CROPPING SYSTEMS AND SOWING METHODS STUDIES FOR RABI FORAGES UNDER RAINFED CONDITIONS

THESIS

By

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Submitted to

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In partial fulfilment of the requirements for the degree of

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1988

Dedicated

to

Parents

CERTIFICATE - I

Certified that the thesis entitled, "Cropping systems and sowing methods studies for rabi forages under rainfed conditions", submitted in partial fulfilment of the requirements for the award of the degree of Master of Science in Agriculture (Agronomy and Agrometeorology) of Himachal Pradesh Krishi Vishva Vidyalaya, Palampur is the bonafide research work carried out by Mr.Naveen Kumar son of Shri Dharam Singh 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 have been fully acknowledged.

10/X/88

(B. R. Sood)
Chairman
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Dated: 10/X/88

CERTIFICATE - II

Certified that the thesis entitled "Cropping systems and sowing methods studies for rabi forages under rainfed conditions", submitted by Mr.Naveen Kumar son of Shri Dharam Singh to the Himachal Pradesh Krishi Vishva Vidyalaya, Palampur, in partial fulfilment of the requirements for the degree of Master of Science in Agriculture (Agronomy and Agrometeorology) has been approved by the examining committee after an oral examination of the same in collaboration with the Co-opted member.

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Advisory Committee

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(NAVEEN KUMAR)

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Chapter - I

INTRODUCTION

Dairy industry, occupies an important position in the economy of the country. India has about one-sixth of the World's cattle and one half of the World's buffalo population numbering 179.4 and 61.7 million, respectively, and that of sheep, goats and poultry is 41.0, 75.0 and 159.0 million, respectively, but the country is still lagging much behind both in milk and meat production (Anon., 1985). An insight of the present day dairy industry of the country would reveal that most of our animals are ill-fed. Semi-starvation and malnutrition is the rule and hence the milk production as well as the working efficiency of the animals is steadily declining.

There exists a wide gap between the demand and supply of feeds and fodders 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, Karbi and Stover and 23.8 million tonnes in case of the concentrates (Singh, 1985).

Himachal Pradesh, one of the most picturesque regions of the country, land of mightly rivers and snows, situated in the lap of Himalayan ranges in extreme north-west of India is idealy suited for the development of livestock industry and has great potential for the improvement of milch cattle. In this direction Department of Animal Science, Himachal Pradesh Krishi Vishva Vidyalaya, Palampur and Department of Animal

Husbandry, Himachal Pradesh together have put efforts to improve the existing livestock population in the state by cross-breeding with imported Jersey and Holstein breeds. The results so for obtained have been quite encouraging. The most important aspect which requires immediate attention, however, is proper and adequate feeding, in the absence of which even the best breeding programmes are not expected to yield desired results.

The gap between the requirements and the availability of fodder is quite high (Whyte, 1964). It is felt that feeds and fodders at present available can maintain only about half of the existing livestock population. The fodder production in the state is at its lowest ebb with only 0.48 per cent of the total cultivable area being devoted to fodder production, which indeed is very less (Anon., 1985). Though, natural grasslands are the major source of fodder supply in the state in terms of hay and grazing needs, more than 90 per cent of the livestock population in Himachal Pradesh subsists on natural grasslands (Anon., 1985). Vegetative growth in these grasslands is observed only for a period of three to four months in a year and for the major part of the year, they serve not more than a play ground for the animals as such acute shortage of green and dry harbages is experienced during lean months, viz., November to June (Sharma, 1983).

The increasing demand of food has led the farmers to grow grains and other food crops even on the grasslands and pastures, thereby causing an acute shortage of fodders. The farmers generally rear their animals on the poor quality roughages, like paddy and wheat straw and to a lesser extent on hay and the fodder trees which, are hardly enough to meet even their normal body requirement. Moreover, animals show reluctance for eating these dry stuffs. Keeping in view the growing demand of grain for human population it would not be possible to divert the grains as concentrates for livestock feeding. The solution would, therefore, appears to lie in the adoption of a 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. The qualitatively rich green fodder will help in increasing the milk production, raising the efficiency of working animals and boosting the growth of young stock.

Keeping in view the area under irrigation in the State which is about 17 per cent (Anon., 1985) of the total cultivable area, there is a great need to put efforts to initiate the fodder production under rainfed conditions.

The livestock industry will not flourish unless the attempts are made to make the green fodder available in lean months. Thus, there is a great need of the suitable packages of technology, probably management techniques such as cropping systems and sowing methods that would help in providing green fodder regularly especially in the months of acute shortages.

The informations with regard to yield and quality of Rabi forages grown singly or in combination under rainfed conditions are not adequately available in the state.

Keeping in view the growing livestock industry, scarcity of fodder during lean months, production potential of the Rabi forages and irrigation facilities in the state an experiment entitled "Cropping Systems and sowing methods studies for Rabi forages under rainfed conditions" was conducted at Himachal Pradesh Krishi Vishva Vidyalaya, Research Farm, Palampur with the following objectives:

1. To find out the best sowing method for getting the highest output of rabi forages,
2. to ascertain the best forage crop vis-a-vis best cropping system under rainfed conditions,
3. to find out the nutritive value of forage obtained under different treatments and
4. to work out the economics of individual treatments.

Chapter - II

REVIEW OF LITERATURE

In this chapter an attempt has been made to review the literature available pertaining to the influence of cropping systems and sowing methods on the growth, yield and quality components of *rabi* forages under rainfed conditions. Evidences available have been reviewed and classified into following heads:

2.1 FORAGE YIELD:

2.1.1 Effect of Cropping Systems:

Number of investigations have been carried out in recent years to see the performance of cereal-legume mixtures in respect of quantity and quality. Many workers have reported considerable increases in forage yield when legume is grown mixed with other forage crops. Rao *et al.* (1979) while studying the effect of cultural practices on the yield of forage cereal-legume mixture noted that cereal+legume mixture yielded more than the sole stand of cereal. Rakhteenko and Egorova (1971) observed that yellow lupin and oat sown in mixture gave higher herbage and dry matter yield than pure stand of each. Root exudates of both crops contained P, and the P exudation by one crop had a stimulating effect on the growth of the other crop. Bacher (1949) noticed a significant increase in the herbage yield of oat with the introduction of pea over pure stand of oat. Singh *et al.* (1983) conducted an experiment for two years on grass-legume intercropping for

getting quality forage production under rainfed conditions. Maximum dry matter production was obtained in alternate rows of grass with legume. Further, the land equivalent ratio was also more under intercropping over monocropping system. Singh et al. (1981) noticed that there is a considerable increase in the herbage yield with the introduction of legume components in the grass species. Chauhan et al. (1981) while studying the effect of intercropping of cowpea with Anjan grass in the establishment year found that grass+legume mixture produced maximum total dry matter and had minimum adverse effect on the yield and growth of Anjan grass. Reddy and Shivashankar (1978) reported that the treatment in which cereal and legume were sown together recorded maximum forage yield over the pure stand of each crop which they attributed to more number of plants per unit area in the mixture.

Kovrygin and Kuzmin (1979) noticed that the hay yield of oat, barley and pea grown singly were 3.80, 3.76 and 2.56 t hay/ha; whereas, mixture of oat+pea and barley+pea resulted in 3.82 and 3.78 t hay/ha, respectively.

Martin and Syaydon (1982) reported that intercropping of barley and bean gave higher yield as compared to the sole stand of these crops. Studies conducted by Gill and Patil (1983) on intercropping of barley with legumes for two years revealed that barley plus legumes recorded higher green fodder and dry matter and also higher land equivalent ratio as

compared to the pure stand of each. Further, studies on intercropping of oat and barley with mustard under rainfed conditions registered higher forage yield as compared to pure oat and barley.

Dahal (1986) observed that growing of oat in rows and legumes by broadcast was found to be the best sowing technique from production, and forage distribution point of view. Similar, findings have been reported by Arora (1971) that sowing of oat in lines and broadcast the legume in oat with optimum seed rate in both the crops, herbage yield showed significant increase in comparison to the yields of legume and oat sown separately.

Singh et al.(1978) suggested that growing of Napiar bajra and legume in combination increased the fodder yield significantly over the pure stand of each crop . This combination was also found to be advantageous from soil fertility building point of view. Shivastava and Varshney (1983) reported that berseem and oat grown in mixed stand gave marked increase in dry matter yield over the pure stand of these crops.

Suput and Dordevic (1977) also reported the superiority of oat+pea and oat+vetch mixture over the pure stand of oat. Tomer and Singh (1968) also concluded that oat+legume mixture was the best for the production of green forage. They also observed that the fodder availability

period was enhanced due to mixture. Tiwari *et al.* (1973) while studying the effect of cereal+legume mixture, noted that the cereal component yielded more in mixture than their sole stand.

Sarson is an important fodder crop belonging to the family cruciferae. Relwani (1979) reported that it can be sown mixed with berseem, persion clover, oat, barley and other fodder crops to provide a high green forage tonnage in early cuts. He was of the opinion that when *sarson* is grown with oat in two cut management under rainfed conditions, it provides high yields from first cut after about two months. It is also grown in association with wheat and barley either for fodder or for grain in alternate rows. Kapoor and Gill (1975) reported that the mixed crop of berseem and *sarson* gave 122 and 189 per cent higher green and dry matter, respectively in the first cut over monoculture of berseem. Mixture of berseem+*sarson* in all combinations resulted in a significant increase in total green fodder as well as dry matter production as compared to the pure stand of the berseem crop. Dhar (1976) reported that berseem+*sarson* mixture yielded a sizeable amount of forage at first cut, but the yield of *sarson* at second cut was practically nil.

Saini and Malich (1949) conducted an experiment to see the effectiveness of legume and *sarson* intercropping on the companion forage crops and reported that mixture of both

the components with main crops resulted in higher forage yield over the sole stand of main crops. They also reported that mixture with legumes yielded higher than mixture with sarson. Gill and Patil (1983) highlighted the role of mustard introduction in triticale. Triticale intercropped with mustard gave higher forage yield as compared to triticale sown in monoculture under rainfed condition.

So, it is quite evident from the review of literature that under rainfed or dryland conditions the role of intercropping is of great importance. Risk of failure of any particular crop due to adverse weather could be avoided, resources are better utilized and finally the prospects of obtaining good yields enhanced considerably.

2.1.2. Effect of Fodder Crops:

Oat (Avena sativa L.) is the most important cereal fodder crop grown in the winter season in the northern-western and central parts of the country under irrigated as well as rainfed conditions. It is a quick growing, palatable, succulent and nutritive crop and form an excellent fodder for animals during lean months (Relwani, 1979). Pathak and Jakhmola (1983) in an experiment to evaluate the production potential of oat, reported that it can yield 618, 119, 9.52 quintal per hectare green forage, dry matter and crude protein, respectively. Salmon (1941) reported that oat can also be grown successfully under rainfed conditions, he also advocated that it can be grown in areas where the annual rainfall is up to 380 mm, but most

extensively where it does not exceeds 760 mm and is well distributed during the growing period of the crop.

Barley is also one of the rabi cereals grown extensively in the northern states of the country which meet the agroclimatic requirements for growing this crop. Barley thrives best on well drained and moderately rich soils. Jain (1974) reported that this crop has low water requirement than wheat and oat, it also gives economically higher yields in area with low or uncertain rainfall.

Misra et al. (1982) conducted a field experiment to compare the relative production potential of oat and barley crops as fodder-cum-feed, they observed that barley registered significantly lower fodder yield than that of oat.

Noworalnik and Strzelles (1985) reported the superiority of oat over oat+barley mixture and barley in pure stand. Similar findings have been reported by Budzynski et al. (1980). They also observed that oat out-yielded both oat+barley and barley alone. However, the mixture of oat+barley yielded significantly better than barley alone. Ermakov (1976) conducted an experiment to see the superiority of oat+barley mixture over the pure stand of these crops, he observed that oat+barley gave higher yield than that of barley but was similar to that obtained with pure oat. It was also observed that in the event of failure of proper rains forage grown in combination (oat+barley) was certainly better than pure oat.

The field investigations were carried out at Indian Grassland and Fodder Research Institute, Jhansi by Shukla et al. (1984) to evaluate the forage production potential of Oat and barley in two cut system of management. The results revealed that on an average Oat outyielded barley in term of both green forage production and dry matter accumulation point of view.

The literature cited in the foregoing pages clearly demonstrates that Oat is a better forage crop than that of Oat+barley and barley alone. However, in the event of worth scarcity during growing period of the crops the mixture of Oat+barley would constitute an ideal combination.

2.1.3. Effect of sowing methods:

Mannikar and Shukla (1974) conducted an experiment to see the effectiveness of sowing methods on the production potential of rabi forages. They found that line sowing of crops resulted in higher green and dry forage yield, than broadcast sowing. The higher yields in line sowing was attributed to better plant stand. Similar, study conducted by Raheja (1968) revealed the superiority of line sowing of Oats over the broadcast sowing because of uniform crop stand under line sowing condition. Jain (1974) reported that method and depth of sowing is a critical issue particularly under rainfed conditions. He advocated better and uniform plant stand in case of line sowing as compared to broadcast sowing.

Graham and Ellis (1980) also obtained higher yield of barley in line sowing over broadcast sowing under identical management practices. Low yield in broadcast sowing was attributed to the poor incorporation of the seed into the soil and as such less number of plant per unit area. Barnett and Comeau (1980) reported that line sowing of Oat and barley resulted in higher production as compared to broadcast sowing. This was the result of uneven distribution of the seeds, lack of seed protection against birds and poor germination on account of non-availability of proper soil moisture.

Tabata and Kumagai (1973) also observed that Oat sown in line produced higher herbage yield over broadcast. However, they found that broadcast sowing could equalize the line sowing provided that the seed rate in case of broadcast sowing is kept 50 per cent higher than the one used for line sowing.

2.2 Nutritive value of forage:

Tomar and Singh (1968) reported that in a balanced diet both legumes and non-legumes should be mixed in a suitable proportion to provide carbohydrates and proteins in the animal ration and this can be achieved by growing legumes and non-legumes together.

Sushcherich (1978) reported that fat yields were the highest in barley-oat mixture but the highest digestible crude protein was given by oat-pea mixture. Arora (1971) observed

that sowing of oat in lines and broadcasting the legume in oat produced the herbage with almost same quality as that of legume alone, while oat alone resulted in the produce with the slightly poor quality. Konstantinova (1971) conducted a field trial in 1965-68 on Oat and barley in pure stand and in mixture with legumes including Vicia sativa, Vicia faba and Pisum sativum. Oat and barley grown mixed with legumes produced herbage with higher crude protein contents than the one obtained from pure stand of each. Merezhko (1972) reported that oat grown in combination with pea produced herbage of better quality than that of oat alone. Better quality of the mixture was attributed to higher chlorophyll content in pea as a result of which crude protein and succulency of forage increased. Similarly, Narayanarn and Dabadyhao (1979) also observed that pea sown in combination with oat, enhanced the feeding value of the produce. Bacher (1949) has also reported increased protein content in oat+pea mixture in comparison to the pure stand of oat. Chandini and Pillai (1983) studied the grass-legume mixture from quality point of view and observed that the grass-legume mixture is superior to grass alone. Singh et al. (1981) reported a considerable increase in crude protein of the herbage with the introduction of legume species in the grasses. Chauhan et al. (1981) .. intercropped cowpea with anjan grass. The total crude protein production was higher in case of intercropping system as compared to anjan grass alone. However, no adverse

effect on the growth of anjan grass was noticed due to cowpea introduction. Sushcherich (1978) reported that Oat+pea mixture resulted in higher crude protein yield over sale stand of oat. He also observed that Oat+pea mixture resulted in higher digestible crude protein as compared to barley+pea mixture. Singh (1985) quoted that mixed cropping of cereals with leguminous crops provide a high protein feed and contribute to soil fertility and as such curtails the nitrogen requirement of cereal crops to some extent. Mehra (1978) suggested that mixing of mustard with other fodder crops like oat, barley and berseem provide succulent, nutritious and protein-rich fodder. Dhar (1976) suggested the mixing of sarson (Var.chinese cabbage) in berseem for getting nutritious green forage. Rajbansdayal (1967) concluded that in a cereal-legume mixture, legume leaves soil richer in nitrogen as compared to cereal alone after crop harvest. Virtanen (1927) observed that a legume plant can obtain from the air not only sufficient nitrogen for its own needs but so much more as to satisfy the nitrogen requirement of at least one suitable non-legume plant grown along its vicinity. Mirchandani and Misra (1957) found that association, of legumes with cereals increased the yield of cereals and improved the protein contents of the produce. Studies conducted by Gill and Patil (1983) on intercropping of barley and oat with saffower and mustard revealed that on per unit area basis both the components combine favourably and did not compete with

each other and thus recorded overall higher rich nutritive fodder yields. Further studies conducted on intercropping of triticale with mustard confirmed their earlier findings. Keftasa (1985) was of the view that use of legumes in mixture should be aimed more at increasing crude protein content rather than dry matter yield.

2.3 Economics of forage production:

The economics of various cropping systems have been studied by various research workers and the reports available indicate that the intercropping system is quite economic under proper management.

Gill and Patil (1983) suggested that intercropping is much more profitable under rainfed conditions. This system ensure some thing to the farmers even under the adverse weather conditions. Rajhans (1967) found a grass-mixture to earn higher net profit as well as high net return per rupee investment as compared to pure stand.

Crowder and Chhedda (1979) also observed that grass-legume mixture grown together earn more profits due to high production and better quality herbage as compared to sole stand.

Rajbansdayal et al.(1967) revealed that intercropping of cereals and legumes gave significantly higher monetary returns as compared to cereals and legumes grown singly. They also observed that growing of cereal-legume mixture under dry farming conditions gave highest net return per rupee investment.

Singh (1985) found oat+berseem mixture more profitable as compared to the pure stand of these crops. He found that mixed stand gave more profit (Rs.17377.53) than pure stand of berseem (Rs. 15096.88) and oat (Rs.13845.22) per hectare. The higher returns were attributed to the availability of fodder in scarcity period due to fast growth of oat in early periods and that of berseem in the late periods. Rao et al. (1979) at Andhra Pradesh Agricultural University, Rajendranagar reported that cereal-legume intercropping gave 23.19 and 66.78 per cent higher net return than that of cereal and legume sown alone. Similar were the findings of Moreno et al. (1973) and Gupta (1976), they found the higher returns from mixture due to higher tonnage. Chandini and Pillai (1983) studied the grass-legume mixture from economic point of view. They observed that the grass-legume intercropping produced higher profit than grass and legume alone. The higher profit in case of mixture was the result of higher production of better quality herbage, which boost the productivity of the animals in terms of milk, meat and wool etc.

Dhar (1976) also observed that intercropping of sarson with other fodder crops is much more profitable and ensures high return per rupee investment. Gill and Patil (1983) found that intercropping of mustard with oat and barley is more beneficial as the mixture increases the palatability and reduces the wastage of herbage used to feed the animals. Dahal (1986) conducted an experiment to see the effectiveness of sowing techniques on

the production and quality of cereal-legume mixture. He observed that Oat in rows and legume by broadcast was found to be best sowing technique. This combination of cereal and legume registered the highest profit as well as high net return per rupee investment as compared to pure stand of these crops.

Misra et. al. (1982) suggested that Oat is more profitable than barley because of higher tonnage in case of oat under the same management practices.

Rehman et al. (1980) also observed that cereal-legume mixture sown in proper arrangement resulted in higher net profit as well as higher net return per rupee investment.

The literature cited above amply demonstrating that proper choice of a crop with a suitable companion crops and proper sowing techniques would enhance the profits of the farmerby increasing the productivity of the animals in terms of milk, wool and meat production.

Chapter - III

MATERIALS AND METHODS

The experiment entitled "Cropping Systems and sowing methods studies for rabi forages under rainfed conditions" was conducted at the Research Farm, College of Agriculture, Himachal Pradesh Krishi Vishva Vidyalaya, Palampur during Rabi 1987-88. The details of the materials and methods employed during the course of these investigations are presented in this chapter.

3.1. Site of the Experiment:

The experimental site was located at 32.6°N latitude and 76.3°E longitude at an elevation of about 1300 meters above mean sea level, the College farm has well established terraces.

3.2. Climate:

Palampur represents the mid-hill temperate zone of Himachal Pradesh. This zone is characterised by mild summers and cool winters. The climate is sub-temperate, with very high rainfall received during summers (monsoon) and medium to high rainfall with an occasional snowfall during winters. The mean weekly meteorological observations of the season recorded at Meteorological observatory of the Department of Agronomy and Agrometeorology, College of Agriculture, Palampur have been appended in Appendix I, and the graphic representation of the same has been given in Fig.1.

Total rainfall received during crop season was 436.24 mm. The average relative humidity ranged between 27.3 to 60.7 per cent during the growth period of the crops. The

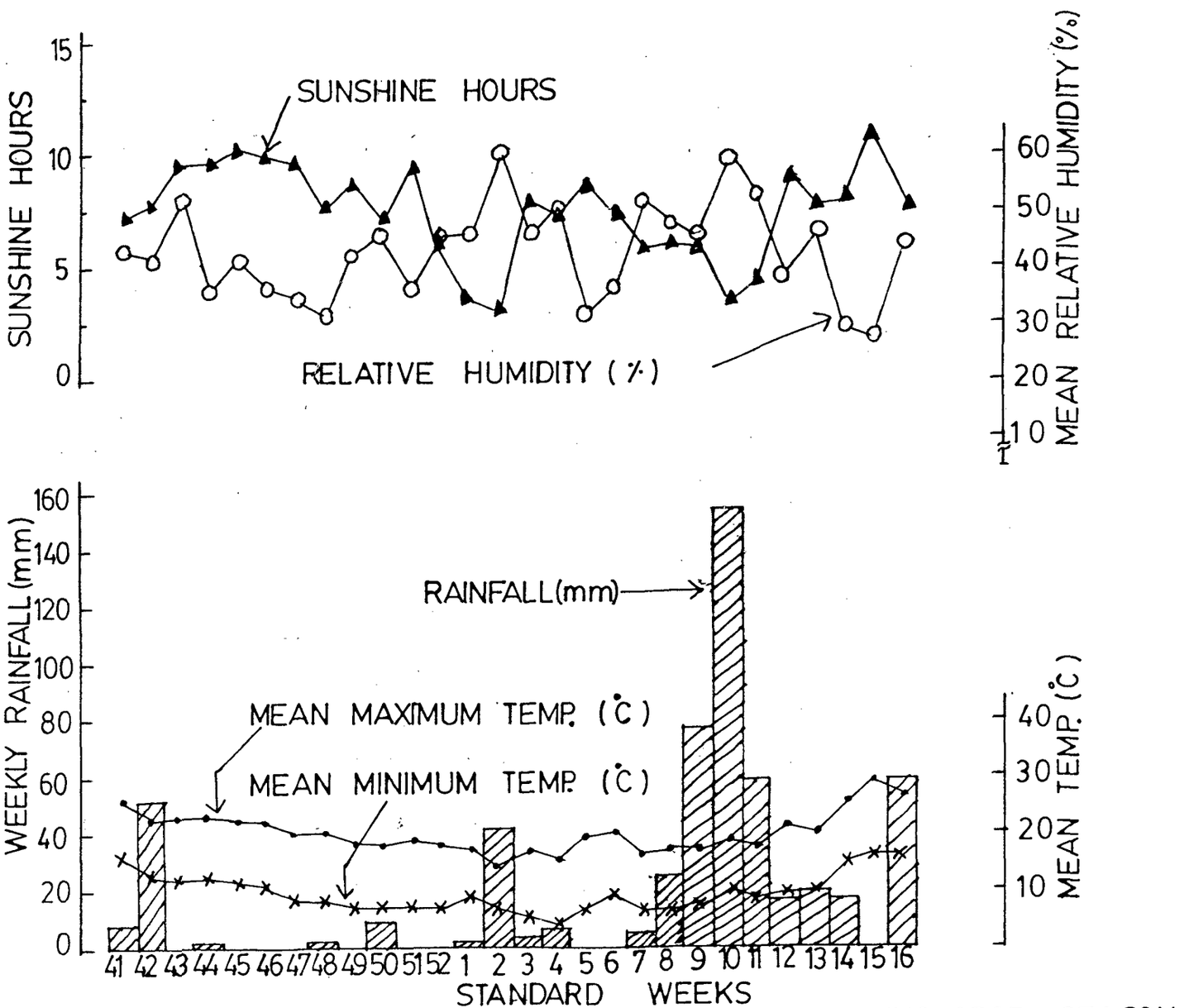


FIG.1: MEAN WEEKLY METEOROLOGICAL DATA DURING CROP SEASON

mean minimum and mean maximum temperature varied from 4.0 to 16.8°C and 14.8 to 29.1°C, respectively, during the crop season. The daily sunshine hours ranged between 3.2 to 10.8.

3.3 Soil characteristics:

Prior to the commencement of the experiment composite soil samples from 0-15 cm depth from each experimental plot were taken at sowing time. These samples were run for mechanical and chemical analysis, the results of which are presented in Table 1. The soil on which the experiment was carried out was silty clay loam. It is classified as Alfisol and belongs to the Subgroup typic hapludalfs (Verma, 1973). It was acidic in reaction and was medium in organic carbon, available nitrogen, phosphorus and high in available potash.

Table 1. Mechanical and chemical analysis of soils (0-15 cm).

Particular	Content	Methods employed
A. Mechanical analysis		
Coarse sand(%)	20.50	International pipette Method (Piper, 1966)
Fine sand (%)	15.40	
Silt (%)	36.90	
Clay (%)	27.12	
Texture	Silty clay loam.	
B. Chemical analysis		
Organic carbon (%)	0.89	Walkley and Black's rapid titration Method (Piper, 1966).
pH	5.5	1:2.5 Soil water suspension, Glass electrode pH meter (Jackson, 1967).

contd....

Table 1 contd....

Particular	Content	Methods employed
Available N (kg/ha)	516	Alkaline permanganate method (Subbiah and Asija, 1956).
Available P (kg/ha)	9.5	Olsen's method (Olsen et al., 1954)
Available K (kg/ha)	316	Ammonium acetate extraction method (Black, 1965).

Table 2. Physical properties of soil

i) Bulk density (g/cc)		
(a) 0-15 cm, surface soil profile depth	1.25	Core sampler method (Bodman, 1942)
(b) 15-30 cm, sub-surface soil profile depth	1.27	
(c) 30-45 cm, sub-surface soil profile depth	1.30	
ii) Field capacity (% on dry weight basis)		
(a) 0-15 cm, surface soil profile depth	27.70 (5.19)	Oven dry method
(b) 15-30 cm, sub-surface soil profile depth	28.12 (5.36)	
(c) 30-45, sub surface soil profile depth	28.30 (5.52)	
iii) Permanent wilting point(% on dry weight basis)		
(a) 0-15 cm, surface	16.23 (3.04)	15 atms. tension value by pressure membrane apparatus
(b) 15-30 cm, sub-surface soil profile depth	16.80 (3.20)	
(c) 30-45 cm, sub-surface soil profile depth	16.75 (3.26)	

contd.....

Table 1 contd....

Particular	Content	Methods employed
IV) Available soil moisture (cm)		
(a) 0-15 cm, surface soil profile depth	2.15	
(b) 15-30 cm, sub-surface soil profile depth	2.16	
(c) 30-45 cm, sub-surface soil profile depth	2.26	
V) Moisture content at the time of sowing (% on dry weight basis)		
(a) 0-15 cm, surface soil profile depth	20.11 (3.76)	Oven dry method.
(b) 15-30 cm, sub-surface soil profile depth	22.40 (4.26)	
(c) 30-45 cm, sub-surface soil profile depth	25.31 (4.93)	

Note: Figures in parenthesis indicate the corresponding values in cm.

3.4 Cropping History

Kharif 85 - Maize grain production (Fertilised with 120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha).

Rabi 85-86- Wheat production (90 kg N, 60 kg P_2O_5)

Kharif 86 - Weed control studies in Maize+soybean (Crops was fertilised with 90 kg N and 60 kg P_2O_5/ha).

Rabi 86-87- Oat and Barley in combination with Pea and Sarson for fodder crop. (Crops was fertilised with 90 kg N and 60 kg P_2O_5/ha)

Kharif 87 - General maize (80 kg N and 60 kg P_2O_5).

The experimental field had a fairly uniform fertility status.

3.5. Experimental details

The experiment was conducted in Split Plot Design and treatments were allocated randomly to main-plots and sub-plots of each replicate. The layout of the experiment is shown in Fig.2. Further details of the experiment have been given below:

A. Treatments

Treatments comprised of three crops, three cropping systems and two methods of sowing as per details given below:

(a) Main Plot treatments

Fodder Crops and Cropping Systems

Fodder Crops		Cropping systems
C_1 - Oat		S_1 - Pure stand
C_2 - Barley	X	S_2 - Pea (Broadcast)
C_3 - Oat+Barley		S_3 - Sarson (Broadcast)

All possible nine combinations were C_1S_1, C_1S_2, C_1S_3, C_2S_1, C_2S_2, C_2S_3, C_3S_1, C_3S_2, C_3S_3.

(b) Sub-plot treatments

Method of Sowing

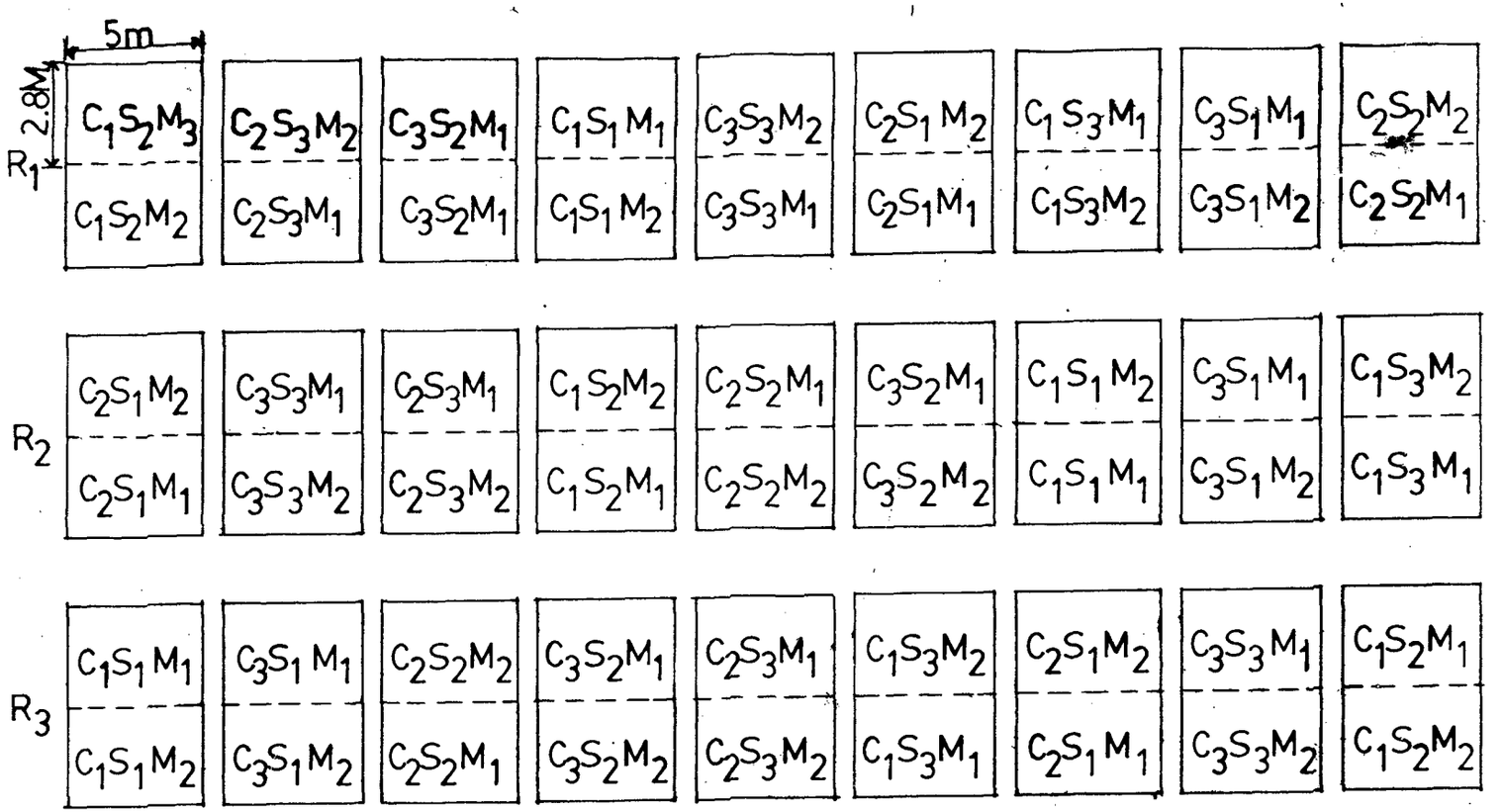
M_1 - Line sowing

M_2 - Broadcast sowing

(c) Design of Layout: Split Plot

(d) Replications: Three

(e) Plot size: Gross: 5m x 2.80m
Net: 4m x 2.4m



MAIN PLOT TREATMENTS- (FODDER CROPS AND CROPPING SYSTEMS)

FODDER CROPS

C_1- OAT
C_2- BARLEY
C_3- OAT+ BARLEY

CROPPING SYSTEMS

S_1- PURE
S_2- PEA (BROADCAST)
S_3- SARSON (BROADCAST)

(C_1S_1, C_1S_2, C_1S_3, C_2S_1, C_2S_2, C_2S_3, C_3S_1, C_3S_2, C_3S_3)

SUB-PLOT TREATMENTS → (SOWING METHODS)

M_1- LINE SOWING
M_2- BROADCAST SOWING

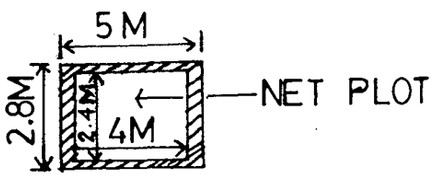


FIG. 2: PLAN OF LAYOUT OF THE EXPERIMENT

3.6 Germination Percentage:

Germination percentage of seeds for various crops as determined in laborayory prior to sowing by germination test on filter paper, were as follow:

1. Oat : 92%
2. Barley : 90%
3. Pea : 78%
4. Sarson : 96%

Accordingly, the seed rate was adjusted.

3.7 Seed Rate:

Optimum seed rate for each crop, whether grown as pure or mixed was used, as given below:

Oat = 125 kg/ha
Barley = 125 kg/ha
Pea = 40 kg/ha
Sarson = 8 kg/ha

3.8 Varieties:

The various crops varieties selected were as under:

1. Oat : HPO 788
2. Barley : Dolma
3. Pea : Local Pea (Sain)
4. Sarson : FOS - 902

3.9 Fertilization:

80 kg N and 60 kg P_2O_5 to each Oat and barley was applied. Half N and all the phosphorus was applied at the time of sowing, and remaining half N was applied after first

cut. No additional dose was given to pea/sarson.

3.10 Seed material and sowing:

The seed of HPO 7B Oat and Dolma Barley was procured from the Seed Production Scientist, Himachal Pradesh Krishi Vishva Vidyalaya, Palampur. The seed of Sarson (FOS-902) was procured from the Oilseed breeder, Department of Plant Breeding, Himachal Pradesh Krishi Vishva Vidyalaya, Palampur. The seed of local Pea (Sain) was procured from the farmers.

After the harvest of maize crop in the September, the field was ploughed, harrowed and finally levelled and than layout and the levelling of individual plot was done. The basal dose of fertiliser was applied by broadcast method and the treatments involving broadcast sowing were applied and incorporated into the soil with the help of spade. In case of line sown treatments sowing of oat and barley was done in furrows 20 cm apart and seeds were placed at a depth of 5 cm, peas and sarson was broadcast in the plots. Suhaga was run after the sowing to cover the seeds.

3.11 Weeding:

Common weeds were Phalaris minor, Lolium tamulantum, Cornopus didymus and Avena sativa, one manual weeding was done after one month of sowing to keep the plots free of weeds. Another weeding was done after the first cutting and before the application of fertiliser.

3.12. Harvesting

In all two cuts were taken from these crops. The first cut was taken at 70 days growth stage of the crops when they attained good growth and sufficient height. While the second cut was taken after 80 days of the first cut. The plants were cut 2-2.5 cm above ground, in case of pea in some plants lower one or two branches were left.

3.13. Observations Recorded

The following observations were recorded from each experimental plot at each cutting, with a view to assess the effect of treatments on the growth, yield and quality of the forage.

3.13.1. Growth Studies

Border of 50 cm from lengthwise of the plot and 20 cm from widthwise of the plot was left as non-experimental area and from the net plot area the various growth observations were recorded.

1. Plant Height:

Height of 5 randomly selected and labelled plants of each crop species (Oat, barley, pea and sarson). was measured in centimetres from ground level to the tip 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.

Table .3. Schedule of cultural operations carried out during the crop season (Rabi 1987-88).

Sr.No.	Particular of operation	Dates	Brief account of operation
1.	Preparatory tillage	2.11.1987	First two ploughing with tractor than with cultivator followed by planking.
2.	Layout	7.11.1987	Each replicate was divided into nine main-plots, then sub-divided into 2 sub-plots
3.	Soil sampling		
	(i) For Physio-chemical properties	8.11.1987	Detail described in text.
	(ii) For Moisture content	10.11.1987	
4.	Fertiliser application		
	(i) At the time of sowing	10.11.1987	-do-
	(ii) After first cut	22.1.1988	-do-
5.	Sowing	10.11.1987	-do-
6.	Weeding		
	First weeding	11.12.1987	
	Second weeding	20.1.1988	
7.	Harvesting		
	First cut	19.1. 1988	
	Second cut	8.4. 1988	

2. Shoot number

The square grid measuring 0.5m x 0.5m was thrown randomly and the number of shoots within each square grid were counted. In case of mixed stand the shoot number was recorded separately for each crop. The average shoot number was worked out from two such samples taken per plot and expressed in per square metre.

3. Fresh and dry weights

The plants within the square grid area were cut 2-2.5 cm above ground and the sample were made free from water drops and soil particles, then the fresh weight was recorded. The total fresh weight in gram per square metre was worked out.

After recording the fresh weight the samples were sun dried for two days and then these were dried in a forced air dryer at $70^{o}C$ till a constant weight was attained, and were reweighed to record their respective dry weights. The per cent dry matter content was determined by the relationship:

$$\text{Dry matter content} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

4. Per cent proportion of legume and sarson in fodder crops:

Samples taken for fresh weight were sundried for 2 days. Main crops (oat, barley) and companion crops (pea, sarson) were separated and were dried in a forced air drier at

70°C till a constant weight was attained, then they were weighed separately. The per cent proportion of companion crops (peas or sarson) in pure crops was worked out as a percentage of companion crop to the combined weight of the mixed stand.

3.13.2. Green and dry forage yields

(a) Green forage yield

The produce from the net plot was cut and weighed. The total yield for each plot was adjusted to include the fresh weight of samples taken for various observations. The cutwise as well as total yield of all the cuts was converted in quintals per hectare.

(b) Dry forage yield

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

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

Then the dry matter yield at each cut as were as total of both the cuts was worked out in quintals per hectare.

3.13.3. Plant chemical studies

(1) Crude Protein

The samples collected at each cutting for green and dry weights determination were run for estimation of total nitrogen. Respresentative samples, weighing 1 g were collected after grinding and total N was determined by the modified kjeldahl method (AOAC, 1970). One quantity of powdered sample was taken in a kjeldahl flask and digested in 20 ml of

concentrated sulphuric acid using 5 gm of digestion mixture for each sample.

The digestion was continued till the material inside the flask attained a pale white or a greenish yellow colour, after which it was allowed to cool. The digested material was then transferred to a 100 ml volumeteric falsk giving five to six washings with water and the final volume was made upto the mark after cooling the contents to room temperature. The content were made homogenous by thorough mixing. Out of this 5 ml were pipetted out and distilled with 40% castic alkali solution in a micro distillation apparatus (Morkharis apparatus) using 10 ml of 4% boric acid solution with mixed indicator to trap the released ammonia which was estimated by titration with N/50 sulphuric acid. The percentage crude protein was calculated by multiplying per cent N by a factor 6.25. Crude protein yield was calculated with the help of following relationship:

$$\text{Crude protein yield} = \frac{\text{Per cent crude Protein content}}{100} \times \text{Dry matter yield(q/ha)}$$

The per cent crude protein of two cuts was expressed on the basis of weighted average.

(2) Crude fibre

Two g of finelly dried powdered and moisture free sample was taken in a paper thimble. It was extracted with petroleum ether (60-90° BP) in a Soxhlet apparatus for fifteen

to eighteen hours to make the sample free from fats. After carrying out the ether extraction the sample was digested with 200 ml of 1.25 per cent sulphuric acid (25 ml of 10% acid + 175 ml water) for 30 minutes in a conical flask under reflux. Filtered through a muslin cloth (45 threads to an inch) using suction to hasten filtration. Washed with water to render it free of acid. Transfered the residue to a beaker and now added 200 ml of 1.25 per cent Sodium hydroxide (25 ml of 10% NaOH+175 ml water) and boiled for half an hour. Filtered this and washed it to free from the alkali using in turn (i) hot water (ii) 1% HNO_3 (iii) hot water for washing. Transferred the residue to a weighed dish and dried it to a constant weight at 100°C. Ignited the residue to get ash and recorded its weight again. The loss in weight due to ignition is equal to crude fibre. So crude fibre = weight of residue - weight of ash. This was expressed as a percentage of original sample taken for ether extraction.

Crude fibre yield quintal per hectare was calculated with the help of following relationship:

$$\text{Crude fibre yield} = \frac{\text{Percent crude fibre content}}{100} \times \text{Dry matter yield(q/ha)}$$

The per cent crude fibre contents of two cuts was expressed on the basis of weighted average.

3.14 Soil moisture studies

Soil samples from experimental area with the help of auger (manually operated) were taken from three soil surface

depths viz.0-15 cm, 15-30 cm and 30-45 cm. After recording fresh weight of samples, these were dried in an electric oven at 105°C till constant weight and moisture percentage was calculated on oven dry weight basis with the help of following formula.

$$Mp = \frac{F_w - D_w}{D_w} \times 100$$

Where,

F_w = Fresh weight of soil sample

D_w = Dry weight of soil sample

M_p = Moisture percentage on oven dry weight basis.

Then data was reported after converting moisture (%) into cm of water with the help of following formula (Binkowski, 1961).

$$\text{Water content (cm)} = \frac{M_p \times BD \times D_{sp}}{100}$$

Where,

M_p = Moisture percentage on oven dry weight basis

BD = Bulk density of the soil layer from where soil sample was taken

D_{sp} = Depth of soil layer.

3.15. Economics Study

The economics of each treatment was worked out. The cost of inputs and outputs have been worked out on the basis of records at the purchase sources. Cost of production of

each treatment, gross profit, net profit and net return per rupee investment have been calculated.

3.15. Statistical analysis

The observations recorded in this study were subjected to statistical analyses by adopting the methods described by Cochran and Cox (1963).

Chapter - IV

EXPERIMENTAL RESULTS

The treatment effects observed during the course of this investigation conducted in Rabi 1987-88, have been described in this chapter. The experimental findings enunciated from the investigation have been presented with the help of data tables and suitable diagrams, wherever necessary. The analyses of variance tables have been given in Appendix section. Only significant interactions have been mentioned and described.

4.1. GROWTH STUDIES

4.1.1. Plant height

The data on average plant height (cm) of oat, barley, pea and sarson as influenced by different treatments are given in Tables 4 to 7 and presented graphically in Fig.3. The corresponding analyses of variance have been appended in Appendices II to V.

The plant height of fodder crops (oat, barley) was the same in both the cuts as well as in the total of the two cuts whether grown pure or in association with pea or sarson. The association with pea or sarson also did not affect the plant height of the main crops whether sown in lines or by broadcast. The main crops produce plants with more height in the second cut as compared to the first cut, whether grown pure or in association with companion crops, as indicated by more growth rate (cm per day) in all the crops in second cut

compared to first cut Appendix . Sowing methods also did not exhibit any influence on the plant height of pure as well as companion crops. It is however, observed that when pea was grown in association with various fodder crops they did regenerate and produce plants of about 30 cm height irrespective of sowing techniques, whereas, sarson totally failed to regenerate (Table 7).

Since pea and sarson as companion crops with oat, barley and their mixture did not affect the plant height of either of the crop and at the same time the plant height of companion crops was also not affected by various crops and the sowing techniques, as such they can be safely grown in association with these crops.

Thus, it is interesting to note that various fodder crops under study did not exhibit any difference in plant height, whether grown pure or in association with pea and sarson following any technique of sowing. So, was the trend in respect of companion crops, indicating thereby that these crops can be grown together without having any adverse affect on their growth when grown in association with each other, Thus, this study sufficiently encourage the growing of cereals and legumes together for getting a quality herbage, without having any detrimental effect on each other.

4.1.2. Shoot number

Data on the number of shoots (m^{-2}) of various crops at different cuts as influenced by different treatments have

Table 4 . Mean Plant height (cm) of Oat as influenced by different treatments at various cuts.

Treatment	Cuts		Cummulative
	I	II	
A. Fodder Crops			
Oat	70.8	84.0	154.8
Oat+Barley	72.3	84.1	156.4
SEm±	1.21	1.58	1.91
CD 5%	NS	NS	NS
B. Cropping systems			
Fodder Crops-Pure stand	72.2	85.3	157.5
Fodder Crops+Pea (broadcast)	71.6	84.2	155.8
Fodder Crops+Sarson (broadcast)	70.9	82.6	153.5
SEm±	1.48	1.94	2.34
CD 5%	NS	NS	NS
C. Sowing methods			
Line sowing	75.2	83.8	159.0
Broadcast sowing	70.0	84.3	154.3
SEm±	1.76	2.08	3.15
CD 5%	NS	NS	NS

Table 5. Mean Plant height (cm) of barley as influenced by different treatments at various cuts.

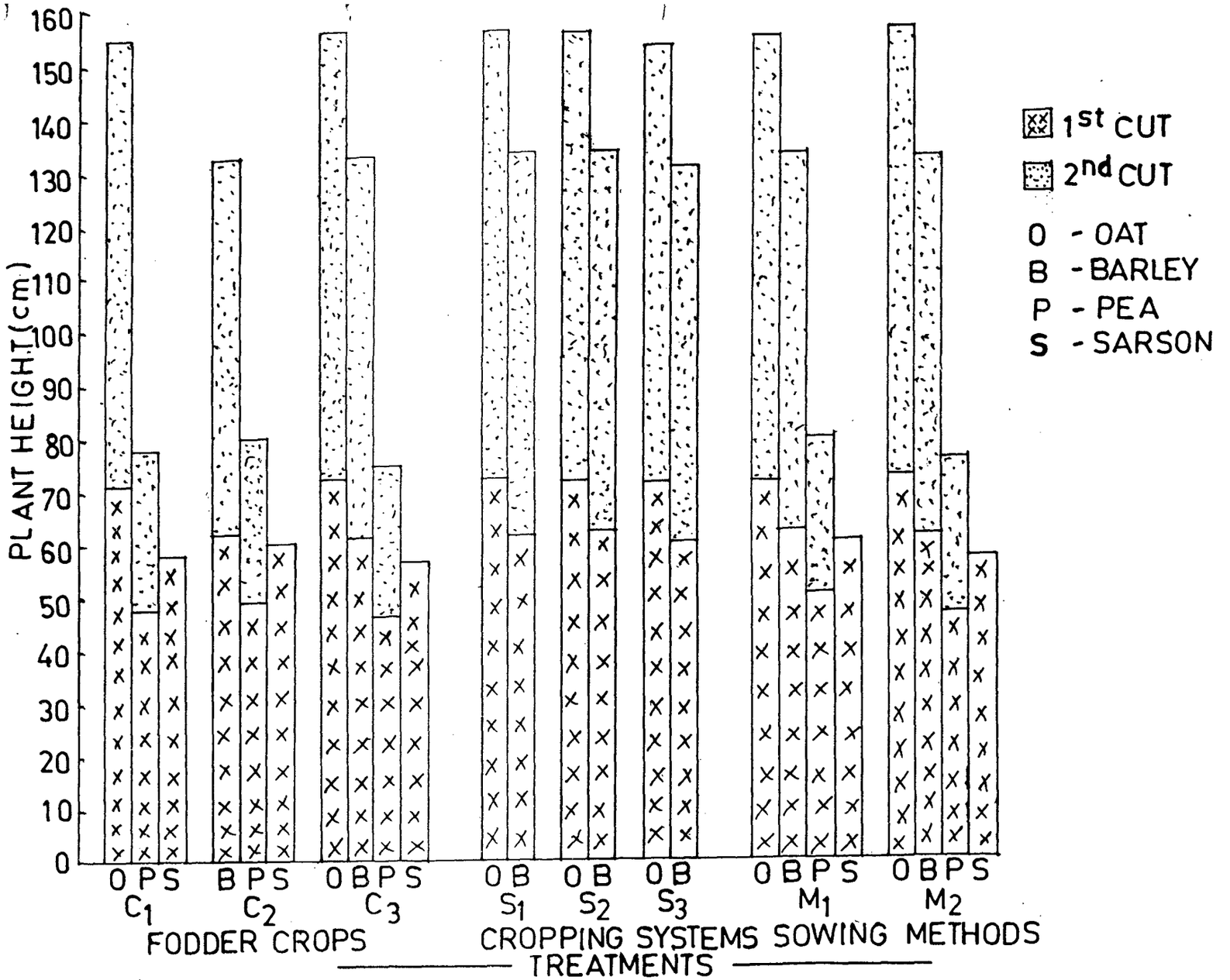
Treatment	Cuts		Cummulative
	I	II	
A. Fodder crops			
Barley	61.8	70.6	132.4
Oat+Barley	60.6	72.0	132.6
SEm±	0.96	1.11	1.79
CD 5%	NS	NS	NS
B. Cropping systems			
Fodder Crops+Pure stand	61.6	71.8	133.4
Fodder Crops+Pea (broadcast)	62.2	71.4	133.6
Fodder Crops+Sarson (broadcast)	59.9	70.4	130.3
SEm±	1.2	1.4	2.2
CD 5%	NS	NS	NS
C. Sowing methods			
Line sowing	63.6	72.0	135.6
Broadcast sowing	60.8	70.6	131.4
SEm±	0.85	1.73	2.04
CD 5%	NS	NS	NS

Table 6. Mean Plant height (cm) of Pea as influenced by different treatments at various cuts.

Treatment	Cuts		Cummulative
	I	II	
A. Fodder crops			
Oat	47.5	29.8	77.3
Barley	49.3	30.4	79.7
Oat+Barley	46.4	28.4	74.8
SEm±	1.97	0.74	1.95
CD 5%	NS	NS	NS
B. Sowing methods			
Line sowing	49.1	30.0	79.1
Broadcast sowing	46.3	28.0	74.3
SEm±	1.12	1.87	2.29
CD 5%	NS	NS	NS

Table 7. Mean Plant height (cm) of Sarson as influenced by different treatments at first cut.

Treatment	I Cut
A. Fodder crops	
Oat	57.5
Barley	59.5
Oat+Barley	56.6
SEm±	1.49
CD 5%	NS
B. Sowing methods	
Line sowing	60.2
Broadcast sowing	56.6
SEm±	1.06
CD 5%	NS



FIG·3:- MEAN PLANT HEIGHT (cm)

been presented in Table 8 to 11 and have been illustrated in Fig.4.5. The analyses of variance of the same have been appended in Appendices VI to IX.

A perusal of the data (Tables 8 and 9) indicated that the oat and barley produced almost similar number of shoots per square metre in both the cuts, whereas, oat+barley mixture produced less shoot number per square metre than oat and barley. An interesting point was noted that when oat was grown mixed with pea or sarson the shoot number of oat remained the same as that of pure stand of oat. However, the shoot number of barley in pure stand and in pea mixed crop recorded similar but significantly higher than that of barley grown with sarson. Similar trend was observed in both the cuts in terms of oat as well as barley.

Sowing methods influenced the oat and barley shoot number in both the cuts. Line sowing recorded more shoots of both the crops at both the cuts over broadcast sowing.

Oat sown in line produced 25.6 and 24.5 per cent higher shoot number at first and second cut, respectively over broadcast sowing, while barley in line sowing resulted in 25.7 and 25.8 per cent higher shoot number in first and second cut, respectively over broadcast sowing.

Neither the fodder crops nor the sowing methods could influence the shoot number of pea and sarson significantly in any of the cut. The shoot number of pea was considerably

reduced in the second cut in all the fodder crops as well as in both the sowing methods. On the other hand the sarson altogether failed in producing any plant in second cut. Thus, above results clearly indicate that both pea or sarson can be grown mixed with oat, however, in case of barley only pea seems to be a good companion crop, as association of sarson significantly reduce the barley population.

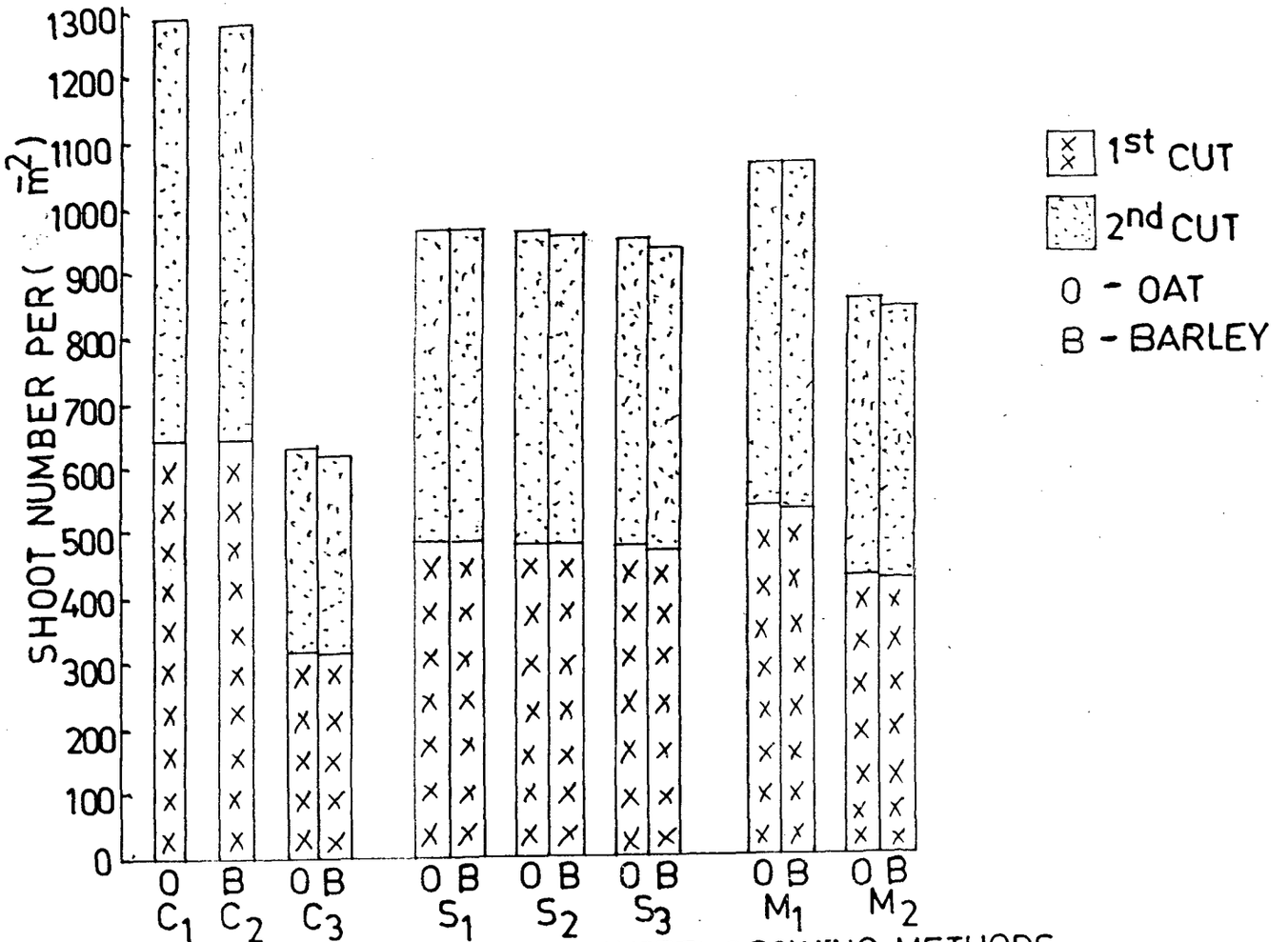
None of the interaction was found to influence the shoot number significantly at any of the cut (Appendix VI to IX).

Table 8. Mean shoot number of oat (m^{-2}) as influenced by different treatments at various cuts.

Treatment	Cuts	
	I	II
A. Fodder crops		
Oat	646	644
Oat+Barley	315	310
SEm±	1.84	1.70
CD 5%	6	5
B. Cropping system		
Fodder Crops-Pure stand	484	479
Fodder Crops+Pea (broadcast)	481	480
Fodder Crops+Sarson(broadcast)	478	474
SEm±	2.26	2.08
CD 5%	NS	NS
C. Sowing methods		
Line sowing	535	529
Broadcast sowing	426	425
SEm±	2.19	1.79
CD 5%	6	6

Table 9. Mean shoot number of barley (m^{-2}) as influenced by different treatments at various cuts.

Treatment	Cuts I	Cuts II
A. Fodder crops		
Barley	645	639
Oat+Barley	312	307
SEm±	1.33	1.33
CD 5%	4	4
B. Cropping systems		
Fodder Crops+Pure stand	484	480
Fodder Crops+Pea (broadcast)	481	476
Fodder Crops+Sarson (broadcast)	470	464
SEm±	1.63	1.63
CD 5%	5	5
C. Sowing methods		
Line sowing	533	527
Broadcast sowing	424	429
SEm±	2.05	1.93
CD 5%	6	6



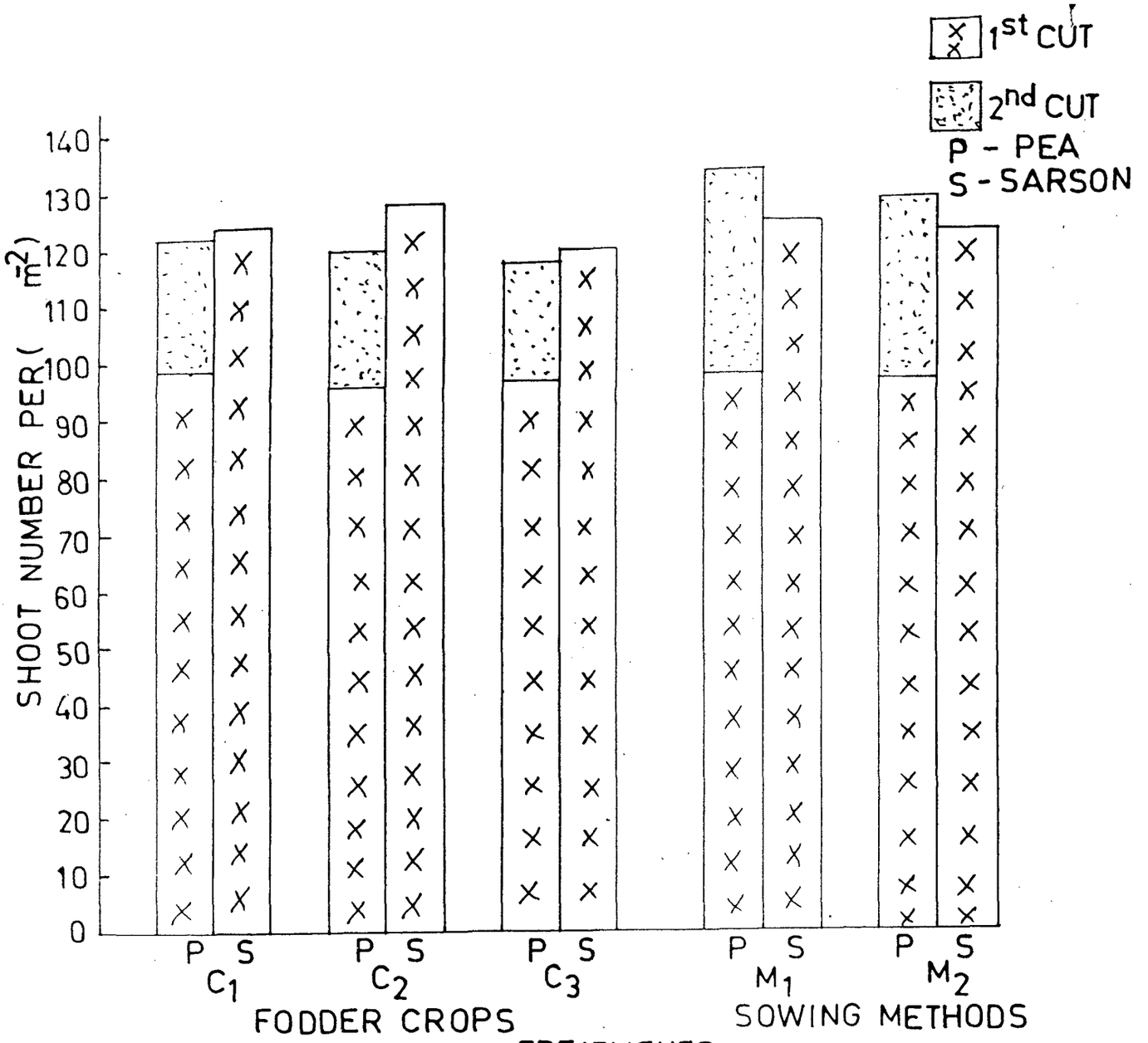
FIG·4:-MEAN SHOOT NUMBER OF OAT AND BARLEY (m^{-2})

Table 10. Mean Shoot number of Pea (m^{-2}) as influenced by different treatments at various cuts.

Treatment	Cuts	
	I	II
A. Fodder crops		
Oat	99	23
Barley	96	24
Oat+Barley	97	21
SEm±	2.00	1.20
CD 5%	NS	NS
B. Sowing methods		
Line sowing	98	36
Broadcast sowing	97	32
SEm±	0.87	1.12
CD 5%	NS	NS

Table 11. Mean Shoot number of Sarson (m^{-2}) as influenced by various treatments at I cut.

Treatment	Shoot number
A. Fodder crops	
Oat	124
Barley	128
Oat+Barley	120
SEm±	2.56
CD 5%	NS
B. Sowing methods	
Line sowing	125
Broadcast sowing	123
SEm±	1.43
CD 5%	NS



FIG·5:-MEAN SHOOT NUMBER OF PEA AND SARSON (m^2)

4.1.3. Per cent proportion of Pea in fodder crops

The data on mean per cent proportion of pea as influenced by different treatments at two cuts is presented in Table 12 and the corresponding analyses of variance have been given in Appendix X.

Table 12. Mean per cent proportion of Pea in fodder crops as influenced by different treatments at various cuts.

Treatment	Cuts		Mean
	I	II	
A. Fodder crops			
Oat	13.9	3.7	8.7
Barley	13.4	3.5	8.4
Oat+Barley	13.0	3.3	8.1
SEm±	0.56	0.09	0.18
CD 5%	NS	NS	NS
B. Sowing methods			
Line sowing	14.9	5.0	9.9
Broadcast sowing	11.8	1.9	6.9
SEm±	0.27	0.12	0.12
CD 5%	0.9	0.4	0.4

A keen observation of data revealed that the percent proportion of pea was not significantly influenced by various fodder crops at both the cuts as well as when averaged over

two cuts. In general, maximum legume per cent was observed in oat and the lowest in oat+barley.

However, two methods of sowing exhibited significant differences in respect of legume dominance. Line sowing resulted in higher proportion of pea over broadcast sowing at both the cuts, as well as when averaged over two cuts. On an average line sowing recorded 21.4 per cent higher proportion of pea over broadcast sowing. Higher proportion of the pea in line sowing may be attributed to the more interrow space for its growth.

4.1.4. Per cent proportion of sarson in fodder crops:

The data on mean per cent proportion of sarson as influenced by different treatments at first cut is presented in Table 13 and the corresponding analyses of variance have been given in Appendix XI.

Table 13. Mean per cent proportion of Sarson in fodder crops as influenced by different treatments at I cut.

Treatment	Per cent proportion
A. Fodder crops	
Oat	14.3
Barley	14.3
Oat+Barley	13.6
SEm±	0.28
CD 5%	NS
B. Sowing methods	
Line sowing	14.4
Broadcast sowing	13.8
SEm±	0.19
CD 5%	NS

Different fodder crops and sowing methods did not influence the per cent proportion of sarson. However, oat and barley recorded 5.15 per cent higher proportion than oat+barley and line sowing registered an increase of 4.35 per cent over broadcast sowing.

4.1.5. Fresh weight

The data on fresh weight (g m^{-2}) at different cuts and mean of all the cuts have been given in Table 14. The corresponding analyses of variance are appended in Appendix XII and data have been illustrated graphically in Fig.6.

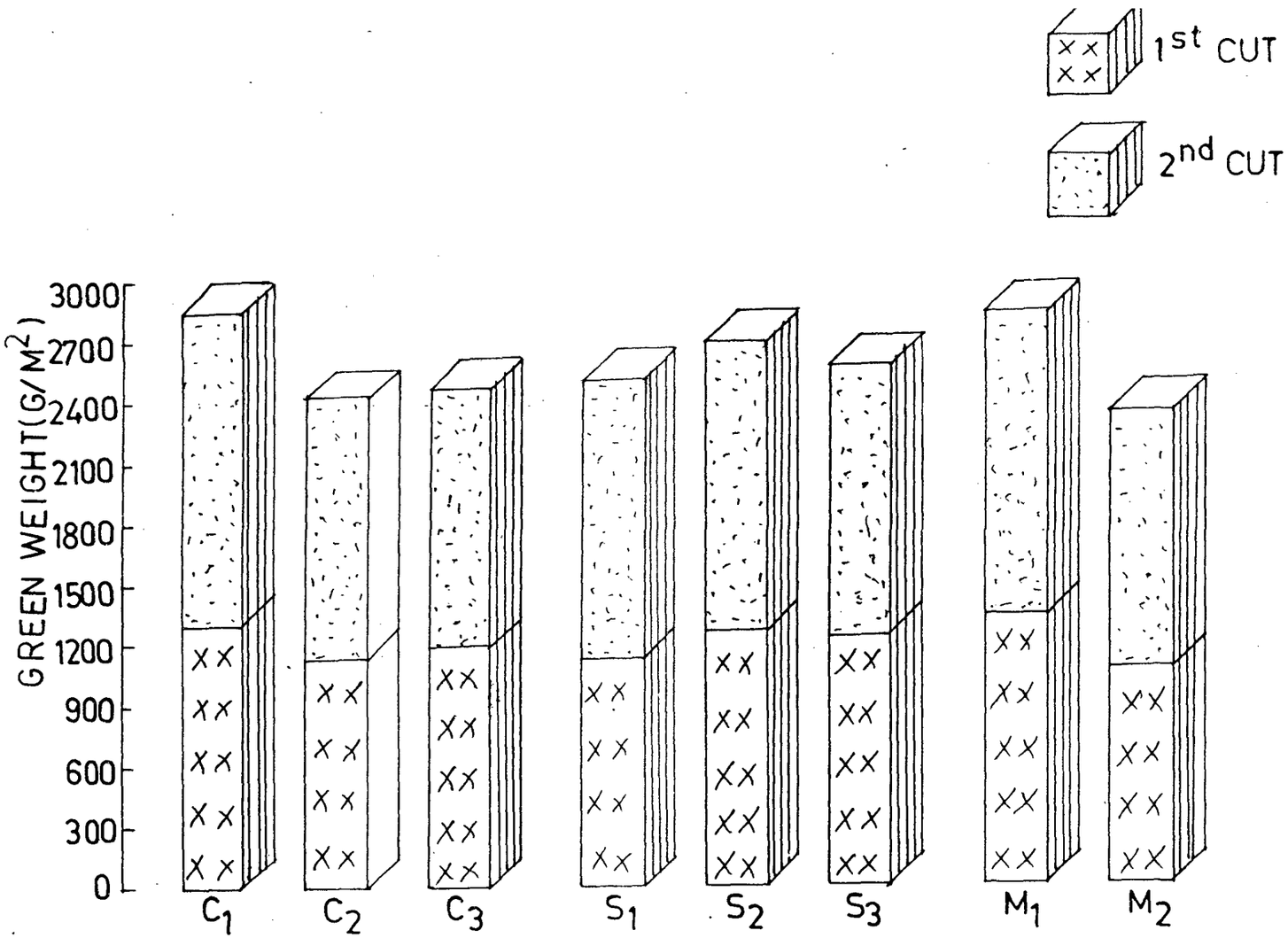
Table 14. Mean fresh weight (g m^{-2}) as influenced by different treatments at various cuts.

Treatment	Cuts		Mean
	I	II	
A. Fodder crops			
Oat	1296.9	1570.3	1433.7
Barley	1134.6	1308.9	1221.7
Oat+Barley	1191.5	1276.1	1233.8
SEm±	0.22	0.23	0.14
CD 5%	0.7	0.7	0.4
B. Cropping systems			
Fodder Crops+Pure stand	1135.2	1372.3	1253.8
Fodder Crops+Pea (broadcast)	1257.3	1433.7	1345.5
Fodder Crops+Sarson (broadcast)	1230.6	1349.2	1289.8
SEm±	0.22	0.23	0.14
CD 5%	0.7	0.7	0.4
C. Sowing methods			
Line sowing	1345.1	1490.2	1417.6
Broadcast sowing	1070.3	1279.9	1175.1
SEm±	0.12	0.11	0.08
CD 5%	0.4	0.3	0.3

A perusal of data (Table 14) indicated that the fresh weight of herbage was influenced significantly by all the treatments at both the cuts as well as when averaged over both the cuts. Oat recorded significantly higher fresh weight compared to barley and oat+barley at both the cuts. The latter two crops also differed significantly with each other. Oat+barley registered higher fresh weight than barley in the first cut and when averaged over two cuts, however, in the second cut pure crop of barley registered higher fresh weight than that of oat+barley. On an average pure crop of oat produced 17.4 and 16.2 per cent higher fresh weight (g m^{-2}) over barley and oat+barley, respectively.

Fodder crops grown mixed with pea as companion crop recorded significantly higher fresh weight than that of pure stand and crops grown in combination with sarson at both the cuts. Crops grown in association with sarson produced significantly higher fresh weight per unit area than pure stand of fodder crops. On an average oat-pea mixture produced 7.3 and 4.3 per cent higher fresh weight per unit area over pure stand and crops grown mixed with sarson, respectively.

Line sowing was found to be significantly superior to broadcast sowing. On an average line sowing registered an increase of 20.6 per cent over broadcast sowing.



FIG·6 :- MEAN GREEN WEIGHT (G/M²)

Table 14.1. Effect of Crops x Cropping Systems intefaction on mean fresh weight (g m^{-2}).

Fodder Crops		Cropping systems		
		Pure stand	Crop+ Pea(broadcast)	Crop+ Sarson (broadcast)
Oat		1377.8	1563.2	1359.9
Barley		1181.5	1232.6	1250.9
Oat+Barley		1202.1	1240.7	1258.4
SEm±	0.24			
CD 5%	0.71			

Crops X Cropping systems influence the mean fresh weight (g m^{-2}) significantly (Table 14.1). Oat grown pure or in association with pea or sarson registered significantly higher fresh weight over barley and oat+barley grown pure or in combination with companion crops. Oat+barley inturn proved better than barley alone in all the cropping systems. Pea was found to be best companion crop with oat however, Sarson proved better for both barley and Oat+barley mixture. All the crops when grown in association with pea or Sarson produced higher fresh weight than that of pure stand of the crops, except oat, however, pure crop of oat produced higher fresh weight than oat grown in association with Sarson.

Fresh weight (g m^{-2}) was also influenced significantly by Crops x sowing methods (Table 14.2). All the fodder crops sown in line resulted in significantly higher fresh weight per unit unit area over broadcast sowing. Oat whether sown in

Table 14.2. Effect of Crops x Sowing methods interaction on mean fresh weight (g m^{-2}).

Fodder Crops	Sowing Methods	
	Line sowing	Broadcast sowing
Oat	1565.2	1302.1
Barley	1352.3	1091.1
Oat+Barley	1335.3	1132.2
	SEm±	CD 5%
For comparison between two sowing methods means at the same level of crops	0.15	0.43
For comparison between two fodder crop means at the same or different levels of sowing methods	0.20	0.52

line or by broadcast produced significantly higher fresh weight than barley and oat+barley mixture. However, barley sown in line produced higher fresh weight over oat+barley mixture whereas, the trend in respect to these crop in broadcast sowing was reverse.

Table 14.3. Effect of Cropping systems x sowing methods interaction on mean fresh weight (g m^{-2}).

Cropping systems	Sowing methods	
	Line sowing	Broadcast sowing
Pure stand	1369.5	1137.9
Fodder Crops+Pea (broadcast)	1477.3	1213.7
Fodder Crops+Sarson (broadcast)	1406.0	1173.7
	SEm±	CD 5%
For comparison between two sowing methods means at the same level of cropping systems	0.18	0.51
For comparison between two cropping system means at same or different levels of sowing methods	0.20	0.51

Cropping systems x sowimg methods interaction on fresh weight (g $m^{\frac{1}{2}2}$) (Table 14.3) revealed that the fodder crops sown pure or mixed with pea or sarson in line sowing produced significantly higher fresh weight (g m^{-2}) than sown by broadcast. All the fodder crops grown mixed with pea and sarson either in line sowing or by broadcast sowing resulted in higher production of fresh weight per unit area over pure stand of fodder crops sown by either of the method.

Table 14.4. Effect of Crops x Cropping Systems x Sowing methods interaction on fresh weight (g m-2).

Fodder crops	Cropping systems	Sowing methods	
		Line sowing	Broadcast sowing
Oat	Pure stand	1489.2	1266.1
	+Pea (broadcast)	1720.7	1405.8
	+Sarson (broadcast)	1485.7	1234.3
Barley	Pure stand	1303.4	1059.6
	+Pea (broadcast)	1372.2	1093.0
	+Sarson (broadcast)	1381.4	1120.8
Oat+Barley	Pure stand	1315.9	1088.2
	+Pea (broadcast)	1339.0	1142.3
	+Sarson (broadcast)	1351.0	1166.0
		SEm+	CD 5%
For the comparison between two sowing method means at the same level of crops and cropping systems		0.25	0.75
For the comparison between crops and cropping system means at the same or different levels of methods		0.4	1.3

The fresh weight was significantly influenced by crops x cropping systems x sowing methods interaction (Table 14.4). Fodder crops following any cropping system produced significantly higher fresh weight in line sowing over broadcast sowing. It is interesting to note that pea was found to be best companion crop with oat irrespective of the methods of sowing, on the other hand Sarson was found to be the best companion crop with barley and oat+barley in both the methods of sowing.

4.1.6. Dry weight

The data on the mean dry weight (g m^{-2}) at different cuts and mean of all the cuts have been given in Table 15. The corresponding analyses of variance are appended in Appendix XIII and graphic representation of the same has been made in Fig.4.

Like green weight, the dry weight was also influenced significantly by various treatments at both the cuts. In all the treatments dry weight showed an increasing trend in second cut.

Oat produced significantly higher dry weight than other crops. Oat+barley produced significantly higher dry weight over barley in first cut however, reverse trend was observed in second cut. On an average oat registered an increase of 14.9 and 14.70 per cent over barley and Oat+barley, respectively.

Table 15. Mean dry weight ($g\ m^{-2}$) as influenced by different treatments at various cuts.

Treatment	Cuts		Mean
	Ist	IInd	
A. Fodder Crops			
Oat	297.3	393.5	345.6
Barley	264.3	337.5	300.9
Oat+Barley	276.5	326.2	301.3
SEm±	0.17	0.11	0.09
CD 5%	0.5	0.3	0.3
B. Cropping Systems			
Fodder Crops+Pure stand	263.9	351.8	307.9
Fodder Crops+Pea (broadcast)	290.9	363.4	327.1
Fodder Crops+Sarson (broadcast)	283.8	341.8	312.8
SEm±	0.17	0.11	0.09
CD 5%	0.5	0.3	0.3
C. Sowing Methods			
Line sowing	309.3	383.0	346.2
Broadcast sowing	249.7	321.7	285.7
SEm±	0.03	0.09	0.08
CD 5%	0.1	0.3	0.2

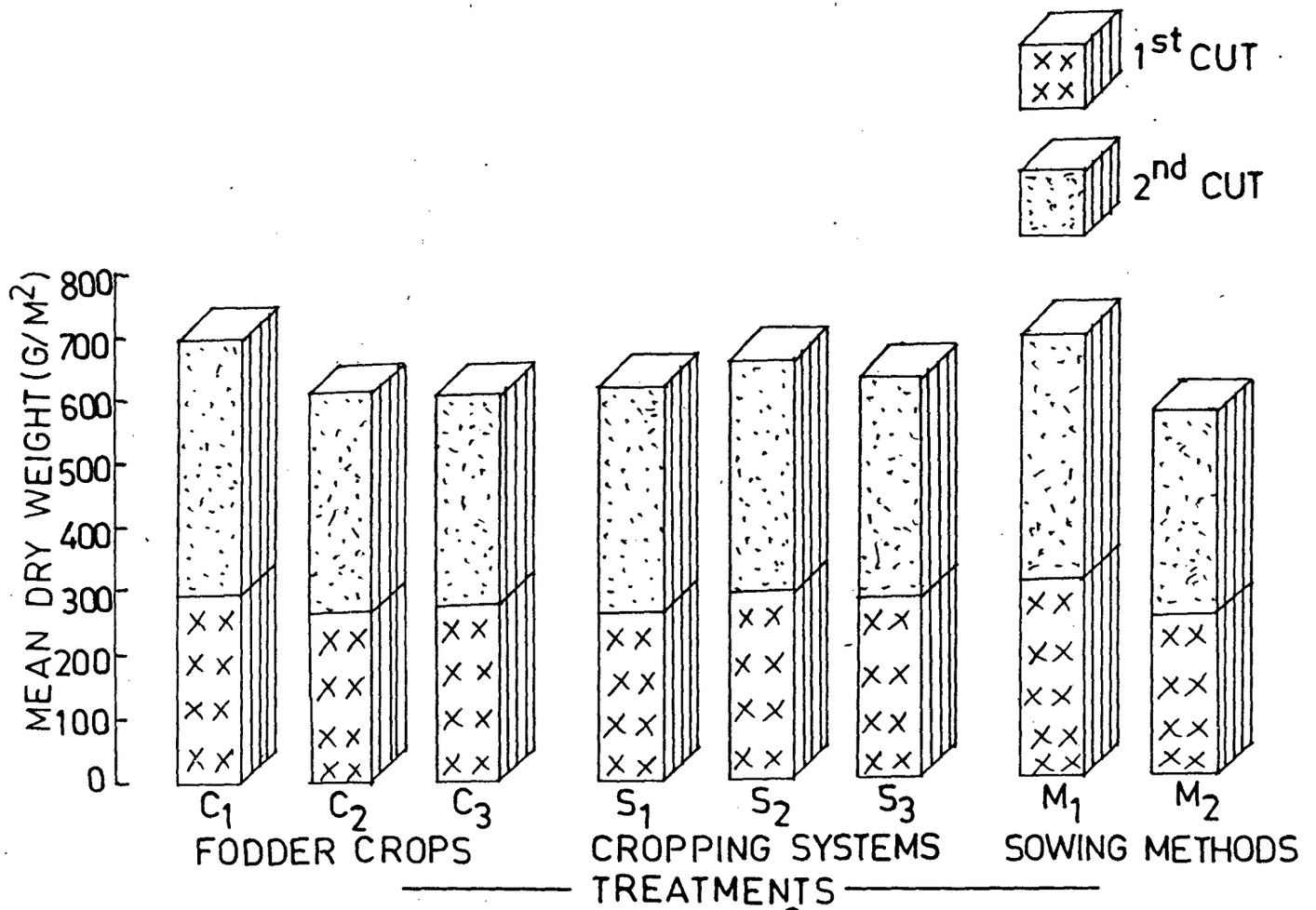


FIG-7:- MEAN DRY WEIGHT (G/M^2)

Fodder crops grown mixed with pea produced significantly higher dry weight (g m^{-2}) at both the cuts as well as when averaged over two cuts. In first cut crops-sarson mixture produced higher dry weight than that of pure stand of the crops however, reverse trend was obtained in the second cut. On an average fodder crops grown in association with pea resulted in 6.2 and 4.6 per cent higher dry weight produce per unit area over pure stand and crops grown in association with sarson, respectively.

Sowing methods significantly influenced the dry weight production per unit area in both the cuts as well as when averaged over two cuts. Line sowing found invariabily significantly better than broadcast sowing. On an average line sowing produced 21.2 per cent higher herbage dry weight over broadcast sowing.

Table 15.1 Effect of Crops x Cropping Systems interaction on mean dry weight (g m^{-2})

Fodder crops		Cropping systems		
		Pure stand	Crop+ Pea(broadcast)	Crop+ Sarson (broadcast)
Oat		335.3	379.5	322.0
Barley		294.6	302.1	308.9
Oat+Barley		295.6	299.8	307.5
SEm±	0.16			
CD 5%	0.5			

Crops x Cropping systems interaction (Table 15.1) revealed that oat grown pure or in association with pea or sarson produced significantly higher dry matter than barley and oat+barley grown under these systems. Barley grown either pure or mixed with pea or sarson produced significantly higher dry weight than that of oat+barley. Oat produced the highest dry weight per unit area in association with pea whereas, barley and oat+barley were found to perform better when grown in association with sarson. However, the latter crops performed certainly better when grown in association with pea over the pure stand of each.

Table 15.2 Effect of Crops x Sowing Methods interaction on dry weight (g m^{-2}).

Fodder crops	Sowing methods	
	Line sowing	Broadcast sowing
Oat	376.7	314.5
Barley	336.3	267.4
Oat+Barley	325.4	275.1

	SEm±	CD 5%
For comparison between two sowing method means at same level of fodder crops	0.13	0.40
For comparison between two crop means at same or different levels of sowing methods	0.16	0.44

Data presented in Table 15.2 revealed that in all the three crops the highest amount of dry weight was produced under line sowing than broadcast sowing. Wether the crops were sown in lines or by broadcast oat produced significantly higher dry weight over barley and oat+barley. However, barley in line sowing produced the higher dry weight per unit area, whereas, oat+barley resulted in higher dry matter production under broadcast sowing.

Table 15.3. Effect of cropping systems x sowing methods interaction on mean dry weight (g m^{-2}).

Cropping systems	Sowing methods	
	Line Sowing	Broadcast sowing
Pure stand	342.3	273.4
Fodder Crops+Pea (broadcast)	357.9	296.3
Fodder Crops+Sarson (broadcast)	328.3	287.3
	SEm±	CD 5%
For comparison between two sowing method means at the same level of cropping systems	0.13	0.40
For comparison between two cropping system means at same or different levels of sowing methods	0.16	0.44

Cropping systems x Sowing methods influence the mean dry weight (g m^{-2}) significantly (Table 15.3). Fodder crops grown in association with pea recorded significantly higher dry weight (g m^{-2}) in both the methods of sowing, however, pure crop in line sowing and crops in association

with *sarson* recorded the highest dry weight under broadcast sowing.

Table 15.4. Effect of Crops x Cropping Systems x Sowing methods interaction on dry weight (g m^{-2}).

Fodder crops	Cropping systems	Sowing methods	
		Line sowing	Broadcast sowing
Oat	Pure	369.1	301.5
	+Pea (broadcast)	411.8	347.2
	+*Sarson* (broadcast)	349.3	294.8
Barley	Pure	334.0	255.3
	+Pea (broadcast)	338.8	265.4
	+*Sarson* (broadcast)	336.2	281.6
Oat+Barley	Pure	323.8	263.5
	+Pea (broadcast)	323.2	276.3
	+*Sarson* (broadcast)	329.4	285.5

	SEm±	CD 5%
For comparison between two sowing methods means at the same level of Crops and Cropping systems	0.23	0.69
For comparison between two crops and cropping systems means at the same or different level of sowing methods	0.28	0.84

Crops X Cropping systems X Sowing methods interaction (Table 15.4) revealed that fodder crops following any cropping system produced significantly higher dry weight per unit area

in line sowing over broadcast sowing. It is interesting to note that pea was found to be the best companion crop with oat irrespective of the sowing methods, however, in barley under line sowing pea was the best companion crop whereas, under broadcast sowing sarson was the best introduction. On the other hand with Oat+barley sarson was found to be the best companion crop in both the methods of sowing.

4.2. FORAGE YIELD

4.2.1. Green forage yield

The data on green forage yield in two cuts and total of both the cuts as influenced by various treatments have been presented in Table 16 and depicted in Fig. 8. The corresponding analyses of variance has been appendied in Appendix XIV.

Green forage yield of two cuts and total of both cuts was significantly influenced by various fodder crops. Oat recorded significantly higher yield at both the cuts over barley and oat+barley mixture, whereas, barley in the first cut and oat+barley mixture in the second cut recorded the lowest. On an average oat produced 37.2 and 40.4 quintal higher green forage yield per hectare over barley and oat+barley, respectively.

The data depicted in Fig. 7 clearly indicated that all the fodder crop registered higher green forage yield in second cut as compared to first cut.

Fodder crops grown in association with pea as companion crop produced significantly higher green yield over pure stand of crops and the crops grown in combination with sarson in both the cuts. On an average fodder crops grown mixed with pea registered 16.0 and 12 quintal higher green forage per hectare than obtained from pure stand of crops and crops grown in combination with sarson.

Methods of sowing also influenced green gorage yield significantly at both the cuts as well as total of two cuts. On an average line sowing produced 34.4 per cent higher forage yield over broadcast sowing.

Fodder crops grown in association with sarson produced significantly higher forage yield over pure stand of crops in first cut while the trend was reverse in second cut. However, on an average fodder crops grown with sarson as companion crop registered significantly higher yield over the pure stand of crops. Introduction of sarson amounted to a yield increase of 2.3 per cent over pure stand of the crops.

It is worth mentioning that the green forage obtained at first and second cut correspondent to a most green fodder scarcity period i.e. January and April, when virtually there is an acute shortage of green forages and

Table 16. Green forage yield (q/ha) as influenced by various treatments.

Treatment	Cuts		Total
	I	II	
A. Fodder Crops			
Oat	88.9	105.1	194.0
Barley	72.2	84.7	156.9
Oat+Barley	77.5	76.2	153.7
SEm±	0.58	0.92	0.80
CD 5%	1.7	2.8	2.4
B. Cropping System			
Fodder Crops+Pure stand	73.4	88.6	162.0
Fodder Crops+Pea (broadcast)	83.6	93.4	177.0
Fodder Crops+Sarson (broadcast)	81.7	84.1	165.8
SEm±	0.58	0.92	0.80
CD 5%	1.7	2.8	2.4
C. Sowing Method			
Line sowing	92.7	100.2	192.9
Broadcast	66.4	77.2	143.6
SEm±	0.28	0.44	0.42
CD 5%	0.8	1.3	1.3

the animals are mainly reared on dry roughages (wheat bhusa, paddy straw and hay) and feeding them mixed with lush green forage will enhance the utilization of these stuffs.

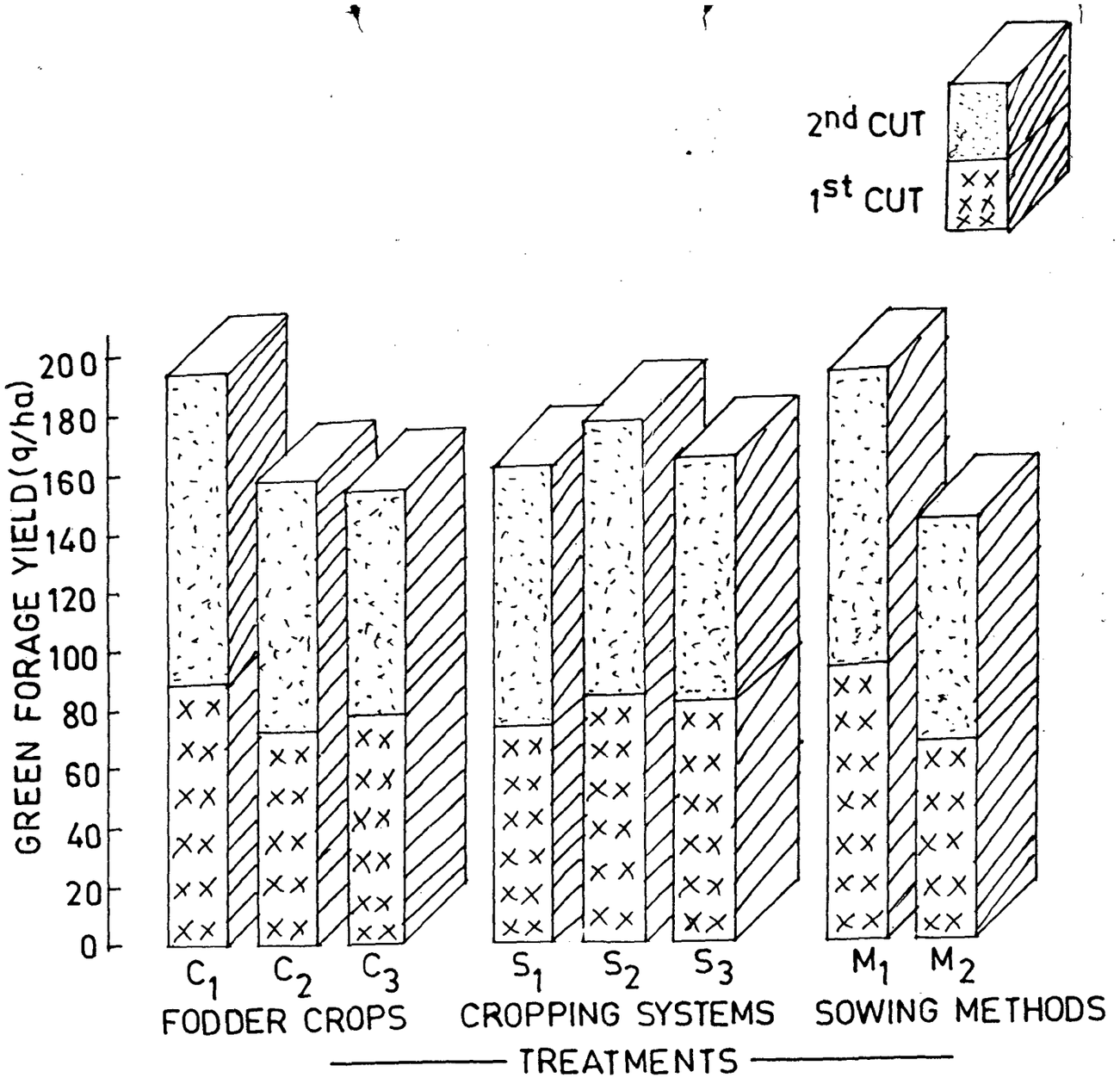


FIG.8:- GREEN FORAGE YIELD (q/ha)

Table 16.1. Effect of Crops x Cropping Systems interaction on the green forage yield (q/ha).

Fodder Crops		Cropping system		
		Pure stand	Crops + Pea (broadcast)	Crop + Sarson (broadcast)
Oat		184.8	213.3	184.1
Barley		151.4	160.1	159.1
Oat+Barley		149.5	157.7	153.9
SEm±	1.37			
CD 5%	4.1			

Crops x Cropping systems interaction also influenced the green forage yield (q/ha) significantly (Table 16.1). Pea was found to be the best companion crop for oat, than sarson. On the other hand barley and oat+barley produced the similar yields whether sown mixed with pea or sarson, but both recorded significantly higher yield in combination with companion crops over the pure stand. It is interesting to note that oat grown pure or in association with companion crops viz. pea or sarson resulted in significantly higher green herbage yield over barley and oat+barley grown in any of the cropping systems. Barley and oat+barley resulted in identical yields when these were grown either pure and in combination with pea, however, sarson was better companion crop for barley than for oat+barley.

Table 16.2. Effect of Crops x Sowing methods on total green forage yield (q/ha).

Fodder crops	Sowing methods	
	Line sowing	Broadcast sowing
Oat	219.0	169.2
Barley	185.1	128.7
Oat+Barley	174.6	132.7

	SEm±	CD 5%
For the comparison between two method means at the same level of crops	0.74	2.2
For the comparison between two crop means at the same or different levels of sowing methods	0.95	2.8

The total green forage yield as influenced by Crops X sowing methods interaction (Table 16.2) revealed that the fodder crops grown in lines produced significantly higher green herbage yield than sown by broadcast. Oat whether sown in lines or by broadcast resulted in significantly higher yield over barley and oat+barley, however, barley produced higher yield in line sowing than oat+barley. Further, it was observed that barley and oat+barley registered higher yield in line sowing over oat sown as broadcast.

The total green forage yield was significantly influenced by Cropping Systems X Sowing methods (Table 16.3). Whether the fodder crops grown pure or in association with companion crops they produced significantly higher green

Table 16.3. Effect of cropping systems x sowing methods interaction on total green forage yield (q/ha).

Cropping Systems	Sowing methods	
	Line sowing	Broadcast sowing
Pure	185.6	138.2
Pea (broadcast)+Fodder Crops	203.6	150.4
Sarson (broadcast)+ Fodder Crops	189.5	142.0

	SEm±	CD 5%
For the comparison of two method means at the same level of system	0.74	2.19
For the comparison of two Cropping systems means at the same or different levels of methods	0.95	2.84

forage yield in line sowing over broadcast sowing. Crops grown in combination with pea as companion crop resulted in higher green yield, whether sown in lines or by broadcast, over the pure crops and crops grown in association with sarson. However, crops grown mixed with sarson produced significantly higher green yield than that of pure stand of the crops. Thus, this can be infered from this interaction that under rainfed conditions green fodder can be considerably enhanced by growing them mixed with suitable companion crop.

Crops x Cropping systems x Sowing methods interaction also influenced the green forage yield (q/ha) significantly (Table 16.4). The data revealed that irrespective of the fodder crops and cropping system line sowing produced

Table 16.4. Effect of Crops x Cropping Systems x Sowing methods interaction on total green forage yield (q/ha).

Fodder Crops	Cropping systems	Sowing methods	
		Line sowing	Broadcast sowing
Oat	Pure stand	205.3	164.3
	+Pea (broadcast)	243.4	183.0
	+Sarson (broadcast)	208.2	160.0
Barley	Pure stand	179.4	123.5
	+Pea (broadcast)	190.0	132.1
	+Sarson (broadcast)	185.8	130.4
Oat+Barley	Pure stand	172.1	126.8
	+Pea (broadcast)	177.3	138.9
	+Sarson (broadcast)	174.3	133.4

	SEm±	CD 5%
For the comparison between crop and Cropping system means at the same or different levels of sowing methods	1.65	4.9
For the comparison between two sowing methods means at the same level of crops and cropping systems	1.27	3.8

significantly higher forage yield over broadcast sowing. Oat sown either pure and in combination with pea or sarson produced significantly higher herbage yield than barley and oat+barley sown in these cropping systems. Line sowing of barley and oat+barley proved significantly better than sowing of oat by broadcast, with the exception that oat sown with pea association

by broadcast recorded the same yield as that obtained with barley sown in line either pure and in association with sarson. Oat+barley sown either pure and in association with pea or sarson resulted in significantly lower yield than that of barley under the same system in line sowing, however, in broadcast sowing the yield response was similar with exception that oat+barley in association with pea recorded significantly higher yield than barley in association with pea.

4.2.2. Dry forage yield:

The data on dry forage yield (q/ha) at different cuts and combined of all the cuts as influenced by different treatments have been given in Table 17 and shown graphically in Fig.9. The corresponding analyses of variance have been given in Appendix XV.

Like green forage yield, dry forage yield was also significantly influenced by fodder crops. Oat registered significant higher dry forage yield over barley and oat+barley at both the cuts as well as total over the two cuts. The latter two crops differed significantly with each other. Oat+barley mixture in the first cut yielded higher than barley and barley in the second cut yielded better than oat+barley. However, when total of two cuts was taken into consideration barley significantly outyielded oat+barley. On an average oat registered an increase of 22.9 and 28.0 per cent over barley and oat+barley mixture, respectively.

Table 17. Dry forage yield (q/ha) as influenced by various treatments.

Treatment	Cuts I	Cuts II	Total
A. Fodder Crops			
Oat	18.7	25.8	44.5
Barley	14.9	21.3	36.2
Oat+Barley	15.4	19.3	34.7
SEm±	0.14	0.22	0.21
CD 5%	0.4	0.6	0.6
B. Cropping systems			
Fodder Crops+Pure stand	15.7	22.2	37.9
Fodder Crops+Pea(broadcast)	17.6	23.4	41.0
Fodder Crops+ Sarson (broadcast)	15.9	20.7	36.6
SEm±	0.14	0.22	0.21
CD 5%	0.4	0.6	0.6
C. Sowing Methods			
Line sowing	19.2	25.4	44.5
Broadcast	13.5	18.8	32.3
SEm±	0.07	0.15	0.20
CD 5%	0.2	0.4	0.5

Fodder crops grown in association with pea yielded significantly higher dry forage yield than that obtained from pure stand and crops grown in association with sarson in both the cuts as well as the total yield of two cuts. The dry forage in first cut remained unaffected whether the fodder Crops were grown in pure stand or in association with sarson. However, in second cut pure stand of crops yielded significantly higher over crop-sarson mixture. Similar, yield trend was observed in total of two cuts. In absolute terms crop-pea association produced 3.0 and 4.6 quintal per hectare more dry forage than pure stand and crop-sarson mixture, respectively.

Line sowing of fodder crops produced significantly higher dry forage yield at both the cuts and in total of two cuts over broadcast sowing. On an average line sowing produced 37.8 per cent higher dry forage over broadcast sowing. The dry matter production was invariably higher in second cut compared to first cut in all the treatments under study.

Table 17.1. Effect of Crops x Cropping systems interaction on the total Dry forage yield (q/ha).

Cr Fodder Crops	Cropping systems		
	Pure stand	crop+ Pea(broadcast)	Crop+ Sarson (broadcast)
Oat	43.2	50.4	39.7
Barley	36.3	36.2	35.9
Oat+Barley	34.0	36.4	33.7
SEm±	0.37		
CD 5%	1.10		

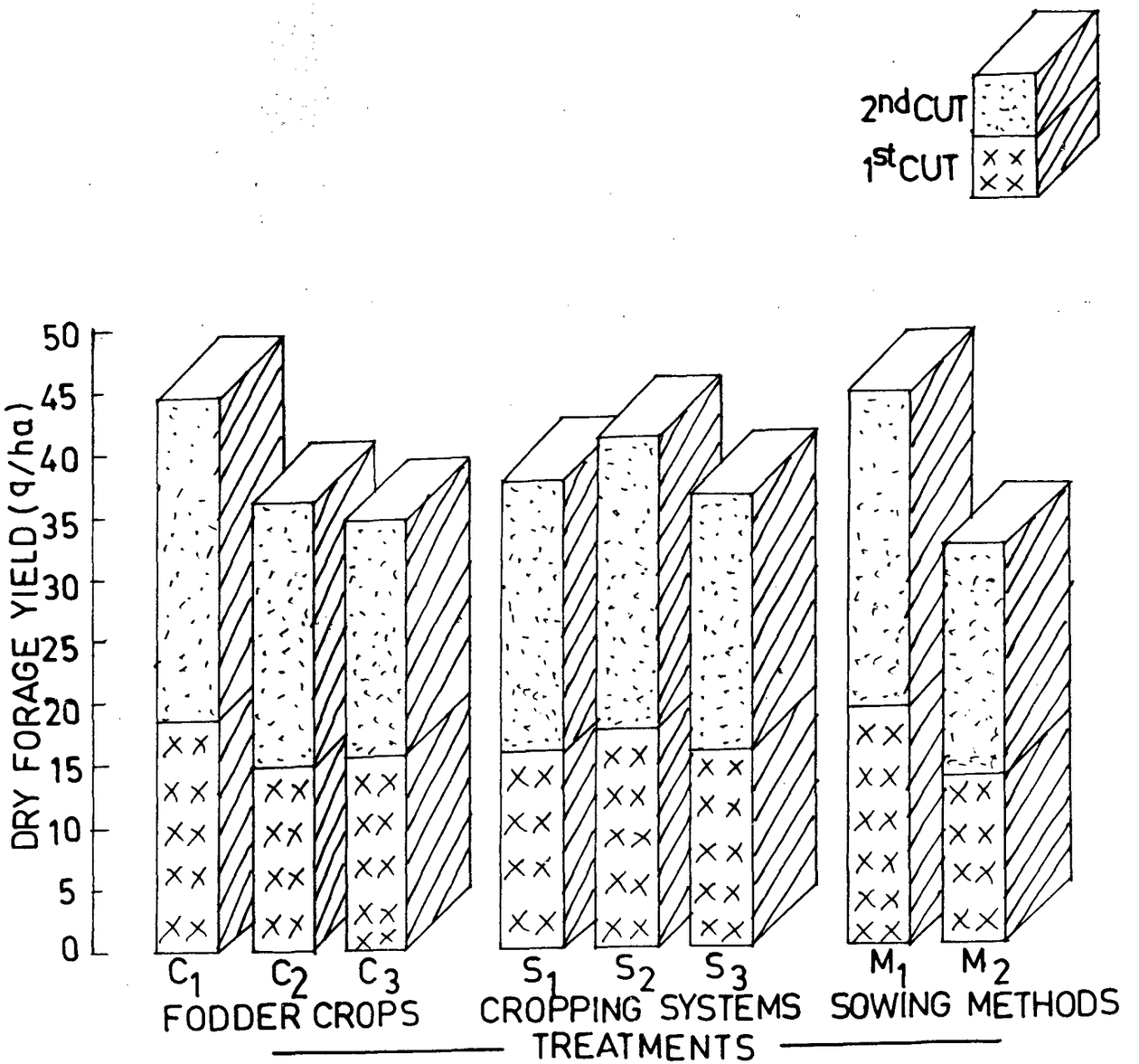


FIG.9:- MEAN DRY FORAGE YIELD (q/ha)

Crops x Cropping systems interaction also influenced the dry forage yield significantly (Table 17.1). Pea was found to be the best companion crop for oat and oat+barley than sarson. On the other hand barley produced the similar yield whether grown pure or in association with pea or sarson. Association of sarson with oat produced low yield than pure stand, whereas, in oat+barley pure stand and sarson association produced the similar yield. Oat grown pure or in association with companion crops resulted in significantly higher dry forage yield over barley and oat+barley grown in any of the cropping systems. Barley also outyielded oat+barley irrespective of the cropping systems except, pea association, where these two crops resulted in identical yield.

Table 17.2. Effect of Crops x Sowing methods interaction on the total Dry forage yield (q/ha).

Fodder Crops	Sowing methods	
	Line sowing	Broadcast sowing
Oat	49.6	39.2
Barley	43.6	28.7
Oat+Barley	40.6	29.0
	SEm+	CD 5%
For comparison between two sowing method means at the same level of crops	0.34	1.1
For comparison between two crop means at same or different levels of methods	0.40	1.1

Crops x sowing methods interaction influenced the dry forage yield significantly (Table 17.2). From the data it is evident that line sowing of all the fodder crops resulted in significantly higher dry forage yield over broadcast sowing. Oat whether sown in lines and by broadcast resulted in significantly higher yield over barley and oat+barley, whereas, barley in lines produced higher yield than oat+barley, however, under broadcast sowing barley and oat+barley resulted in similar yield. Broadcast sowing of oat produced significantly lower dry forage than line sown barley.

Table 17.3. Effect of cropping systems x sowing methods interaction on dry forage yield (q/ha).

Cropping systems	Sowing methods	
	Line sowing	Broadcast
Pure stand	45.1	30.6
Fodder crops+Pea(broadcast)	47.5	34.5
Fodder crops+Sarson (broadcast)	41.0	31.8
	SEm±	CD 5%
For comparison between two sowing methods means at same level of cropping systems	0.59	1.7
For comparison between two cropping system means at same or different levels of sowing methods	0.40	1.1

Cropping Systems x Sowing methods interaction (Table 17.3) revealed that all the fodder crops whether grown pure or in combination with pea or sarson produced significantly higher dry forage yield in line sowing over broadcast sowing. Pea as an associate crop with fodder crops resulted in higher dry forage yield whether sown in lines and by broadcast over pure stand and crops grown in combination with sarson. However, pure stand of crops produced significantly higher yield over crops grown in combination with sarson in line sowing, whereas the trend was reverse in broadcast sowing.

Table 17.4. Effect of Fodder Crops x Cropping systems x Sowing methods interaction on Dry forage yield (q/ha).

Fodder Crops	Cropping systems	Sowing methods	
		Line sowing	Broadcast
Oat	-Pure stand	48.3	38.1
	+Pea (broadcast)	56.5	44.3
	+Sarson (broadcast)	44.2	35.2
Barley	-Pure	45.8	27.2
	+Pea (broadcast)	43.9	28.5
	+Sarson (broadcast)	41.5	30.5
Oat+Barley	-Pure	42.5	26.6
	+Pea (broadcast)	42.3	30.6
	+Sarson (broadcast)	37.4	29.9

	SEm+	CD 5%
For comparison between two sowing method means at the same level of crops and cropping systems	0.59	1.7
For comparison between two crop and cropping system means at the same or different levels of sowing methods	0.69	1.9

Crops x Cropping systems x sowing methods interaction on dry forage yield (q/ha) (Table 17.4) revealed that line sowing produced significantly higher dry forage yield over broadcast sowing irrespective of fodder crops and cropping systems. Oat sown either pure or in combination with pea produced significantly higher yield over barley and oat+barley grown in any of the cropping system. Growing of oat in line with pea produced the highest dry forage yield over rest of the treatments. Pure crop of barley under line sowing produced significantly higher forage over oat+barley grown in any of the cropping system and sowing method.

4.3 QUALITY STUDIES:

4.3.1. Crude Protein content

The results showing the effect of different treatments on crude protein content (per cent) at both the cuts and average of two cuts have been summarised in Table 18 and have also been depicted in Fig.10. The corresponding analyses of variance has been appended in Appendix XVI.

Different fodder crops did not exhibit any significant influence on the crude protein contents at any of the cut. In general higher average of crude protein contents were given by oat+barley mixture than oat and barley alone.

The crude protein contents were significantly influenced by different cropping systems. Fodder crops grown in association with pea recorded significantly higher contents at both the cuts

Table 18. Mean crude protein content (%) as influenced by different treatments at various cuts.

Treatment	Cuts I	Cuts II	Average
A. Fodder Crops			
Oat	14.63	10.99	12.54
Barley	14.62	11.12	12.53
Oat+Barley	14.87	11.07	12.76
SEm±	0.09	0.16	0.16
CD 5%	NS	NS	NS
B. Cropping Systems			
Fodder Crops+Pure stand	11.48	8.90	9.68
Fodder Crops+Pea (broadcast)	18.05	12.48	14.85
Fodder Crops+Sarson (broadcast)	14.60	9.20	10.90
SEm±	0.09	0.16	0.16
CD 5%	0.27	0.49	0.48
D. Sowing Methods			
Line sowing	14.79	10.92	12.59
Broadcast sowing	14.62	11.20	12.60
SEm±	0.11	0.15	0.09
CD 5%	NS	NS	NS

over pure stand and crops-Sarson mixture. Sarson grown mixed with fodder crops recorded significantly higher crude protein contents over pure stand in first cut, however, in second cut both these cropping systems produced herbage with

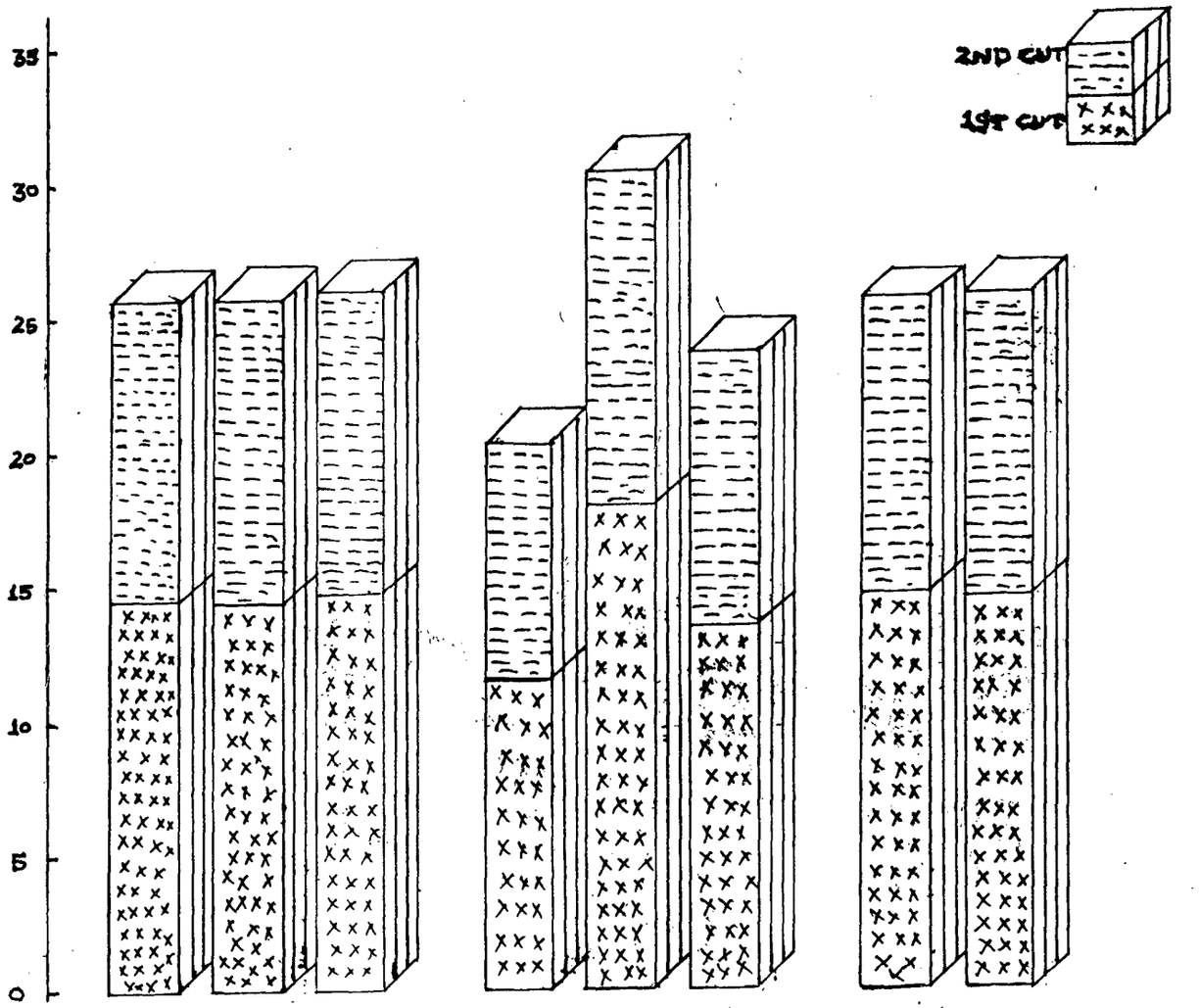


FIG. 10 :- MEAN CRUDE PROTEIN CONTENT (%)

similar crude protein contents. On the basis of weighted average taken of the two cuts, fodder crops grown in association with pea produce herbage with significantly higher crude protein contents than that of pure stand of crops and crops sown in association with sarson. Crops-sarson mixture was found to produce herbage with higher protein contents than that of pure stand. On an average pea in association with fodder crops registered 53.4 and 36.2 percent higher crude protein contents over pure stand of the crops and one grown in association with sarson, respectively.

Whether the crop grown in lines by broadcast the crude protein contents of the herbage remained unaffected.

Crude protein content in herbage in general showed a decreasing trend with successive cut. None of the interaction could influence the crude protein contents significantly at any of the cut (Appendix XVI).

4.3.2. Crude protein yield

The data on Crude protein yield (q/ha) at different cuts have been presented in Table 19. The pertinent analyses of variance are given in Appendix XVIII.

Crude protein yield was influenced significantly by various treatments at both the cuts.

Among different fodder crops oat registered the highest crude protein yield over barley and oat+barley mixture

at both the cuts as well as in total of the two cuts. Barley in the first cut and oat+barley in the second cut recorded the lowest protein yields, whereas, on total yield basis latter two crops remained at par with each other. Oat produced 23.7 and 26.8 per cent higher total crude protein yield over barley and oat+barley, respectively.

Table 19. Crude protein yield (q/ha) as influenced by different treatments.

Treatment	Cut		Total
	I	II	
A. Fodder Crops			
Oat	2.80	2.83	5.63
Barley	2.20	2.35	4.55
Oat+Barley	2.31	2.13	4.44
SEm±	0.03	0.03	0.05
CD 5%	0.11	0.11	0.16
B. Cropping Systems			
Fodder Crops+Pure stand	1.82	1.86	3.68
Fodder Crops+Pea(broadcast)	3.20	2.91	6.11
Fodder Crops+Sarson (broadcast)	2.30	2.54	4.84
SEm±	0.03	0.03	0.05
CD 5%	0.10	0.11	0.16
C. Sowing Methods			
Line sowing	2.86	2.75	5.61
Broadcast sowing	2.00	2.12	4.12
SEm±	0.02	0.03	0.03
CD 5%	0.07	0.10	0.10

Fodder crops grown in association with pea produced the highest crude protein yield in both the cuts as well as in total of two cuts. Crops grown in association with sarson produced though significantly lower than that of the crops grown in association with pea, however, this treatment resulted in significantly higher protein yield over pure stand of the crops in both the cuts.

Line sowing of the crops proved significantly superior to broadcast sowing in respect of crude protein yield at both the cuts as well as in the total of two cuts. It produced 1.49 quintal higher crude protein per hectare over broadcast sowing.

Table 19.1. Effect of Crops x Cropping systems on total crude protein yield (q/ha).

Fodder Crops		Cropping systems		
		Pure stand	Crop + Pea(broadcast)	Crop + Sarson (broadcast)
Oat		4.18	7.56	5.14
Barley		3.51	5.37	4.71
Oat+Barley		3.31	5.34	4.66
SEm±	0.09			
CD 5%	0.28			

Crops and cropping systems interaction influenced the crude protein yield (q/ha) significantly (Table 19.1). Oat crop, whether grown pure or in combination with pea or sarson registered

significantly higher crude protein yield over barley and oat+barley grown pure or in combination with companion crops. Whereas, barley and oat+barley produced the same yield growing in any of the cropping system. On the other hand association of pea recorded higher protein yield over pure stand and crops grown in association with sarson, irrespective of the fodder Crops. All the fodders crops grown in pure stand recorded the lowest protein yield.

Table 19.2. Effect of Crops x sowing methods interaction on total crude protein yield (q/ha).

Fodder Crops	Sowing methods	
	Line sowing	Broadcast sowing
Oat	6.26	4.99
Barley	5.45	3.61
Oat+barley	5.13	3.75
	SEm±	CD 5%
For the comparison between two sowing method means at the same level of crops	0.08	0.23
For the comparison between two fodder crop means at the same or different levels of sowing methods	0.08	0.22

Crops x sowing methods interaction on crude protein yield (q/ha) (Table 19.2) revealed that all the fodder crops sown in lines resulted in significantly higher crude protein yield over broadcast sowing. Oat whether sown in lines or by broadcast produced significantly higher crude protein yield

over barley and oat+barley mixture. However, barley in line sowing produced higher crude protein over oat+barley, whereas, remaining at par under broadcast sowing.

Table 19.3. Effect of Cropping Systems x Sowing methods interaction on total crude protein yield (q/ha).

Cropping systems	Sowing methods	
	Line sowing	Broadcast sowing
Pure stand	4.37	2.96
Fodder Crops+Pea (broadcast)	7.04	5.15
Fodder Crops+Sarson (broadcast)	5.43	4.25
	SEm±	CD 5%
For the comparison between two sowing method means at the same level of Cropping systems.	0.08	0.23
For the comparison between two cropping system means at the same or different levels of sowing methods	0.08	0.22

Crude protein yield (q/ha) was also influenced significantly by cropping systems x sowing methods (Table 19.3). Fodder crops whether grown pure or in combination with pea or sarson in lines produced significantly higher crude protein yield over broadcast sowing. All the fodder crops grown mixed with pea either in line or by broadcast sowing resulted in higher production of crude protein over pure stand and crops grown mixed with sarson sown by either of the method.

4.3.3 Crude fibre content

The data on the crude fibre content (per cent) as influenced by different treatments at two cuts and mean of both the cuts have been given in Table 20 and Fig. 11. The corresponding analyses of variance are appended in Appendix XVII.

Table 20. Mean Crude fibre content (%) as influenced by different treatments at various cuts

Treatment	Cuts		Average
	I	II	
A. Fodder Crops			
Oat	27.55	33.20	30.70
Barley	27.03	32.83	29.78
Oat+Barley	27.70	32.40	30.38
SEm±	0.49	0.41	0.31
CD 5%	NS	NS	NS
B. Cropping Systems			
Fodder Crops-Pure stand	29.74	34.56	32.42
Fodder Crops+Pea (broadcast)	26.45	31.42	29.25
Fodder Crops+Sarson(broadcast)	26.09	33.98	29.96
SEm±	0.49	0.41	0.31
CD 5%	1.50	1.22	0.92
C. Sowing methods			
Line sowing	27.33	32.55	30.16
Broadcast sowing	27.52	32.46	30.41
SEm±	0.32	0.34	0.27
CD 5%	NS	NS	NS

Like crude protein, the crude fibre contents were also not influenced significantly by any of the fodder crops. Pea or sarson grown in association with fodder crops recorded significantly lower fibre contents than that of pure stand in first cut, however, in second cut sarson grown in association with fodder crops and the crops grown as pure produced the herbage with same fibre contents. At this cut also pea grown mixed with fodder crops recorded significantly lowest contents over the other two cropping systems. However, when the data was averaged over of the two cuts it was observed that fodder crops grown either in association with pea or sarson recorded similar but significantly lower contents than that of the pure stand, indicating thereby that the crude fibre content in the herbage can be considerably reduced following an association of pea or sarson in fodder crops.

Methods of sowing also could not influenced the crude fibre contents of the herbage significantly at any of the cut (Table 20).

Unlike crude protein, crude fibre content of the herbage in all the treatments increased in successive cut.

None of the interaction was found to affect crude fibre content in herbage significantly (Appendix XVII).

4.3.4. Crude fibre yield

The data on crude fibre yield (q/ha) at different cuts have been presented in Table 21, and corresponding analyses of variance have been appended in Appendix XIX.

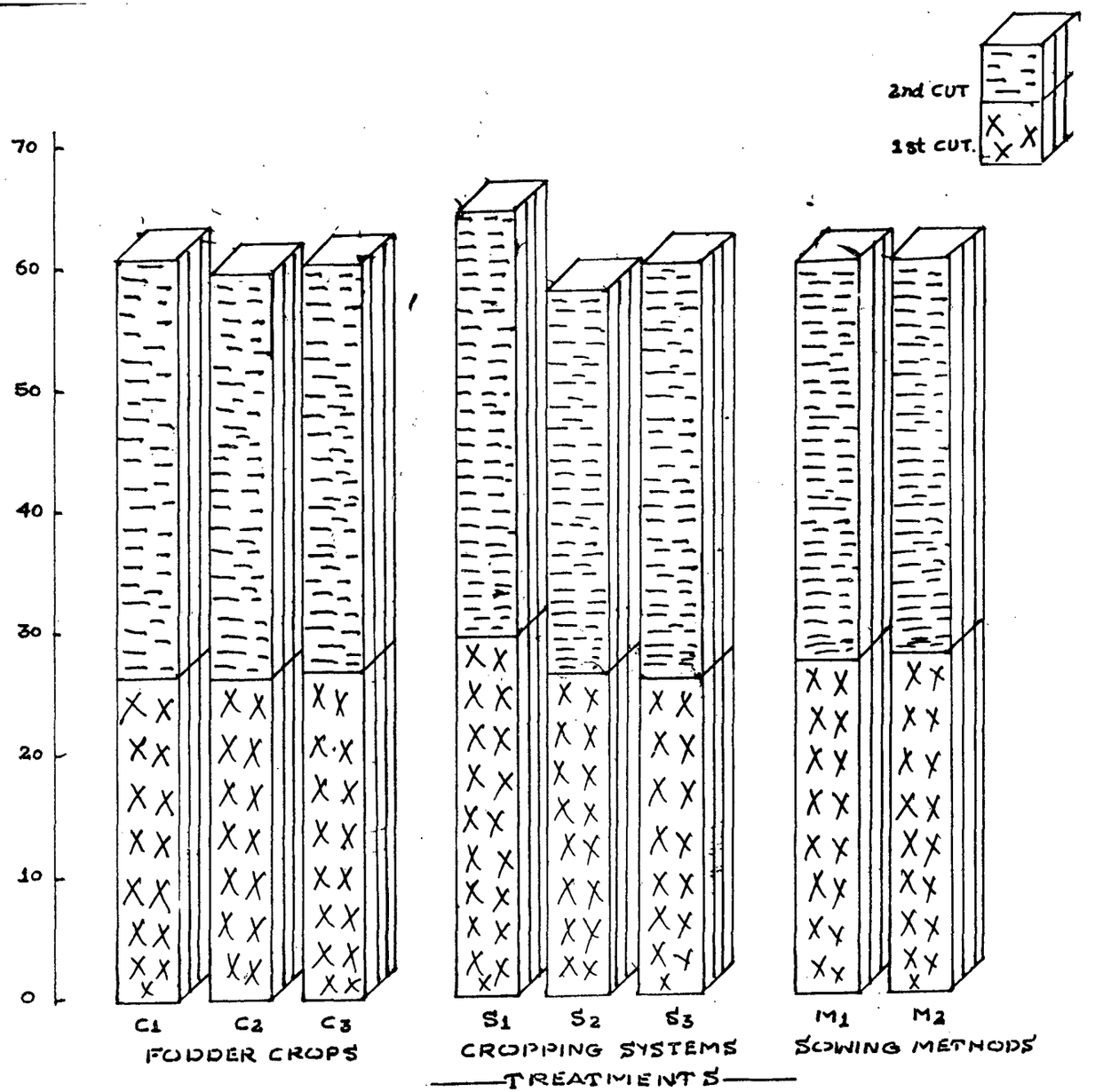


FIG. 11:- MEAN CRUDE FIBRE CONTENT (%)

A perusal of data (Table 21) indicated that the crude fibre yield was influenced significantly by all the treatments at both the cuts as well as when total over two ctus.

Table 21. Mean crude fibre yield (q/ha) as influenced by different treatments

Treatments	Cuts		Total
	I	II	
A. Fodder Crops			
Oat	5.13	8.55	13.68
Barley	4.03	6.78	10.81
Oat+Barley	4.18	6.27	10.45
SEm±	0.11	0.44	0.15
CD 5%	0.33	1.32	0.44
B. Cropping Systems			
Fodder Crops-Pure stand	4.67	7.69	12.36
Fodder Crops+Pea (broadcast)	4.66	7.37	12.03
Fodder Crops+Sarson (broadcast)	4.01	6.37	10.38
SEm±	0.11	0.44	0.15
CD 5%	0.33	1.32	0.44
C. Sowing methods			
Line sowing	5.19	8.28	13.47
Broadcast sowing	3.71	6.12	9.83
SEm±	0.06	0.44	0.13
CD 5%	0.17	1.30	0.40

Oat recorded significantly higher crude fibre yield over barley and oat+barley at both the cuts however, barley and Oat+barley remained at par with each other at both the cuts.

On an average oat produced 26.5 and 30.9 per cent higher crude fibre yield over barley and oat+barley, respectively.

Fodder crops whether sown pure or mixed with pea produced similar but significantly higher crude fibre yield over crops grown in association with sarson. Same trend was observed in both the cuts. Crops sown in combination with sarson produced 19.1 and 15.9 per cent lower fibre yield over pure stand and crops grown in combination with pea, respectively.

Line sowing of the crops produced higher fibre yield over broadcast sowing at both the cuts. On an average line sowing recorded 37.0 per cent higher fibre yield over broadcast sowing.

Table 21.1. Effect of Crops x Cropping systems interaction on total crude fibre yield (q/ha)

Fodder Crops		Cropping systems		
		Pure stand	Crop+Pea (broadcast)	Crop+Sarson (broadcast)
Oat		14.42	14.86	11.78
Barley		11.79	10.41	10.23
Oat+barley		10.88	10.84	9.62
SEm±	0.25			
CD 5%	0.76			

Crops x Cropping systems interaction (Table 21.1) revealed that oat grown either pure or mixed with pea or sarson produced significantly higher crude fibre yield over barley and

oat+barley grown under these Cropping systems. Barley and oat+barley, produced the similar yield under all the cropping systems except the pure stand, where, oat+barley produced the lowest. Pure stand of oat and oat+barley and their mixture with pea produced similar, but significantly higher crude fibre yield than their association with sarson. However, barley in pure stand produced higher than barley grown with pea and sarson. Latter two being statistically at par with each other.

Table 21.2. Effect of Crops x sowing methods interaction on total crude fibre yield (q/ha).

Fodder Crops	Sowing methods	
	Line sowing	Broadcast sowing
Oat	15.28	12.09
Barley	13.05	8.55
Oat+Barley	12.06	8.83
	SEm+	CD 5%
For the comparison between two sowing method means at the same level of fodder crops	0.23	0.69
For the comparison between two fodder crop means at the same or different levels of sowing methods	0.27	0.76

Data presented in Table 21.2 indicated that the all the fodder crops produced significantly higher crude fibre yield under line sowing than broadcast sowing. Oat sown by either of the sowing methods produced higher than barley and

Oat+barley mixture. However, barley in line sowing produced the higher crude fibre yield than Oat+barley, but producing similar under broadcast sowing.

Table 21.3. Effect of Cropping Systems x Sowing methods interaction on total crude fibre yield (q/ha).

Cropping systems	Sowing methods	
	Line sowing	Broadcast sowing
Pure stand	14.75	9.99
Fodder Crops+Pea (broadcast)	13.94	10.11
Fodder Crops+Sarson (broadcast)	11.72	9.37
	SEm±	CD 5%
For the comparison between two sowing method means at the same levels of cropping systems	0.23	0.69
For the comparison between two cropping systems means at the same or different levels of sowing methods	0.27.	0.76

Crude fibre yield was significantly influenced by cropping systems x sowing methods interaction (Table 21.3). All the fodder crops grown in lines produced significantly higher crude fibre yield over broadcast sowing irrespective of the cropping systems. Under line sowing pure stand of the crops produced higher fibre yield than crop grown in association with pea and sarson, however, in broadcast sowing none of the Cropping systems differed among themselves.

4.4. ECONOMIC STUDY

The economics of individual treatment was worked out on the basis of fresh forage yield and have been presented in Table 24.

Table 24. Economics of different treatments.

Treatment	Cost of production (Rs/ha)	Gross profit (Rs/ha)	Net profit (Rs/ha)	Net return per rupee investment (Rs/ha)
A. Fodder Crops				
Oat	2586.82	8402.06	5815.24	2.25
Barley	2618.07	6808.42	4190.35	1.60
Oat+Barley	2602.45	6665.65	4063.20	1.56
B. Cropping Systems				
Fodder Crops+ Pure stand	2495.78	6476.00	3980.22	1.59
Fodder Crops+ Pea(broadcast)	2735.78	7942.88	5207.10	1.90
Fodder Crops+ Sarson(broadcast)	2575.78	7457.25	4881.47	1.90
C. Sowing Methods				
Line sowing	2624.94	8370.66	5745.72	2.19
Broadcast sowing	2579.94	6213.42	3633.48	1.41

Oat crop gave maximum net profit of Rs.5815.24 followed by barley and oat+barley which resulted in a net profit of Rs.4190.35 and Rs.4063.20, respectively. The net return per

rupee investment was also higher in oat (Rs.2.25) followed by barley (Rs.1.60) and oat+barley (Rs.1.56).

Net profit as well as net return per rupee investment was higher when fodder crops were grown in association with pea. This treatment registered highest net profit (Rs.5207.1) followed by crops grown in combination with sarson (Rs.4881.47) and pure stand of the crops (Rs.3980.22). Net return per rupee investment in fodder crops grown mixed with pea was higher (Rs.1.90) than their solid stand (Rs.1.59), while crops grown in association with sarson produced similar net return per rupee investment (Rs.1.90) as that of crops grown mixed with pea.

Line sowing of crops registered a net profit of Rs.5745.72, which was Rs.2112.24 higher over broadcast sowing. Net return per rupee investment was also higher under line sowing (Rs.2.19) as compared to broadcast sowing (Rs.1.41).

Chapter - V

DISCUSSION

The experimental results emanating from the present investigation "Cropping systems and sowing methods studies for rabi forages under rainfed conditions" have been described in the preceding chapter and are discussed here with suitable reasonings to establish cause and effect relationship in the light of available evidences.

The forage yield as obtained in the present investigation (Table 16) in general was less than 200 quintals, but yields as high as 300 to 350 quintals per hectare have been reported in oat and barley under rainfed conditions (Anon.,1985). This is obviously because of the fact that the rainfall which is one of the major climatic parameters happens to be eratically distributed during the crop season (Appendix I). Although early critical growth stages of the crops (crown root initiation and tillering) were not adversely affected for want of soil moisture, because conserved soil moisture at the time of sowing (Table 1) was quite enough to maintain the moisture supply to the crops during their early stages of growth. It is probably the dryspell though of shorter duration which might have caused reduction in yield. The second important parameter i.e. temperature, which has been very congenial for the growth of various crops under study could also not produce its significant effect in the absence of proper moisture. It is invariably due to the poor impact of these two parameters, the yield in the first cut was considerably low which ultimately reflected in the total lower forage production.

5.1 Effect of fodder crops

The fresh and dry forage yield was significantly influenced by different fodder crops (Table 16; 17). Oat recorded significantly higher fresh as well as dry forage yield over barley and oat+barley mixture in the first cut as well as in the second cut, followed by oat+barley in the first cut and barley in the second cut. On an average Oat registered an increase of 23.7 and 26.3 per cent over barley and oat+barley, respectively.

Several factors were apparently responsible for the variable productivity of the fodder crops. The various growth components like plant height (cm), shoot number/m^2, fresh and dry weights (g m^{-2}) varied among different fodder crops. Though the shoot number of oat and barley did not show much difference (Table 8; 9) but oat produced plants with taller height in the first as well as in the second cut as compared to barley (Table 4; 5), which reflected in higher green and dry weights (g m^{-2}) (Table 14; 15) of oat as compared to barley. It is probably the fast growth rate of oat as compared to barley, which might have attributed to higher yield of oat over barley. Jatasara *et al.* (1980) also observed a significant positive correlation of plant height with forage yield. Higher yields from oat as compared to barley were also reported by Noworalnik and Strzelles (1985), Budzynski *et al.* (1980) and Misra *et al.* (1982).

Lower yield by oat+barley mixture might be the cause of more competition among two crops. Graf (1981) also observed that competition is greater between individual of the same and closely related species because they make the demands for moisture, nutrients and light at about the same time and at about the same level. More over the plants of shorter height of barley in oat+barley mixture may also be held responsible for lower yield in this treatment. It has been amply substantiated by lower green and dry weight (g m^{-2}) (Table 14; 15) in this treatment.

Overall higher yield of barley over oat+barley might be due to the fact that the total shoot numbers per unit area in the first as well as in the second cut were higher in pure barley compared to oat+barley mixture (Table 8; 9).

Neither the crude protein nor the crude fibre contents were significantly influenced by various fodder crops (Table 18; 20). This is because of the fact that oat and barley has almost similar chemical composition in respect of protein and fibre contents (Ahlgren, 1956). Further oat crop produced significantly higher crude protein and crude fibre yields over barley and oat+barley (Table 19; 21). This is because of the higher dry matter production of oat as compared to barley and oat+barley.

Barley in the first cut and oat+barley in the second cut recorded the lowest crude protein yield. This is again related to their respective dry matter productions. Higher fibre yield in case of oat crop is not by virtue of its having

higher crude fibre content but it is due to the significantly higher dry matter production as compared to barley and oat+barley. On the other hand barley and oat+barley did not show any significant influence on the crude fibre yield. This is because of the fact that the crude fibre contents were same in barley and oat+barley at both the cuts, however, higher dry matter yield of oat+barley in the first and that of barley in the second cut nullified each other, as such no significant difference in crude fibre yield was observed in these two crops.

5.2 Effect of Cropping Systems

The superiority of mixed stand, established the importance of the principle of forage seed mixtures. Growing of crops in inter-row space of the main crop is a tool for utilization of solar energy and carbon-dioxide present in the microclimate of the crop. It was seen that in terms of yield (green as well as dry) mixed stand of the crops resulted in significantly higher yield over pure stand (Table 16; 17). Fodder crops grown in combination with pea or *sarson* as companion crop produced significantly higher herbage yield over pure stand of the crops. Higher yield from cereal-legume and cereal-*sarson* mixture were also reported by Tomer and Singh (1968); Rao *et al.* (1979); Kovrygin and Kuzmin (1979); Gill and Patil (1983) and Dahal (1986).

The yield per unit area in fodder crops is a resultant of number of plants per unit area and weight per plant, the latter depends on growth characters such as plant height, number of leaves and dry matter accumulation per plant. The poor yield of the pure stand of the crops compared to the crops grown either in association with pea or sarson lies in the fact that the plant height of various fodder crops, due to the introduction of pea or sarson remained unaffected (Table 4; 5), whereas, total shoot number per unit area (main+companion crop) were considerably increased, which reflected in higher green and dry weights per unit area in the mixed stands, with the result they proved their superiority over pure stand. Soil fertility restoring property of pea being a leguminous crop also hold good in the favour of crop-pea mixed stand.

The higher herbage yield in pea or sarson cropping systems over pure stand may also be attributed to the fact that in the pure stand interrow space was occupied by the weeds, whereas in the mixed stand this space was occupied by companion crops, which has a smothering effect on the growth of the weeds. It is abvious that the crops grown in weed free environment naturally yield higher than the one infested with weeds. Shetty and Ra (1979) also reported that growing of crops in inter-row spaces have a smothering effect on the growth of the weeds.

The higher yielding ability of fodder crops grown in combination with pea or sarson can be attributed to better compatibility of pea or sarson as a companion crop. This situation envisaged that under favourable environment two species can grow in association without impinging on the environment of its neighbouring plant i.e. there is practically no competition. The differential growth rate of main crops and companion crops created competition free environment for the growth of the crops. The data on plant height (Table 4 to 7) gives enough proof that with the subsequent cut the height of main crops increased and that of pea decreased.

Fodder crops grown in combinations with pea as companion crop produced significantly higher green as well as dry forage yield than the crops grown in combination with sarson in both the cuts as well as in the total of the two cuts (Table 16; 17). Similar findings have been reported by Saini and Malich (1949), that mixture of forage crops with legume yielded higher than their mixture with sarson.

The failure of sarson to prove a better associate crop than pea in different fodder crops may lies in the fact that sarson contributed only in the first cut, whereas it failed to regenerate in the second cut. On the other hand pea showed regeneration in the second cut also, thus made a significant contribution in the total herbage yield. It is though strange to observe that sarson did not regenerate in

the second cut. This was obviously due to the fact that sarson was all in flowering at the time of first cut as such it had fully covered its vegetative phase. This is known fact that once the crop passes into reproductive phase does not repeat its vegetative phase. Dhar (1976) also reported the failure of sarson to regenerate in the second cut.

The superiority of pea as companion crop over sarson in various fodder crops may also lies in the fact that sarson being more exhaustive crop than pea have higher nutritional requirements than that of pea (Anon., 1986). Due to higher demand for nutrition sarson exerted more competition with component crop as a result of that it reduced the shoot number of barley per square metre (Table 9) though the shoot number of oat remained unaffected (Table 8), as such it resulted in overall reduction of the forage yield. Significant reduction in green and dry weights ($g\ m^{-2}$) of fodder crops grown with sarson (Table 14; 15) sufficiently substantiate its poor yielding ability over the crops grown in association with pea.

Fodder crops grown in association with pea recorded significantly higher crude protein content at both the cuts, over pure stand and mixture with sarson (Table 18). This is obviously, a legume component in the mixture having high crude protein content, which might have increased the protein content of the produce. Whereas, sarson grown mixed with fodder crops recorded significantly higher crude protein content over pure

stand in the first cut, however, in the second cut both these cropping systems produced herbage with similar crude protein content. This is due to the presence of sarson in the first cut, as sarson is having a good amount of crude protein, (Anon., 1985), but its absence in the second cut brought the produce to the same protein content as that of pure stand. Crude fibre, which is another important parameter determining the quality of the herbage was also influenced significantly by cropping systems (Table 20). Pea or sarson grown in association with fodder crops recorded significantly lower fibre contents than that of pure stand in the first cut, however, in the second cut sarson grown in association with fodder crops and the pure stand of crops produced the herbage with same fibre content. In the second cut pea mixture recorded the lowest crude fibre content. Lower fibre contents in the herbage may be attributed to legume and sarson inclusion. Whitney and Green (1969) also observed that the herbage obtained from cereal-legume mixture are generally high in crude protein and low in crude fibre as compared to cereals alone. He was of the view that legumes contain higher amount of nitrogen vis-a-vis higher amount of crude protein and lower fibre content than cereals.

Further the crude protein and crude fibre yields which are the functions of dry matter production and their respective contents were significantly influenced by various cropping systems (Table 19; 21). Fodder crops grown in association with pea produced significantly higher crude

protein yield over pure stand and mixture with sarson. This was due to the higher dry matter production and higher crude protein content in this s treatment. Pure stand of crops and crops mixture with pea produced similar crude fibre yield. This might be because of the fact that fodder crops in association with pea recorded higher dry matter yield and lower fibre content on the other hand pure stand of the crops produced lower dry matter yield but at the same time resulted in produce with higher fibre contents, as such the fibre yield difference was levelled off (Table 17; 20). The fibre component which is otherwise considered to be a poor parameter in terms of quality has its own significance in the digestion of various feed components in the ruman of the animals (Miller, 1979).

5.3. Effect of Sowing methods

Comparison of two sowing methods indicated that line sowing resulted in higher green and dry forage yield at both the cuts as well as total of the two cuts over broadcast sowing. On an average line sowing produced 34.4 and 37.8 per cent higher green and dry forage yield over broadcast sowing, respectively. These results are in agreement with the findings of Mannikar and Shukla (1974) and Rdheja (1968). They have also reported superiority of line sowing over broadcast sowing.

Although methods of sowing did not exhibit any significant effect on the plant height but in general plant height of main crops as well as companion crops was more under

line sowing than broadcast sowing. Line sowing of the crops ensured better and uniform stand of the crops hence significantly more shoot number of crops (Table 8 to 11) were recorded under line sowing. Barnett and Comeau (1980) also advocated that line sowing of the crops ensures even distribution of the seeds, protection of seeds against birds and thus better germination which inturn reflects in more plant number per unit area. Significantly higher shoot number per square metre, more fresh and dry weights ($g\ m^{-2}$) (Table 14; 15) in line sown crops through their cummulative effect might have resulted in significant increase in herbage yield in the present study.

However, line sowing of the crops ensured the proper depth of the seed, which resulted in proper development of the root system, this inturn reflected in efficient nutrients absorption and stress tolerance during water scarcity period leading to better plant stand.

Danilchuk (1970) also confirmed more production under line sowing as compared to broadcast sowing because of better plant stand and facilitation in intercultural operations.

Crude protein and crude fibre contents were not influenced by sowing methods (Table 18, 20), because of the similar plant component under both the sowing methods. However, crude protein and crude fibre yields were significantly higher under line sowing (Table 19; 21). Line sowing registered 36.2 and 37.0 per cent higher crude protein and crude fibre yield

over broadcast sowing, respectively. This higher yield can be attributed to higher dry matter production in line sowing compared to broadcast sowing.

5.4. Interaction Effects:

Fodder crops x Cropping systems was one of the most conspicuous interaction, which significantly influenced the green and dry herbage yield (Table 16.1; 17.1). Oat whether grown pure or in association with pea or sarson produced significantly higher green and dry forage yield over barley and oat+barley grown in these cropping systems. Higher yield of oat in these cropping systems over barley and oat+barley may be attributed to taller plants produced by oat as compared to barley (Table 4; 5). Oat grown in combination with pea produced significantly higher herbage yield over pure stand and sown mixed with sarson. Superiority of oat-pea mixture over pure stand of oat lies in the fact that pea contributed good amount of herbage without affecting the plant height and shoot number of oat crop (Table 4; 8) and its superiority over sarson mixed stand is obviously because of the failure of sarson to regenerate in the second cut. Significantly higher green and dry weights per unit area in oat-pea mixture sufficiently suports its higher yielding ability over other treatments (Table 14.1; 15.1).

Growing of oat with pea also resulted in higher crude protein yield over rest of the combinations (Table 19.1). This may be because of the fact that in cereal-legume mixture,

nitrogen fixed by the legume in supplied to the associated crops, resulted in better growth and more succulency of the crops. This helps in better translocation and assimilation of absorbed nutrients, which in turn reflects in higher crude protein content of the cereals. Along with this higher protein content of the pea made oat-pea mixture rich in protein. Higher dry matter yield and more protein content of the oat-pea mixture reflected in higher crude protein yield.

On the other hand pure stand of the oat and its combination with pea produced similar but significantly higher crude fibre yield over rest of the treatments (Table 21,1). Higher crude fibre content and lower dry matter production of pure stand and lower crude fibre content and higher dry matter production of Oat-pea mixture might have equalized each other, as such no yield differences could be exhibited.

Crops x sowing methods interaction on green and dry matter yield (Table 16.2; 17.2) revealed that fodder crops sown in line registered significantly higher green and dry forage yield over broadcast sowing. This may be attributed to better and uniform stand of the crops resulting in more shoot number per unit area under line sowing compared to broadcast sowing (Table 8;9). Sowing of oat in lines produced significantly higher herbage yield over rest of the treatments. Taller plants of oat compared to barley (Table 4; 5) reflected in superiority of oat in terms of higher herbage yield.

Oat crop grown in lines produced higher crude protein and crude fibre yields over broadcast sowing and also over barley and oat+barley sown by any of the methods. This is not by virtue of higher protein or fibre contents of oat than barley, and oat+barley, but it is higher dry matter production of oat sown in line, which, might be the probable cause of its superiority over other treatments.

Cropping systems and sowing methods interaction also revealed that growing of fodder crops in combination with pea under line sowing resulted in higher herbage and protein yields (Table 16.3; 17.3; 19.3). Second order interaction of Crops x Cropping systems x sowing methods on green and dry forage yield (Table 16.4; 17.4) revealed that oat crop grown in association with pea under line sowing resulted in significantly higher green and dry forage yield over all other treatments. This superiority of oat-pea mixture in lines may be attributed to the facts cited in fore-discussed interactions.

5.5. Economics of production:

It is certain that any practice can not be viable and acceptable to the farmers until and unless it is economically profitable.

Oat crop not only resulted in higher production and better quality forage but also resulted in higher net profit (Rs.5815.24) as well as higher net return per rupee investment

(Rs.2.25) followed by barley and oat+barley, which resulted in net profits of Rs.4190.35 and Rs.4063.20 and net return per rupee investment of Rs.1.60 and Rs.1.56, respectively. The higher net profit in oat can be ascribed to higher forage yield and comparatively lower cost of production. The lower production cost in case of oat is due to its lower investment on seed, which is being cheaper than barley (Appendix XX).

Highest net profit of Rs.5207.10 was given by fodder crops grown in association with pea, followed by crops sown in combination with sarson (Rs.4881.47) and pure stand (Rs.3980.22). The production cost of pure stand was the lowest but it is the lower forage yield in this treatment which reduced the net profit as well as net return per rupee investment. Net return per rupee investment was same in crops grown either in association with pea or sarson. This may be because of the higher cost of production of crops-pea mixture as a result of higher seed cost of pea than that of sarson.

In methods of sowing the cost of production was higher in line sowing over broadcast sowing. Net profit (Rs.5745.72) as well as net return per rupee investment (Rs.2.19) were higher in line sowing over broadcast sowing. This may be ascribed to higher tonnage of the forage under line sowing compared to broadcast sowing.

Chapter - VI

SUMMARY AND CONCLUSIONS

A field experiment entitled "Cropping systems and sowing methods studies for Rabi forages under rainfed conditions" was conducted at Research Farm of the Department of Agronomy and Agrometeorology, Himachal Pradesh Krishi Vishva Vidyalaya, Palampur (H.P.) during Rabi 1987-88; with following objectives in view:

1) To find out the best sowing method for getting the highest output of rabi forages,
2) to ascertain the best forage crop vis-a-vis best cropping system under rainfed conditions,
3) to find out the nutritive value of fodder obtained under different treatments and
4) to work out the economics of individual treatments.

The observations on growth viz. plant height (cm), shoot number (m^{-2}), fresh and dry weights (g m^{-2}), forage yield (green and dry) (q/ha), forage quality (crude protein and crude fibre content (per cent) and crude protein and crude yield (q/ha) were recorded with a view to explaining the behaviour of the treatments. The important findings obtained during the course of this study are summarised in the following section:

6.1. GROWTH AND YIELD STUDIES

6.1.1. Plant Height

Plant height of fodder crops (oat and barley) were not influenced significantly by different cropping systems following any of the sowing method.

Plant height of companion crops *viz.* pea or *sarson* remained unaffected by fodder crops and sowing methods.

Maximum increase in height (cm/day) was observed in oat crop than that of barley.

Plant height was more in second cut as compared to first cut under all the treatments.

6.1.2. Shoot number

Oat and barley produced almost similar total number of shoots per square meter, whereas, oat+barley produced less shoot number (m^{-2}) than oat and barley.

Shoot number of oat was not influenced significantly by various cropping systems, whereas pure stand of barley produced significantly higher shoot number of both the cuts over the association of barley with *sarson* but remaining at par with pea as companion crop.

Line sowing of the fodder crops produced significantly higher shoot number (m^{-2}) over broadcast sowing.

Mean shoot number of pea or *sarson* remained unaffected by various treatments.

Shoot number in all the crops showed a decreasing trend with successive cuts.

6.1.3. Per cent proportion of pea or sarson

Pea or sarson proportion was not influenced significantly by various fodder crops at any of the cuts. However, linesowing resulted in significantly higher proportion of pea in various fodder crops over broadcast sowing at both the cuts.

On the contrary sowing methods did not exhibit any significant influence on the per cent proportion of sarson in fodder crop.

6.1.4. Fresh weight:

Oat registered significantly higher fresh weight at both the cuts as well as when averaged over two cuts.

Pea as an associate crop produced significantly higher fresh weight at both the cuts over pure stand and sarson as an associate crop.

Line sowing of crops proved its superiority over broadcast sowing by producing higher fresh weight at both the cuts. Growing of oat in combination with pea under line sowing produced significantly higher fresh weight over rest of the treatments. Broadcast sown oat with pea was also superior to barley and Oat+barley sown in any of the cropping system.

6.1.5. Dry weight

Like green weight oat also produced significantly higher dry weight (g m^{-2}) over barley and oat+barley at both the cuts.

Oat+barley in the first cut and barley in the second cut was the next best treatments.

Crop grown in association with pea produced significantly higher dry weight than pure stand and crops in combination with sarson. Pure stand of the crops in the first cut, and crop-sarson mixture in the second cut recorded the lowest dry weight.

Line sowing produced significantly higher dry weight over broadcast sowing at both the cuts.

Highest dry weight was produced by oat sown in lines in combination with pea, this was followed by pure stand of Oat sown in lines.

6.1.6. Forage Yield

Total forage yield fresh as well as dry (q/ha) was significantly influenced by various treatments.

Oat recorded significantly higher green and dry forage yield over barley and oat+barley, however, barley produced higher yield over oat+barley.

Association of pea with fodder crops resulted in higher green and dry forage yields. Crop-sarson mixture was

found next best treatment in case of fresh forage yield, however, pure stand of the crops produced higher dry matter over crop-sarson mixture.

Growing of Oat in combination with pea under line sowing produced significantly higher green and dry forage yield over rest of the treatments.

Association of pea with oat under broadcast sowing recorded higher green forage yield over barley and oat+barley sown in any of the cropping systems and sowing methods, except, the line sown barley in combination with pea which recorded higher green forage yield over oat with pea under broadcast sowing.

6.2. Quality Studies

Crude protein content (%) in herbage in general showed a decreasing trend with successive cut, whereas, in term of crude fibre content (%) the trend was reverse.

Neither the crude protein nor the crude fibre contents were significantly influenced by various fodder crops.

Pea mixture produced higher crude protein content over pure stand and mixture with sarson. Mixture with sarson produced higher crude protein content over pure stand in the first cut, but producing similar in the second cut. Pure stand of the crops resulted in highest amount of crude fibre content. Mixture of crops with pea or sarson produced the similar amount of crude fibre content.

Sowing methods did not exhibit any significant effect on the crude protein and crude fibre content of the herbage.

Oat crop resulted in higher crude protein and crude fibre yields over barley and oat+barley. Barley in the first cut and oat+barley in the second cut recorded the lowest crude protein yield. Whereas, in terms of crude fibre yield these two crops did not differs significantly with each other.

Association of pea with fodder crops produced significantly higher crude protein and crude fibre yield over other two cropping systems, except pure stand of crop which resulted in similarly crude fibre yield.

Line sowing of the fodder crops produced higher crude protein and crude fibre yields over broadcast sowing.

Sowing of Oat in lines in combination with pea produced highest crude protein yield.

Line sowing of the crops in any of the cropping systems recorded the highest crude fibre yield.

Pure stand of Oat and its combination with pea produced similar fibre yield.

6.3. Economics

The overall economics of the treatments revealed that oat crop gave highest net profit (Rs.5815.24) as well as highest net return per rupee investment (Rs.2.25).

Association of fodder crops with pea gave higher net profit (Rs.5207.10), however, net return per rupee investment remained the same whether crops were grown either in association with pea or sarson (Rs.1.90).

Line sowing of the crops resulted in higher net profit as well as higher net return per rupee investment of Rs.5745.72 and Rs.2.19, respectively.

CONCLUSIONS

1. Cultivation of oat crop proved advantageous from production, quality and economic point of view under rainfed conditions.
2. Fodder crops grown in association with pea produced higher yield as well as better quality forage vis-a-vis higher profit over pure stand of crops and crops grown in association with sarson.
3. Growing of Oat with pea was found to be the best cropping system from production and quality point of view under rainfed conditions.
4. Line sowing of the Crops produced higher herbage yield over broadcast sowing.

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*Original not seen.

APPENDICES

APPENDIX - I

Mean weekly meteorological data during Rabi 1987-88

Standard week	Dates	Temperature Max.°C	Temperature Min.°C	Relative humidity (%)	Rainfall (mm)	Sunshine hours
41	8/10 - 14/10	26.2	16.4	43.3	6.6	7.2
42	15/10 - 21/10	22.3	12.6	41.3	50.6	7.8
43	22/10 - 28/10	23.0	12.0	52.1	-	9.8
44	29/10 - 4/11	23.1	12.3	35.3	0.8	9.7
45	5/11 - 11/11	22.9	11.3	41.1	-	10.2
46	12/11 - 18/11	22.1	10.7	36.4	-	10.0
47	19/11 - 25/11	20.6	8.7	34.6	-	9.8
48	26/11 - 2/12	20.3	8.5	31.6	0.5	7.7
49	3/12 - 9/12	18.4	7.0	42.1	-	7.0
50	10/12 - 16/12	18.2	7.1	46.6	8.7	7.0
51	17/12 - 23/12	19.0	7.3	36.6	-	9.6
52	24/12 - 31/12	18.0	6.9	45.8	-	5.9
1	1/1 - 7/1/88	17.6	9.0	45.9	0.5	3.7
2	8/1 - 14/1	14.8	6.9	60.7	42.1	3.2
3	15/1 - 21/1	17.0	5.7	46.4	3.4	8.1
4	22/1 - 28/1	15.3	4.0	51.1	6.6	7.6
5	29/1 - 4/2	19.4	6.8	31.9	-	8.9
6	5/2 - 11/2	20.4	9.4	36.0	-	7.5
7	12/2 - 18/2	16.8	6.6	51.7	4.9	6.0
8	19/2 - 25/2	17.4	6.6	47.8	25.1	6.2
9	26/2 - 4/3	17.0	7.1	45.1	77.4	6.0
10	5/3 - 11/3	19.4	10.4	59.6	154.6	3.6
11	12/3 - 18/3	17.3	8.7	53.9	58.6	4.4
12	19/3 - 25/3	21.5	9.7	38.9	16.8	9.1
13	26/3 - 1/4	20.9	9.9	46.7	19.7	8.0
14	2/4 - 8/4	25.9	15.3	29.6	17.3	8.1
15	9/4 - 15/4	29.1	16.8	27.3	-	10.9
16	16/4 - 22/4	26.5	16.0	44.4	59.4	7.9

APPENDIX - II

Analyses of variance of mean plant height (cm) of Oat

Source of variation	d.f.	Mean sum of squares		
		Cuts		
		I	II	Cummulative
Replications	2	25.3	33.19	90.26
Fodder Crops	1	20.55	0.17	24.5
Cropping Systems	2	5.00	22.48	48.63
Fodder Crops X Cropping Systems	2	4.53	6.79	19.84
Error 'a'	10	26.15	45.22	65.64
Sowing methods	1	5.76	1.82	14.06
Fodder Crops X Sowing methods	1	2.15	2.95	10.14
Cropping Systems X Sowing methods	2	7.60	4.96	1.19
Fodder Crops x Cropping Systems X sowing methods	2	2.39	6.84	16.87
Error 'b'	12	55.95	78.18	178.94

APPENDIX -III

Analyses of variance of mean plant height (cm) of barley

Source of variation	d.f.	Mean sum of squares		
		Cuts		
		I	II	Cummulative
Replication	2	10.25	15.45	4.94
Fodder Crops	1	11.67	17.22	0.19
Cropping systems	2	17.15	4.06	32.96
Fodder Crops x Cropping Systems	2	3.49	1.59	0.94
Error 'a'	10	16.49	22.30	57.97
Sowing methods	1	5.06	3.67	0.40
Fodder Crops x Sowing methods	1	25.51	0.52	21.47
Cropping Systems x Sowing methods	2	1.24	7.25	12.64
Fodder Crops x Cropping x Sowing methods	2	24.11	1.05	30.73
Error'b'	12	13.08	53.7	74.62

APPENDIX - IV

Analyses of variance of mean plant height (cm) of pea

Source of variation	d.f.	Mean sum of squares		
		Cuts		
		I	II	Cummulative
Replication	2	4.26	7.88	2.28
Fodder Crops	2	12.8	6.26	35.80
Error (a)	4	23.38	21.34	22.84
Sowing methods	1	33.08	4.70	62.72
Fodder Crops x Sowing methods	2	9.42	2.10	6.85
Error (b)	6	11.27	31.39	47.04

APPENDIX - V

Analyses of variance of mean plant height (cm) of Sarson

Source of variation	d.f.	Mean sum of squares
		I cut
Replication	2	4.24
Fodder Crops	2	13.31
Error (a)	4	23.27
Sowing methods	1	29.9
Fodder Crops x Sowing methods	2	5.93
Error (B)	6	10.48

APPENDIX - VI

Analysess of variance of mean shoot number (m^{-2}) of Oat

Source of variation	d.f.	Mean sum of squares Cuts	
		I	II
Replications	2	306.19	4.53
Fodder Crops	1	989361.78*	1001667.36*
Cropping systems	2	219.53	206.36
Fodder Crops x Cropping systems	2	127.19	207.60
Error 'a'	10	61.06	57.10
Sowing methods	1	1062.76*	96410.25*
Fodder Crops x sowing methods	1	58.78	17.36
Cropping System x Sowing methods	2	73.58	72.75
Fodder Crops x Cropping systems X sowing methods	2	37.7	75.19
Error 'b'	12	78.97	57.42

APPENDIX - VII

Analyses of variance of mean shoot number (m^{-2}) of barley

Source of variation	d.f.	Mean sum of squares cuts	
		I	II
Replication	2	76.36	67.36
Fodder crops	1	1000333.36*	996669.44*
Cropping systems	2	649.2*	809.53*
Fodder Crops X Cropping Systems	2	83.06	75.03
Error 'a'	10	32.0	31.76
Sowing methods	1	105733.36*	105792.11*
Fodder Crops x Sowing methods	1	23.36	5.45
Cropping Systems x sowing methods	2	37.19	17.69
Fodder Crops x Cropping Systems X sowing methods	2	15.34	32.85
Error 'b'	12	75.39	67.36

*Significant at P = 0.05

APPENDIX -VIII

Analyses of variance of mean shoot number (m^{-2}) of pea

Source of variation	d.f.	Mean sum of squares Cuts	
		I	II
Replications	2	7.39	3.50
Fodder crops	2	10.72	10.67
Error 'a'	4	23.97	8.67
Sowing methods	1	6.72	24.3
Fodder Crops x Sowing methods	2	20.06	0.67
Error 'b'	6	6.78	11.28

APPENDIX - IX

Analyses of variance of mean shoot number (m^{-2}) of sarson.

Source of variation	d.f.	Mean sum of squares I cut
Replications	2	47.39
Fodder Crops	2	90.39
Error 'a'	4	39.44
Sowing methods	1	29.39
Fodder Crops x Sowing methods	2	9,38
Error 'b'	6	18.39

APPENDIX - X

Analyses of variance of mean per cent proportion of pea.

Source of variation	d.f.	Mean sum of squares		
		Cuts		Mean
		I	II	
Replications	2	0.12	0.06	0.005
Fodder Crops	2	0.89	0.26	0.53
Error 'a'	4	0.47	0.05	0.20
Sowing methods	1	4.91*	5.23*	5.07*
Fodder Crops x sowing methods	2	0.73	0.04	0.12
Error 'b'	6	0.65	0.14	0.14

* Significant at P = 0.05

APPENDIX - XI

Analyses of variance of mean per cent proportion of sarson

Source of variation	d.f.	Mean sum of squares
		I cut
Replications	2	1.99
Fodder crops	2	0.89
Error 'a'	4	0.48
Sowing methods	1	1.56
Fodder Crops x Sowing methods	2	0.16
Error 'b'	6	0.31

APPENDIX - XII

Analyses of variance of mean fresh weight ($g\ m^{-2}$)

Source of variation	d.f.	Mean sum of squares		
		Cuts		Mean
		I	II	
Replications	2	3.29	1.05	1.74
Fodder Crops	2	122202.10*	468029.77*	255190.23*
Cropping systems	2	74117.02*	343888.1*	38444 .90*
Fodder Crops x Cropping Systems	4	38689.81*	21373.81*	25108.17*
Error 'a'	16	0.88	0.96	0.34
Sowing methods	1	1019480.51*	4108.50*	793896.5*
Fodder Crops x sowing methods	2	17367.22*	1663.34*	5018.63*
Cropping Systems x sowing methods	2	5593.98*	429.43*	1539.10*
Fodder Crops x Cropping systems Sowing methods	4	10104.62*	7170.63*	1592.25*
Error 'b'	18	0.38	0.33	0.19

APPENDIX - XIII

Analyses of variance of mean dry weight ($g\ m^{-2}$)

Source of variation	d.f.	Mean sum of squares		
		Cuts		Mean
		I	II	
Replications	2	0.19	0.73	0.38
Fodder crops	2	5171.58*	23888.77*	11906.25*
Cropping systems	2	3506.54*	2102.48*	1804.2*
Fodder Crops x Cropping systems	4	2386.29*	2413.62*	2113.7*
Error 'a'	16	0.53	0.23	0.16
Sowing methods	1	48017.36*	50689.59*	49343.82*
Fodder Crops x sowing methods	2	632.36*	217.43*	397.82*
Cropping systems x sowing methods	2	330.22*	186.69*	363.48*
Fodder Crops x Cropping systems X Sowing methods	4	473.07*	164.87*	31.49*
Error 'b'	18	0.02	0.20	0.16

* Significant at P = 0.05

APPENDIX - XIV

Analyses of variance of green forage yield (q/ha)

Source of variation	d.f.	Mean sum of squares		
		Cuts		Total
		I	II	
Replications	2	34.42	16.86	36.22
Fodder crops	2	1319.21*	3976.39*	9067.69*
Cropping systems	2	508.94*	391.46*	1111.53*
Fodder Crops x Cropping Systems	4	223.06*	47.24*	391.74*
Error 'a'	16	6.09	15.22	11.39*
Sowing methods	1	9376.78*	7142.65*	32887.08*
Fodder Crops x Sowing methods	2	132.37*	49.39*	237.34*
Cropping systems x sowing methods	2	28.50*	19.44*	49.03*
Fodder Crops x Cropping Systems X sowing time	4	61.19*	26.55*	62.40*
Error 'b'	18	2.13	5.29	4.87

*Significant at P = 0.05

APPENDIX - XV

Analyses of variance of dry forage yield (q/ha)

Source of variation	d.f.	Mean sum of squares		
		Cuts		Total
		I	II	
Replications	2	0.49	2.26	4.07
Fodder Crops	2	75.83*	198.55*	496.04*
Cropping systems	2	21.51*	33.75*	98.78*
Fodder Crops x Cropping Systems	4	21.83*	5.55*	46.61*
Error 'a'	16	0.34	0.83	0.81
Sowing methods	1	439.26*	575.19*	2020.83*
Fodder Crops x Sowing methods	2	4.78*	8.62*	25.75*
Cropping systems x sowing methods	2	6.58*	10.69*	33.24*
Fodder Crops x Cropping systems X Sowing methods	4	3.78*	2.59*	8.32*
Error 'b'	18	0.14	0.65	1.03

*Significant at P = 0.05

APPENDIX - XVI

Analyses of variance of crude protein content (%)

Source of variation	d.f.	Mean sum of squares		
		Cuts		Average
		I	II	
Replications	2	1.48	0.72	0.92
Fodder crops	2	0.37	0.07	0.27
Cropping systems	2	194.37*	95.51*	227.16*
Fodder Crops x Cropping systems	4	0.96	0.01	1.91
Error 'a'	16	0.15	0.49	1.46
Sowing methods	1	0.41	1.10	0.01
Fodder Crops x Sowing methods	2	0.25	0.14	0.1
Cropping Systems x Sowing methods	2	0.12	0.09	0.04
Fodder x Cropping systems x sowing methods	4	0.39	0.10	0.03
Error 'b'	18	0.35	0.60	0.23

* Significant at P = 0.05

APPENDIX - XVII

Analyses of variance of crude fibre content (%)

Source of variation	d.f.	Mean sum of squares		
		Cuts		Average
		I	II	
Replications	2	2.29	12.71	8.48
Fodder Crops	2	2.27	8.43	3.90
Cropping systems	2	72.82*	57.02*	61.58*
Fodder Crops x Cropping systems	4	1.37	1.80	1.29
Error 'a'	16	4.35	2.96	1.68
Sowing methods	1	0.49	0.10	0.87
Fodder Crops x Sowing methods	2	1.30	0.21	0.02
Cropping systems x sowing methods	2	1.16	0.24	0.09
Fodder Crops x Cropping systems X sowing methods	4	0.33	1.86	0.24
Error 'b'	18	2.79	3.20	1.99

*Significant at P = 0.05

APPENDIX - XVIII

Analyses of variance of crude protein yield (q/ha)

Source of variation	d.f.	Mean sum of squares		
		Cuts		Total
		I	II	
Replications	2	775.98	988.7	3401.78
Fodder Crops	2	19.3*	2.31*	7.8*
Cropping systems	2	8.88*	0.51*	26.6*
Fodder Crops x Cropping Systems	4	1.13*	0.11*	1.76*
Error 'a'	16	.02	.02	.05
Sowing methods	1	10.06*	5.42*	30.23*
Fodder Crops x Sowing methods	2	0.14*	.10*	0.41*
Cropping systems x Sowing methods	2	0.34*	.03*	0.59*
Fodder Crops x Cropping systems X Sowing methods	4	.37	.04	.08*
Error 'b'	18	.015	.02	.03

* Significant at P = 0.05

APPENDIX - XIX

Analyses of variance of crude fibre yield (q/ha)

Source of variation	d.f.	Mean sum of squares		
		Cuts		Total
		I	II	
Replications	2	0.039	1.35	1.6
Fodder Crops	2	6.48*	25.81*	56.68*
Cropping systems	2	2.52*	6.51*	16.85*
Fodder Crops x Cropping systems	4	1.48*	13.58*	3.62*
Error 'a'	16	0.22	0.22	0.39
Sowing methods	1	29.6*	62.93*	178.91*
Fodder Crops x Sowing methods	2	0.75*	0.99*	2.51*
Cropping Systems X sowing methods	2	1.52*	1.75*	6.51*
Fodder Crops x Cropping systems x Sowing methods	4	0.06	0.31	0.66
Error 'b'	18	0.08	0.29	0.48

* Significant at P = 0.05

APPENDIX - XX

Economics of Production

	Sowing methods		
	Line sowing	Broadcast sowing	Mean
Cost of Production (Rs/ha)			
Fodder Crops			
Oat	2609.32	2564.32	2586.82
Barley	2640.57	2595.57	2618.07
Oat+barly	2624.95	2579.95	2602.45
Cropping systems			
Pure fodder crops	2518.28	2473.28	2495.78
Fodder Crops+Pea (broadcast)	2758.28	2713.28	2735.78
Fodder Crops+Sarson (broadcast)	2624.95	2579.95	2602.44
Mean	2624.95	2579.95	

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

1. Oat seed @ Rs.3.25 per kg.
2. Barley seed @ Rs.3.50 per kg.
3. Pea seed @ Rs.6.00 per kg.
4. Sarson seed @ Rs.10.00 per kg.
5. Urea @ Rs.2.35 per kg.
6. SSP @ Rs.1.01 per kg.
7. Tractor charges @ Rs. 50 per hour.
8. Rent of land @ Rs.250 per crop season.
9. Labour @ Rs. 15.00 per day.
10. Sale of green forage produce @ Rs.45.00 per quintal.