CD5%	CV(%)
		T ₁	T ₂	T ₃	T ₄			
<u>Per cent establishment</u>								
<u>Setaria</u>	1980	90.2	-	89.5	-	0.48	NS	3.0
	1981	88.0	-	85.6	-	0.69	NS	4.5
<u>Desmodium</u>	1980	-	83.1	80.4	-	1.08	NS	7.4
	1981	-	76.2	72.5	-	0.92	NS	7.0
<u>Per cent proportion of</u>								
<u>Setaria</u>	1981	39.0	-	26.9	-	0.15	0.68	2.6
<u>Desmodium</u>	1981	-	33.2	22.8	1.1	1.05	3.61	31.1
<u>Plant height (cm)</u>								
Grass	1980							
25 DAP*		27.7	-	30.8	-	5.94	NS	28.7
50 DAP		37.3	-	39.7	-	8.72	NS	32.0
75 DAP		49.5	-	49.6	-	6.47	NS	18.4
	1981							
0 DAR*		30.8	-	24.3	15.3	1.63	5.64	43.6
25 DAR		30.6	-	29.5	22.0	1.93	6.65	39.7
50 DAR		35.3	-	33.3	28.0	1.66	5.72	29.1
75 DAR		56.8	-	53.0	45.0	3.31	11.42	36.2
100 DAR		92.8	-	88.0	87.8	5.37	NS	33.8
125 DAR		126.1	-	116.9	107.6	5.04	17.37	24.3
130 DAR		136.4	-	124.7	114.8	6.38	NS	28.7

* DAP - Days after planting
 DAR - Days after regeneration
 NS - Non-significant

Contd.

Character	Year	T ₁	T ₂	T ₃	T ₄	SE _m ±	CD5%	CV(%)
Legume	1980							
25 DAP		-	14.2	16.3	-	0.88	NS	32.6
50 DAP		-	20.7	19.3	-	1.40	NS	39.3
75 DAP		-	33.1	26.6	-	1.50	NS	28.2
	1981							
0 DAR		-	11.4	9.7	-	1.65	NS	28.5
25 DAR		-	17.5	12.4	-	3.65	NS	37.7
50 DAR		-	22.5	14.7	-	5.28	NS	39.8
75 DAR		-	34.5	22.5	-	7.43	NS	47.1
100 DAR		-	66.0	44.6	-	10.50	NS	37.1
125 DAR		-	90.9	61.9	-	11.67	NS	40.2
130 DAR		-	95.7	68.3	-	12.92	NS	38.8
<u>Fresh weight (kg/m²)</u>								
	1980							
25 DAP		0.29	0.28	0.23	0.33	0.017	0.054	34.7
50 DAP		0.52	0.53	0.54	0.55	0.032	NS	34.1
75 DAP		0.79	0.84	0.81	0.80	0.032	NS	22.3
	1981							
0 DAR		0.14	0.13	0.11	0.11	0.011	NS	49.0
25 DAR		0.20	0.16	0.16	0.14	0.013	NS	45.0
50 DAR		0.20	0.20	0.20	0.18	0.010	NS	30.0
75 DAR		0.77	0.71	0.72	0.72	0.038	NS	29.8
100 DAR		1.06	0.76	0.89	0.70	0.043	0.137	28.5
125 DAR		0.94	0.61	0.74	0.64	0.040	0.127	30.7
130 DAR		1.04	0.78	0.90	0.74	0.048	0.153	31.2

Contd..

Character	Year	T ₁	T ₂	T ₃	T ₄	SEm±	CD5%	CV(%)
<u>Dry weight (kg/m²)</u>								
	1980							
25 DAP		0.08	0.09	0.06	0.09	0.005	0.016	34.6
50 DAP		0.16	0.16	0.16	0.17	0.007	NS	25.0
75 DAP		0.23	0.25	0.24	0.24	0.006	NS	14.5
	1981							
0 DAR		0.11	0.11	0.10	0.10	0.005	NS	25.3
25 DAR		0.12	0.11	0.11	0.11	0.005	NS	23.3
50 DAR		0.12	0.13	0.12	0.12	0.006	NS	27.9
75 DAR		0.17	0.16	0.15	0.16	0.009	NS	33.2
100 DAR		0.41	0.32	0.35	0.28	0.015	0.049	25.3
125 DAR		0.41	0.33	0.34	0.33	0.017	0.055	28.0
130 DAR		0.42	0.38	0.36	0.37	0.021	NS	31.6
<u>Green fodder yield(q/ha)</u>								
	1980	86.76	81.21	83.83	81.67	1.825	NS	12.3
	1981	282.64	219.99	241.68	201.41	8.072	25.745	19.2
<u>Dry fodder yield (q/ha)</u>								
	1980	25.36	23.91	24.63	24.27	0.481	NS	11.1
	1981	136.24	116.75	119.31	104.93	3.397	10.834	16.1
<u>Nitrogen content(%)</u>								
	1980							
25 DAP		1.21	1.22	1.18	1.12	0.043	NS	20.4
50 DAP		1.21	1.23	1.13	1.28	0.045	NS	21.0
75 DAP		1.07	1.20	1.08	1.05	0.026	0.084	13.5

Contd...

Character	Year	T ₁	T ₂	T ₃	T ₄	SEm±	CD5%	CV(%)
<u>Nitrogen content(%)</u>								
1981								
0 DAR		0.90	0.88	0.90	0.87	0.013	NS	8.4
25 DAR		1.21	1.19	1.18	1.32	0.048	NS	23.0
50 DAR		1.18	1.22	1.07	1.28	0.051	NS	24.0
75 DAR		1.14	1.25	1.34	1.31	0.045	0.143	20.1
100 DAR		1.41	1.40	1.36	1.43	0.019	NS	7.5
125 DAR		0.99	1.18	0.99	0.90	0.047	0.150	26.1
130 DAR		0.99	1.19	1.00	0.90	0.048	0.153	26.2
<u>Nitrogen uptake (g/m²)</u>								
1980								
25 DAP		0.99	1.07	0.97	1.01	0.052	0.166	30.9
50 DAP		1.98	2.04	1.90	2.13	0.081	NS	22.7
75 DAP		2.61	3.16	2.71	2.62	0.092	0.293	18.7
1981								
0 DAR		1.01	0.97	0.91	0.90	0.045	NS	26.8
25 DAR		1.44	1.35	1.28	1.21	0.058	NS	24.7
50 DAR		1.47	1.60	1.32	1.57	0.055	0.175	20.9
75 DAR		1.93	2.10	2.10	2.14	0.114	NS	31.0
100 DAR		5.93	4.50	4.55	4.11	0.332	1.059	39.3
125 DAR		4.21	3.99	3.48	3.15	0.217	0.692	33.1
130 DAR		4.27	4.69	3.84	3.53	0.331	NS	45.7

4.1.2. Setaria and Desmodium proportion

At harvest in 1981, the relative proportion of Setaria and Desmodium were worked out on the basis of their dry weight in proportion to the total dry matter of herbage. The data are present in Table 4.1 and analysis of variance in Appendix IV.

The proportion of Setaria was significantly higher in the plots introduced with Setaria alone (39.0%) than its introduction with Desmodium (26.9%). Introduction of Desmodium alone also had significantly higher proportion than its introduction in alternate rows with Setaria. In the plots where introduction was not made, 1.1 per cent Desmodium was found which was significantly lowest than rest of the treatments. This was due to presence of local Desmodium in natural grassland.

4.1.3. Plant height of grass

The data on the plant height of introduced grass (Setaria) during 1980 and mixed herbage (including existing indigenous species and Setaria) during 1981 measured at various growth stages are presented in Table 4.1. The analyses of variance are appended in Appendix V and VI. The data have also been illustrated graphically in Fig. 4.1.

In 1980, the height of Setaria increased from 25 days after planting (DAP) to 75 DAP linearly. It is also clear from the Fig. 4.1 that there was increase in plant height from regeneration to harvest stage in 1981. In the initial stage of regeneration i.e. from 0 to 50 DAR (days after regeneration), the rate was slow that increased at faster rate upto 125 DAR and again at a relatively slow rate, thus giving rise to a sigmoid curve.

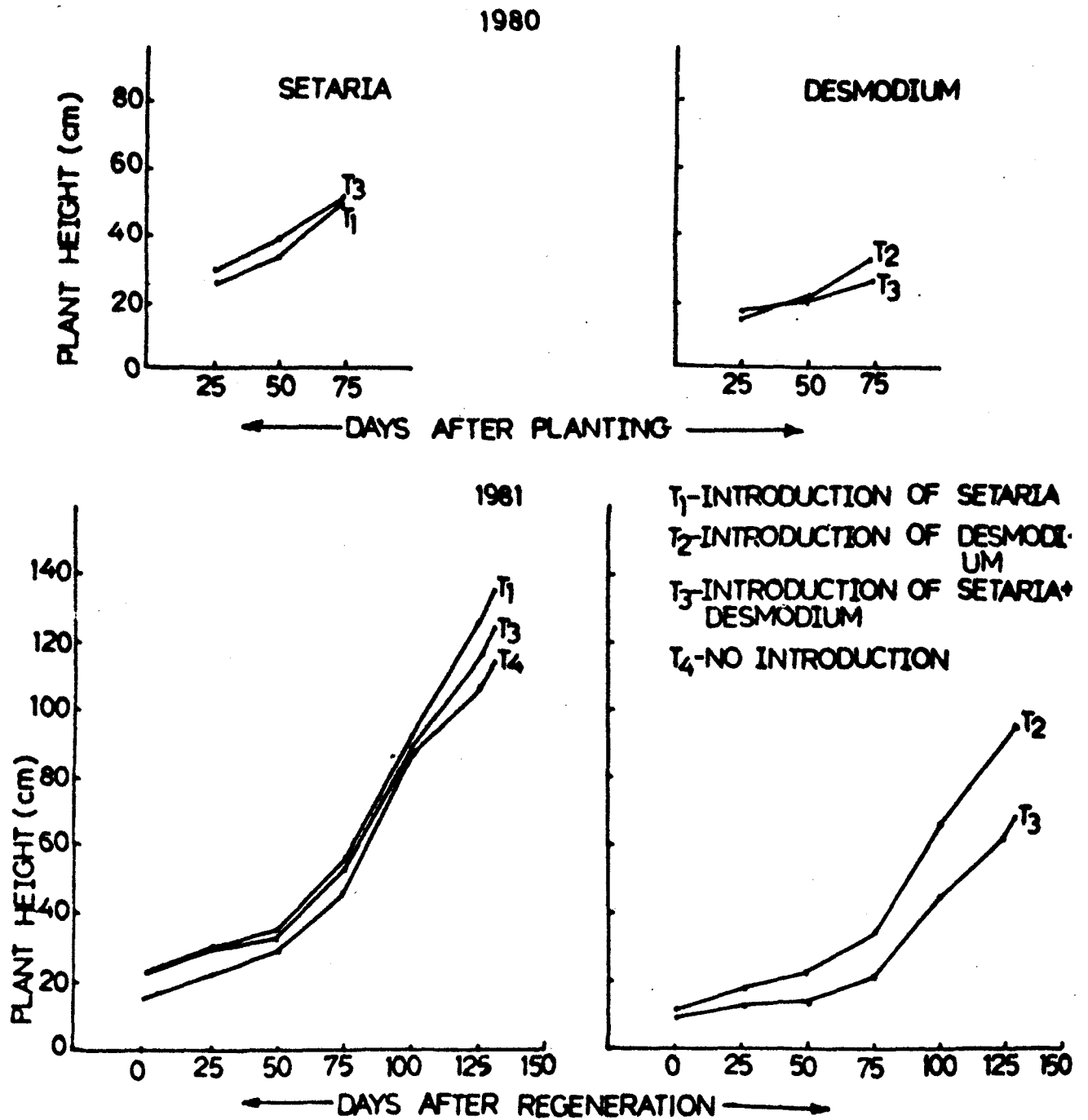


FIG.4.1. MEAN HEIGHT OF GRASS AND LEGUME SPECIES AT DIFFERENT GROWTH STAGES AS AFFECTED BY INTRODUCTION

It is evident from the data that height of introduced Setaria in 1980 was not affected significantly at any stage of growth due to its introduction alone or in combination with Desmodium. In 1981, the plant height of mixed species including Setaria was measured as both of them showed regeneration almost at the same time. Data presented in Table 4.1 show that the plant height of herbage was significantly higher in those plots which were introduced with Setaria alone or Setaria with Desmodium as compared to the plots without introduction (T_4). However, the difference in height due to introduction of Setaria alone or in combination with Desmodium was not significant at all stages of growth. At 100 and 130 DAR, the height difference due to T_3 and T_4 was also non-significant.

4.1.4. Plant height of Desmodium

The data on the plant height of introduced legume (Desmodium) during 1980 and 1981 measured at various growth stages are presented in Table 4.1. The analyses of variance are appended in Appendix VII and VIII and IX. The data have also been illustrated graphically in Fig. 4.1 for perusal at a glance.

A perusal of Fig. 4.1 shows that height of Desmodium introduced alone or in combination with Setaria increased linearly during 1980 till harvest. However, in 1981, the plant height of Desmodium whether alone or in combination with Setaria increased slowly from the initiation of regeneration to 75 DAR but increased sharply thereafter upto 125 DAR and again increase was slow till harvest.

It is evident from the data that the height of introduced Desmodium was not affected significantly at any stage of growth due to its introduction alone or in association with Setaria during both the years of experimentation.

4.1.5. Fresh herbage weight

The data on fresh weight (kg/m^2) at different stages of sampling during both years have been given in Table 4.1. The corresponding analyses of variance are appended in Appendix IX and X. The progressive increase in fresh weight as affected by main effects of the treatments have been depicted graphically in Fig. 4.2.

A perusal of Fig. 4.2 shows that the fresh weight of herbage, irrespective of treatments, increased linearly with increase in age right from 25 to 75 days after planting in 1980. However, in 1981, the increase in the herbage weight remained very slow till 50 days from the date of regeneration. Thereafter the rate of increase in fresh weight was very fast upto 100 DAR in T_1 , T_2 and T_3 treatments while such trend was observed only upto 75 DAR in case of T_4 . In general there was decline in fresh weight at 125 DAR and again it showed an increase at 130 DAR.

Introduction of Setaria and Desmodium alone and in combination influenced the fresh weight significantly only at 25 DAP during 1980. The effect of introduction was non-significant on fresh weight of herbage upto 75 DAR in 1981 also but brought significant difference afterwards. At 100, 125 and 130 DAR, plots introduced with Setaria alone (T_1) resulted in significantly higher green herbage than other treatments,

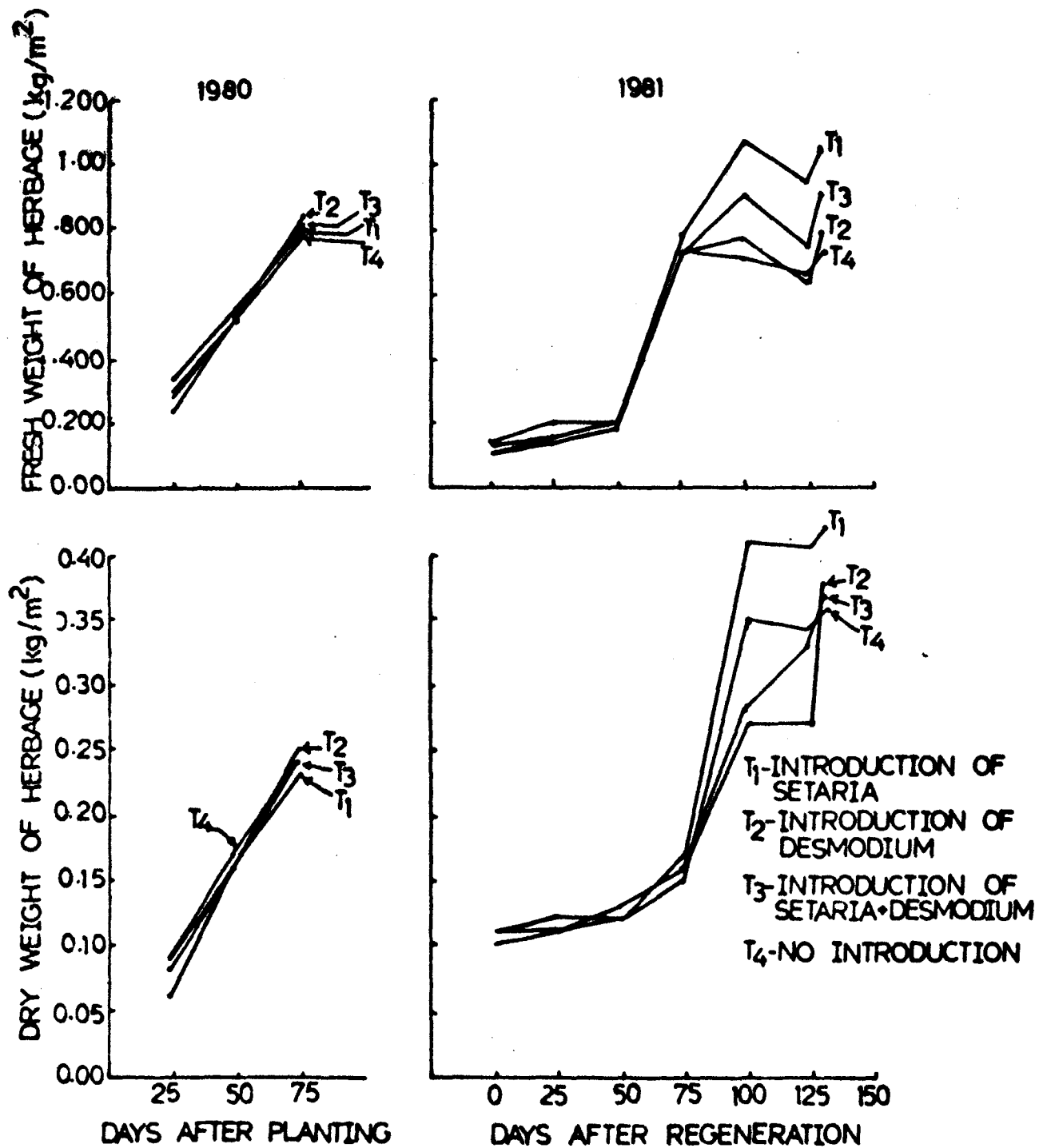


FIG.4.2: MEAN FRESH AND DRY WEIGHT OF HERBAGE AT DIFFERENT GROWTH STAGES AS AFFECTED BY GRASS/LEGUME INTRODUCTION

though this (T_1) did not differ significantly with T_3 , i.e. introduction of Setaria and Desmodium together at 130 DAR. Introduction of Desmodium alone (T_2) did not bring significant difference in fresh herbage weight as compared to no introduction (T_4).

4.1.6. Dry herbage weight

The data pertaining to the dry weight of herbage (kg/m^2) at different stages of sampling during 1980 and 1981 as influenced by introduction of grass and legume have been presented in Table 4.1. The corresponding analyses of variance are appended in Appendix XI and XII. These data have also been illustrated graphically in Fig. 4.2.

A perusal of Fig. 4.2 shows that dry weight of the herbage increased with advancement in crop age irrespective of the treatment effects. In 1980, the increase from 25 to 75 days after planting was linear while in 1981, dry matter accumulation showed a different trend. After start of regeneration to 50 DAR, there was very slow rate of accumulation which increased at faster rate upto 100 DAR and showed a slower rate of accumulation afterwards. There were reductions also in some cases after this stage of sampling.

In 1980, the dry weight of herbage was not affected by introduction treatments except at 25 DAP where, dry weight in plots introduced with Setaria and Desmodium was significantly lower than remaining treatments that did not differ significantly among them.

During 1981, the influence of introduction treatments on dry weight of herbage was non-significant at all stages of sampling except 100 and 125 DAR. At both these stages of sampling the plots introduced with Setaria alone (T_1) produced highest dry weight and differed

significantly with other treatments. The remaining three treatments (T_2 , T_3 and T_4) did not differ significantly among them at 125 DAR while at 100 DAR, the differences between T_2 and T_3 as well as between T_2 and T_4 were non-significant.

4.1.7. Green fodder yield

The data on green fodder yield as affected by various introductions during two years have been given in Table 4.1. The corresponding analyses of variance are appended in Appendix XIII. The data have also been depicted graphically in Fig. 4.3.

In general, the yield levels were lower in first year which was the year of establishment as compared to second year (Fig.4.3). On an average 183.6 per cent higher yield was obtained in 1981 than 1980.

Various introductions did not influence the green forage yield significantly during first year of establishment (1980). In 1981, the green herbage yield was significantly higher from all those treatments where introduction of Setaria or Desmodium was done as compared to no introduction except that the difference between T_2 (introduction of Desmodium alone) and T_4 (no introduction) was non-significant. Introduction of Setaria alone yielded significantly higher green fodder than remaining all treatments followed by treatment in which Setaria and Desmodium both were introduced (T_3) which however, did not differ significantly with T_2 (Desmodium alone).

4.1.8. Dry fodder yield

The data on dry fodder yield as affected by treatments of introduction during 1980 and 1981 are presented in Table 4.1. The

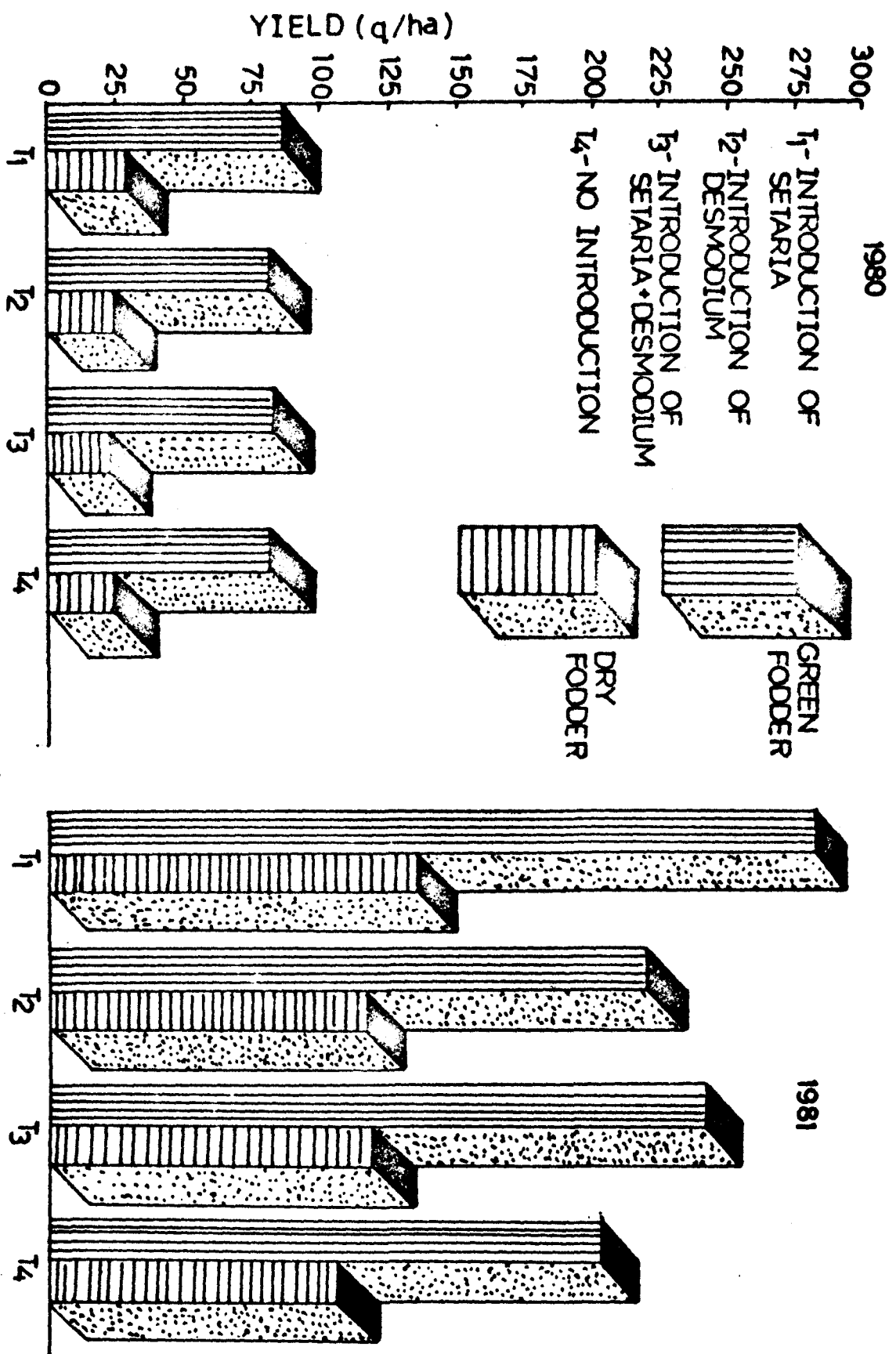


FIG.4.3: GREEN AND DRY FODDER YIELD AS INFLUENCED BY GRASS/LEGUME INTRODUCTION

corresponding analyses of variance are appended in Appendix XIV. The data have also been depicted graphically in Fig. 4.3.

Similar to green fodder yield, the dry fodder yield was also not affected significantly by various treatments of introduction in the year of establishment. The dry matter yield was significantly higher when introduction of Setaria alone was done (T_1) as compared to other treatments. Introduction of Desmodium alone (T_2) and in combination with Setaria (T_3) resulted in statistically similar dry matter production but significantly higher than that where introduction was not done (T_4).

4.1.9. Nitrogen content

The data on nitrogen content (%) at different sampling stages during 1980 and 1981 have been presented in Table 4.1. The corresponding analyses of variance are appended in Appendix XV and XVI. The nitrogen content in herbage at different sampling stages has also been depicted graphically in Fig. 4.4.

In general, the nitrogen content in herbage showed increase upto 50 DAP in 1980 and decreased afterwards till harvest. In 1981, the mean nitrogen concentration showed increase upto 100 DAR and declined afterwards upto harvest stage. However, this trend was modified under different treatments of introduction as clear from Fig. 4.4.

The influence of grass and legume introduction on nitrogen content was significant at 75 DAP only in first year i.e. the year of introduction. At this stage, herbage obtained from plots introduced with Desmodium alone had significantly higher nitrogen content than other treatments that had statistically similar nitrogen content. During 1981,

introduction effects on nitrogen content of herbage were significant at 75, 125 and 130 DAR only. At later two stages of growth, nitrogen content was significantly higher in the plots introduced with Desmodium alone than rest of the treatments which did not differ significantly among them in this respect. At 75 DAR, however, T_1 (introduction of Setaria alone) recorded the lowest nitrogen content although at par with T_2 (introduction of Desmodium) alone. The nitrogen content of herbage from T_2 , T_3 and T_4 treatments were statistically same.

4.1.10. Nitrogen uptake

The data on nitrogen uptake (g/m^2) at different growth stages as affected by various treatments during 1980 and 1981, have been presented in Table 4.1. The corresponding analyses of variance are given in Appendix XVII and XVIII. The data have also been depicted graphically in Fig. 4.4.

It is clear from Fig. 4.4 that nitrogen accumulation increased linearly upto 75 DAP in 1980, while in the second year the uptake increased upto 100 DAR and there was decline afterwards in case of all the treatments. The rate of uptake in 1981 was at slower rate upto 50 DAR and it was at much faster rate between 75 and 100 DAR.

The nitrogen uptake in 1980 was significantly higher when legume alone was introduced as compared to other introductions that did not differ significantly among them at 25 and 75 DAP while the effect was non-significant at 50 DAP. At 25 DAP, however, the difference between T_2 and T_4 was also non-significant.

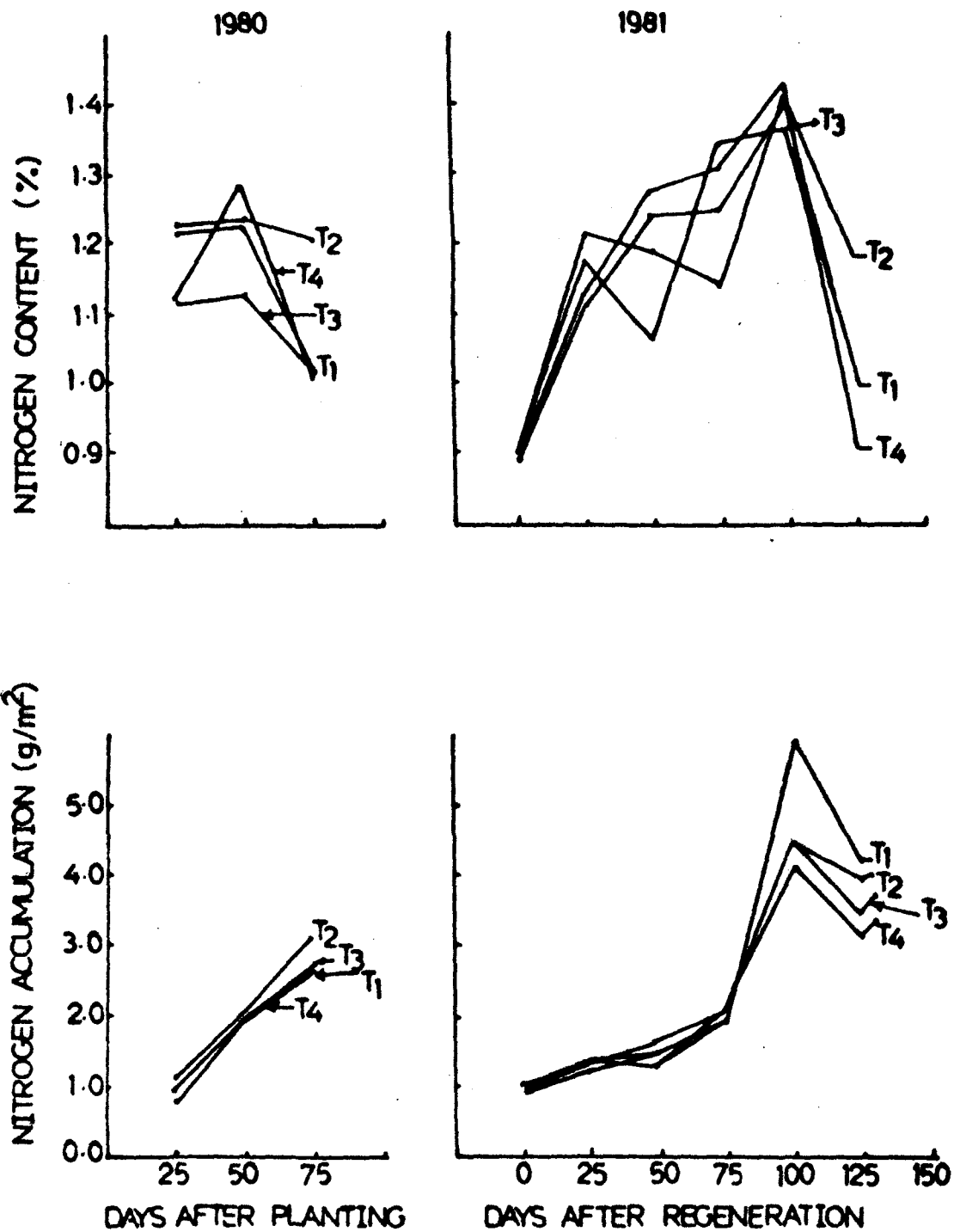


FIG.4.4: NITROGEN CONTENT & ACCUMULATION IN HERBAGE AT DIFFERENT GROWTH STAGES AS INFLUENCED BY GRASS/LEGUME INTRODUCTION

In the second year, nitrogen uptake was affected significantly at 50, 100 and 125 DAR only. At later two stages, introduction of Setaria alone resulted in significantly higher nitrogen uptake than other introductions that did not differ significantly among them at 100 DAR, while at 125 DAR, nitrogen content of T_2 was on par with T_1 and that of T_3 and T_4 was also non-significant between them. At 50 DAR, all the treatments had significantly higher nitrogen uptake than introduction of Setaria and Desmodium in alternate rows (T_3), though this was on par with T_1 (introduction of Setaria alone).

4.1.11 Herbage quality

The quality parameters studied in the present investigation included, crude protein, calcium, phosphorus, NDF(Neutral detergent fibre) ADF(Acid detergent fibre), cellulose, hemi-cellulose, lignin, silica, total ash, acid insoluble ash, cell content and IVDMD (In-vitro dry matter digestibility), and the data pertaining to them as influenced by different treatments of introduction are presented in Table 4.2 and their analyses of variance are appended in Appendices XIX to XXII for both years.

a. Crude protein content

Crude protein content (%) was influenced significantly due to introduction of grass and legume during both the years. Herbage produced from the plots introduced with Desmodium alone had significantly higher protein content than other treatments which were non-significant among them during both the years of experimentation.

Table 4.2. Effect of grass and legume introduction on various quality parameters of herbage at harvest

Quality parameters (%)	Year	Grass and legume introduction				SE _{em}	CD _{5%}	CV(%)
		T ₁	T ₂	T ₃	T ₄			
Crude protein	1980	6.68	7.50	6.74	6.55	0.164	0.453	13.5
	1981	6.19	7.46	6.28	5.84	0.314	0.868	27.5
Calcium	1980	0.45	0.47	0.53	0.52	0.008	0.022	8.8
	1981	0.40	0.87	0.57	0.48	0.059	0.163	23.4
Phosphorus	1980	0.22	0.22	0.23	0.22	0.002	NS	6.6
	1981	0.10	0.12	0.11	0.10	0.004	0.011	19.7
NDF	1980	81.26	78.66	78.44	81.58	0.495	1.368	3.7
	1981	74.73	74.87	74.65	77.50	0.589	1.628	4.2
ADF	1980	51.53	49.76	51.36	51.13	0.468	NS	5.2
	1981	56.08	53.66	53.14	55.26	0.274	0.757	2.8
Cellulose	1980	37.46	36.46	36.42	36.46	0.571	NS	8.8
	1981	43.38	42.57	40.83	40.98	0.228	0.630	3.1
Hemi-cellulose	1980	25.59	25.11	23.29	23.54	0.469	1.296	10.8
	1981	24.17	23.20	25.49	26.91	0.834	2.305	18.9
Lignin	1980	11.09	9.81	9.99	10.77	0.285	0.788	15.2
	1981	10.00	9.68	9.76	9.52	0.173	NS	10.0
Silica	1980	3.40	3.37	3.51	3.81	0.095	0.262	15.0
	1981	2.50	2.55	2.57	2.82	0.076	0.210	16.4
Total ash	1980	8.95	8.81	8.72	8.84	0.277	NS	17.7
	1981	7.71	6.16	7.23	6.03	0.373	1.031	30.9
Acid insoluble ash	1980	4.39	4.17	4.30	4.31	0.176	NS	23.2
	1981	2.30	2.21	2.25	3.03	0.162	0.448	37.3
Cell content	1980	18.74	21.34	21.50	18.42	0.594	1.641	16.3
	1981	25.27	25.13	25.35	22.50	0.506	1.398	11.6
IVDMD	1980	43.97	44.81	45.11	38.01	0.283	0.782	3.7
	1981	45.30	45.57	46.67	42.40	0.377	1.042	4.7

b. Calcium and phosphorus content

The calcium content was affected significantly by introductions in both the years, while phosphorus content was affected in 1981 only. In 1980, herbage obtained from the plots introduced with Setaria and Desmodium together (T_3) and without introduction (T_4) contained similar calcium which were significantly higher than the herbage obtained from the plots introduced with Setaria and Desmodium alone (T_1 and T_2).

In second year, calcium and phosphorus contents were significantly higher in the herbage obtained from the plots introduced with Desmodium alone (T_2). The difference with other treatments was significant. The remaining treatments of introduction did not differ significantly among them in respect of Ca and P contents except that T_1 and T_4 did not differ significantly in respect of Ca content.

c. Neutral detergent fibre(NDF)and acid detergent fibre (ADF)

The effect of introduction treatments was significant in respect of NDF only in the year of establishment when T_4 (no introduction) resulted in production of herbage having significantly higher NDF values, followed by T_1 (introduction of Setaria alone) and these two differed significantly with T_2 and T_3 . In second year, NDF and ADF both were affected significantly due to introduction treatments. NDF was significantly higher in T_4 than other treatments and differed significantly from all other treatments. The herbage obtained from the plots introduced with Setaria alone (T_1) and no introduction (T_4) contained significantly higher ADF than T_2 and T_3 . The difference in ADF values due to T_2 and T_3 was also non-significant.

d. Cellulose and hemi-cellulose content

The effect of introductions on cellulose content of herbage at harvest was significant in 1981 only while it was significant during both years in respect of hemi-cellulose. The herbage from the plots introduced with Setaria alone had highest cellulose content and the difference with other treatments was significant. Introduction of Desmodium alone (T_2) produced the herbage having significantly higher cellulose content than remaining two treatments (T_3 and T_4) that did not differ significantly between them.

Introduction of Setaria and Desmodium alone (T_1 and T_2) produced the herbage having significantly higher hemi-cellulose content than rest two treatments viz., T_3 and T_4 which were also non-significant between them in 1980. In second year, the trend was reverse except that T_1 , T_2 and T_3 were also at par in this respect.

e. Lignin and silica content

Lignin content of the herbage at harvest was significantly influenced by introduction during establishment year only (Table 4.2). The introduction of Desmodium alone (T_2) or in combination with Setaria resulted in significantly lower lignin content as compared to other two treatments, which did not differ significantly. The difference in lignin content due to T_2 (introduction of Desmodium alone) and T_3 (Setaria + Desmodium) was not significant while silica content of herbage was significantly influenced by introduction during both the years of experimentation. T_4 treatment (no introduction) recorded the maximum silica content and differed significantly from rest of the treatments.

The remaining treatments did not differ significantly among themselves in respect of silica content of herbage (Table 4.2).

f. Total ash content

Various introductions significantly influenced the total ash content of herbage in the second year of the experimentation only, recording maximum values in case of herbage obtained from the plots introduced with Setaria alone (T_1). The difference between T_1 and T_3 was non-significant but both had significantly higher values than T_4 . The difference in ash content of herbage from T_4 and T_2 was non-significant.

g. Acid insoluble ash content

The various introduction treatments did not influence the acid insoluble ash content in herbage in 1980. In second year, the herbage obtained from the plots without introduction contained highest acid insoluble ash and the difference was significant over remaining three treatments of introduction which were non-significant among themselves.

h. Cell content

Cell content of the herbage at harvest was significantly influenced by the introductions during both the years (Table 4.2). Introduction of Setaria in combination with Desmodium produced the herbage with maximum cell content which however, was on par with T_2 but differed significantly from T_1 and T_4 in the establishment year. In 1981, treatments T_1 , T_2 and T_3 , though on par had maximum cell content

and differed significantly from T_4 . However, the amount of cell content was considerably higher in the second year.

i. In-vitro dry matter digestibility (IVDMD)

The in-vitro dry matter digestibility (IVDMD) was significantly influenced by introduction treatments during both the years. The herbage obtained from the plots introduced with Desmodium alone (T_2) or Desmodium + Setaria (T_3) had significantly higher IVDMD than the plots having no Desmodium (T_1 and T_4) during both the years. However, the difference between T_1 and T_2 was non-significant in second year. IVDMD values were minimum in case of herbage obtained from the control plot (T_4) during both the years of experimentation.

4.2. Effect of nitrogen levels

4.2.1. Establishment of introduced grass and legume

The data on the effects of various nitrogen levels on the establishment (%) of Setaria and Desmodium at harvest during 1980 and 1981 are given in Table 4.3 and corresponding analyses of variance are appended in Appendix III.

Per cent establishment of Setaria increased with increasing levels of nitrogen upto 60 kg N/ha and further increase did not bring significant difference in per cent establishment during both the years. The plots not supplied with nitrogen had minimum establishment percentage of Setaria during both the years.

The trend of effect of nitrogen application on establishment of Desmodium was also almost similar to that of Setaria except that 30kg N/ha did not prove significantly superior over control during second year.

Table 4.3. Effect of nitrogen levels on growth, development, yield and nutrient accumulation

Character	Year	Nitrogen level				SEm _±	CD5%	CV (%)
		N ₀	N ₁	N ₂	N ₃			
<u>Per cent establishment</u>								
<u>Setaria</u>	1980	81.2	88.4	95.4	94.3	0.92	2.74	4.1
	1981	78.3	86.2	92.9	89.9	1.09	3.23	5.0
<u>Desmodium</u>	1980	37.0	76.0	88.1	89.9	1.24	3.67	6.0
	1981	67.9	69.1	80.4	79.8	1.18	3.51	6.4
<u>Per cent proportion of</u>								
<u>Setaria</u>	1981	17.84	29.42	38.33	46.09	0.87	2.58	10.6
<u>Desmodium</u>	1981	10.45	17.51	26.37	21.80	0.89	2.58	22.8
<u>Plant height (cm)</u>								
<u>Grass</u>	1980							
25 DAP		25.91	28.21	31.80	30.91	6.18	NS	29.8
50 DAP		31.71	35.3	42.0	44.9	8.76	NS	32.1
75 DAP		39.4	44.8	53.3	60.6	6.27	NS	17.8
	1981							
0 DAR		18.7	20.3	21.6	23.8	1.088	3.15	25.2
25 DAR		24.1	26.0	27.9	31.5	1.392	4.03	24.8
50 DAR		27.5	31.2	32.9	37.1	1.643	4.75	24.9
75 DAR		39.1	49.4	54.1	63.3	1.326	3.84	12.6
100 DAR		67.0	85.0	95.0	111.1	2.025	5.86	11.0
125 DAR		93.5	112.3	122.1	139.5	2.985	8.64	12.5
130 DAR		99.9	119.5	130.0	151.7	3.553	10.28	13.8

Contd.

Character	Year	N ₀	N ₁	N ₂	N ₃	SE _m ±	CD5%	CV(%)
Legume	1980							
25 DAP		14.9	14.0	15.3	16.7	0.87	2.58	22.8
50 DAP		18.5	20.4	20.1	21.0	0.97	NS	19.4
75 DAP		25.2	29.3	31.3	33.6	0.73	2.16	9.7
0 DAR	1981	10.0	11.8	10.0	10.2	1.13	NS	33.7
25 DAR		13.2	17.2	14.7	14.7	1.26	3.74	33.7
50 DAR		15.9	21.3	18.1	19.2	1.60	4.75	34.4
75 DAR		23.5	35.3	28.3	26.9	3.28	9.71	45.9
100 DAR		44.2	70.5	48.6	58.1	6.38	18.9	46.0
125 DAR		66.9	95.6	64.8	78.0	8.56	25.36	44.7
130 DAR		72.5	99.9	69.2	86.5	9.04	26.78	43.9
<u>Fresh weight (kg/m²)</u>								
	1980							
25 DAP		0.25	0.28	0.30	0.30	0.016	0.043	31.5
50 DAP		0.37	0.50	0.59	0.68	0.029	0.081	31.0
75 DAP		0.48	0.80	0.93	1.05	0.032	0.090	22.6
	1981							
0 DAR		0.13	0.11	0.13	0.13	0.008	NS	38.7
25 DAR		0.14	0.14	0.19	0.20	0.014	0.040	48.6
50 DAR		0.13	0.16	0.22	0.26	0.010	0.028	29.8
75 DAR		0.41	0.61	0.84	1.07	0.032	0.088	24.6
100 DAR		0.60	0.77	0.91	1.13	0.059	0.164	39.3
125 DAR		0.55	0.70	0.77	0.92	0.032	0.090	24.9
130 DAR		0.63	0.77	0.97	1.09	0.035	0.098	23.1

contd..

Character	Year	N ₀	N ₁	N ₂	N ₃	SE _m _±	CD5%	CV(%)
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Dry weight (kg/m²)

1980

25 DAP	0.08	0.08	0.09	0.09	0.004	NS	29.2
50 DAP	0.13	0.16	0.18	0.19	0.08	0.021	26.7
75 DAP	0.14	0.25	0.27	0.30	0.007	0.019	16.1

1981

0 DAR	0.11	0.10	0.11	0.11	0.004	NS	21.5
25 DAR	0.10	0.10	0.12	0.12	0.005	0.015	27.9
50 DAR	0.09	0.11	0.13	0.15	0.005	0.015	25.4
75 DAR	0.13	0.15	0.17	0.19	0.005	0.014	17.6
100 DAR	0.25	0.31	0.35	0.46	0.024	0.066	26.5
125 DAR	0.28	0.32	0.36	0.44	0.016	0.046	36.5
130 DAR	0.31	0.35	0.43	0.45	0.015	0.041	21.7

Grain fodder yield (g/ha)

1980	48.53	78.68	100.04	106.23	2.343	6.476	15.8
1981	171.64	234.61	258.92	280.55	4.506	12.454	10.7

Dry fodder yield (g/ha)

1980	14.74	24.59	28.59	30.25	0.548	1.516	12.6
1981	80.35	122.50	135.56	138.82	2.499	6.906	11.8

Character	Year	N ₀	N ₁	N ₂	N ₃	SE _{m±}	CD5%	CV(%)
<u>Nitrogen content</u>								
1980								
25 DAP		0.93	1.10	1.33	1.37	0.032	0.088	15.1
50 DAP		0.94	1.14	1.26	1.51	0.020	0.056	9.4
75 DAP		0.82	1.08	1.20	1.30	0.018	0.049	9.1
1981								
0 DAR		0.85	0.90	0.89	0.91	0.031	0.035	8.1
25 DAR		0.94	1.08	1.34	1.36	0.034	0.093	16.1
50 DAR		0.90	1.13	1.27	1.45	0.022	0.062	10.6
75 DAR		1.06	1.29	1.27	1.41	0.034	0.093	15.1
100 DAR		1.14	1.39	1.56	1.52	0.021	0.060	8.7
125 DAR		0.68	0.92	1.18	1.28	0.026	0.071	14.3
130 DAR		0.68	0.93	1.19	1.29	0.025	0.068	13.6
<u>Nitrogen uptake (g/m²)</u>								
1980								
25 DAP		0.70	0.88	1.08	1.18	0.059	0.165	34.9
50 DAP		1.26	1.83	2.20	2.76	0.114	0.314	31.9
75 DAP		1.18	2.71	3.30	3.91	0.085	0.236	77.3
1981								
0 DAR		0.92	0.93	0.95	0.99	0.040	NS	24.1
25 DAR		0.99	1.10	1.52	1.67	0.073	0.203	31.3
50 DAR		0.83	1.22	1.69	2.22	0.068	0.188	25.7
75 DAR		1.35	1.96	2.21	2.75	0.085	0.235	23.3
100 DAR		2.79	4.26	5.48	6.57	0.306	0.846	86.2
125 DAR		1.88	3.01	4.27	5.67	0.207	0.572	31.6
130 DAR		2.11	3.29	5.11	5.83	0.179	0.496	24.1

4.2.2. Setaria and Desmodium proportion

The data on the per cent proportion of Setaria and Desmodium at harvest stage as affected by nitrogen levels determined in 1981 have been presented in Table 4.3. The corresponding analyses of variance are appended in Appendix IV.

The perusal of data presented in Table 4.3 reveals that the proportion of Setaria was higher than that of Desmodium in the herbage irrespective of level of nitrogen applied. Averaged over all levels of nitrogen, Setaria constituted 32.9 per cent of the total dry herbage while Desmodium was only 19.03 per cent.

The application of different levels of nitrogen increased the proportion of Setaria significantly and consistently upto 90kg N/ha while increase in case of Desmodium was only upto 60kg N/ha beyond which the proportion decreased considerably.

4.2.3. Plant height of grass

The data on the plant height of grass species recorded at various stages during both years as influenced by nitrogen levels are given in Table 4.3 and corresponding analyses of variance are appended in Appendix V and VI. The data have also been illustrated graphically in Fig. 4.5 and 4.6.

The plant height of Setaria in first year of experimentation was not influenced significantly due to nitrogen application at any of the growth stages recorded.

In the subsequent year, plant height of grass species including Setaria increased significantly and consistently with increase in levels of nitrogen upto 90 kg N/ha at all the stages under study. However, at

1980

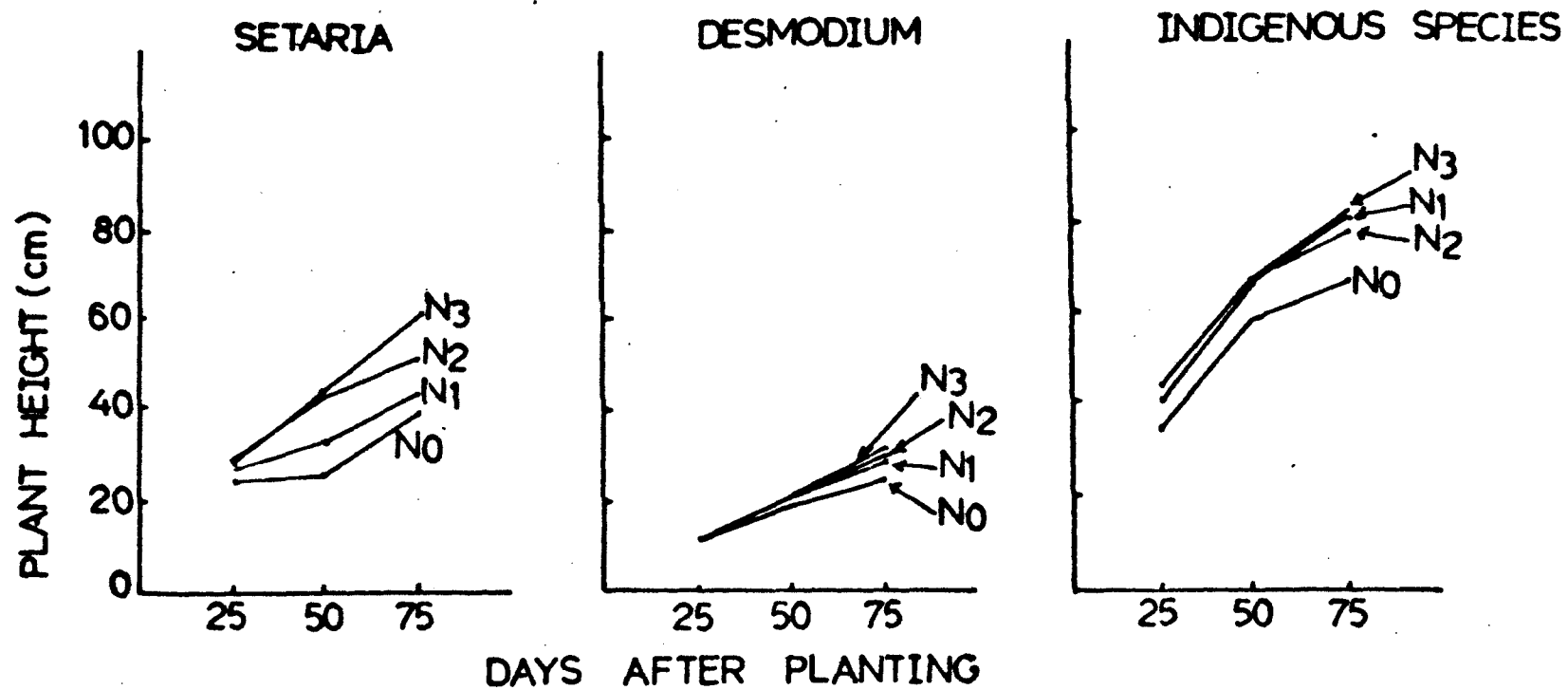


FIG.4.5: MEAN HEIGHT OF GRASS AND LEGUME SPECIES AT DIFFERENT GROWTH STAGES AS INFLUENCED BY LEVELS OF NITROGEN

early stages of growth viz., initiation of regeneration, 25 and 50 DAR, the differences in plant height between 30 and 60 kg N/ha were non-significant.

Fig. 4.6 depicting the progressive mean height reveals that there is an increase in the height of the plant with increasing levels of nitrogen and advancement of growth, although slow upto 50 days from the initiation of regeneration, followed by rapid increase upto 125 DAR and almost constant thereafter till harvest. In 1980, the plant height of Setaria grass increased linearly upto harvesting.

4.2.4. Plant height of Desmodium

The data on the plant height of introduced Desmodium at different stages during 1980 and 1981 have been given in Table 4.3. The corresponding analyses of variance are appended in Appendix VII and VIII for the first and second year, respectively. The data have also been illustrated graphically in Fig. 4.5 and 4.6.

Plant height was influenced significantly by various levels of nitrogen at 25 and 75 DAP in the establishment year. At 25 DAP, tallest plants were noticed at 90 kg N/ha, which was significant with 30 kg N/ha but statistically similar with control and 60 kg N/ha. At 75 DAP also, 90 kg N/ha produced tallest plants of all levels of nitrogen fertilization. The height obtained with the application of 30 and 60 kg N/ha did not differ significantly but both resulted in significantly taller plants than control.

In the second year, the plant height of Desmodium was influenced significantly at all stages excepting at the initiation of regeneration

1981

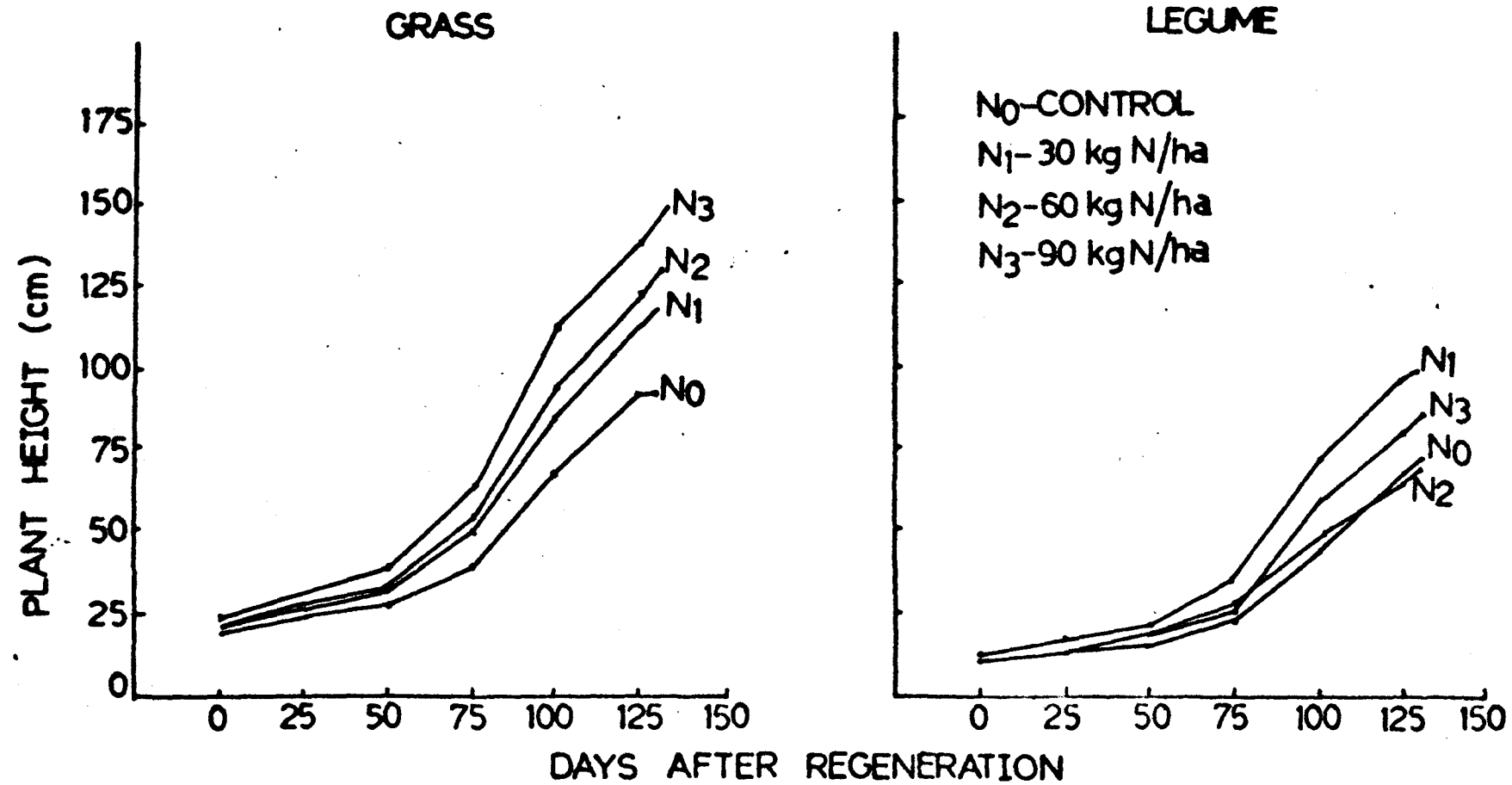


FIG. 4.6: MEAN HEIGHT OF GRASS AND LEGUME SPECIES AT DIFFERENT GROWTH STAGES AS INFLUENCED BY LEVELS OF NITROGEN

with different levels of nitrogen application. Application of 30kg N/ha resulted in significantly taller Desmodium plants than control that did not differ with higher levels of nitrogen application (60 and 90 kg N/ha) excepting at 100, 125 and 130 DAR applied with 60 kg N/ha. The differences in height due to higher two levels of nitrogen were non-significant at all stages of growth.

4.2.5. Fresh herbage weight

The data on fresh weight (kg/m^2) at different stages of sampling during two years have been given in Table 4.3. The corresponding analyses of variance are appended in Appendix IX and X for first and second year, respectively. The data have also been illustrated graphically in Fig. 4.7.

A perusal of Fig. 4.7 shows that the fresh weight of herbage increased with successive sampling with increasing levels of fertilizer N in the year 1980. The maximum fresh weight was obtained at harvest with 90kg N/ha. In 1981, the increase in herbage yield with all the levels of nitrogen was very slow upto 50 days from the time of initiation of regeneration. Thereafter, the increase was very rapid between 75 and 100 DAR and showed declining trend afterwards.

The effect of levels of nitrogen on fresh weight of herbage recorded at various stages was significant in both years except at first stage of sampling in 1981.

In 1980, increased levels of nitrogen increased the fresh weight significantly and consistently upto 90 kg N/ha at 50 and 75 DAP while similar trends were observed at 25 DAP also with slight difference.

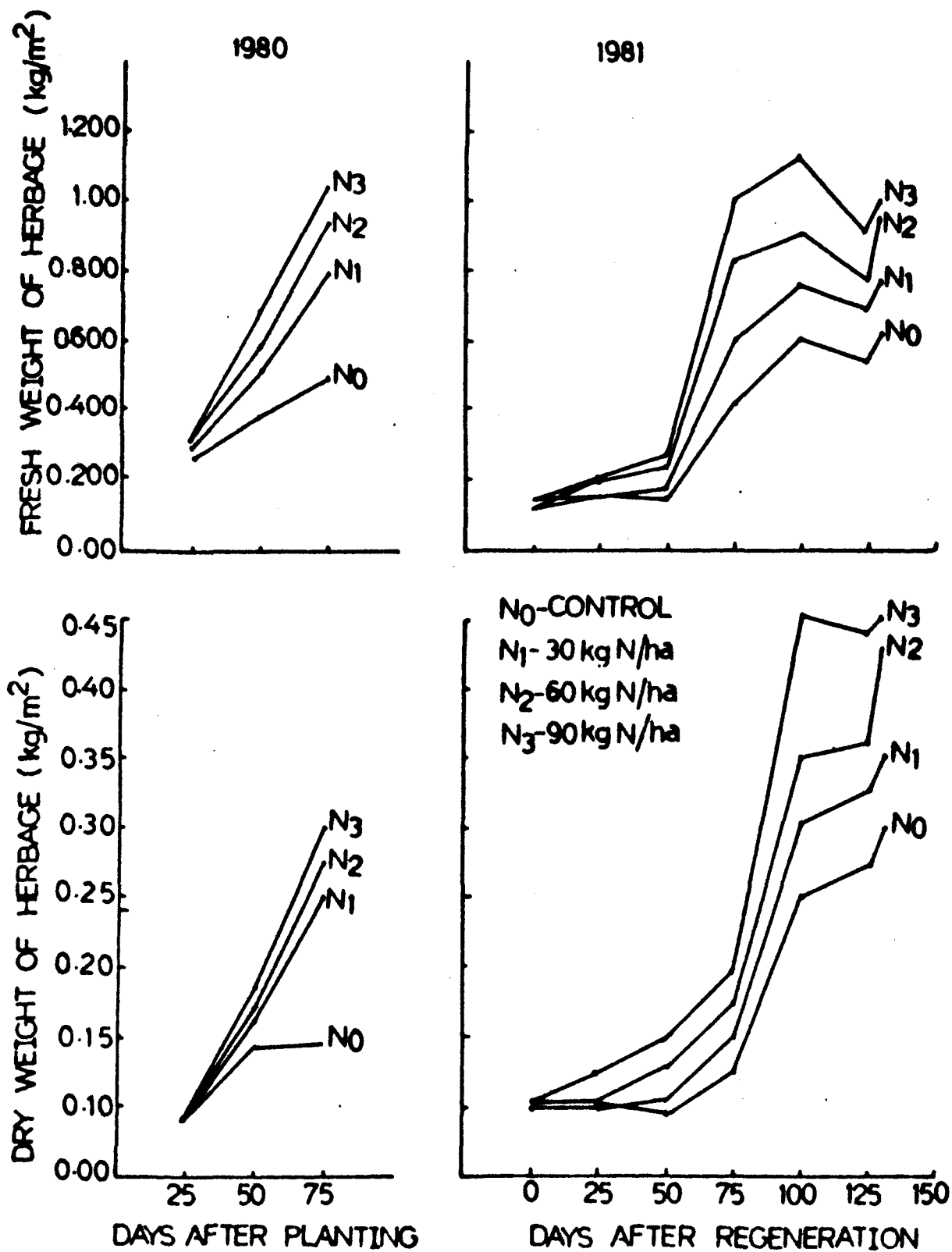


FIG.4.7: MEAN FRESH AND DRY WEIGHT OF HERBAGE AT DIFFERENT GROWTH STAGES AS INFLUENCED BY LEVELS OF NITROGEN

At 25 DAP, the differences in fresh weight due to 30, 60 and 90kg N/ha remained non-significant among them but significantly superior over control except 30 kg N/ha which was at par with no nitrogen application.

In 1981, nitrogen fertilization increased the fresh weight significantly over no nitrogen application at all the stages of sampling. This increase was significant and consistent upto 90kg N/ha at 50, 75 and 130 DAR, upto 30 kg N/ha at 100 and 125 DAR. At all the stages, 90 kg N/ha produced highest fresh weight that was significant over other rates except at 25 DAR where it did not differ significantly with 60kg N/ha. At 100 and 125 DAR, the differences in fresh weight of herbage due to 30 and 60 kg N/ha were non-significant, while at 25 DAR, weight from control plots did not differ significantly with 30 kg N/ha.

4.2.6. Dry herbage weight

The data on the dry weight of herbage (kg/m^2) at different stages of growth during 1980 and 1981 have been given in Table 4.3. The corresponding analysis of variance are appended in Appendix XI and XII for first and second year, respectively. The data have also been depicted graphically in Fig. 4.7.

Dry weight (kg/m^2) was influenced significantly by the levels of nitrogen at all the growth stages excepting 25 DAP in 1980 and at the initiation of regeneration in 1981.

Maximum dry weight was recorded at 90 kg N/ha at all the growth stages during both the years and lowest was obtained from the control plots. The increase in dry weight with increase in nitrogen levels from 30 to 60 kg N/ha was significant at 50 and 75 DAP in 1980, and at 25, 50, 75 and 130 DAR in 1981, while at other growth stages, the differences were statistically non-significant.

A perusal of Fig. 4.7 shows that there was linear increase in dry weight accumulation upto harvest in 1980, while in the second year the increase was almost stationary upto 50 DAR, increased steadily upto 75 DAR, and thereafter rose sharply upto 100 DAR and later on levelled off till harvest.

4.2.7. Green fodder yield

The data on green fodder yield (q/ha) as affected by various levels of nitrogen during two years have been given in Table 4.3. The corresponding analyses of variance are appended in Appendix XIII. The data have also been depicted graphically in Fig. 4.8.

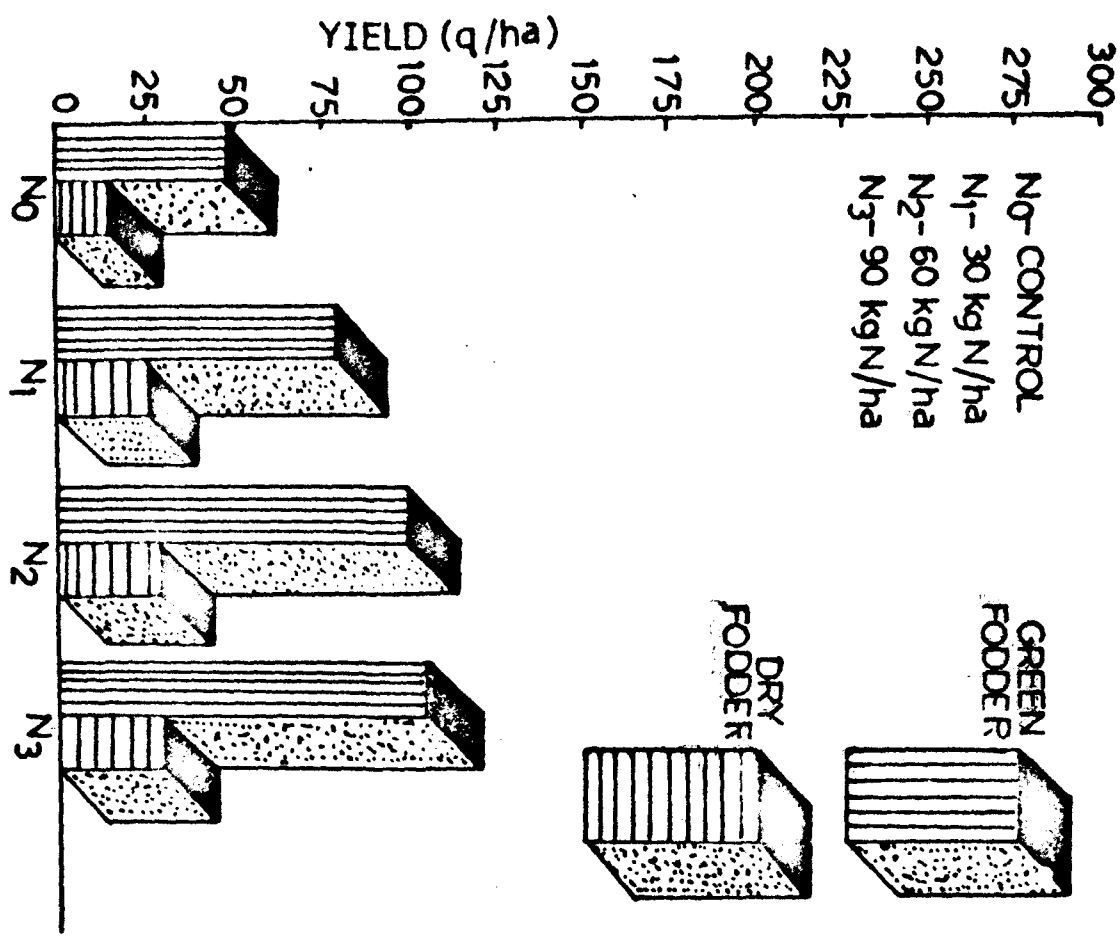
The green fodder yield increased significantly and consistently upto 60 and 90 kg N/ha in the first and second year, respectively. The difference in yield due to 60 and 90 kg N/ha was non-significant in first year. The per cent yield increase due to nitrogen application over control was 100.5, 85.8 and 60.8 per cent and 209.9, 145.5 and 121.0 per cent for the first and second year in case of 30, 60 and 90 kg N/ha, respectively.

4.2.8. Dry fodder yield

The data on dry fodder yield as affected by various nitrogen levels during 1980 and 1981 are presented in Table 4.3. The corresponding analyses of variance are appended in Appendix XV. The data have also been depicted graphically in Fig. 4.8.

There was significant and consistent increase in yield with increase in nitrogen level upto 90 and 60 kg N/ha in first and second year, respectively. The difference in dry fodder yield due to 60 and 90kg

1980



1981

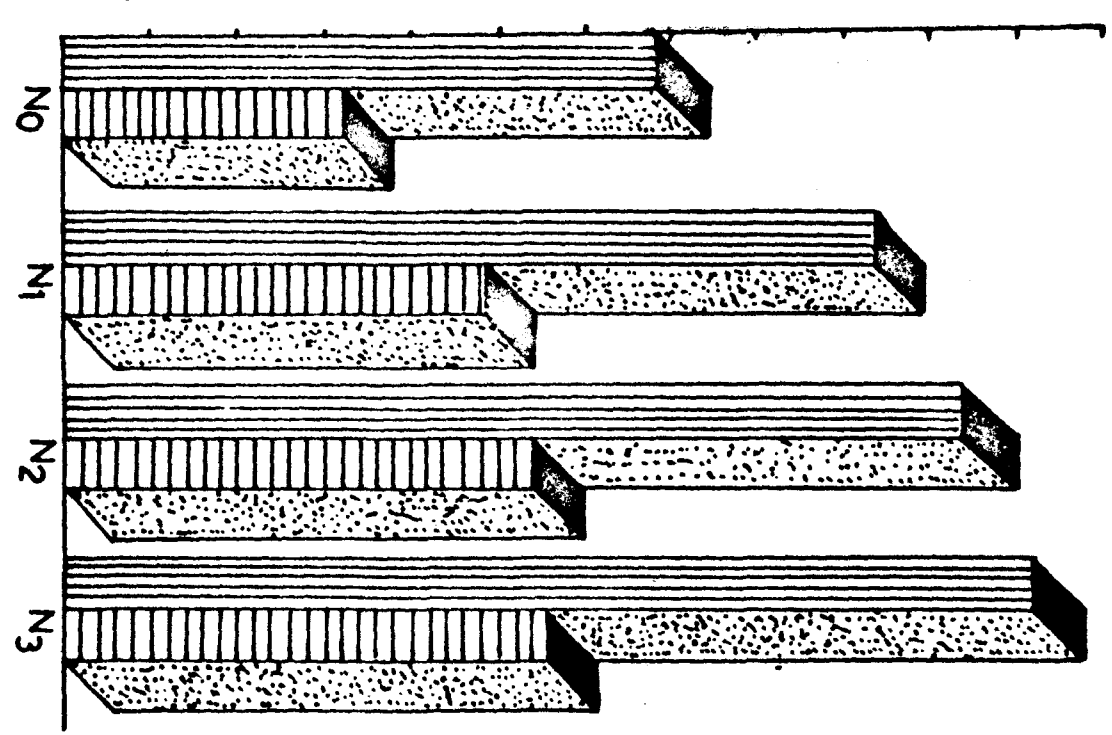


FIG. 4.8: GREEN AND DRY FODDER YIELD AS INFLUENCED BY LEVELS OF NITROGEN

N/ha in second year was non-significant. The per cent increase in dry fodder yield due to application of nitrogen over control was 35.0, 23.1 and 17.3 per cent and 140.5, 92.0 and 58.5 per cent in first and second year in case of 30, 60 and 90 kg N/ha, respectively.

4.2.9. Nitrogen content

The data on nitrogen content (%) in herbage at different growth stages during 1980 and 1981 have been presented in Table 4.3. The corresponding analyses of variance are appended in Appendix XV and XVI for the first and second year. The nitrogen content in plants at various stages of sampling has been depicted graphically in Fig.4.9.

A perusal of the Fig. 4.9 shows that with increase in nitrogen levels, there has been increase in nitrogen content. The maximum nitrogen content was observed at 50 DAP in 1980 that declined thereafter. In 1981, the maximum nitrogen content of the herbage was recorded at 100 DAR and sharp decline was observed thereafter upto 125 DAR, however, the decline was at slower rate afterwards till harvest.

The different levels of nitrogen significantly affected the nitrogen content (%) at all the stages of growth during both the years. Maximum nitrogen content was recorded at 90 kg N/ha at all the growth stages during both the years which was statistically different from rest of the levels excepting at 25 DAP in 1980 and 0, 25 and 100 DAR in 1981, where the differences were statistically similar with 60 kg N/ha. The lowest nitrogen content was noticed in the herbage obtained from the control plots followed by 30 kg N/ha.

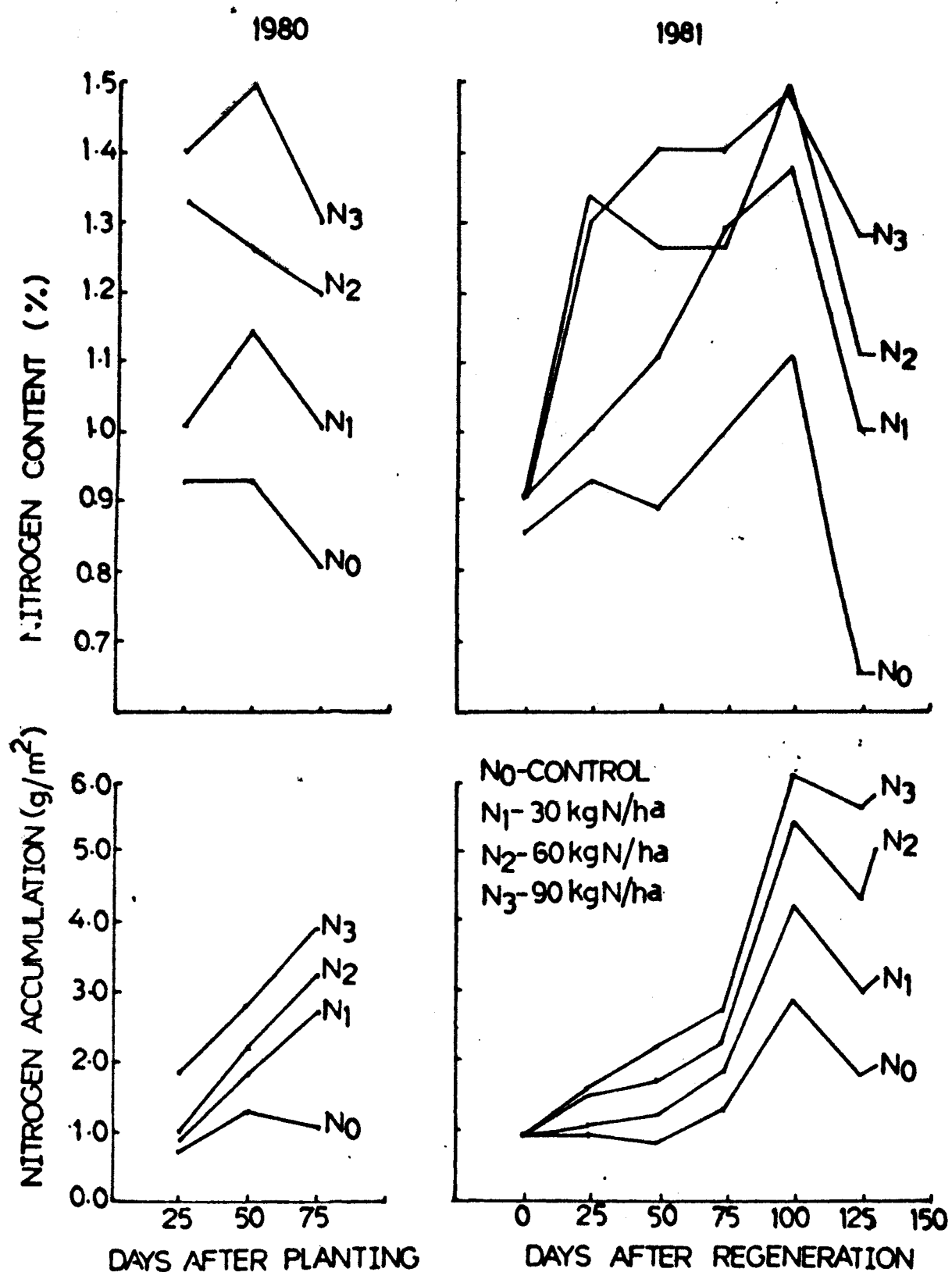


FIG.4.9: NITROGEN CONTENT AND ACCUMULATION IN HERBAGE AT DIFFERENT GROWTH STAGES AS INFLUENCED BY LEVELS OF NITROGEN

4.2.10. Nitrogen uptake

The data on nitrogen uptake (g/m^2) at different growth stages as affected by different levels of nitrogen fertilization in 1980 and 1981 are summarized in Table 4.3. The corresponding analyses of variance are appended in Appendix XVII and XVIII for first and second year. The data have also been depicted graphically in Fig. 4.9.

It is clear from Fig. 4.9 that nitrogen uptake increased with increase in nitrogen levels. This increase was conspicuous with the advancement in crop age. In 1980, there was steady increase in uptake upto 75 DAP, while in 1981, this increase was upto 100 DAR and thereafter, showed a declining trend.

It is seen from the data (Table 4.3) that different levels of nitrogen affected its uptake significantly at all the growth stages during both the years excepting at the initiation of regeneration in second year. The uptake of nitrogen increased significantly and consistently upto 90 kg N/ha at all the growth stages during both the seasons except at 25 DAP in 1980 and 25 DAR in 1981. At both these stages, the increase in uptake was upto 60 kg N/ha only and further increase in nitrogen application did not bring significant difference. The nitrogen uptake values were highest at 90 kg N/ha during both the years of experimentation while minimum in case of control plots followed by 30 kg N/ha.

4.2.11. Herbage quality

The quality parameters studied in the present investigation included crude protein, calcium, phosphorus, NDF, ADF, cellulose, hemi-cellulose, lignin, silica, total ash, acid insoluble ash, cell

content and IVDMD and the data pertaining to them as influenced by different treatments of nitrogen levels are presented in Table 4.4 and their analyses of variance are appended in Appendices XIX to XXII for first and second year, respectively.

a. Crude protein content

The crude protein content of herbage increased significantly with increase in nitrogen fertilization upto 90 kg N/ha during both the years. However, there has been a decreasing trend in the crude protein content values during second year in comparison to establishment year (Table 4.4). The herbage obtained from the control plots contained lowest crude protein during both the years of experimentation.

b. Calcium and phosphorus content

The calcium and phosphorus content of the herbage were significantly influenced by various levels of nitrogen in the establishment year only. Application of 30 kg N/ha and 90kg N/ha produced the herbage with maximum calcium and phosphorus content, respectively that differed significantly with remaining levels of nitrogen which did not differ significantly among them.

c. Neutral and acid detergent fibre (NDF and ADF)

Different levels of nitrogen significantly influenced the NDF(%) during both the years of study while the effect was non-significant in respect of ADF. Higher levels of nitrogen resulted in significantly lower NDF content during both the years whereas 30kg N/ha produced the herbage with maximum NDF content which was on par with control but significantly different from 60 and 90 kg N/ha. The difference between 60 and 90 kg N/ha was non-significant.

d. Cellulose and hemi-cellulose content

Cellulose content was influenced significantly due to nitrogen application during second year while hemi-cellulose was affected in first year only. The cellulose content was highest with 90 kg N/ha and lowest when nitrogen was not applied. The differences in cellulose content of herbage obtained from first three levels of nitrogen (0, 30 and 60kg N/ha) and last three levels (30, 60 and 90 kg N/ha) were non-significant.

The hemi-cellulose content of herbage in 1980 was highest with 60 kg N/ha which however, did not differ significantly with 90 kg N/ha. The differences in hemi-cellulose content of herbage due to 0, 30 and 90kg N/ha were also non-significant.

e. Lignin and silica content

Lignin content (%) was significantly influenced by various nitrogen levels during the establishment year only and 90kg N/ha produced the herbage containing lowest lignin content though it did not differ significantly with 60kg N/ha. The remaining levels of nitrogen did not differ significantly among them in this respect.

Silica content of herbage was higher in first year than second year of experimentation. The effect of nitrogen fertilization was also reverse in this case. During both years, herbage obtained from lower fertilizer levels had significantly maximum silica content than highly fertilized plots. In second year, remaining three levels of nitrogen (30, 60 and 90 kg N/ha) did not differ significantly among themselves, while in establishment year, 90 kg N/ha resulted in reduced silica content than all other levels of nitrogen.

Table 4.4. Effect of nitrogen levels on quality parameters of herbage at harvest

Quality parameters (%)	Year	Nitrogen level				SEm±	CD5%	CV(%)
		N ₀	N ₁	N ₂	N ₃			
Crude protein	1980	5.11	6.74	7.51	8.11	0.111	0.307	9.1
	1981	4.33	5.84	7.47	8.14	0.149	0.412	13.1
Calcium	1980	0.48	0.52	0.49	0.48	0.008	0.022	9.1
	1981	0.54	0.59	0.59	0.59	0.021	NS	20.2
Phosphorus	1980	0.22	0.22	0.22	0.23	0.002	0.005	4.9
	1981	0.11	0.11	0.10	0.10	0.003	NS	17.0
NDF	1980	75.63	76.73	74.94	74.32	0.514	1.420	3.8
	1981	80.16	79.87	79.02	78.88	0.245	0.677	1.7
ADF	1980	50.87	50.79	50.88	51.24	0.285	NS	3.2
	1981	54.23	54.74	54.13	55.04	0.333	NS	3.4
Cellulose	1980	36.77	36.38	37.07	36.57	0.271	NS	4.2
	1981	41.33	42.03	41.84	42.57	0.266	0.735	3.6
Hemi-cellulose	1980	24.07	23.52	25.53	24.39	0.448	1.238	10.4
	1981	24.65	24.27	25.74	25.12	0.380	NS	8.6
Lignin	1980	11.60	10.98	10.11	10.08	0.248	0.685	13.3
	1981	9.81	9.61	9.77	9.77	0.135	NS	7.8
Silica	1980	3.88	3.68	3.59	3.26	0.072	0.199	11.4
	1981	2.90	2.69	2.49	2.51	0.085	0.235	18.2
Total Ash	1980	9.05	9.09	8.18	9.00	0.125	0.345	8.00
	1981	6.54	7.13	6.78	6.74	0.145	0.401	12.0
Acid Insoluble Ash	1980	4.68	4.76	3.95	3.77	0.084	0.232	11.1
	1981	2.61	2.27	2.58	2.34	0.097	0.268	22.4
Cell content	1980	24.37	23.27	25.06	25.68	0.522	1.442	12.0
	1981	19.84	20.13	20.98	21.12	0.246	0.680	6.8
IVDMD	1980	42.18	42.65	43.31	43.76	0.122	0.337	1.6
	1981	43.58	44.75	45.47	46.13	0.142	0.392	1.8

f. Total ash content

There has been a decreasing trend in the values of total ash content during second year in comparison to establishment year (Table 4.4). The total ash content was significantly influenced during both the years by various levels of nitrogen. Maximum ash content was recorded in the herbage of control plots, which was statistically similar to 30 and 90 kg N/ha during first year. However, during the second year, maximum total ash content was noted when 60 kg N/ha was applied which had significantly higher content than other treatments that were at par.

g. Acid insoluble ash

Decreasing trend was also observed in the values of acid insoluble ash during second year of experimentation in comparison to establishment year (Table 4.4). The different levels of nitrogen affected acid insoluble ash content significantly during both the years. There was significant decrease in acid insoluble ash content with increase in nitrogen level. However, the differences due to 0 and 30 kg N/ha in the first year and, 60 and 90 kg N/ha in the both years were non-significant. In second year of experimentation, the difference in acid insoluble ash in herbage obtained from the plots receiving 30 and 90 kg N/ha was also non-significant.

h. Cell content

Similar to acid insoluble ash content, there was decrease in values of cell content of the herbage obtained in second year as compared to first year. The per cent cell content was significantly influenced by various nitrogen levels at harvest during both the years. The cell content

increased significantly with increase in nitrogen levels during both years. However, control, 60 and 90 kg N/ha did not differ significantly in this respect in first year. 60 and 90 kg N/ha was at par but differed significantly from control and 30 kg N/ha, but 60 kg N/ha was at par with 30 kg N/ha and significantly different from the control in the second year.

i. In-vitro dry matter digestibility (IVDMD)

It is clear from the data Table 4.4 that in-vitro dry matter digestibility increased significantly and consistently with the increasing levels of nitrogen upto 90kg N/ha in both the years.

In contrast to most of the above mentioned quality parameters, there has been increasing trend in the values of the in-vitro dry matter digestibility during second year in comparison to establishment year (Table 4.4).

4.3. Effect of methods of nitrogen application

4.3.1. Establishment of introduced grass and legume

The data on various growth and development characters as influenced by methods of nitrogen application have been presented in Table 4.5 and the analyses of variance are appended in Appendices III to XVIII.

During the year of establishment as well as subsequent year, the effect of methods of nitrogen application was significant in affecting the per cent establishment of introduced grass and legume worked out at the time of harvest. Application of nitrogen in three splits ($1/3$ at planting/regeneration + $1/3$ at 25 DAP/DAR and $1/3$ at 50 DAP/DAR) helped

Table 4.5. Effect of methods of nitrogen application on growth, development, yield and nutrient accumulation

Character	Year	Methods of application		SE _m ±	CD5%	CV(%)
		M ₁	M ₂			
<u>Per cent establishment</u>						
<u>Setaria</u>	1980	88.8	90.9	0.60	1.751	3.8
	1981	85.7	87.9	0.61	1.768	3.9
<u>Desmodium</u>	1980	79.9	83.6	0.72	2.106	5.0
	1981	72.9	75.8	0.87	2.530	6.6
<u>Percentage proportion of</u>						
<u>Setaria</u>		32.6	33.2	0.33	NS	5.7
<u>Desmodium</u>	1981	18.8	19.3	0.30	NS	14.0
<u>Plant height (cm)</u>						
	1980					
Grass (introduced)						
25 DAP		28.6	29.8	4.23	NS	20.4
50 DAP		40.4	36.6	4.44	NS	16.3
75 DAP		50.4	48.6	6.08	NS	17.3
	1981					
0 DAR		20.7	21.6	0.65	NS	21.1
25 DAR		27.6	27.2	0.85	NS	21.4
50 DAR		32.2	32.1	0.86	NS	18.4
75 DAR		52.8	50.4	1.08	NS	14.4
100 DAR		88.8	90.3	1.53	NS	11.8
125 DAR		116.0	117.7	2.28	NS	13.5
130 DAR		123.5	127.1	2.13	NS	11.7

contd...

Character	Year	Methods of application		SE _m ±	CD5%	CV(%)
		M ₁	M ₂			
<u>Legume</u>						
	1980					
25 DAP		15.1	15.4	0.74	NS	27.5
50 DAP		20.7	19.4	0.96	NS	26.9
75 DAP		30.8	29.0	0.73	NS	13.8
	1981					
0 DAR		10.0	11.1	0.51	NS	27.5
25 DAR		14.1	15.8	1.26	NS	47.6
50 DAR		18.0	19.2	1.92	NS	58.2
75 DAR		27.4	29.6	3.10	NS	61.4
100 DAR		50.1	60.6	4.14	NS	42.1
125 DAR		69.0	83.7	4.48	13.031	33.1
130 DAR		73.3	90.8	4.86	NS	33.4
<u>Fresh weight (kg/m²)</u>						
	1980					
25 DAP		0.30	0.26	0.006	0.018	18.7
50 DAP		0.55	0.52	0.017	NS	25.6
75 DAP		0.78	0.84	0.015	0.042	14.9
	1981					
0 DAR		0.12	0.13	0.006	NS	38.6
25 DAR		0.17	0.16	0.010	NS	45.9
50 DAR		0.20	0.19	0.006	NS	23.1
75 DAR		0.73	0.73	0.017	NS	18.4
100 DAR		0.83	0.87	0.032	NS	29.9
125 DAR		0.70	0.77	0.028	NS	30.6
130 DAR		0.84	0.89	0.028	NS	25.9

contd..

Character	Year	Methods of application		SEm±	SC5%	CV(%)
		M ₁	M ₂			
<u>Dry weight (kg/m²)</u>						
	1980					
25 DAP		0.08	0.08	0.002	NS	24.3
50 DAP		0.17	0.16	0.005	NS	23.8
75 DAP		0.23	0.25	0.004	0.010	12.6
	1981					
0 DAR		0.10	0.11	0.002	NS	17.6
25 DAR		0.11	0.11	0.003	NS	25.4
50 DAR		0.12	0.12	0.003	NS	19.4
75 DAR		0.17	0.16	0.004	NS	18.9
100 DAR		0.34	0.34	0.014	NS	32.2
125 DAR		0.34	0.36	0.014	NS	31.4
130 DAR		0.36	0.41	0.011	0.03	23.9
<u>Green fodder yield (g/ha)</u>						
	1980	80.95	85.78	0.841	2.323	8.0
	1981	232.33	240.52	2.424	6.700	8.2
<u>Dry fodder yield (g/ha)</u>						
	1980	23.87	25.22	0.242	0.668	7.9
	1981	117.99	120.63	1.489	NS	10.0

contd...

Character	Year	M ₁	M ₂	SEm±	CD5%	CV(%)
<u>Nitrogen content (%)</u>						
1980						
25 DAP		1.19	1.17	0.022	NS	15.2
50 DAP		1.19	1.24	0.016	0.043	10.2
75 DAP		1.10	1.10	0.012	NS	8.9
1981						
0 DAR		0.88	0.90	0.009	NS	8.4
25 DAR		1.19	1.17	0.024	NS	16.3
50 DAR		1.16	1.21	0.019	NS	12.8
75 DAR		1.18	1.34	0.020	0.06	12.9
100 DAR		1.36	1.44	0.012	0.03	7.1
125 DAR		1.03	1.00	0.016	NS	12.5
130 DAR		1.04	1.01	0.016	NS	12.3
<u>Nitrogen accumulation (g/m²)</u>						
1980						
25 DAP		1.01	0.91	0.032	0.090	27.0
50 DAP		2.03	1.10	0.079	NS	31.5
75 DAP		2.68	2.87	0.051	0.140	14.6
1981						
0 DAR		0.93	0.97	0.022	NS	18.4
25 DAR		1.33	1.31	0.034	NS	20.4
50 DAR		1.46	1.52	0.040	NS	21.6
75 DAR		1.98	2.15	0.056	0.154	21.5
100 DAR		4.58	4.97	0.161	NS	27.0
125 DAR		3.62	3.79	0.159	NS	34.3
130 DAR		3.94	4.23	0.133	NS	26.1

in significantly better establishment of Setaria as well as Desmodium during both years, than application in two splits (1/2 at planting/ regeneration + 1/2 at 25 DAP/DAR).

4.3.2. Setaria and Desmodium proportion

Table 4.5 shows that the methods of nitrogen application did not alter the relative proportion of grass and legume in the herbage determined at harvest in the second year of experimentation.

4.3.3. Plant height of grass and legume species

The plant height of grasses measured at different stages in 1980 and 1981 were not affected significantly by two methods of nitrogen application.

Similar to the plant height of grass species, the height of legume (Desmodium) was also not affected significantly by the two methods of nitrogen application at any stage of growth in any year of experimentation. However, the only exception was at 125 DAR in 1981 when height was significantly more in case of three splits than two splits of nitrogen application.

4.3.4. Fresh herbage weight

In 1980, the green weight per square metre was significantly affected by methods of nitrogen application at 25 and 75 DAP. At first stage, nitrogen applied in two splits (M_1) resulted in significantly higher fresh weight than three splits (M_2) while the trend was reverse at 75 DAP. The influence of methods of nitrogen application was non-significant on fresh weight at all stages in 1981.

4.3.5. Dry herbage weight

The dry weight of herbage taken at harvest in both the years of experimentation was influenced significantly due to methods of nitrogen application while the effect was non-significant at all other stages of sampling. Application of nitrogen in three splits produced significantly higher dry matter than application of nitrogen in two splits.

4.3.6. Green fodder yield

It is clear from the data presented in Table 4.5 that three splits of nitrogen application during both the years of experimentation resulted in significantly higher green forage yield (q/ha) as compared to two splits of nitrogen application (M_1). The per cent increase over two split was 5.97 and 3.52 during first and second year, respectively.

4.3.7. Dry fodder yield

The effect of methods of nitrogen application on dry fodder yield was significant in first year only when nitrogen application in three splits resulted in higher yield than its application in two splits. The increase was in the tune of 5.6 per cent.

4.3.8. Nitrogen content

The nitrogen content in the herbage was significantly affected by methods of application at 50 DAP in 1980, and at 75 and 100 DAR in 1981 (Table 4.5). At these stages, application of nitrogen in three splits produced the herbage with higher nitrogen content than application in two splits (M_1).

4.3.9. Nitrogen uptake

Nitrogen uptake (g/m^2) was significantly influenced by methods of nitrogen application at 25 and 75 DAP in 1980 and 75 days after the initiation of regeneration in 1981, the nitrogen uptake was significantly higher when nitrogen was applied in three splits as compared to two splits while the trend was reverse at 25 DAP in 1980.

4.3.10. Herbage quality

The quality parameters studied in the present investigation included the contents of crude protein, calcium, phosphorus, NDF, ADF, Cellulose, hemi-cellulose, lignin, silica, total ash, acid insoluble ash, cell content and IVDMD as influenced by different treatments of methods of nitrogen application are presented in Table 4.6 and their corresponding analyses of variance are appended in Appendices XIX to XXII for both the years.

a. Crude protein content

The crude protein content (%) was not influenced significantly by different methods of nitrogen application during both the years.

b. Calcium and phosphorus content

Methods of nitrogen application did not influence calcium and phosphorus content significantly excepting that herbage with two splits of nitrogen application produced significantly higher calcium content during first year of experimentation.

Table 4.6. Effect of methods of nitrogen application on quality parameters of herbage at harvest

Quality parameters (%)	Year	Methods of N application		SE _{em}	CD5%	CV(%)
		M ₁	M ₂			
Crude protein	1980	6.87	6.87	0.076	NS	8.9
	1981	6.54	6.35	0.100	NS	12.4
Calcium	1980	0.50	0.48	0.004	0.010	5.9
	1981	0.58	0.58	0.002	NS	15.7
Phosphorus	1980	0.22	0.22	0.001	NS	4.9
	1981	0.11	0.11	0.002	NS	14.8
NDF	1980	75.85	74.96	0.254	0.701	2.7
	1981	79.59	79.38	0.216	NS	2.2
ADF	1980	50.79	51.10	0.228	NS	3.6
	1981	54.41	54.66	0.271	NS	4.0
Collulose	1980	36.88	36.52	0.174	NS	3.8
	1981	41.73	42.15	0.194	NS	3.7
Hemi-collulose	1980	24.90	23.86	0.228	0.630	9.5
	1981	25.17	24.72	0.352	NS	11.3
Lignin	1980	10.26	10.84	0.182	0.503	13.7
	1981	9.95	9.53	0.090	0.249	7.4
Silica	1980	3.54	3.66	0.053	NS	11.8
	1981	2.56	2.70	0.054	NS	16.5
Total ash	1980	8.81	8.85	0.095	NS	0.3
	1981	6.66	6.94	0.127	NS	14.9
Acid insoluble ash	1980	4.16	4.43	0.096	NS	17.9
	1981	2.37	2.53	0.060	NS	19.4
Cell content	1980	24.09	25.04	0.256	0.708	8.3
	1981	20.41	20.63	0.217	NS	8.4
IVDMD	1980	43.11	42.83	0.083	0.229	1.5
	1981	45.07	44.90	0.147	NS	2.6

c. NDF and ADF content

Similar to that of calcium and phosphorus contents, only NDF content was significantly increased during first year of investigation by two splits of nitrogen application and differences were non-significant during second year whereas ADF content was not affected significantly during any of the years of experimentation.

d. Cellulose and hemi-cellulose content

The methods of nitrogen application affected the hemi-cellulose content of herbage in 1980 only and two splits of nitrogen application produced the herbage with more hemi-cellulose than that produced in the plots with three splits of nitrogen. The effect was non-significant in case of cellulose content during both the years. The hemi-cellulose content was also not affected significantly in second year.

e. Lignin content

Lignin content of herbage was significantly influenced by the methods of nitrogen application during both the years of experimentation. The application of nitrogen in three splits in 1980 and in two splits in second year, produced the herbage with significantly higher lignin content as compared to other methods of nitrogen application.

f. Silica content

The methods of nitrogen application either in two or three splits did not influence the silica content significantly during both the years.

g. Total ash and acid insoluble ash content

Similar to silica content, both these parameters were not influenced significantly by methods of N application during both the years.

h. Cell content

The per cent cell content a desirable quality parameter, was significantly higher in fodder obtained from plots receiving nitrogen in three splits than the other method in first year only whereas the effect was non-significant in second year.

i. IVDMD

The in-vitro dry matter digestibility of the fodder was influenced by methods of nitrogen application in 1980 only while it was non-significant in second year. The herbage obtained from the plots receiving nitrogen in two splits had significantly higher IVDMD than three splits (Table 4.6).

4.4 Effect of interactions

The various interactions influencing the different characters significantly are listed below for the year 1980 and 1981. The data pertaining to the significant interactions in respect of different characters have been appended in Appendices XXIII to XXV. However, the interactions affecting green and dry fodder yield have been described in detail in this section.

<u>Interactions</u>	<u>Year</u>	<u>Character</u>
Introduction x level of nitrogen	1980	a.Establishment(%) of introduced grass b.Nitrogen content(%) at 25 DAP c.Phosphorus content(%) at harvest d.Neutral detergent fibre (%) e.Hemi-cellulose content (%) f.Lignin content(%) g.Silica content (%) h.Cell content (%) i.Total ash (%) j.Acid insoluble ash (%)
	1981	a.Establishment(%) of introduced grass b.Per cent proportion of <u>Desmodium</u> at harvest c.Nitrogen content (%) at 0, 25, 75 and 100 DAR d.Calcium content (%) e.NDF content (%) f.ADF content (%) g.Cellulose content (%) h.Hemi-cellulose content (%) i.Lignin content (%) j.Cell content (%)
Introduction x Methods of N application	1980	a.Fresh weight (kg/m ²) at 75 DAP b.Green fodder yield (q/ha) c.Dry fodder yield (q/ha) d.Nitrogen content(%)at 25 and 50 DAP e.Calcium content (%) f.NDF content (%) g.Cellulose content (%) h.Hemi-cellulose content (%) i.Lignin content (%) j.Cell content (%) k.Acid insoluble ash (%)
	1981	a.Nitrogen content (%) at 0, 25,75 and 100 DAR b.Nitrogen uptake (g/m ²)at 25,75 and 100 DAR c.Phosphorus content (%) d.NDF content (%) e.ADF content (%) f.Cellulose content (%) g.Hemi-cellulose content (%) h.Lignin content (%) i.Silica content (%) j.Cell content (%) k.Total ash content (%)

Levels of nitrogen x
method of N application

- 1980
- a. Establishment (%) of introduced grass
 - b. Green fodder yield (q/ha)
 - c. Dry fodder yield (q/ha)
 - d. NDF content (%)
 - e. ADF content (%)
 - f. Hemi-cellulose content (%)
 - g. Lignin content (%)
 - h. Silica content (%)
 - i. Cell content (%)
 - j. Total ash content (%)
 - k. Acid insoluble ash (%)

- 1981.
- a. Establishment(%) of introduced grass
 - b. Green fodder yield (q/ha)
 - c. Nitrogen content (%) at 0, 75 and 100 DAR
 - d. Nitrogen uptake at 0, 25, 75 and 100 DAR
 - e. Crude protein content (%)
 - f. NDF content (%)
 - g. Cellulose content (%)
 - h. Lignin content (%)
 - i. Cell content (%)

Introduction x level of
nitrogen x method of N
application

- 1980
- a. Fresh weight (kg/m²) at 75 DAP
 - b. Nitrogen content (%) at 25 DAP
 - c. Green fodder yield (q/ha)
 - d. Calcium content (%)
 - e. Phosphorus content (%)
 - f. NDF content (%)
 - g. ADF content (%)
 - h. Cellulose content (%)
 - i. Silica content (%)
 - j. Cell content (%)

- 1981
- a. Mean height of legume at 100 and 125 DAR
 - b. Fresh weight (kg/m²) at 50 DAR
 - c. Nitrogen content at 0, 25 and 100 DAR
 - d. Nitrogen uptake at 0, 25 and 100 DDAR
 - e. NDF content (%)
 - f. Hemi-cellulose content (%)
 - g. Lignin content (%)
 - h. Cell content (%)

It is evident from above that the green fodder yield was influenced significantly by introduction x method of nitrogen application in 1980, levels of nitrogen x method of nitrogen application in both years and introduction x level x methods of nitrogen application in 1980 only. The dry fodder yield was affected significantly by introduction x method of nitrogen application in 1980 only. The effect of these interactions on green and dry fodder yield as well as on other important characters that were affected significantly shall be described in pages to follow.

4.4.1. Effect of interaction between grass and legume introduction and method of nitrogen application

The data pertaining to green and dry fodder yield (q/ha) as affected by introductions x methods of nitrogen application are given in Table 4.7.1. The introduction of Setaria alone (T_1) in the existing sward produced highest green as well as dry fodder yield when nitrogen was applied in three splits ($1/3$ at planting + $1/3$ at 25 DAP + $1/3$ at 50 DAP) and differed significantly with application of nitrogen in two splits ($1/2$ at planting + $1/2$ at 25 DAP). In case of nitrogen application in three splits, the green and dry fodder obtained from the plots introduced with Setaria alone were significantly higher than other methods of introduction including control. However, different introductions did not differ significantly when supplied with nitrogen in two splits only.

Table 4.7.1. Effect of interaction between introduction and method of nitrogen application on green and dry fodder yield (q/ha), 1980

Introduction	Method of nitrogen application			
	M ₁	M ₂	M ₁	M ₂
	<u>Green fodder yield</u>		<u>Dry fodder yield</u>	
T ₁	80.32	93.21	23.78	26.94
T ₂	79.37	83.05	23.42	24.41
T ₃	83.47	84.19	24.42	24.85
T ₄	80.66	82.69	23.87	24.67
	<u>SEm±</u>	<u>CD5%</u>	<u>SEm±</u>	<u>CD5%</u>
For introduction means at same method of N application	2.178	6.208	0.590	1.682
For method of N application means at same introduction	1.681	4.771	0.484	1.372

4.4.2. Effect of interaction between level and method of nitrogen application

The effect of interaction between level and method of nitrogen application was significant in respect of green fodder yield in both the years, dry fodder yield in 1980, establishment percentage in both the years, nitrogen content at 0, 75 and 100 DAR in 1981, nitrogen uptake at 0, 25, 75 and 100 DAR in 1981, NDF, lignin and cell content in both the years and ADF, hemi-cellulose, silica, total ash content and acid insoluble ash in 1980 and crude protein as well as cellulose in 1981.

Table 4.7.2. Effect of interaction between levels and methods of nitrogen application on green and dry fodder yield (g/ha), 1980

Levels of nitrogen	Methods of nitrogen application			
	M ₁	M ₂	M ₁	M ₂
	<u>Green fodder yield</u>		<u>Dry fodder yield</u>	
N ₁	74.71	82.65	23.31	25.87
N ₂	100.24	99.83	28.67	28.51
N ₃	102.04	110.42	29.22	31.29
	<u>SEm±</u>	<u>CD5%</u>	<u>SEm±</u>	<u>CD5%</u>
For N means at the same method of N application	2.628	7.460	0.646	1.835
For methods of N application means at same level of N	1.681	4.771	0.484	1.372

Application of 90 kg N/ha either in two or three splits produced highest green and dry fodder in 1980. The differences in green as well as dry fodder yield due to 90 and 60 kg N/ha were non-significant when applied in two splits. However, the later did not differ significantly with 30 kg N/ha when applied in three splits in case of green fodder yield. At all levels of nitrogen, application in three splits proved significantly better than two splits from green and dry fodder yield point of view. However, two methods of nitrogen application resulted in production of same quantity of green and dry fodder yield at 60 kg N/ha.

Table 4.7.3. Effect of interaction between levels and methods of nitrogen application on green fodder yield (q/ha), 1981

Level of nitrogen	Methods of nitrogen application	
	M ₁	M ₂
N ₁	222.57	246.64
N ₂	252.16	265.69
N ₃	273.75	287.34
	SEm±	CD5%
For N means at the same method of nitrogen application	5.663	16.073
For methods of nitrogen application means at same level of N	4.849	13.761

It is clear from the above table (4.7.3) that green fodder yield in 1981 increased significantly and consistently upto 90 kg N/ha irrespective of methods of nitrogen application. At all the levels of nitrogen, its application in three splits resulted in significantly higher production of green fodder than its application in two splits.

Table 4.7.4 embodying the data on NDF content as affected by the interaction between introduction and N levels shows that the introduction of Setaria alone produced highest NDF content of herbage obtained from control as well as plots fertilized with 60 kg N/ha. The differences were significant with other introductions excepting introduction of Desmodium alone (T₂) in the control plots (no nitrogen), which was at par with T₁. Application of nitrogen significantly increased the NDF content only in T₁ and T₄ treatments while the differences were non-significant in respect of T₂ and T₃.

Table 4.7.4. Effect of interaction between introduction and levels of nitrogen on NDF content (%) of herbage at harvest 1980

Introduction	Nitrogen levels			
	N ₀	N ₁	N ₂	N ₃
T ₁	77.81	75.81	80.91	75.19
T ₂	76.21	73.96	74.62	74.68
T ₃	73.70	74.10	74.70	76.11
T ₄	72.04	73.41	76.69	76.52
		SEm ₊	CD5%	
For introduction means at same level of N		1.019	2.926	
For N levels means at same level of introduction		1.029	2.944	

Table 4.7.5. Effect of interaction between introduction and level of nitrogen on lignin content(%) of herbage at harvest, 1980

Introduction	Nitrogen levels			
	N ₀	N ₁	N ₂	N ₃
T ₁	10.47	10.86	10.50	10.39
T ₂	9.51	10.69	8.62	10.44
T ₃	10.03	9.70	11.82	12.79
T ₄	10.32	11.21	10.69	10.84
		SEm ₊	CD5%	
For introduction means at same level of nitrogen		0.516	1.483	
For N level means at same introduction		0.496	1.420	

Application of nitrogen upto 90 kg/ha significantly increased the lignin content (%) of herbage obtained from the plots introduced with Desmodium alone (T_2) and Setaria + Desmodium (T_3). The differences were non-significant with respect to T_1 (introduction of Setaria alone) and T_4 (no introduction). In case of T_2 , 0, 30 and 90 kg N/ha produced the fodder with similar lignin content and, in T_3 it was same when 90 and 60 kg N/ha were applied.

The data presented in Table 4.7.6 show that the herbage obtained from the plots without introduction of grass and legume and not supplied with nitrogen contained highest cell content that was at par with T_3 (Setaria + Desmodium) but significantly higher than T_1 and T_2 at the same level of nitrogen. At 60 kg N/ha, the differences in the cell content of T_2 , T_3 and T_4 were also non-significant among them but significantly higher than T_1 (Setaria alone). There was no definite trend of variation in cell content with respect to nitrogen application in different introductions.

Table 4.7.6. Effect of interaction between introduction and levels of nitrogen on cell content(%) of herbage at harvest, 1980

Introduction	Nitrogen level			
	N ₀	N ₁	N ₂	N ₃
T_1	22.19	24.19	19.09	24.56
T_2	23.79	26.04	25.38	25.32
T_3	26.30	25.89	25.30	23.39
T_4	27.96	26.59	23.31	23.23
		SEm ₊	CD5%	
For introduction means at the same level of N		1.037	2.977	
For N level means at same introduction		1.045	2.990	

The data pertaining to NDF content (%) as affected by introduction x method of nitrogen application are given in Table 4.7.7. The introduction of Setaria alone resulted in significantly higher NDF content of herbage in both methods of nitrogen application. The remaining introductions did not differ significantly among them. Application of nitrogen in three splits (M_2) resulted in significantly higher NDF than M_2 in case of T_4 only i.e. when no introduction was made.

Table 4.7.7. Effect of interaction between introduction and methods of nitrogen application on NDF content(%) of herbage at harvest, 1980

Introduction	Method of nitrogen application	
	M_1	M_2
T_1	77.52	77.34
T_2	74.65	75.08
T_3	75.24	74.06
T_4	75.98	73.36
	SEm ₊	CD5%
For introduction means at the same method of nitrogen application	0.611	1.741
For methods of N application means at same introduction	0.507	1.439

Table 4.7.8 shows that three splits of nitrogen application significantly increased the lignin content (%) compared to two splits in respect of T_1 and T_4 only i.e. when introduced with Setaria alone and without introduction. The influence was non-significant with respect to other introductions. Lignin content reduced significantly in case of T_2 when nitrogen was applied in three splits as compared to other

introductions that did not differ significantly among them. All the introduction treatments produced the herbage with same lignin content when nitrogen was applied in two splits only.

Table 4.7.8. Effect of interaction between introduction and method of nitrogen application on lignin content (%) of herbage at harvest, 1980

Introduction	Methods of nitrogen application	
	M ₁	M ₂
T ₁	9.84	11.27
T ₂	10.25	9.37
T ₃	10.86	11.31
T ₄	10.10	11.43
	<u>SEm</u> ±	CD5%
For introduction means at the same method of N application	0.384	1.093
For methods of N application at same introduction	0.364	1.032

It is clear from the data presented in Table 4.7.9 that the two methods of nitrogen application brought significant difference in NDF content at 60 kg N/ha only when two splits produced the herbage with significantly higher NDF content than three splits. The NDF content of herbage obtained with 30 and 90 kg N/ha in case of two split application was same and significantly lower than 60 kg N/ha. In case of three splits, the increasing levels of nitrogen increased the NDF content but 60 and 90 kg as well as 30 and 60 kg N/ha did not differ significantly in this respect.

Table 4.7.9. Effect of interaction between level and method of nitrogen application on NDF content(%) of herbage at harvest, 1980

Level of nitrogen	Method of nitrogen application	
	M ₁	M ₂
N ₁	74.73	73.91
N ₂	78.35	75.11
N ₃	75.51	75.75
	SEm ₊	CD5%
For N means at same method of nitrogen application	0.627	1.780
For method of N application means at same level of N	0.507	1.439

4.5. Correlation studies

4.5.1. Relationship between dry fodder yield, nitrogen content (%) and nitrogen uptake (g/m²) at harvest

Correlation coefficients between all possible combinations of the following characters for 1980 and 1981 seasons were worked out.

1. Dry fodder yield (q/ha)
2. Nitrogen content (%)
3. Nitrogen uptake (g/m²)

The correlation coefficients are presented in Table 4.8.1. In both the years, it has been observed that dry fodder yield was positively and significantly correlated with nitrogen content (%) and nitrogen uptake (g/m²). Significant and positive correlation was observed between nitrogen content (%) and nitrogen uptake (g/m²) also. In both the cases, it was observed that the degree of correlation was more in the year 1981 as compared to year 1980.

Table 4.8.1. Correlation coefficients (r) between dry fodder yield, nitrogen content (%) and nitrogen uptake (g/m^2) at harvest during 1980 and 1981

	Nitrogen content(%)	Nitrogen uptake(g/m^2)
Dry fodder yield (q/ha)	+0.6624*	+ 0.7124*
	(+0.7159)*	(+0.8757)*
		+ 0.8336*
		(+ 0.8741)*

Figures in parenthesis show correlation coefficients for the year 1981

*Significant at 5 per cent level of significance

4.5.2. Relationship between in-vitro dry matter digestibility (IVDMD) and chemical constituents of the herbage

Table 4.8.2. shows the correlation coefficients between in-vitro dry matter digestibility and cell wall constituents, cell content and crude protein for the year 1980 and 1981. IVDMD had a significant positive correlation with crude protein and cell content in both years and significant negative relationship with acid insoluble ash in 1980, and lignin and silica content in both the years. There was no significant correlation of IVDMD with per cent NDF, ADF and cellulose in both the years.

However, acid insoluble ash (%) exhibited positive correlation with NDF content in first year, lignin and cell content (%) during second year and per cent silica during both the years. There was significant negative correlation with per cent NDF, cellulose and crude protein in the second year, and per cent ADF, cellulose, lignin, cell content and

Table 4.8.2. Correlation coefficient(r) between in-vitro dry matter digestibility (IVDMD) and some other quality parameters of herbage, 1980 and 1981

	Acid insoluble ash(%)	NDF (%)	ADF (%)	Cellulose (%)	Lignin (%)	Silica (%)	Cell content (%)	Crude protein (%)
IVDMD(%)	-0.3709* (-0.0757)	-0.1205 (0.1140)	0.0615 (0.0679)	0.1414 (0.0236)	-0.2315 (-0.2254)*	-0.3082* (-0.2471)*	0.2214* (0.1825)*	0.4685* (0.3038)
Acid insoluble ash(%)		0.2955* (-0.3846)*	-0.2182* (-0.0934)	-0.2132* (-0.5523)*	-0.2865* (-0.3861)*	0.4256* (0.5736)*	-0.2958* (0.3903)*	-0.2420* (-0.2120)
NDF(%)			0.0455 (0.3678)*	0.1865* (0.3582)*	-0.2896* (-0.0832)	0.1079 (-0.1149)	-0.0607 (-0.9975)*	-0.0162 (0.0692)
ADF(%)				0.8364* (0.3276)*	0.5193* (0.3783)*	0.0047 (0.0424)	-0.0424 (-0.3780)	0.1429 (-0.0654)
Cellulose (%)					0.2232* (-0.6825)*	-0.0969 (-0.6219)*	-0.1840* (-0.3708)*	0.1741* (-0.0373)
Lignin(%)						-0.2966* (0.4717)*	0.2933* (0.0888)	0.0707 (0.0681)
Silica(%)							-0.1085 (0.1169)	-0.2919* (-0.1892)*
Cell content(%)								0.0180 (-0.0759)

* Significant at 5 per cent level of significance

Values given in parenthesis are for 1981 crop season.

crude protein in the first year. The silica content, which is one of the major parameters determining the IVDMD had significant negative correlation with crude protein and no correlation with cell content.

4.6 Economic studies

The economics of individual treatment was worked out for the year 1980 and 1981, and have been presented in Table 4.9.1 and 4.9.2, respectively. Since the first year of experimentation was the year of establishment, and P and K fertilizers were applied in first year only, the combined yield data for 1980 and 1981 have also been used for working out the economics to have more valid comparisons (Table 4.9.3). The details of economics worked out are presented in Appendix XXVI.

4.6.1. Effect of introduction

The data embodied in Table 4.9.1 indicate that introduction of Desmodium alone gave higher net profit than control i.e. T_4 (no introduction) during 1980, while in the second year of experimentation, introduction of Setaria alone resulted in conspicuously higher net return than other treatments. The per cent advantage was 121.7 and 130.4 over T_2 and T_3 , respectively. It was observed that during the year of establishment, introduction of Setaria alone or in combination with Desmodium resulted in monetary loss as compared to control.

However, when the combined economics of both the years was worked out, introduction of Setaria alone (T_1) recorded the maximum net profit which was Rs. 1281.28 over control followed by T_2 and T_3 (Table 4.9.3).

Table 4.9.1. Economics of grass and legume introduction, level and method of nitrogen application, 1980

	Cost of production (Rs/ha)	Gross income (Rs/ha)	Net profit (Rs/ha)	Net profit/ loss over control*	Net profit per rupee invested
<u>Introduction</u>					
T ₁	903.37	1560.60	657.23	-180.27	0.73
T ₂	733.80	1624.00	890.20	52.70	1.21
T ₃	833.91	1508.40	674.49	-163.01	0.81
T ₄	631.30	1468.80	837.50	-	1.33
<u>Nitrogen level</u>					
N ₀	648.10	873.00	224.90	-	0.35
N ₁	734.00	1572.00	838.00	613.10	1.14
N ₂	818.15	1800.00	981.85	756.95	1.20
N ₃	902.12	1911.60	1009.48	784.58	0.87
<u>Method of N application</u>					
M ₁	764.71	1456.20	691.49	-	0.90
M ₂	786.47	1544.11	757.64	-	0.96

* (-) before any figure indicates loss.

Table 4.9.2. Economics of introduction, level and method of nitrogen, 1981

Treatment	Cost of production (Rs/ha)	Gross income (Rs/ha)	Net profit (Rs/ha)	Net profit/loss over control	Net profit per dupee invested
<u>Introduction</u>					
T ₁	565.75	5086.80	4521.05	1461.60	7.99
T ₂	565.75	4398.00	3832.25	772.80	6.77
T ₃	565.75	4348.80	3783.05	723.60	6.69
T ₄	565.75	3625.20	3059.45	-	5.41
<u>Nitrogen level</u>					
N ₀	435.00	3088.80	2653.80	-	6.10
N ₁	519.75	4222.80	3703.05	1049.25	7.12
N ₂	608.12	4660.20	4052.08	1398.28	6.66
N ₃	700.12	5049.00	4348.88	1695.08	6.21
<u>Method of N application</u>					
M ₁	558.87	4181.40	3622.53	-	6.48
M ₂	572.62	4329.00	3756.38	-	6.56

Table 4.9.3. Economics of introduction, level and method of nitrogen application (on the basis of two years data) for 1980 and 1981

Treatment	Cost of production (Rs/ha)	Gross income (Rs/ha)	Net profit (Rs/ha)	Net profit/loss over control	Net profit per rupee invested
<u>Introduction</u>					
T ₁	1469.12	6647.40	5178.28	1281.28	3.52
T ₂	1299.55	6022.00	4722.45	825.45	3.63
T ₃	1399.66	5857.20	4457.54	560.54	3.18
T ₄	1197.05	5094.00	3897.00	-	3.25
<u>Nitrogen fertilization</u>					
N ₀	1083.10	3961.80	2878.70	-	2.65
N ₁	1253.75	5794.80	4541.05	1662.35	3.62
N ₂	1426.27	6460.20	5033.93	2155.23	3.53
N ₃	1602.24	6960.60	5358.36	2479.66	4.34
<u>Method of N application</u>					
M ₁	1323.58	5637.60	4314.02	-	3.26
M ₂	1359.09	5873.11	4514.02	-	3.32

During the establishment year, T_4 gave the maximum net profit per rupee investment (Rs.1.33) followed by T_2 , T_3 and T_1 whereas in subsequent year it was highest in T_1 followed by T_2 , T_3 and T_4 .

4.6.2. Effect of nitrogen

Out of various nitrogen levels, 90 kg N/ha resulted in maximum net profit in the two years separately as well as when combined for both years. The net profit recorded was to the tune of Rs.784.58 and Rs.1695.08 in the first and second year, respectively when 90kg N/ha was applied. On the basis of combined economics, application of 90 kg N/ha maintained its edge over all the other levels of nitrogen and increased the net profit over control by a margin of Rs. 2479.66/ha.

Net profit per rupee investment was maximum (Rs.1.20) with 60 kg N/ha in the establishment year followed by 30 kg N/ha (Rs.1.14), whereas it was rupee 7.12, 6.66 and 6.21 for 30, 60 and 90 kg N/ha, respectively in the second year.

On the basis of combined economics, 90 kg N/ha resulted in maximum net profit of Rs.4.34 per rupee investment followed by 30 and 60 kg N/ha.

4.6.3. Effect of method of nitrogen application

During both the years, three splits of nitrogen application resulted in higher net profit over two splits and similar was the case when this was computed on the basis of two years data. Three splits of nitrogen application also resulted in higher net return per rupee investment as compared to two splits during both the years as well as on the basis of two years which was Rs.0.96, 6.56 and 3.32, respectively.

DISCUSSION

5. DISCUSSION

The experimental results obtained in the present investigation "Nitrogen management studies with grass and legume introduction in natural grassland under mid-hill conditions" have been presented in the foregoing chapter. The important results emerging out are discussed in this section with a view to establish the cause and effect relationship in the light of available evidences.

As described in detail in Chapter 3, Setaria and Desmodium were introduced in natural grassland after burning the existing vegetation. The introduction was done without disturbing the existing slope of land during monsoon rains on July 20th, 1980. The data pertaining to green and dry fodder yield presented in Table 4.1 show that the average dry fodder yield per hectare in 1980 was 24.5 q/ha as against 119.3 q/ha in the subsequent year while the green fodder yield was 83.3 and 236.4 q/ha in first and second year, respectively. The yield levels were lower in the first year i.e. the establishment year as compared to 1981. The lower yields (green and dry fodder) during the year of establishment may be attributed to the fact that the experimental area was a grazing land and usually subjected to heavy indiscriminate grazing after cutting the herbage for winter feeding as hay and leaving no reserves what so ever, thus affecting the regeneration of the vegetation severely. The indiscriminate grazing causes deterioration of grasslands which has been considered as the most important factor for poor condition of most of the grasslands of the country (Dabadghao, 1972). This contention is supported by the yield level in the plots where no introduction was made. This was higher in 1981 than 1980 reflecting

that closure of area from grazing resulted in 146.6 and 332.3 per cent more green and dry fodder yield, respectively. The introductions were done in July, 1980 which obviously took some time for establishment and could not contribute as effectively as in second year towards total herbage yield. This is clear from the data on plant height as well as the dry matter accumulation at last sampling stage. Apart from the above reasons, weather conditions of both seasons also differed conspicuously thus greatly affecting the performance of grasses and legumes in two years (Fig. 3.1). The difference in the amount of rainfall received during two years for the crop period was 982.8mm, being 1927.4mm in 1981 as against 1144.6 mm in 1980.

Not only in respect of herbage yield, but there was difference in quality of the fodder also obtained in two years. In general, the values for quality parameters that lower down the quality of fodder were higher in 1980 than 1981 viz., hemi-cellulose, lignin, silica, total ash, acid insoluble ash and lower cell content. This clearly indicates that the quality of fodder obtained in the year of establishment was definitely inferior than subsequent year which is evident from the higher values of desirable quality parameters in 1981 viz., Ca, P, cell content and IVDMD. The inferior quality of herbage in 1980 may be due to relatively less proportion of desirable grass species and lack of legume component (Desmodium) as being year of establishment. The contribution of introduced species might have been proportionately lower, resulting in poor quality. Contrary to many quality parameters, the protein content of herbage in 1980 was, in

general, higher than that of herbage obtained in 1981. This can be explained on the basis of total production that was many times higher in 1981 and might have followed the inverse yield nitrogen law of Wilcox (1954) that often the plants that produce the highest yield of dry matter have the lowest percentage of nitrogen in their tissues.

However, one of the main characteristics of a good fodder crop is that it should yield as large a crop of fodder per hectare as possible (Dabadghao, 1969). This gives importance to the total yield of dry matter per unit area. Even a highly nutritious and palatable forage can not contribute much to the nutrition of an animal unless it is available in adequate quantity. Likewise, a high dry matter yield is of little use unless the forage has an optimum nutritional quality.

Protein is the most important component of a feed stuff in its own way. Infact, the usually accepted classification of feedstuffs is essentially based on protein content, and the forages that are high in protein, are almost sure to be correspondingly lower in fibrous material. Such a product is more digestible than the one which has a little fibre content as well as low protein content (Crampton and Harris, 1969). The digestibility of forage is of particular importance in representing their digestible energy moiety. High digestibility of forage indicates that the forage is not highly lignified or mature. It is a common observation that the animals look for plants or plant parts which are actively growing and are not mature. Palatability is a factor as important as nutritive value and taking all aspects together, palatability is related to the cellulose content (Craplett, 1963).

5.1.1. Effect of introduction

The four introduction treatments in the present investigation included the introduction of Setaria alone, Desmodium alone, Setaria and Desmodium together and no introduction. The results obtained show that the effect of introduction on green and dry fodder yield was non-significant in first year, i.e. the year of establishment. This behaviour is quite expected as the introduced grass or legume may not be expected to contribute significantly towards production until and unless established properly to exhibit their full potential. Sood (1981) has also shown that the contribution of introduced species was not upto significant level in the first year. Though, not studied in the present investigation, it was felt that for marked contribution of introduced species, Setaria and Desmodium should have been planted at a bit closer spacing and two to three seedlings of Setaria per hill should have been used. This might have increased the per cent establishment as well as proportion of introduced grass and legume in the total herbage obtained after harvest.

In second year, the introduction of Setaria alone produced the highest green and dry fodder yield (Table 4.1). This treatment resulted in an increase of 40.3 and 29.8 per cent over control in respect of green and dry fodder yield, respectively. The treatments involving introduction of Desmodium alone or Setaria + Desmodium produced the herbage yield (dry and green) significantly higher than control but did not differ significantly between them.

Before looking into the possible reasons for increase in herbage yield due to introduction of Setaria, it may not be out of place to mention some characteristics of this grass. Setaria sphacelata is

said to have high seedling vigour, winter hardiness, high and low temperature tolerance, drought resistance, succulence, up right leaf orientation for lesser mutual shading effect, taller height and well developed root system. All these characters make it a suitable species for introduction with a view to improve the conditions of natural grasslands, (Harris, 1968). Levy(1968) has also emphasized that selection of proper species for introduction is very important for grassland improvement. These qualities of Setaria are well reflected in data regarding per cent establishment. This was 90.16 and 89.47 per cent in T_1 and T_3 , respectively, in the year of establishment (Table 4.1). The regeneration in 1981 was also 88.03 and 85.60 per cent, respectively in T_1 and T_3 treatments. The relative proportion of Setaria in total herbage on dry weight basis was 38.96 per cent in T_1 which was significantly higher than T_3 . The higher proportion of Setaria played important role in increasing the herbage yield significantly. The samples taken at various stages also showed that the dry and fresh weights were significantly higher in treatments introduced with Setaria alone especially after 100 days of initiation of regeneration. The progressive increase in plant height, and dry matter accumulation thus, resulted in increased herbage yield as the total dry matter yield at harvest may be said as a gradual and progressive build up in dry matter from the initial growth stage till harvest of the crop. The suitability of Setaria as a productive forage species and its introduction into the grasslands of various tropical and subtropical regions has been advocated by many workers (Thomas et al., 1979; Ludlow, 1980, and Thomas, 1980).

Introduction of Setaria in combination with Desmodium (T_3) and Desmodium alone (T_2) also produced higher green and dry fodder yields than control but did not differ between them (Table 4.1). The introduction of either one or two species, superior than existing vegetation is always expected to increase the production and quality against the indigenous species especially in a degraded grassland. The introduction of Setaria on one hand, might have contributed in the way described earlier, and Desmodium on the other hand, played important role being a legume species. Desmodium like other legumes might have helped the associated grass especially in the second year through symbiotic N fixation apart from supplementing its own requirement of nitrogen. In first year, the difference in green and dry fodder yield due to these treatments was also non-significant. The effects of introduction whether legume or grass, are more pronounced in subsequent years as observed by Morrison (1966) also who explained this on the basis that nitrogen fixation by perennial legume is higher in the second year compared to the establishment year due to better and healthy nodulation. The results convincingly established the fact that Setaria sphacelata and Desmodium uncinatum were suitable for introduction in the midhills of Himachal Pradesh as observed by Singh (1971-76) also.

The findings of several workers have shown the beneficial effects of introduction of grass and legume together for sustained herbage productivity from natural grasslands. The treatment T_3 did not prove better than Setaria alone in the present investigation though it included Setaria and Desmodium in 1:1 ratio. Though, the establishment

of Desmodium was about 80.45 per cent in 1980 and 72.47 per cent of that regenerated in second year also but being a trailing type in habit and presence of indigenous grasses underneath, the nodes producing roots did not find soil for establishment. This inherent drawback in the sward where indigenous herbage attained sufficient height, resulted in less proportion of Desmodium in herbage and thus could not exhibit its full potential. However, Hutton (1978); Rajani (1979), and Ludlow (1980) have shown that Desmodium was suitable for introduction as single or mixed component. Another good reason to support the higher yields in case of mixture (Setaria + Desmodium) and legume as a single component of the pasture over control is significantly higher proportion of Desmodium in T₂ and T₃, higher nitrogen content and nitrogen accumulation at various growth stages including harvest that ultimately manifested in final yield.

The various quality parameters such as crude protein, calcium, phosphorus, NDF, ADF, cellulose, hemi-cellulose, lignin, silica, total ash, acid insoluble ash, cell content and in-vitro dry matter digestibility (Table 4.2) were significantly influenced by different treatments of introduction during both the years of study (Table 4.2). It was observed that herbage with legume component (Desmodium) was qualitatively better than the herbage without legume. The quality of the herbage in T₂ (Desmodium alone) and T₃ (Desmodium + Setaria) was almost similar in respect of most of the quality parameters. The nutritional quality of a forage is determined primarily by its ability to meet the requirements of the animal for energy and protein (Crampton, 1947). Besides, the

apparent digestibility of a forage is very useful single measure of its nutritive value as it measures the largest single loss to the animal by secretion of energy and nutrients (Corbett, 1969).

The crude protein content (%) and IVDMD were significantly higher in treatment T₂ (Desmodium alone) than other treatments during both the years of experimentation except that first three treatments (T₁, T₂ and T₃) did not differ significantly in case of later (IVDMD) in 1980. This may be due to the higher proportion of legume in T₂ followed by T₃. IVDMD which is one of the major parameters determining the quality of the herbage, was significantly higher in T₃ (Setaria + Desmodium) compared to T₁ (Setaria alone) and T₄ (no introduction) but on par with T₂ (Desmodium alone) in 1981 as a result of favourable response of the quality components determined.

The increased IVDMD in the treatments involving legume component in 1980 may be ascribed to the higher crude protein content (%) which is mostly available to the animal rumen micro-organism and, lower amounts of lignin and silica which are major barriers in determining IVDMD. Sood (1981) has also reported that the effect of lignin on digestibility is wiped out when the forages are having higher protein and cell contents. It was observed that crude protein and cell contents were found to be positively correlated with IVDMD while silica, lignin and acid insoluble ash had a significant negative correlation with IVDMD (Table 4.8.2). The reduced in-vitro dry matter digestibility in T₄ (no introduction) may be attributed to the lower contents of crude protein and higher content

of silica and acceleration of the progressive lignification of the cell wall which commences in grasses about the time that the inflorescence starts elongating and builds upto a maximum, thereafter.

The progressive accumulation of nitrogen in herbage showed almost the similar trend as the the dry matter accumulation. At 125 DAR, the uptake was significantly higher in T₁ (Table 4.1) mainly due to increased dry matter accumulation in this treatment as compared to others. The lower accumulation was noticed in the plots having no introduction of grass or legume. The other two treatments involving legume, resulted in almost similar nitrogen uptake due to higher nitrogen content inspite of low dry matter accumulation as the nutrient uptake is a function of its content and total dry matter produced. At the stages when N content was significantly affected by introduction, it was invariably higher in herbage with legume. It is quite obvious as legumes are richer in N content than grasses.

5.1.2. Effect of nitrogen fertilization

Grasses and legumes in natural grasslands whether introduced or natural, require judicious use of fertilizers. One of the prominent factors responsible for low production of grasslands is the lack of adequate fertilization. The efficacy and utility of fertilizers in increasing the production and quality of grasslands have been reported by several workers in the country (Dabadghao et al., 1965; Bahl et al., 1970 and Shankarnaryan, 1973). Nitrogen content of grasses is relatively low unless nitrogen was applied in excess of the requirements for maximum

growth. The efficiency of dry matter production relative to applied nitrogen and nitrogen recovery could be improved substantially when adequate quantities of fertilizer nitrogen are added. Nitrogen rather than soil moisture is the primary limiting factor to grass growth under rainfed conditions (Henzel and Strik, 1963). Fertilizer nitrogen not only increases the protein content of grasses but the digestibility of protein also. Another dynamic role of fertilizer nitrogen is the change in voluntary intake, considered to be most important character from the quality point of view.

Nitrogen fertilization significantly increased the fresh and dry matter yields during both the years of experimentation (Table 4.3). Fertilized plots had significantly higher establishment and proportion of grass and legume both, taller plants, higher fresh and dry weights per square metre compared to control plots at various stage of growth and all these reflected in increased green and dry fodder yield.

Further, nitrogen content and nitrogen accumulation (Table 4.3) at all the growth stages including harvest were significantly higher in fertilized plots compared to unfertilized ones. The nitrogen content and nitrogen accumulation both showed positive correlation with dry fodder yield (Table 4.8.1) indicating that higher nitrogen uptake by herbage as a result of application of nitrogen resulted in better nutrition of the plants meeting the metabolic requirements of this nutrient.

In 1980, increase in green fodder yield was obtained upto 60 kg N/ha while this was upto 90 kg N/ha in subsequent year. The trend was reverse in respect of dry fodder yield. A perusal of the data on

plant height and dry matter accumulation at various stages of sampling shows that the plant height of Setaria was not affected significantly in the year of establishment may be due to the fact that plants were not able to make efficient use of applied N as in the subsequent year with better established root system. However, the total dry matter accumulation per square metre at 50 and 75 DAP in first year showed significant response upto 90kg N/ha. This is an indication that though the plant height of herbage did not increase significantly but the application of nitrogen helped in better accumulation of photosynthates which might have been by virtue of more leaf area and its duration.

The interesting point in respect of plant height of Desmodium was that it increased significantly due to N fertilization in both seasons. In establishment year, plant height measured at 25 and 75 DAP, indicated significant increase upto 90 kg N/ha which was more consistent at latter stages. The lack of sufficient nodulation in first year may be held responsible for this however, when well established in second year, application of 30 kg N/ha was enough to produce tallest Desmodium plants which was significant over no nitrogen application. As reported by Morrison (1966), the response to nitrogen application in leguminous crops are generally not obtained when nodulation is adequate.

Increasing levels of nitrogen from 30 to 90 kg/ha brought significant increase in green as well as dry fodder yield in both the years of experimentation (Table 4.3). Significantly taller plants, higher fresh and dry weights per square metre in plots fertilized with 90kg N/ha and comparatively higher establishment of grass and legume

species might have resulted in significant increase in yield through their cumulative effect as the yield per unit area is the resultant of number of plants per unit area and weight per plant. The later depends upon growth characters viz., plant height, number of leaves per plant and dry matter accumulation per plant. Secondly, such an increase in dry matter yield is quite obvious in light of deficiency of nitrogen in growing medium. The soil samples analysed before start of the experiment showed that the available N was in lower range (189 kg/ha). The data pertaining to per cent proportion of Setaria and Desmodium as affected by N are given in Table 4.3. The proportion of Setaria increased significantly and consistently upto 90 kg N/ha while that of Desmodium increased upto 60 kg N/ha only and there was significant reduction in its proportion when 90 kg N/ha was applied. Application of nitrogenous fertilizers in a soil deficient in N provided better nutrition not only to the introduced but also to the indigenous species. At high levels of nitrogen, the plants grow vigorously, produce more leaves with increased leaf area and leaf area duration causing shading effect and increase the competition for rooting space, nutrients and soil moisture thus, reducing the proportion of legumes (McLlory, 1972) in a mixed sward. Similar reasonings can be advanced for reduced proportion of Desmodium at 90 kg N/ha in the present investigation also.

The increase in the final yield as a result of beneficial effects of N fertilization on various characters of introduced grass as well as indigenous vegetation, like plant height (1981 only), dry matter accumulation, better utilization of applied N as evident from Nuptake values, cumulatively might have be

responsible for increased yield of green and dry fodder. Stern and Donald (1962) also forwarded almost same reasonings, for increased herbage production and relatively lower proportion of clovers in a sward of grass/clover. They summarized that:

- a. Increased rate of nitrogen application gave increased yield of grass,
- b. increased yield of grass gave higher leaf area of grass disposed over clover leaf canopy,
- c. higher leaf area of grass above the clover reduced the light density at the clover leaf canopy,
- d. reduced light density at the clover leaf canopy caused a reduced growth of the clover.

At higher levels of nitrogen fertilization, the nitrogen content (%) and nitrogen accumulation (g/m^2) were also higher, which had significant positive correlation with dry matter yield (Table 4.8.1). The increased plant growth with adequate fertilization might have been responsible for better nitrogen content, nitrogen accumulation and other mineral nutrients.

Higher in-vitro dry matter digestibility which is an important parameter of fodder quality showed significant positive correlation with cell content and crude protein, and significantly negative correlation with silica and lignin contents (Table 4.8.2). Application of nitrogen resulted in significant increase in cell content, crude protein content and, reduction in lignin and silica contents which might have been responsible for higher in-vitro dry matter digestibility.

5.1.3. Effect of method of nitrogen application

As a general principle, the nutrients should be applied to the plants when they need it most to ensure the regular supply in accordance with the demand by the growing crop. Nitrogen is highly mobile in soil as well as in plant system. Application of fertilizers in natural grassland are not like the cultivated crops. The irregular slope, diversity in vegetative composition and different physiographic conditions etc. require more careful and judicious use of fertilizers that is a costly but essential input in grassland management. Nitrogen when applied in natural sward is subject to washing off, leaching and denitrification losses depending on the source through which applied. Application of fertilizer at a time when plants are not able to utilize it is of no use and may be wastage of the resource. In present investigation, two methods of nitrogen application were, therefore, studied with the objective of making best use of nitrogen applied to the grassland. The nitrogen applied in three splits ($1/3$ at planting/regeneration + $1/3$ at 25 DAP/DAR + $1/3$ at 50 DAP/DAR) showed significantly better establishment/regeneration of Setaria as well as Desmodium as compared to application in two splits ($1/2$ at planting/ regeneration + $1/2$ at 25 DAP/DAR). The green fodder yield also increased significantly in case of three splits over two splits during both the years, however, the effect of dry matter yield was significant in 1980 only. The effect of three splits was not reflected in other characters under study to a significant level. Significantly better establishment in case of this (3 splits) may be attributed to the fact that introduced grass and legume were not able to derive the full benefit of

high amount (1/2 dose) of N applied at planting/regeneration and this have resulted in more loss of N on account of rain following the application. This is an indication that rain distribution plays an important role in efficient utilization of nitrogen applied alongwith other soil and plant factors.

Similarly, the fresh and dry yield also increased as a result of better utilization of applied N as indicated by N accumulation data at 75 DAP in first and 75 DAR in second year when uptake was significantly higher in three split application of nitrogen than two splits (Table 4.5). The effect of split application of nitrogen on quality parameters was also not significant in almost all the important characters excepting lignin content in both the years, cell content, NDF, hemi-cellulose and IVDMD during establishment year. There was no indication that nitrogen applied in three splits in the establishment year reduced the IVDMD probably due to increased lignification. Contrary to this lignin content reduced significantly in 1981 when nitrogen was applied in three splits (Table 4.6). It is difficult to find any explanation for this behaviour looking at the effect of N on IVDMD and lignin, described in foregoing section.

5.1.4. Interaction effects

The interaction between introduction and methods of nitrogen application affected the green and dry fodder yield significantly in 1980. The introduction of Setaria alone in the existing sward produced highest green as well as dry fodder yield when nitrogen was applied in three splits and differed significantly with two applications of nitrogen and also yielded highest as compared to other introductions including control. This might have been possible due to high production potential of Setaria

coupled with timely application of nitrogen fertilizer that boosted the yield.

The interaction between levels of nitrogen and its methods of application was significant in influencing green fodder yield in both years and dry fodder yield in 1980 (Table 4.7.2). Application of 90kg N/ha irrespective of the methods of nitrogen application produced highest green and dry fodder yield. At all the levels of nitrogen application, three splits proved significantly better than two splits in respect of green and dry fodder yields. The beneficial effects of three splits over two lies in the fact that smaller quantities applied resulted in better utilization and subjected to lesser losses as against applied in two splits only. This interaction affected the nitrogen uptake at 0,25,75 and 100 DAR in 1981 almost in same way providing additional support to the above contention that the utilization of applied N was probably better in three split application due to reduced losses.

5.2.5. Economics of grassland management

Improvement of a natural grassland in Himachal Pradesh is a necessity at present to meet the ever increasing demand for quality fodder as highlighted in Chapter 1. It is certain that any practice cannot be viable and acceptable to the farmers until and unless economically profitable. However, the economic aspect of a pasture improvement programme can not be assessed on the basis of immediate economic return only. This is because an improved grassland from total production and quality point of view will have to go a long way in improvement of the production from cattle, improvement of soil and simultaneously an

improvement in overall ecology of the area. There are certain management practices that exhibit their effect in a cumulative manner and thus, the gain from such practices be considered on long time cumulative basis, may be immediate gain from such measures are less remunerative. Keeping all these points in consideration, the economic returns in the present investigation have been calculated for individual years as well as on the basis of combined return and expenses during two years of experimentation. It is still felt that data would have been more informative by continueing the experiment for some more period.

In the year of establishment, introduction of Desmodium in the natural grassland registered the highest net profit per hectare. This was mainly due to lesser cost of production and relatively higher gross income as a result of better quality fodder produced in this treatment, thus fetching more price. Since the cost of production in control was minimum, inspite of low yield and lower gross return, the net profit was next to T_2 and net return per rupee invested was highest of all. The relatively lower net profit and monetary loss in comparison to no introduction treatment in case of Setaria introduced treatments (T_1 and T_3) were obviously due to high cost of planting material, thus increasing the total cost of production per hectare. However, the gross return in these treatments was definitely higher than control.

As mentioned in the beginning of this section, the economics of a pasture improvement programme should not be considered only on the basis of the first year results. This is strongly supported when we consider the yield data of second year and its economics. In second year,

the cost of cultivation in case of various introductions was same in all the plots but as reported and discussed earlier, there was significant difference in yield of herbage that brought marked difference in net profit as well as gross return. In contrary to first year results, the net profit was highest in T_1 (introduction of Setaria alone) followed by T_2 (introduction of Desmodium alone). As a result of lower yield, the net profit from the control plot was minimum. All the three treatments involving introductions resulted in additional benefit over no introduction, the magnitude being highest in T_1 . This trend was a resultant of 40.3% and 29.3% higher green and dry fodder production in this treatment over control. The benefit derived per rupee invested on management was around Rs. 8.00 in case of T_1 , followed by Rs 6.77 in T_2 and it was minimum (Rs 5.41) in the treatment having no introduction either of grass or legume. The economics of introduction when worked out combining the cost and return for both years (1980 and 1981) it was again apparent that gross income, net return and net profit over control (no introduction) were considerably higher in the treatments where Setaria alone was introduced followed by introduction of Desmodium alone. The relative superiority of T_2 over T_3 was observed due to reduced cost of production coupled with production of fodder having more leguminous component thus, fetching more price. On the basis of two years combined data, the net profit per rupee invested was slightly lower in T_1 than T_2 , which of course was due to the fact that cost of production in first year in this treatment was much higher than T_2 .

Out of the various nitrogen levels, 90 kg N/ha resulted in maximum net profit over control during 1980 and 1981, and when combined for both years. The net profit per rupee investment was also higher with 90 kg N/ha in first year and when computed for both years together, whereas in the second year, net profit per rupee investment was highest with 30 kg N/ha. The higher net return per rupee investment in case of 30 kg N/ha was because of much lower cost of added fertilizer compared with other two higher levels of nitrogen. The perusal of the data pertaining to herbage yield given in Table 4.3 shows that the fresh fodder yield increased significantly upto 60 kg N/ha in first year and 90 kg N/ha in second year. This response has been responsible for increased net profit with increasing levels of N. It may ~~not~~ be out of context to mention here that in computing the economics of N fertilization, the price for fodder obtained from the plots receiving differential doses of nitrogen has been kept same though there was marked improvement in fodder quality due to N over control and lower levels of its application as evident from the data presented in Table 4.4. The increase in crude protein, IVDMD and reduction in lignin as well as silica contents were responsible for improvement in quality of fodder and were significantly influenced by increasing levels of nitrogen.

Application of nitrogen in three splits increased the fresh fodder yield significantly during both years of experimentation over two splits as discussed in foregoing section of this chapter which has reflected in increased gross return, net return as well as net profit/rupee invested

in 1980 and 1981, and also in the combined computation for both years. All these parameters were higher when nitrogen was applied in three splits than two splits (M_1). Though the application of nitrogen in three splits included some extra cost of production in the form of labour charges but that was well compensated by increase in yield (Table 4.9.3). On the basis of two years data, total extra expenditure involved in M_2 over M_1 works out to Rs 35.51 per hectare and the net profit obtained was Rs 200.00 per hectare which may be considered as a worthwhile investment, obviously there was no other advantage of applying nitrogen in three splits over two in the present investigation.

SUMMARY AND CONCLUSION

6. SUMMARY AND CONCLUSION

The investigation entitled "Nitrogen management studies with grass and legume introduction in natural grassland under mid-hill conditions" was carried out at Himachal Pradesh Krishi Vishva Vidyalaya Palampur (Himachal Pradesh) during kharif seasons of 1980 and 1981.

The main objectives of the investigation were:

1. To study the impact of grass/legume introduction on the production potential and quality of natural grassland in Kangra Valley,
2. to workout the nitrogen requirement and its best method of application for natural grassland when introduction of grass/legume has been made,
3. to workout the nutritive value of grass/legume mixtures thus produced, and
4. to study the relative economics of grass/legume introduction and nitrogen fertilization in natural grassland.

The experiment consisted four treatments of introduction (introduction of Setaria alone (T_1); introduction of Desmodium alone (T_2); introduction of Setaria + Desmodium (T_3) and no introduction (T_4) in main plots and four nitrogen levels (0, 30, 60 and 90 kg N/ha) in sub-plots and two methods of nitrogen application (1/2 at planting/regeneration + 1/2 at 25 DAP/DAR and 1/3 at planting/regeneration + 1/3 at 25 DAP/DAR + 1/3 at 50 DAP/DAR) in sub-sub-plots of a split-split plot design with four replications. The experiment was established in kharif, 1980. The experimental area had a natural slope of 7.9 to 9.7 per cent and dominant grass species at the time of introduction were Heteropogon Contortus P. Beauv., Chrysopogon fulvus Trin. and Setaria glauca P. Beauv.; and the legume component was almost absent from the site except for rare presence of Desmodium species.

Nitrogen was applied through urea in two ($1/2$ at planting/regeneration + $1/2$ at 25 DAP/DAR) and three splits ($1/3$ at planting/regeneration + $1/3$ at 25 DAP/DAR + $1/3$ at 50 DAP/DAR) during both the years of experimentation, whereas, entire quantity of $80 \text{ kg P}_{25}\text{O}_5$ (through single super phosphate, $16\% \text{ P}_{25}\text{O}_5$) and $60 \text{ kg K}_2\text{O}$ (through muriate of potash, $60\% \text{ K}_2\text{O}$) were applied as broadcast at the time of planting in first year only.

The effect of various treatments on different growth and development characters of legume and grasses, dry matter and fresh forage yield, nitrogen content and nitrogen accumulation, have been described in detail in Chapter 4 and discussed in Chapter 5. The important findings obtained are summarized here under.

1. The effect of introduction of grass/legume was non-significant in the year of establishment in respect of green and dry fodder yield. Introduction of Setaria alone produced the highest green and dry fodder yield in the next year of establishment. The increase in green and dry fodder yield due to Setaria introduction during the year of establishment over control was 6.2 and 4.5 per cent only, while in the second year this increase was 40.3 and 29.8 per cent respectively. Next to T_1 , introduction of Setaria in combination with Desmodium (T_3) resulted in higher green and dry fodder yield which were not however, significantly different from T_2 (introduction of Desmodium alone). There was increase in green and dry fodder yield obtained from control plot (T_4) in 1981 as compared to 1980 which is an indication that simply closure of area from grazing can increase the herbage yield conspicuously^u with passage of time.

The green fodder yield increased significantly and consistently with the application of nitrogen up to 60 and 90 kg N/ha in 1980 and 1981, respectively while the dry fodder yield increased upto 90 and 60 kg N/ha in first and second year respectively.

Three splits of nitrogen application significantly increased the fresh fodder yield in both years and dry fodder yield in the year of establishment only over nitrogen applied in two splits.

2. Per cent establishment of Setaria and Desmodium was not influenced significantly by different introduction treatments during both the years.

Increasing levels of nitrogen significantly increased the per cent establishment of Setaria and Desmodium during both the years. The differences between 60 and 90 kg N/ha however, were non-significant.

Application of nitrogen in three splits proved superior over two splits from the view point of Setaria and Desmodium establishment and regeneration during first and second years respectively.

3. Per cent proportion of Setaria was significantly more when introduced alone compared to its introduction in combination with Desmodium (T_3) as was also case with Desmodium when introduced alone than its introduction with Setaria in 1981.

Increasing levels of nitrogen from 0 to 90 kg/ha significantly increased the proportion of Setaria in herbage while proportion of Desmodium declined significantly when nitrogen was applied beyond 60 kg/ha.

Per cent proportion either of Setaria or Desmodium was not influenced significantly by different methods of nitrogen application.

4. Plant height was significantly influenced by different introductions at all the growth stages excepting at 100 and 130 DAR in 1981.

Setaria in the mixed herbage exhibited taller height and was comparable with the herbage involving introduction of Desmodium in the existing vegetation.

At most of the growth stages, increasing levels of nitrogen increased the plant height of grass species significantly upto 90 kg N/ha.

The application of nitrogen influenced the plant height of Desmodium significantly at all stages under study during both years except 50 DAP in 1980 and 0 DAR in 1981.

In second year of experimentation tallest Desmodium plants were obtained with the application of 30 kg N/ha at almost all the stages.

Plant height either of grass species or Desmodium was not influenced significantly by the methods of nitrogen application.

5. The plant samples taken at various stages of growth showed that the fresh and dry weight per square metre were higher at most of the stages when Setaria was introduced in the natural sward. However, the effect of introduction treatments was significant at 100, 125 and 130 DAR in 1981 in respect of fresh weight and that in respect of dry weight at 25 DAP in 1980 and 100 and 125 DAR in 1981.

The influence of nitrogen levels on fresh and dry weight recorded at various stages of sampling were significant in both the years except at 25 DAP in 1980 and 0 DAR in 1981. The fresh and dry weight both increased with increase in nitrogen level in most of the cases.

Methods of nitrogen application did not influence the fresh and dry weight at all stages excepting 25 and 75 DAP during 1980. Application of nitrogen in two splits recorded maximum fresh and dry weight at 25 DAP while reverse was the trend at 75 DAP. In 1981, dry

weight was significantly more with three splits than two splits at harvest stage only and the differences were non-significant at all other stages under study.

6. The effect of introduction treatments on nitrogen content was non-significant at all the growth stages except at 75 DAP in 1980 and 75, 125 and 130 DAR in 1981. Introduction of Desmodium alone (T_2) produced the herbage with significantly higher nitrogen content than other treatments in 1980 and same trend was observed in 1981 excepting at 75 DAR.

The nitrogen content in herbage increased significantly with increase in nitrogen level upto 90 kg N/ha however, the increase was upto 60 kg N/ha only at early stages of growth.

Application of nitrogen in three splits increased the nitrogen content significantly at 25 DAP in 1980 and 0, 50, 75 and 100 DAR in 1981 as compared to application in two splits. The differences in N content due to two methods of nitrogen application were non-significant at other growth stages.

7. Nitrogen accumulation (g/m^2) was significantly influenced by different introductions at 25 and 75 DAP in 1980 and 50, 100, and 125 DAR in 1981. Introduction of Desmodium alone (T_2) had maximum nitrogen accumulation (g/m^2) at 25 and 75 DAP which was however, on par with T_1 and T_4 at 25 DAP and significantly higher than other introduction treatments at 75 DAP in 1980. In 1981, T_2 again recorded maximum nitrogen accumulation at 50 DAR, which was on par with T_1 and T_4 . However, at 100 and 125 DAR, the herbage obtained from the plots introduced with Setaria alone accumulated highest amount of nitrogen and the differences with

other treatments were significant.

Nitrogen accumulation (g/m^2) increased significantly and consistently upto 90 kg N/ha at all the growth stages except at 0 DAR in 1981, where the effect of N application was non-significant. However, the differences in N uptake at 25 DAP in 1980 and 25 DAR in 1981 were non-significant due to 60 and 90 kg N/ha.

The effect of methods of nitrogen application on nitrogen accumulation was non-significant except at 25 and 75 DAP in 1980 and 75 DAR in 1981 where splitting the nitrogen dose in three equal splits increased the accumulation significantly as compared to two splits, however, the trend was reverse at 25 DAP in 1980.

8. Introduction of Desmodium alone in the existing sward recorded significantly higher protein content (%) during both the years and differed significantly with rest of the treatments of introduction.

The crude protein content increased significantly and consistently upto 90 kg N/ha during both years of study.

9. Calcium and phosphorus content of herbage were significantly influenced by different introductions during both years. Calcium and phosphorus contents in herbage during 1981 were highest when Desmodium alone was introduced. In general, these contents were lower in the herbage having more proportion of grass whether indigenous or Setaria. However, in 1980, the calcium content was highest in the herbage obtained from the plots that was not introduced with either legume or grass.

Different levels of nitrogen influenced calcium and phosphorus contents in the year of establishment only. Application of 30 and 90kg N/ha produced the herbage with significantly higher contents of calcium

and phosphorus, respectively.

10. NDF and ADF content of herbage were significantly influenced by different introduction treatments during both the years except ADF content in 1980. Introduction of Setaria alone (T_1) produced highest NDF and ADF contents during both the years and differed significantly with other treatments of introduction during both the years excepting that difference with T_4 was non-significant in case of NDF content (1981).

Various levels of nitrogen affected the NDF content significantly during both the years but the effect was non significant with respect to ADF content. With increased application of nitrogen, NDF content of fodder decreased significantly however, differences between 0 and 30 as well as 60 and 90 kg N/ha were non-significant during both the years.

11. Cellulose and hemi-cellulose content of herbage were significantly influenced by various introductions during both years except cellulose content in 1980. The herbage produced from the plots introduced with Setaria alone (T_1) had highest cellulose content in 1981 and hemi-cellulose content in 1980. In 1981, the hemi-cellulose content was maximum in the herbage from control plot.

Cellulose content of the herbage was significantly higher at 90 kg N/ha during 1981 and differed significantly with control. The differences in cellulose content of the herbage at 0, 30 and 60 kg N/ha were non-significant. Hemi-cellulose content of the herbage was significantly higher with 60 kg N/ha during 1980 than lower levels of nitrogen and difference with 90 kg N/ha was non-significant.

Methods of nitrogen application influenced hemi-cellulose content of herbage only in the establishment year where application in

two splits produced herbage with significantly higher hemi-cellulose content.

12. The introduction treatments influenced the lignin of herbage significantly during establishment year only while that of silica content during both the years. Lignin content of the herbage was significantly higher when introduction of Setaria alone was made and did not differ significantly with T_4 . The herbage containing Desmodium had significantly lower lignin content. The content of silica in herbage decreased significantly with introduction of Setaria or Desmodium or both as compared to control during both years.

Lignin and silica contents of the herbage decreased significantly with increasing levels of nitrogen and the effect of different levels of nitrogen application was significant during 1980 in respect of both and during 1981 in case of silica.

Only lignin content was significantly influenced by methods of nitrogen application. Three splits in case of first year and two splits in the second year resulted in herbage with highest lignin content.

13. The effect of introduction treatments on total ash and acid insoluble ash was significant in 1981 only. Introduction of Setaria alone and in combination with Desmodium resulted in significantly higher total ash content than other two treatments that were at par. The acid insoluble ash content was significantly higher than remaining three treatments of introduction that did not differ significantly among them.

The total ash and acid insoluble ash contents of herbage were affected by nitrogen application during both years but there was no definite trend. In general, these two contents showed declining trend with increased levels of nitrogen.

14. Various introductions significantly influenced the cell content of herbage during both the years. During both the years, significantly minimum cell content was recorded in herbage obtained from control plot (without introduction) which however, did not differ significantly with T_1 in 1981. Other introduction treatments did not differ significantly among them.

The effect of varying levels of nitrogen on cell content was also significant during both years. There was significant reduction in cell content at higher levels of nitrogen during both the years. The differences between 0 and 30 as well as 60 and 90 kg N/ha were nonsignificant.

Application of nitrogen in three splits produced the fodder that contained significantly higher cell content than that obtained from two splits of nitrogen application during the year of establishment.

15. Introduction of Setaria in combination with Desmodium produced the herbage with significantly higher digestibility than introduction of Setaria and control but was on par with T_2 (introduction of Desmodium alone). The IVDMD of the herbage obtained from control plots was lowest and differences with other treatments were not significant during both the years.

Increasing levels of nitrogen significantly and consistently increased the in-vitro dry matter digestibility of fodder during both years.

Application of nitrogen in two splits produced the herbage with higher digestibility than three splits in the establishment year only.

16. Introduction of Desmodium in natural grassland registered the highest net profit and net return per rupee investment. In the second year net profit over control and net profit per rupee investment were highest when Setaria was introduced alone in the existing sward. However, on the basis of combined economics for both the years, the highest net profit was obtained in case of Setaria introduction and minimum when no introduction was done.

The net profit obtained in first year, second year and on the basis of two years data combined together, increase in nitrogen application upto 90kg N/ha increased the net return per hectare as well as net profit per rupee investment except in 1981 when this was highest with 30 kg N/ha.

Conclusion

On the basis of results obtained from the two years of experimentation it can be concluded that Setaria sphacelata can successfully be introduced in natural grasslands of mid-hills in Himachal Pradesh for increased production of good quality fodder. A dose of 60 kg N/ha in the establishment year and 90 kg N/ha in the subsequent year applied in three splits ($\frac{1}{3}$ at planting/regeneration + $\frac{1}{3}$ at 25 DAP/DAR + $\frac{1}{3}$ at 50 DAP/DAR) proved beneficial from yield, quality and economics point of view. Introduction of Desmodium alone or in combination with Setaria in 1:1 ratio increased the quality of fodder but the yield and economic returns were not comparable with introduction of Setaria alone. The results have convincingly shown that fertilization with 60 and 90 kg N/ha has increased the green fodder yield of indigenous grass

species also to the tune of 115.6 and 92.6 per cent, respectively, over control (no nitrogen) and can be adopted as an immediate measure for increasing the production from degraded grasslands (ghasnis) of the state.

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APPENDICES

APPENDIX I

Mean weekly meteorological data recorded at Meteorological Observatory,
Department of Agronomy and Agrometeorology, Krishi Vishva Vidyalaya,
Palampur, Himachal Pradesh during Kharif, 1980.

Week	Period	Temperature °C		Relative Humidity(%)	Rainfall (mm)
		Max.	Min.		
1.	1st May- 7th May	32.0	20.6	30.1	-
2.	8th May-14th May	30.6	18.9	31.7	9.0
3.	15th May-21st May	31.5	19.3	28.1	8.6
4.	22nd May-28th May	32.2	20.8	26.7	1.2
5.	29th May-4th June	30.5	18.8	44.2	9.0
6.	5th June-11th June	31.3	21.0	46.4	10.9
7.	12th June-18th June	29.7	19.3	49.8	78.8
8.	19th June-25th June	28.3	20.5	65.2	90.4
9.	26th June-2nd July	27.5	20.7	81.1	45.7
10.	3rd July-9th July	26.2	20.0	87.2	69.5
11.	10th July-16th July	24.8	19.6	90.4	280.9
12.	17th July-23rd July	26.6	19.5	88.6	260.6
13.	24th July-30th July	25.3	19.5	94.2	231.6
14.	31st July-6th Aug.	25.6	19.7	89.1	296.4
15.	7th Aug.-13th Aug.	25.4	19.3	85.4	207.1
16.	14th Aug.-20th Aug.	26.9	17.8	71.5	64.3
17.	21st Aug.-27th Aug.	26.5	19.2	83.1	66.2
18.	28th Aug.-3rd Aug.	27.1	18.8	77.4	67.0
19.	4th Sept.-10th Sept.	25.6	18.3	86.7	56.0
20.	11th Sept.-17th Sept.	29.5	17.3	60.1	25.3
21.	18th Sept.-24th Sept.	29.5	16.3	72.4	9.2
22.	25th Sept.-1st Oct.	26.1	16.5	56.0	11.8
23.	2nd Oct. -8th Oct.	28.7	16.5	72.0	8.2

Total rainfall = 1907.7 mm during 23 weeks

Rainfall for the cropped season = 1144.6 mm

Mean Maximum Temperature range = 24.8°C -27.1°C

Mean Minimum Temperature range = 16.3 - 19.6°C

Relative Humidity range = 58.1 - 93.8%

APPENDIX II

Mean weekly meteorological data recorded at Meteorological Observatory,
Department of Agronomy and Agrometeorology, Krishi Vishva Vidyalaya, Palampur
Himachal Pradesh during Kharif, 1981.

Week	Period	Temperature °C		Relative Humidity(%)	Rainfall (mm)
		Max.	Min.		
1.	1st May - 7th May	29.0	17.2	49.8	28.4
2.	8th May - 14th May	25.3	15.7	56.9	48.4
3.	15th May - 21st May	28.1	19.3	37.4	18.2
4.	22nd May - 28th May	29.5	19.3	45.3	18.2
5.	29th May - 4th June	29.6	18.4	46.8	17.4
6.	5th June - 11th June	30.9	19.3	37.0	15.6
7.	12th June - 18th June	32.5	21.4	31.3	5.2
8.	19th June - 25th June	30.8	20.4	62.6	46.6
9.	26th June - 2nd July	22.4	19.5	87.8	373.8
10.	3rd July - 9th July	26.8	19.5	78.7	18.2
11.	10th July - 16th July	25.3	20.0	92.5	177.5
12.	17th July - 23rd July	24.3	19.8	96.3	137.8
13.	24th July - 30th July	25.1	19.6	93.7	389.8
14.	31st July - 6th Aug.	24.9	19.4	92.2	197.8
15.	7th Aug. - 13th Aug.	25.3	19.9	89.0	267.7
16.	14th Aug. - 20th Aug.	26.5	19.7	89.5	48.0
17.	21st Aug. - 27th Aug.	25.8	17.8	83.1	83.1
18.	28th Aug. - 3rd Sept.	26.9	18.2	78.0	35.7
19.	4th Sept. - 10th Sept.	27.2	17.7	70.1	-
20.	11th Sept. - 17th Sept.	26.1	16.9	68.7	44.11
21.	18th Sept. - 24th Sept.	25.5	15.5	76.5	21.8
22.	25th Sept. - 1st Oct.	24.6	16.6	77.5	20.0
23.	2nd Oct. - 8th Oct.	23.8	15.7	76.8	20.9

Total rainfall = 20.34.2 mm during 23 weeks

Rainfall for the cropped season = 1927.4mm

Mean Maximum Temperature range = 22.4 - 32.5°C

Mean Minimum Temperature range = 15.7 - 21.4°C

Relative Humidity range = 31.3 - 96.3%

APPENDIX III

Analysis of variance of establishment(%) of introduced grass and legume in different treatments at harvest

Source of variation	d.f.	Mean squares			
		1980		1981	
		Legume	Grass	Legume	Grass
Replications	3	33.1500	6.2666	83.5100	10.9400
Introductions (A)	1	108.3000	7.5000	224.3300	95.0000
Error(a)	3	36.8200	7.4033	27.2266	15.2533
Levels of Nitrogen (B)	3	1149.8066*	679.2633*	724.2533*	633.6466*
A x B	3	60.5166	142.5600*	46.6233	153.3500*
Error (b)	18	24.4322	13.5661	22.3155	18.8950
Methods of application(C)	1	224.0200*	70.3100*	135.0200*	74.7200*
A x C	1	7.32	3.4900	59.2500	13.1000
B x C	3	26.1600	48.7933*	3.9333	43.1533*
A x B x C	3	31.7900	33.9666	43.2233	15.4500
Error (C)	24	16.6679	11.5241	24.0358	11.7462
Total	63	82.4473	53.2858	65.4515	54.2892

APPENDIX IV

Analyses of variance of per cent proportion of introduced grass and legume in different treatments at harvest (1981).

Source of variation	d.f. for legume	d.f. for grass	Mean squares	
			Legume	Grass
Replications	3	3	19.2070	5.6480
Introductions (A)	2	1	8588.2320*	2333.8530*
Error(a)	6	3	34.9486	0.7340
Levels of nitrogen (B)	3	3	1099.6900*	2359.4790*
A x B	6	3	354.3385*	12.4313
Error (b)	27	18	18.9126	12.0807
Methods of application(C)	1	1	7.6220	6.5750
A x C	2	1	2.9120	1.1840
B x C	3	3	3.9093	2.9646
A x B x C	6	3	4.7536	8.5173
Error (C)	36	24	7.1139	3.5523
Total	95	63	249.3612	155.7721

APPENDIX V

Analyses of variance for mean height(cm) of *Setaria* grass at different stages of growth (1980).

Source of variation	d.f.	Mean squares		
		Days after planting		
		25	50	75
Replications	3	105.2930	181.6600	239.9240
Introductions (A)	1	153.9466	88.5900	0.0853
Error(a)	3	70.1890	151.4000	83.1540
Levels of nitrogen (B)	3	113.9570	581.1770	1375.8090
Introductions x levels	3	56.0820	16.4560	43.2780
Error (b)	18	75.9840	152.7200	78.1290
Methods of application (C)	1	23.8000	221.6370	16.3520
Introductions x methods of application	1	81.5050	221.6460	45.1370
Levels x methods	3	4.9130	18.3070	14.5720
Levels x Introduction x methods	3	36.7330	13.0580	11.1300
Error (c)	24	35.6690	39.2220	73.6310

APPENDIX VI

Analyses of variance of mean height(cm) of mixed herbage at different stages of growth (1981)

Source of variation	d.f.	Mean squares						
		Days after regeneration						
		0	25	50	75	100	125	130
Replications	3	90.6396	32.5610	87.4526	114.4466	20.6933	3170.5000	109.9000
A	2	811.8820	697.3670	451.8050	1175.5150	254.9500	2762.1500	3744.8000
Error(a)	6	84.9476	118.1940	87.5703	348.6000	916.7583	806.9166	1296.7666
B	3	108.9413	242.0290	377.6733	2344.6966	8171.8333	8818.6666	11177.4333
A x B	6	8.2421	17.3620	37.2450	39.5466	166.5833	502.0666	726.1666
Error (b)	27	28.2623	46.2598	64.3914	41.9833	97.8655	212.5518	301.1259
C	1	20.3490	2.6970	0.5850	131.8300	54.4100	70.3000	321.9000
A x C	2	5.2130	24.4905	34.7175	2.3550	37.7500	49.7500	7.4500
B x C	3	9.7456	7.3886	67.1916	112.7033	164.9500	374.2000	281.1666
A x B x C	6	7.9143	14.8383	31.6318	64.4533	39.4183	108.7166	302.3000
Error (C)	36	19.8936	34.5355	35.4952	55.4952	112.0616	249.2027	216.5444
Total	95	45.9831	59.8632	68.5596	168.9483	411.8462	600.0063	761.9821

APPENDIX VII

Analyses of variance of mean height(cm) of introduced legume in mixed herbage at different stages of growth (1980).

Source of variation	d.f.	Mean squares		
		Days after planting		
		25	50	100
Replications	3	222.4843	77.7433	84.7586
Introductions (A)	1	66.8300	31.5010	674.0500
Error (a)	3	24.7096	62.1246	70.8366
Levels of nitrogen (B)	3	20.2610*	18.0416	201.3263*
A x B	3	20.5146	26.5580	18.4230
Error (b)	18	12.0395	15.0877	8.4508
Methods of application (C)	1	1.9600	29.5680	51.3000
A x C	1	0.3310	22.2060	31.7840
B x C	3	2.1640	13.9940	5.2606
A x B x C	3	8.1933	26.8550	6.1376
Error (c)	24	17.5611	28.9943	17.1227
Total	63	25.4330	27.4074	39.3756

APPENDIX VIII

Analyses of variance of mean height (cm) of introduced legume in mixed herbage at different stages of growth(1981)

Source of variation	d.f.	Mean squares						
		Days after regeneration						
		0	25	50	75	100	125	130
Replications	3	111.1885	510.6760	946.6010	1615.5310	2324.0700	1236.9133	1349.5066
Introductions(A)	1	46.9225	405.5190	967.9890	2313.6100	7259.0400	13441.4800	12003.9300
Error(a)	3	87.0429	424.5006	885.3683	1755.3490	3510.0933	4331.7366	5310.016
Levels of N(B)	3	12.0577	44.1830*	80.6223	395.3386	2170.8666*	3181.2433*	3171.4500
A x B	3	14.7079	59.2070	96.7953	266.5146	456.1333	1077.1866	1205.9700
Error (b)	18	20.4105	25.3771	40.9630	170.9280	647.2211	1165.5988	1300.0400
Methods of application (C)	1	20.4756	47.7830	20.8180	80.1000	1776.6200	3470.6700*	4880.7500
A x C	1	7.2900	4.3570	30.6620	66.8330	0.1200	184.6500	223.1400
B x C	3	14.6719	28.2956	83.1150	159.5246	234.2666	312.7733	322.4466
A x B x C	3	5.7195	71.8080	124.1896	621.5876	1993.0333*	2337.2933*	2228.4400
Error (c)	24	8.4112	50.7589	117.5708	306.7250	543.9570	637.7529	750.4433
Total	63	21.9065	88.0741	178.2314	433.9711	1044.5415	1441.5093	1575.9153

APPENDIX IX

Analyses of variance of mean fresh weight (kg/m^2) at different growth stages(1980).

Source of variation	d.f.	Mean squares		
		Days after planting		
		25	50	75
Replications	3	0.0350	0.3050*	0.2270*
Introductions (A)	3	0.0561*	0.0052	0.0167
Error(a)	9	0.0096	0.0334	0.0329
Levels of nitrogen (B)	3	0.0229	0.5404*	1.9052*
A x B	9	0.0097	0.0289	0.0321
Error(b)	36	0.0079	0.0275	0.0336
Methods of application(C)	1	0.0374*	0.0318	0.1313*
A x C	3	0.0056	0.0067	0.0527*
B x C	3	0.0076	0.0095	0.0100
A x B x C	9	0.0033	0.0299	0.0431
Error(C)	48	0.0028	0.0188	0.0147
Total	127	0.0082	0.0422	0.0760

APPENDIX X

Analyses of variance of mean fresh weight (kg/m^2) at different growth stages(1981)

Source of variation	d.f.	Mean squares						
		Days after regeneration						
		0	25	50	75	130	125	130
Replications	3	0.0059	0.0052	0.0043	0.2233*	0.3799*	0.5946*	0.2520
Introductions(A)	3	0.0068	0.0218	0.0030	0.0270	0.8308*	0.7125*	0.6028*
Error(a)	9	0.0036	0.0057	0.0034	0.0473	0.0589	0.0511	0.0734
Levels of N(B)	3	0.0018	0.0317*	0.1123*	2.5751*	1.5794*	0.7313*	1.2965*
A x B	9	0.0017	0.0055	0.0008	0.0278	0.1874	0.0778*	0.0557
Error(b)	36	0.0023	0.0067	0.0033	0.0323	0.1118	0.0336	0.0402
Methods of application(C)	1	0.0009	0.0020	0.0008	0.0019	0.0612	0.1250	0.0913
A x C	3	0.0007	0.0044	0.0028	0.0040	0.0332	0.0636	0.0044
B x C	3	0.0025	0.0125	0.0013	0.0197	0.0760	0.1152	0.0819
A x B x C	9	0.0035	0.0035	0.00053*	0.0214	0.0395	0.1034	0.0335
Error (c)	48	0.0022	0.0059	0.0020	0.0180	0.0647	0.0506	0.0504
Total	127	0.0025	0.0070	0.0053	0.0901	0.1453	0.0985	0.0956

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APPENDIX XI

Analyses of variance of dry weight (kg/m^2) at different growth stages (1980).

Source of variation	d.f.	Mean squares		
		Days after planting		
		25	50	75
Replications	3	0.0012	0.0190*	0.0111*
Introductions (A)	3	0.0036*	0.0006	0.0021
Error(a)	9	0.0007	0.0016	0.0012
Levels of nitrogen (B)	3	0.0006	0.0176*	0.1505*
A x B	9	0.0010	0.0011	0.0016
Error (b)	36	0.0005	0.0019	0.0015
Methods of application (C)	1	0.0012	0.0033	0.0084*
A x C	3	0.0002	0.0004	0.0020
B x C	3	0.0006	0.0010	0.0009
A x B x C	9	0.0002	0.0028	0.0025
Error(c)	48	0.0003	0.0015	0.0009
Total	127	0.0006	0.0024	0.0051

APPENDIX XI

Analyses of variance of dry weight (kg/m^2) at different growth stages (1981)

Source of variation	d.f.	Mean squares						
		Days after regeneration						
		0	25	50	75	100	120	130
Replications	3	0.0009	0.0036	0.0019	0.0048	0.0695*	0.0623*	0.0379
Introductions(A)	3	0.0009	0.0009	0.0007	0.0011	0.0906*	0.0461*	0.0202
Error (a)	9	0.0007	0.0006	0.0011	0.0029	0.0074	0.0097	0.0148
Levels of N (B)	3	0.0001	0.0032*	0.0230*	0.0266*	0.2453*	0.0593*	0.1406*
A x B	9	0.0003	0.0004	0.0006	0.0003	0.0368	0.0130	0.0041
Error (b)	36	0.0005	0.0009	0.0009	0.0008	0.0182	0.0086	0.0070
Methods of application(C)	1	0.0000	0.0000	0.0002	0.0027	0.0002	0.0076	0.0528*
A x C	3	0.0001	0.0005	0.0010	0.0004	0.0163	0.0152	0.0010
B x C	3	0.0005	0.0013	0.0002	0.0014	0.0252	0.0227	0.0053
A x B x C	9	0.0006	0.0003	0.0007	0.0004	0.0060	0.0060	0.0154
Error (c)	48	0.0003	0.0008	0.0005	0.0009	0.0120	0.0121	0.0084
Total	127	0.0004	0.0009	0.0013	0.0016	0.0238	0.0170	0.0121

APPENDIX XIII

Analyses of variance of green fodder yield (q/ha), 1980 and 1981.

Source of variation	d.f.	Mean squares	
		1980	1981
Replications	3	2147.4300*	5093.6000
Introductions (A)	3	205.5866	39038.7000*
Error (a)	9	105.9177	2072.6888
Levels of nitrogen (B)	3	21721.5760*	70967.0330*
A x B	9	299.2466	1118.4888
Error(b)	36	174.6763	646.0416
Methods of application (C)	1	746.7100*	2145.5000*
A x C	3	242.4200*	25.3666
B x C	3	138.2233*	2716.8333*
A x B x C	9	126.0700*	540.2333
Error(c)	48	44.9600	373.9875
Total	127	687.7162	3389.4622

APPENDIX XIV

Analyses of variance of dry fodder yield (q/ha), 1980 and 1981.

Source of variation	d.f.	Mean squares	
		1980	1981
Replications	3	107.4460*	722.5666
Introductions (A)	3	12.1780	5333.0333*
Error (a)	9	7.3684	367.1555
Levels of nitrogen (B)	3	1546.8436*	23181.7660*
A x B	9	18.0244	227.2888
Error (b)	36	9.5733	198.6000
Methods of application (C)	1	57.7810*	223.0000
A x C	3	12.1136*	335.9666
B x C	3	11.8856*	389.7666
A x B x C	9	7.4315	170.4222
Error (c)	48	3.7199	141.0812
Total	127	46.8330	873.3669

APPENDIX XV

Analyses of variance of nitrogen content (%) at different growth stages(1980).

Source of variation	d.f.	Mean squares		
		Days after planting		
		25	50	75
Replications	3	0.0231	0.0683	0.0023
Introductions (A)	3	0.0549	0.1233	0.1555*
Error (a)	9	0.0586	0.0648	0.0219
Levels of nitrogen (B)	3	1.3494*	1.8438*	1.3856*
A x B	9	0.1709*	0.0110	0.0086
Error (b)	36	0.0320	0.0129	0.0100
Methods of application (C)	1	0.0128	0.0693*	0.0000
A x C	3	0.1731*	0.0595*	0.0021
B x C	3	0.0367	0.0172	0.0008
A x B x C	9	0.1595*	0.0299	0.0081
Error (c)	48	0.0320	0.0154	0.0094
Total	127	0.0875	0.0674	0.0457

APPENDIX XVI

Analyses of variance of nitrogen content (%) at different growth stages (1981).

Source of variation	d.f.	Mean squares						
		Days after regeneration						
		0	25	50	75	100	125	130
Replications	3	0.0259*	0.0354	0.1521	0.1266	0.0539*	0.1480	0.1288
Introductions(A)	3	0.0064	0.0366	0.2697	0.2657*	0.0303	0.4425*	0.4756*
Error(a)	9	0.0056	0.0733	0.0816	0.0640	0.0111	0.0699	0.0719
Levels of N (B)	3	0.0183	1.3561*	0.7703*	0.6802*	1.1691*	2.3742*	2.4309*
Ax B	9	0.0198*	0.1768*	0.0266	0.0890*	0.0865*	0.0137	0.0143
Error (b)	36	0.0052	0.0362	0.0160	0.0362	0.0149	0.0209	0.0195
Methods of application (C)	1	0.0215	0.0110	0.0648	0.8288*	0.1852*	0.0282	0.0297
A x C	3	0.0329	0.2091*	0.0521	0.3722*	0.1602*	0.0383	0.0321
B x C	3	0.0456*	0.0311	0.0254	0.1161*	0.0623*	0.0297	0.0322
A x B x C	9	0.0204*	0.1989*	0.0644	0.0442	0.0347*	0.0098	0.0091
Error (c)	48	0.0055	0.0370	0.0232	0.0265	0.0099	0.0161	0.0159
Total	127	0.0100	0.0956	0.0797	0.0777	0.0537	0.0905	0.0917

APPENDIX XVII

Analyses of variance of nitrogen uptake (g/m^2) at different growth stages (1980)

Source of variation	d.f.	Mean squares		
		Days after planting		
		25	50	75
Replications	3	0.2649	4.5746	1.4368*
Introductions (A)	3	0.5288*	0.3019	2.1754*
Error(a)	9	0.0880	0.2093	0.2704
Levels of N (B)	3	1.4618*	12.8035*	43.8360*
A x B	9	0.2302	0.3487	0.3859
Error(b)	36	0.1129	0.4121	0.2320
Methods of application(C)	1	0.2738*	0.0449	1.1044*
A x C	3	0.0713	0.1315	0.3308
B x C	3	0.1814	0.1943	0.1758
A x B x C	9	0.1438	0.3884	0.4362
Error (c)	48	0.0672	0.4028	0.1646
Total	127	0.1515	0.7618	1.3469

APPENDIX XVIII

Analyses of variance of nitrogen uptake (g/m^2) at different growth stages (1981)

Source of variation	d.f.	Mean squares						
		Days after regeneration						
		0	25	50	75	100	120	130
Replications	3	0.1778	0.7080*	0.4119*	0.8648	5.8156	13.5718*	9.6880
Introductions(A)	3	0.0857	0.3207	0.5194*	0.2732	20.3155*	7.4968*	8.2063
Error(a)	9	0.0647	0.1064	0.0968	0.4106	3.5216	1.5042	3.4788
Levels of N(B)	3	0.0380	3.4084*	11.5958*	10.7196*	84.5679*	85.2683*	92.2297*
A x B	9	0.0594	0.2796	0.1737	0.3562	7.6924	1.4993	0.4189
Error (b)	36	0.0521	0.1713	0.1473	0.2315	2.9839	1.3697	1.0264
Methods of application(C)	1	0.0402	0.0122	0.1404	0.9282*	4.7778	0.8810	2.7144
A x C	3	0.0196	0.6504*	0.0899	0.9669*	9.7115	0.6448	0.5827
B x C	3	0.1222*	0.2570*	0.1119	0.5576*	4.6515	2.5659	0.5028
A x B x C	9	0.1363*	0.1914	0.2409*	0.1777	3.8241*	2.5835	1.1039
Error(c)	48	0.0305	0.0727	0.1042	0.1971	1.6554	1.6202	1.1336
Total	127	0.0555	0.24333	0.4192	0.5305	5.5290	3.9912	3.7222

APPENDIX XIX

Analyses of variance of per cent crude protein, calcium and phosphorus at harvest 1980 and 1981.

Source of variation	d.f.	Mean squares		
		Crude protein	Calcium	Phosphorus
<u>1980</u>				
Replications	3	0.0955	0.0032	0.0086*
Introductions (A)	3	5.9909*	0.0400*	0.0004
Error (a)	9	0.8560	0.0018	0.0002
Levels of nitrogen (B)	3	54.1389*	0.0101*	0.0004
A x B	9	0.3322	0.0029	0.0010*
Error (b)	36	0.3913	0.0020	0.0001
Methods of application(C)	1	0.9340	0.0116*	0.0000
A x C	3	0.0800	0.0219*	0.0001
B x C	3	0.0344	0.0018	0.0001
A x B x C	9	0.3221	0.0106*	0.0008*
Error (c)	48	0.3724	0.0008	0.0001
Total	127	1.7841	0.0039	0.0004
<u>1981</u>				
Replications	3	4.4725	0.1080	0.0035*
Introductions (A)	3	15.9779*	1.3372*	0.0024*
Error (a)	9	3.1429	0.1129	0.0004
Levels of nitrogen (B)	3	93.3785*	0.0186	0.0004
A x B	9	0.6747	0.0486*	0.0005
Error (b)	36	0.7121	0.0137	0.0003
Methods of application(C)	1	1.2343	0.0025	0.0024
A x C	3	1.2498	0.0037	0.0012*
B x C	3	1.8026*	0.0178	0.0001
A x B x C	9	0.3977	0.0169	0.0022
Error (c)	48	0.6352	0.0082	0.0002
Total	127	3.5113	0.0547	0.0004

APPENDIX XX

Analyses of variance of per cent NDF, ADF, cellulose and hemi-cellulose at harvest

Source of variation	d.f.	Mean squares			
		NDF	ADF	Cellulose	Hemi-cellulose
Replications	3	13.6633	5.9366	¹⁹⁸⁰ 238.3400*	27.5520*
Introductions (A)	3	58.7900*	20.8833	8.1666	41.4123*
Error (a)	9	7.8011	6.9855	10.3611	7.0038
Levels of nitrogen (B)	3	34.0066*	1.2600	2.7666	23.0416*
A x B	9	25.9533*	3.0133	5.4266*	15.8024*
Error(b)	36	8.4158	2.5886	2.3394	6.3947
Methods of application(C)	1	25.0900*	3.2400	4.1500	35.1110*
A x C	3	14.1666*	2.6000	15.4966*	22.1036*
B x C	3	21.8466*	17.4433*	0.9166	31.3140*
A x B x C	9	16.3155*	7.6733*	9.3222*	6.9601
Error (c)	48	4.0927	3.3089	1.9302	3.3204
Total	127	11.0437	4.3990	9.4808	8.8887

1981

Replications	3	4.9733	11.9400*	7.1366*	32.2153
Introductions (A)	3	37.7333*	60.0633*	49.4566*	83.3083*
Error (a)	9	11.0233	2.3955	1.6566	22.1513
Levels of nitrogen (B)	3	12.7033*	5.9166	8.3766*	12.7633
A x B	9	7.4966*	10.2255*	8.4377*	10.8420*
Error (b)	36	1.9061	3.5330	2.2566	4.5978
Methods of application(C)	1	1.4500	1.9100	5.4100	6.6890
A x C	3	20.3500*	53.5000*	22.1400*	27.3870*
B x C	3	17.4000*	8.7633	11.0833*	9.2026
A x B x C	9	16.9777*	9.0522	4.5422	39.5810*
Error(c)	48	2.9620	4.6614	2.4031	7.8931
Total	127	6.3874	7.6256	4.9473	13.3770

APPENDIX XXI

Analyses of variance of per cent lignin, silica, cell content and IVDMD(in-vitro dry matter digestibility) at harvest.

Source of variation	d.f.	Mean squares			
		Lignin	Silica	Cell content	IVDMD
1980					
Replications	3	155.7310*	9.2933*	15.6830	0.2000
Introductions (A)	3	9.3606*	1.0628*	60.5613*	357.9933*
Error (a)	9	2.5915	0.2900	8.1631	2.5411
Levels of nitrogen (B)	3	6.0253*	2.1434*	34.7373*	15.6700*
A x B	9	6.5944*	2.1620*	25.6300*	0.8233
Error (b)	36	1.9589	0.1670	8.6806	0.4772
Methods of application(C)	1	10.7940*	0.4962	28.7670*	2.5600*
A x C	3	9.1483*	0.4254	14.9130*	0.4000
B x C	3	18.4020*	1.4910*	20.4683*	0.2633
A x B x C	9	3.0383	0.5904*	16.2070*	0.1988
Error (c)	48	2.1033	0.1793	4.1825	0.4385
Total	127	6.9944	0.6752	11.2687	9.4207
1981					
Replications	3	11.1340*	3.3098*	5.1033	5.9166
Introductions (A)	3	1.3076	0.4892*	38.0013*	106.3300*
Error (a)	9	0.9488	0.1867	11.2098	4.5322
Levels of nitrogen (B)	3	0.2530	1.1542*	12.5283*	38.0766*
A x B	9	1.5912*	0.5042	7.4765*	1.2922
Error (b)	36	0.5815	0.2302	1.9391	0.6436
Methods of application(b)	1	5.7330*	0.6119	1.5020	0.9800
A x C	3	1.7290*	1.0487*	20.2080*	1.6566
B x C	3	2.5996*	0.3572	17.4616*	0.5933
A x B x C	9	4.0008*	0.3523	17.1816*	0.9133
Error (c)	48	0.5166	0.1889	2.9976	1.3731
Total	127	1.2709	0.3656	6.4402	4.7907

APPENDIX XXII

Analyses of variance of per cent total ash and acid insoluble ash at harvest.

Source of variation	d.f.	Mean squares	
		Total ash	Acid insoluble ash
		<u>1980</u>	
Replications	3	16.5553*	23.9569*
Introductions (A)	3	0.2986	0.2662
Error (a)	9	2.4518	0.9902
Levels of nitrogen (B)	3	6.0343*	8.0871*
A x B	9	1.6814*	2.6959*
Error (b)	36	0.4994	0.2285
Methods of application (C)	1	0.0318	2.3060
A x C	3	1.4008	2.2170*
B x C	3	4.4707*	6.7054*
A x B x C	9	1.9257*	0.6116
Error (c)	48	0.5736	0.5897
Total	127	1.4673	1.5843
		<u>1981</u>	
Replications	3	1.5148	0.5770
Introductions (A)	3	22.7872*	4.8646*
Error (a)	9	4.4207	0.8348
Levels of nitrogen (B)	3	1.9207*	0.9235*
A x B	9	0.9537	0.3552
Error (b)	36	0.6703	0.3004
Methods of application (C)	1	2.5283	0.8288
A x C	3	5.6295*	0.2386
B x C	3	2.8225	0.0585
A x B x C	9	1.3005	0.1382
Error (c)	48	1.0286	0.2268
Total	127	1.8908	0.4289

APPENDIX XXIII

Effect of interaction between introductions and levels of nitrogen on various characters in 1980 and 1981

Introductions	Nitrogen levels							
	N ₀	N ₁	N ₂	N ₃	N ₀	N ₁	N ₂	N ₃
	<u>1980</u>				<u>1981</u>			
<u>a. Establishment(%) of introduced grass</u>								
T ₁	78.87	85.68	96.67	98.41	78.40	84.31	94.08	95.33
T ₃	82.55	91.02	94.04	90.28	78.23	88.06	91.66	84.33
					1980		1981	
					SEm±	CD5%	SEm±	CD5%
For introduction means at the same level of N					1.230	3.710	1.504	4.572
For N means at the same introduction					1.306	3.871	1.541	4.566
<u>b. Per cent proportion of Desmodium (1981)</u>								
	N ₀			N ₁			N ₂	
							N ₃	
T ₂	17.95			30.70			38.43	
T ₃	11.52			20.43			25.97	
T ₄	1.88			1.41			1.01	
					SEm±		CD5%	
For introduction means at the same level of N					1.698		4.982	
For N means at the same introduction					1.542		4.462	
<u>c. Nitrogen content(%) at 25 DAP, 1980</u>								
	N ₀			N ₁			N ₂	
							N ₃	
T ₁	0.88			1.07			1.52	
T ₂	1.12			1.32			1.12	
T ₃	0.88			1.03			1.35	
T ₄	0.86			0.97			1.34	
					SEm±		CD5%	
For introduction means at the same level of N					0.070		0.201	
For N means at the same introduction					0.063		0.182	

Contd....

d. Nitrogen content (%) at 0 DAR, 1981.

Introduction	Nitrogen levels			
	N ₀	N ₁	N ₂	N ₃
T ₁	0.85	0.92	0.95	0.89
T ₂	0.84	0.86	0.93	0.89
T ₃	0.83	0.92	0.92	0.94
T ₄	0.90	0.89	0.78	0.92

SEm± CD5%

For introduction means at the same level of N

0.026 0.074

For N means at the same level of introduction

0.026 0.073

e. Nitrogen content (%) at 25 DAR, 1981

T ₁	0.90	1.06	1.52	1.36
T ₂	1.12	1.26	1.09	1.28
T ₃	0.86	1.03	1.38	1.46
T ₄	0.86	0.97	1.37	1.32

SEm± CD5%

For introduction means at the same level of N

0.076 0.218

For N means at the same level of introduction

0.067 0.193

f. Nitrogen content(%) at 75 DAR, 1981

T ₁	1.04	1.19	1.13	1.20
T ₂	0.99	1.18	1.31	1.51
T ₃	1.23	1.44	1.33	1.38
T ₄	0.99	1.37	1.32	1.57

SEm± CD5%

For introduction means at the same level of N

0.074 0.212

For N means at the same level of introduction

0.067 0.193

g. Nitrogen content (%) at 100 DAR, 1981

T ₁	1.01	1.48	1.69	1.48
T ₂	1.19	1.40	1.46	1.56
T ₃	1.10	1.24	1.51	1.59
T ₄	1.26	1.44	1.57	1.46

SEm± CD5%

For introduction means at the same level of N

0.042 0.120

For N means at the same level of introduction

0.043 0.124

Contd

h.

Introduction	Nitrogen levels			
	N ₀	N ₁	N ₂	N ₃

h. NDF content (%) at harvest.1980

T ₁	77.81	75.81	80.91	75.19
T ₂	76.21	73.96	74.62	74.68
T ₃	73.70	74.10	74.69	76.11
T ₄	72.04	73.41	76.69	76.52

SEm± CD5%

For introduction means at the same level of N

1.019 2.926

For N means at the same level of introduction

1.029 2.944

i. ADF content (%) 19811981

T ₁	56.10	56.67	55.18	56.39
T ₂	55.35	53.75	54.67	57.27
T ₃	53.53	53.82	52.36	52.87
T ₄	51.95	54.73	54.32	53.63

SEm± CD5%

For introduction means at the same level of N

0.639 1.833

For N means at the same level of introduction

0.666 1.907

j. NDF content (%) at harvest1981

T ₁	79.34	79.43	81.41	80.83
T ₂	79.39	77.47	77.59	79.41
T ₃	77.66	79.34	78.77	78.77
T ₄	79.13	79.83	81.71	81.62

SEm± CD5%

For

For introduction means at the same level of N

0.725 2.113

For N means at the same introduction

0.489 1.401

k. Cellulose content (%) 1981

T ₁	43.13	43.68	43.45	43.27
T ₂	42.71	41.01	42.23	44.35
T ₃	40.42	40.89	40.43	41.48
T ₄	39.06	42.45	41.24	41.16

SEm± CD5%

For introduction means at the same level of N

0.515 1.477

For N means at the same level of introduction

0.533 1.524

Contd.....

Introduction	Nitrogen levels							
	N ₀	N ₁	N ₂	N ₃	N ₀	N ₁	N ₂	N ₃
l. <u>Hemi-cellulose content(%)</u>	1980				1981			
T ₁	25.65	24.72	28.29	23.68	23.24	22.77	26.24	24.44
T ₂	26.07	24.36	25.20	24.80	24.04	23.71	22.92	22.14
T ₃	22.70	23.36	23.37	23.72	24.13	25.52	26.41	25.90
T ₄	21.87	21.66	25.27	25.34	27.18	25.10	27.39	27.99
			SEm ₊	CD5%		SEm ₊	CD5%	
For introduction means at the same level of N			0.907	2.606		1.063	3.089	
For N means at the same level of introduction			0.897	2.566		0.760	2.176	
m. <u>Lignin content (%)</u>								
T ₁	10.47	10.86	10.50	10.39	9.88	10.19	9.51	10.43
T ₂	9.51	10.69	8.62	10.44	9.94	9.01	9.52	9.88
T ₃	10.03	9.70	11.82	12.79	9.98	10.02	10.14	9.54
T ₄	10.32	11.21	10.69	10.84	9.45	9.23	10.14	9.24
			SEm ₊	CD5%		SEm ₊	CD5%	
For introduction means at the same level of N			0.516	1.483		0.291	0.837	
For N means at the same level of introduction			0.496	1.420		0.270	0.774	
n. <u>Cell content (%)</u>								
T ₁	22.19	24.19	19.09	24.56	20.66	20.56	18.59	19.17
T ₂	23.79	26.04	25.38	25.32	20.61	22.53	22.41	20.64
T ₃	26.30	25.89	25.30	23.39	22.34	20.66	21.23	21.23
T ₄	27.96	26.59	23.31	23.23	20.87	20.17	18.29	18.37
			SEm ₊	CD5%		SEm ₊	CD5%	
For introduction means at the same level of N			1.037	2.977		0.732	2.131	
For N means at the same level of introduction			1.045	2.990		0.494	1.413	
o. <u>Phosphorus content (%) 1980</u>								
	N ₀	N ₁	N ₂	N ₃				
T ₁	0.23	0.22	0.21	0.23				
T ₂	0.21	0.23	0.20	0.22				
T ₃	0.22	0.21	0.23	0.23				
T ₄	0.21	0.22	0.23	0.23				
			SEm ₊	CD5%				
For introduction means at the same level of N			0.004	0.012				
For N means at the same level of introduction			0.004	0.012				

Introduction	Nitrogen levels			
	N ₀	N ₁	N ₂	N ₃
p. <u>Calcium content (%) 1981</u>				
T ₁	0.41	0.39	0.40	0.40
T ₂	0.67	0.96	0.96	0.89
T ₃	0.57	0.55	0.54	0.62
T ₄	0.53	0.48	0.46	0.47
		SEm ₊	CD5%	
For introduction means at the same level of N		0.069	0.204	
For N means at the same level of introduction		0.041	0.119	
q. <u>Silica content (%) 1980</u>				
T ₁	4.01	3.55	3.51	3.21
T ₂	4.18	3.71	2.63	2.95
T ₃	4.19	3.40	3.35	4.28
T ₄	3.12	3.68	3.54	4.26
		SEm ₊	CD5%	
For introduction means at the same level of N		0.158	0.454	
For N means at the same level of introduction		0.145	0.415	
r. <u>Acid insoluble ash content (%) 1980</u>				
T ₁	4.54	4.27	3.96	4.77
T ₂	4.69	5.48	3.31	3.18
T ₃	4.90	4.84	4.13	3.33
T ₄	4.59	4.45	4.41	3.79
		SEm ₊	CD5%	
For introduction means at the same level of N		0.229	0.666	
For N means at the same level of introduction		0.169	0.485	
s. <u>Total ash content (%) 1980.</u>				
T ₁	9.30	8.82	8.20	9.50
T ₂	8.75	9.76	7.96	8.77
T ₃	9.10	9.31	7.88	8.59
T ₄	9.06	8.47	8.69	9.14
		SEm ₊	CD5%	
For introduction means at the same level of N		0.352	1.024	
For N means at the same level of introduction		0.250	0.717	

Effect of interaction between levels of nitrogen and its methods of application on various characters in 1980 and 1981

Levels of nitrogen	Methods of application			
	M ₁	M ₂	M ₁	M ₂
a. Establishment(%) of introduced grass				
	1980		1981	
N ₁	87.91	88.79	85.36	87.01
N ₂	96.25	94.46	93.54	92.21
N ₃	92.96	95.73	89.02	90.75
	SEm ₊	CD5%	SEm ₊	CD5%
For N means at the same level of methods of application	1.256	3.658	1.388	4.043
For methods of application means at the same level of N	1.204	3.503	1.215	3.537
B. Nitrogen content(%) at 0 DAR, 1981				
	M ₁	M ₂		
N ₁	0.84	0.95		
N ₂	0.87	0.92		
N ₃	0.94	0.88		
		SEm ₊	CD5%	
For N means at the same level of methods of application means		0.018	0.052	
For methods of application means at the same level of N		0.019	0.053	
c. Nitrogen content (%) at 75 DAR, 1981.				
N ₁	1.29	1.30		
N ₂	1.16	1.38		
N ₃	1.27	1.56		
		SEm ₊	CD5%	
For N means at the same level of methods of application means		0.035	0.100	
For methods of application means at the same level of N		0.038	0.108	
d. Nitrogen content(%) at 100 DAR, 1981				
N ₁	1.34	1.44		
N ₂	1.46	1.65		
N ₃	1.53	1.52		
		SEm ₊	CD5%	
For N means at the same level of methods of application means		0.044	0.126	
For methods of application means at the same level of N		0.041	0.116	

Contd...

Levels of nitrogen	Methods of application			
	M ₁	M ₂		
<u>e. Nitrogen accumulation (g/m²) at 0 DAR, 1981</u>				
N ₁	0.85	1.00		
N ₂	0.88	1.02		
N ₃	1.03	0.96		
	SEm±	CD5%		
For N means at the same level of methods of application means	0.051	0.145		
For methods of application means at the same level of N	0.044	0.124		
<u>f. Nitrogen accumulation(g/m²) at 25 DAR, 1981</u>				
N ₁	1.00	1.21		
N ₂	1.63	1.42		
N ₃	1.66	1.68		
	SEm±	CD5%		
For N means at same level of methods of application means	0.087	0.249		
For methods of application means at the same level of N	0.067	0.192		
<u>g. Nitrogen accumulation (g/m²) at 75 DAR, 1981</u>				
N ₁	1.96	1.97		
N ₂	2.21	2.20		
N ₃	2.47	3.03		
	SEm±	CD5%		
For N means at the same level of methods of application means	0.116	0.329		
For methods of application means at the same level of N	0.111	0.316		
<u>h. Nitrogen accumulation (g/m²) at 100 DAR, 1981</u>				
N ₁	3.60	4.91		
N ₂	5.42	5.53		
N ₃	6.26	6.88		
	SEm±	CD5%		
For N means at the same level of methods of application means	0.382	1.084		
For methods of application means at the same level of N	0.323	0.915		
<u>i. Green fodder yield (g/ha)</u>				
	M ₁	M ₂	M ₁	M ₂
N ₁	74.71	82.65	222.57	246.64
N ₂	100.24	99.83	252.16	265.69
N ₃	102.04	110.42	273.75	287.34
	SEm±	CD5%	SEm±	CD5%
For N means at the same level of method of application means	2.628	7.460	5.663	16.073
For methods of application means at the same level of N	1.681	4.771	4.849	13.761

Contd....

Levels of nitrogen	Methods of application			
	M ₁	M ₂		
j. <u>Dry fodder yield (g/ha), 1980.</u>	23.31	25.87		
N ₁	23.31	25.87		
N ₂	28.67	28.51		
N ₃	29.22	31.29		
		SEm _±	CD5%	
For N means at the same level of methods of application means		0.646	1.835	
For methods of application means at the same level of N		0.484	1.372	
k. <u>NDF content (%)</u>	M ₁	M ₂	M ₁	M ₂
	1980		1981	
N ₁	74.73	73.91	79.08	78.95
N ₂	78.35	75.11	79.05	80.69
N ₃	75.51	75.75	80.36	79.96
	SEm _±	CD5%	SEm _±	CD5%
For N means at the same level of methods of application means	0.627	1.780	0.391	1.110
For methods of application means at the same level of N	0.507	1.439	0.431	1.225
l. <u>Lignin content (%)</u>				
N ₁	10.33	10.90	9.93	9.29
N ₂	10.39	10.43	10.30	9.24
N ₃	10.59	10.64	9.63	9.91
	SEm _±	CD5%	SEm _±	CD5%
For N means at the same level of methods of application means	0.357	1.014	0.186	0.527
For methods of application means at the same level of N	0.364	1.032	0.180	0.511
m. <u>Cell content (%)</u>				
N ₁	22.27	26.09	20.92	21.04
N ₂	21.65	24.89	20.95	19.31
N ₃	24.24	24.25	19.64	20.06
	SEm _±	CD5%	SEm _±	CD5%
For N means at the same level of method of application means	0.636	1.805	0.394	1.118
For methods of application means at the same level of N	0.513	1.455	0.434	1.232

contd...

Levels of nitrogen	Methods of application	
	M ₁	M ₂
<u>n. ADF content (%) 1980.</u>		
N ₁	50.45	51.14
N ₂	50.80	50.96
N ₃	52.02	50.46
	SEm+	CD5%
For N means at the same level of methods of application	0.430	1.222
For methods of application means at the same level of N	0.456	1.294
<u>o. Silica content(%) 1980</u>		
N ₁	3.61	3.56
N ₂	2.91	3.60
N ₃	3.84	3.51
	SEm+	CD5%
For N means at the same level of methods of application	0.104	0.296
For methods of application means at the same level of N	0.106	0.301
<u>p. Total ash content (%) 1980.</u>		
N ₁	9.04	9.13
N ₂	7.66	8.71
N ₃	9.34	8.66
	SEm+	CD5%
For N means at the same level of methods of application	0.184	0.521
For methods of application means at the same level of N	0.190	0.539
<u>q. Acid insoluble ash content(%) 1980.</u>		
N ₁	4.37	5.15
N ₂	3.30	4.61
N ₃	4.03	3.50
	SEm+	CD5%
For N means at the same level of methods of application	0.160	0.455
For methods of application means at the same level of N	0.192	0.546

Contd....

Levels of nitrogen	Methods of application	
	M ₁	M ₂
<u>r. Crude protein content(%) 1981</u>		
N ₁	5.92	5.76
N ₂	7.50	7.44
N ₃	8.00	8.28
	SEm±	CD5%
For N means at the same level of methods of application	0.206	0.584
For methods of application means at the same level of N	0.200	0.567
<u>s. Cellulose content (%) 1981</u>		
N ₁	42.34	41.72
N ₂	40.01	42.67
N ₃	41.98	43.15
	SEm±	CD5%
For N means at the same level of methods of application	0.383	1.086
For methods of application means at the same level of N	0.389	1.103
<u>t. Hemi-cellulose content (%) 1980</u>		
N ₁	24.28	22.77
N ₂	26.92	24.15
N ₃	23.49	25.29
	SEm±	CD5%
For N means at the same level of methods of application	0.553	1.569
For methods of application means at the same level of N	0.457	1.297

APPENDIX XXV

Effect of interaction between introductions and methods of nitrogen application on various characters in 1980 and 1981.

Introduction	Methods of application	
	M ₁	M ₂
<u>a. Fresh weight (kg/m²) at 75 DAP, 1980</u>		
T ₁	0.70	0.88
T ₂	0.83	0.86
T ₃	0.79	0.82
T ₄	0.80	0.81
		SEM± CD5%
For introduction means at the same level of methods of application	0.039	0.110
For methods of application means at the same level of introduction	0.030	0.086
<u>b. Green fodder yield (g/ha) 1980</u>		
T ₁	80.32	93.21
T ₂	79.37	83.05
T ₃	88.47	84.19
T ₄	80.66	82.69
For introduction means at same level of methods of application	2.178	6.208
For methods of application means at the same level of introduction	1.681	4.771
<u>c. Dry fodder yield (g/ha) 1980</u>		
T ₁	23.78	26.94
T ₂	23.42	24.41
T ₃	24.42	24.85
T ₄	23.87	24.67
For introduction means at the same level of methods of application	0.590	1.682
For methods of application means at the same level of introduction	0.484	1.372
<u>d. Nitrogen content(%) at 25 DAP, 1980.</u>		
T ₁	1.27	1.14
T ₂	1.12	1.32
T ₃	1.23	1.14
T ₄	1.16	1.09
For methods of application means at the same level of introduction	0.045	0.127
For introduction means at the same level of methods of application	0.053	0.152

Contd....

Introduction	M ₁	M ₂
<u>e. Nitrogen content(%) at 50 DAP, 1980</u>		
T ₁	1.19	1.24
T ₂	1.23	1.22
T ₃	1.14	1.12
T ₄	1.20	1.37
		SEm± CD5%
For introduction means at the same level of methods of application	0.050	0.144
For methods of application means at the same level of introduction	0.031	0.088
<u>f. Nitrogen content(%) at 0 DAR, 1981</u>		
T ₁	0.85	0.95
T ₂	0.85	0.91
T ₃	0.92	0.88
T ₄	0.89	0.86
For introduction means at the same level of methods of application	0.019	0.053
For methods of application means at the same level of introduction	0.019	0.053
<u>g. Nitrogen content(%) at 25 DAR, 1981</u>		
T ₁	1.28	1.14
T ₂	1.08	1.30
T ₃	1.23	1.14
T ₄	1.17	1.10
For introduction means at the same level of methods of application	0.059	0.168
For methods of application means at the same level of introduction	0.048	0.137
<u>h. Nitrogen content(%) at 75 DAR, 1981</u>		
T ₁	1.18	1.09
T ₂	1.19	1.30
T ₃	1.25	1.44
T ₄	1.10	1.53
For introduction means at same level of methods of application	0.053	0.152
For methods of application means at same level of introduction	0.041	0.116

Contd...

Introduction	Methods of application		
	M ₁	M ₂	
i. <u>Nitrogen content (%) at 100 DAR, 1981.</u>			
T ₁	1.47	1.36	
T ₂	1.37	1.44	
T ₃	1.24	1.47	
T ₄	1.37	1.49	
		SEm±	CD5%
For introduction means at the same level of methods of application		0.026	0.073
For methods of application means at the same level of introduction		0.025	0.071
j. <u>Nitrogen accumulation (g/m²) at 25 DAR, 1981</u>			
T ₁	1.57	1.32	
T ₂	1.17	1.54	
T ₃	1.38	1.18	
T ₄	1.21	1.21	
For introduction means at the same level of methods of application		0.075	0.213
For methods of application means at the same level of introduction		0.067	0.192
k. <u>Nitrogen accumulation (g/m²) at 75 DAR, 1981</u>			
T ₁	2.08	1.78	
T ₂	2.02	2.18	
T ₃	1.94	2.26	
T ₄	1.88	2.39	
For introduction means at the same level of methods of application		0.138	0.394
For methods of application means at the same level of introduction		0.111	0.316
l. <u>Nitrogen accumulation (g/m²) at 100 DAR, 1981</u>			
T ₁	5.84	6.02	
T ₂	4.64	4.36	
T ₃	3.55	5.55	
T ₄	4.30	3.93	
For introduction means at the same level of methods of application		0.403	1.149
For methods of application means at the same level of introduction		0.323	0.915

Contd.....

Introduction		Methods of application			
		M ₁	M ₂	M ₁	M ₂
m. <u>NDF content (%)</u>		1980		1981	
T ₁		77.52	77.34	79.67	80.84
T ₂		74.65	75.08	77.92	79.01
T ₃		75.24	74.06	79.66	77.61
T ₄		75.98	73.36	81.10	80.05
		1980		1981	
		SEm±	CD5%	SEm±	CD5%
For introduction means at the same level of methods of application		0.611	1.741	0.663	1.895
For methods of application means at the same level of introduction		0.507	1.439	0.431	1.225
n. <u>Cellulose content (%)</u>					
T ₁		38.28	36.64	43.16	43.60
T ₂		35.65	37.27	41.23	43.91
T ₃		36.76	36.09	40.95	40.70
T ₄		36.83	36.08	41.60	40.36
For introduction means at the same level of methods of application		0.621	1.781	0.357	1.015
For methods of application means at the same level of introduction		0.384	0.988	0.389	1.103
o. <u>Hemi-cellulose content (%)</u>					
T ₁		25.22	25.95	23.53	24.81
T ₂		25.36	24.85	24.66	21.74
T ₃		23.86	22.72	25.88	25.10
T ₄		25.16	21.91	26.62	27.21
For introduction means at the same level of methods of application		0.570	1.623	0.972	2.772
For methods of application means at same level of introduction		0.457	1.297	0.704	1.999

Contd....

Introduction	Methods of application			
	M ₁	M ₂	M ₁	M ₂
p. <u>Lignin content (%)</u>	1980		1981	
T ₁	9.84	11.27	10.30	9.70
T ₂	10.25	9.37	9.55	9.82
T ₃	10.86	11.31	10.09	9.42
T ₄	10.10	11.43	11.43	9.17
	1980		1981	
	S.E.m _±	CD5%	S.E.m _±	CD5%
For introduction means at the same level of methods of application	0.384	1.093	0.215	0.611
For methods of application means at the same level of introduction	0.364	1.032	0.180	0.511
q. <u>Cell content (%)</u>				
T ₁	22.35	22.66	20.33	19.16
T ₂	25.35	24.91	22.07	21.01
T ₃	24.76	25.94	20.34	22.39
T ₄	23.90	26.64	18.90	19.95
For introduction means at the same level of methods of application	0.623	1.774	0.668	1.910
For methods of application means at the same level of introduction	0.513	1.455	0.434	1.232
r. <u>ADF content (%) 1981</u>			M ₁	M ₂
T ₁			56.14	56.02
T ₂			53.26	57.26
T ₃			53.78	52.51
T ₄			54.47	52.84
			S.E.m _±	CD5%
For introduction means at the same level of methods of application			0.471	1.338
For methods of application means at the same level of introduction			0.541	1.536
s. <u>Phosphorus content (%) 1981</u>				
T ₁			0.10	0.10
T ₂			0.12	0.12
T ₃			0.10	0.12
T ₄			0.11	0.09
For introduction means at the same level of methods of application			0.005	0.013
For methods of application means at the same level of introduction			0.004	0.011

Contd.....

Introduction	Methods of application	
	M ₁	M ₂
<u>t. Calcium content (%) 1980</u>		
T ₁	0.48	0.43
T ₂	0.48	0.47
T ₃	0.50	0.55
T ₄	0.55	0.48
		SEm+ CD5%
For introduction means at the same level of methods of application	0.009	0.026
For methods of application means at the same level of introduction	0.007	0.021
<u>u. Total ash content(%) 1981</u>		
T ₁	7.49	8.05
T ₂	6.27	6.05
T ₃	7.50	6.96
T ₄	5.36	6.69
For introduction means at same level of methods of application	0.414	1.184
For methods of application means at same level of introduction	0.254	0.722
<u>v. Acid insoluble ash content(%) 1981</u>		
T ₁	4.62	4.15
T ₂	4.02	4.31
T ₃	4.04	4.56
T ₄	3.94	4.68
For introduction means at same level of methods of application	0.183	0.522
For methods of application means at same level of introduction	0.119	0.339
<u>w. Silica content(%) 1981</u>		
T ₁	2.61	2.50
T ₂	2.33	2.85
T ₃	2.69	2.46
T ₄	2.63	3.01
For introduction means at the same level of methods of application	0.109	0.309
For methods of application means at the same level of introduction	0.109	0.309

APPENDIX XXVI

The following rates have been used for calculation of cost of production and for sale of the produce.

1. Labour Rs. 7.25 per day.
2. Desmodium seed Rs.40.00 per kg
3. Setaria seedlings Rs. 5/100 seedlings
4. Urea (46%) Rs. 235.00 per quintal.
5. Single super phosphate (16% P_2O_5) Rs.130.00 per quintal.
6. Muriate of Potash (60% K_2O) Rs.110.50 per quintal
7. Cost of produce of introduced + existing grass at Rs.18.00 per quintal while for introduced legume + existing grass at Rs.20.00 per quintal, respectively.

These rates have been collected from the Department of Animal Husbandry, Palampur and the current fertilizer rates were obtained from the records of the department of Agronomy and Agrometeorology, H.P. Krishi Vishva Vidyalyaya, Palampur.

ABSTRACT

The field experiments were conducted during Kharif seasons of 1980 and 1981 to study the suitability and economic feasibility of Setaria and Desmodium introduction in natural grassland and also to workout their response to levels and methods of nitrogen application under mid-hill conditions of Kangra Valley. There were four treatments of introduction (introduction of Setaria alone, introduction of Desmodium alone, introduction of Setaria + Desmodium in 1:1 ratio and no introduction) in main plots and four nitrogen levels (0, 30, 60 and 90 kg N/ha) in Sub-plots and two methods of nitrogen application (1/2 at planting/regeneration + 1/2 at 25 DAP/DAR, and 1/3 at planting/regeneration + 1/3 at 25 DAP/DAR + 1/3 at 50 DAP/DAR) in sub-sub plots of a split-split plot design with four replications. The introduction of Setaria and Desmodium was made in Kharif 1980 in a natural grassland having 7.9 to 9.7 per cent slope. The dominant resident vegetation at the time of introduction was Heteropogon contortus P. Beauv., Chrysopogon fulvus Trin. and Setaria glauca P. Beauv., and the legume component was almost absent from the site except for rare presence of Desmodium species. Nitrogen was applied through urea as per treatments. An uniform application of 80kg P₂O₅ (through single super phosphate, 16% P₂O₅) and 60 kg K₂O (through muriate of potash, 60% K₂O) was made as broadcast at the time of planting in first year only.

The introduction of Setaria resulted in significantly higher production of green and dry fodder yield during both years of experimentation. However, the magnitude of increase was less in first year i.e. the year of introduction. Introduction of Desmodium improved the fodder quality significantly. The quality as well as quantity of fodder produced from the plots introduced with Setaria was also significantly better than that of indigenous grass i.e. un-introduced plots. The introduction of Setaria sphacelata proved successful for introduction in natural grasslands of mid-hills in Himachal Pradesh for increased production of good quality fodder.

Introduction of Desmodium alone or in combination with Setaria in 1:1 ratio increased the quality of fodder but the yield and economic returns were not comparable with introduction of Setaria alone. A dose of 60 kg N per hectare in the establishment year and 90 kg N per hectare in the subsequent year applied in three splits (1/3 at planting/regeneration + 1/3 at 25 DAP/DAR + 1/3 at 50 DAP/DAR) proved significantly superior to other treatments in respect of yield, quality and overall economics. Fertilization of natural grassland with 60 and 90 kg N per hectare increased the green fodder yield of indigenous grass species also to the tune of 115.6 and 92.6 per cent, respectively over control (no nitrogen). Application of nitrogen at the rate of 90 kg N per hectare proved economical from total net return as well as return per rupee investment during both years of investigation as well as when computed combinedly for both years.

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