EFFECT ON GROWTH, YIELD AND QUALITY OF OAT (*Avena sativa* Linn.) AND BERSEEM (*Trifolium alexandrinum* Juslen.) GROWN IN PURE AND MIXED STANDS AT VARYING LEVELS OF NITROGEN AND PHOSPHOROUS

THESIS

BY

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CERTIFICATE I

Certified that the thesis entitled " Effect on growth, yield and quality of Oat (Avena sativa Linn.) and berseem (Trifolium alexandrinum Juslen) grown in pure and mixed stands at varying levels of nitrogen and phosphorus", submitted in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy (Agronomy and Agrometeorology) of the Himachal Pradesh Krishi Vishva Vidyalaya, Palampur, is the bonafide research work carried out by Mr.Brijender Singh son of Shri Ram Das Deer under my supervision and that no part of this thesis has been submitted for any other degree.

The assistance and help received during the course of this investigation has been fully acknowledged.

30.8.85

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Chairman
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August 30, 1985.

CERTIFICATE II

This is to certify that the thesis entitled " Effect on growth, yield and quality of oat (*Avena sativa* Linn.) and berseem (*Trifolium alexandrinum* Juslen) grown in pure and mixed stands at varying levels of nitrogen and phosphorus" submitted by Mr. Brijender Singh son of Mr. Ram Das Deor to Himachal Pradesh Krishi Vishva Vidyalaya, Palampur in partial fulfilment of the requirements for the award of degree of Doctor of Philosophy (Agronomy and Agrometeorology) has been approved by the Students' Advisory Committee after an oral examination in collaboration with External Examiner.

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1. INTRODUCTION

An insight of the present day dairy industry of the country would reveal that most of our animals are ill-fed. Semi-starvation or malnutrition is the rule and hence the milk production as well as the working efficiency is steadily declining. According to the estimates of the Institute of Agricultural Research Statistics, an average Indian cow produces 173 kg milk per annum as compared to its counterparts in Denmark, Netherlands, U.K. and U.S.A., which produce 3,810, 4,180, 3,680 and 3,580 kg milk per annum, respectively. It is primarily for this reason that most of the work on livestock improvement has so far been directed towards breeding and disease control, while feeding, without which neither of these can be fully effective, has been grossly neglected.

The Nutrition Advisory Committee of the Indian Council of Medical Research and the Animal Nutrition Committee of the Indian Council of Agricultural Research (1952) jointly estimated the shortages of the order of about 58 per cent in case of the roughages and 80 per cent in case of the concentrates for the whole of India. Kehar (1953) puts the feed requirement of India's bovine population as 80 million tonnes of Digestible Crude Protein and 210 million tonnes of Starch Equivalent, whereas the present supplies from all available sources are just 23 and 38 per cent, respectively of the needed amounts. According to the estimates of the Feeds and Fodder Sub-Committee of the Central Council of Gosamvardhana (1961), there exists a wide gap between the demand and supply of feeds and fodder in the country. The shortages running to the tune of 258 million tonnes in case of green fodder, 26 million tonnes in case of straw, Kadbi and stover and 23.8 million tonnes in case of the concentrates.

How to solve, then this vexed problem of animal feeding? In view of the just balanced position of human food in the country, it is not advisable to divert more quantities of concentrates, particularly grains, for livestock feeding. The solution would, therefore, appear to lie in the adoption of a new system of animal feeding which inter alia envisages the increased use of green fodders and roughages and cutting down the requirement of concentrates, thereby tackling both the problems of human nutrition as well as livestock feeding simultaneously. This system will not only reduce the cost of production of milk, enabling the availability of more milk to the masses at a cheapter rate, but will also spare lot of conventional concentrates feeds like barley, gram, maize, etc., for human consumption. The use of nutritious green fodder rich in vitamins, minerals and proteins will help the bovine population in several ways; increase the milk production, raise the efficiency of working animals and provide comparatively faster growth rate to the young stock. In most of the agriculturally developed and dairy advanced countries, sound animal husbandry is developed around the practice of green fodder production and pasturage.

At present, the area devoted to fodder production in India is very small, only about 4 to 5 per cent of the total cultivated acreage, as compared to about 25 per cent in U.K. and 60 per cent in USA. A thriving dairy industry invariably demands cultivation of green fodders. Sen and Ray (1964) have pointed out that the problem of feeding the milk production milch animals can easily be solved if, by some reorientation of the cropping programme, about 10 per cent of the total arable acreage of the country could gradually be appropriated for organised production of fodder crops.

Accordingly, Singh (1967) recommended that the farmer should be encouraged to adopt a blanced agricultural policy by the adoption of mixed farming pattern of crop rotations, which should include suitable fodders specially legumes to provide nutritious fodder for cattle besides enriching the soil fertility.

Keeping in view these agro-animal husbandry conditions, the present investigations were planned to identify for the mid-hills of Himachal Pradesh the new vistas of forage production whereby it may be possible to produce the increased quantities of fodder and harvest the enhanced supplies of feed units per unit area of land through the use of fertilizers and improved agro-techniques. The objectives were:

1. To assess the comparative performance of berseem and oat grown in pure and mixed stand for fodder production,
2. to study the effect of three levels each of nitrogen and phosphorus on the growth, yield and quality of oat and berseem grown in pure and mixed stand,
3. to study the economics of fertilizer application to oat and berseem cultivated in pure and mixed stands, and
4. to find out the effect of legume and non-legume association on the fertility status of the soil.

2. REVIEW OF LITERATURE

2.1. BERSEEM

Berseem (Trifolium alexandrinum Juslen) is one of the most nutritious fodders containing about 14.10 kg crude protein per 100 kg of dry matter (Sen and Ray, 1964). According to Nelson et al. (1965) berseem hay made at bud stage contains about 15.4 per cent crude protein, compared to 7.8 per cent protein from milk stage oats. Patel et al. (1958) found it four times richer in calcium than cereal fodders. Khatta and Katoch (1981) reported that amongst the Rabi fodders studied, T.alexandrinum was found to contain 27.6 per cent crude protein.

Saini and Malik (1949) opined that berseem is capable of giving very high yields of green fodder in 4 to 5 cuttings from November to May under suitable environments and the fodder is highly nutritious and palatable as evinced by the contents of various constituents (protein 11.20 to 17.44 %, CaO 2.63 to 4.06 % and P_2O_5 0.29 to 0.69 %).

Tiwari (1966) reported that out of the winter legumes grown under irrigation, berseem is the most productive crop, yielding 24.6 tons[1] green matter per hectare followed by lucerne with 20.6 tons. Bonadale (1967) also concluded that berseem is the only high yielding Rabi forage with green fodder yields averaging 34 tons per hectare.

As quoted by Khan et al.(1954) increased yield of legumes due to manuring were obtained by Hayman (1943) and Roberts and Allison (1943). According to Chandnani (1958) manuring of berseem is economical and helps to increase its quantity as well as quality.

2.1.1. Effect of nitrogen: Nitrogen application for legume establishment is apparently associated with the concept that inoculated legumes benefit

1. 1 ton = 1.016 tonnes.

from nitrogen during the prefixation stage (Sherwin, 1923). It is desirable to add little quantities of nitrogen for early growth and nodulation in legumes (Giobel, 1926; Weber, 1930) because of its stimulatory effect on the legume plant in the early stages; at no stage it is known to have a retarding effect. However, inorganic nitrogen at high levels is known to interfere with normal nodulation of certain legumes, besides reducing emergence caused by reduced germination and seedling plasmolysis. Several workers from different parts of the world have found the application of small quantity of nitrogen to legumes to be rational. With abundant supply of other minerals, the application of nitrogen helps in increasing the yields of clover (Chandnani and Obhrai, 1955).

Results contrary to this have also been obtained on the basis of a series of experiments, Parr and Bose (1944, 1945) reported that berseem did not respond to purely nitrogenous fertilizers and maximum growth was not obtained even with high dose of FYM. Similarly, in a 3 year trial, Ganguli and Relwani (1961) observed that berseem yields did not increase due to direct or residual effect of the application of 30 and 60 lb[2] nitrogen per acre[3] in the form of ammonium sulphate to paddy and/or berseem crop in a paddy-berseem rotation. Shah (1965) found that the quality of berseem forage as determined by crude protein percentage is not affected by higher level of nitrogen application.

During the course of investigations on the cultivation of berseem in Egypt, Shaaban et al. (1966) noted that extra nitrogen applied to berseem or to berseem mixed with wheat/barley or field beans increased the yields at the first two cuts. Jimeno and Lozano (1966) conducted trials on nitrogen nutrition in berseem in which berseem was grown in the pots in the open.

2. 1 pound (lb) = 0.4536 kg
3. 1 acre = 0.405 hectare.

Nitrogen was applied at rates equivalent to 10, 150 and 300 kg per hectare two third before sowing and one third when the plants were 3cm high. The seed was inoculated. Herbage yields increased with the plant age; being higher with 150 kg nitrogen. In general, nitrogen content in the herbage also increased with the rates of applied nitrogen.

Tomar and Singh (1968) noted that the forage yields were very much improved when 44.4 kg nitrogen per hectare was applied to berseem. However, on the basis of experiments conducted at Sarkanda farm, Bilaspur (M.P.), it appeared to Bondale (1967) that doses of 20 and 40 kg nitrogen per hectare were too high and detrimental to the forage. Tomar and Arora (1971) also observed that berseem was not benefitted by higher doses of nitrogen application. Sinha et al.(1982) experienced that nitrogen dose beyond 40 kg per hectare proved detrimental to berseem possibly due to some injurious effect on symbiotic bacteria and as a result it reduced the green fodder yield significantly. For general soil, Arora and Jackson (1969) recommended a dose of 25 kg N per hectare to berseem. According to Tomer and Arora (1971) nitrogen application beyond 40 kg nitrogen per hectare did not show beneficial effect on berseem, rather the forage yield declined to the extent that at 80 kg N per hectare the yield was even lower as compared to control (No nitrogen).

2.1.2. <u>Effect of phosphorus</u>: Extensive work conducted in India as well as abroad has established that phosphatic manuring of legumes, especially of berseem, helps in increasing yields and improving the quality of legumes in addition to building up soil fertility (Chandnani and Obhrai, 1955). As cited by Sen and Bains (1952), the results of numerous field trials (Wohltmann and Bergene, 1902; Truesdell, 1917; Erdman and Wilkins, 1928;

West, 1936; Blaser et al., 1941; Robinson, 1942; Parr and Bose, 1944; Mursell, 1944) have shown that legume fodders (Alfalfa, lucerne, soybean, etc.) respond markedly well to the application of phosphatic fertilizers. There is evidence to indicate that the application of phosphorus results in the production of fodders of better quality (Sewell and Latshaw, 1931; Rogers and Sturkie, 1939; Parr and Bose, 1944; Singleton et al., 1945; Greaves and Pitman, 1946). Increases in bacterial action, weight of plants and total dry matter of legume crop due to phosphatic manuring have been noted by Mac Taggart (1921), Hutchinson (1923), Mercer (1948); Bartholomew (1950), Sen and Bains (1952) and many others. West (1938), and Gericke (1938) simultaneously reported that phosphatic fertilizers improve the quality of legume fodders. Singleton et al. (1945), however, concluded that application of phosphorus did not show response to alfalfa when sown on new lands having sufficient P_2O_5 supply.

Through a series of experiments Parr and Bose (1944, 1945) clearly demonstrated the importance of phosphatic manuring of legumes, particularly of berseem under Indian conditions. The results of their trials indicated that application of superphosphate increased (i) the fodder yield from 100 to 150 per cent and (ii) phosphorus content of berseem plant by 250 to 400 per cent over no manure. Concentration of phosphorus in berseem forage increased with the increasing doses of phosphorus. It was further observed that in the year of low yields, the phosphorus content tended to decrease while that of calcium increased.

In lysimeter studies of crop rotations, Desai et al. (1953a) observed that berseem fertilized with phosphorus in the form of superphosphate gave very good response in yield varying from 81 to 230 per cent. They further observed that phosphatic fertilization did not alter the nitrogen content but increased the P_2O_5 content and decreased the K_2O content, whereas the application of phosphorus at 200 lb per acre increased the CaO content (1953b). Sen and Bains (1952) concluded, interalia, that application of superphosphate alone or in combination with potash to berseem brought about marked increases in yield over control. The nitrogen content of the crop remained unaffected by phosphatic treatments but this materially increased the P_2O_5 content and slightly increased the CaO content in the plant material, thereby improving the quality of fodder for feeding purposes. Rao and Ghose (1954) noticed in their pot experiments that application of increasing doses of phosphorus progressively reduced the reddening of leaves (which was very marked in soil deficient in available phosphorus) and increased the yield of fodder. Bains (1961) reported that fodder yields of berseem showed a substantial cumulative response to phosphorus over 3 cycles of 3 year rotation. In trials in which N, P, K, FYM and 6 micronutrients were applied alone or mixed to berseem, Kanwar (1962) observed that yield increases resulted only by applying P (with or without K or N singly or in combination or FYM. Chandnani and Obhrai (1955) concluded that, in general, application of P_2O_5 to berseem improves the quality of berseem fodder; the soils having adequate supply of P_2O_5, however, may not show response to the application of P_2O_5.

Singh and Verma (1953) conducted a replicated experiment to study the influence of varying rates of phosphorus application on the yield and quality of berseem. It was seen that per cent increases in yield over untreated plots given by application of 66, 132, 198 and 264 lb P_2O_5 per acre were 37.66, 53.43, 63.94 and 67.58 per cent, respectively. The

The corresponding crude protein contents were 20.19, 19.38, 18.94 and 21 per cent, respectively. In a 3 year trial, Ganguli and Relwani (1961) applied 0, 30 and 60 lb N and 0, 80 and 160 lb P_2O_5 per acre to rice and berseem in 1 year rice-berseem rotation on a loamy soil low in nitrogen. The only significant response was in respect of yield of berseem or to the preceding rice crop. There was, however, no significant difference in the yields of berseem due to 80 lb and 160 lb P_2O_5 doses. Economically, 80 lb P_2O_5 dose was highly remunerative. Sen and Bains (1952) observed that the rate of 50 lb P_2O_5 per acre was as effective as the double dose of 100 lb P_2O_5 per acre in maintaining the yield. On the other hand, Singh et al. (1957) concluded that atleast an application of 56 to 64 lb P_2O_5 per acre in the form of superphosphate is required to derive maximum profit with regard to berseem green fodder and seed production. In an experiment at Punjab Agricultural University (1967-68), application of 80 kg P_2O_5 per hectare appreciably improved the forage yields. Bondale (1967) reported that application of phosphorus almost doubled the yield of berseem over control. A further increase in phosphorus level from 40 to 80 kg per hectare did increase the yield but it was not significant. Tomer and Singh (1968) observed that forage yields were much improved with an application of 44.8 kg P_2O_5 per hectare. On the other hand, Singh and Singh (1977) noticed better performance of berseem when phosphorus application was made at 320 kg per hectare. It resulted in maximum green fodder yield except during 2nd and 4th cutting when it was found to be at par with 160 kg P_2O_5 per hectare. During 3rd cutting, application of 320 kg P_2O_5 per hectare was significantly better than 160 kg P_2O_5 per hectare when accompanied with 2 kg of Mo per hectare. It resulted in maximum profit.

Sinha et al. (1982) reported that application of phosphorus markedly enhanced the fodder yield of berseem. A dose of 35 kg P per hectare increased the fodder yield significantly over control. Further increase in P level to 70 kg pushed up the yield over 35 kg P per hectare to significant level, but was not statistically different from 105 kg P per hectare. Thus response to P was quadratic in nature. Arora and Jackson (1969) noticed that phosphate application made at 100 kg per hectare resulted in maximum contents of Ca and P in the plant. Phosphorus uptake increased sufficiently over the control when applied at 50 and 100 kg P_2O_5 per hectare. The maximum percentages of both Ca and P were recorded when the crop was fertilized at the rate of 50 kg N and 100 kg P_2O_5 per hectare. According to their observation 50 kg P_2O_5 per hectare seemed to be a suitable dose for most P deficient soils, whereas the yield increased upto 100 kg P_2O_5 per hectare in medium phosphorus soils with lesser moisture.

Singh et al. (1972) demonstrated that an application of 120 kg P_2O_5 per hectare gave higher dry matter yield of berseem. Husain et al. (1976) observed that the application of phosphorus tended to exercise its differential effect on protein content of shoots even in the first cut, but the differences were not sufficient enough to attain the level of significance. However, the differences in the subsequent cuts were well marked.

2.1.3. <u>Complementary effect of nitrogen and phosphorus</u>: Many workers have postulated that the combined application of nitrogen and phosphorus to berseem crop results in better production than single application of these nutrients. Chopra (1950) noted that berseem needs application of both nitrogen and phosphorus. The recommended dose is 80 lb nitrogen per acre in the form of ammonium phosphate which not only supplies nitrogen but also the requisite quantity of phosphorus. The work done in the Division of Agronomy, Indian Agricultural Research Institute, New Delhi confirmed that application of ammonium phosphate to berseem has always given better results than the application of P_2O_5 in the form of superphosphate and rock phosphate (Annual Report of the Division of Agronomy, IARI 1950-1951). Sen and Bains (1951) also observed that among phosphatic fertilizers such as ammonium phosphate, superphosphate, basic slag and bone meal, best response was obtained by ammonium phosphate possibly because it supplied both nitrogen and phosphorus simultaneously. Chandnani and Obhrai (1955) concluded that application of both nitrogen and phosphorus is necessary for berseem and of all the forms tried ammonium phosphate gave the highest yield per acre as well as the highest response per lb of P_2O_5 applied.

Tomer and Singh (1968) reported that though the forage yield was improved by separate applications of nitrogen and phosphorus, this improvement was further enhanced when nitrogen and phosphorus were applied in combination. In five crop treatments, oat-berseem mixture responded most to the combined application of nitrogen and phosphorus and they recommended a dose of 44.8 kg per hectare of each of these nutrients for Agra region. In an experiment at Punjab Agricultural University (1967-68) it was noted that green forage yield of berseem and oats grown in pure as well as mixed stands improved appreciably with the combined application of 80 kg each of nitrogen and P_2O_5 per hectare (Tomer and Arora 1971). El-Gindi et al. (1963) observed that berseem fertilized with 150 kg superphosphate with or without 100 kg Calcium nitrate per feddan (1 feddan = 0.42 ha) in two applications out yielded by 12 and 4 per cent per feddan, respectively.

Bains (1961) conducted trials at I.A.R.I. on the phosphate fertilization of berseem with and without potash and/or nitrogen and found that fodder yields of berseem showed a substantial commulative response to phosphorus over 3 cycles of a 3 year rotation and additional benefit accrued only when nitrogen and no potassium was administered alongwith phosphorus. Khan et al. (1954) reported that fertilization of berseem with phosphorus alone or in combination with nitrogen and potash was advantageous and higher yields were obtained in the presence of N, P and K in comparison to an application of one or two of these fertilizers. The increases in yield with the complete mineral treatment ranged between 44 and 140 per cent over control in different years. But Shekhawat et al. (1973), while working on the same lines, obtained maximum yields of berseem and senji (M.indica) from the combined application of nitrogen and phosphorus without potash. They recorded that the fresh fodder yield of berseem was higher than that of senji and application of 40 kg N plus 80 kg P_2O_5 per hectare gave the highest yield of the former.

On the basis of the experiments conducted at Sarkanda Farm, Bilaspur (M.P.), Bondale (1967), however, reported that nitrogen in conjuction with phosphorus gave slightly lesser yields as compared with the corresponding dose of phosphorus alone.

2.2. OAT

Oat (Avena sativa Linn) is the most important cereal forage grown in the north west region of India for providing green forage from November to March. It is highly palatable nutritious energy rich forage and is highly valued for feeding livestock. According to Joshi and Parsad (1979) it is valuable in the sense that it gives a s high green fodder yield as 300 quintal per hectare with a crude protein content of about 7 per cent. Patel et al. (1958) have reported the composition of oat fodder as below:

Period of growth	Crude protein (%)	Phosphorus (%)	Calcium (%)
1 month after sowing	18.81	0.39	0.73
3 months after sowing	5.26	0.16	0.43

2.2.1. Effect of nitrogen

Nitrogen is the most important element for oat as it increases the vegetative growth so essentially desired for the production of increased quantities of fodder. Significant increases in the yield of oat by application of nitrogen have been reported by many Indian workers including Sen and Kavitkar (1958), Datta and Bains (1960), Dabadghao and Sikka (1961), Pal and Sikka (1961), Bhaid (1964), Hunsigi and Mani (1966) and Tomer and Singh (1968).

In preliminary trials at I.A.R.I., Chopra (1961) observed that application of 16.8 and 13.6 kg nitrogen per hectare gave upto 117 and 123 per cent increased yields of green fodder over control, respectively. Sinha (1968) found that growth, yield and quality of oat increased considerably as the doses of nitrogen increased from 0 to 120 kg per hectare. Singh and Joshi (1961) recommended the application of 112 kg ammonium sulphate per hectare at the time of Ist irrigation to 'Kent' grown for fodder or grain in Delhi, Punjab and Tarai regions of Uttar Pradesh. Bokde (1968) reported yield increase of the order of 128.7 234.2 and 329.7 quintals per hectare in green fodder, 2.1, 35.79, 58.98 and

75.32 quintals per hectare in dry matter and 232.1, 368.2 and 575.4 kg per hectare in total protein from the applications of 33.6, 67.3 and 100.9 kg nitrogen per hectare, respectively, over those from control. Differences between yields at different levels of nitrogen were significant. Appplied nitrogen was more effective in increasing the total protein yield than in increasing the green fodder or dry matter. He further observed that the nature of response to nitrogen levels was linear when only one cutting was taken, whereas it was quadratic under two cuttings treatment giving higher yield increases at lower levels of nitrogen but lower yield increases at higher levels of nitrogen. Economically also, application of nitrogen was found to be highly remunerative and income rose with increasing nitrogen application.

Miaki and Nose (1967) observed that the application of 25 kg nitrogen per acre caused a marked increase in the crude protein content of oat forage at the vegetative and boots stages, while crude protein digestibility increased significantly at all stages (i.e. vegetative, boot head and milk stage). Weisemuller (1963) found that nitrogen increased yield and protein content as well as the concentration of soluble nitrogen and amide nitrogen in green plants of meadow fescue and oats. Burczyk and Cwojdzinski (1967) noted that application of 360 kg nitrogen per hectare doubled the crude protein content of forage, tripled the dry matter yields and increased the crude protein content yield five fold in some forage crops including tall oat grass. Crofts (1966) observed that nitrogen at 90 lb per acre increased the total dry matter yields of the forage in winter by more than 1600 lb per acre and fairly increased the crude protein content of oats.

Nehring and Schutt (1961) noticed increased contents of carotene and chlorophyll in green oat fodder fertilized with nitrogen. Dzurkov (1962) and Scharrer and Bruke (1953) also found that application of nitrogen alone or in combination with phosphorus increased the carotene content. According to latter workers nitrogen in the nitrate form was more effective in the biosynthesis of carotene than the ammonium salts. Contrary to this Stallcup et al.(1960) reported that the observed differences in crude protein, and cellulose contents due to levels of fertilization tried (20, 40 or 60 lb per acre in the form of ammonium nitrate) were not significant.

During the course of field investigations carried out during Rabi 1975-76 and 1976-77 at Forage Production Farm, Andhra Pradesh Agricultural University, Rajendra Nagar, Veera Raghavaiah (1979) reported that oat seed rate of 50 kg per hectare was optimum for obtaining higher fodder yield and net income. It was also observed that application of 80 kg N/ha resulted in higher yield of green fodder (447 q/ha) and gave a higher net income of Rs.3041/ha from oat fodder grown on soils medium in available nitrogen and phosphorus, high in potash and having a pH of 7.6. However, the interaction between seed rate x nitrogen levels did not exhibit any significant effect on green forage yield and the protein percentage was highest (10.15%) with 50 kg seed/ha. Joshi and Parsad (1979) obtained a significant response to nitrogen upto 200 kg per hectare for the total green forage yield. This indicated that oat forage can be fertilized upto 200 kg nitrogen per hectare or even beyond. From the economic analysis they observed that while the application of first dose of 100 kg N per hectare gave an increase of 22 tonnes per ha of green forage the next dose of 100 kg N per hectare gave an additional yield of 15 tonnes per hectare. Thus economically, nitrogen application was found to be highly remunerative and income rose to Rs.800/- per ha due to first dose and Rs.450/- per ha due to the next dose of 100 kg N per hectare.

2.2.2. Effect of phosphorus

Tomer (1969) observed that application of 50 kg P_2O_5 per hectare proved beneficial as yield, crude protein content and mineral matter were increased and carbohydrates were decreased. Chhillar (1981) recorded significant response of oat to the application of 40 kg P_2O_5 per hectare whereas Tomer and Arora (1971) noticed that pure oat was least responsive to phosphate application. Similarly Kirpal Singh et al. (1975) also observed that phosphorus application had no effect on green and dry matter yield of oat. Recently Keftasa (1985) while working under highland of Arsi region of Ethopia reported that no significant response to P rates was obtained.

Tripathi et al.(1979) reported that increasing phosphate levels increased the green and dry forage yields of oat, the highest forage yield was obtained with the application of 60 kg P_2O_5 per hectare. They further observed that application of 30 kg P_2O_5 per hectare recorded significantly higher green and dry forage yields over the control (No phosphate) during 3 year study period. Similar results have been reported by Singh et al. (1973), who recorded significant response of forage oat to the application of 35 kg P_2O_5 per hectare under the mid-hill conditions of Himachal pradesh.

2.2.3. Complementary effect of nitrogen and phosphorus

It is a general belief that comparatively the beneficial effects of nitrogen and phosphorus are more when applied together. Smith et al. (1950) made studies on the utilization of fertilizer and soil phosphorus by pure stands of oats and clover (*Trifolium incarnatum*). The treatments comprised 0, 30 and 60 lb per acre of nitrogen and 0, 60, 120 and 180 lb per acre of phosphorus in all possible combinations and potassium was applied to all the plots at the rate of 60 lb K_2O per acre. Application of phosphorus but not that of nitrogen increased the total phosphorus content of the oat forage. The greatest amount of fertilizer phosphorus removal was observed with 30, 120 and 60 lb per acre of N, P and K application.

Barak (1963) studied the effects of superphosphate and its ammonification on oat and barley and observed that ammoniated superphosphate of 2.8 per cent nitrogen content was as effective as powdered superphosphate, but an increased degree of ammoniation (upto 11.88 per cent nitrogen) depressed average yields and caused an increase in nitrogen content.

Datta and Bains (1961) studied the effect of soil application of N, P and K alone and in conjunction with some micronutrients. The test crops were sorghum, oat and rape. An application of 40 lb N + 60 lb P_2O_5 + 30 lb K_2O per acre increased the yield of all crops significantly. Extra yields due to N, P and K averaged 79.82, 10.00 and 2.56 mds[4] per acre for sorghum, oats and rape, respectively. Ivanko (1960) noticed that the amino acid content in oat declined at the flowering stage and increased at the end of vegetative cycle especially when N, P and K fertilizers were added. Tripathi et al. (1979) reported that application of 120 kg N alongwith 60 kg P_2O_5 per hectare gave the highest crude protein in oats. They ascribed the higher crude

4. 1 mound = 37.324 kg

protein content in oat to the combined effect of N and P in enhancing cell division and accumulation of protein bodies and their derivatives through better translocation and assimilation of the absorbed nutrients. Similar observations were also made by Bokde (1968), Tomer (1969) and Sandhu et al. (1976). Mukherjee et al. (1981) reported that under short and mild winter conditions of West Bengal, the effect of nitrogen and phosphorus was additive and the highest yield of 62.5 tonnes per hectare was obtained at 120 kg N and 30 kg P_2O_5 per hectare and in the like manner nitrogen and phosphorus contents of forage oat were also high when combined application of nitrogen and phosphorus was made.

2.3. BERSEEM OAT MIXTURE

Many workers have reported considerable increases in forage yields when berseem is grown mixed with another forage crop, perferably a non-legume, and berseem + oats form one of the best combinations. Shah (1965) conducted an experiment to find out the influence of companion crops on the yield and quality of berseem (*Trifolium alexandrimum* Juslen). Berseem was grown (a) alone, or with a companion crop (b) Tetraploid berseem (c) *Melilotus alba* (d) Oats Cv. 'Kent' (e) *Phalaris minor* or (f) an unnamed *Brassica* spp. He concluded that (i) yield of berseem fodder, dry matter and crude protein in the first cutting of berseem could be increased to the extent of 20 to 120 per cent by growing with it another fodder crop; (ii) the quality of berseem plants determined by crude protein content was not affected by the asosicated growth of companion crops, (iii) companion crops tended to increase the total yield of green fodder, dry matter and protein during the season; (iv) non-legumes were better companions than legumes and (v) oat at 50 kg per hectare seed rate with berseem at 25 kg per hectare proved to be the best combination markedly increasing the yield of green fodder, dry matter and protein in the first cutting as well as during the season. Tomer and Singh (1968) also concluded that oat+berseem mixture was the best for the production of green forage; berseem in pure stand being next best among five crop treatments, Viz, berseem, oat, senji, oat + berseem and oat + senji. Saini and Malik (1949), however, found Oat + berseem combination next to rape + berseem. In their trials at Sirsa during 1942-45, average mean yield of the green fodder was 1197, 1430, 1291 and 1218 mds per acre from berseem alone, berseem + rape, berseem + oat and berseem + senji, respectively.

In an experiment at Hissar Agricultural University (1967-68) and 1968-69) berseem and oat were sown in five seed proportions, viz.,berseem alone, 2/3 berseem + 1/3 oat, 1/2 berseem + 1/2 oat, 1/3 berseem + 2/3 oat and oat alone with 3 levels each of nitrogen and phosphorus, viz., 0, 40 and 80 kg per hectare. The seeds of berseem (diploid) and oat (Weston II) were broadcast at the rate of 25 kg per hectare and 65 kg per hectare, respectively. The pooled data showed that 1/2 berseem + 1/2 oat yielded significantly higher forage yield over those obtained from berseem pure and oat pure. However, the variations between 1/2 berseem + 1/2 oat, 2/3 berseem + 1/3 oat and 1/3 berseem + 2/3 oat mixture were not significant.

In mixed stand, the yield proportion of oat was higher than that of legume in the first cutting, while in the successive cutings owing to better regeneration and growth of berseem the yield results of mixture were superior to pure cultures, (Henderson and Davies, 1955, and Tomer and Singh, 1968).

The lower yields under high proportions of oat might be due to the fact that oat as compared to berseem gives lesser number of cuttings, while lower yields under high proportions of berseem may be because it gives poor yield during the first cut. Thus equal proportions of legume and non-legume components gave the maximum yield. The forage yields increased with the increase in the nitrogen level. The improvements brought about by the application of 40 and 80 kg N per hectare were significant over that from no nitrogen treated plots. However, the superiority of 80 kg N over 40 kg N with regard to yield was not significant. With the application of 40 kg and 80 kg phosphate per hectare, the forage yields were significantly improved over those from no phosphate applied plots. However, the improvement brought about by 80 kg P_2O_5 over 40 kg P_2O_5 per hectare was not significant. Nitrogen application did not show beneficial effect on berseem and 2/3 berseem + 1/3 oat. 1/2 berseem + 1/2 oat and 1/3 berseem + 2/3 oat responded significantly only upto 40 kg N per hectare, while oat pure was most responsive to the application of nitrogen even upto the level of 80 kg N per hectare.

Berseem pure responded well to the application of phosphorus and significantly higher yields were obtained with the increasing levels of phosphorus. 1/3 berseem + 2/3 oat and 1/2 berseem + 1/2 oat mixture responded only upto 40 kg P_2O_5 per hectare, beyond this dose no significant increase was noticed. 1/3 berseem + 2/3 oat and oat pure did not respond to the application of phosphorus (Tomer and Arora, 1971).

Desale (1974) obtained total yield of 252.5 tonnes fresh fodder per hectare when berseem was sown 20 cm apart on 1 November, maize + teosinte hybrid between the rows of berseem after 3rd cut on 14 February and sorghum Cv. MPKV-1 in May after harvesting the berseem/hybrid mixture. In this system of crop cafetaria, the first, second and third crop contributed 75, 90 and 87.5 tonnes of fresh fodder yield per hectare in a calender year, respectively. Rai (1973) recommended that tetraploid and diploid berseem should be sown mixed in 2:1 ratio using 25-30 kg seed per hectare or with fodder sarson using 2 kg seed per hectare. For this practice, a fertilizer dose of 50-60 kg P per hectare and 25-30 kg N per hectare was the best. According to him, additional nitrogen at the initial stage helps in better and quick growth when nodules are still not formed. Magoon et al.(1974) recommended that berseem and lucerne should be grown with oat for augmenting low fodder yield in the first cut.

Rao et al., (1979), while studying the effect of cultural practices on the yield of forage cereal-legume mixture, noted that cereal component yielded more in mixture than in monoculture. The highest ceral cereal green fodder yield (32.5 tonnes per hectare) was obtained with 1:1 cereal legume mixture. The legume component yielded lower in mixture than in pure stand. In pure stand, green fodder yield was similar under line sowing as well as when broadcast. Total yield of the mixture was similar to the yield of cereal component alone, indicating that response of the mixtures was mostly contributed by cereal.

Relwani et al.(1971) while studying the comparative performance of tetraploid and diploid berseem at varying seed rates and their mixtures in different combinations, found that increasing the seed rate from 25 to 50 kg per hectare increased yields from 69.1 to 86.1 tonnes fresh fodder from 8.5 to 10.1 tonnes dry matter and from 1.71 to 2.02 tonnes crude protein per hectare in tetraploid berseem, whereas diploid berseem gave the highest yields of 96.7, 13.1 and 2.57 tonnes per hectare, respectively when sown at 25 kg per hectare. Mixing 37.5 kg seed of diploid seed with 12.5 kg of tetraploid berseem gave the highest yield of 103.7, 14.6 and 3.06 tonnes per hectare, respectively.

Kaufhold and Martin (1973) found that 'Egyptian Clover' (T.alexandrinum) and Persian Clover (T.resupinatum) gave higher total yield when grown with forage cover crops of which the best were spring forage on the lighter soils of Northern GDR and forage oat elsewhere, than in pure stands. Two clovers and clover + western worlds rye grass mixture did not differ in dry matter and crude protein yields. Dry matter and crude protein contents of the dry matter tended to be higher in 'Persian Clover' than in berseem. Without cover crops, clover + western world rye grass mixture gave significantly higher yields than did pure stands. Further, 20 kg N per hectare applied after each cut increased the mixture yield by 5-8 per cent. Pure western world rye grass given 200 kg N per hectare gave yield equal to that of clover given 90 kg nitrogen per hectare.

Rao et al. (1979) obtained the highest yield of green fodder (673.2 q/ha) and protein yield (26 to 99 q/ha) from paired rows of oat crop at 20 cm spacing and intercropped with one row of berseem in between two pairs of oat while using oat and berseem seed rates of 100 kg and 25 kg per hectare, respectively. Singh et al.(1978) suggested that growing 15 to 20 quintal of stem cutting of napier and broadcasting 30 kg per hectare of berseem as intercrop increased the fodder yields besides building up soil fertility. Shivastava and Varshney (1983) reported that berseem and oat grown either in pure or mixed stand with different seed proportion gave marked increases in dry matter yield and crude protein content of both crops with increasing levels of nitrogen (0-75 kg N/ha). However, the proportion showed no marked effect on yield and quality. Keftasa (1985) concluded that use of legumes in mixture should be aimed more at increasing crude protein content rather than dry matter yield.

3. MATERIALS AND METHODS

The present investigations were conducted at the Agronomy and Agrometeorology Farm, Satya Nand Stokes Nagar, P.O.Nauni, Solan, of Himachal Pradesh Krishi Vishva Vidyalaya during Rabi 1980-81 and 1981-82. The details of the material used and the techniques employed during the course of these investigations have been described in this chapter.

3.1. GENERAL

3.1.1. Location

The Satya Nand Stokes Nagar is situated about 15 kilometres from Solan on Solan - Rajgarh road, and is located between $30^{o}51'$ N latitude and $77^{o}11'$ E longitude. The elevation of the campus ranges between 950 and 1350m above m.s.l.

3.1.2. Climate

In general, the climate of the campus is temperate to sub-tropical (Semi-arid) and is characterized by moderately hot summers. May and June are the hottest months and January and February are the coldest ones. Long term, average annual precipitation at experimental site ranges between 1000 and 1300 mm, of which 75 per cent is received during monsoon months (June to September) and rest between October and May. Mean weekly meteorological data, pertaining to the period of experimentation, have been appended in Appendix I and are shown graphically in Fig.1. The monthly averages of the weather data have been tabulated in Table 3.1.

3.1.3. Rabi (1980-81)

Though the crop was irrigated depending upon the atmospheric demand, the total dry conditions during September and October adversally affected initial seedling growth and subsequently its establishment. The low

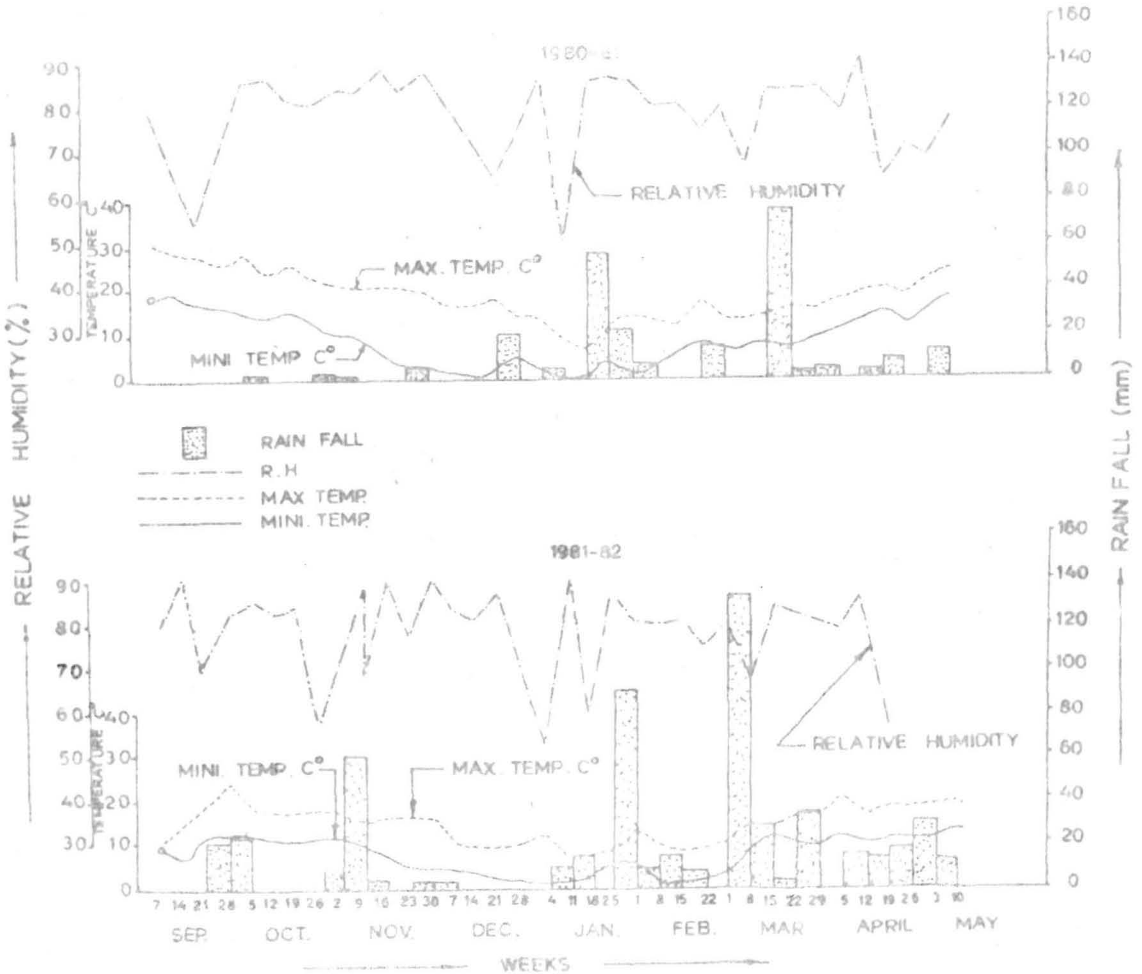

FIG-1 MEAN WEEKLY WEATHER DATA DURING CROP SEASON temperatures during January accompanied by unusual snowfall of about 9 mm gave great set back to the crop growth and reduced the regeneration capacity of berseem. However, normal and frequent rains during March and thereafter were helpful for crop growth.

Table 3.1. Mean monthly meteorological data for the crop duration (1980-81 and 1981-82)

Month	Temperature°C			Mean Relative	Total
	Maximum	Minimum	Mean	Humidity (%)	Rainfall(mm)
			Rabi 1980-81		
September	29.08	18.20	23.64	69.25	-
October	25.05	14.90	19.95	88.00	3.0
November	21.42	16.11	13.76	90.25	10.8
December	16.88	2.75	9.81	88.75	20.0
January	10.22	2.07	6.14	87.25	60.5
February	17.55	6.44	11.53	82.75	26.0
March	15.83	8.16	11.99	62.50	90.0
April	20.22	13.96	17.09	72.25	12.5
May	22.61	19.11	20.86	88.50	25.8
			Rabi 1981-82		
September	20.22	11.44	15.83	79.00	47.0
October	18.61	12.16	15.38	73.00	-
November	17.27	8.61	12.94	91.00	78.0
December	11.33	4.16	7.74	75.00	5.0
January	11.84	5.01	8.42	92.00	26.5
February	10.22	0.05	5.13	78.00	118.2
March	17.61	13.11	15.36	85.25	172.4
April	19.50	12.55	16.02	75.50	56.0
May	19.72	15.83	17.77	81.50	84.0

3.1.4. Rabi (1981-82)

Timely rain at the time of sowing had favourable effect on seedling establishment. The rains from the beginning of first week of January were fairly well distributed and this had favourable effect on the crop growth and its regeneration capacity.

3.1.5. Soil characteristics

These experiments were laid out on the two well levelled and flat terraces. The slight variation in slope was made good by the levelling of individual plots.

In order to fully characterise the soil of the experimental terraces, composite soil samples were taken from 0 to 15 cm depth from each experimental plot at sowing time. These were run for mechanical and chemical analyses, the results of which are presented in Table 3.2.

The soil of the experimental fields was neutral in reaction and sandy loam in texture. Although the experimental fields had very high organic carbon content, their fertility was medium in respect of available nitrogen and phosphorus and high in potassium.

3.1.6. Cropping history

The experimental terraces have been under different medicinal and aromatic crops till 1977-78. In 1978-79 and 1979-80 a general crop of maize during Kharif and wheat during Rabi was grown using uniform fertilizer doses In Kharif 1980-81 cowpea was grown for fodder purpose.

3.1.7. Pests and diseases

There was no incidence of insect-pests on the crop throughout the period of experimentation. However, during the first year, berseem in few plots was damaged particularly at seedling stage due to stem rot which is a

Table 3.2. Mechanical and chemical analysis of the experimental fields

S.No.	Particulars	Experiment I		Experiment- II		Method employed
A.	Mechanical analysis	1980-81	1981-82	1980-81	1981-82	
	Course sand (%)	43.5	42.3	41.3	39.5	International pipette
	Fine sand (%)	14.4	15.6	18.3	17.4	method (Robinson,
	Silt (%)	32.0	30.9	29.9	29.3	1922).
	Clay (%)	18.0	11.0	10.2	13.1	
B.	Chemical analysis					
	Available nitrogen (kg/ha)	498.4	503.5	480.6	500.3	Alkaline permanganate method (Subhia and Asija, 1954).
	Available phosphorus (kg/ha)	42.5	50.6	52.6	50.4	Olsen's method (Olsen et al., 1954).
	Available potassium (kg/ha)	215.8	221.6	220.8	223.8	Ammonium acetate method using flame photometer (Marwin and Peach, 1950).
	Organic carbon (%)	0.9	1.2	1.0	1.1	Walkley and Black's titration method (Piper, 1966).
	Soil pH	7.6	7.7	7.8	6.8	Potentiometeric method using soil-water ratio 1:2
	CEC me/100g soil	12.0	12.8	11.2	12.3	Ammonium acetate method (Black et al., 1961)

kind of damping off caused by *Rhizoctonia solani*. The seedlings developed yellowish patches, which in few days turned dark brown and died. In the later stages this disease reduced the stand per unit area.

3.2. EXPERIMENTAL PROCEDURE

3.2.1. Layout

This study comprised two experiments, which were laid out simultaneously during Rabi season of 1980-81 and 1981-82. In both the crop seasons the experiments were laid out in the same terraces following similar randomization. The layout plan are given in Figures 2 and 3, respectively.

The experiment-wise details of treatments are given below:

3.2.2. Experiment I

Treatments comprised of 2 pure stands and 3 mixtures according to proportions of individual crop viz., 1:1, 1:2 and 2:1 using oat seed rate as 120 kg and that of berseem as 30 kg per hectare, respectively as per details given below:

Whole plot treatments

Cropping system	Proportions
Oat @ 120 kg/ha	Pure
Berseem @ 30 kg/ha	Pure
Oat + berseem	1:1
Oat + berseem	1:2
Oat + berseem	2:1

Sub-plot treatments

All possible combinations of 3 levels each of nitrogen and phosphorus for pure oat, pure berseem and their mixture were as follows:

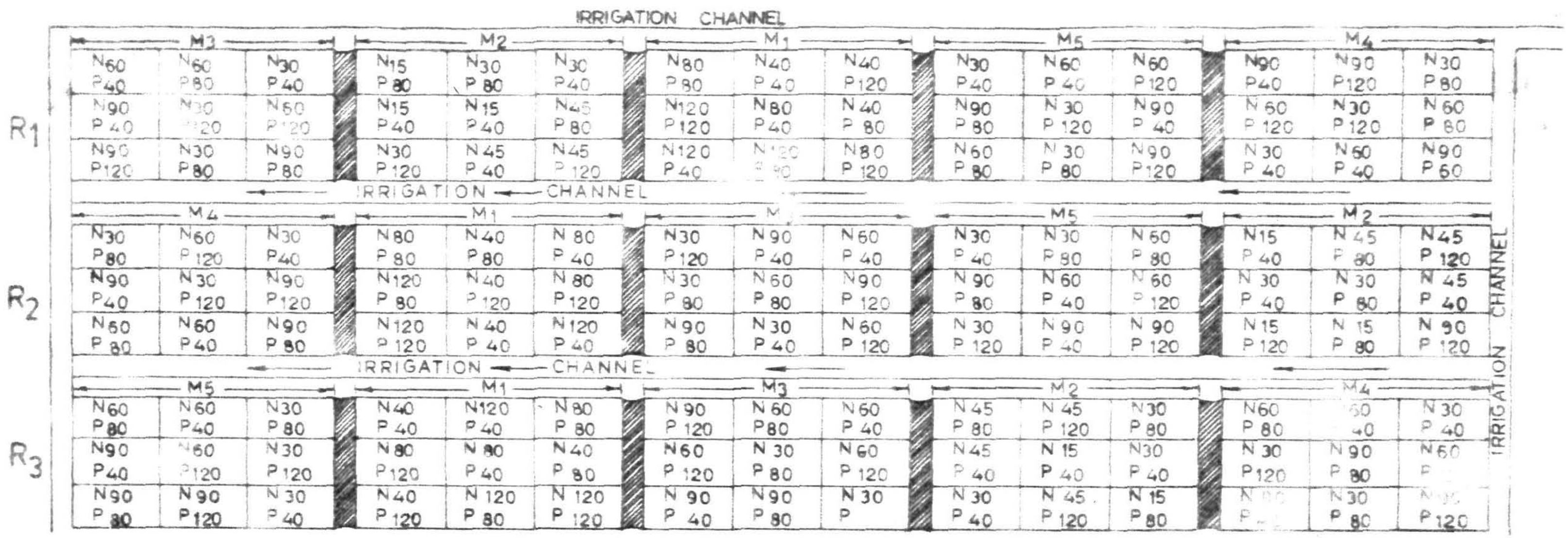

FIG.2 FIELD LAY OUT PLAN

EXPERIMENT NO – I

WHOLE-PLOT

M_1 PURE OAT @ 120 KG / HA.

M_2 PURE BERSEEM @ 30 KG/ HA

M_3 OAT + BERSEEM (1:1)

M_4 OAT + BERSEEM (1:2)

M_5 OAT + BERSEEM (2:1)

SUB-PLOT

SUFFIXES OF N E'P ARE DOSES OF NITROGEN AND PHOSPHOROUS KG PER HECTARE.

GROSS PLOT SIZE : 4 X 3 Sq.m.

DESIGN OF EXPERIMENT :- SPLIT PLOT.

Pure Oat	Pure berseem	Mixture (1:1, 1:2 and 2:1)
	(Doses of N and P_2O_5 kg/ha)	
$N_{40}P_{40}$	$N_{15}P_{40}$	$N_{30}P_{40}$
$N_{80}P_{40}$	$N_{30}P_{40}$	$N_{60}P_{40}$
$N_{120}P_{40}$	$N_{45}P_{40}$	$N_{90}P_{40}$
$N_{40}P_{80}$	$N_{15}P_{80}$	$N_{30}P_{80}$
$N_{80}P_{80}$	$N_{30}P_{80}$	$N_{60}P_{80}$
$N_{120}P_{80}$	$N_{45}P_{80}$	$N_{90}P_{80}$
$N_{40}P_{120}$	$N_{15}P_{120}$	$N_{30}P_{120}$
$N_{80}P_{120}$	$N_{30}P_{120}$	$N_{60}P_{120}$
$N_{120}P_{120}$	$N_{45}P_{120}$	$N_{90}P_{120}$

Design of layout : Split plot

Replications : 3

Plot size : Gross: $3 \times 4\ m^2$ (accomodating 12 rows of oat 25 cm apart and having a length of 4 m).

Net : $2 \times 3\ m^2$ (accomodating 8 rows of oat 25 cm apart and having a length of 3 m).

Experiment II

Treatments

These comprised 3 seed rates of oat, 3 seed rates of berseem and their mixtures in 3 proportions of individual crop viz., 1:1, 1:2 and 2:1 in all possible combinations. There were 36 treatments for the purpose of study which also included 3 dummy treatments as per details given below:

1. Pure oat @ 80 kg seed/ha
2. Pure oat @ 120 kg seed/ha
3. Pure oat @ 160 kg seed/ha
4. Pure berseem @ 20 kg seed/ha
5. Pure berseem @ 30 kg seed/ha
6. Pure berseem @ 40 kg seed/ha

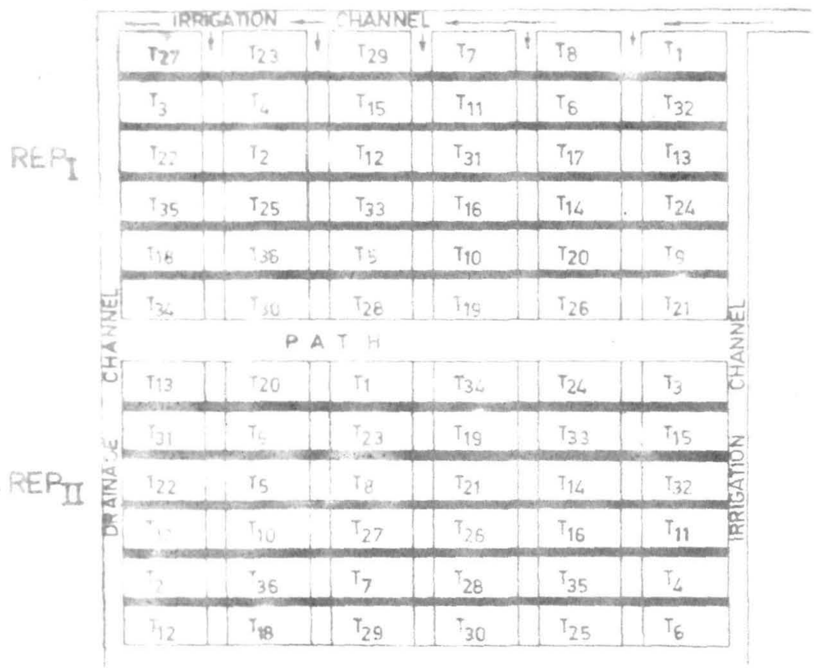

FIG.3 FIELD LAYOUT PLAN
EXPERIMENT NO.- II

TREATMENTS

Sr. NO		
T_1	PURE OAT 80 Kg/HA	
T_2	" " 120 Kg/HA	
T_3	" " 160 Kg/HA	
T_4	PURE BERSEEM 20 Kg/HA	
T_5	" " 30 Kg/HA	
T_6	" " 40 Kg/HA	
	MIXTURE	(RATIO)
T_7	80+20	1:1
T_8	80+20	1:2
T_9	80+20	2:1
T_{10}	80+30	1:1
T_{11}	80+30	1:2
T_{12}	80+30	2:1
T_{13}	80+40	1:1
T_{14}	80+40	1:2
T_{15}	80+40	2:1
T_{16}	120+20	1:1
T_{17}	120+20	1:2
T_{18}	120+20	2:1
T_{19}	120+30	1:1
T_{20}	120+30	1:2
T_{21}	120+30	2:1
T_{22}	120+40	1:1
T_{23}	120+40	1:2
T_{24}	120+40	2:1
T_{25}	160+20	1:1
T_{26}	160+20	1:2
T_{27}	160+20	2:1
T_{28}	160+30	1:1
T_{29}	160+30	1:2
T_{30}	160+30	2:1
T_{31}	160+40	1:1
T_{32}	160+40	1:2
T_{33}	160+40	2:1
T_{34}	[illegible]+30	1:1 DUMMY
T_{35}	[illegible]+30	1:2 DUMMY
T_{36}	[illegible]+30	2:1 DUMMY

GROSS PLOT SIZE = 4×3 Sqm

DESIGN OF EXPERIMENT - INCOMPLETE BLOCK SIMPLE LATTICE DESIGN

	Mixtures			
	Seed rate of oat (kg/ha)		Seed rate of berseem (kg/ha)	Ratio
7.	80	+	20	1:1
8.	80	+	20	1:2
9.	80	+	20	2:1
10.	80	+	30	1:1
11.	80	+	30	1:2
12.	80	+	30	2:1
13.	80	+	40	1:1
14.	80	+	40	1:2
15.	80	+	40	2:1
16.	120	+	20	1:1
17.	120	+	20	1:2
18.	120	+	20	2:1
19.	120	+	30	1:1
20.	120	+	30	1:2
21.	120	+	30	2:1
22.	120	+	40	1:1
23.	120	+	40	1:2
24.	120	+	40	2:1
25.	160	+	20	1:1
26.	160	+	20	1:2
27.	160	+	20	2:1
28.	160	+	30	1:1
29.	160	+	30	1:2
30.	160	+	30	2:1
31.	160	+	40	1:1
32.	160	+	40	1:2
33.	160	+	40	2:1
34.	120	+	30	1:1 (Dummy)
35.	120	+	30	1:2 (Dummy)
36.	120	+	30	2:1 (Dummy)

Design : Incomplete block simple lattice design

Replications: 2

Plot size :Gross: 3 x 4 m (accomodating 12 rows of oat 25 cm apart and having a length of 4 m)

Net : 2 x 3 m (accomodating 8 rows of oat 25 cm apart and having a length of 3 m).

3.2.3. Seed material and sowing

In both the crop seasons, the seed of Algerian oat was procurred from the Seed Production Scientist, Satya Nand Stokes Nagar, P.O.Nauni, Solan of Himachal Pradesh Krishi Vishva Vidyalaya. The seed of berseem (BL-1) was procurred from the Economic Botanist, Department of Animal Science, Punjab Agricultural University, Ludhiana. These crops were sown using pre-assigned seed quantities of each crop.

a. Oat sowing: Oat sowing was done in furrows length-wise in the plots, 25 cm apart and seeds were placed at a depth of 5 cm.

b. Berseem sowing: Berseem seeds as per quantities worked out per plot were soaked in beaker containing water for overnight. These seeds were then inoculated with appropriate strain of Rhizobia prior to seeding by broadcast in pre-irrigated fields.

3.2.4. Water management

Irrigation interval for berseem was broadly 10 days during September, October and November, 15 days during December and January, 12 days during February, March, April and May and for oat 15 days, the objective being to maintain soil moisture above 75 per cent availability in the 15-30 cm soil layer.

3.2.5. Cutting interval

During 1980-81, 4 cuttings were taken from oat, berseem and oat+berseem mixture, while from the crop of 1981-82, 3 cuttings were taken from oat and 5 from berseem and oat+berseem mixture. The first cutting from oat, berseem and mixtures was taken after 60 days of sowing, while the subsequent ones were taken at an interval of 40 to 45 days after the plants attained the height of about 40 cm.

3.2.6. Fertilizer application

a. Nitrogen differential: In case of pure berseem and mixed plots, calculated quantities of nitrogen as per treatment was added by surface broadcast at the time of sowing whereas in case of pure oat plots, half of nitrogen was applied in furrow at the time of sowing and remaining half top-dressed after the first cutting. Fertilizer, Calcium ammonium nitrate (25% N) was used as the source of nitrogen in each year.

b. Phosphorus differential: Whole quantity of phosphorus as per treatment was broadcast on the surface and throughly incorporated in the soil one day before sowing. Fertilizer, Single superphosphate (16% P_2O_5) was used as the source of phosphorus application in each year. No potassic fertilizer was applied.

3.2.7. Cultural operations

The schedule of cultural operations carried in both the experiments during the two crop seasons is given in Table 3.3.

3.3. OBSERVATIONS RECORDED

The following observations were recorded from each experimental plot (at each cutting wherever possible) with a view to assessing the effect

Table 3.3. Schedule of cultural operations carried out during the two crop seasons (1980-81-82).

Sr. No.	Particulars of operation	Dates 1980-81	1981-82	Brief account of operation
1.	2.	3.	4.	5.
		Experiment I		
1.	Preparatory tillage	1.9.1980	3.9.1980	First two ploughing with power tiller and third with desi plough each followed with planking.
2.	Layout	5.9.1980	7.9.1981	Each replicate was divided into five main plots which were raked and levelled individually and then sub-divided into 9 sub-plots.
3.	Soil sampling	8.9.1980	9.9.1980	Detail described in the text.
4.	Fertilizer application	12.9.1980	17.9.1981	Detail described in the text.
5.	Sowing	13.9.1980	18.9.1981	-do-
6.	Irrigation			
	I	13.9.1980	18.9.1981	Irrigation water was applied in check basins of the size 4m x 3m diked from all sides to control overflow of water.
	II	25.9.1980	12.10.1981	
	III	5.10.1980	23.11.1981	
	IV	20.10.1980	11.12.1981	
	V	30.10.1980	22.12.1981	
	VI	15.11.1980	3.1.1982	
	VII	30.11.1980	22.2.1982	
	VIII	15.12.1980	4.3. 1982	
	IX	30.12.1980	15.3.1982	
	X	12.1. 1981	30.3.1982	
	XI	24.1. 1981	10.4.1982	
	XII	2.2. 1981	-	
	XIII	14.2. 1981	-	
	XIV	26.2.1981	-	
	XV	6.3. 1981		
	XVI	18.3.1981		
	XVII	28.3.1981		
7.	Cutting intervals			
	I	15.11.1980 to 16.11.1980	18.11.1981 to 19.11.1981	
	II	30.12.1980 to 31.12.1980	30.12.1981 to 31. 12. 1981	
	III	14.2.1981 to 15.2.1981	14.2.1982 to 15.2.1982	
	IV	31.3.1981 to 1.4. 1981	31.3.1982 to 1.4.1982	
	V	-	5.5.1982 to 6.5.1982	

Condt. -

Table 3.3 Condt.

1.	2.	3.	4	5.
		Experiment II		
1.	Preparatory tillage	4.9.1980	6.9.1981	As followed in Experiment I
2.	Layout	6.9.1980	8.9.1981	Each replicate was divided into six blocks consisting of six plots in each block.
3.	Soil sampling	9.9.1980	10.9.1981	As in Expt.I.
4.	Fertilizer application	14.9.1980	19.9.1981	60 kg nitrogen through Calcium Ammonium nitrate and 80 kg phosphorus through single superphosphate was broadcast a day before sowing of the crop during each year.
5.	Sowing	15.9.1980	20.0.1981	As in Expt.I.
6.	Irrigation			As in Expt.I
	I	15.9.1980	20.9.1981	
	II	25.9.1980	30.9.1981	
	III	5.10.1980	10.10.1981	
	IV	15.10.1980	20.10.1981	
	V	25.10.1980	5.11.1981	
	VI	5.11.1980	20.11.1981	
	VII	15.11.1980	5.12.1981	
	VIII	25.11.1980	25.12.1981	
	IX	5.12.1980	5.1. 1982	
	X	20.12.1980	20.1.1982	
	XI	30.12.1980	25.1.1982	
	XII	15.1.1981	5.2.1982	
	XIII	30.1.1981	17.2.1982	
	XIV	12.2.1981	-	
	XV	24.2.1981	-	
	XVI	6.3.1981	-	
	XVII	16.3.1981	-	
	XVIII	26.3.1981	-	
7.	Cuttings			
	I	15.11.1980	20.11.1981	As in Expt.I
	II	30.12.1980	3.1. 1982	
	III	14.2. 1981	17.2. 1982	
	IV	31.3.1982	31.4. 1982	
	V	-	14. 5.1982.	

of treatments on the growth, yield and quality of the forage as well as chemical properties of the soil.

3.3.1. Crop growth and yield

a. Plant height

b. Leaf : stem ratio

c. Proportions of berseem and oat in mixture

d. Green forage yield (q/ha)

e. Dry matter yield (q/ha)

f. Dry matter content in forage (%)

3.3.2. Crop analysis

a. Nitrogen content (%) in forage

3.3.3. Soil analysis

a. Organic matter content (%)

b. Available nitrogen (kg N/ha)

c. Available phosphorus (kg P_2O_5/ha)

d. pH

e. CEC (me/100g soil)

3.4. TECHNIQUES EMPLOYED

3.4.1. Plant height

Height of 5 plants selected at random in case of pure crops and 10 plants in case of mixed stand was measured in centimetres from ground level to the base of the last fully opened leaf at each cutting. Cumulative mean plant height was determined by summing up of the mean plant height over different cuttings.

3.4.2. Leaf : stem ratio

Samples were collected by hand clipping from two 30 cm sections in each plot. These two sampling areas within each plot were within the area to be harvested for forage yield determination and 1 m apart; otherwise, they were randomly selected at each harvest. Sampling areas were delineated for hand-clipping by use of a 'U' shaped metal rod, having 40 cm long arms and a base of 30 cm. Forage from each sampling area was separated into oat and berseem fractions in case of mixed stand and fractions from the two sampling areas in each plot were composited. The leaves were detached carefully with hand from stems and their respective weight in kgs were recorded. Leaf:stem ratio at each cutting was computed by taking leaf weight as numerator and stem weight as denominator. The weighted averages of leaf:stem ratio was worked out over different cuttings.

3.4.3. Proportions of berseem and oat in mixture

Immediately after harvest for yield determination, forage in mixed stands was separated into oat and berseem fractions and their respective weights in kgs were recorded to determine the composition of each component at each harvest.

3.4.4. Green and dry weights

Green forage samples were obtained by harvesting from a delineated area of 1 metre square quadrangle. The sampling area within each plot was so chosen, albeit randomly, that it fell within the area to be harvested for yield determination. The samples were weighed in the field immediately after the harvest, dried in a forced air dryer at 70°C for 48 hours and reweighed to record their respective dry weights. The dry matter content was determined by the relationship :

$$\text{Dry matter content} = \frac{\text{Dry weight of sample}}{\text{Green weight of sample}} \times 100$$

3.4.5. Forage yield determination

i. Forage yield: The non-experimental area - 0.5 metre all round each plot was removed by field harvesting. The remaining forage within 6 square metre area including the sampling area of 1 sq. metre was harvested and weighed immediately for green forage yield determination. In mixed crop stands, forage yields of oat and berseem fractions were recorded. The total yield for each plot was adjusted upward to include the fresh weight removed in the hand-clipping samples taken for determination of leaf:stem ratio.

ii. Dry matter yield: Dry matter yield was computed with the help of following relationship:

$$= \frac{\text{Dry matter content x green forage yield per net plot}}{100}$$

3.4.6. Plant chemical studies

i. Nitrogen content: The samples collected at different harvests for green and dry weight determinations were run for estimation of total nitrogen. Representative samples, weighing 1 g were collected after grinding and total N was determined by the modified Kjeldahl method (AOAC, 1970). Crude protein of harvested forage was determined for each plot at each harvest from samples employed in estimating DM yield and nitrogen content. Crude protein contents of pure stand and as well as mixture was computed as 6.25 times total nitrogen. Crude protein yield was calculated with the help of following relationship:

$$\frac{\text{Percentage crude protein content}}{100} \times \text{Dry matter yield}$$

3.4.7. Soil chemical studies

Soil samples were collected from 0-15 and 15-30 cm depths from each sub-plot before sowing and at the end of crop season. These samples were composited and analysed for determining the organic matter content, available nitrogen, phosphorus, CEC and pH by the methods mentioned in Table 3.2.

3.4.8. Economic studies

a. Estimation of production function: The estimation of optimum doses for different fertilizers has been done through regression analysis. The following type of production function has been used to examine the relationship between the yield of green fodder and input of different fertilizers:

$$Y = a + bx + cx^2$$

Where Y = Green fodder yield in q/ha

x = the input dose of fertilizer nutrient

a, b and c are the constants.

In the above regression equation, 'a' is the intercept which indicates the yield of fresh fodder when no nutrient fertilizer is applied. The sign of square term (x^2) indicates the scale of returns, i.e. increasing returns if it is positive and decreasing returns if it is negative.

b. Estimation of optimum dose: The production function has been used to estimate the optimum dose of fertilizer which gives maximum profit. The mathematical computation used in arriving at the optimum is as follows:

$$Y = a + bx + cx^2 \quad \text{..........(i)}$$

$$\frac{dy}{dx} = b + 2cx \quad \text{..........(ii)}$$

Equation (ii) which is the first derivative of equation (i) shows the marginal physical product. In order to get the optimum dose of input the following condition must be satisfied.

(MPPx) (PY) = Px

i.e.(Marginal physical product) (Price of output)= price of input

or MVPx = px ....(iii)

i.e. Marginal Value product = Price of input.

From equation (iii) the dose of 'x' which gives the highest net profit can be estimated. Thus, the optimum dose, yield of the crop at the optimum dose, value of the crop at optimum dose, cost of the fertilizer at optimum dose have all been computed and the net profit has been estimated by deducting the cost of fertilizer at the optimum dose from the value of the crop at the optimum dose. This is the maximum profit which can be derived from the crop by applying the nutrient at the optimum dose.

3.4.9. Statistical analysis

Observation recorded in this study were subjected to statistical analysis adopting the method described by Cochran and Cox (1963). Since crop stand differed widely in growth habit and longivity, the plant height and green forage as well as dry matter yields of individual plots were summed over each cutting for obtaining cumulative plant height and total green forage as well as dry matter yield. The variance analyses of leaf:stem ratio per cent dry matter content, crude protein content and protein yield were conducted on the basis of weighted average of different cuttings. The data recorded at different cutting stages on plant height, leaf stem ratio, green and dry fodder yield have been presented diagrammatically. The per cent values of the data were tested and found within the acceptable range, hence were not transformed into angular values before subjecting them to statistical analysis. The level of significance 'F' and 't' tests was kept at 5 per cent.

4. EXPERIMENTAL RESULTS

The treatment effects observed during the course of this investigation conducted in Rabi 1980-81 and 1981-82 through two experiments have been described in this chapter. The results have been presented with the help of data tables and suitable diagrams, wherever necessary. The relevant analysis of variance have been given in Appendix section.

A. EXPERIMENT - I

4.1. Growth, Yield and Quality

Effects of stand type, crop, seed proportions as well as nitrogen and phosphorus levels on the growth (plant height and leaf:stem ratio), yield (green and dry matter yields), forage quality (dry matter and crude protein contents) and crude protein yield have been presented through Table 4.1a to 4.1e. The corresponding analysis of variance have been appended in Appendix II.

4.1.1. Effect of stand type (Pure Vs. mixture)

The growth of forage was not significantly influenced by stand type in 1980-81; but during 1981-82 while the cumulative plant height of the mixed stand was significantly more than that of the pure stand, in case of leaf:stem ratio the pure stand was significantly superior to the mixed stand (Table 4.1a). The fodder yield (green as well as dry) was not significantly influenced by stand type in the first season (1980-81); but in the following one, maintaining a similar trend, oat+berseem mixture recorded significantly higher green and dry fodder yields than those obtained from the pure stand. Similarly, dry matter content in pure stand did not differ significantly with that of mixed stand in 1980-81, whereas during 1981-82 the dry matter content of pure stand was significantly more than that of the mixed stand.

Table 4.1a. Effect of stand type on growth (cumulative plant height and leaf:stem ratio) yield (green fodder and dry matter yields) quality (dry matter and crude protein contents) and protein yield.

Stand type	Growth		Yield(q/ha)		Quality		Protein yield (q/ha)
	Plant height (cm)	Leaf: stem ratio	Green fodder yield	Dry matter yield	Dry matter content(%)	Protein content (%)	
				1980-81			
Pure	165.0	1.04	226.35	50.08	22.70	14.99	7.63
Mixture	156.5	1.01	228.38	52.55	23.38	20.44	10.78
SEd.	7.4	0.04	18.10	3.45	0.96	0.42	0.81
CD5%	NS	NS	NS	NS	NS	0.97	1.84
				1981-82			
Pure	212.5	0.64	437.46	73.19	17.59	14.42	12.97
Mixture	289.7	0.51	733.88	120.01	16.38	18.53	22.97
SEd.	7.8	0.01	31.46	3.69	0.33	0.59	0.58
CD5%	18.0	0.02	72.61	8.52	0.77	1.36	1.34

The crude protein content of the forage was significantly influenced by the stand type in both the crop seasons (Table 4.1a). The forage producedby mixed stand contained significantly higher crude protein than that observed in the pure stand. These effects were reflected in the like manner in the crude protein yield per unit area; the increases being of the order of 41 and 77 per cent in the two crop seasons, respectively.

The data recorded on growth and yield characters at different cutting stages (Appendix IV) could not be analysed statistically, but the averages have been illustrated graphically in Fig.4 which demonstrate that in 1980-81 plant height at different cutting stages did not vary much as a function of stand type, but in 1981-82 mixed stand had comparatively taller plants from second cutting stage onwards. The leaf:stem ratio of pure stand

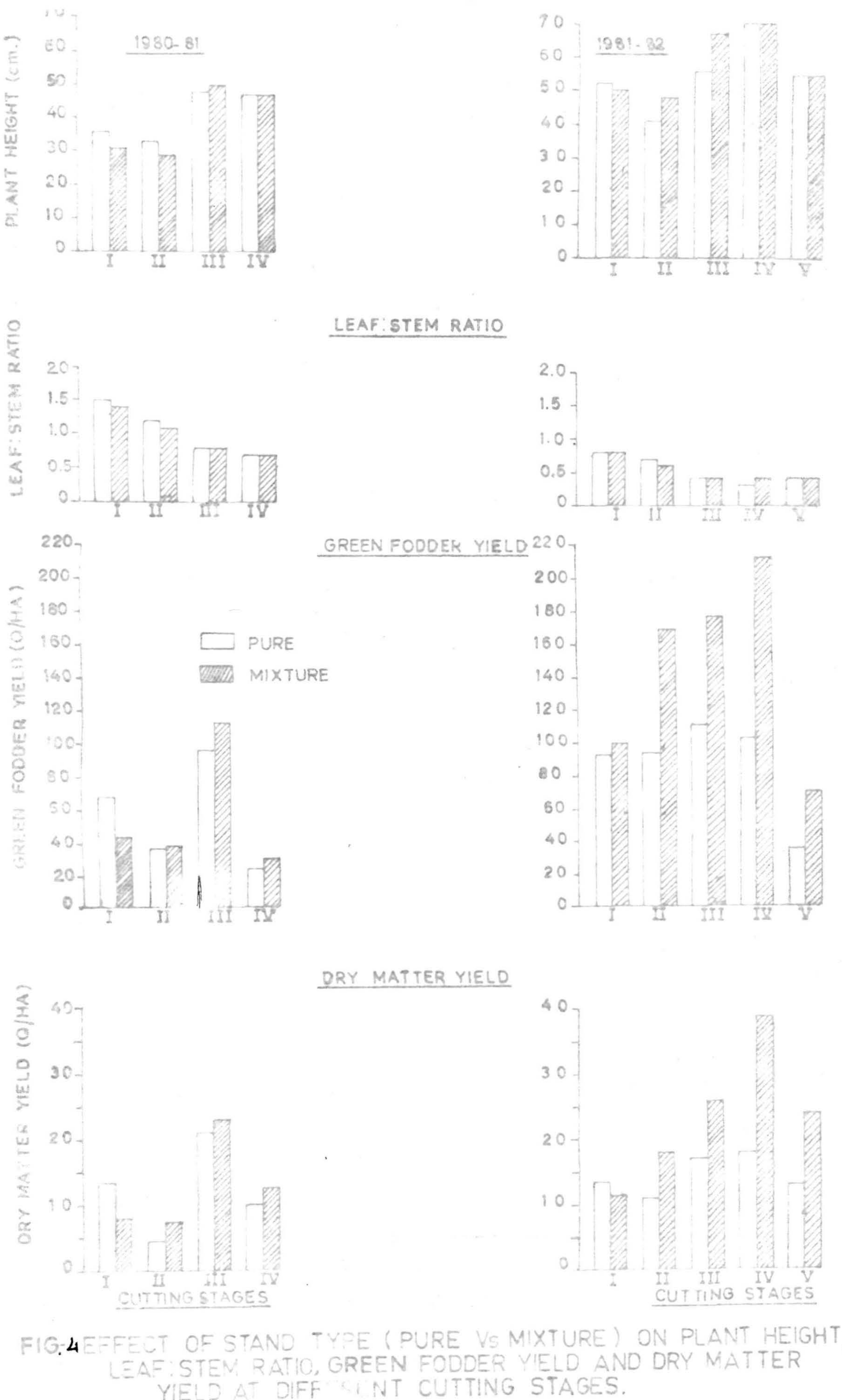

FIG.4 EFFECT OF STAND TYPE (PURE Vs MIXTURE) ON PLANT HEIGHT, LEAF: STEM RATIO, GREEN FODDER YIELD AND DRY MATTER YIELD AT DIFFERENT CUTTING STAGES.

was more than that of the mixed stand and similar trend was maintained at each cutting. Contrary to this, the green fodder yield was more in mixed stand excepting the first stage in 1980-81. Identical trend was reflected in the dry matter yield as well.

4.1.2. Effect of crops (within pure stand)

Although the data on plant height of pure oat and pure berseem were recorded and analysed statistically, yet due to the inherent differences in their growth habit and physiology, the statistical comparison between the two species are redundent and have, therefore, been omitted. The leaf : stem ratio would appear to be the only meaningful growth character for comparing pure oat and berseem. Table 4.1b shows that during both the crop seasons pure oat recorded significantly more leaf:stem ratio as compared to pure berseem. As compared to 1981-82, the leaf:stem ratio was higher in 1980-81 but the magnitude of the difference between the two crops was high during the second season.

Though pure berseem gave higher green and dry fodder yields than pure oat in both the seasons, yet the differences were significantly manifested in 1981-82 only (Table 4.1b). In a normal season (1981-82) pure berseem produced 4.5 and 4.0 times more green and dry fodder than pure oat. Contrary to this, dry matter content in pure oat was higher than that in pure berseem during both the seasons, but the difference between the two was significant only in 1981-82.

As would be expected, the per cent crude protein content of pure berseem on dry matter basis was significantly higher than that of pure oat during both the seasons. It was seen that pure berseem contained 141 per cent and 126 per cent more crude protein than was the case with pure oat in

Table 4.1b. Effect of crops on growth (cumulative plant height and leaf:stem ratio) yield (green fodder and dry matter yields), quality (dry matter and crude protein contents) and protein yield.

Crops	Growth		Yield(q/ha)		Quality		Protein yield (q/ha)
	Plant height (cm)	Leaf : stem ratio	Green fodder yield	Dry matter yield	Dry matter content(%)	Protein content (%)	
				1980-81			
Pure oat	179.3	1.12	206.83	48.71	23.55	8.79	4.34
Pure Berseem	150.7	0.96	245.87	51.44	20.92	21.20	10.94
SEd.		0.06	28.04	5.34	1.48	0.64	1.25
CD5%		0.14	NS	NS	NS	1.49	2.88
				1981-82			
Pure oat	150.0	0.92	160.82	30.07	18.86	8.84	2.73
Pure Berseem	274.4	0.36	714.11	116.32	16.32	20.01	23.22
SEd.		0.02	48.74	5.72	0.52	0.59	0.90
CD5%		0.04	112.39	13.19	1.20	1.37	2.08

1980-81 and 1981-82, respectively (Table 4.1b). The total protein yield, calculated on the basis of crude protein content and dry matter yield was also significantly higher in pure berseem than oat during both the seasons. The increases were about 2.5 and 8.5 times higher than pure oat in 1980-81 and 1981-82, respectively.

The effect of crops on characters like leaf:stem ratio, green fodder and dry matter yields at different cutting stages has been illustrated graphically in Fig.5 and the corresponding data have been given in Appendix V. The leaf:stem ratio of pure oat was higher than that of pure berseem at all the cutting stages (Fig.5). On the contrary, except for the first and second cutting stages in 1980-81, the green and dry fodder yields were more in case of berseem.

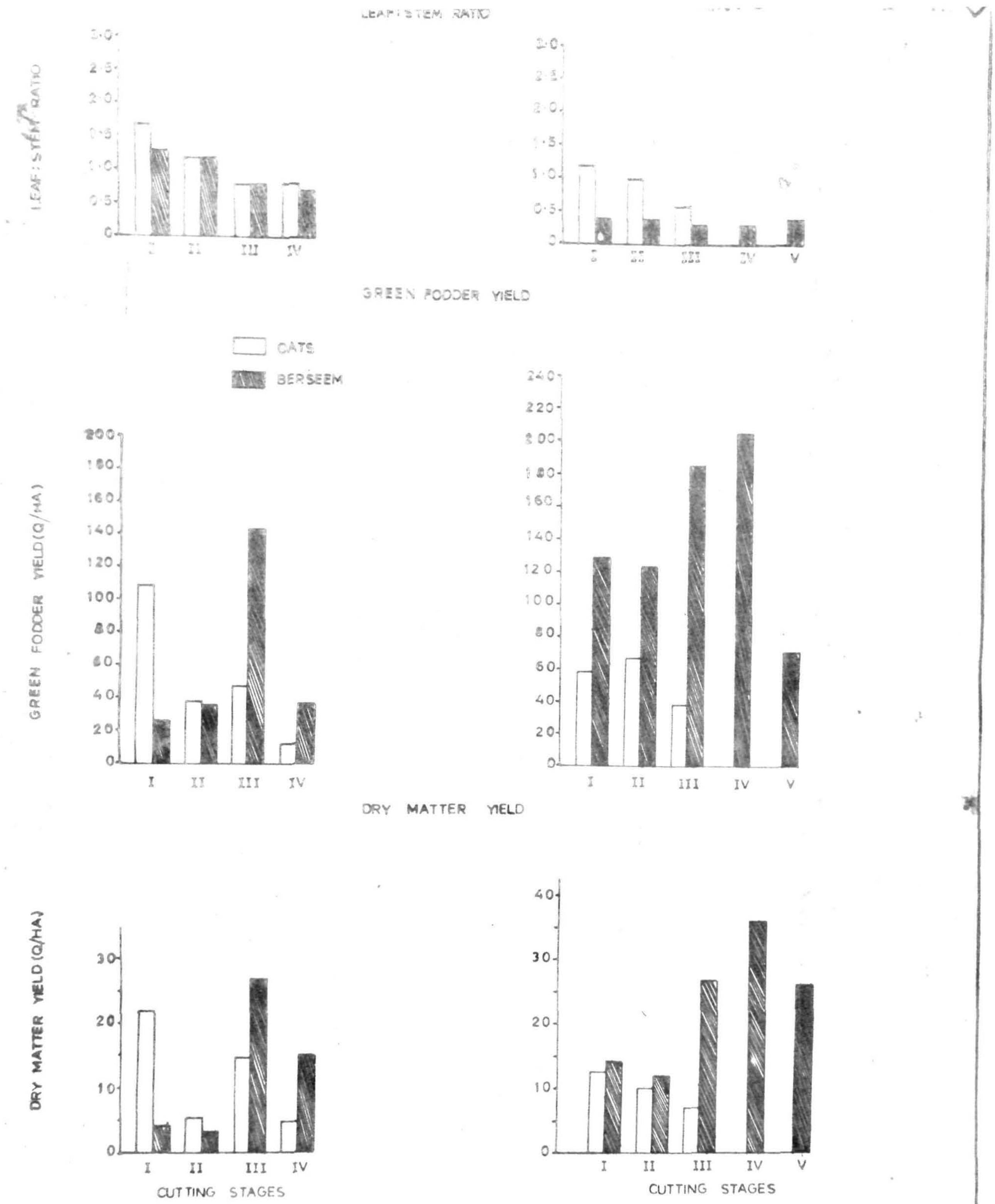

FIG.-5 EFFECT OF CROPS ON ~~PLANTHEIGHT~~, LEAF:STEM RATIO, GREEN & DRY MATTER YIELD AT DIFFERENT CUTTINGS.

4.1.3.Effect of seed proportions (Ratios within mixture)

The relevant data presented in Table 4.1c show that during both the crop seasons, mean cumulative plant height was not significantly influenced by any of the three seed proportions tried in this study, albeit mean cumulative plant height tended to be more during 1981-82 than in 1980-81. Similarly, leaf:stem ratio was also not significantly affected by the seed proportions during both the crop seasons. However, unlike mean cumulative plant height, leaf:stem ratio was low during 1981-82. Again green fodder yield was not significantly influenced during both the crop seasons, but the dry matter yield was significantly influenced by the seed proportions during 1980-81 only. The dry matter yield was comparatively low in 1980-81. Mixing the seeds of oat+berseem in 2:1 ratio recorded significantly higher dry matter yield than their mixture in 1:1 proportion. Mixtures of oat + berseem in the ratio of 1:2 was statistically at par with their mixtures in 1:1 and 2:1 proportions.

During 1980-81 the dry matter as well as crude protein contents were not significantly influenced by the seed proportions (Table 4.1c), but in 1981-82 the former was significantly affected whereas the latter was not by the seed proportions. Dry matter content of fodder obtained from 1:3 oat + berseem mixture was not only minimum but also significantly inferior to 1:1 and 2:1 proportions in that order. Protein yield was also significantly affected by seed proportions in 1980-81 crop season only. The crop raised from oat + berseem mixture of 2:1 seed ratio while remaining at par with that raised from 1:2 seed ratio, recorded significantly higher protein yield as compared to one raised from 1:1 seed ratio, the latter two proportions being statistically at par.

Table 4.1c. Effect of seed proportions on growth (cumulative plant height and leaf:stem ratio) Yield (green and dry matter yield) quality (dry matter and crude protein content) and protein yield.

Seed proportions (Ratio with in mixture)	Growth		Yield (q/ha)		Quality		Protein yield (q/ha)
	Plant height (cm)	Leaf: stem ratio	Green fodder yield	Dry matter yield	Dry matter content (%)	Crude protein content (%)	
				1980-81			
1:1	146.4	1.03	207.80	43.96	22.05	19.97	8.82
1:2	156.5	1.01	216.04	53.73	25.28	21.19	11.37
2:1	166.5	1.00	261.31	59.96	22.83	20.14	12.14
SEm±	8.1	0.03	19.83	3.77	1.05	0.45	0.88
CD5%	NS	NS	NS	12.32	NS	NS	2.88
				1981-82			
1:1	286.3	0.50	739.88	120.57	16.13	18.06	21.82
1:2	302.7	0.51	761.93	117.65	15.51	19.10	22.47
2:1	280.2	0.51	699.60	121.83	17.49	18.42	22.23
SEm±	8.6	0.01	34.46	4.04	0.37	0.42	0.64
CD5%	NS	NS	NS	NS	1.20	NS	ND

The effect of seed proportions on growth, yield and quality parameters has also been shown graphically in Fig.6. The corresponding data are given in Appendix V. The cumulative plant height did not appear to be influenced consistently by seed proportions. Whereas at one stage 2:1 seed ratio produced taller plants, while at the other stage 1:2 seed proportion produced taller plants. It was interesting to note that leaf:stem ratio was high at first cut under all the seed proportions but with the advancement of cutting stage the ratio went on decreasing. The green as well as dry matter yield increased progressively upto the third cutting stage in 1980-81

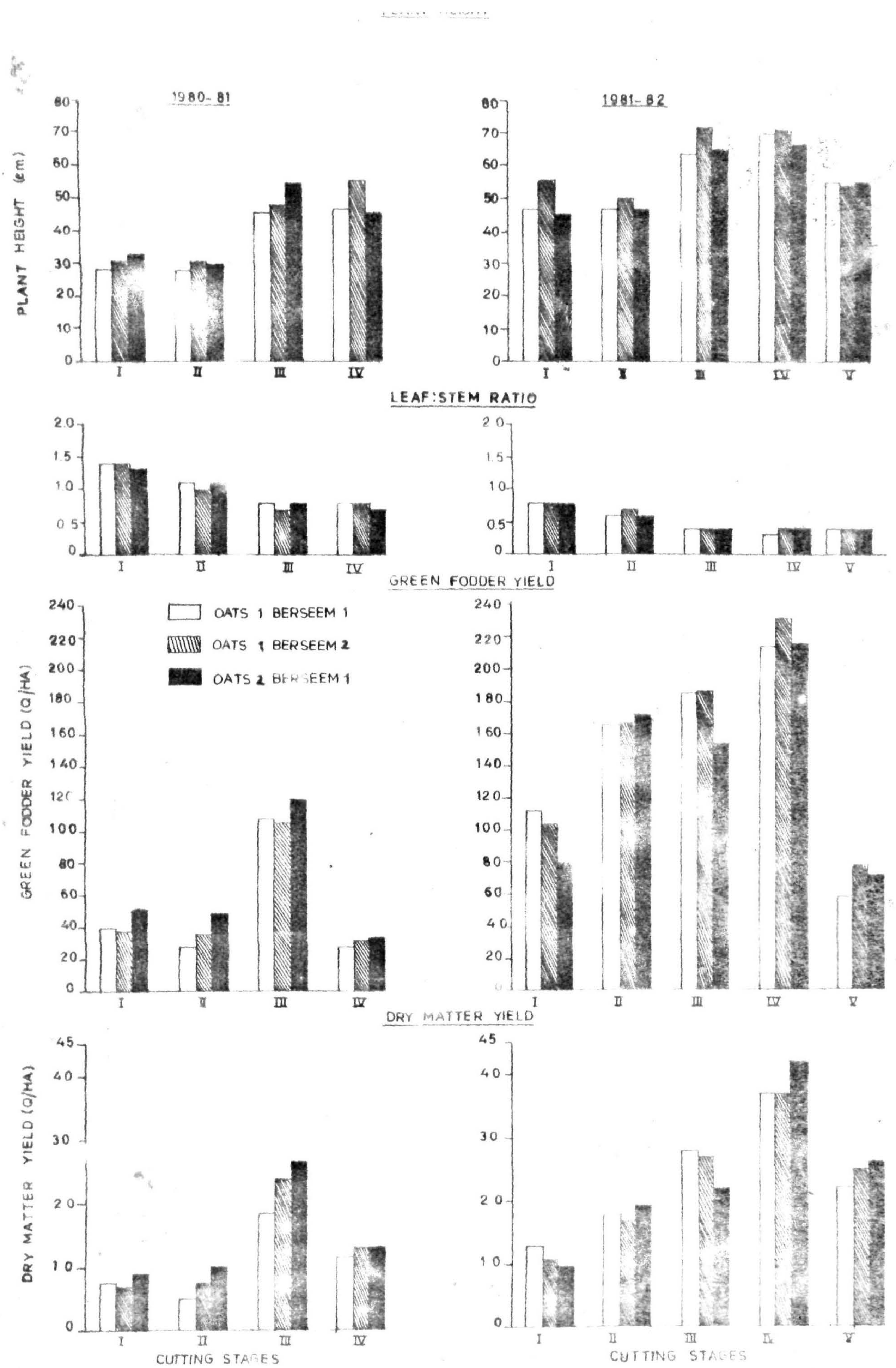

FIG.6 EFFECT OF SEED PROPORTIONS ON PLANT HEIGHT, LEAF: STEM RATIO, GREEN AND DRY MATTER YIELDS AT DIFFERENT CUTTINGS

and upto the fourth cutting stage in 1981-82. The superiority of 2:1 seed proportion in respect of dry matter production in 1980-81 was also reflected at different cutting stages (Fig.5).

4.1.4. Effect of nitrogen levels

Data pertaining to the effect of nitrogen levels have been given in Table 4.1d, which shows that mean cumulative plant height was significantly affected by the levels of nitrogen in both the seasons. In general, plant height increased with the increasing levels of nitrogen. During 1980-81 the medium andhigh levels of nitrogen produced significantly taller plants than the low level of nitrogen. However, in 1981-82, only the high level of nitrogen resulted in significantly taller plants than the low and medium levels which in turn were statistically at par with each other. Levels of nitrogen had no significant effect on leaf : stem ratio which, however, tended to be high at the low and medium nitrogen levels in both the seasons (Table 4.1d).

The green fodder yield was significantly influenced by nitrogen levels in both the seasons. During 1980-81, green fodder yield increased with an increase in nitrogen level andthe differences turned out to be signficant. However, in the second crop season only high nitrogen level registered a significant increase over the low and medium nitrogen levels, which were statistically at par with each other.

The dry matter yield was also significantly higher at high levels of nitrogen as compared to low and medium levels in 1980-81. But in 1981-82 no such influence was observed.

The dry matter content remained unaffected by nitrogen levels in both the seasons. On the other hand, crude protein content was significantly affected. During 1980-81, crude protein content increased significantly with increasing nitrogen levels. It was the highest (19.43%) at high nitrog level and the lowest (16.83%) at low nitrogen level. However, in 1981-82 the medium and high nitrogen levels, while remaining at par with each other recorded significantly higher crude protein content than that observed in the case of the low nitrogen level.

Table 4.1d. Effect of nitrogen levels on growth (cumulative plant height and leaf : stem ratio), yield (green fodder and dry matter yields) quality (dry matter and crude protein contents) and protein yiel

Nitrogen levels (kg/ha)	Growth		Yield (q/ha)		Quality		Protein yield (q/ha)
	Plant height (cm)	Leaf : stem ratio	Green fodder yield	Dry matter yield	Dry matter content (%)	Crude protein content (%)	
				1980-81			
Low (29)	154.2	1.02	203.81	47.79	23.66	16.83	8.36
Medium(58)	160.1	1.03	227.47	50.23	23.31	18.57	9.28
High (87)	165.4	1.01	251.30	56.69	23.35	19.43	10.93
SEm±	2.0	0.02	6.53	1.83	0.71	0.26	0.34
CD5%	5.6	NS	17.48	4.90	NS	0.76	0.96
				1981-82			
Low (29)	254.9	0.58	603.32	100.40	16.85	15.86	17.50
Medium(58)	256.9	0.56	600.48	100.17	17.29	17.31	18.66
High (87)	264.7	0.55	642.14	103.28	16.44	17.49	19.32
SEm±	1.98	0.01	11.38	2.67	0.42	0.20	0.59
CD5%	5.6	NS	30.46	NS	NS	0.55	NS

*Averaged over cropping systems tried in this study, the low, medium and high levels of N work out as indicated in parenthesis.

The effect of nitrogen levels on protein yield was exactly the same as observed in case of dry matter yield (Table 4.1d). In 1980-81 the protein yield was significantly higher at high level of nitrogen as compared to low and medium levels. In 1981-82, however, there was no such influence of nitrogen on protein yield which though, tended to increase with the increasing nitrogen levels.

The effect of nitrogen levels on plant height, leaf:stem ratio, green and dry matter yields at various cutting stages has been illustrated graphically in Fig.7. The corresponding data have been given in Appendix VII. A perusal of Fig.7 shows that except for the fourth stage during both the years, the medium and high levels of nitrogen had a tendency to produce taller plants. Not much of the difference was observed in leaf : stem rati at different cutting stages. Except for the third cutting stage in 1980-81 the green fodder yield went on increasing with the increasing levels of nitrogen. More or less a similar trend was observed in case of dry matter production also except that in 1980-81 there was slight deviation from this trend. That is why, perhaps, there was no significant effect of nitrogen levels on the total dry matter yield during this year (Table 4.1d).

4.1.5. <u>Effect of phosphorus levels</u>

The data presented in Table 4.1e show that, except for green forage yield in the first season (1981-82) and crude protein content in both the seasons no other growth and yield characters were affected significantly by the phosphorus levels. During 1981-82, medium and high levels of phosphorus, behaving statistically alike, gave green forage yields which were significantly higher than that obtained from the low level of phosphorus application. However, the crude protein content behaved in the like manner in both the seasons. The protein yield was also not affected by the phosphorus levels tried in this study.

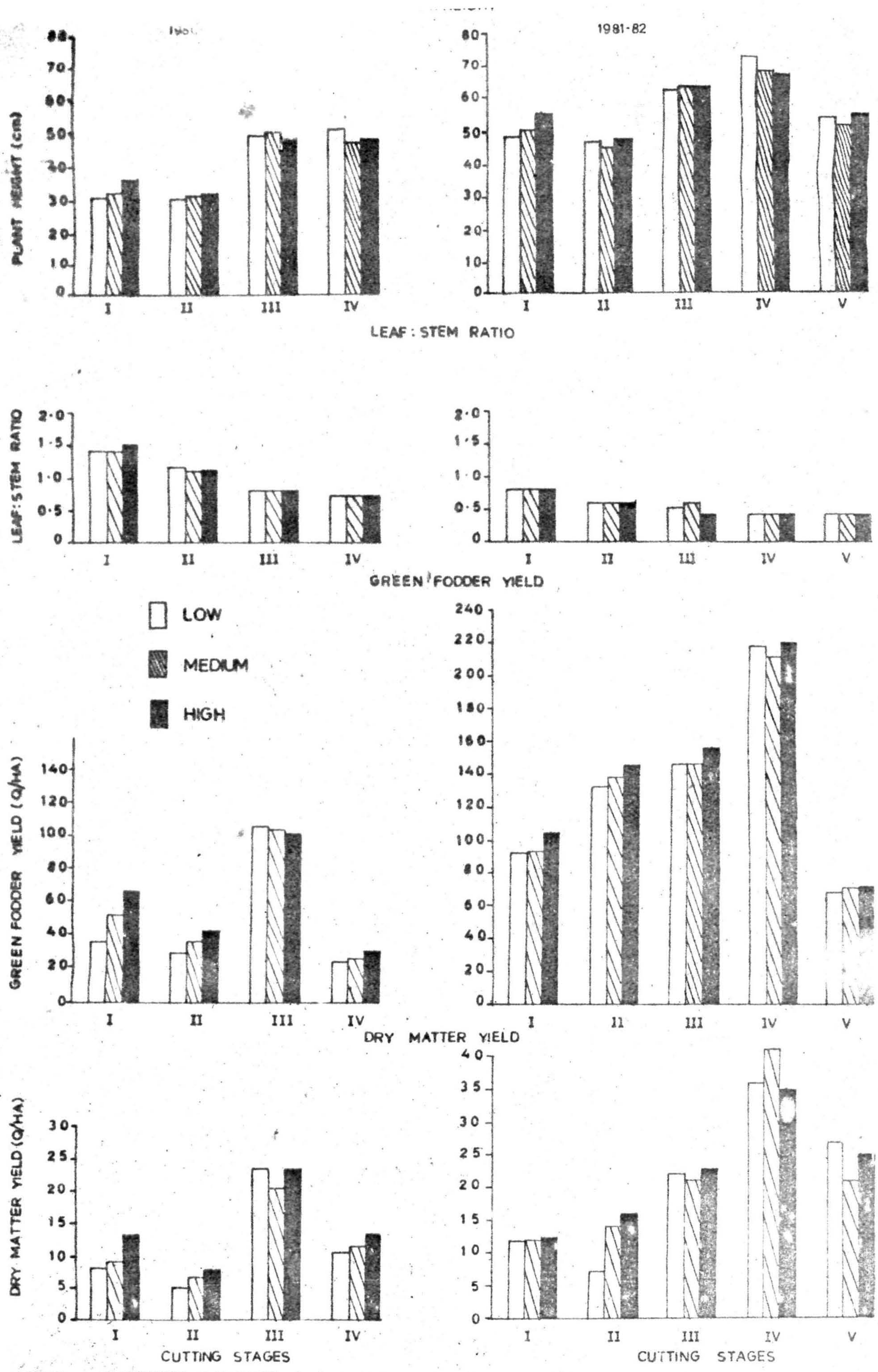

FIG-7 EFFECT OF NITROGEN LEVELS ON PLANT HEIGHT, LEAF:STEM RATIO, GREEN AND DRY MATTER YIELDSAT DIFFERENT CUTTINGS

Table 4.1e. Effect of phosphorus levels on growth (cumulative plant height and leaf : stem ratio) yield (green fodder and dry matter yields quality (dry matter and crude protein contents) and protein yield.

Phosphorus levels (kg/ha)	Growth		Yield (kg/ha)		Quality		Protein yield (q/ha)
	Plant height (cm)	Leaf : stem ratio	Green fodder yield	Dry matter yield	Dry matter content (%)	Protein content (%)	
				1980-81			
Low (40)	159.9	1.03	232.37	51.90	22.42	17.24	9.07
Medium(80)	158.1	1.03	225.51	50.27	22.78	19.14	9.73
High (120)	161.7	1.01	224.70	52.50	24.13	18.40	9.76
SEm+	1.98	0.02	6.65	1.83	0.71	0.26	0.34
CD5%	NS	NS	NS	NS	NS	0.76	NS
				1981-82			
Low (40)	256.3	0.56	590.37	99.73	17.15	16.12	17.33
Medium(80)	260.9	0.56	631.11	101.78	16.77	17.41	19.07
High (120)	259.3	0.56	624.47	102.36	16.66	17.14	19.07
SEm+	2.0	0.01	11.38	2.67	1.78	0.20	0.09
CD5%	NS	NS	30.46	NS	NS	0.55	NS

The Fig. 8 (data given in Appendix VIII) shows that there was no definite pattern of the influence of phosphorus levels on plant height, leaf : stem ratio and dry matter yield. Only the green fodder yield in 1981-82 was seen to increase as the phosphorus level was raised from low to medium level. Increasing the phosphorus level further demonstrated an increase in green fodder yield only at the second cutting stage.

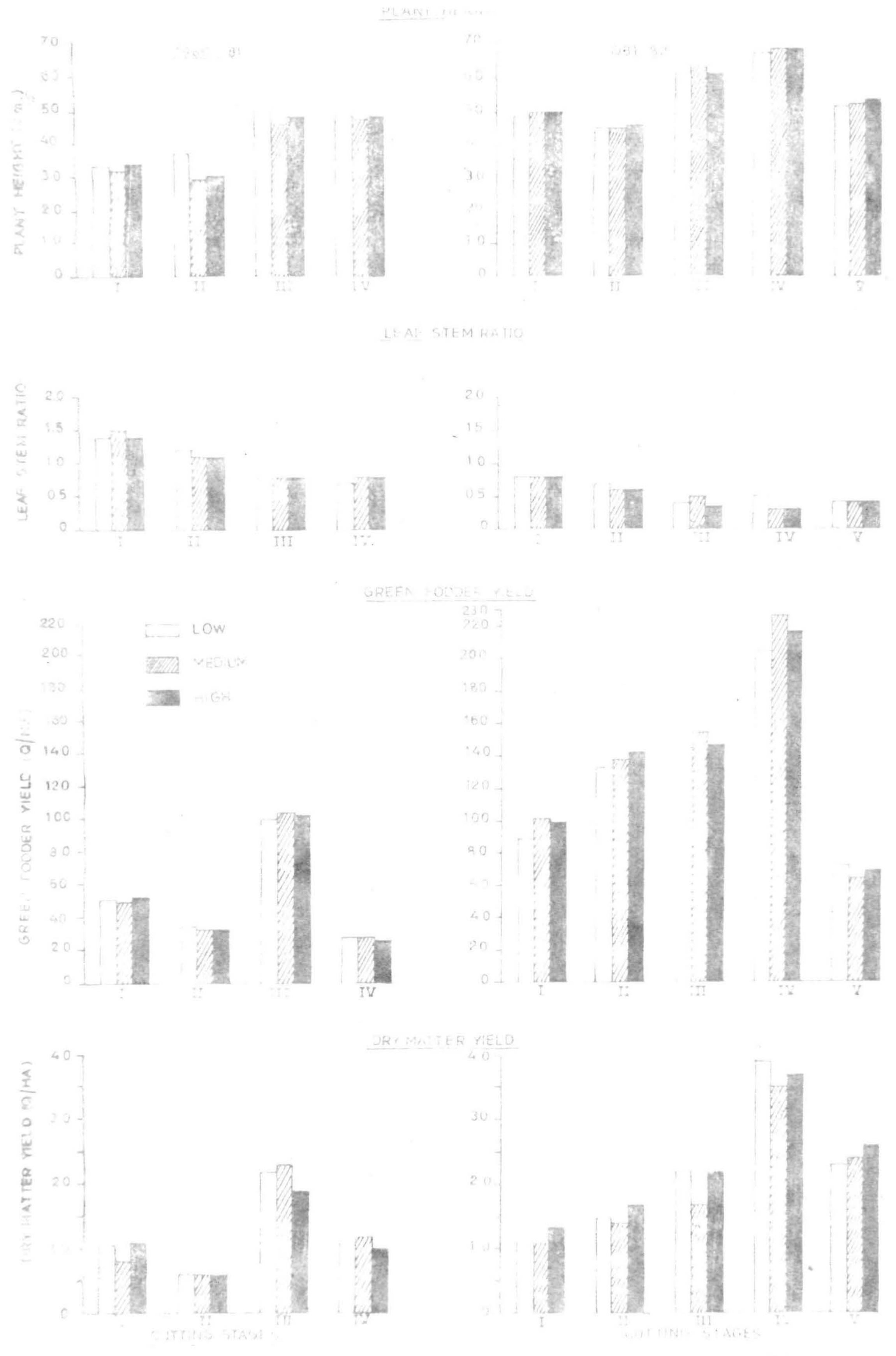

FIG. 8 EFFECT OF PHOSPHOROUS LEVELS ON PLANT HEIGHT, LEAF: STEM RATIO, FRESH AND DRY MATTER YIELDS AT DIFFERENT CUTTINGS

4.2. Interaction effects

The effect of interaction between various treatments on the growth yield and quality of oat/berseem fodder or as mixture have been presented in Tables 4.2a to 4.2k. The corresponding analyses of variance have been given in Appendix II.

4.2.1. Effect of nitrogen x phosphorus (N x P) interaction

The N x P interaction significantly affected the dry matter yield (Table 4.2a) crude protein content (Table 4.2b) and protein yield (Table 4.2c in both the crop seasons.

Table 4.2a. Effect of nitrogen x phosphorus interaction on dry matter yield (q/ha)

Phosphorus levels	Nitrogen levels					
	1980-81			1981-82		
	Low(29)	Medium(58)	High (87)	Low(29)	Medium (58)	High (87)
Low (40)	49.50	42.88	63.36	97.94	106.02	95.22
Medium (80)	47.91	50.34	52.58	104.00	99.15	102.18
High (120)	45.88	57.49	54.16	99.27	95.35	112.46
SEm±		4.49			6.55	
CD5%		8.95			13.06	

*Averaged over cropping systems tried in this study, the low, medium and high levels of N work out as indicated in parenthesis.

At low phosphorus level, in 1980-81, dry matter yield was maximum as well as significantly more than its medium and high levels when nitrogen was administered at high level, the latter two being statistically at par (Table 4.2a). At medium levels of phosphorus (80 kg P_2O_5/ha) the effect of nitrogen levels was not significant. However, under high phosphorus (120 kg P_2O_5/ha) fertility conditions the medium nitrogen level recorded significantly more dry matter yield than the lower nitrogen dose., increasing the phosphorus dose resulted in a decrease though not significant. The combinations of low phosphorus and high nitrogen gave the highest dry matter yield followed by the high phosphorus and medium nitrogen combination. During 1981-82 the dry matter yield was not significantly affected by the nitrogen levels at the low and medium levels of phosphorus. But under the condition of high phosphorus status, the highest dose of nitrogen tried produced maximum dry matter yield which was significantly superior to those obtained with the administration of low and medium levels of nitrogen.

The effect of N x P interaction on crude protein content was significant in both the crop seasons (Table 4.2b). At low level of phosphorus, high level of nitrogen gave maximum crude protein content, which behaving statistically akin to medium dose of nitrogen, was significantly superior to its lower level; in effect the significant increase was obtained only at medium level of nitrogen. However, at the high level of phosphate manuring, crude protein content increased with the increasing levels of nitrogen in both the crop seasons. At medium phosphorus level, while in 1980-81 the effect of nitrogen levels was not significantly manifested, but in 1981-82 the medium phosphorus and medium nitrogen combination recorded the highest crude protein cont t which was significantly superior to the other two combinations. The interaction effect presented in Table 4.2b clearly demonstrates that both the nutrients when administered at their respective high levels recorded the highest crude protein content in the forage on dry weight basis.

Table 4.2b. Effect of nitrogen x phosphorus (N x P) interaction on crude protein content (%)

Phosphorus levels(kg P_2O_5/ha)	Nitrogen levels					
	1980-81			1981-82		
	Low(29)*	Medium(58)*	High(87)*	Low(29*)	Medium(58*)	High(87*)
40	15.7	17.9	18.2	15.1	16.4	16.8
80	18.5	19.6	19.3	17.0	18.1	17.0
120	16.3	18.1	20.8	15.4	17.4	18.6
SEm±		0.6			0.5	
CD5%		1.3			0.9	

*Averaged over cropping systems tried in this study, the low, medium and high levels of N work out as indicated in parenthesis.

The N x P interaction significantly affected the protein yield in both the crop seasons, albeit the effects were differently manifested in the two crop seasons (Table 4.2c). In 1980-81, low phosphorus and high nitrogen combination gave maximum protein yield which was significantly superior to the combinations wherein low phosphorus was supplemented by low or medium doses of nitrogen. At medium phospharus level the dose of nitrogen tried failed to significantly influence the protein yield. However, at high phosphorus level the protein yield increased with the increasing doses of nitrogen but no significant increase was obtained when the dose of nitrogen was increased from medium to high level.

In 1981-82 at low level of phosphorus an increase in nitrogen dose from low to medium level significantly increased the protein yield but further increase in nitrogen level had no significant effect. Again, at medium level of phosphorus increasing levels of nitrogen had no significant effect on the protein yield. Like the preceding year, at high level of phosphorus protein yield increased with increasing levels of nitrogen but the significant increase over the lowest nitrogen dose was observed only with the highest dose of nitrogen, which combination recorded maximum protein yield (Table 4.2c).

Table 4.2c. Effect of nitrogen x phosphorus (N x P) interaction on protein yield (q/ha).

Phosphorus levels (kg P_2O_5/ha)	Nitrogen levels					
	1980-81			1981-82		
	Low(29*)	Medium(58*)	High(87*)	Low(29*)	Medium([illegible]*)	High([illegible]*)
40	8.22	7.43	11.38	16.15	18.81	17.03
80	9.19	9.87	10.14	19.45	19.21	18.56
120	7.67	10.34	11.27	16.90	17.95	22.36
SEm±		0.84			0.55	
CD5%		2.37			1.55	

* Averaged over cropping systems tried in this study, the low, medium and high levels of N work out as indicated in the parenthesis.

4.2.2. Effect of stand type x nitrogen level interaction

The interaction effect between stand type and nitrogen levels on leaf : stem ratio and crude protein content in 1981-82 has been presented in Table 4.2d.

Within the pure stand leaf : stem ratio narrowed significantly with the increasing levels of nitrogen, whereas within the mixed stand it remained constant irrespective of the dose applied (Table 4.2d). It was, therefore, to be expected that at the same level of nitrogen pure stand had significantly higher leaf : stem ratio than that exhibited by the mixed stand.

Table 4.2d. Effect of stand type x N levels interaction on leaf:stem ratio and crude protein content in 1981-82

Nitrogen levels	Leaf : stem ratio		Crude protein content	
	Stand type		Stand type	
	Pure	Mixed	Pure	Mixed
Low	(27.5*)0.68	(30*)0.51	(27.5*) 12.99	(30*) 17.78
Medium	(55*) 0.64	(60) 0.51	(55*) 14.74	(60*) 19.02
High	(82.5*)0.60	(90*)0.51	(82.5*) 15.54	(90*) 18.79
SEd. (i)		0.02		0.40
CD5%		0.04		0.80
SEd.(ii)		0.02		0.44
CD5%		0.04		0.88
SEd.(iii)		0.02		0.36
CD5%		0.04		0.72

*Averaged over the cropping systems tried in this study, the low, medium and high levels of N worked out as indicated in parenthesis.

i. For the comparison of difference between two stand type means at the same level of nitrogen.

ii. For the comparison of difference between two nitrogen levels means in pure stand.

iii. For comparison of difference between two nitrogen levels mean in a mixed stand.

Irrespective of the level of nitrogen tried in this study, crude protein content in forage obtained from the mixed stand was significantly higher than that of pure stand (Table 4.2d). In pure stand crude protein content in forage increased with the increasing levels of nitrogen, the difference between the medium and high levels being not significant. In case of mixed stand crude protein content increased significantly over low level when medium or high levels of nitrogen were administered but the difference between the latter two doses was not significant.

4.2.3. Effect of stand type x P level interaction

Crude protein content and protein yield were significantly influenced by the interaction between stand type x P level in 1980-81. The summary of these observations have been presented in Tables 4.2e and 4.2f, respectively.

Table 4.2e. Effect of stand type x phosphorus levels interaction on crude protein content(%) in 1980-81

Phosphorus levels (kg/ha)	Stand type	
	Pure	Mixed
40	14.39	19.15
80	15.16	21.79
120	15.43	20.37

	SEd.	CD5%
For the comparison of difference between two phosphorus level means in pure stand	0.60	1.20
For the comparison of difference between two phosphorus level means in mixed stand	0.49	0.98
For the comparison of difference between two stand type means at same level of phosphorus	0.87	1.73

The crude protein content in the forage obtained from pure stand was not significantly affected by the phosphorus levels tried in this study (Table 4.2e). In mixed stand, however, an increase in phosphorus level from low to medium resulted in a significant increase in the crude protein content. A further increase in the level of phosphatic manuring resulted in a slight decrease in crude protein content in forage obtained from the mixed stand but the differences was not significant. Again the forage obtained from the mixed stand had significantly more crude protein content as compared to that obtained from the pure stand irrespective of the level of phosphatic manuring.

Like crude protein content, protein yield was significantly more in mixed stand than the pure stand irrespective of the level of phosphorus (Table 4.2f). However, within pure stand maximum protein yield was obtained with the highest level of phosphatic manuring, whereas in case of mixed stand medium dose of phosphorus accounted for the highest protein yield. Both these combinations were significantly superior to medium dose in case of the former and low dose in case of the latter.

Table 4.2f Effect of stand type x phosphorus levels interaction on protein yield (q/ha) in 1980-81

Phosphorus levels (P_2O_5 kg/ha)	Stand type		
	Pure	Mixed	
40	7.45	10.15	
80	6.94	11.59	
120	8.52	10.58	
		SEd.	CD5%
For the comparison of difference between two phosphorus level means in pure stand		0.76	1.52
For the comparison of difference between two phosphorus level means in mixed stand		0.62	1.24
For the comparison of difference between to stand type means at the same level of phosphorus		0.70	1.39

4.2.4. Effect of stand type x N x P interaction

The second order interaction between stand type x N x P influenced the leaf : stem ratio significantly in 1981-82. The interaction effect has been presented in Table 4.2g. The widest leaf : stem ratio in pure stand was obtained at medium level of nitrogen and phosphorus. This, however, was at par with low level of nitrogen and phosphorus, low level of nitrogen and medium level of phosphorus, low level of nitrogen and high level of phosphorus and high level of nitrogen and phosphorus. The pure stand administered with high level of nitrogen and medium dose of phosphorus gave the narrowst leaf : stem ratio. In case of mixed stand the widest leaf : stem ratio was obtained when administered with high level of nitrogen and low level of phosphorus which was statistically at par with all the levels of nitrogen and phosphorus excepting the combination employing high levels of nitrogen and phosphorus, which recorded the narrowestleaf :stem ratio.

Table 4.2.g. Effect of stand type x N x P levels interaction on leaf : stem ratio in 1981-82

Fertilizer levels		Stand type	
N	P_2O_5	Pure	Mixed
Low		0.69	0.52
Medium	Low	0.60	0.52
High		0.57	0.55
Low		0.67	0.50
Medium	Medium	0.71	0.49
High		0.55	0.50
Low		0.68	0.50
Medium	High	0.61	0.51
High		0.67	0.48

	SEd.	CD5%
For the comparison of difference between NP levels in pure stand.	0.04	0.08
For the comparison of difference between NP levels in mixed stand	0.03	0.06
For the comparison of difference between stand type at the same or different levels of NP	0.04	0.07

The leaf : stem ratio of the forage obtained from pure stand was wider than that recorded by the mixed stand and the differences were significant in all the treatment combinations of nitrogen and phosphorus levels except for the combinations high level of nitrogen and low as well as medium levels of phosphorus. In these treatment combinations, leaf stem ratio in pure and mixed stand was at par with each other.

4.2.5. Effect of crops x nitrogen level interaction

The interaction between crops and nitrogen level significantly influenced green and dry matter yields in 1980-81 and the mean cumulative plant height in 1981-82. The relevant data have been presented through Tables 4.2h to 4.2j.

The interaction between crops x nitrogen application levels significantly affected the green and dry matter yields in 1980-81 (Table 4.2h and 4.2i). While isolating the effects involved in this interaction it was seen that in case of pure oat, increasing level of nitrogen resulted in significantly higher green fodder yield. Each increase in nitrogen level resulted in a significant increase in green fodder yield. In case of pure berseem, however, increase in the level of nitrogen from low (15 kg N/ha) to medium (30 kg N/ha) did increase the green forage yield but not to a level of significance. At higher level of nitrogen (45 kg N/ha) the forage yield was suppressed which indicated that the dose beyond 30 kg N/ha was detrimental to pure berseem.

Further comparison of the two pure stands at a fixed level of nitrogen application demonstrates that pure berseem, both at low (15 kg N/ha) and medium (30 kg N/ha) level of its nitrogen application resulted in higher green forage yield compared to oat receiving low (40 kg N/ha) and medium (80 kg N/ha) level of nitrogen, respectively. However, the difference was significant only at low level of nitrogen.

Table 4.2h. Crops x nitrogen level interaction effect on green forage yield (q/ha) in 1980-81

Nitrogen levels	Crops					
	Pure oat		Pure berseem			
	Kg N/ha		Kg N/ha			
Low	40	149.63	15	226.30		
Medium	80	205.94	30	259.38		
High	120	264.91	45	251.93		
					SEd.	CD5%
For the comparison of difference between two nitrogen level means in the same crop.					20.67	41.21
For the comparison of difference between two crop means at the same or different levels of nitrogen					45.10	89.93

At high level of nitrogen application, two crops did not differ significantly from each other. The highest yield was obtained in case of pure oat at high level of nitrogen but it did not differ significantly with berseem yield at any of the nitrogen levels.

Crops x nitrogen level interaction significantly influenced the dry matter yield in 1980-81. The relevent data have been presented in Table 4.2i.

An analysis of the effects inherent in this interaction reveals that the nitrogen application made at its low level (40 kg N/ha) in case of pure oat resulted in significantly low dry matter yield than that accurring from medium and high level of nitrogen applications which in turn were statistically alike. The nitrogen levels however, did not influence the dry matter yield of berseem. Further, examination of this interaction effect reveals that oat and berseem dry matter yield did not differ significantly at same or different levels of nitrogen.

Table 4.2i Effect of crops x nitrogen interaction on dry matter yield (q/ha) in 1980-81

Nitrogen levels	Crops			
	Pure oat		Pure berseem	
	Kg N/ha		Kg N/ha	
Low	40	36.95	15	51.79
Medium	80	51.98	30	49.99
High	120	57.22	45	52.56

	SEd.	CD5%
For the comparison of difference between two nitrogen levels at the same crop stand.	5.80	10.97
For the comparison of difference of two crop means at the same or different level of nitrogen.	10.37	20.69

Crops x nitrogen level interaction also influenced the mean cumulative plant height in 1981-82. The interaction effect has been presented in Table 4.2j.

It is clearly evident from the Table 4.2i that pure oat at its high level of nitrogen application (120 kg N/ha) produced plants which were significantly taller than those adminstered with low (40 kg N/ha) and medium level (80 kg N/ha) of nitrogen, respectively. However, in case of pure berseem, nitrogen levels did not bring out the difference to a significant level. Rather a decreasing trend in plant height was observed with each increment of nitrogen level.

Table 4.2j Effect of crop x nitrogen level interaction on mean cumulative plant height (cm) in 1981-82

Nitrogen levels	Crops			
	Oat		Berseem	
	Kg N/ha		Kg/N/ha	
Low	40	135.9	15	277.4
Medium	80	147.9	30	275.2
High	120	167.7	45	270.7

	SEd.	CD5%
For the comparison of difference between two nitrogen levels at the same crop stand.	6.3	12.3
For the comparison of difference of two crop means at the same or different level of nitrogen	8.90	17.75

As stated earlier also, because of the difference in plant species the comparison of plant height between two crops (i.e. oat and berseem) has not been made.

4.2.6. Effect of crops x N x P interaction

The leaf : stem ratio was significantly influenced by the crops x N x P level interaction in 1981-82. The data pertaining to these observations have been presented in Table 4.2k.

An assessment of the effects inherent in this interaction demonstrates that in case of pure oat the widest leaf :stem ratio was obtained at medium level of nitrogen supply (80 kg N/ha) accompanied by medium level of phosphorus (80 kg P_2O_5/ha). This however, was at par with low levels of nitrogen and phosphorus (40 kg each of N and P_2O_5/ha) and high levels of nitrogen and phosphorus (120 kg each of N and P_2O_5/ha).

Nitrogen and phosphorus levels did not seem to have influenced the leaf : stem ratio significantly in case of pure berseem. Further, it was seen that at all levels of NP combinations pure oat resulted in significantly **wider** leaf : stem ratio as compared to pure berseem.

Table 4.2k. Effect of crops x N x P level interaction on leaf : stem ratio in 1981-82

Fertilizer levels		Crops			
Nitrogen	Phosphorus	Pure oat	Pure berseem		
Low		1.01	0.37		
Medium	Low	0.87	0.33		
High		0.79	0.35		
Low		0.94	0.40		
Medium	Medium	1.07	0.36		
High		0.76	0.34		
Low		0.93	0.43		
Medium	High	0.88	0.35		
High		1.01	0.34		
				SEd.	CD5%
For the comparison of different between two NP levels in pure stand				0.06	0.11
For the comparison of difference between two pure stand at same or different level of NP				0.05	0.11

4.3. Soil Chemical Properties

The soil samples after the harvest of the crop were analysed for soil pH, cation exchange capacity (CEC me/100 g soil), per cent organic matter, available soil nitrogen and available phosphorus. The relevent data have been summarised in Tables 4.3a through 4.3e. The corresponding analyses of variance have been appended in the Appendix III.

4.3.1. Effect of stand type (Pure Vs mixture)

The data pertaining to the effect of stand type on various soil chemical properties presented in Table 4.3a show that the cation exchange capacity and the organic matter (%) were not influenced by the stand type during both the years. In 1980-81, significantly higher pH was observed in pure stand in comparison to mixed stand. The trend was more or less same in 1981-82 but the difference was not significant. Significantly higher available nitrogen was observed in mixed stand in 1980-81 in comparison to pure stand. In 1981-82 also higher available nitrogen was found in the plots having oat + berseem together (mixed stand) but the difference was not significant. The quantity of available phosphorus was affected by the stand type only in 1981-82 where it was seen that significantly higher quantity of available phosphorus was found in mixed stand.

4.3.2. Effect of crops (within pure stand)

The data in respect of the effect of crops on different soil chemical properties have been presented in Table 4.3b. A perusal of the data shows that only available nitrogen in the soil was affected by different crops. It was seen that during both the years significantly higher available nitrogen was found in the soil having pure berseem. Rest of the chemical properties studied remained unaffected during both the years.

Table 4.3a. Effect of stand type on soil pH, CEC, organic matter, available nitrogen and phosphorus in 1980-81 and 1981-82

Treatments (stand type)	Soil pH	CEC me/100g soil	Organic matter(%)	Available N kg/ha	Available P_2O_5 kg/ha
			1980-81		
Pure	7.31	14.20	1.71	533.75	41.26
Mixed	7.01	14.06	1.76	555.18	39.11
SEd.	0.02	0.13	0.02	6.69	1.86
CD5%	0.04	NS	NS	15.44	NS
			1981-82		
Pure	7.17	15.33	1.88	543.79	52.52
Mixed	7.01	15.47	1.90	559.54	57.95
SEd.	0.13	0.21	0.04	8.93	1.99
CD5%	NS	NS	NS	NS	4.59

Table 4.3b. Effect of crop on soil pH, CEC, organic matter, available nitrogen and phosphorus in 1980-81 and 1981-82

Crops	Soil pH	CEC me/100g soil	Organic matter(%)	Available N kg/ha	Available P_2O_5 kg/ha
			1980-81		
Pure oat	7.36	13.90	1.52	454.24	44.83
Pure berseem	7.27	14.49	1.89	613.27	37.69
SEd.	0.20	0.73	0.19	10.38	2.00
CD5%	NS	NS	NS	23.93	NS
			1981-82		
Pure oat	7.22	15.54	1.81	462.89	50.18
Pure berseem	7.12	15.11	1.94	624.70	54.89
SEd.	0.20	0.71	0.06	13.85	3.08
CD5%	NS	NS	NS	31.93	NS

4.3.3. Effect of seed proportions (Ratios within mixture)

The comparison of seed proportions (Ratios within mixture) in respect of different soil chemical properties (Table 4.3c) shows that only in 1980-81 available nitrogen in the soil was influenced due to seed proportions. It was seen that the highest available nitrogen was found in the fields having oats + berseem in the ratio of 1:1. This was however, at par with oat+berseem having a ratio of 2:1 . Both these ratios resulted in significantly higher available nitrogen when compared with oat+berseem plots having a seed proportion of 1:2. Other proportion of soil were not affected significantly. In 1980-81, however, none of these chemical properties of the soil were influenced significantly by the seed proportion.

Table 4.3c. Effect of seed proportions on soil pH,CEC, organic matter, available nitrogen and phosphorus in 1980-81 and 1981-82

Seed proportions	Soil pH	CEC (me/100g soil)	Organic matter(%)	Available N (kg/ha)	Available P_2O_5(kg/ha)
(Ratio within mixture)			1980-81		
1:1	7.18	13.79	1.81	561.52	36.56
1:2	7.07	13.51	1.72	539.44	39.14
2:1	6.77	14.88	1.76	564.58	41.62
SEm+	0.14	0.52	0.84	7.34	2.05
CD5%	NS	NS	NS	NS	NS
			1981-82		
1:1	7.02	15.18	1.87	581.12	57.26
1:2	7.09	15.53	1.95	522.64	60.54
2:1	6.92	15.71	1.89	574.84	56.05
SEm+	0.26	0.28	0.45	9.79	2.18
CD5%	NS	NS	NS	27.62	NS

4.3.4. Effect of nitrogen levels

The data in respect of the effect of nitrogen levels on various soil chemical properties have been presented in Table 4.3d. It will be seen from the data table that soil pH, cation exchange capacity and organic matter (%) remained unaffected due to nitrogen levels during both the years. The available nitrogen andphosphorus contents of the soil however, were influenced significantly. With each increase in the nitrogen level a significant increase in the available nitrogen was observed during both the years. More or less similar trend was observed during both the years.

Table 4.3d. Effect of nitrogen levels on soil pH, CEC, organic matter, available nitrogen and phosphorus in 1980-81 and 1981-82

Nitrogen levels (kg/ha)	Soil pH	CEC (me/100g soil)	Organic matter(%)	Available N (kg/ha)	Available P_2O_5 (kg/ha)
			1980-81		
Low (29*)	7.21	13.94	1.73	472.26	38.40
Medium(58*)	7.05	14.11	1.70	545.53	40.10
High (87*)	7.14	14.30	1.79	622.04	41.35
SEm±	0.08	0.33	0.04	6.43	0.49
CD5%	NS	NS	NS	18.12	1.38
			1981-82		
Low (29*)	6.99	15.33	1.90	476.34	54.61
Medium (58*)	7.04	15.44	1.93	545.74	55.32
High (87*)	7.20	15.48	1.85	637.64	57.42
SEm±	0.08	0.36	0.06	5.87	0.45
CD5%	NS	NS	NS	16.55	1.28

* Averaged over the cropping systems tried in this study the low, medium and high levels of N work out as indicated in parenthesis.

More or less similar trend was observed in case of available phosphorus also, but in 1980-81, the significant increase was observed only when nitrogen level was raised from low to medium. Further increase to high level did not result in significant increase in available phosphorus in the soil. On the other hand in 1981-82 it was seen that an increase in nitrogen level from low to medium did not result in significant increase in available soil phosphorus. Only high level of nitrogen resulted in significant increase.

4.3.5. Effect of phosphorus levels

The data pertaining to effect of phosphorus level on soil pH, cation exchange capacity, organic matter and available phosphorus of the soil have been presented in Table 4.3e. Like the effect of nitrogen levels in this case also it was seen that the soil pH, cation exchange capacity and organic matter remained unaffected during both the years due to variation in phosphorus levels. However, unlike nitrogen the available phosphorus of the soil also remained unaffected. Only available nitrogen in the soil was influenced significantly due to phosphorus levels.

During both the years an increase in the available soil nitrogen was observed as the phosphorus levels were increased from low to medium and from medium to high. However, in 1980-81 it was observed that only low and high levels of phosphorus resulted in significant difference in available soil nitrogen whereas in 1981-82 even the medium level of phosphorus resulted in significant increase. During both the years the medium and high levels of phosphorus remained at par with each other.

Table 4.3c. Effect of phosphorus on soil pH, CEC, organic matter, available nitrogen and phosphorus in 1980-81 and 1981-82

Phosphorus levels	Soil pH	CEC (me/100g soil)	Organic matter(%)	Available N (kg/ha)	Available P_2O_5 (kg/ha)
			1980-81		
Low	7.02	14.29	1.74	532.86	39.97
Medium	7.25	13.97	1.77	546.05	39.51
High	7.12	14.08	1.71	560.92	40.43
SEm±	0.08	0.33	0.04	6.43	0.49
CD5%	NS	NS	NS	18.12	NS
			1981-82		
Low	7.05	15.27	1.88	531.61	55.11
Medium	7.12	15.05	1.86	559.93	56.30
High	7.05	15.93	1.94	568.18	55.92
SEm±	0.08	0.36	0.06	5.87	0.45
CD5%	NS	NS	NS	16.53	NS

4.4. Interaction Effects

The interaction effect of various treatments that influenced the soil chemical properties significantly have been presented in Table 4.4a through Table 4.4h. The corresponding analyses of variance have been given in Appendix III.

4.4.1. Effect of stand type x phosphorus level interaction

During both the years stand type x phosphorus levels significantly influenced the available soil nitrogen. In 1980-81, the presence of stand type x P levels interaction (Table 4.4a) indicated that the mixture receiving fairly high level of phosphorus (120 kg P_2O_5/ha) resulted in significantly higher soil nitrogen value as compared to low and medium phosphorus levels. The latter two levels were at par with each other. In pure stand, however, medium level of phosphorus while remaining at par with high level resulted in significantly higher soil nitrogen value.

Table 4.4a. Effect of stand type x P levels interaction on available soil nitrogen (kg/ha) in 1980-81 and 1981-82

Phosphorus levels (kg/ha)	1980-81		1981-82	
	Pure	Mixed	Pure	Mixed
Low (40)	518.44	542.47	528.25	533.85
Medium (80)	551.78	542.23	565.58	556.15
High (120)	531.04	580.84	537.55	588.60

	1980-81		1981-82	
	SEd.	CD5%	SEd.	CD5%
For comparison of difference between two phosphorus level means in pure stand	14.37	28.65	13.12	26.16
For the comparison of difference between two phosphorus levels mean in mixed stand	11.73	23.39	10.72	21.38
For the comparison of difference between two stand types at the same of different levels of phosphorus	13.12	26.16	11.98	23.89

In 1981-82 more or less similar trend was observed. During this season in pure stand the medium level of phosphorus resulted in highest available soil nitrogen. It was significantly higher than that obtained at low level of nitrogen. Further increase to higher level of phosphorus resulted in significant decrese in available soil N. In mixed stand, however, each increase in the phosphorus level resulted in a significant increase in available soil nitrogen. During both years high level of phosphorus (120 kg P_2O_5/ha) in mixed stand resulted in highest available soil nitrogen and except for the available nitrogen obtained at medium level of phosphorus in 1981-82 in pure stand the difference was significant.

4.4.2. Effect of stand type x nitrogen x phosphorus interaction

Stand type x nitrogen x phosphorus level interaction influenced soil pH and available soil nitrogen significantly during both the years. The data depicting the influence of this interaction have been presented in Table 4.4b. It will be seen from the data table that in 1980-81 low level of nitrogen accompanied by medium level of phosphorus in pure stand resulted in highest pH of 7.7. However, it differed significantly only from low level of nitrogen and phosphorus and medium level of nitrogen plus low level of phosphorus. In 1981-82, however, the highest pH of 7.7 was found in the plots having high level of nitrogen and low level of phosphorus. However, this was found to be at par with low level of nitrogen accompanied by medium level of phosphorus and differed significantly from low level of nitrogen and phosphorus.

In case of mixed stand during both the years medium level of nitrogen and phosphorus resulted in highest pH (7.2 and 7.3, respectively) but significant difference was observed in 1980-81 only where it differed significantly from medium level of nitrogen accomapnied by high level of phosphorus.

A close perusal of data table indicates that the highest pH of 7.7 that was obtained by supplying low level of nitrogen and medium level of phosphorus to pure crop in 1980-81 was significantly higher to the highest pH of 7.2 that was obtained in mixed stand by supplying medium level of nitrogen and phosphorus. Similarly, in 1981-82 also, it was seen that the highest pH of 7.7 that was obtained in pure stand by supplying high level of nitrogen and low level of phosphorus was significantly higher than pH value of 7.3 in mixed stand resulted by supplying medium level of nitrogen and phosphorus.

Table 4.4b. Effect of stand type x nitrogen x phosphorus level interaction on soil pH and available nitrogen in 1980-81 and 1981-82

N	P levels	Soil pH				Available N (kg/ha)			
		1980-81		1981-82		1980-81		1981-82	
		Pure	Mixed	Pure	Mixed	Pure	Mixed	Pure	Mixed
L		7.0	7.2	6.8	7.0	467.8	446.6	470.3	444.3
M	L	7.0	6.8	7.3	6.8	494.0	557.3	509.6	548.8
H		7.4	6.8	7.7	7.0	593.6	623.5	604.8	608.5
L		7.7	7.0	7.1	6.8	473.2	471.4	492.8	489.0
M	M	7.4	7.2	7.0	7.3	558.6	560.1	571.1	529.9
H		7.3	7.0	7.1	7.3	623.5	595.1	632.8	649.6
L		7.2	7.2	7.4	6.8	452.0	514.5	459.2	500.2
M	H	7.5	6.6	7.2	6.8	542.0	547.2	548.7	563.7
H		7.2	7.2	7.0	7.2	599.2	680.7	604.7	701.9
		SEd.	CD5%	SEd.	CD5%	SEd.	CD5%	SEd.	CD5%
i.		0.3	0.6	0.3	0.6	24.9	49.6	22.7	45.3
ii.		0.3	0.5	0.3	0.5	20.3	40.5	18.6	37.0
iii.		0.3	0.6	0.3	0.6	22.7	45.3	17.8	34.6

L: Low, M: Medium and H : High
i. For the comparison of difference between two NP levels in pure stand
ii. For the comparison of difference between two NP levels in mixed stand.
iii. For the comparison of difference between two stand means at the same or different levels of NP.

Stand type x nitrogen x phosphorus interaction effect also presented in Table 4.4b shows that in pure crop stand during both the year at each level of nitrogen alongwith phosphorus brought an increase in available soil nitrogen and except for low and medium level of nitrogen at low level of phosphorus the difference was significant. It was interesting to note that during both the years high level of nitrogen accompanied by medium level of phosphorus resulted in highest available soil nitrogen and was found to be at par with high level of nitrogen each at low and high levels of phosphorus.

In case of mixed stand it was seen that during both the years high level of nitrogen accompanied by high level of phosphorus resulted in highest available soil nitrogen. Only in 1981-82 it was found to be at par with high level of nitrogen accompanied by medium level of phosphorus otherwise this treatment was found to be significantly superior to rest of the treatments. A close examination of the table will further indicate that during both the years in pure stand as well as in mixed stand low level of nitrogen accompanied by low level of phosphorus resulted in lowest available soil nitrogen. Further, it was seen that during both the years, the highest available soil nitrogen that was obtained by supplying high level of nitrogen and phosphorus in mixed stand was significantly higher to the corresponding highest quantity of available soil nitrogen obtained in pure stand by supplying high level of nitrogen and medium level of phosphorus.

4.4.3. Effect of crops x nitrogen level interaction on available phosphorus

Crops x N level interaction significantly influenced the available soil phosphorus value in 1981-82 (Table 4.4c).

It was seen that available soil phosphorus increased significantly with each increase in nitrogen level in case of plots sown with pure oat and not in case of plots sown with pure berseem. In latter case slightly decreasing trend in soil phosphorus was observed with each increase in nitrogen level. However, the comparison of two crop means at the same level of nitrogen indicated that both at low and medium level of nitrogen pure berseem resulted in significantly higher available phosphorus as compared to pure oat. Again, pure berseem plots administered with its low, medium and high level of nitrogen registered significantly higher available soil phosphorus as compared to oat plots administered with low level of N.

Table 4.4c. Effect of crops x N level interaction on available soil phosphorus in 1981-82.

Nitrogen levels (kg N/ha)	Oat	Berseem	
Low	(40) 45.31	(15) 55.48	
Medium	(80) 49.30	(30) 55.05	
High	(120) 55.92	(45) 54.14	
		SEd.	CD5%
For the comparison of difference between two nitrogen level means in the same crop		1.42	2.84
For the comparison of difference between two crop means at same or different levels of N		2.85	5.69

4.4.4. Effect of crops x phosphorus level interaction

Crops x phosphorus interaction influenced the available soil nitrogen significantly during both the years. The relevant data have been presented in Table 4.4d. It was seen during both years that in pure oat an increase in phosphorus level from low to medium resulted in significant increase in available soil nitrogen. Further increase to high level resulted in a significant decrease in available soil nitrogen. However, low and high levels of phosphorus were found to be at par with each other. On the other hand the phosphorus levels did not influence the available soil nitrogen significantly in pure berseem plots. A further examination of the data table ind cates that during both the years at each level of phosphorus the available soil nitrogen was significantly higher in pure berseem in comparison to that obtained in pure oat plots.

Table 4.4d. Effect of crops x phosphorus levels interaction on available soil nitrogen (kg/ha) in 1980-81 and 1981-82

Phosphorus levels	1980-81		1981-82	
	Oat	Berseem	Oat	Berseem
40 kg P_2O_5/ha	433.0	623.5	427.5	609.4
80 kg P_2O_5/ha	515.2	616.0	500.2	603.5
120 kg P_2O_5/ha	440.4	634.7	435.0	627.0

	1980-81		1981-82	
	SEd.	CD5%	SEd.	CD5%
For the comparison of difference between two phosphorus levels at the same crop	20.3	40.5	18.6	37.0
For the comparison of difference between two crop means at the same or different levels of phosphorus	19.95	33.80	16.98	33.86

4.4.5. Effect of crops x N x P interaction

The soil pH and CEC were significantly influenced by the crops x N x P level interaction in 1980-81 and 1981-82, respectively. The data relevant to these observations have been presented in Table 4.4e.

An assortment of the effects inherent intthis interaction demonstrated that in case of pure oat the highest soil pH was observed when nitrogen and phosphorus were applied at their respective medium levels. However, it differed significantly only from high level of nitrogen when accompanied by low level of phosphorus and low level of nitrogen accompanied by high level of phosphorus. In case of pure berseem high level of nitrogen supplement with low level of phosphotus tested significantly higher pH as compared to low and medium level of nitrogen supplement with low level of phosphorus and medium and high level of nitrogen accompanied by medium level of phosphorus. Further comparison of two crops at the same or different NP combinations showed that in case of pure berseen nitrogen at higher level supplemented with low level of phosphorus resulted in significantly higher pH as compared to high level of nitrogen supplemented with low level of phosphorus or at low level of nitrogen accompanied by high level of phosphorus.

Table 4.4c. Effect of crops x nitrogen x phosphorus interaction on soil pH and CEC in 1980-81 and 1981-82

N x P levels		1980-81 Soil pH		1981-82 CEC (me/100g soil)	
		Oat	Berseem	Oat	Berseem
Low		7.3	6.8	15.8	15.8
Medium	Low	7.2	6.8	10.7	16.3
High		6.9	7.9	16.1	14.3
Low		7.8	7.7	16.8	11.0
Medium	Medium	7.9	6.9	16.2	13.3
High		7.7	6.9	14.5	16.6
Low		6.9	7.5	16.5	15.0
Medium	High	7.5	7.5	17.6	17.3
High		7.1	7.3	15.7	16.4

	1980-81 SEd.	1980-81 CD5%	1981-82 SEd.	1981-82 CD5%
For the comparison of difference between two NP level means in the same crop stand	0.4	0.9	2.0	4.0
For the comparison of difference between two pure stand means at the same or different levels of NP	0.4	0.9	1.7	3.5

Further examination of Table 4.4e reveals that in case of pure oat medium level of nitrogen accompanied by high level of phosphorus resulted in highest CEC (17.6 me/100g soil), however, it differed significantly only from that obtained by applying medium level of nitrogen supplemented with low level of phosphorus. In case of pure berseem also medium level of nitrogen accompanied by high level of phosphorus resulted in highest CEC (17.3 me/100g soil). However, it differed significantly only from low level of nitrogen accompanied by medium level of phosphorus. Interestingly it was seen that at medium level of nitrogen having low supply of phosphorus, berseem plots results in significantly higher CEC in comparison to oat. On the other hand at low level of nitrogen accompanied by ~~medium level~~ of phosphorus oat resulted in significantly higher CEC in comparison to berseem. The highest CEC (17.6 me/100g soil) which was tested in case of pure oat when the medium level of nitrogen was supplemented with high level of phosphorus differed significantly from berseem plots when low or medium level of nitrogen were accompanied by medium level of phosphorus.

4.4.6. Effect of seed proportion x nitrogen level interaction

Seed proportion x nitrogen level interaction significantly influenced the soil pH in 1980-81. The interaction effect on available soil nitrogen was observed during both the years. The data pertaining to these interaction effects have been presented in Table 4.4f. An examination of Table 4.4f show that low level of nitrogen resulted in significantly higher soil pH in comparison to that under medium nitrogen level in seed proportion of 1:1. However, it did not differ significantly with the high level of nitrogen. Under other seed proportions (1:2 and 2:1) the nitrogen levels did not result in a significant difference in soil pH. The highest soil pH (7.4) that was obtained in 1:1 seed proportion at low level of nitrogen was significantly higher than that obtained at medium or high level of nitrogen in 2:1 seed proportion.

Table 4.4f. Effect of seed proportions x nitrogen level interaction on soil pH 1980-81 and available soil nitrogen in 1980-81 and 1981-82

Nitrogen levels	Soil pH 1980-81			Available soil nitrogen (kg/ha) 1980-81			1981-82		
	1:1	1:2	2:1	1:1	1:2	2:1	1:1	1:2	2:1
kg/ha									
Low (30)	7.4	6.8	7.1	446.9	492.8	472.9	477.8	494.1	481.6
Medium(60)	6.8	7.2	6.6	554.1	558.1	552.4	563.7	507.7	570.9
High (90)	7.2	7.2	6.6	663.6	567.3	668.4	701.8	586.1	672.0
	SEd.	CD5%		SEd.	CD5%		SEd.	CD5%	
i.	0.2	0.4		20.3	41.5		18.6	37.1	
ii.	0.3	0.6		31.4	62.6		31.2	62.1	

i. For the comparison of difference between two nitrogen levels at the same seed proportion.
ii. For the comparison of difference between two seed proportions at the same or different levels of nitrogen.

The available soil nitrogen data showing the influence of seed proportion x nitrogen level interaction also presented in Table 4.4f show that during both the years as the nitrogen level was increased from low to medium or from medium to high an increase in available soil nitrogen was observed under each seed proportion. Except for the difference between medium and high level of nitrogen in 1980-81 under 1:1 seed proportion and between low and medium level of nitrogen under the same seed proportion in 1981-82 the increase was significant.

In respect of the highest available soil nitrogen that was obtained under different proportions the results were more or less consistent during both the years. In 1981-82 the highest quantity of available nitrogen was tested at high level of nitrogen in 1:1 seed proportion. This was followed by 2:1 seed proportion at the same level of nitrogen. The difference however, was not significant. On the other hand in 1980-81 the highest available soil nitrogen was tested at high level of nitrogen in 2:1 seed proportion at the same nitrogen levels. The difference albiet was not significant.

4.4.7 Effect of seed proportions x phosphorus level interaction

Seed proportion x phosphorus level interaction significantly affected the soil available nitrogen value in 1980-81 only. The relevant data have been presented in Table 4.4g.

Table 4.4g. Effect of seed proportions x phosphorus level interaction on available soil nitrogen (kg/ha) in 1980-81

Phosphorus levels	Seed proportions		
	1:1	1:2	2:1
Low (40)	555.5	539.3	532.6
Medium (80)	539.5	503.5	583.6
High (120)	589.5	575.5	577.5

	SEd.	CD5%
For the comparison of difference between two phosphorus level means at the same seed proportion.	20.3	40.5
For the comparison of difference between two seed proportion means at the same or different level of phosphorus.	18.1	36.1

It is seen from data table that high level of phosphorus application registered significantly higher available soil nitrogen in case of plots having sown with oat + berseem in 1:1 and 1:2 ratio as compared to medium level of phosphorus and remained at par with low level of phosphorus. In this instance low and medium level of phosphorus did not differ significantly from each other. However, in case of 2:1 seed proportion medium and high level of phosphorus while remaining at par with each other resulted in significantly higher available soil nitrogen. On the other hand the comparison of seed proportions at a fixed level of phosphorus demonstrated that at low level as well as at high level of phosphorus application, the seed proportions did not differ significantly in available soil nitrogen. However, at medium level of phosphorus, both 1:1 and 1:2 seed proportions behaving statistically alike tested significantly lower available soil nitrogen value as compared to 2:1 seed proportion. While comparing two seed proportion means at different levels of phosphorus it was seen that the highest available soil nitrogen that was obtained in 1:1 seed proportion at high level of phosphorus differed significantly from 1:2 seed proportion at low and medium level of phosphorus and from 2:1 seed proportion at low level of phosphorus only.

4.4.8. Effect of seed proportions x nitrogen x phosphorus levels interaction

Seed proportions x nitrogen x phosphorus levels interaction significantly influenced the available soil nitrogen in 1980-81. The data presented in Table 4.4h show that both under 1:1 and 1:2 seed proportion high level of nitrogen accompanied by high level of phosphorus resulted in highest available soil nitrogen. In 2:1 seed proportion also this fertility level combination resulted in 702.6 kg available soil nitrogen per hectare which was more or less the same as that of high level of nitrogen accompanied by medium level of phosphorus (703.7 kg N/ha).

Table 4.4h. Effect of seed proportions x nitrogen x phosphorus interaction on available soil nitrogen (kg/ha) in 1980-81

N x P levels		Seed proportions		
		1:1	1:2	2:1
Low		403.3	457.9	451.7
Medium	Low	567.2	557.7	547.0
High		669.0	602.4	599.0
Low		456.9	480.4	477.1
Medium	Medium	540.0	570.1	570.2
High		621.7	460.1	703.7
Low		513.5	540.2	490.0
Medium	High	555.0	546.7	540.0
High		700.2	639.5	702.6

	SEd.	CD5%
For the comparison of difference between two NP levels at the same seed proportion	35.2	70.2
For the comparison of difference between seed proportions at the same or different levels of NP	35.9	71.6

The highest available soil nitrogen that was obtained at high level of nitrogen accompanied by high level of phosphorus in 1:1 and 1:2 seed proportions was found to be at par with high level of nitrogen and low level of phosphorus and differed significantly from rest of the treatments.

In 2:1 seed proportion high level of nitrogen and high level of phosphorus was found to be at par with high level of nitrogen and medium level of phosphorus. Both the treatments differed significantly from rest of the treatments. The highest available soil nitrogen that was found under different seed proportions remained statistically at par. In this case also it was seen that the lowest available soil nitrogen under each seed proportion was obtained at low level of nitrogen having low level of phosphorus. An increase in nitrogen level from low to medium at the same level of phosphorus resulted in significant increase in available soil nitrogen.

B. EXPERIMENT II

Experiment II was planned with an objective of finding out the seed rates of individual crops either in pure stand or in mixed stand in respective seed ratios of 1:1, 1:2 and 2:1. Only the total green fodder and the dry matter yield was recorded during both the years. The data were analysed in Incomplete Block Simple Lattie Design. The data in respect of green fodder yield have been given in Table 4.4i and that of dry matter yield in Table 4.4j. The corresponding analysis of variance have been given in Appendix

A perusal of green fodder yield data given in Table 4.4i reveals that during both the years pure oat as well as pure berseem yield did not differ significantly due to seed rates. Further examination of the data table indicates that in 1980-81 the highest fodder yield that was obtained with a seed rate of 120 kg oat + 20 kg berseem per hectare in the ratio of 2:1 (T_8) was found to be at par with 120 kg oat + 30 kg berseem per hectare in 1:1, 1:2, or 2:1 ratio (T_{19}, T_{34}, T_{35} and T_{36}). In 1981-82 the highest green fodder yield was, however, obtained by having a seed rate of 160 kg oat + 40 kg berseem per hectare in the ratio of 1:1 (T_{31}) but it was also found to be at par with the seed rate of 120 kg oats + 30 kg berseem per hectare in all the three ratios i.e. 1:1, 1:2 or 2:1 (T_{19}, T_{20}, T_{21}, T_{34} and T_{35}).

This therefore, shows that a seed rate of 120 kg oat + 30 kg berseem per hectare can be used in any of the seed ratio (1:1, 1:2 or 2:1) for getting stable green fodder yield. This also confirms the results of Experiment-I where the seed ratios did not influence the green fodder yield significantly during both the years (Table 4.1c).

Table 4.4i. Green fodder yield (q/ha) as affected by different treatments in 1980-81 and 1981-82

Treatments			Green fodder yield (q/ha)	
			1980-81	1981-82
1. Pure oat @ 80 kg/ha			194.79	106.50
2. Pure oat @ 120 kg/ha			292.12	185.09
3. Pure oat @ 160 kg/ha			236.67	206.00
4. Pure berseem @ 20 kg/ha			218.71	730.83
5. Pure berseem @ 30 kg/ha			282.91	691.08
6. Pure berseem @ 40 kg/ha			184.75	711.41
7. Oat + berseem	80+20 kg/ha	1:1	240.45	726.83
8. "	"	1:2	218.22	770.58
9. "	"	2:1	288.92	690.50
10. "	80+30	1:1	307.80	745.75
11. "	"	1:2	243.06	754.75
12. "	"	2:1	308.97	641.41
13. "	80+40	1:1	220.81	794.08
14. "	"	1:2	220.54	858.83
15. "	"	2:1	220.39	687.75
16. "	120+20	1:1	216.31	753.91
17. "	"	1:2	188.86	756.50
18. "	"	2:1	379.65	611.58
19. "	120+30	1:1	305.00	725.91
20. "	"	1:2	232.87	773.05
21. "	"	2:1	213.77	726.25
22. "	120+40	1:1	234.20	858.60
23. "	"	1:2	245.81	747.08
24. "	"	2:1	225.17	859.66
25. +	160+20	1:1	284.99	747.75
26. "	"	1:2	236.58	819.08
27. "	"	2:1	277.85	549.75
28. "	160+30	1:1	312.71	729.58
29. "	"	1:2	242.45	757.33
30. "	"	2:1	217.41	748.50
31. "	160+40	1:1	248.67	867.91
32. "	"	1:2	209.01	703.58
33. +	"	2:1	232.10	780.50
34. "	120+30	1:1 (dummy)	318.75	807.41
35. "	"	1:2 (dummy)	282.17	774.58
36. "	"	2:1 (dummy)	271.32	617.91
	SEm±		40.09	55.99
	CD5%		114.91	163.11

Table 4.4j. Dry matter yield (q/ha) as affected by different treatments in 1980-81 and 1981-82

Treatments			Dry matter yield (q/ha) 1980-81	1981-82
1. Pure oat @ 80 Kg/ha			34.08	24.94
2. Pure oat @ 120 kg/ha			61.67	34.20
3. Pure oat @ 160 kg/ha			59.83	27.64
4. Pure berseem @ 20 kg/ha			46.33	112.31
5. Pure berseem @ 30 kg/ha			76.17	112.05
6. Pure berseem @ 40 kg/ha			52.08	104.61
7. Oat + berseem	80+20 kg/ha	1:1	46.92	124.53
8. "	"	1:2	46.42	114.54
9. "	"	2:1	38.58	108.94
10. "	80+30	1:1	71.58	112.82
11. "	"	1:2	50.50	126.46
12. "	"	2:1	68.25	82.92
13. "	80+40	1:1	42.08	125.44
14. "	"	1:2	41.83	131.25
15. "	"	2:1	48.42	118.50
16. "	120+20	1:1	49.08	130.69
17. +	"	1:2	37.00	135.92
18.	"	2:1	84.67	101.69
19. "	120+30	1:1	60.83	114.05
20.	"	1:2	62.50	116.56
21.	"	2:1	46.67	123.37
22.	120+40	1:1	44.42	135.66
23.	"	1:2	45.92	133.93
24.	"	2:1	52.92	120.21
25.	160+20	1:1	51.67	111.60
26.	"	1:2	43.50	112.95
27.	"	2:1	46.33	82.12
28.	160+30	1:1	66.42	128.01
29.	"	1:2	47.92	116.27
30.	"	2:1	62.58	119.64
31.	160+40	1:1	47.17	164.32
32.	"	1:2	38.67	111.10
33.	"	2:1	47.83	115.79
34.	120+30	1:1 (Dummy)	58.50	107.82
35.	"	1:2 (Dummy)	50.75	120.78
36.	"	2:1 (Dummy)	54.67	95.94
SEm±			9.43	12.41
CD5%			27.04	35.67

The data pertaining to dry matter yield presented in Table 4.4j show that in 1980-81, the dry matter yield of pure oat increased significantly as the seed rate was increased from 80 to 120 kg per hectare (T_1 and T_2). A further increase to 160 kg per hectare (T_3) was found to be at par with T_1 and T_2. In respect of pure berseem also the dry fodder yield increased as the seed rate was increased from 20 to 30 kg per hectare (T_4 and T_5). Further increase to 40 kg per hectare (T_6) brough a significant decrease in dry matter yield. In 1981-82, however, the dry matter yield of pure oat or that of pure berseem did not differ signifiaantly due to seed rates.

In 1980-81, like green fodder yield, the dry matter yield was also highest when a seed rate of 120 kg oats + 20 kg borseem per hectare was used in the ratio of 2:1 (T_{18}). However, this was found to be at par with 120 kg oats + 30 kg berseem per hectare in the ratios of 1:1 or 1:2 (T_{19}, T_{20} and T_{34}). Other seed rates such as 80 kg oats + 30 kg berseem and 160 kg oats + 30 kg berseem in 2:1 seed ratio (T_{12} and T_{30}) respectively also proved to be equally effective for the production of dry matter yield.

Contrary to 1980-81, in 1981-82 the highest dry matter yield was obtained by using a seed rate of 160 kg oat + 40 kg berseem per hectare in the ratio of 1:1 (T_{31}) but it was found to be at par with 120 kg oats + 20 kg berseem per hectare in the ratio of 1:1 (T_{16}) or in the ratio of 1:2 (T_{17}). This was also fould to be at par with the 80 kg oats + 40 kg berseem per hectare and 120 kg oat + 40 kg berseem per hectare in the ratio of 1:2 (T_{14} and T_{23}, respectively).

C. ECONOMIC STUDIES

This section deals with the economics of nitrogen and phosphorus fertilization of the crops/crop mixture. The economic optima have been estimated through production functions by the procedure discussed in detail under materials and methods. The prices of outputs and inputs have been shown in Table 4.4k

The regression equations have been estimated for the crop season of 1980-81 and 1981-82 with respect to nitrogen and phosphorus fertilizer application for pure stand viz; pure oat and pure berseem and their mixture in different proportions viz., 1:1, 1:2 and 2:1.

It may be pointed out here that in the production equation while one nutrient has been varied to study the response on the yield of crop, the doses of the second nutrient has been kept constant. Thus the estimation of the net profit is over and above the variable nutrient under study.

Table 4.4k. Prices of output and inputs

Commodity	Price (Rs/q)	
	1980-81	1981-82
Green fodder	20	25
Nitrogen (Calcium ammonium nitrate) 25%	384	640
Phosphorus(Single superphosphate) 16%	850	850

4.5 Economics of nitrogen fertilization

Table 4.4l presents the production function of nitrogen fertilization on the green fodder yield of pure oats, pure berseem and crop mixture in different seed ratios during two crop seasons. It can be seen from the Table 4.4l that the quadratic type of response of nitrogen fertilization was obtained only in case of pure berseem and in crop mixture in the ratio of 1:2 where the coefficient of N^2 had negative signs. The production function have also been presented graphically in Fig.9. The magnitude of the response to nitrogen fertilization in pure berseem was more in 1981-8 . To some extent this can be attributed to seasonal variation which is apparent from Table 4.4l which shows that where no nitrogen is applied the berseem fodder yield was

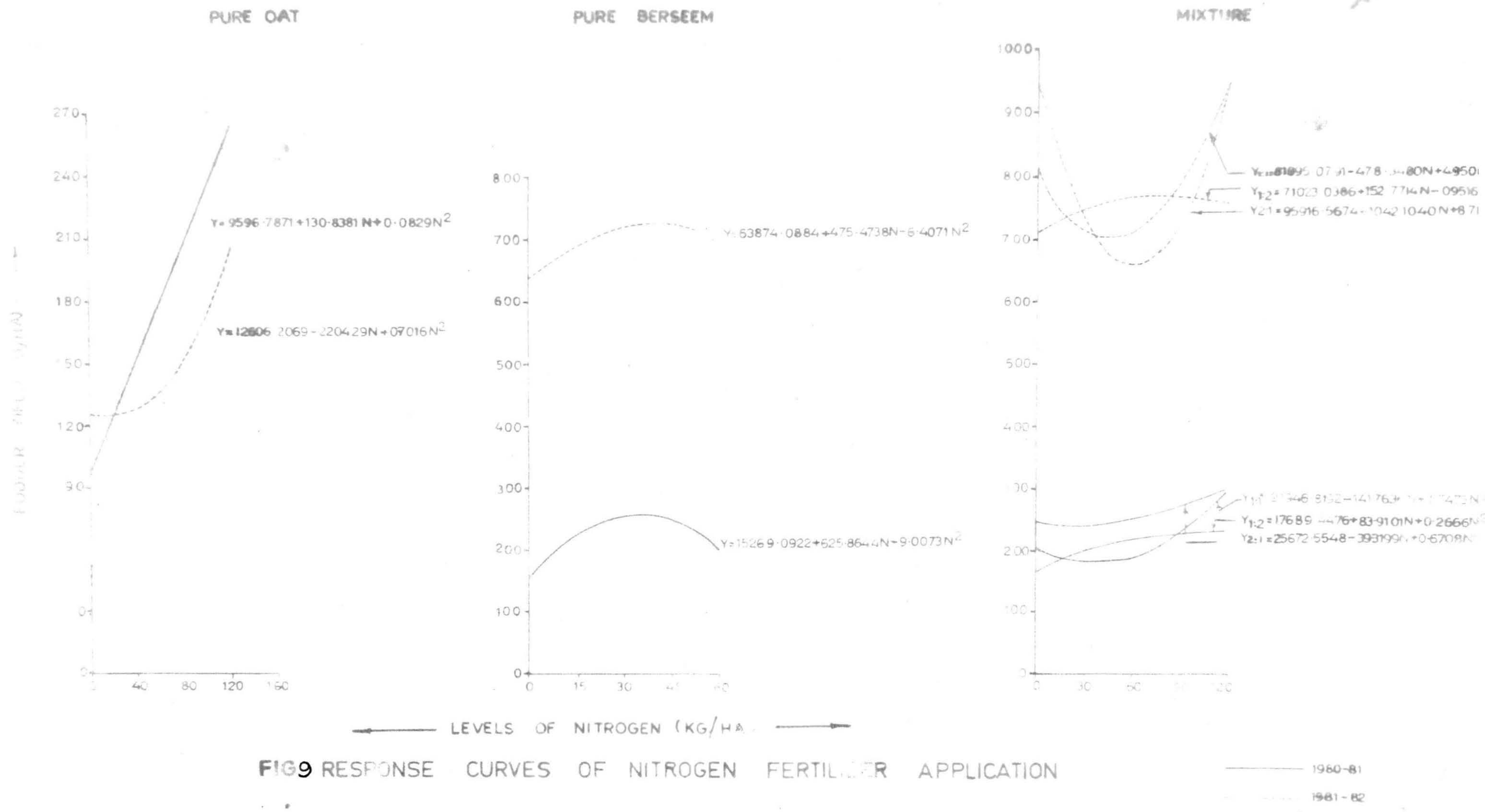

FIG9 RESPONSE CURVES OF NITROGEN FERTILIZER APPLICATION

15269.0922 kg/ha in 1980-81 and 6374.0884 kg/ha in 1981-82. Similarly in 1:2 crop mixture also it is seen that when no nitrogen was applied the fodder yield was 17,689.4476 kg/ha in 1980-81 and 71023.0386 kg/ha in 1981-82. Like pure berseem the magnitude of response in this case also was more in 1981-82.

Table 4.41. Quadratic functions of green fodder yield of oat, berseem and their mixtures in relation to nitrogen fertilization.

Crop/crop mixture	Year	Equation No.	Intercept (a)	Coefficient of N (b)	Coefficient of N^2 (c)
Pure oat	1980-81	1	9596.7871	130.8381	0.0829
	1981-82	2	12606.2069	-22.0429	0.7016
Pure berseem	1980-81	3	15269.0922	625.8644	-9.00732
	1981-82	4	63874.0884	475.738	-6.4071
<u>Crop mixture</u>					
1:1	1980-81	5	21946.8197	141.7636	1.7473
1:2		6	17689.4476	83.9101	-0.2666
2:1		7	25672.5548	-39.3199	0.6708
1:1		8	81895.0791	-478.3480	4.9508
1:2	1981-82	9	71023.0386	152.7714	-0.9516
2:1		10	95916.5674	-1042.1040	8.7125

Table 4.4m. Net profit from green fodder yield at optimum dose of nitrogen

Crop/crop mixture	Year	Optimum dose (kg/ha)	Yield at Optimum dose (q/ha)	Value of crop at optimum dose (Rs/ha)	Cost of nitrogen at optimum dose (Rs/ha)	Net profit (Rs/ha)
Pure oat	1980-81	-	-	-	-	-
	1981-82	-	-	-	-	-
Pure berseem	1980-81	33.68	261.31	5226.20	192.32	5096.88
	1981-82	35.11	726.71	18167.76	224.70	17943.06
Crop mixture						
1:1		-	-	-	-	-
1:2	1980-81	121.36	239.46	4789.20	466.02	4323.18
2:1		-	-	-	-	-
1:1		-	-	-	-	-
1:2	1981-82	66.82	769.82	19245.60	477.65	18817.90
2:1		-	-	-	-	-

Table 4.4m. presents the net profit from the crop(s)/crop mixture at the optimum doses of nitrogen in both the years. It can be seen from the table the table that the optimum dose of pure berseem was more or less same during both the years (33.68 and 35.11 kg/ha, respectively). But there was a large difference in the net profits. The net profit in the years 1980-81 was estimated at Rs.5096.88 as against Rs. 17943.06 per hectare in 1981-82. On the contrary the optimum dose of nitrogen in 1:2 crop mixture which showed a quadratic type of response was 121.36 kg/ha in 1980-81 whereas it was 66.82 kg/ha in 1981-82. Also the net profit was more in 1981-82

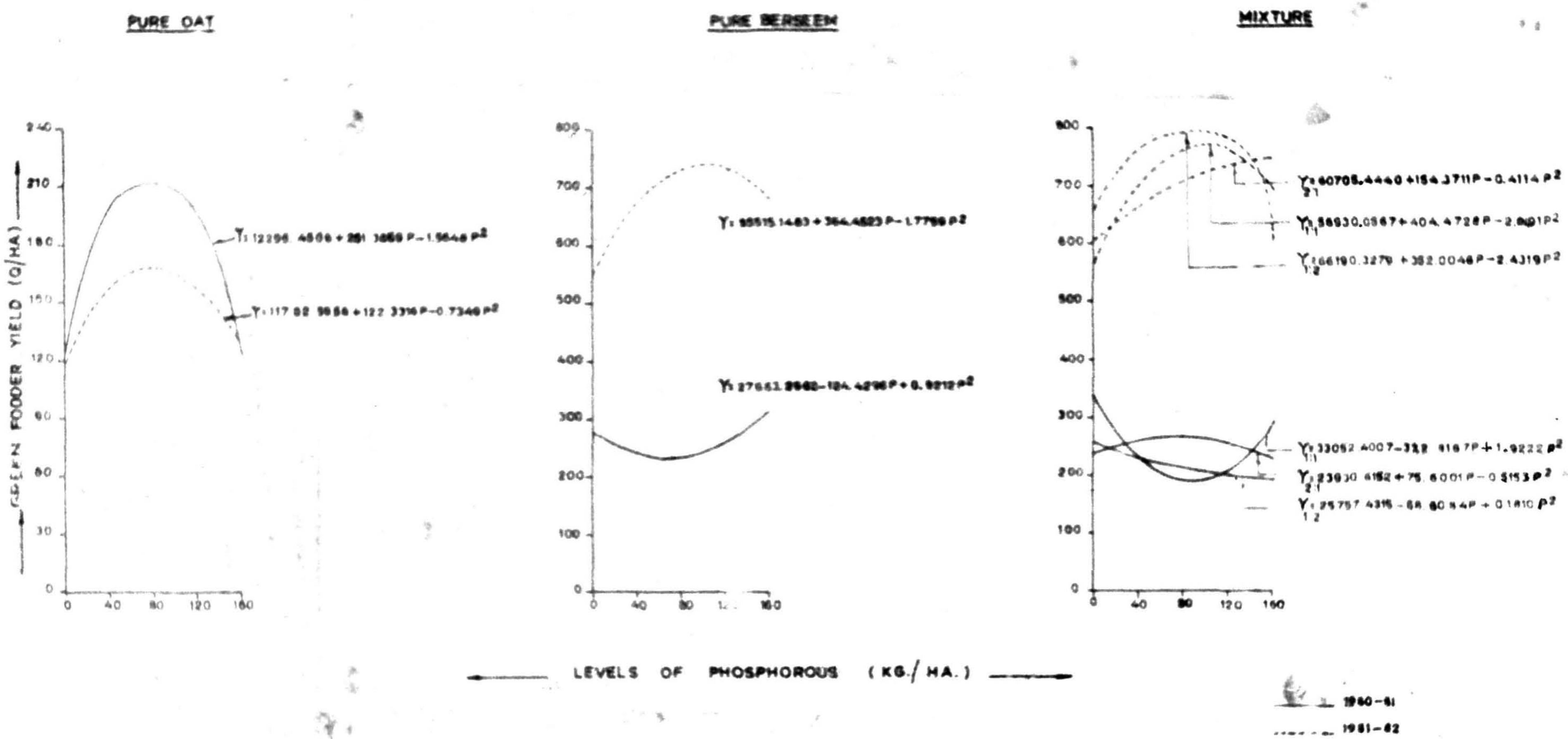

FIG.10 RESPONSE CURVES OF PHOSPHOROUS FERTILIZER APPLICATION

(Rs.18817.95/ha) in comparison to that of 1980-81 (Rs.4323.18/ha).

4.6. Economics of phosphorus fertilization

The response equations of green fodder yield of pure oat, pure berseem and crop mixtures in different seed ratios during two crop seasons have been given in Table

It can be seen from the table that the sign of coefficient of P^2 in pure oat during both the seasons, pure berseem in 1981-82 2:1 crop mixture in 1980-81, and that of 1:1, 1:2 and 2:1 in 1981-82 was negative indicating that yield increased at diminishing rates due to the phosphorus application. It can be further seen from the regression equation for pure oat that the magnitude of the b and c were relatively much higher in 1980-81 as compared to that in 1981-82. This shows that the marginal physical product in case of oats in 1980-81 were greater than the marginal physical product in 1981-82. More or less a similar trend was observed in case of 1:2 crop mixture in comparison to other two ratios (1:1 and 2:1) in 1981-82.

The production function have also been presented graphically in Fig.10.

Table 4.4n. Quadratic function of green fodder yield of oat, berseem and their mixtures in relation to phosphorus

Crop/crop mixture	Year	Equation No.	Intercept (a)	Co-efficient of P (b)	Co-efficient of P^2 (c)
Pure oat	1980-81	1	12255.4508	251.3869	-1.5648
	1981-82	2	11782.5958	122.3316	-0.7349
Pure berseem	1980-81	3	27663.2982	-124.4298	0.9212
	1981-82	4	55515.1483	364.4523	-1.7759
Crop mixture					
1:1	1980-81	5	33052.4007	-332.8167	1.9222
1:2	"	6	25757.4315	- 68.8084	0.1810
2:1	"	7	23930.6152	75.6001	-0.5153
1:1	1981-82	8	56930.0567	404.4728	-2.0491
1:2	"	9	66190.3279	352.0046	-2.4319
2:1	"	10	60705.4440	154.3711	-0.4114

The net profit from the fodder yield at the optimum doses of phosphorus fertilization have been computed and presented in Table 4.4m For pure oat the optimum dose of phosphorus was more or less same during both the years (56.75 and 60.10 kg/ha in 1980-81 and 1981-82, respectively). However, the net profit was more in 1980-81 (Rs.3845.22/ha) in comparison to 1981-82 (3609.19/ha). The quadratic type of response which was observed for pure berseem fodder yield in 1981-82 only worked out a optimum dose of phosphorus as 93.04 kg/ha resulting in a net profit of Rs.17721.88/ha. 2:1 crop mixture resulted in a quadratic type of response during both the years but the magnitude of response was quite different during both the years. Where the optimum dose in 1980-81 worked out as 32.12 kg/ha, it was 146.29 kg/ha in 1981-82. The net profit was Rs.17377.53/ha in 1981-82 in comparison to Rs.4892.40 in 1980-81. Among the crop mixture in 1981-82 1:2 seed ratio appeared to have resulted in reasonably good economic returns. The optimum dose of phosphorus was worked out as 65.38 kg/ha. in contrast to 91.40 kg/ha in case of 2:1 seed ratio. Also the net profit was more in case of 1:2 seed ratios (Rs.19146.55/ha) in comparison to Rs.18418.29 per ha of 1:1 seed ratio and Rs.17377.53/ha of 2:1 seed ratio.

Table 4.40. Net profit from green fodder yield at optimum dose of phosphorus

Crop(s)/Crop mixture	Year	Optimum dose (kg/ha)	Yield at optimum dose (q/ha)	Value of crop at optimum (Rs/ha)	Cost of phosphorus (Rs/ha)	Net profit (Rs/ha)
Pure oat	1980-81	66.75	220.63	4412.60	567.35	3845.22
	1981-82	60.10	164.80	4120.00	510.85	3609.15
Pure berseem	1980-81	-	-	-	-	-
	1981-82	93.04	740.51	18512.70	790.84	17721.86
<u>Crop mixture</u>						
1:1	1980-81	-	-	-	-	-
1:2	"	-	-	-	-	-
2:1	"	32.12	258.27	5165.40	273.02	4892.40
1:1	1981-82	91.40	767.81	19195.19	776.90	18418.29
1:2	"	65.38	788.09	19702.28	555.73	19146.55
2:1	"	146.29	744.84	18621.00	1243.47	17377.53

5. DISCUSSION

The experimental results emanating from the present investigation " Effect on growth, yield and quality of oat (*Avena sativa* Linn.) and berseem (*Trifolium alexandrinu* Juslen) grown in pure and mixed stands at varying levels of nitrogen and phosphorus" have been described in the preceding chapter and are discussed here with suitable reasoning to establish cause and effect relationship in the light of available evidences.

This study extended over two crop seasons Rabi 1980-81-82. The green forage and dry matter yield obtained during the two crop seasons differed considerably; the second year recording higher yields than the first year. The low yield during the first crop season (1980-81) may be ascribed to the following reasons:

1. Berseem was grown for the first time in the field.
2. Though irrigations were applied to the crop depending upon atmospheric demand, the weather immediately after sowing remained comparatively hot and dry for about five weeks (Fig.1) which tended to adversely affect the crop growth.
3. An unusual snowfall of 90 mm during the month of January 1981 adversely affected the crop stand of berseem when it was in its early stage of growth; consequently its regeneration was affected adversely.
4. In the first year, the response to various levels of phosphorus was low probably owing to its fixation and thus over all yield levels were low.

Contrary to this, the weather immediately after sowing the crop in 1981-82 was comparatively cool and humid and intermittent light showers during the first two weeks after sowing helped in better establishment of seedlings. The total rainfall of 581.7 mm received during this crop season was distributed normally throughout growing season (Fig.1). This also helped in dispensing with irrigation from third week of February till the end of crop season. It is also quite obvious that there might have been fairly good supply of available phosphorus as indicated by the soil phosphorus value (Table 3.2). This might have helped in better formation of root nodules thus enhancing the activities of Rhizobia and resulting in higher green and dry forage yields during this season.

That the berseem yield was low during the first crop season (1980-81) either for its cultivation for the first time in the experimental field or due to unusual snowfall during the month of January is further substantiated by the data on proportionate contribution of oat and berseem to the green forage yield (Appendix X), which show that the oat contribution remained more or less constant during both the years, whereas the proportion of berseem was quite high during the second crop season.

5.1. Effect of stand type (Comparison of pure stand with mixed)

The superiority of mixed stand, particularly during 1981-82 crop season, established the importance of the principle of forage seed mixtures. It was seen that in terms of yield (green as well as dry matter) mixed stand resulted in significantly higher yields (Table 4.1a). Increased plant height which might have contributed to high yield was obtained in mixed stand. During 1980-81 also, more or less a similar trend was observed, but the difference was not significant. This situation envisaged that under favourable environment the two species can grow in association without impinging on the environment of its neighbouring plant, i.e., there is practically no competition. Not only the total forage yield but the mixture of two species was superior in respect of quality (reflected by per cent dry matter, crude protein content and the total protein yield) also. The crude protein content as well as the protein yield were significantly higher in mixed stand during both the years. The oat + berseem mixture therefore, can be considered a desirable proposition both from yield (forage and the protein) and quality point of view.

Increased forage yields from the mixed stands of oat and berseem or legume-nonlegume forage in association has also been reported by Bacher (1949), Henderson and Davies (1955) and Tomer and Arora (1971). This situation is also true in case of grass-legume association under natural pasture. Baylor (1974) observed that inclusion of legume in sward usually resulted in increased forage yield, high quality and improved seasonal distribution of forage under natural pasture. The sole objective of a cropping system should not be merely to harvest higher yields of the crops in question but should be to maintain the soil fertility also. A mixed stand had a moderating effect on soil pH and marginal increases in organic matter (Table 4.3a). The influence, however, was not significant. Since even a marginal difference in these soil chemical properties may have a bearing in the control of soil fertility, statistical significance may not be of much relevance. The cumulative effect of these soil chemical properties was noticed in the available soil nitrogen in 1980-81 and available soil P_2O_5 during 1981-82 where mixed stand resulted in significantly higher values in comparison to that of pure stand. Though the differences were not significant in respect of available soil nitrogen during 1981-82 and available P_2O_5 during 1980-81 yet the trend was more or less same. This increase in plant nutrients, particularly available P_2O_5, was quite natural due to higher organic matter content and the decrease in pH (Table 4.3a). The release of carbon dioxide during organic matter decomposition is thought to be important in the release of inorganic phosphorus via carbonic acid influence which is formed in the soil (Tisdale and Nelson, 1970). The formation of this carbonic acid can also be held responsible for the temporary reduction in soil pH.

The better soil fertility conditions that were obtained under mixed stand can also be held responsible atleast in part for the increased green fodder and dry matter yields obtained from this stand during the second year of experimentation.

5.2. Effect of crops (Comparison of pure oat with pure berseem)

Since favourable conditions did not exist as indicated earlier for the growth of berseem during 1980-81, no significant difference was observed between pure oat and pure berseem as far as green and dry matter yields were concerned. However, during 1981-82 when favourable conditions existed for the growth of the berseem, it out yielded pure oat significantly and yield increases in respect of green and dry fodder were 4.5 and 4.0 times, respectively.

Significantly lower leaf : stem ratio that was observed in pure berseem may not be a desirable trait but it was to be expected since the leaf : stem ratio was based on fresh weight basis and the shoot of berseem usually contain more moisture in comparison to those of oat plants. This was reflected in the per cent dry matter content also which was significantly lower in the pure berseem (Table 4.1b). As expected, the crude protein content and the protein yield of pure berseem were significantly higher during both the years. The legumenous nature of berseem was evidently exhibited by the available soil nitrogen status after harvest of the crop during both the years of experimentation (Table 4.3b). Pure berseem recorded significantly higher available soil nitrogen in comparison to pure oat during both the years. Thus berseem crop not only can grow and yield higher forage yields at considerably low levels of nitrogen but can benefit the succeeding crop by way of atmospheric nitrogen fixation.

5.3. Effect of seed proportions (Comparison of seed ratios within mixture)

The mixing of two forage species at an empirical rate of varying seed proportions viz., 1:1, 1:2 and 2:1 of oat-berseem mixture showed that there was no significant influence on the mean cumulative plant height, Leaf : stem ratio, green forage yield and crude protein content during both the seasons (Table 4.1c). This suggest that both the species used their share of environment without impinging on the environment of each other when they are grown in association in any of the seed proportions. While corroborating the results with the data presented in Table 4.1b it may be suggested that for high yields the crops should be taken in mixed stand and they can be sown in any of the seed proportion (i.e. 1:1, 1:2 or 2:1). However, 2:1 seed ratio resulted in significantly higher dry matter production and protein yields compared to 1:1 seed ratio in 1980-81. This may be attributed to higher component yield of oat fraction in this seed proportion compared to that obtained in 1:1 seed proportion (Appendix X). This superiority of 2:1 seed proportion for the total dry matter production was reflected in different cutting stages also (Fig. 5).

That the green forage yield in all the seed proportions viz., 1:1, 1:2 and 2:1 using an empirical rate of 120 kg per ha of oat and 30 kg per hectare of berseem in Experiment I behaved statistically alike was confirmed through Experiment II also, where it was seen that mixture in these ratios gave more or less the same green forage yield during both the seasons (Table 4.4i). In 1980-81, berseem contribution was low in all the seed proportions and just the reverse position held good during 1981-82

Fig.11 and corresponding data presented in Appendix XI illustrate the sensitivity of the two species of contrasting habits to the seed proportion and time of cutting. In the first crop season (1980-81) the yield proportion of oat was higher than that of berseem at first and second cutting stage, while in the subsequent cuttings owing to better regeneration of berseem in comparison to oat the yield proportions of berseem improved in all the seed proportions. In a normal season (1981-82) yield proportion of berseem was high in all the 3 seed proportions (ratios within mixture) at all cutting stages except the first cutting stage in 2:1 oat-berseem seed proportion. The improved forage yield during second season as stated earlier may be due to the favourable weather conditions. The experimental data on these aspects are inadequate but it is reasonable to suggest that the two species though possessing contrasting habits with respect to leaf distribution, plant height, root distribution, mineral uptake, morphological as well as physiological characters, are able to exploit the environment more effectively in mixed stand than in pure culture, thereby giving increased over all yield (Table 4.1c, Appendix X).

The statistical significance not withstanding, 2:1 seed proportion which tended to record higher dry matter yield (Table 4.1c) also had a tendency to record higher available nitrogen status after harvest of the crop. During 1981-82, the difference was even significant when compared with 1:2 seed proportion (Table 4.3c).

5.4. Effect of nitrogen levels

Rising costs of commercial nitrogen, essential for increased forage yield have renewed the interest of forage specialists in grass-legume association. In this study nitrogen application significantly

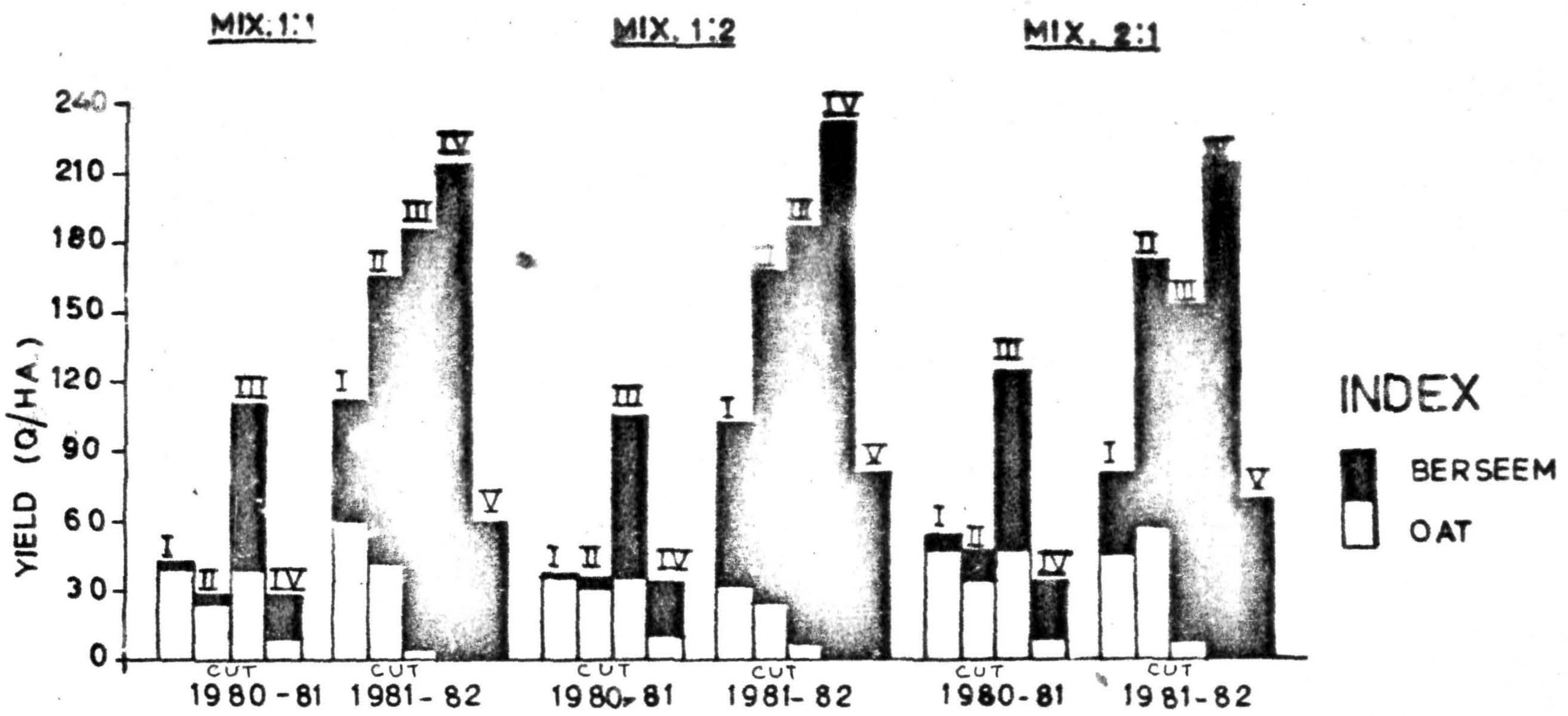

FIG. 11 RELATIVE CONTRIBUTION OF THE TWO FODDER CROPS AT DIFFERENT CUTTING STAGES

increased the plant height which accounted for the significant increase in green as well as dry matter yields and crude protein content (Table 4.1d). The better response was the result of higher productivity of plots receiving high level of nitrogen than those receiving lower or medium fertility levels of nitrogen. The increase in green as well as dry matter production with each increasing level of nitrogen may be attributed to higher meristamatic activity helping in better growth and ultimately resulting in higher yields vis-a-vis reduced formation of polysaccharides which generally accounted largely for increased crude protein in forage during both the seasons. These results are partially in agreement with those of Rathi and Vaishya (1983) who reported that increase in nitrogen application resulted in higher green forage yield, promoted dry matter production and accumulation of crude protein but adversely affected the dry matter content of the forage oat. The significant effect of nitrogen on soil chemical properties like pH, CEC, and organic matter was not evident but each level of nitrogen brought a significant increase in available soil nitrogen. In respect of available soil P_2O_5 also, there was significant increase as the nitrogen level was increased from low to medium level during 1980-81. During 1981-82, however, low and medium levels of nitrogen did not differ significantly, but a further increase to high level resulted in significantly higher available soil P_2O_5 (Table 4.3d). It can therefore be surmised from Tables 4.1d and 4.3d that increase in nitrogen levels not only resulted in increased green and dry matter yields but also increased the available soil nitrogen and phosphorus status which is an important feature in the maintenance of soil fertility particularly when exhaustive forage crops are grown.

5.5. Effect of phosphorus levels

In the light of the fact that phosphorus being an important constituent of nucleic acids phospholipids, the co-enzymes, NAD, NADP and that of ATP and consequently its involvement in the synthesis of nucleoproteins, it may not be difficult to explain that the increase in phosphorus levels from 40 to 80 kg P_2O_5/ha resulted in significant increase in crude protein content of forage during both the years (Table 4.1e). That phosphorus is found in the nucleic acid moiety of nucleoproteins molecule and is involved through ATP in the activation of amino acids for the synthesis of protein moiety, the importance of this compound is well documented (Devlin, 1973). Further, increase to higher levels of 120 kg P_2O_5 may not be required. Phosphorus not only helped in efficient nitrogen metabolism in plants but also there was more residual nitrogen in the soil when phosphorus levels were increased from low to high, i.e., 40 to 120 kg P_2O_5/ha (Table 4.3e). This further explains the desirability of phosphorus fertilization of forage crops particularly when legume is one of the components.

5.6. Effect of interaction

Nitrogen x phosphorus (N x P) was one of the most conspicuous interactions which influenced the dry matter yield, crude protein content and protein yield during both the seasons (Tables 4.2a, 4.2b and 4.2c). Phosphorus at low level when applied in conjunction with high level of nitrogen resulted in significantly higher dry matter yield of the forage as compared to all other combinations excepting high level of phosphorus supplemented with medium as well as high level of nitrogen in 1980-81. In 1981-82, the highest dry matter yield that was obtained with a nutrient combination of both nitrogen and phosphorus at high levels was found statistically at par with low level of phosphorus supplemented with medium level of nitrogen or vice-versa. Thus there seems to be a synergistic effect when both the nutrients are applied in conjunction. This may also imply that if the fertility level of soil is such that it supplies at least 40 kg of available phosphorus, a high dry matter yield of forage can be obtained by adding sufficient quantity of nitrogen. In this case nitrogen and phosphorus appear to have acted as an economic substitute for each other. This concept of substitution does not imply physiological substitution of nutrients but only that either of nutrients will increase dry matter yield when applied to soil. This is probably due to the fact that addition of one nutrient might help in better utilization of other nutrient. Further, the higher crude protein content obtained due to the application of nitrogen alongwith phosphorus (Table 4.2b) both at high level may be ascribed to the combined effect of nitrogen and phosphorus in enhancing cell division and accumulation of protein bodies and their derivatives through increased efficiency of water utilization by a forage crop and better translocation and assimilation of absorbed nutrients which in turn, have resulted in higher crude protein content vis-a-vis protein yield. Similar observations were also recorded by Bokde (1968), Tomar (1969), Sandhu et al., (1976) and Tripathi et al. (1979) in case of forage oat.

The next important interaction which influenced the green and dry matter yields significantly was the crop x nitrogen levels during 1980-81 crop season (Table 4.2h and 4.2i). It was observed that with each successive increase in nitrogen level green forage yield of pure oat increased significantly. While the application of 80 kg nitrogen per hectare gave an additional yield of 56.31 q/ha of green forage over 40 kg N per hectare, next dose of 120 kg N per hectare registered an increase of 58.97 q/ha over 80 kg N per hectare. Liberal availability of nitrogen is expected to increase the meristematic activity of plants which might have resulted in an increase in green forage yields at higher levels of nitrogen. Gill et al., (1968), Singh (1971), Saxana et al.(1971), Singh et al.,(1975), Hukkeri et al., (1977) and Tripathi et al., (1979) have also reported higher forage yields of oat due to increasing levels of nitrogen application. Likewise, Joshi and Prashad (1979) have observed a significant linear response to nitrogen upto 200 kg per hectare. Further investigation of this significant interaction showed that green forage yield of pure berseem was not influenced due to the nitrogen application levels. Although the forage yield increased as the nitrogen dose was increased from 15 kg to 30 kg N/ha but further increase to 45 kg N/ha had a retarding effect. This quadratic type of response in case of pure berseem appears to be owing to the lower responses in yields at the higher levels of nitrogen primarily caused by a possible injurious effect of ni[illegible]ogen on Rhizobia. Sinha et al.,(1982) have also experienced that the dose beyond 40 kg N/ha proved detrimental to berseem possibly due to some injurious effect on symbiotic bacteria and as a result the green forage yield was reduced to significant level. More or less similar trend was reflected in the dry matter production also (Table 4.2i).

The significant influence of stand type x P levels interaction on protein content and protein yield during 1980-81 (Tables 4.2e and 4.2f) indicated that both protein content as well as protein yield were high in mixed stand. This is also indicative of the fact that oat + berseem mixture formed a compatible mixture. Further, a higher dose beyond 80 kg P_2O_5/ha for the mixture may not be required both from protein content as well as protein yield point of view.

Stand type x P levels interaction which significantly affected the protein content and protein yield of the forage plants during 1980-81 (Tables 4.2e and 4.2f) also affected the available soil nitrogen during 1980-81 as well as during 1981-82 and the effect was more or less similar. As an increase in phosphorus level resulted in significant increase in protein content and protein yield of forage plants, more or less similar trend was observed for the available nitrogen also. However, during 1980-81, 40 and 80 kg P_2O_5/ha did not differ significantly from each other but 120 kg P_2O_5/ha resulted in significant increase in comparison to the lower two levels.

It can, therefore, be surmised that adequate supply of phosphorus in grass-legumes mixture as that of oat + berseem not only helps in improving the quality of the fodder but also results in the maintenance of soil fertility.

Crop x P level interaction which significantly influenced the available soil nitrogen during both the years indicated that at each level of phosphorus berseem significantly out yielded the pure oat. This indicated that phosphatic fertilization is more renumerative in berseem that in oat.

The 2:1 seed proportion which resulted in significantly higher dry matter yield in 1980-81 at high level of nitrogen also resulted in fairly high amount of available soil nitrogen, the difference albeit was not significant. This fact is indicated through Table 4.4h. which represented the effect of seed proportion x nitrogen level interaction on available soil nitrogen during 1980-81 and 1981-82. In 1980-81 available soil nitrogen in this proportion at high level of nitrogen was the maximum whereas in 1981-82 though the highest available soil nitrogen was tested in 1:1 seed proportion but it was at par with 2:1 seed proportion.

There were few other interactions which influenced one or the other character significantly but the interaction influences were not consistent over years. Hence they have been excluded from the discussion.

5.7. Economic analysis

The production functions were obtained with the help of second degree parabola fof the type $Y = a + bx + cx^2$ with a view to ascertaining the economic optima for nitrogen and phosphorus fertilization in different cropping systems in both the years.

It can be visualized from equation 1 and 2 (Table 4.41) that the nature of response in case of pure oat was such that green forage yield of pure oat went on increasing with each successive increase in nitrogen dose during 1980-81 and more or less similar trend was observed in 1981-82 also but response at low level of nitrogen was poor and steadly increased at higher levels. Earlier workers (Bokde, 1968, Tomer, 1968 , and Sexana et al., 1971) have also tested N doses varying from 0 to 120 kg N/ha and invariably the highest yields were obtained at the highest dose tested. A linear relationship between green forage yield of oat and applied N was obtained in this study also which suggests the need for testing still higher doses.

However, in case of pure berseem where diminishing returns were observed with nitrogen application during both the crop season (equation 3 and 4, respectively) the optimum dose worked out to more or less the same value i.e., 33.68 and 35.11 kg N/ha during 1980-81 and 1981-82, respectively. The net profit accurring from these optima was Rs.5096.88 /ha in 1980-81 as against Rs.17945.06 /ha in 1981-82. This may be attributed to the seasonal variation which is apparent from the value of intercept 'a'. The net profit in 1981-82 was 252 per cent higher compared to 1980-81 even when the cost of nitrogen increased.

In 1:2 crop mixture diminishing returns were observed due to nitrogen application during both the seasons (equation 6 and 9, respectively). The optimum dose worked out to 121.26 kg N/ha in 1980-81 as against 66.82 kg N/ha in 1981-82. The net profit in 1981-82 was 339 per cent higher compared to 1980-81. This may be attributed to higher green forage yield of berseem component in this mixture.

In respect of phosphorus application the mixture of oat + berseem in 1:2 seed proportion registered the highest net profit which was 4 and 10 per cent higher compared to 1:1 and 2:1 seed proportion, respectively in 1981-82. The net profit from pure berseem in 1981-82 was also relatively higher than 2:1 seed proportion. The higher net profit from the mixtures of 1:1 and 1:2 are attributed to higher green forage yield of berseem component and better response to P in these mixtures as compared to that in 2:1 seed proportion.

6. SUMMARY

The study entitled " Effect on growth, yield and quality of Oat (*Avena sativa* Linn.) and berseem (*Trifolium alexandrinum* Juslen) grown in pure and mixed stands at varying levels of nitrogen and phosphorus" was carried out at the Agronomy and Agronometeorology Farm, Himachal Pradesh Krishi Vishva Vidyalaya, Satya Nand Stokes Nagar, P.O.Nauni,Solan during *Rabi* 1980-81 and 1981-82 with the following objectives in view:

(i) To assess the comparative performance of berseem and oat grown in pure and mixed stands for fodder production,

(ii) to study the effect of three levels each of nitrogen and phosphorus on the growth, yield and quality of oat and berseem grown in pure and mixed stands,

(iii) to study the economics of fertilizer application to oat and berseem cultivated in pure and mixed stands, and

(iv) to find out the effect of legume and non-legume association on the fertility status of the soil.

The farm is situated an an elevation of about 950 metres above mean sea level and, based on long-term average, the annual precipitation ranges between 1000 and 1300 mm. It received an unusual snowfall of about 90 mm during the first crop season. Soils of the experimental fields were neutral in reaction, sandy loam in texture, high in organic carbon, medium in respect of available nitrogen and phosphorus and high in potassium.

Two field experiments were laid out simultaneously during both the years. Experiment I was laid out in a split-plot design with 3 replications. The main plots comprised 5 cropping systems, viz., pure oat, pure berseem, 1/2 oat + 1/2 berseem, 1/3 oat + 2/3 berseem and 2/3 oat + 1/3 berseem. Three levels each of nitrogen and phosphorus forming 9 all possible combinations were assigned to the sub-plots. In view of the differences inherent in the nutritional needs of the cropping systems studied, the nitrogen levels tried were 40, 80 and 120 kg N/ha for oat, 15, 30 and 45 kg N/ha for berseem and 30, 60 and 90 kg N/ha for mixture - phosphorus levels tried were 40, 80 and 120 kg P_2O_5/ha for both the pure and mixed stands.

The Experiment II was planned with the sole objective of finding out the best seed rate of oat and berseem either in pure or in mixed stands. The treatments comprised 3 seed rates of pure oat (80, 120 and 160 kg/ha), 3 seeds rates of pure berseem (20, 30 and 40 kg/ha), 27 all possible combinations of the mixed stands of oat and berseem (3 seed rates of oat x 3 seed rates of berseem x 3 proportions - 1:1, 1:2 and 2:1) and 3 dummy treatments. Thus there were 36 treatments which were laid out in 6 x 6 incomplete block simple lattice design. Only total green and dry matter yields were recorded.

The observations on growth (cumulative plant height and leaf : stem ratio), forage yield (green and dry matter yields), forage quality (dry matter and crude protein contents), protein yield and soil chemical properties, (pH, CEC, organic matter, available nitrogen and phosphorus) were recorded with a view to explaining the behaviour of the treatments. The important results obtained during two years of study are summarised in this chapter.

6.1. Effect on growth

1. The growth of forage (cumulative plant height and leaf : stem ratio) was not significantly affected by the stand type (pure vs mixture) in 1980-81, but during 1981-82, while the cumulative plant height of the mixed stand was significantly more than that of the pure stand, the pure stand exhibited significantly wider leaf:stem ratio than the mixed stand.

2. The leaf : stem ratio, which appeared to be the only meaningful growth character for comparing pure oat and pure berseem, was significantly wider in pure oat as compared to pure berseem in both the seasons.

3. Mean cumulative plant height and leaf : stem ratio were not significantly influenced by any of the seed proportions tried in this study. Although, the former teneded to be taller and the latter narrower during 1981-82 than in 1980-81.

4. In general, cumulative plant height increased with the increasing levels of nitrogen. In 1980-81 , the medium and high nitrogon levels produced significantly taller plants than low level of nitrogen. But in 1981-82 only high level of nitrogen resulted in significantly taller plants than the low and medium levels which in turn were statistically at par. Leaf : stem ratio which tended to be wide at the low and medium levels of nitrogen during both the season did not differed significantly from that obtained with high level of nitrogen.

5. The mean cumulative plant height as well as leaf : stem ratio was not significantly affected by varying levels of phosphorus during both the crop seasons.

6.2 <u>Effect on green and dry fodder yields</u>

1. The forage yield (green as well as dry matter) was not significantly influenced by the stand type in the first season (1980-81); but in the following one, maintaining a similar trend, oat + berseem mixture recorded significantly higher green and dry forage yields than those obtained from the pure stand.

2. Though pure berseem gave higher green and dry fodder yields than pure oat in both the seasons, yet the differences were significantly manifested

in 1981-82 only. During this season pure berseem produced 4.5 and 4 times more green and dry fodder yields than pure oat.

3. Green forage yield was not significantly influenced by the seed proportions during both the seasons. But in 1980-81 the dry matter yield was significantly influenced by the seed proportions tried in this study. Mixing the seeds of oat + berseem in 2:1 ratio resulted in significantly higher dry matter yield than mixing them in 1:1 proportion. Further, the mixed stand of oat + berseem raised in the ratio of 1:2 was statistically at par with the mixed stands raised in proportions of 1:1 and 2:1 .

4. The green fodder yield was significantly influenced by nitrogen levels in both the seasons. During 1980-81 green fodder yield increased significantly with an increase in nitrogen levels; the increases at high nitrogen level being 23 and 10 per cent over than obtained at low and medium levels of nitrogen. However, in the second crop season (1981-82) only high nitrogen level registered a significant increase over the low and medium levels, the latter two being statistically at par with each other. Dry matter yield was significantly higher at high level of nitrogen as compared to low and medium levels in 1980-81, the increases being of the order of 19 and 12 per cent.

5. During 1981-82 green forage yield was significantly influenced by the phosphorus levels. The medium and high phosphorus levels, behaving statistically alike, gave green forage yields which were significantly more than that obtained from low phosphorus level.

6.3. Effect on quality

1. Dry matter content in pure stand forage did not differ significantly with that of mixed stand forage in 1980-81, whereas during 1981-82 the former was significantly superior to latter. The crude protein content of the mixed forage was significantly higher than that of the pure stand. These effects were reflected in the like manner in the crude protein yield per unit area, the increases being of the order of 41 and 77 per cent, respectively in 1980-81 and 1981-82.

2. Dry matter content in pure oat was higher than that in pure berseem during both the seasons, but the difference between the two was significant only in 1981-82. Furthermore, the crude protein content of pure berseem (dry weight basis) was significantly higher than that of pure oat during both the seasons. Pure berseem contained 141 and 126 per cent more crude protein than pure oat in 1980-81 and 1981-82, respectively. Total protein yield was also significantly higher in pure berseem than pure oat during both the seasons. These increases were about 2.5 and 8.5 times of the values exhibited by pure oat in 1980-81 and 1981-82, respectively.

3. During 1980-81 the dry matter as well as crude protein contents were not significantly influenced by the seed proportions. However, in 1981-82 the dry matter but not the protein content was significantly affected by the seed proportions trend. The dry matter content of the fodder obtained from 1:2 oat + berseem mixture was significantly inferior to 1:1 and 2:1 proportions in that order. Protein yield was also significantly affected by seed proportions in 1980-81 crop season only. The mixture of 2:1 seed ratio, while remaining at par with that of 1:2 seed ratio, recorded significantly higher protein yield as compared to 1:1 seed ratio, the latter two proportions being statistically at par.

4. The dry matter content remained unaffected by nitrogen levels in both the seasons. On the other hand, crude protein content was significantly affected. During 1980-81 crude protein content increased significantly with an increase in nitrogen levels. It was the highest (19.43%) at high nitrogen level and the lowest (16.8%) at low nitrogen level. However, in 1981-82, the medium and high levels, while giving similar values, recorded significantly higher crude protein content than that observed in case of the low nitrogen level. In 1980-81, protein yield was significantly higher at high level of nitrogen as compared to low and medium levels. In 1981-82, however, no such influence was observed though the protein yield tended to increase with the increasing nitrogen levels.

5. Only the crude protein content was significantly influenced by the phosphorus levels tried during both the seasons. The forage produced by medium and high levels of phosphorus, behaving statistically alike, contained more crude protein compared to that obtained with low level of phosphorus during both the season.

6.4 Effect on chemical properties of soil

1. Barring one exception, the soil chemical properties such as pH, CEC, and organic matter content were not significantly influenced by the main effects of this study. However, the soil pH during 1980-81 was significantly higher in pure stand than in mixed stand.

2. During both seasons a marginal increase in organic matter content was observed in plots sown with oat + berseem, compared to those sown with pure oat and pure berseem.

3. In 1980-81, the plots sown with oat + berseem recorded significantly higher available soil nitrogen than was the case with those of pure stand. Similar trend was observed in 1981-82 but the difference was not significant.

4. The plots sown with pure berseem exhibited significantly higher available soil nitrogen during both the seasons than those of pure oat.

5. In 1981-82, the highest available nitrogen that was tested in the field having been sown with oat + berseem in the ratio of 1:1 behaved statistically akin to 2:1 see ratio. These ratios,in turn, recorded significantly higher available soil nitrogen content as compared to 1:2 seed ratio.

6. Significant increases in available soil nitrogen were observed with each increase of nitrogen level during both the years.

7. Significantly higher available soil nitrogen was obtained when phosphorus was administered at high and medium levels as compared to that obtained at its low level. The former two levels, however, remained statistically alike during both the years.

8. In 1981-82, significantly higher available soil phosphorus was recorded in plots sown with oat + berseem as compared to those sown with pure oat and berseem.

9. The available soil phosphorus remained unaffected by the crops, seed proportions and phosphorus levels tried. However, nitrogen levels significantly influenced the available soil phosphorus status during both the seasons. In 1980-81, medium and high nitrogen levels, behaving statistically alike, exhibited significantly higher available soil phosphorus values than the low nitrogen level. However, in 1981-82, high levels of nitrogen resulted in significantly more available soil phosphorus value as compared to low and medium nitrogen application levels. The latter two being statistically at par with each other.

6.5. Interaction effects

1. The N x P interaction significantly influenced the dry matter yield, crude protein content and protein yield during both the crop seasons. Invariably, both the nutrients when administered in combination at their respective high levels recorded maximum dry matter yield, crude protein content and protein yield, which were significantly superior to the combination involving low levels of phosphorus and nitrogen.

2. The interaction between crop and N levels significantly affected the green and dry forage yields in 1980-81. The pure oat green forage yield increased significantly with the increasing levels of nitrogen, whereas the pure berseem green forage yield was not significantly influenced by the nitrogen levels tried in this study. At the respective low levels of the two crops, the green forage yield of pure berseem was significantly higher than that of pure oat. Dry matter yield of pure oat was significantly more at high (120 kg N/ha) and medium (80 kg N/ha) levels of nitrogen compared to its low (40 kg N/ha) level. The latter two were statistically at par. The nitrogen levels failed to significantly influence the pure berseen dry matter yield. Further, the dry matter yields of pure oat and pure berseem did not differ significantly from each other, irrespective of the nitrogen levels tried.

3. The green forage and dry matter yields were not significantly influenced by the crop x P, seed proportion x N, seed proportion x P, crop x N x P, and seed proportion x N x P interactions during both the crop seasons.

6.6. Economic analysis

Under the favourable weather conditions of 1981-82 the responses to applied nitrogen and phosphorus were better than in the unfavourable season (1980-81). Thus, higher net profits were obtained in the 1981-82 cropping season.

The oat + berseem cropping system, where the two crops were sown in the proportion of 1:2 gave more net profit (Rs.18817.90/ha) than pure berseem (Rs.17,943.06/ha). The optimum nitrogen doses for the two cropping systems worked out to 66.82 kg N/ha and 35.11 kg N/ha, respectively. The optimum dose of phosphorus for oat + berseem grown in the ratio of 1:2 was found to be 65.3 kg P_2O_5/ha. At this level of manuring, the net profits amounted to Rs.19146.55/ha.

CONCLUSION

The studies convincingly demonstrated the superiority of pure berseem over pure oat in green and dry matter production as well as protein yield. Growing of the two fodder crops in a mixed stand, irrespective of their individual seeding proportions, proved to be a sound practice both from the yield as well as quality point of view. The optimum dose of nitrogen for pure berseem ranged between 33 and 35 kg per hectare. The optimum dose of phosphorus for pure oat ranged between 60 and 67 kg per hectare. In the absence of consistent results during the two years the optimum doses of nitrogen for pure oat and mixtures and that of phosphorus for pure berseem and mixtures could not be worked out and therefore need further confirmation before passing on the recommendations to the farmers.

LITERATURE CITED

Arora, K.N. and Jackson, M.G. 1969. Effect of variation in nitrogen and phosphorus levels on the yield and quality of berseem (T.780). Annual Report of Experiment Station, U.P.Agril. Univ. Pantnagar, pp. 131-132.

Bacher, I. 1949. Mixed crops of oats and peas. Results of experiments with mixed crop of oats and peas carried out by Agronomy Experiment Station of Sweden during the year 1936-43 (c.f. Indian J.Agric. Sci. 38 : 971-977.

Bains, S.S. 1961. Phosphate fertilization of berseem (Trifolium alexandrinum) with and without potash and/or nitrogen. 1. Effect on forage yield and soil productivity. J. Indian Soc. Soil Sci. 9:281-7.

Barak, K. 1963. The effect of different degrees of ammoniation of superphosphate on yield and quality of oats and barley. Sborn. vys. Skol. Zemed. Lesn. Brne A.No.2:83-90. (c.f.Soils and Fertilizers, Vol. XXVII, 431).

Bartholomew, R.P. 1950. Crop rotation and fertilization for soil improvement Arkansas Agric.Expt.Sta. Bull. 497-188 (1950).

Baylor, J.E. 1974. Satisfying the nutritional requirement of grass-legume mixture (c.f. Agron. J. 75, July-August 1983 pp.582-582).

Bhaid, S.U. 1964 . Relative efficiency of soil and foliar application of different levels of nitrogen on the growth, nutrient uptake and yield of oat varieties. Ph.D thesis, I.A.R.I.,New Delhi.

Blaser, R.E.; Volk, G.M. and Smith, F.B. 1941 . The yield, composition and nodulation of several clover varieties as affected by sources of calcium and phosphorus in combination with other fertilizers on several soils, Proc.Soil Sci. Soc.Amer. 6: 298-302.

Bokde, S. 1968 . Effect of different levels of nitrogen application and cutting intervals on growth, yield and quality of two varieties of oat. I. Oat grown for fodder. Indian J.agric. Sci. 38 (5): 887-909.

Bondale, K.V. 1967 . Berseem enters Chhattisgarh farming. Gosamvardhana. 15(9) : 11-12.

Burozyk, E. and Cwojdzinski, W. 1967 . Introductory investigations on the effect of fertilizing grasses with high nitrogen rates on the yield of green and dry matter as well as of raw protein. Pam. Pulaw. No. 24: 203-15 (c.f.Herb.Abstr. Vol.XXXVIII:92).

Chandnani, J.J. and Obhrai, S.R. 1955. Studies on the relative values of different phosphatic manures. Indian J.agric.Sci.25(3):175-92.

Chandnani, J.J. 1958 . Role of berseem in irrigated agriculture. Indian J. agric.Sci. 28(3): 355-8.

Chhillar, R.K. 1980. Effect of levels of nitrogen and phosphorus on the yield of oat in sodic soils. Indian J.Agron.25(3): 512-13.

Chopra, J.D. 1950 . Punjab Farmer, April 1950. Quoted by Chandnani and Obhrai (1955).

Chopra, J.D. 1961 . Quoted by Bokde (1968).

Cochron, W.G. and Cox, G.M.1963. Experimental Designs. New York John Willey & Sons. Inc. Tokyo, Charles E. Tutt

Crofts, F.C. 1966 . The effect of seedling rate and nitrogen fertilizer on the winter production of irrigated sod sown oats at Badgery's Creek. Aust.J.Exp.agri. Anim.Husb. 6(20):42-7. (c.f.Herb. Abstr. XXXVI.1680).

Cummins, D.G.; Craigmiles, J.P. and Newton,J.P. 1965 . Seasonal response of temporary winter grazing mixtures to split application of nitrogen. Agron. J. 57(5): 451-3.

Dabadghao, P.M. and Sikka, S.M. 1961 . Oats. In Handbook of Agriculture, pp. 268-9. I.C.A.R., New Delhi.

Datta, N.P. and Bains, S.S. 1960 . Effect of soil application of fertilizer mixture (NPK) alone and in conjunction with soil and/or spray fertilization of micro-nutrients. Indian J.Agron. 4(4):258-63.

Desale, J.S. 1974 . Yield of new forage crops. Res.J.Mahatma Phule Agric. Univ. 5(2): 109-111.

Devlin, R.M. 19 . Functions of phosphorus. Plant Physiology.Chapter 14:237 271, (An east-west 2nd Edition) Affiliated East West Press Pvt. Ltd. New Delhi.

Desai, S.C.; SundraRao, W.V.B. and Tejwani, K.G. 1953a . A lysimeter study of crop rotations.(i.) Crop yields and soil fertility. Indian J. agric.Sci. 23(3): 243-54.

Desai, S.C.; SundraRao, W.V.B. and Tejwani, K.G. 1953b . A lysimeter study of crop rotations. (ii) The quality and chemical composition of crops. Indian J.agric. Sci. 23(4): 255-67.

Dzurkov, D. 1962 . Carotene and vitamin A content of basic forages Izv. Centr. nauc. izsled. Inst. Zivotnovadstvo "Georgi Dimitrov", Kostinbrod, Bulgaria. 13: 57-69. (c.f.Herb. Abstr. XXXIII, 1745).

El-Gindi, I.M.; Ghoneim,A.; Raaft, M.A.; Abou-Hussein, E.R.M. and Gihad,P.S. 1963 . Effect of fertilization practices upon the yield, chemical composition and nutritive value of berseem. J. Anim. Prod. U.A.R. 3: 95-103 (c.f. Herb.Abstr. XXXVI,110).

Erdman, L.W. and Wilkins, P.S. 1928 . Soybean inoculation studies. Iowa Agri. Expt. Sta. Res. Bull. 114.

Ganguli, B.D. and Relwani, L.L. 1961 . Effect of fertilizers on the yield of paddy and berseem in paddy-berseem rotation. Indian J. agric. Sci. 31(3): 173-82.

Gericke, S. 1938 . Phosphate fertilizing and national phosphorus. 7: 470-86.

Gill, A.S., Karnani, J.T. and Mishra, M.N. 1968 . Response of different varieties of oats to nitrogen application. I.G.F.R.I. Jhansi. Annual Report I pp 3-5.

Giobel, G. 1926 . The relation of soil N and nodule development and fixation of N by certain legumes. N.J. Agri.Expt. Sta. Bull 436 (c.f. Indian J. Agron. 14(1): 92.

Greaves, J.E. and Pittman, D.W. 1946 . Influence of fertilizers on the yield and composition of certain crops and on the soil. Soil Sci. 61 : 239-46.

Hayman, R.H. 1943 . Maintenance of soil fertility and production. Vict.J. Agri. U. 41(7): 329-55.

Henderson, J.L. and Davies, R.O. 1955. The yield and composition of mixed cereal legume crops at different stages of growth. Exp.J. Exp.Agri. 131-44.

Hunsigi, G. and Mani, V.S. 1966 . Effect of N, P, K on yield and quality of oat. Indian J.Agron. 11(1): 38-44.

Hukkeri, S.B., Shukla, N.P., and Rajput, R.K. 1971 . Effect of levels of soil moisture and nitrogen on fodder yield of oat on two types of soil. Indian J. agric. Sci. 47 : 204-209.

Hussain, M.M., Bains, S.S. and De.R. 1976 . Studies on the effect of phosphate fertilization, cutting interval and varieties on forage yield and chemical composition in berseem. Indian J. Agron. 21(4): 375-378.

Hutchinson, C.H. 1923 . Value of green manure as tested at Pusa. Agri.18: C 19.

Indian Agricultural Research Institute. 1951 . Annual report of Division of Agronomy. I.A.R.I., New Delhi.

Ivanko, S. 1960 . The influence of nitrogen, phosphorus and potassium deficiencies on changes in the content and ratio of amino acids in the vegetative organs of oats. Pol'nosho-Spodarstvo 7(3): 165-74. (c.f. Herb. Abstr. XXXII, 1324).

Jimeno, L. and Lozano, J.M. 1966 . Nitrogen nutrition in berseem. An Edafol. Agrobiol. 25(11,12): 707-15.(c.f. Herb.Abstr.XXXVIII,591).

Joshi, B.S. and Prasad, R. 1979 . Effect of Rates and Sources of Nitrogen including Sulphur Coated Urea and Sulphathiazole treated urea on Yield and Quality of Oats Forage. Indian J.Agron. 24(3): 301-306.

Kanwar, J.S. 1962 . Direct and residual effect of major and micro-nutrients applied to berseem in a sandy loam soil. Indian J.Agron. 7(2): 112-8.

Kaufhold, W. and Martin,B. 1973 . On the cultivation of Egyptian clover (T. alexandrinum L.) and Persian clover (T.resupinatum L.) (c.f. Herb. Abstr. 43(3)).

Keftasa, D. 1985 . Productivity offorage oats in tropical high lands of Ethopia with special refrences to the condition in Arsi region. (c.f. Herb. Abstr. 1057, 55(5)).

Kehar, N.D. 1953 . The problem of animal nutrition and its bearing on human welfare. Prs.address, Section of Physiology, 40th Indian Science Congress. Lucknow. pp.20.

Khan, A.R.; Bajpai, M.R. and Mathur, B.P. 1954 . Response of berseem to fertilizers and comparison of after effects with those in cereals. Indian J. agric. Sci. 24(4): 317-22.

Khatta, V. and Katoch, B.S. 1981. Nutrient components of some forages available in the sub-mountainous region of Himachal Pradesh. Forage Res. 7: 149-154.

Mac Taggart, A. 1921. The influence of certain fertilizer salts the growth and nitrogen content of legumes. Soil Sci. 11: 435-55.

Magoon, M.L., Singh, A., Mehra, K.L., Yadav, M.S. and Krishan, R. 1974. New high Yielding varieties of forage crops. Indian Fmg. 24: 5.

McBeath, D.K. and Toogood, J.A. 1960 . The effect of nitrogen top dressing on yield and protein content of nitrogen deficient cereals. Canad. J.Soil Sci. 40: 130-5.

Mercer, A.D. 1948 . Improving soil fertility by direct nitrogenous manuring Sum Biol. Abstr. 24 Ent. 1950.

Merwin, H.D. and M Peech 1950. Exchangeability of soil potassium in sand, silt and clay fraction as influenced by the nature of complimentary exchangeable cations. Soil, sci. soc. Am. Proc.

Miaki, T. and Nose, I. 1967 . Studies on chemical composition and feeding values in forage crops. 4. The influence of nitrogen fertilization and stage of maturity on chemical composition and digestibility in oats forage. J.Jap.Soc. Grassld. Sci. 12 (4): 213-17 (c.f. Herb. Abstr. XXXVIII, 722).

Mursell, V.E. 1944 . Superphosphate and pasture development in western Australia. J. Dep. agric. W.Aust. 21: 125-32.

Mehring, K. and Schutt, W. 1961. The effect of fertilizers on the content of carotene and chlorophyll in green fodders. Z.lander Versu. Untersuch Wes. 7(3): 206-18 (c.f.Herb. Abstr. XXXII,1325).

Nelson, C.J.; Schmid,A.R. and Cuykendall, C.H. 1965 . Performance of berseem clover (Trifolium alexandrinum) as a companion crop. Agron. J. 57(6): 537-9.

Olsen, S.R., Cole, C.W, Watanabe, F.S and Dean, L. A (1954) Estimation of available phosphorous in soils by extraction with $NaHCO_3$ USDA. Circ., 939: 19 (C.f Soils and fertilizer., 17: 1890

Pal, B.P. and Sikka, S.M. 1961. Oats.In Handbook of Agriculture, I.C.A.R. New Delhi, pp. 118-20.

Parr, C.H. and Bose, R.D. 1944 . Phosphate manuring of legumes. Indian Fmg. 5(4): 156-62.

Parr, C.H. and Bose, R.D. 1945. Phosphate manuring of legumes.II. Indian Fmg. 6 (5): 201-8.

Patel, B.M.; Shah, B.C. and Mistry, V.V. 1958 . A study of fodders of Hissar district in the Punjab. Indian J.agric.Sci. 28(4):597-607.

Piper, C.S 1966. Soil and plant analysis. Hans bd Pub. Bombay India.

Punjab Agricultural University (1967-68). Sixth Annual Report of the Director of Research, P.A.U. 1:102.

Raghavaiah, C.V., Khan, M.S., Rao, Y.Y. and Reddy, N. 1979 . Fodder yield of of oats in relation to seed rate and nitrogen level. Indian J.Agron. 24(3): 291-295.

Rai, S.D. 1973. Berseem, A. productive and nutritious winter forage. Indian Farmer Digest. 6(10):31.

Rao, C.N., Sastry, J.A. and Verma, C.F. 1979. A note on the effect of cultural practices on yield of forage cereal- legume mixture (c.f. Herb. Abstr. 53(12):1983,5244-5905).

Rao, Y.Y.; Khan, M.S.; Raghavaiah, C.V. and Reddy, D.N. 1979. Intercropping of berseem with oats for higher forage production. Indian J. Agron. 24(3): 367-369.

Rathi, K.S. and Vaishya, R.D. 1983 . Effect of rates and times of nitrogen application on forage yield and quality of oats. Indian J. Agron. 28(1): 16-19.

Relwani, L.L., Kumar, A. and Sidhu, M.S. 1971. Comparative performance of tetraploid and diploid berseem at varying seed rates and in different combinations. Indian J.Agron. 16(3): 381-382.

Roberts, V. and Allison .1943 . The original field plot studies of Rothamstead. Proc.Soil Sci. Amer. 8 :6-11.

Robinson, R.R. 1942 . The mineral content of various cloves of white clover when grown on different soils. J. Amer. Soc. Agron. 34: 933-9.

Robinson G.W. 1922. A new method for the mechanical analysis of soil and other dispersions J. Agric. Sci. Cambridge 12: 306-321.

Rogers, T.H. and Sturkie, D.G. 1939. Effect of fertilizers and methods of application on nodulation, growth and nitrogen content of hairy vetch. J. Amer.Soc.Agron. 34:141-8.

Saini, H.R. and Malik, H.C. 1949 . Influence of some of the environmental factors on the yield of green fodder and seed in berseem in the Punjab. Indian J.agric. Sci. 19(2):277-94.

Sandhu, H.S., Brar, S.S., and Puri, K.P. 1976. Effect of nitrogen and phosphorus on the yield and quality of oat fodder. J. Res. P.A.U. Ludhiana. XIII(2): 151-155.

Saxena, M.C., Joshi Leelamber and Rai, S.D. 1971. Studies on the performance of two varieties of oats as affected by dates of planting and levels of nitrogen fertilization. Indian J.Agron.16:288-292.

Scharrer, K. and Burke, R. 1953. The effect of fertilizers on the development of provitamin A (carotene) in agricultureal plants. Z.Plf. Ernahr Dung. 62(3): 244-62 (c.f.Herb.Abstr.XXIV,57).

Shekhawat, G.S., Jain, K.M. and Sharma, D.C. 1973. Influence of NPK fertilization on green fodder of berseem (T. alexandrinum) and senji (M.indica) Rajasthan J. Agri. Sci. 4(2):82-87.

Sherwin, M.E. 1923 . The effect of fertilizers on germination and seedling growth. J.Am. Soc. Agron. 15:68-73.

Sen, K.C. and Ray, S.N. 1964 . Nutritive value of Indian cattle feeds and the feeding of animals. I.C.A.R. Bull No.25 (Revised).

Sen, S. and Bains, S.S. 1951 . Effects of different forms of phosphates alone and in combination with other manures on berseem and after effects on maize and wheat. Indian J.agric.Sci.21: 197-202.

Sen, S. and Bains, S.S. 1952 . Effect of phosphate manuring with or without potash on the yield and quality of berseem fodder. Indian J. agric Sci. 22: 257-65.

Sen, S. and Kavitkar, A.C. 1958 . Statistical studies of the crop yield data. 2. Studies of oats, peas, wheat and gram yields. Indian J. agric. Sci. 22: 257-65.

Sewell, M.C. and Latshaw, W.L. 1931. The effect of lime, superphosphate and potash on the reaction of soil, growth and composition of alfalfa. J. Amer.Soc. Agron. 23: 799-814.

Shaaban, K.; Atanasiu, N. and Lashin.E. 1966 . Investigation on cultivation of berseem in Egypt. Bodenkultur 17(4):355-9 (c.f.Herb.Abstr. XXXVII,1090).

Shah, V.H. 1965 . Influence of companion crops on the yield and quality of berseem. Indian J.agric Sci. 35(4): 291-304.

Shivastava, S.N. and Varshney, M.L. 1983 . Effect of nitrogen levels on dry matter yield and protein content of berseem and oats grown pure and mixed. (c.f. Herb. Abstr. 53(12)).

Singh, Daljit; Bains, S.S. and Sen, S. 1957. Relationship between fodder and seed yields of berseem and response to phosphate levels. Indian J. agric. Sci. 27(1): 103-24.

Singh,G. and Verma, P.S. 1953. Effect of phosphate manuring of berseem on its yield and quality. Agra Univ.J.Res.(Sci.),1953,2.(I): 45-51.

Singh, Harbans. 1967. Supply nutritious fodders for optimum livestock production. Cosamvardhana 15(3): 11-13.

Singh, H.B. ahd Joshi, A.B. 1961 . Kent : on oat of note. Indian Fmg.(N.S.) 11(8):7.

Singh, J. and Singh, S.D. 1977 . Effect of phosphorus and molybdenum on yield performance of berseem. Indian J.Agron. 22(1): 57.

Singh, L.N.; Katoch,D.C. and Verma, R.K. 1973. Note on the response of forage oat to different levels of nitrogen and phosphorus in the mid-hills of Himachal Pradesh. Indian J.agric.Sci. 43:826-27.

Singh, H.K. 1971. Grow oats for more green fodder. Indian Fmg. 21(4): 38-39 and 43.

Singh, V. Joshi, Y.P. and Verma, S.S. 1978 . Grow hybrid napier intercropped with legumes for regular green forage supply. Indian Farmer's Digest. 11(3):37.

Singleton, H.P.; Nelson, C.E. and Stanberry, C.O. 1945. Fertilizers for irrigated alfalfa. Wash. Agric.Expt.Sta. Bull. 465.

Sinha, M.N. 1968. Effect of rates and times of nitrogen application on growth yield and quality of oats. Indian J.agric.Sci. 38(4):730-5.

Sinha, M.M., R.K.Rai and Latif, L.T. 1982 . Effect of NPK on berseem and their residual effect in Maize-wheat sequence. Indian J. Agron. 27(2): 187-88.

Smith, A.M. and Robb,W.J. 1943. The carotene and protein in oats and barley at different stages of growth. J.agric Sci. Camb.33:119-31.

Smith, J.C.,Fudge,J.F.,Kapp, L.C., Adams, J.E.,Peterson,R.W., and Howard Leaf, Jr. 1960. Utilization of fertilizers and soil P by oats and crimson clover as affected by rates and ratio of added N and P_2O_5. Proc.Amer.Soc.Soil Sci. 15: 209-12.

Stallcup, O.T. and others. 1960. Composition of oat plant as affected by level of nitrogen fertilization and stage of maturity. J. Dairy Sci. 43(6):867.

Stitt, E.R. 1944 . Effect of moisture, seeding dates and fertilizer on stand and yield of crimson clover. J.Amer.Soc.Agron.36: 464-67.

Subbiah, B.V and C.L Asija 1956. A rapid procedure for the estimation of available nitrogen in soil Curr. Sci. 25

Tisdale, S.L. and Nelson W.L. 19 . Effect of added organic matter on availability of nutrients in the soil. Chapter 14. Soil Fertility and Fertilizer, 555-593. Second Edition. The Macmillan Company Collier-Macmillan limited, London.

Tiwari, S.R. 1966. Cattle feeds in India. World Crops. 18: 259-61.

Tomer, P.S. 1969. Effect of levels of nitrogen and phosphorus on yield and quality of oat forage in semi-arid tracts of Haryana. Annual Arid Zone 8(1): 130-134.

Tomer, P.S. and Singh,R.R. 1968. Manurial practices affecting yield potential of winter forages grown pure and mixed. Indian J.agric. Sci. 38(6): 971-7.

Tomer, P.S. and Arora, N.D. 1971. Effect of nitrogen and phosphorus levels on yield potential of oat-berseem forage grown with different seed production in semi-arid tract of Haryana. Annals of Arid Zone. 10(4):247-50.

Tripathi,S.N., Singh, A.P., Mathur, R.B. and Gill.A.S. 1979 . Effect of Nitrogen and phosphate levels on yield and quality of oats. Indian J.Agron. 24(3): 250-254.

Waber, E. 1930. The deleterious effect of salf peter manuring on accumulation of nitrogen by leguminase. Zbl.Bakt.2 Advt. 32: 353-97 (c.f. Indian J.Agron. 14(1):92).

Weisemuller,W. 1963. N application and nutrient content of various fodder plants. Z. lander. Vers.-U.Untersuch Wes. (c.f.Herb.Abstr. XXXV,1791).

West, E.S. 1936 . The influence of phosphate fertilizers on the yield of irrigated lucern at gGriffoth. Aust.Jour.Conc. Sci. Indus. Res.11: 179-81.

Wohltmann and Borgent,F.W. 1902 . Effect of different forms of phosphates on the yield and nodulation of alfalfa. J.landw.Jahrg.50: 377-95.

APPENDIX I

Mean weekly weather data during the crop season (1980-81 and 1981-82)

Weeks	Temperature°C		Relative humidity(%)	Rainfall (mm)
	Max.	Min.		
1.	2.	3.	4.	5.
			1980-81	
Sept. 1-7	31.2	19.3	81.5	-
8-14	30.2	20.5	67.7	-
15-21	28.6	17.9	57.7	-
22-28	26.7	16.0	71.5	-
29- 5 Oct.	29.4	16.9	87.7	-
Oct. 5-12	21.6	14.6	88.5	3.0
13-19	25.8	15.8	83.5	-
20-26	23.0	14.4	82.0	-
27- 2 Nov.	22.5	11.6	85.2	3.0
Nov. 3 -9	21.8	10.1	85.0	2.0
10-16	21.6	5.8	90.7	-
17-23	21.1	3.8	89.7	-
24-30	20.8	3.0	89.2	5.8
Dec. 1 -7	17.8	2.9	81.0	-
8-14	17.4	0.8	75.0	-
15-21	19.8	2.3	66.7	-
22-28	14.8	5.1	74.0	20.0
29-4 Jan.81	14.5	2.2	88.2	-
Jan 5-11	7.9	0.2	52.0	4.5
12-18	7.3	1.5	87.0	-
19-25	13.5	5.6	88.5	56.0
26-1 Feb.	13.8	1.1	75.5	20.0
Feb. 2-8	14.1	2.3	81.2	6.0
9-15	13.6	7.5	82.0	-
16-22	8.5	9.2	76.0	-
23-1 March	14.6	7.4	82.0	14.0
March 2-8	14.6	7.7	68.0	-
9-15	14.9	7.5	85.2	-
16-22	17.3	7.3	85.2	76.0
23-29	16.2	9.0	85.7	3.0
30-5 April	18.8	14.6	80.7	4.5
April 6-12	18.7	13.6	91.0	-
13-19	22.0	16.0	65.0	5.0
20-26	19.0	13.0	75.0	11.8
27-3May	23.0	17.0	70.7	-
May 4-10	25.0	18.0	79.5	14.0
			Total	248.6

Contd.

APPENDIX I CONTD.

1.	2.	3.	4.	5.
		1981-82		
Sept. 1- 7	12.6	10.0	80.0	-
8-14	16.9	7.3	92.0	-
15-21	20.9	13.8	71.0	22.0
22-28	25.1	13.3	83.0	25.0
29-5 Oct.	18.6	13.0	86.0	-
Oct. 6-12	18.7	12.5	83.0	-
13-19	18.8	11.4	84.0	-
20-26	19.4	13.5	59.0	-
27-2 Nov.	18.1	12.1	70.0	10.0
Nov. 3-9	16.3	11.9	80.0	62.5
10-16	17.6	8.4	69.0	5.5
17-23	16.9	5.5	81.0	-
24-30	17.6	6.5	79.0	2.5
Dec. 1-7	12.7	5.1	81.0	2.5
8-14	10.9	4.4	84.0	-
15-21	10.1	2.9	82.0	-
22-28	12.1	3.2	86.0	-
29-4 Jan.	13.0	2.4	70.0	-
Jan. 5-11	8.6	3.2	53.0	10.5
12-18	8.9	3.2	92.0	16.0
19-25	9.6	8.4	60.0	-
26-1 Feb	14.4	7.1	87.0	93.7
Feb. 2-8	10.0	2.2	82.0	8.5
9-15	9.2	2.7	81.0	16.0
16-22	10.8	3.1	82.0	9.5
23.1 March	11.6	4.7	76.0	-
March 2-8	16.8	15.7	81.0	134.0
9-15	16.2	11.4	67.0	29.0
16-22	18.0	14.1	85.0	3.0
23-29	18.0	11.6	84.0	35.0
30-5 April	22.2	14.0	82.0	-
April 6-12	17.8	13.0	80.0	18.0
13-19	19.0	13.0	59.0	16.0
20-26	18.0	13.0	78.0	20.0
27-3	19.0	13.0	82.0	33.0
May 4-10	21.0	15.0	80.0	15.0
			Total	581.7

Appendix - II

Analysis of variance of plant height, leaf:stem ratio, green fodder yield, dry matter yield, dry matter content crude protein content and protein in 1980-81 and 1981-82 (Mean sums of squares)

Source of variation	d.f.	Cumulative plant height	Leaf: stem Ratio	Green fodder yield	Dry matter yield	Dry matter content	Crude protein content	Protein yield
			1980-81					
Replication	2	5778.368	0.076	7.951	0.665	101.147	180.335	0.224
Stand type	1	2358.272	0.032	0.483	0.714	15.325	959.986**	1.149**
Crops	1	11028.164*	0.340*	74.096	0.362	111.658	2080.350**	2.115**
Seed proportions	2	2724.093	0.005	80.684	6.326*	77.051	11.779	0.961**
Error (a)	8	1800.607	0.054	38.216	1.388	29.686	5.611	0.076
Nitrogen levels(N)	2	1414.580**	0.004	91.391**	3.450**	22.593	78.332**	0.275**
Phosphorous levels (P)	2	146.924	0.005	2.879	0.216	36.542	40.859**	0.020
N X P	4	281.506	0.007	12.498	2.335**	32.853	15.309**	0.075**
Stand type X N	2	65.760	0.004	17.507	0.472	27.865	4.804	0.007
Stand type X P	2	91.826	0.015	10.696	0.713	52.926	11.476*	0.075
Stand type X N X P	4	198.508	0.034	1.917	0.336	24.754	2.208	0.016
Crops X N	2	484.526	0.028	35.067**	1.809*	39.076	5.035	0.023
Crops X P	2	274.202	0.000	9.792	0.247	2.943	0.825	0.010
Crops X N X P	4	347.472	0.013	7.232	0.327	4.470	2.683	0.014
Seed proportion X N	4	143.813	0.006	1.416	0.072	5.446	6.618	0.006
Seed proportion X P	4	383.921	0.051	5.776	0.399	30.935	6.197	0.014
Seed proportion X N X P	8	160.131	0.005	6.471	0.339	11.595	0.530	0.016
Error (b)	80	176.972	0.027	6.922	0.545	23.222	3.250	0.019

Appendix-II contd....

Appendix-II contd......

Source of variation	d.f.	Cumulative plant height	Leaf: stem ratio	Green fodder yield	Dry matter yield	Dry matter content	Crude protein content	Protein yield
				1981-82				
Replication	2	787.245	0.007	356.609	4.576	4.751	0.342	0.162
Stand type	1	93438.648	0.563**	10248.357**	255.687**	47.591**	545.909**	9.867**
Crops	1	90253.725	4.128**	14878.082**	361.502*	86.691**	1686.614**	20.398**
Seed proportions	2	3653.371	0.001	96.323	0.445	27.55*	7.460	0.011
Error (a)	8	1991.084	0.004	115.480	1.593	3.656	4.746	0.039
Nitrogen levels (N)	2	1217.567**	0.010	87.771*	0.486	8.006	35.450**	0.137
Phosphorous levels (P)	2	240.461	0.001	77.398*	0.309	2.913	20.867**	0.164
N x P	4	87.307	0.006	10.932	2.939*	20.929	10.876**	0.214**
Stand type X N	2	80.260	0.021*	23.679	2.348	4.400	6.610*	0.055
Stand type X P	2	61.958	0.012	0.468	0.247	5.415	4.482	0.013
Stand type X N X P	4	52.429	0.018**	23.281	1.463	5.086	1.116	0.076
Crops X N	2	1708.192**	0.008	11.701	0.825	0.003	2.119	0.040
Crops X P	2	82.009	0.001	16.295	0.046	4.766	3.687	0.019
Crops X N X P	4	72.243	0.027**	3.292	0.834	18.000	0.467	0.019
Seed proportion X N	4	113.497	0.006	30.394	1.071	8.718	3.093	0.033
Seed proportion X P	4	73.294	0.004	28.118	0.346	3.517	2.985	0.050
Seed proportion X N X P	8	56.062	0.006	10.632	0.889	5.742	0.939	0.021
Error (b)	80	178.216	0.005	20.990	1.160	8.161	1.741	0.056

* Significant at 5% level.

** Significant at 1% level.

Appendix - III

Analyses of variance of Soil pH, C.E.C, Organic matter, Available soil N and P_2O_5 (Mean sums of squares)

Source of varition	d.f.	Soil pH	C.E.C. me/100gr. soil	Organic matter (%)	Available N (Kg/ha)	Available P_2O_5(kg/ha)
			1980-81			
Replication	2	1.408	0.005	1.288	9437.933	366.515
Stand type	1	3.037*	0.586	0.096	14873.878*	149.260
Crops	1	0.125	4.741	1.830	341420.711**	689.160*
Seed proportions	2	1.187	14.115	0.054	5080.841	115.196
Error (a)	8	0.548	7.201	0.516	1453.571	111.824
Nitrogen levels (N)	2	0.297	1.442	0.099	252437.550**	93.534**
Phosphorous levels(P)	2	0.593	1.226	0.049	8869.827*	9.205
N X P	4	0.163	7.383	0.047	3084.922	16.430
Stand type X N	2	0.149	0.849	0.032	597.922	30.45
Stand type X P	2	0.077	4.363	0.124	9562.329**	5.445
Stand type X N X P	4	0.743*	4.756	0.033	6280.579**	12.572
Crops X N	2	0.400	1.336	0.091	3235.813	30.295
Crops X P	2	0.458	0.939	0.076	10625.834**	17.125
Crops X N X P	4	0.766*	6.507	0.058	1644.220	21.715
Seed proportion X N	4	0.747*	2.597	0.094	12956.053**	9.720
Seed proportion X P	4	0.156	9.518	0.234	5587.060*	24.757
Seed proportion X N X P	8	0.553	4.538	0.045	4197.872*	11.791
Error (b)	80	0.289	4.969	0.096	1859.276	10.841

contd,.....

Appendix-III contd .....

Source of varition	d.f.	Soil pH	C.E.C. me/100g soil	Organic matter (%)	Available N Kg/ha	Available P_2O_5(kg/ha)
			1981-82			
Replication	2	1.112	1.387	0.081	5175.660	22.120
Stand type	1	0.841	0.675	0.022	8029.667	950.972*
Crops	1	0.135	1.492	0.217	353468.281**	299.344
Seed proportions	2	0.180	2.009	0.040	27827.554**	146.134
Error (a)	8	0.550	6.804	0.057	2588.876	128.136
Nitrogen levels (N)	2	0.538	0.275	0.080	294597.450**	96.336**
Phosphorous levels(P)	2	0.081	9.557	0.085	16551.626**	16.656
N x P	4	0.161	4.752	0.077	1614.416	3.687
Stand type X N	2	0.048	0.969	0.120	4460.144	2.227
Stand type X P	2	0.524	7.555	0.053	10707.768**	7.482
Stand type X N X P	4	0.851*	6.739	0.141	4421.907**	2.449
Crops X N	2	0.329	13.645	0.084	3553.227	164.060
Crops X P	2	0.101	13.014	0.129	12592.927**	10.846
Crops X N X P	4	0.469	17.117*	0.411	2125.399	4.465
Seed proportion X N	4	0.332	9.229	0.086	7773.831**	4.540
Seed proportion X P	4	0.352	13.314	0.064	2561.331	2.932
Seed proportion X N X P	8	0.426	10.596	0.045	1800.393	4.465
Error (b)	80	0.297	5.831	-	1550.493	9.132

* Significant at 5% level.

** Significant at 1% level.

Appendix IV

Effect of stand type on plant height (cm), leaf:stem ratio, green fodder and dry fodder yield(Q/ha) at different cuts in 1980-81 & 1981-82

Treatment	Character								
	1980-81				1981-82				
	I	II	III	IV	I	II	III	IV	V
	(a) Plant height (cm)								
Pure stand	36.5	33.8	48.4	47.0	52.2	41.4	56.3	70.0	55.0
Mixed stand	30.9	29.6	49.8	47.3	49.9	48.3	67.3	70.0	55.0
	(b) Leaf:stem ratio								
Pure stand	1.5	1.2	0.8	0.7	0.8	0.7	0.4	0.3	0.4
Mixed stand	1.4	1.1	0.8	0.7	0.8	0.6	0.4	0.4	0.4
	(c) Green fodder yield(Q/ha)								
Pure stand	68.0	37.0	96.0	24.5	93.0	94.5	11.5	102.5	35.0
Mixed stand	44.3	38.2	113.9	31.4	99.1	169.1	176.4	221.8	70.2
	(d) Dry fodder yield (Q/ha)								
Pure stand	13.5	4.6	21.4	10.2	13.5	10.9	17.1	18.3	13.1
Mixed stand	8.0	7.7	23.4	12.8	11.9	18.4	26.0	39.0	24.5

Appendix-V

Effect of crops on height (cm), leaf:stem ratio, green and dry fodder yield (Q/ha) at different cuts in 1980-81 & 1981-82

Treatments	Characters								
	1980-81			(a) Plant height (cm)				1981-82	
	I	II	III	IV	I	II	III	IV	V
Pure oat	51.5	41.4	43.3	43.3	58.2	43.2	49.5	-	-
Pure berseem	21.4	26.2	53.5	50.7	48.2	39.7	63.1	68.1	54.9
				(b) Leaf:stem ratio					
Pure oat	1.7	1.2	0.8	0.8	1.2	1.0	0.6	-	-
Pure berseem	1.3	1.2	0.8	0.7	0.4	0.4	0.3	0.3	0.4
				(c) Green Fodder yield					
Pure oat	109.0	38.0	48.0	12.0	58.0	66.0	38.0	-	-
Pure berseem	27.0	36.0	144.0	37.0	128.0	123.0	185.0	205.0	70.0
				(d) Dry matter yield					
Pure oat	22.1	5.7	15.3	4.9	12.8	10.0	7.1	-	-
Pure berseem	4.8	3.5	27.4	15.4	14.1	11.8	27.1	36.5	26.1

Appendix-VI

Effect of seed proportion on plant height (cm), leaf:stem ratio, green and dry fodder yield (Q/ha) in 1980-81 and 1981-82

Treatments	Character								
	1980-81				1981-82				
	I	II	III	IV	I	II	III	IV	V
	(a) Plant height (cm)								
Seed proportions									
1:1	28.8	28.0	46.0	45.0	47.1	47.4	64.3	70.5	55.0
1:2	31.0	30.9	48.6	46.5	56.5	50.2	71.9	71.3	54.2
2:1	33.2	29.9	54.6	50.7	45.9	47.4	65.8	67.1	55.3
	(b) Leaf :stem ratio								
1:1	1.4	1.1	0.8	0.8	0.8	0.6	0.4	0.3	0.4
1:2	1.4	1.0	0.7	0.8	0.8	0.7	0.4	0.4	0.4
2:1	1.3	1.1	0.8	0.7	0.8	0.6	0.4	0.4	0.4
	(c) Green fodder yield (Q/ha)								
1:1	41.5	28.1	109.1	28.5	113.0	166.7	186.1	215.0	59.3
1:2	38.7	37.5	106.5	32.8	104.2	167.3	187.8	233.2	79.1
2:1	52.7	49.0	120.1	32.9	80.0	173.3	155.4	217.1	72.2
	(d) Dry matter yield (Q/ha)								
1:1	7.9	5.0	18.7	11.7	13.2	18.0	27.9	37.1	22.1
1:2	7.0	7.9	24.9	13.7	11.8	17.4	27.3	37.3	25.2
2:1	9.0	10.2	26.7	13.1	10.8	19.7	22.8	42.2	26.2

Appendix-VII

Effect of phosphorous levels on plant height(cm), leaf:stem ratio, green and dry matter yields at different cuts in 1980-81 and 1981-82

Treatment Level of phosphorous	Characters								
	1980-81 cuts				1981-82 cuts				
	I	II	III	IV	I	II	III	IV	V
	(a) Plant height (cm)								
Low	33.0	37.0	50.8	49.3	49.7	45.4	62.3	68.6	52.8
Medium	32.0	30.4	46.9	48.5	50.0	45.1	64.2	69.9	53.8
High	34.4	31.4	48.3	49.6	50.9	46.1	62.2	69.2	54.9
	(b) Leaf:Stem ratio								
Low	1.4	1.2	0.8	0.7	0.8	0.7	0.4	0.5	0.4
Medium	1.5	1.1	0.8	0.8	0.8	0.6	0.5	0.3	0.4
High	1.4	1.1	0.8	0.7	0.8	0.6	0.4	0.3	0.4
	(c) green Fodder yield (Q/ha)								
Low	53.3	38.7	111.2	29.0	90.2	134.9	147.1	206.1	73.0
Medium	52.5	37.3	106.1	29.1	100.3	139.0	155.9	228.5	66.4
High	55.9	37.3	104.5	27.9	100.0	144.0	148.1	218.5	71.5
	(d) Dry matter yield (Q/ha)								
Low	10.53	6.60	22.40	11.67	11.13	15.47	22.67	39.50	23.17
Medium	8.53	6.40	23.07	12.13	11.07	14.27	17.2	35.33	24.62
High	11.67	6.40	19.13	10.6	13.13	17.31	22.2	37.33	26.92

Appendix - VIII

Effect of nitrogen level on plant height (cm), leaf:stem ratio, green yield and dry matter yield (Q/ha) at different cuts in 1980-81 and 1981-82

Treatments Levels of nitrogen	1980-81 Cuts I	II	III	IV	1981-82 cuts I	II	III	IV	V
	(a) Plant height (cm)								
Low	30.5	30.0	49.0	50.8	48.3	46.0	62.0	72.0	54.4
Medium	32.5	31.3	50.1	47.1	50.5	45.4	63.5	68.5	52.1
High	36.3	32.6	48.5	48.0	54.9	47.3	63.3	67.3	54.3
	(b) Leaf:stem ratio								
Low	1.4	1.2	0.8	0.7	0.8	0.6	0.5	0.4	0.4
Medium	1.4	1.1	0.8	0.7	0.8	0.6	0.6	0.3	0.4
High	1.5	1.1	0.8	0.7	0.8	0.6	0.4	0.4	0.4
	(c) Green Fodder Yield(Q/ha)								
Low	38.1	31.3	109.3	26.1	92.7	133.5	146.9	219.0	68.00
Medium	54.7	37.2	106.5	27.9	93.6	138.0	146.5	213.6	71.20
High	68.9	44.1	105.9	32.1	104.2	146.5	157.7	220.7	71.60
	(d) Dry matter yield (Q/ha)								
Low	8.27	5.20	23.93	10.93	12.47	7.27	22.27	36.75	27.58
Medium	9.20	6.60	20.80	11.27	12.27	14.47	21.93	41.17	21.50
High	13.00	7.60	23.07	13.00	12.87	16.53	23.13	35.92	25.67

APPENDIX IX

Analysis of variance of green and dry matter yield during 1980-81 and 1981-82 (Mean sum of squares).

Source of variation	d.f.	Mean sum of square			
		Green fodder yield		Dry matter yield	
		1980-81	1981-82	1980-81	1981-82
Replication	1	4.454	558.894	1.063	25.235
Treatments	35	13.569*	214.091 ** (Adjusted 205.883)	0.928*	5.985*
Block within replication adjusted	10 } 35	11.424Eb	35.578Eb	0.607Eb	0.439Eb
Intra-block error	25 }	11.630Ee	20.399Ee	0.722Ee	1.310Ee
		(Pooled 11.571)		(Pooled 0.641)	(pooled 1.109)
Total	71				

Eb < Ee no adjustment of the treatment total is required and the experiment is being analysed as R.B.D.

APPENDIX X

Relative contribution of oat and berseem in forage mixture (q/ha)

Mixture	1980-81			1981-82		
	Oat	Berseem	Total	Oat	Berseem	Total
1:1	110.35	97.45	207.80	105.19	634.69	739.88
1:2	114.80	101.24	216.04	63.44	698.49	761.93
2:1	137.58	123.73	260.31	110.90	588.68	699.69

APPENDIX XI

Relative contribution of the two fodders in the mixture at different cuttin stages.

Seed ratio oat + berseem	Cutting stages								
	I		II		III		IV		Total
	O +	B	O +	B	O +	B	O +	B	O + B
					1980-81				
1:1	39	3	24	4	38	71	10	19	111+ 97
1:2	36	2	31	6	37	69	10	25	114+102
2:1	38	4	35	14	46	81	9	24	138+123

	Cutting stages										
	I		II		III		IV		V		Total
1:1	60	53	40	[illegible]	5	181	Nil	215	nil	59	105+635
1:2	32	72	25	142	6	182	Nil	233	nil	79	63+708
2:1	45	36	58	116	8	148	Nil	217	nil	72	111+589

O= oat
B= Berseem