FORAGE PRODUCTION POTENTIAL UNDER CEREALS AND LEGUMES INTERCROPPING SYSTEMS

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ABSTRACT

FORAGE PRODUCTION POTENTIAL UNDER CEREALS AND LEGUMES INTERCROPPING SYSTEMS

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ABSTRACT

A field experiment was carried out during *kharif* season of 2005 on loamy sand soil at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar to study the effect of "Forage production potential under cereals and legumes intercropping systems." Twelve treatments comprising of sole crops (Two main crops *viz.*, sorghum and pearlmillet and two legume crops *viz.*, cowpea and clusterbean) and intercropping in different row ratios (1:1 and 2:1) were tried in randomized block design with four replications.

Taller plants of pearlmillet and clusterbean were recorded by T_{12} (Pearlmillet + Clusterbean 2:1 row ratio) in mean of both cuts of cereal crops

and in a single cut of legume crops, though, the effect on legume crops was not significant. Higher number of tillers per plant of pearlmillet was recorded by T_{12} (Pearlmillet + Clusterbean 2:1 row ratio) on mean basis and the effect on number of branches per plant of legume crops was not significant, however, treatment T_4 (Sole clusterbean) recorded the higher value of it. The leaf : stem ratios of cereal and legume crops were not significant, however, maximum leaf : stem ratio of pearlmillet was recorded by treatment T_{12} (Pearlmillet + Clusterbean 2:1 row ratio) and treatment T_{10} (Pearlmillet + Cowpea 2:1 row ratio) on mean basis. Treatment T_5 (Sorghum + Cowpea 1:1 row ratio) recorded higher leaf : stem ratio of cowpea.

Significantly the highest green forage yield was recorded by sole pearlmillet (T_2) during 1st, 2nd cut and in total of both cuts of cereal crops and sole cowpea (T_3) in a single cut of legume crops. The highest total green forage yield was recorded by T_{12} (Pearlmillet + Clusterbean 2:1 row ratio). It was 14.32 per cent more than sole pearlmillet.

Maximum dry matter yield of pearlmillet was recorded by sole pearlmillet (T_2) during 1st, 2nd cut and in total of both cuts of cereal crops and sole clusterbean (T_4) in a single cut of legume crops. The higher total dry matter yield was recorded by T_{12} (Pearlmillet + Clusterbean 2:1 row ratio). It was 19.48 per cent more than sole pearlmillet.

Crude protein content was recorded higher by T_4 (Sole clusterbean) and crude fibre content was recorded higher by T_1 (Sole sorghum) on mean basis.

Intercropping of Pearlmillet + Clusterbean 2:1 row ratio (T_{12}) produced significantly higher green forage equivalent yield than rest of the treatments except treatment T_9 (Pearlmillet + Cowpea 1:1 row ratio). More than 20.98 per cent pearlmillet green forage equivalent yield was recorded in Pearlmillet + Clusterbean 2:1 row ratio (T_{12}) than sole pearlmillet (T_2).

Intercropping of Pearlmillet + Clusterbean 2:1 row ratio (T_{12}) recorded maximum net realization (Rs.35,476) and Benefit : Cost ratio (4.33).

The highest LER (1.92) was recorded by intercropping of Sorghum + Cowpea 1:1 row ratio (T_5).

Thus, it is indicated that intercropping system of Pearlmillet + Clusterbean at 2:1 row ratio (T_{12}) was distinctly superior to sole crops and other intercropping systems and found most profitable.

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CERTIFICATE

This is to certify that the thesis entitled **"FORAGE PRODUCTION POTENTIAL UNDER CEREALS AND LEGUMES INTERCROPPING SYSTEMS"** submitted by **PAWAN KUMAR PAREEK** in partial fulfilment of the requirements for the award of the degree of **"MASTER OF SCIENCE (AGRICULTURE)"** in the subject of **AGRONOMY** by the Sardarkrushinagar Dantiwada Agricultural University is a record of bonafide research work carried out by him under my personal guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma or other similar title.

Place : Sardarkrushinagar
Date : 14th December, 2006

(B. J. PATEL)
MAJOR ADVISOR

DECLARATION

This is to declare that the whole of the research work reported in the thesis in partial fulfilment of the requirement for the degree of **MASTER OF SCIENCE (Agriculture)** in the subject of **AGRONOMY** is the result of investigations done by me under the direct guidance and supervision of **Dr. B. J. PATEL**, Associate Professor, Department of Agronomy, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar and no part of the work has been submitted for any other degree so far.

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Place : Sardarkrushinagar
Date : 14th December, 2006

(PAWAN KUMAR PAREEK)

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LIST OF ABBREVIATIONS

%	:	Per cent
BCR	:	Benefit Cost Ratio
C.V.	:	Coefficient of Variation
CD	:	Critical Difference
cm	:	Centimetre
cv.	:	Cultivar
DAS	:	Days After Sowing
dSm^{-1}	:	Decisiemens per metre
EC	:	Electrical Conductivity
et al.	:	et allii ; and others
etc.	:	Et citeras
Eve.	:	Evening
Fig.	:	Figure
g^{-1}	:	Per gram
ha^{-1}	:	Per hectare
hr.	:	Hour
i.e.	:	That is
kg	:	Kilogram
km	:	Kilometre
m	:	Metre
Max.	:	Maximum
Min.	:	Minimum
Morn.	:	Morning
No.	:	Number
NS	:	Not Significant
R.H.	:	Relative Humidity
°C	:	Degree Celsius
q^{-1}	:	Per quintal
Rs.	:	Rupees
S.Em.±	:	Standard Error of mean
t	:	tone
var.	:	Variety
Viz.	:	Namely

INTRODUCTION

I INTRODUCTION

India ranks first among major livestock holding (483.71 m heads) as well as milk producing country (87 M T) in the world (FAO, 2002). Beyond this status is a contribution of large low producing bovine population. One of the major reasons for low animal production and productivity is the shortage of feed and fodder as well as its poor quality.

Singh (1993) reported as only 4.4 per cent (8.27 m ha) of the country's cropped area is under fodder crops. At present, only 3.7 per cent of country's total cultivated land used for production (Chhabra and Dinh, 2002).

Gujarat state has a total animal population of 18.44 million heads, while the total forage production is 20.0 m tonnes but the requirement is 49.2 m tonnes. Thus, a gap of 29.2 m tonnes exists between the demand and supply of fodder, which is ought to further wider owing to steady rise in the livestock population and diversion of more area to the grain and cash crops. The total area under forage crops in the state is 0.8 million ha (*i.e.*, 6.4 % of the total cultivated area), which highlight the facts that farmers of Gujarat are predominantly crop growers and livestock production is only a subsidiary occupation. The animals are chiefly fed on poor quality roughages like stovers of sorghum and pearlmillet, sugarcane tops and straw of paddy and wheat except rainy season. It may not be possible to increase the area under forage crops because of ever increasing pressure on arable land from grain and commercial crops. So that only alternative to meet the forage requirement will be to increase the yield of forage per unit area per unit time which can be

achieved by intercropping of high yielding varieties and hybrids of cereal forage with legumes.

Intercropping is a practice of growing two or more crops simultaneously on the same area in a definite row pattern. Intercropping is a common practice in low level equilibrium farmers of semi-arid and arid tropics, where primary concern is to insulate his investment of labour and meagre capital against adversities of nature in order to sustain his living. A significant feature of intercropping is that, it is biologically more dynamic than a pure crop and is, therefore, less likely to succumb to vagaries of weather. For example, reduction in yield of one component may be compensated by the other component.

It has also been recognized that intercropping has several advantages besides increasing the yields. This includes insurance against crop failure, better labour utilization, maintenance of soil fertility and improve forage quality.

The intercropping of cereal with legumes fodder crops thus, assumes great. importance in providing stable production, ensuring profitability and enriching the quality of fodder. Among the important crops compatible with pearlmillet and sorghum, clusterbean is an important legume ideally suited for arid and semi-arid regions of the country. It is tolerant to drought and can successfully be grown on light soils having poor water retentivity and fertility. Cowpea is another such crops popularly grown mixed/intercrop with other cereal crops. The practice of growing the cereals + legumes in association can improve the digestibility of fodder by 10.0 to 15.0 per cent over monoculture

(Paroda *et al.,* 1979). The increase in crude protein content of fodder with sorghum + cowpea intercropping was also observed by Tiwana *et al.* (1979). The higher green and dry fodder yields with pearlmillet + cowpea or clusterbean have also been reported by Gupta and Meena (1995) and Hazara *et al.* (1995).

Since, there is paucity of information on aforesaid aspects a field experiment entitled "Forage production potential under cereals and legumes intercropping systems" was planned during *kharif* season of 2005 laid out at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar with the following objectives.

[1] To find out the suitable row ratio ~~of different intercropping~~ systems for higher green forage and dry matter yields

[2] To study the quality of forage as influenced by different row ratio ~~under~~ ~~different~~ intercropping systems

[3] To ascertain the best intercropping combination for obtaining maximum benefit from intercropping system

REVIEW OF LITERATURE

II REVIEW OF LITERATURE

An attempt has been made to review the available literature on this experiment. The works done on this experiment of the crops are very limited. Hence, similar work on other related crops have also been included whenever necessary. Attempts are, therefore made to present a brief summary of work carried out in India and abroad relating to the problem under study which has been highlighted and reviewed under given headings.

2.1 Effect of intercropping on growth parameters

2.2 Effect of intercropping on green forage and dry matter yields

2.3 Effect of intercropping on crude protein and crude fibre contents

2.4 Effect of intercropping on economics, Land Equivalent Ratio (LER) and Crop equivalent yield

2.1 EFFECT OF INTERCROPPING ON GROWTH PARAMETERS

Anjeneyulu *et al.* (1982) reported that plant height and tillers per plant were influenced marginally by intercropping. However, increase in production was observed by pearlmillet + moongbean as compared to sole pearlmillet.

Sharma (1987) conducted an experiment during *kharif* season on loamy sand soil at Jobner revealed that paired row planting of pearlmillet with one or two rows of clusterbean significantly increased the total number of tillers per plant in pearlmillet.

Mohammed Ibrahim (1987) conducted an experiment during *kharif* season and reported that intercropping of maize with legumes gave significantly higher plant height over sole maize.

Singh (1992) conducted an experiment during summer season at Jobner and observed that number of tillers per metre row length increased significantly when pearlmillet was intercropped with cowpea, clusterbean or greengram as compared to sole pearlmillet.

Khateek (1997) studied different intercropping systems during *kharif* season 1996 at Jobner and reported that intercropping of pearlmillet with cowpea, clusterbean or moongbean significantly increased the number of tillers, plant height as compared to sole pearlmillet.

A field experiment was conducted during the summer seasons of 1996 and 1997 on medium black soil at the National Research Centre for groundnut, Junagadh by Ghosh (2002) and reported that sorghum plant attained the highest plant height in first year in groundnut + sorghum (Single cut) combination and in second year, groundnut + pearlmillet (Single cut) combination attained the highest plant height of pearlmillet and it produced more number of tillers than that of sorghum in both groundnut + pearlmillet (Single cut) and groundnut + pearlmillet (Two cuts) treatment combinations.

Dadhich and Gupta (2005) carried out a field experiment during summer seasons 1999-2000 on loamy sand soil at Agronomy Farm, S.K.N. College of Agriculture, Jobner and reported that the pearlmillet + cowpea intercropping proved significantly superior to sole pearlmillet with respect to plant height, tillers per plant, leaves per plant and leaf area in both the years and in pooled data except plant height, leaves per plant and leaf area at second cut.

2.2 EFFECT OF INTERCROPPING ON GREEN FORAGE AND DRY MATTER YIELDS

Mishra (1964) conducted an experiment during *kharif* season at Jodhpur and observed that Pearlmillet + Clusterbean intercropping system resulted in the highest production of green forage and dry matter yields followed by Pearlmillet + Cowpea.

Relwani *et al.* (1976) conducted an experiment during *kharif* season and reported that pearlmillet was grown with clusterbean or cowpea in mixture the green and dry fodder yields increased significantly as compared to sole pearlmillet. The total productivity of pearlmillet increased when intercropped with greengram as compared to sole pearlmillet (De *et al.*, 1978).

Tiwana *et al.* (1979) conducted an experiment during *kharif* season and observed significantly increase in green and dry fodder yields (363 and 76 q ha^{-1}) of maize intercropped with cowpea than sole maize at Ludhiana.

Taneja *et al.* (1980) conducted an experiment during *kharif* season at Hisar and revealed that the highest green forage yield was recorded when sorghum was sown with cowpea in 4:1 ratio, however, it was at par with pure sorghum. The green forage yield obtained from the sorghum and cowpea sown in 2:1 and 3:1 ratio, was also at par with the above combinations.

Tripathi *et al.* (1987) conducted an experiment during summer season, 1983 at IGFRI, Jhansi and reported that sorghum + cowpea alternate rows system gave the highest green and dry fodder yields as compared to pearlmillet + cowpea or maize + cowpea intercropping.

An experiment was conducted during summer season at Akola on different cropping systems (sole maize, sole cowpea, maize + cowpea in 1:1, 2:1, 3:1 row ratios) by Pillai *et al.* (1990) and observed that intercropping of maize + cowpea gave significantly higher green and dry fodder yields over sole crop.

An experiment was conducted during 1987 to 1989 at Rahuri by Khot *et al.* (1991) and reported that planting of two rows of maize in between the rows of leucaena (*Leucaena leucocephala*) was better for green forage and the highest dry matter yield was obtained by planting two rows of maize in between the rows of leucaena followed by planting two rows of sorghum.

Khot *et al.* (1992) conducted an experiment at Rahuri during *kharif* seasons of 1988 and 1989 and observed that maize + common sesban (*Sesbania sesban*) in 2:1 row ratio yielded 27.7 per cent higher green fodder and 35.5 per cent increase in dry matter yield over sole maize.

Sood and Sharma (1992) conducted an experiment at Palampur during the *kharif* seasons of 1987 and 1988 on silty – clay loam soil and reported that sorghum intercropped with legume produced significantly higher green forage than sorghum alone. The increase in dry forage yields was 12 to 18 per cent. Higher yields in the intercropping systems may be ascribed to greater utilization of environmental resources by the mixed stands.

Keshwa and Singh (1992) conducted an experiment during summer season 1988 on loamy sand soil at Jobner and reported that pearlmillet

intercropped with clusterbean produced more fodder yield (396 q ha^{-1}) as compared to pure pearlmillet (380 q ha^{-1}).

A field experiment was conducted during summer and *kharif* season of 1988 and 1989 at IGFRI, Jhansi on sandy loam soil by Gill and Verma (1992) and concluded that intercropping of cereal (*Bajra*, sorghum) and leguminous (Cowpea/*guar*) fodder crops resulted in higher forage yields.

Gill and Verma (1993) conducted a field experiment during summer season on sandy loam soil at IGFRI, Jhansi on sorghum and *bajra* intercropping with cowpea and *guar* in alternate rows, paired rows or mixed stand or cross sowing and observed that maize + cowpea intercropping with cross sowing gave the highest green and dry fodder yields over all other treatments.

An experiment was conducted during rainy seasons of 1990 and 1991 at Modipuram, on sandy – loam soil by Gangwar and Sharma (1994) and reported that significantly higher mean green fodder (140 q ha^{-1}) and mean dry matter (29.9q ha^{-1}) of prickly sesban (*Sesbania cannabina*) followed by sannhemp (*Crotalaria juncea*) 122.8 q ha^{-1} green fodder and 28.1 q ha^{-1} dry matter in maize + prickly sesban and maize + sannhemp intercropping, respectively.

Hazara *et al.* (1995) conducted an experiment and reported that pearlmillet was grown in single or paired rows with cowpea or clusterbean, the legume yields compensated for the loss of pearlmillet yield in intercropped systems, increasing total green forage yield by 11-29 per cent and dry forage by 5-23 per cent over sole pearlmillet.

Tripathy *et al.* (1997) conducted field experiment during summer season of 1990-1991 at the Central Research Station, Bhubaneshwar on sandy loam soil and reported that mean total green forage yield (50.8 t ha^{-1}) and mean total dry matter yield (10.8 t ha^{-1}) from growing maize with cowpea intercrop in a 2:2 ratio as compared to sole maize.

Mishra *et al.* (1997) conducted a field experiment during rainy seasons of 1990-91 and 1991-92 at Ambikapur (Madhya Pradesh) on sandy loam soil and suggested that the intercropping of sorghum with cowpea in paired alternate rows (2:2) recorded the highest 42.48 t ha^{-1} green fodder and 8.17 t ha^{-1} dry matter yield over sole sorghum 29.8 t ha^{-1} green fodder and 6.84 t ha^{-1} dry matter yield.

Kumar and Bhanumurthy (2001) conducted an experiment during *kharif* season of 1998 and summer season of 1999 at Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad and reported that intercropping maize + cowpea in 2:1 row ratio better than other intercropping systems and comparable to any of the sole crop maize and cowpea.

Yadava and Solanki (2002) conducted a field experiment during *kharif* seasons of 1996, 1997 and 1998 at Bikaner and reported that sole pearlmillet gave the highest green fodder (263.16 q ha^{-1} and dry matter yield (64.35 q ha^{-1}) followed by sole crop of *guar* (218.85 and 39.33 q ha^{-1} green and dry fodder, respectively). When pearlmillet grown in combination with *guar* and cowpea, green fodder yield obtained from pearlmillet + *guar* under 2:2 row proportion

was significantly higher than the sole crop of pearlmillet. Sorghum either as a sole crop or as an intercrop was not found beneficial.

An experiment was conducted at Acharya N.G. Ranga Agricultural University, Rajendranagar, during *kharif* seasons 2000-2001 by Reddy *et al.* (2004) and reported that the mean green fodder yield of sole maize was 46.8 t ha^{-1} and that of cowpea 17.1 t ha^{-1}. Among the intercropped systems, maize and cowpea at 4:1 ratio with 42.8 t ha^{-1} green fodder yield was significantly superior to most of other intercrop treatments. This was due to the higher contributions of maize in the system. This was evident from the fact that 1:4 system gave the lowest green fodder yield *i.e.*, 33.6 t ha^{-1}.

Singh *et al.* (2004) conducted an experiment on sandy loam soil at Hisar during summer season and revealed that sorghum as sole crop produced maximum green fodder yield of 56.38 t ha^{-1} amongst all treatments which was at par with sorghum + cowpea intercropping (2:1) with 55.21 t ha^{-1}. Combined forage yield of the intercropping system was better and comparable to any of the sole crop and the highest dry matter yield observed in same treatment *i.e.*, sole sorghum and at par with sorghum + cowpea (2:1) intercropping system.

Dadhich and Gupta (2005) conducted a field experiment during summer seasons of 1999 and 2000 on loamy sand soils at Jobner and reported that the pearlmillet + cowpea (3:1) intercropping proved significantly superior to sole pearlmillet with respect to green fodder yield.

Kumar *et al.* (2005) conducted a field experiment during *kharif* seasons in three consecutive years 1999 to 2001 at IGFRI, Jhansi on sandy loam soil

and reported that green fodder and dry matter yields were significantly affected by different intercropping treatments. The total green fodder and dry matter yields were the highest under maize + cowpea in 2:2 row ratio and significantly superior to the other intercropping systems and sole stand of maize and cowpea. The increase in total green fodder and dry matter yields with the maize + cowpea intercrop combination in 2:2 row proportion was 23.1 and 25.0 per cent over sole maize, respectively.

2.3 EFFECT OF INTERCROPPING ON CRUDE PROTEIN AND CRUDE FIBRE

Roat *et al.* (1990) concluded that the maize and cowpea mixed stands in 2 : 1 row ratio gave average yield of 0.48 t ha^{-1} and 9.76 per cent crude protein in dry matter followed by 0.43 t ha^{-1} crude protein and 8.79 per cent crude protein in dry matter of sorghum and cowpea in similar stands (2:1), respectively.

A field experiment was conducted during rainy seasons of 1990 and 1991 at Modipuram on sandy loam soil by Gangwar and Shama (1994) and observed that higher crude protein yield in prickly sesban followed by cowpea. The higher crude protein yield in prickly sesban was due to its higher forage yield whereas, higher crude protein yield in cowpea was on account of higher nitrogen per cent in its foliage. They also recorded significantly higher crude protein yield (3.7 q ha^{-1}) with prickly sesban (*Sesban cannabina*) followed by cowpea (3.6 q ha^{-1}) and sannhemp (*Crotolaria juncea*) (3.3 q ha^{-1}) in maize systems.

Khanna *et al.* (1996) reported that crude protein yield in all cuts and in aggregates were significantly higher in sole sorghum (6.68 q ha^{-1}) than sorghum + cowpea in 2:2 (6.50 q ha^{-1}) and 3:3 (6.42 q ha^{-1}).

Mishra *et al.* (1997) conducted an experiment during rainy seasons of 1990-1991 and 1991-1992 at Ambikapur (Madhya Pradesh) on sandy loam soil. Treatments consisted of three sole cropping of fodder sorghum, cowpea and horse gram and combinations of intercropping of cowpea and horsegram with sorghum in 1:1, 1:2 and 2:2 row ratios and they observed that intercropping of sorghum with cowpea in paired alternate rows (2:2) recorded the highest crude protein yield (9.26 q ha^{-1}) compared with other sole and intercropping systems.

Tripathy *et al.* (1997) conducted an experiment during summer season 1990 and 1991 at Bhubaneshwar and observed the highest crude protein yield (12.25 ha^{-1}) when maize c.v. HGT-3 and cowpea were sown in 2:2 row proportions over other treatments.

A field experiment was conducted during the *kharif* season of 1991-92 at Rudrur (Andhra Pradesh) on the clay loam soil by Krishna *et al.* (1998) and reported that intercropping of maize + cowpea (30 + 60 cm) paired row of maize with one row of cowpea could produce 8.26 per cent higher crude protein and significantly superior to sole maize (6.49 %). The planting pattern did not causes any significant variation in crude fibre.

Kumar and Bhanumurthy (2001) conducted an experiment during *kharif* season 1998 and summer 1999 at Hyderabad and reported that the crude

protein yields were higher with sole cowpea in *kharif* 1998 and summer 1999. Intercropping of maize and cowpea in 2:1 ratio was better than other 1:1 and 1:2 ratios.

Reddy *et al.* (2004) conducted an experiment at Rajendranagar and reported that the intercrops 2:2 ratio showed the highest crude protein yield which gave 8 per cent higher crude protein yield over that of sole maize. This system was closely followed by maize + cowpea 2:1 system.

Dadhich and Gupta (2005) conducted a field experiment during summer seasons of 1999 and 2000 on loamy sand soil at Jobner and reported that the pearlmillet + cowpea intercropping proved significantly superior to sole pearlmillet with respect to crude protein yield. The reason for superior quality fodder may be that cowpea being a legume fixing atmospheric nitrogen could have increased the availability of nitrogen which has been utilized by pearlmillet for its growth and ultimately increased green fodder yield.

Singh *et al.* (2005) conducted an experiment during summer season 2002 on sandy loam soil at Hisar and observed that the highest percentage of crude protein was recorded in sole crop of cowpea. Amongst intercropping combinations, sorghum + cowpea in 2 : 1 ratio recorded the highest production of crude protein, while maximum crude fibre content (%) was recorded in sole sorghum.

Kumar *et al.* (2005) conducted a field experiment during *kharif* seasons 1999 to 2001 at IGFRI, Jhansi on sandy loam soil and reported that significantly higher total crude protein yield was recorded with maize +

cowpea (2:2) than the other treatments. The results indicated superiority of 35.5 and 68.9 per cent in crude protein yield with maize + cowpea (2:2) to sole stands of maize and cowpea, respectively.

2.4 EFFECT OF INTERCROPPING ON ECONOMICS, LAND EQUIVALENT RATIO (LER) AND CROP EQUIVALENT YIELD

Waghmare *et al.* (1982) conducted an experiment and reported that all intercropping systems had higher productivity and net return than sole sorghum. Similar results have also been reported by Waghmare and Singh (1982).

Tripathi *et al.* (1987) observed that LER was more than one in maize/sorghum in cropped with cowpea at different proportions.

Manoharan and Subramanian (1993) concluded that maize and cowpea combination (2:1) recorded the highest net income of Rs.3260 ha^{-1} $year^{-1}$ with a return of Rs.2.90 per rupees invested.

Yadav and Joon (1993) conducted an experiment during *kharif* seasons of 1989 and 1990 at Hisar and observed that the sole crop of *guar* gave higher net return than sole crop of *Bajra* and their different intercropping ratios. Amongst different intercropping ratios, 3:1 gave the highest net return closely followed by 2:1 ratio.

Mishra *et al.* (1997) conducted an experiment during rainy seasons of 1990-1991 and 1991-1992 at Ambikapur on sandy loam soil and reported that the intercropping of sorghum with cowpea in paired alternate rows (2:2)

recorded the highest land equivalent ratio *i.e.,* 1.35 and the highest net monetary returns (Rs. 6804 ha^{-1}) compared with other sole and intercropping systems. This treatment gave 63.0 per cent more monetary returns and 21 per cent benefit : cost ratio (2.77) over sole crop of sorghum (2.29).

Desale *et al.* (2002) reported that the normal planting of sorghum at 45 cm and intercropped one row of soyabean in between two rows of sorghum recorded significantly higher economic returns and 28.9 per cent increase in gross monetary returns. The highest LER values of 1.75 recorded in same treatment.

Singh *et al.* (2005) conducted an experiment during summer season 2002 at Hisar and reported that sorghum + cowpea (2:1) ratio was the most profitable which gave the highest net profit (Rs.12990) and benefit : cost ratio (1.97).

Kumar *et al.* (2005) conducted an experiment during *kharif* seasons 1999 to 2001 at IGFRI, Jhansi and reported that the mean gross return (Rs.15236 ha^{-1}), net return (Rs. 8346 ha^{-1}) and benefit : cost ratio (2.21) were significantly higher with maize + cowpea (2:2) than other treatments which was closely followed by intercropping of maize and cowpea in the row proportion of (2:1). Significantly the highest mean LER (1.41) was recorded in intercropping of maize and cowpea planted in the row ratio of (2:2), followed by maize + cowpea (2:1) LER (1.21) and mixed seed in same row (1:1) LER (1.22).

MATERIALS AND METHODS

III MATERIALS AND METHODS

A field experiment entitled "Forage production potential under cereals and legumes intercropping systems" was carried out during *kharif* season of the year 2005. The details of the experimental procedure adopted, materials used and techniques implied during the course of present investigation are described in this chapter.

3.1 EXPERIMENTAL SITE

The field experiment was conducted on Plot No. B-11 at Agronomy Instructional farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar.

3.2 CLIMATE AND WEATHER CONDITIONS

Geographically, Sardarkrushinagar is situated at 24° - 19' North latitude and 72° – 19' East longitude with an elevation of 154.52 metres above the mean sea level. It is located in the North Gujarat Agro-climatic Zone. This zone is characterized by arid and semi-arid climate with extreme cold winter, hot and dry windy summer. Generally, monsoon in this part commences in the middle of June and retreats by the middle of September. Most of the precipitation is received from southwest monsoon concentrating in the months of July and August. Monsoon is warm and moderately humid with an average annual rainfall of 510 mm (1996 to 2005), most of which is received during July and August.

The winter season is fairly cold and dry. It sets usually with the end of October and setback in February. The temperature starts dropping with the

beginning of November and the lowest minimum temperature of the season is observed in the month of December or January. Overall, winter season remains fairly cold and dry.

The summer (March – June) is fairly hot and dry. The temperature reaches the peak in the month of April and May are the hottest months of the years. The wind velocity is very high and stormy during summer.

The meteorological data pertaining to the period of present investigation were recorded from the meteorological observatory of the Department of Meteorology, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar are presented in Table 1 and graphically depicted in Fig. 1.

3.3 PHYSICO-CHEMICAL PROPERTIES OF SOIL

The experimental field has an even topography with a gentle slope and good drainage. To ascertain physico-chemical characteristics of soil, soil samples were collected randomly from the experimental plots to a depth of 0-15 cm and 15-30 cm before preparing of layout and composite soil samples were prepared depthwise and analysed for physico-chemical properties of soil. The value of these properties of the soil alongwith the methods used to determine them are presented in Table 2. The data revealed that the soil of the experimental plot was loamy sand in texture having pH value of 7.5 and 7.8 for 0-15 cm and 15-30 cm depths, respectively. The soil analysis indicated that the soil was low in organic carbon and available nitrogen, medium in available phosphorus and rich in available potassium status.

Table 1 : Standard weekwise meteorological data recorded at the Meteorological Observatory of the Department of Meteorology, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar during crop season of the year 2005

Month and year	Std. week	Date	Temperature (°C)		Relative Humidity (%)		Wind velocity (kg hr^{-1})	Sunshine hours	Rainfall (mm)	Rainy days
			Max.	Min.	Morn.	Even.				
July-2005	27	2-8	32.4	26.1	89.6	59.6	10.8	1.5	30.8	2
	28	9-15	34.0	26.7	84.0	55.6	11.2	3.0	0.0	0
	29	16-22	35.3	26.4	79.3	45.7	11.9	4.2	3.0	1
	30	23-29	35.0	26.0	85.9	60.7	11.4	4.1	101.5	2
	31	30-5	31.1	25.4	94.7	82.4	6.5	1.0	124.9	5
Aug.-2005	32	6-12	30.7	24.9	91.6	69.0	10.9	0.7	2.4	0
	33	13-19	32.9	25.2	90.1	58.9	7.8	4.3	6.2	1
	34	20-26	33.0	23.9	86.7	54.3	9.0	5.0	0.0	0
	35	27-02	34.4	24.0	82.1	48.7	5.5	9.1	0.0	0
Sept.-2005	36	3-9	36.9	26.1	83.4	47.7	5.6	6.9	23.9	1
	37	10-16	34.1	25.8	91.7	67.4	5.2	5.5	56.0	4
	38	17-23	32.6	25.5	93.6	68.1	5.9	3.9	79.9	3
	39	24-30	31.4	23.2	90.4	56.0	5.8	6.0	52.0	1

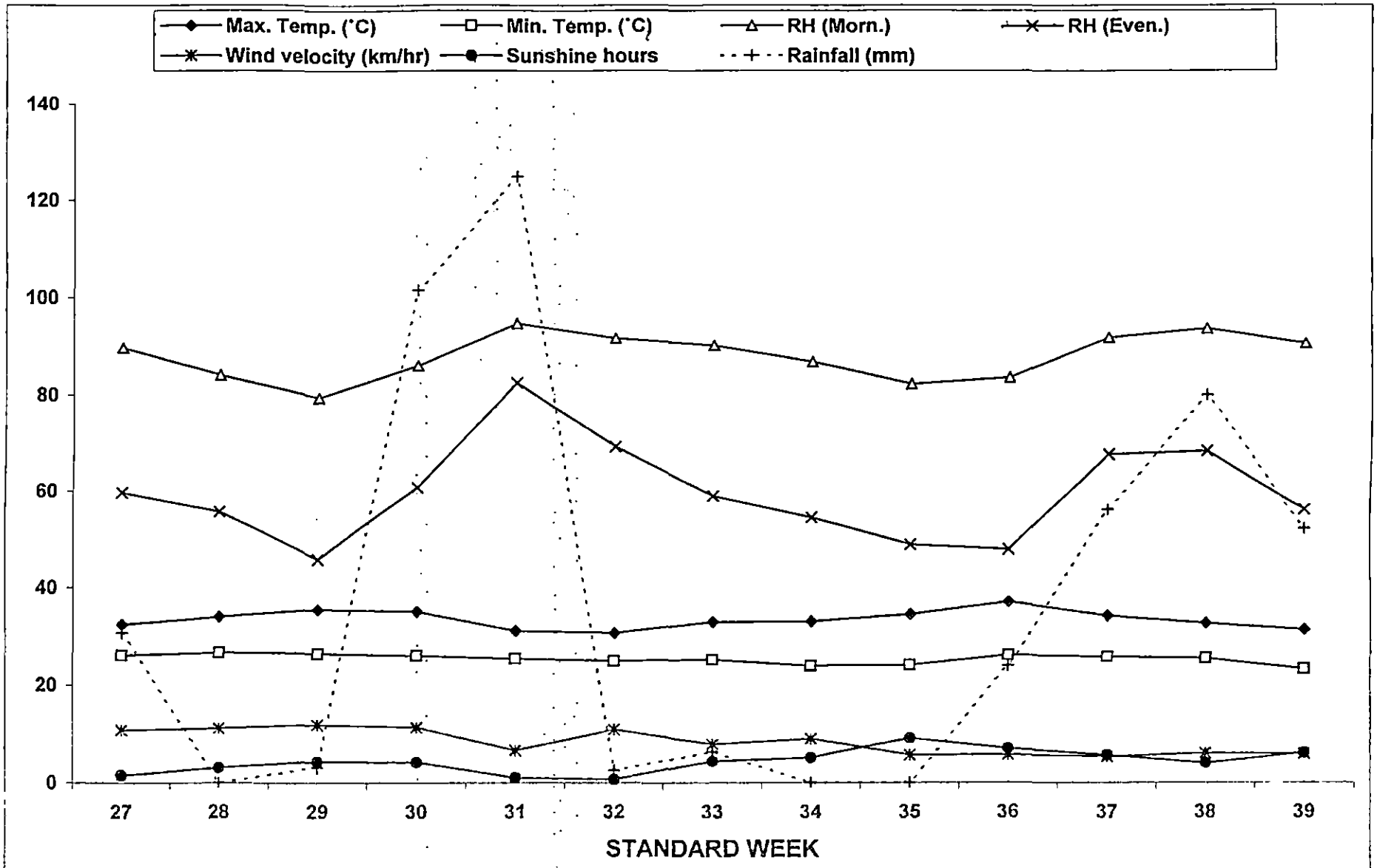

Fig. 1 : Standard weekwise meteorological data during crop season of the year 2005

Table 2 : Physical and chemical properties of the experimental soil

Sr. No.	Properties		Soil depth (cm) 0-15	Soil depth (cm) 15-30	Method employed
[A]	**PHYSICAL PROPERTIES**				
	(a)	Sand (%)	83.90	84.98	International Pipette method (Piper, 1966)
	(b)	Silt (%)	5.55	5.47	
	(c)	Clay (%)	9.83	9.02	
[B]	**CHEMICAL PROPERTIES**				
	(a)	Soil pH (1:2.5, Soil : Water ratio)	7.5	7.8	Potentiometric method (Jackson, 1973)
	(b)	Electrical Conductivity (dSm^{-1}) at 25°C	0.16	0.12	Schofield method (Jackson, 1973)
	(c)	Organic carbon (%)	0.15	0.17	Walkley and Black's rapid titration method (Jackson, 1973)
	(d)	Available N ($kg\ ha^{-1}$)	148	140	Alkaline permanganate method (Jackson, 1973)
	(e)	Available P_2O_5 ($kg\ ha^{-1}$)	47	50	Olsen's method (Jackson, 1973)
	(f)	Available K_2O ($kg\ ha^{-1}$)	288	270	Flame photometer method (Jackson, 1973)

3.4 CROPPING HISTORY

The cropping history of experimental plot with respect to crops taken and fertilizer applied during previous three years is given in Table 3.

3.5 EXPERIMENTAL DETAILS

3.5.1 Treatments

The field experiment conducted with twelve treatments are described as under.

T_1 : Sole sorghum

T_2 : Sole pearlmillet

T_3 : Sole cowpea

T_4 : Sole clusterbean

T_5 : Sorghum + cowpea (1:1)

T_6 : Sorghum + cowpea (2:1)

T_7 : Sorghum + clusterbean (1:1)

T_8 : Sorghum + clusterbean (2:1)

T_9 : Pearlmillet + Cowpea (1:1)

T_{10} : Pearlmillet + Cowpea (2:1)

T_{11} : Pearlmillet + clusterbean (1:1)

T_{12} : Pearlmillet + clusterbean (2:1)

3.5.2 Experimental design

A randomized block design was employed in this study. The treatments were replicated four times and were assigned randomly to each plot in the replication.

Table 3 : Cropping history of experimental plot

Year	Season	Crop	Fertilizer applied (kg ha^{-1})		
			N	P_2O_5	K_2O
2002-2003	*Kharif*	Fallow	-	-	-
	Rabi	Forage chicory	150	30	-
	Summer	Cowpea	20	40	-
2003-2004	*Kharif*	Fallow	-	-	-
	Rabi	Lucerne and forage chicory mixed			
		Lucerne	20	80	-
		Chicory	150	30	-
	Summer	Fallow	-	-	-
2004-2005	*Kharif*	Fodder sorghum	75	40	-
	Rabi	Fallow	-	-	-
	Summer	Fallow	-	-	-
2005	*Kharif*	Present investigation forage crops *viz.*,			
		Sorghum	75	40	-
		Pearlmillet	100	40	-
		Cowpea	20	40	-
		Clusterbean	20	40	-

3.5.3 Details of layout

1. Total number of treatments : 12
2. Total number of replications : 4
3. Plot size : Gross : 6.0 m x 3.6 m

   Net : 5.0 m x 1.8 m
4. Total number of plots : 48
5. Spacing : 30 cm between two rows

Numbers of rows in various treatments are given in Table 4. The plan of layout showing allotment of treatment is depicted in Fig. 2.

3.6 CROP AND VARIETY

The varieties selected of different crops and their important characteristics are given in Table 5.

3.7 CULTURAL OPERATIONS

The calendar of the cultural operations carried out for cultivation of the experimental crop is presented in Table 6. The details of these operations are as under.

3.7.1 Preparations of land and layout

The field was cross cultivated with tractor drawn cultivator and finally land was levelled by one harrowing followed by planking. The field channels were prepared manually according to the plan of layout. The furrows were opened manually in each plot at 30- cm apart and about 5-6 cm deep at the time of sowing.

Table 4 : Particular regarding number of rows in various treatments

Treatments		Number of rows per plot	
		Main crop	Inter crop
T_1	Sole sorghum	12	-
T_2	Sole pearlmillet	12	-
T_3	Sole cowpea	-	12
T_4	Sole clusterbean	-	12
T_5	Sorghum + cowpea (1:1)	6	6
T_6	Sorghum + cowpea (2:1)	8	4
T_7	Sorghum + clusterbean (1:1)	6	6
T_8	Sorghum + clusterbean (2:1)	8	4
T_9	Pearlmillet + Cowpea (1:1)	6	6
T_{10}	Pearlmillet + Cowpea (2:1)	8	4
T_{11}	Pearlmillet + clusterbean (1:1)	6	6
T_{12}	Pearlmillet + clusterbean (2:1)	8	4

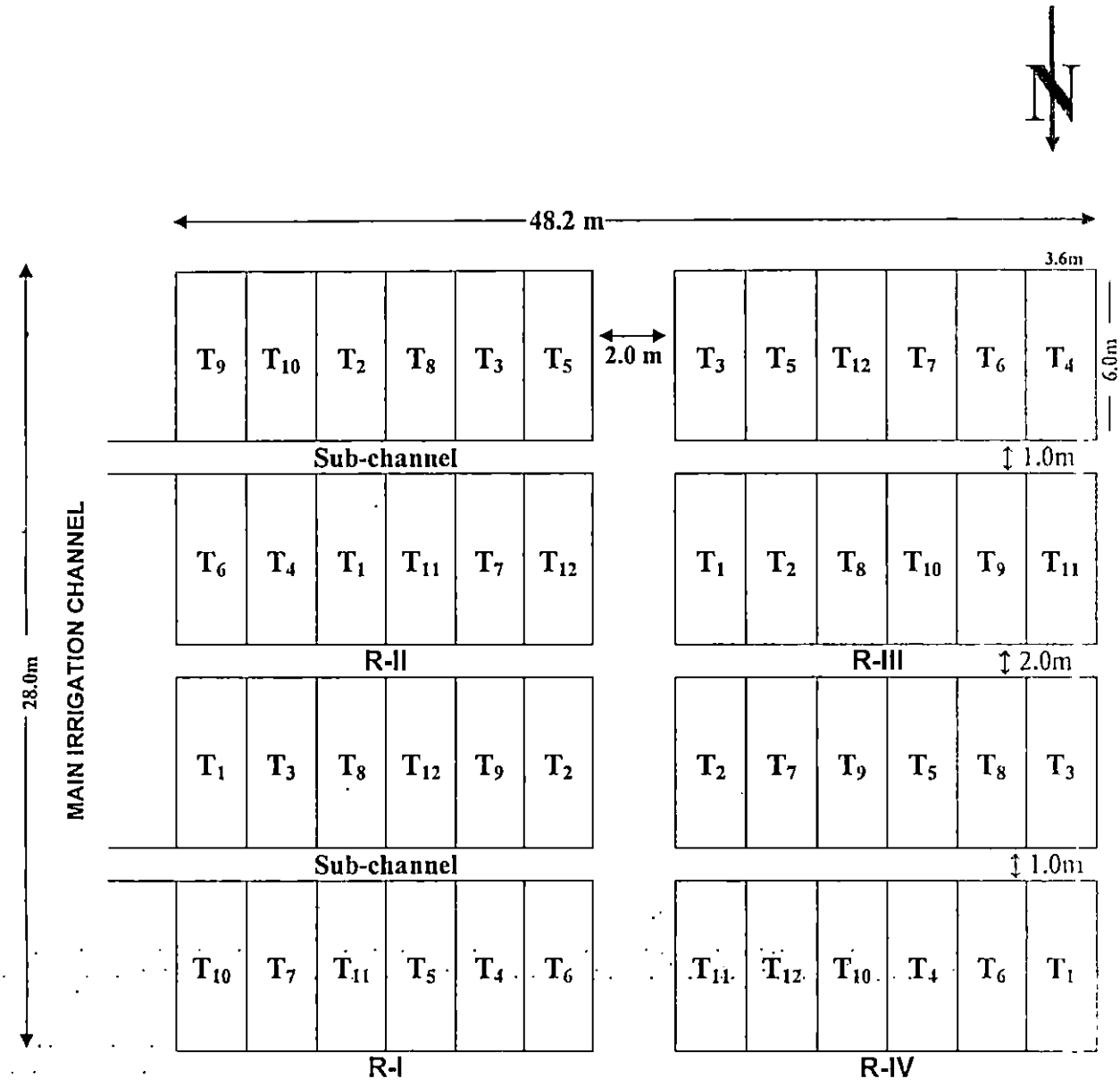

Fig. 2 : Layout plan of field experiment

Table 5 : Crops, varieties and their important characteristics

Sr. No.	Crop	Variety	Characters
1.	**Sorghum**	**GFS-4**	Pedigree – by hybridization (GJ-37 x Sudan type); plant height 175-195 cm; days to flowering 40-45 days; crude protein 6.5 to 9.0 per cent.
2.	**Pearlmillet**	**AFB-2**	It has been identified as promising based on its superior performance at many locations in the country particularly in Gujarat and Rajasthan. It has very good regeneration ability and can be harvested many times.
3.	**Cowpea**	**EC-4216**	It is one of the most promising varieties of fodder cowpea. It is mid duration variety. It is suitable for intercropping with various cereal forage.
4.	**Clusterbean**	**BG-1**	Indeterminate growth habit, seed is whitish grey seed (light colour category) germination energy higher in seed. It is most promising variety for forage clusterbean.

Table 6 : Calendar of cultural operations

Sr. No.	Particulars	Date
[1]	**Pre-sowing operations**	
	i. Cultivation with tractor	22.6.05
	ii. Harrowing and planking	23.6.05
	iii. Field lay out and preparation of plots, bunds and channels	24.6.05
	iv. Opening of furrow	4.7.05
[2]	**Fertilizer application**	
	[A] Main crops – Sorghum, Pearlmillet	
	i. Basal application	4.7.05
	ii. Top dressing	4.8.05
	iii. Top dressing	4.9.05
	[B] Inter crops – Cowpea, Clusterbean	
	i. Basal application	4.7.05
[3]	**Sowing**	
	i. Cereal crops : sorghum, pearlmillet	4.7.05
	ii. Legume crops : cowpea, clusterbean	4.7.05
[4]	**Post-sowing operations**	
	i. Interculturing	
	First	20.7.05
	Second	13.8.05
	ii. Hand weeding	21.7.05
	iii. **Irrigation** :	
	First	11.7.05
	Second	20.8.05
	Third	4.9.05
[5]	**Harvesting**	
	i. Main crops : sorghum, pearlmillet (1^{st} cut)	28.8.05
	(2^{nd} cut)	30.9.05
	ii. Intercrops : cowpea, clusterbean (Single cut)	28.8.05

3.7.2 Application of fertilizers

The crops were fertilized with nitrogen and phosphorus in the forms of urea and single super phosphate. The recommended doses of fertilizers are given in Table 7. The entire quantity of phosphorus was applied as basal in case of sorghum, pearlmillet, cowpea and clusterbean. The entire quantity of nitrogen was applied as basal in inter crops and in case of main crop : sorghum 25 kg ha^{-1} nitrogen was applied as basal and 50 kg ha^{-1} nitrogen was applied in equal two splits as top dressing 30 days after sowing and after first cutting. In case of pearlmillet nitrogen was applied @ 25 kg ha^{-1} as basal, 25 kg ha^{-1} as top dressing 30 days after sowing and 50 kg ha^{-1} after first cut.

Table 7 : Recommended doses of fertilizers for different crops

Sr. No.	Crop	(kg.ha^{-1})			
		N		P_2O_5 (as basal)	K_2O
		Basal	Top dressing		
1.	Sorghum	25	25 25	40	-
2.	Pearlmillet	25	25 50	40	-
3.	Cowpea	20	-	40	-
4.	Clusterbean	20	-	40	-

3.7.3 Seeds and sowing

The seed rates of 60, 12, 40 and 40 kg per hectare were kept for sorghum, pearlmillet, cowpea and clusterbean, respectively. The healthy seeds of these crops were selected and used for sowing purpose. The seeds were sown on 4th July by hand in previously fertilized furrow in each plot to a depth

of 3-4 cm for sorghum and pearlmillet. For cowpea and clusterbean, the depth of 5-6 cm was kept.

3.7.4 Interculturing and weeding

For the control of weeds and proper aeration two interculturing and one hand weeding were carried out.

3.7.5 Irrigation

The irrigation was applied only when the crops attained stress conditions due to prolonged dry spell. The crops were irrigated with three life saving irrigations.

3.7.6 Harvesting

The experimental crops were raised for the purpose of fodder production. So that two cuttings were taken in forage cereal crops *viz.*, sorghum and pearlmillet. The first cut was taken at 53 DAS and the second cut was taken at 33 days after first cut. Only one cut was taken at 53 DAS from forage legume crops *viz.*, cowpea and clusterbean. Normally, the plants were cut leaving stubble height about 5 cm from ground level. The green forage harvested from each net plot was weighed and recorded plot-wise yield.

3.8 BIOMETRIC OBSERVATIONS

The details of the techniques employed for recording observations for various growth and yield attributing characters during the course of investigation which are listed in Table 8. The details regarding the biometric observations are given as under.

Table 8 : Biometric observations

Sr. No.	Parameters	Sample size	Time of recording
[A]	**BASE CROPS : Sorghum and Pearlmillet**		
1.	Final plant population	One metre row length of three rows in net plot	At harvest
2.	Plant height (cm)	Five plants per net plot	At harvest
3.	Number of tillers per plant	Five plants per net plot	At harvest
4.	Leaf : Stem ratio	Five plants per net plot	At harvest
5.	Green forage yield	Net plot	At harvest
6.	Dry matter yield	Net plot	After harvest
[B]	**INTER CROPS : Cowpea and Clusterbean**		
1.	Final plant population	One metre row length of three rows in net plot	At harvest
2.	Plant height (cm)	Five plants per net plot	At harvest
3.	Number of branches per plant	Five plants per net plot	At harvest
4.	Leaf : Stem ratio	Five plants per net plot	At harvest
5.	Green forage yield	Net plot	At harvest
6.	Dry matter yield	Net plot	After harvest

3.8.1 Growth characters of cereal crops

[1] Final plant population

Final plant population was recorded at harvest of both the crops. This was done by the number of plants per metre row length counted from three randomly spots in each net plot and the average was worked out. Plant population was converted in to hectare basis.

[2] Plant height (cm)

The plant height was measured from base of the plant to the tip of the plant at each cut. The average of five plants from each net plot of both the crops *viz.,* sorghum and pearlmillet were considered as average plant height.

[3] Number of tillers per plant

Number of tillers per plant was counted from five randomly selected plant in each net plot. The average of five plants each of sorghum and pearlmillet was considered as average number of tillers per plant.

[4] Leaf : stem ratio

A sample of five fresh plants was taken from each treatments and all leafy portion of the plants was stripped off from the plant. The leaf portion and stem portion were weighed in gram and the ratio of leaf to stem was worked out based on leafy weight to stem weight of sample at each cut of both the crops.

3.8.2 Yield

[1] Green forage yield

The plants from ring area of each plot were harvested first separately and collected. Then, the plants from the net plot were cut leaving stubble height

about 5 cm from ground level and the fresh weight (kg) was recorded for each treatment separately and converted in to quintal per hectare at each cut.

[2] Dry matter yield

The green plant sample from each net plot was randomly collected for each treatment and weighed the samples of 500 g. Thereafter, samples were cut in to small pieces, first samples were sun-dried and then oven dried at 70°C to attain a constant weight. The dry matter yield in quintal per hectare was calculated on the basis of dry weight of the samples for each treatment at each cut.

3.8.3 Growth characters of legume crops

[1] Final plant population

The plant population was recorded at harvest of both the crops. This was done by the number of plants per metre row length counted from three randomly spots in each net plot and the average was worked out. Plant population was converted into hectare basis.

[2] Plant height (cm)

The plant height was measured from base of the plant to the tip of the plant at harvest. The average of five plants from each net plot of both the crops *viz.,* cowpea and clusterbean were considered as average plant height.

[3] Number of branches per plant

The numbers of branches arising from the main shoot of randomly selected five plants were counted and then mean value was worked out for each intercrop.

[4] Leaf : stem ratio

A sample of five fresh plants was taken from each treatment and all leafy portions of the plants were stripped off from the plant. The leaf portion and stem portion were weighed in gram and the ratio of leaf to stem was worked out based on leafy weight to stem weight of sample at harvest of the crops *viz.*, cowpea and clusterbean.

3.8.4 Yield

[1] Green forage yield

The plants from the ring area of each plot harvested first separately and collected. Then, the plants from the net plot were cut leaving height about 5 cm from ground level and the fresh weight (kg) was recorded for each treatment separately and converted in to quintal per hectare at harvest.

[2] Dry matter yield

The green plant sample from each net plot was randomly collected for each treatment and weighed the sample of 500 g. There after, samples were cut in to small pieces, first samples were sun dried and then oven dried at 70°C to attain a constant weight. The dry matter yield in quintal per hectare was calculated on the basis of dry weight of the sample for each treatment.

3.9 BIOCHEMICAL STUDIES

3.9.1 Crude protein content

The quality of the forage is judged by its protein content. The oven dried plant samples first grind with the help of mechanical grinder and powdered samples were taken from each cut for determination of crude protein content in

forage. Nitrogen percentage was estimated by using modified Kjeldhal's method (Jackson, 1973). Nitrogen per cent was multiplied by factor 6.25 (Dubetz and Wells, 1968) to obtain the protein content and was expressed as percentage on dry weight basis.

3.9.2 Crude fibre content

Crude fibre content of the plant sample was estimated by using modified method described by Singh and Pradhan (1981) at each cut and expressed as percentage on dry weight basis.

$$\text{Crude fibre (\%)} = \frac{\text{(Weight of silica crucible with oven dry residue)} - \text{(Weight of silica crucible with Ash)}}{\text{Weight of sample taken}} \times 100$$

3.10 ECONOMICS

3.10.1 Crop equivalent yield

Pearlmillet green forage equivalent yield is worked out with the help of following formula.

$$\text{Pearlmillet green forage equivalent yield} = \frac{\text{Price of forage of intercrop (Rs.kg}^{-1}\text{)}}{\text{Price of forage of main crop (Rs. kg}^{-1}\text{)}} \times \text{Forage yield of intercrop (kg ha}^{-1}\text{)} + \text{Yield of main crop (kg ha}^{-1}\text{)}$$

3.10.2 Gross and Net realization

In order to evaluate the effectiveness of individual treatment the relative economics of each treatment was worked out in term of profit so that the most effective and remunerative treatment could be identified.

The gross realization in terms of rupees per hectare was worked out based on forage yield of sorghum, pearlmillet, cowpea and clusterbean for each

treatment and prevailing market price. The total cost of cultivation of the forage crop for each treatment was worked out by considering the expenses incurred for all cultural and mechanical operations as well as cost of various inputs. The net realization was worked out by deducting the cost of cultivation from the gross realization for the respective treatments.

3.10.3 Benefit : cost ratio

The Benefit : Cost Ratio (BCR) was calculated as the ratio of net realization to total cost of cultivation by using following formula.

$$BCR = \frac{\text{Net realization (Rs.)}}{\text{Total cost of cultivation (Rs.)}}$$

3.10.4 Land Equivalent Ratio (LER)

Land Equivalent Ratio (LER) denotes the relative land area under sole crop required to produce the same yield as obtained under intercropping or mixed cropping system at the same management level. It is calculated as sum total of the ratio of yield of each component crop in an intercropping or a mixed cropping system to its corresponding yields when grown as a sole crop.

Thus,

$$\text{Land Equivalent Ratio} = \frac{\text{Yield of main crop in intercropping (q ha}^{-1}\text{)}}{\text{Yield of main crop in sole cropping (q ha}^{-1}\text{)}} + \frac{\text{Yield of associate crop in intercropping (q ha}^{-1}\text{)}}{\text{Yield of associate crop in sole cropping (q ha}^{-1}\text{)}}$$

3.11 STATISTICAL ANALYSIS

The data collected on various characters studied in present investigation were statistically analysed with the help of computer by using appropriate

programme for the design of experiment as suggested by Panse and Sukhatme (1967).

To test significance of result five per cent level of significance was used. The critical differences were calculated when differences were found significant by the 'F' test. The c.v. per cent was also worked out for the same.

EXPERIMENTAL RESULTS

IV EXPERIMENTAL RESULTS

Results of the present investigation entitled "Forage production potential under cereals with legumes intercropping systems" conducted during *kharif* season of 2005 at Agronomy Instructional farm, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar are presented in this chapter. The results pertaining to the growth parameters, yield and quality characters were subjected to statistical analysis in order to test of significance of the results. The analysis of variance for treatment evaluation has been given in the Appendices.

4.1 GROWTH PARAMETERS

4.1.1 Final plant population

The data regarding the effect of cereals with legumes intercropping systems on final plant population of the cereals *viz.*, sorghum and pearlmillet and legumes *viz.*, cowpea and clusterbean recorded during both the cuts of cereals and a single cut of legume crops are presented in Table 9.

It was observed from the data that satisfactory plant population of sole crops as well as intercropping systems was maintained in both the row ratios.

4.1.2 Plant height (cm)

The data regarding the effect of cereals with legumes intercropping systems on plant height recorded at both the cuts of cereals and a single cut of legume crops are presented in Table 10 and graphically illustrated in Fig. 3 and their analysis of variance are presented in Appendix-I.

Table 9. Effect of cereals with legumes intercropping systems on final plant population ha^{-1}

Treat. No.	Treatments	Main crops		Intercrops
		Sorghum and Pearlmillet		Cowpea and Clusterbean
		I cut	II cut	Single cut
T_1	Sole sorghum	666667	551667	-
T_2	Sole pearlmillet	511000	436000	-
T_3	Sole cowpea	-	-	375000
T_4	Sole clusterbean	-	-	416667
T_5	Sorghum + Cowpea (1:1)	335833	285500	184167
T_6	Sorghum + Cowpea (2:1)	407137	346166	123530
T_7	Sorghum + Clusterbean (1:1)	328833	266667	210833
T_8	Sorghum + Clusterbean (2:1)	407583	352420	134750
T_9	Pearlmillet + Cowpea (1:1)	241333	203833	184166
T_{10}	Pearlmillet + Cowpea (2:1)	322717	261970	120780
T_{11}	Pearlmillet + Clusterbean (1:1)	250000	220833	258000
T_{12}	Pearlmillet + Clusterbean (2:1)	322717	291450	154500

Table 10. Effect of cereals with legumes intercropping systems on plant height (cm)

Treat. No.	Treatments	Main crops			Intercrops
		Sorghum and Pearlmillet			Cowpea and Clusterbean
		I cut	II cut	Mean	Single cut
T_1	Sole sorghum	105.71	83.55	94.63	-
T_2	Sole pearlmillet	121.63	107.60	114.61	-
T_3	Sole cowpea	-	-	-	84.55
T_4	Sole clusterbean	-	-	-	75.65
T_5	Sorghum + Cowpea (1:1)	113.45	84.80	99.12	84.90
T_6	Sorghum + Cowpea (2:1)	112.35	86.80	99.17	86.63
T_7	Sorghum + Clusterbean (1:1)	107.15	87.60	97.37	86.55
T_8	Sorghum + Clusterbean (2:1)	108.45	88.60	98.52	86.60
T_9	Pearlmillet + Cowpea (1:1)	127.35	109.38	118.36	86.70
T_{10}	Pearlmillet + Cowpea (2:1)	123.55	109.60	116.57	85.90
T_{11}	Pearlmillet + Clusterbean (1:1)	124.85	110.35	117.60	80.67
T_{12}	Pearlmillet + Clusterbean (2:1)	128.06	112.35	120.20	87.35
S.Em.±		6.03	8.82	5.91	6.63
C.D. at 5 %		NS	NS	17.61	NS
C.V. %		10.28	18.0	11.0	15.68

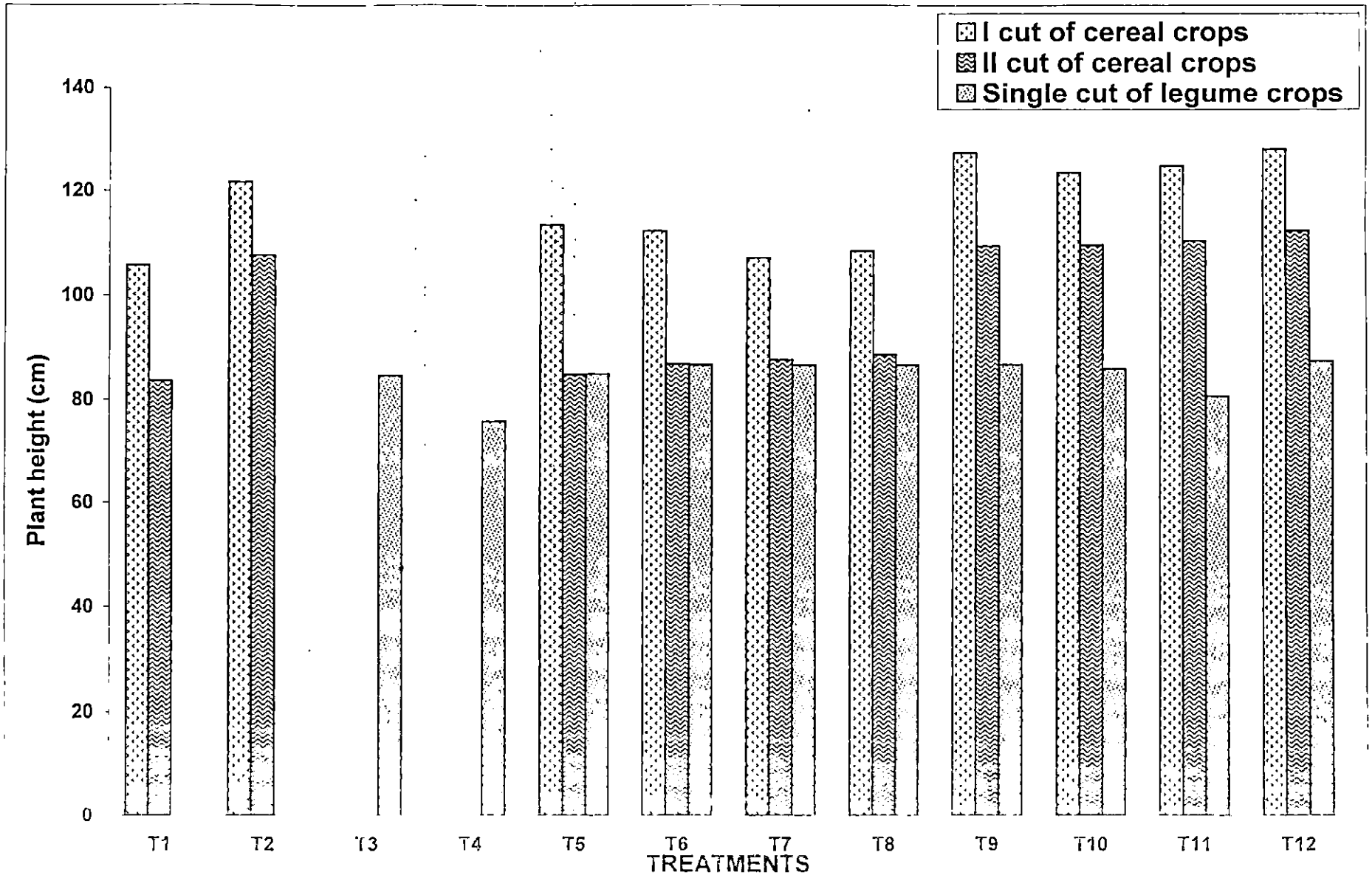

Fig. 3 : Effect of cereals with legumes intercropping systems on plant height (cm)

The plant height of sorghum and pearlmillet were not significantly influenced with different intercropping systems during 1st cut and 2nd cut. However, intercropping of pearlmillet and clusterbean in 2:1 row ratio (T_{12}) recorded taller plant of pearlmillet (128.06 cm) during 1st cut followed by treatment T_9. In this treatment, the plant height of pearlmillet was 127.35 cm. The same treatment T_{12} also recorded taller plant of pearlmillet (112.35 cm) during 2nd cut.

The mean plant height of pearlmillet observed significantly higher in treatment T_{12} (Pearlmillet + Clusterbean 2:1 row ratio) than observed in T_1, T_5, T_6, $T_7$and T_8 but was remained at par with T_9. T_{11}, T_{10} and T_2.

The plant height of intercrops was increased when they were intercropped in pearlmillet and sorghum in both row ratios. However, treatments had no significant effect on plant height of cowpea and clusterbean.

4.1.3 Number of tillers per plant/Number of branches per plant

The data regarding the effect of cereals with legumes intercropping systems on number of tillers per plant recorded during both the cuts of cereal and number of branches per plant of legume crops recorded during a single cut are presented in Table 11 and their analysis of variance are presented in Appendix-I.

The results revealed that treatment T_2 (Sole pearlmillet) recorded significantly higher tillers of pearlmillet (5.35) than that recorded in rest of the treatments except treatments T_{12}, T_9 and T_{11}. Whereas, treatment T_5 (Sorghum + Cowpea 1:1 row ratio) and T_8 (Sorghum + Clusterbean 2:1

Table 11. Effect of cereals with legumes intercropping systems on number of tillers per plant of main crops and number of branches per plant of intercrops

Treat. No.	Treatments	Main crops			Intercrops
		Number of tillers per plant of Sorghum and Pearlmillet			Number of branches per plant of Cowpea and Clusterbean
		I cut	II cut	Mean	Single cut
T_1	Sole sorghum	1.88	1.93	1.89	-
T_2	Sole pearlmillet	5.35	7.40	6.37	-
T_3	Sole cowpea	-	-	-	4.90
T_4	Sole clusterbean	-	-	-	5.45
T_5	Sorghum + Cowpea (1:1)	1.40	2.20	1.80	4.65
T_6	Sorghum + Cowpea (2:1)	1.60	2.20	1.90	4.80
T_7	Sorghum + Clusterbean (1:1)	1.68	2.05	1.86	5.05
T_8	Sorghum + Clusterbean (2:1)	1.40	1.95	1.67	5.35
T_9	Pearlmillet + Cowpea (1:1)	5.23	7.60	6.41	4.80
T_{10}	Pearlmillet + Cowpea (2:1)	4.50	7.60	6.13	4.85
T_{11}	Pearlmillet + Clusterbean (1:1)	5.03	7.40	6.21	5.05
T_{12}	Pearlmillet + Clusterbean (2:1)	5.30	7.95	6.61	5.35
	S.Em±	0.21	0.32	0.15	0.30
	C.D. at 5 %	0.60	0.93	0.45	NS
	C.V. %	12.48	13.28	7.75	11.95

row ratio) produced significantly lower tillers of sorghum (1.40) during 1st cut which were at par with treatments T_6, T_7 and T_1. During 2nd cut, treatment T_{12} (Pearlmillet + Clusterbean 2:1 row ratio) recorded significantly higher tillers of pearlmillet (7.95) but it was at par with treatments T_9, T_{10}, T_{11} and T_2. Whereas, treatment T_1 recorded significantly the lowest tillers of sorghum (1.93) during 2nd cut. It was at par with treatments T_8, T_7, T_6 and T_5.

The mean number of tillers per plant of pearlmillet observed significantly higher in same treatment T_{12} than that recorded in rest of the treatments except T_9, T_2 and T_{11}. The lowest number of tillers per plant of sorghum was recorded in treatment T_8 (Sorghum + Clusterbean 2:1 row ratio) but was not statistically differed with the treatments T_5, T_7, T_1 and T_6.

The number of branches of cowpea and clusterbean were observed not-significant, eventhough, treatment T_4 (sole clusterbean) recorded the higher number of branches of clusterbean (5.45).

4.1.4 Leaf : stem ratio

The data regarding the effect of cereals with legumes intercropping systems on leaf : stem ratio recorded at both the cuts of cereal and a single cut of legume crops are presented in Table 12 and their analysis of variance are presented in Appendix-I.

The leaf : stem ratio of sorghum and pearlmillet were not significantly influenced with different intercropping systems during 1st, 2nd cut and on mean basis. However, intercropping of pearlmillet and cowpea in 2:1 row ratio (T_{10})

Table 12. Effect of cereals with legumes intercropping systems on leaf : stem ratio

Treat. No.	Treatments	Main crops			Intercrops
		Sorghum and Pearlmillet			Cowpea and Clusterbean
		I cut	II cut	Mean	Single cut
T_1	Sole sorghum	0.53	0.51	0.52	-
T_2	Sole pearlmillet	0.65	0.57	0.61	-
T_3	Sole cowpea	-	-	-	0.55
T_4	Sole clusterbean	-	-	-	0.53
T_5	Sorghum + Cowpea (1:1)	0.58	0.52	0.55	0.65
T_6	Sorghum + Cowpea (2:1)	0.54	0.54	0.54	0.57
T_7	Sorghum + Clusterbean (1:1)	0.56	0.57	0.56	0.63
T_8	Sorghum + Clusterbean (2:1)	0.55	0.54	0.54	0.59
T_9	Pearlmillet + Cowpea (1:1)	0.65	0.61	0.63	0.58
T_{10}	Pearlmillet + Cowpea (2:1)	0.69	0.62	0.65	0.57
T_{11}	Pearlmillet + Clusterbean (1:1)	0.66	0.60	0.63	0.58
T_{12}	Pearlmillet + Clusterbean (2:1)	0.68	0.61	0.65	0.57
	S.Em.±	0.04	0.02	0.03	0.03
	C.D. at 5 %	NS	NS	NS	NS
	C.V. %	13.95	10.10	12.66	10.32

recorded higher leaf : stem ratio followed by intercropping of pearlmillet and clusterbean in 2:1 row ratio (T_{12}).

The leaf : stem ratio of cowpea and clusterbean were increased when they were intercropped in pearlmillet and sorghum in both row ratios. However, treatments had no significant effect on the same.

4.2 YIELDS

4.2.1 Green forage yield

The data regarding the effect of cereals with legumes intercropping systems on green forage yield recorded at both the cuts of cereal and a single cut of legume crops as well as total of all cuts are presented in Table 13 and graphically illustrated in Fig. 4. The analysis of variance are presented in Appendices II and III.

The results revealed that the green forage yield of sole pearlmillet (T_2) recorded significantly higher green forage yield of pearlmillet than that recorded in rest of the treatments except treatment T_{12} (Pearlmillet + Clusterbean 2:1 row ratio) during 1st, 2nd cut and total of two cuts of cereal crops. Intercropping of sorghum and cowpea in 1:1 row ratio produced significantly the lowest green forage yield of sorghum (94.44 q ha^{-1}) during 1st cut of cereal crops. However, it was at par with treatments T_7, T_8, T_1, T_6 and T_{10}.

Treatment T_7 (Sorghum + Clusterbean 1:1 row ratio) produced significantly lower green forage yield of sorghum during 2nd cut and total of two cuts of cereal crops. However, it was at par with treatments T_1, T_8, T_5

Table 13. Effect of cereals with legumes intercropping systems on green forage yield (q ha^{-1})

Treat. No.	Treatments	Main crops			Intercrops	Total GFY
		Sorghum and Pearlmillet			Cowpea and Cluster-bean	
		I cut	II cut	Total of two cuts	Single cut	
T_1	Sole sorghum	100.55	82.36	182.91	-	182.91
T_2	Sole pearlmillet	236.61	244.52	481.13	-	481.13
T_3	Sole cowpea	-	-	-	209.69	209.69
T_4	Sole clusterbean	-	-	-	173.61	173.61
T_5	Sorghum + Cowpea (1:1)	94.44	88.88	183.32	194.44	377.76
T_6	Sorghum + Cowpea (2:1)	111.73	91.24	202.97	136.66	339.63
T_7	Sorghum + Clusterbean (1:1)	96.69	82.39	179.08	112.49	291.57
T_8	Sorghum + Clusterbean (2:1)	97.20	84.72	181.92	77.78	259.70
T_9	Pearlmillet + Cowpea (1:1)	180.93	170.83	351.76	141.06	492.83
T_{10}	Pearlmillet + Cowpea (2:1)	113.65	131.94	245.58	121.09	366.68
T_{11}	Pearlmillet + Clusterbean (1:1)	165.32	154.86	320.18	93.05	413.22
T_{12}	Pearlmillet + Clusterbean (2:1)	230.55	223.53	454.07	95.99	550.07
	S.Em±	9.79	10.81	16.40	9.73	18.08
	C.D. at 5 %	28.40	31.36	47.60	28.24	52.03
	C.V. %	13.71	15.95	11.79	14.36	10.48

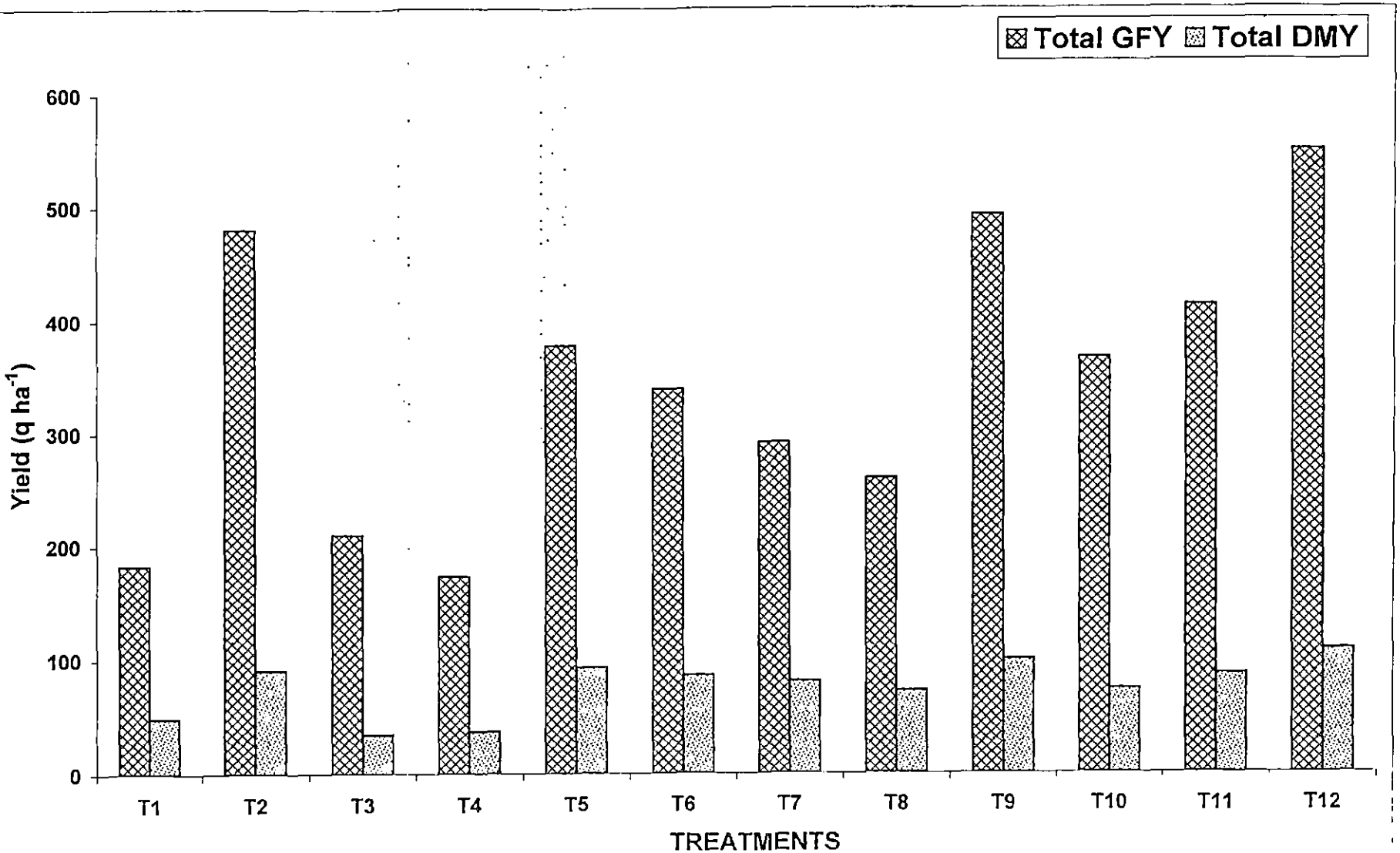

Fig. 4 : Effect of cereals with legumes intercropping systems on green forage and dry matter yield (q ha^{-1})

and T_6. In a single cut of legume crops significantly higher green forage yield was obtained by treatment T_3 (Sole cowpea) but it was at par with treatment T_5 (Sorghum + Cowpea 1:1 row ratio). Whereas, treatment T_8 (Sorghum + Clusterbean 2:1 row ratio) produced significantly lower green forage yield of clusterbean (77.78 q ha^{-1}). However, it was at par with treatments T_{11} and T_{12}.

In total forage yield of cereal crops (two cuts) and legume crops (single cut), treatment T_{12} (Pearlmillet + Clusterbean 2:1 row ratio) produced significantly higher green forage yield (550.07 q ha^{-1}). Whereas, treatment T_4 (Sole clusterbean) produced significantly lower green forage yield (173.61 q ha^{-1}). However, it was at par with treatments T_1 and T_3.

4.2.2 Dry matter yield

The data regarding the effect of cereals with legumes intercropping systems on dry matter yield recorded at both the cuts of cereal and a single cut of legume crops as well as total of all cuts are presented in Table 14 and graphically depicted in Fig. 4. The analysis of variance is presented in Appendices II and III.

The results revealed that the dry matter yield of sole pearlmillet recorded significantly higher dry matter yield (44.49 q ha^{-1}) than that recorded in rest of the treatments except intercrop of T_{12} (Pearlmillet + Clusterbean 2:1 row ratio), T_9 (Pearlmillet + Cowpea 1:1 row ratio) and T_{11} (Pearlmillet + clusterbean 1:1 row ratio). Treatment T_{10} (Pearlmillet + Cowpea 2:1 row ratio) produced significantly the lowest dry matter yield of pearlmillet (23.28 q ha^{-1}) during

Table 14. Effect of cereals with legumes intercropping systems on dry matter yield (q ha^{-1})

Treat. No.	Treatments	Main crops			Intercrops	Total DMY
		Sorghum and Pearlmillet			Cowpea and Cluster-bean	
		I cut	II cut	Total of two cuts	Single cut	
T_1	Sole sorghum	26.92	22.56	49.47	-	49.48
T_2	Sole pearlmillet	44.49	46.05	90.53	-	90.54
T_3	Sole cowpea	-	-	-	35.36	35.36
T_4	Sole clusterbean	-	-	-	38.08	38.08
T_5	Sorghum + Cowpea (1:1)	30.77	28.75	59.51	33.22	92.74
T_6	Sorghum + Cowpea (2:1)	35.27	28.52	63.79	22.61	86.40
T_7	Sorghum + Clusterbean (1:1)	28.17	25.88	54.05	27.13	81.19
T_8	Sorghum + Clusterbean (2:1)	29.44	24.52	53.96	18.13	72.09
T_9	Pearlmillet + Cowpea (1:1)	37.93	37.74	75.67	23.88	99.55
T_{10}	Pearlmillet + Cowpea (2:1)	23.28	26.97	50.24	23.39	73.63
T_{11}	Pearlmillet + Clusterbean (1:1)	37.48	27.19	64.66	22.44	87.10
T_{12}	Pearlmillet + Clusterbean (2:1)	43.58	42.11	85.68	22.49	108.13
	S.Em.±	2.68	2.74	4.17	2.16	3.87
	C.D. at 5 %	7.78	7.95	12.11	6.29	11.13
	C.V. %	15.90	17.66	12.89	16.25	10.16

1st cut of cereal crops. However, it was at par with treatments T_1, T_7, T_8, T_5 and T_6.

During 2nd cut of cereal crops, sole pearlmillet produced significantly higher dry matter yield (46.05 q ha^{-1}) except treatment T_{12} (Pearlmillet + Clusterbean 2:1 row ratio). Whereas, treatment T_1 (Sole sorghum) produced significantly lower dry matter yield (22.56 q ha^{-1}) during 2nd cut. However, it was at par with treatments T_8, T_7, T_{10}, T_{11}, T_6 and T_5. In total of two cuts of sorghum and pearlmillet, sole pearlmillet (T_2) produced significantly higher dry matter yield of pearlmillet but was not statistically differed with the treatment T_{12} (Pearlmillet + Clusterbean 2:1 row ratio). Significantly, the lowest dry matter yield of two cuts of sorghum was recorded by treatment T_1 (Sole sorghum). It was at par with treatments T_{10}, T_8, T_7 and T_5.

In a single cut of legume crops, significantly the highest dry matter yield was obtained by treatment T_4 (Sole clusterbean) but it was at par with treatments T_3 and T_5. Whereas, treatment T_8 (Sorghum + Clusterbean 2:1 row ratio) produced significantly lower dry matter yield of clusterbean (18.13 q ha^{-1}). However, it was at par with T_{11}, T_{12}, T_6, T_{10} and T_9.

In total dry matter yield of cereal crops (two cuts) and legume crops (single cut), treatment T_{12} (Pearlmillet + Clusterbean 2:1 row ratio) produced significantly higher dry mater yield (108.18 q ha^{-1}) but it was at par with treatment T_9 (Pearlmillet + cowpea 1:1 row ratio) whereas, treatment T_3 (Sole cowpea) produced significantly lower dry matter yield (35.36 q ha^{-1}). However, it was at par with treatment T_4.

4.3 BIOCHEMICAL STUDIES

4.3.1 Crude protein content

The data related to cut wise and mean crude protein content (%) as affected by cereals with legumes intercropping systems are given in Table 15 and the analysis of variance are presented in Appendices II and III.

The results revealed that treatment T_2 (Sole pearlmillet) recorded significantly higher crude protein (8.45 %), however, it was at par with intercrops of cowpea and clusterbean in pearlmillet at both row ratios during 1st cut of cereal crops. Whereas, treatment T_1 (Sole sorghum) and T_6 (Sorghum + Cowpea 2:1 row ratio) were recorded significantly lower crude protein (7.38 %), however, they were at par with treatments T_8, T_5 and T_7.

During 2nd cut, treatment T_{12} (Pearlmillet + Clusterbean 2:1 row ratio) recorded significantly the highest crude protein (8.80 %) of pearlmillet, however, it was at par with crude protein content of T_9, T_{11}, T_{10} and T_2. Whereas, treatment T_1 (Sole sorghum) and T_5 (Sorghum + Cowpea 1:1 row ratio) recorded significantly lower crude protein of sorghum (7.0 %) during 2nd cut. However, they were at par with treatments T_6 and T_7. In a single cut of legume crops treatment T_4 (Sole clusterbean) recorded significantly the highest crude protein (18.60 %) but it was at par with treatments T_{12}, T_7, T_8 and T_{11}. Whereas, treatment T_9 (Pearlmillet + Cowpea 1:1 row ratio) recorded significantly lower crude protein of cowpea (16.10 %). However, it was at par with treatments T_{10}, T_3, T_6 and T_5.

Table 15. Effect of cereals with legumes intercropping systems on crude protein content (%)

Treat. No.	Treatments	Main crops		Intercrops	Mean
		Sorghum and Pearlmillet		Cowpea and Clusterbean	
		I cut	II cut	Single cut	
T_1	Sole sorghum	7.38	7.00	-	7.19
T_2	Sole pearlmillet	8.45	8.10	-	8.28
T_3	Sole cowpea	-	-	16.38	16.38
T_4	Sole clusterbean	-	-	18.60	18.60
T_5	Sorghum + Cowpea (1:1)	7.55	7.00	16.80	12.04
T_6	Sorghum + Cowpea (2:1)	7.38	7.60	16.65	12.07
T_7	Sorghum + Clusterbean (1:1)	7.80	7.60	18.25	12.98
T_8	Sorghum + Clusterbean (2:1)	7.50	7.80	18.23	12.94
T_9	Pearlmillet + Cowpea (1:1)	8.10	8.60	16.10	12.23
T_{10}	Pearlmillet + Cowpea (2:1)	8.35	8.20	16.38	12.31
T_{11}	Pearlmillet + Clusterbean (1:1)	8.40	8.60	18.20	13.35
T_{12}	Pearlmillet + Clusterbean (2:1)	8.35	8.80	18.35	13.46
	S.Em.±	0.22	0.25	0.36	0.34
	C.D. at 5 %	0.63	0.73	1.04	0.99
	C.V. %	5.44	6.35	4.11	3.07

In mean of crude protein content of both the cuts of cereal crops and a single cut of legume crops, significantly the highest crude protein content was recorded by treatment T_4 (Sole clusterbean) than that recorded in rest of the treatments. Whereas, treatment T_1 (Sole sorghum) recorded significantly the lowest crude protein (7.19 %).

4.3.2 Crude fibre content

The data related to cutwise and mean crude fibre content (%) as affected by cereals with legumes intercropping systems are given in Table 16 and the analysis of variance are presented in Appendices II and III.

The results revealed that treatments T_1, T_7, T_8, T_5 and T_6 being at par, significantly recorded more crude fibre content than that recorded in rest of the treatment during 1st cut of sorghum.

During 2nd cut, treatment T_1 (Sole sorghum) recorded significantly higher crude fibre content of sorghum (35.40 %). It was at par with treatment T_7. In a single cut of legume crops, treatment T_6 (Sorghum + Cowpea 2:1 row ratio) recorded significantly higher crude fibre content (33.75 %) but it was at par with treatments T_{10}, T_3, T_5 and T_9.

In mean of crude fibre content of both the cuts of cereal crops and a single cut of legume crops, significantly higher crude fibre content was recorded by treatment T_1 : sole sorghum (34.61 %) but it was at par with treatments T_6, T_3, T_5, T_{10}, T_7 and T_8.

Table 16. Effect of cereals with legumes intercropping systems on crude fibre content (%)

Treat. No.	Treatments	Main crops		Intercrops	Mean
		Sorghum and Pearlmillet		Cowpea and Clusterbean	
		I cut	II cut	Single cut	
T_1	Sole sorghum	33.83	35.40	-	34.61
T_2	Sole pearlmillet	32.35	33.00	-	32.68
T_3	Sole cowpea	-	-	33.63	33.63
T_4	Sole clusterbean	-	-	31.15	31.15
T_5	Sorghum + Cowpea (1:1)	33.58	33.78	33.50	33.59
T_6	Sorghum + Cowpea (2:1)	33.48	33.85	33.75	33.71
T_7	Sorghum + Clusterbean (1:1)	33.83	34.45	31.70	32.92
T_8	Sorghum + Clusterbean (2:1)	33.83	33.85	31.90	32.87
T_9	Pearlmillet + Cowpea (1:1)	31.60	32.55	33.40	32.74
T_{10}	Pearlmillet + Cowpea (2:1)	32.50	32.85	33.70	33.19
T_{11}	Pearlmillet + Clusterbean (1:1)	32.15	32.85	31.85	32.18
T_{12}	Pearlmillet + Clusterbean (2:1)	32.40	32.60	31.40	31.95
	S.Em.±	0.46	0.42	0.42	0.61
	C.D. at 5 %	1.33	1.23	1.21	1.76
	C.V. %	2.78	2.53	2.55	2.02

4.4 ECONOMICS OF THE TREATMENTS

4.4.1 Pearlmillet green forage equivalent yield

The data regarding the effect of cereals with legumes intercropping systems on pearlmillet green forage equivalent yield is presented in Table 17 and graphically illustrated in Fig. 5 and their analysis of variance are given in Appendix III.

The results revealed that treatment T_{12} (Pearlmillet + Clusterbean 2:1 row ratio) recorded significantly higher pearlmillet green forage equivalent yield (582.06 q ha^{-1}), but it was at par with treatment T_9 (Pearlmillet + Cowpea 1:1 row ratio), whereas, treatment T_1 (Sole sorghum) recorded significantly lower pearlmillet green forage equivalent yield (182.93 q ha^{-1}) and it was at par with treatment T_4 (Sole clusterbean).

Intercropping of pearlmillet and clusterbean in 2:1 row ratio (T_{12}) and intercropping of pearlmillet and cowpea in 1:1 row ratio (T_9) recorded 20.98 and 12.20 per cent higher pearlmillet green forage equivalent yield than that recorded under sole pearlmillet (T_2), respectively.

4.4.2 Gross and net realization

The data regarding the effect of cereals with legumes intercropping systems on gross and net realization in rupees per hectare are presented in Table 17 and also graphically illustrated in Fig. 6. The analysis of variance for the same is given in Appendix III. The cost of different products and inputs taken in to consideration for calculation of economics are given in Appendix IV.

Table 17. Effect of cereals with legumes intercropping systems on pearlmillet green forage equivalent yield, net return, benefit : cost ratio and land equivalent ratio

Treat. No.	Treatments	Pearlmillet green forage equivalent yield (q ha^{-1})	Gross realization (Rs. ha^{-1})	Total cost of cultivation (Rs. ha^{-1})	Net realization (Rs. ha^{-1})	BCR	LER
T_1	Sole sorghum	182.93	13718	8971	4747	0.52	1.00
T_2	Sole pearlmillet	481.12	36084	8288	27796	3.35	1.00
T_3	Sole cowpea	279.62	20969	6910	14058	2.03	1.00
T_4	Sole clusterbean	231.47	17361	6711	10650	1.58	1.00
T_5	Sorghum + Cowpea (1:1)	442.57	33193	8566	24627	2.87	1.92
T_6	Sorghum + Cowpea (2:1)	385.01	28858	8701	20151	2.31	1.75
T_7	Sorghum + Clusterbean (1:1)	329.08	24680	8466	16214	1.91	1.61
T_8	Sorghum + Clusterbean (2:1)	285.62	21422	8634	12788	1.48	1.43
T_9	Pearlmillet + Cowpea (1:1)	539.84	40488	8225	32263	3.92	1.40
T_{10}	Pearlmillet + Cowpea (2:1)	407.04	30528	8246	22282	2.70	1.08
T_{11}	Pearlmillet + Clusterbean (1:1)	443.48	33262	8125	25137	3.09	1.19
T_{12}	Pearlmillet + Clusterbean (2:1)	582.06	43655	8179	35476	4.33	1.49
	S.Em.±	20.98	-	-	983.27	-	0.29
	C.D. at 5 %	60.38	-	-	2829.13	-	0.08
	C.V. %	10.97	-	-	9.58	-	4.38

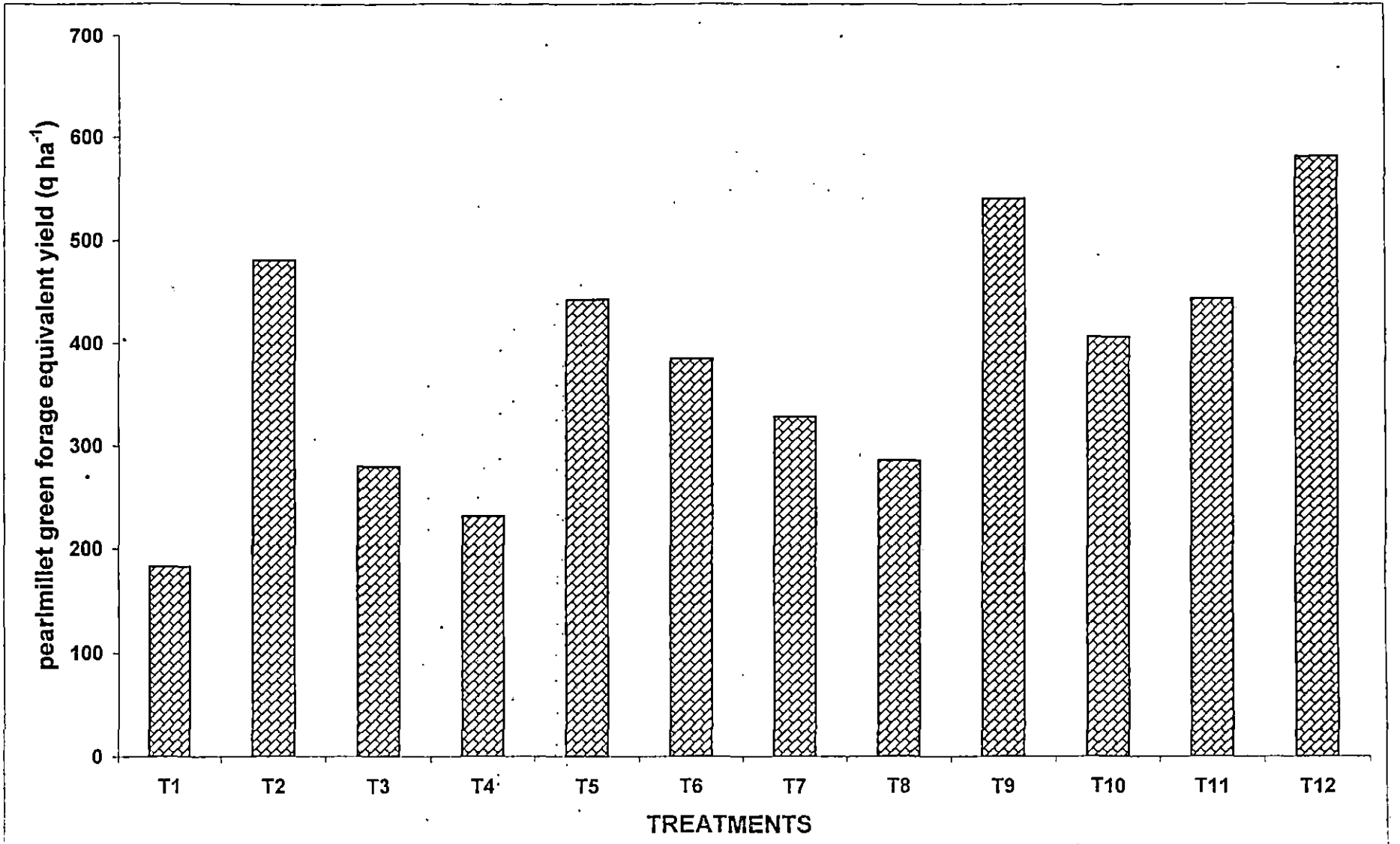

Fig. 5 : Effect of cereals with legumes intercropping systems on pearlmillet green forage equivalent yield (q ha^{-1})

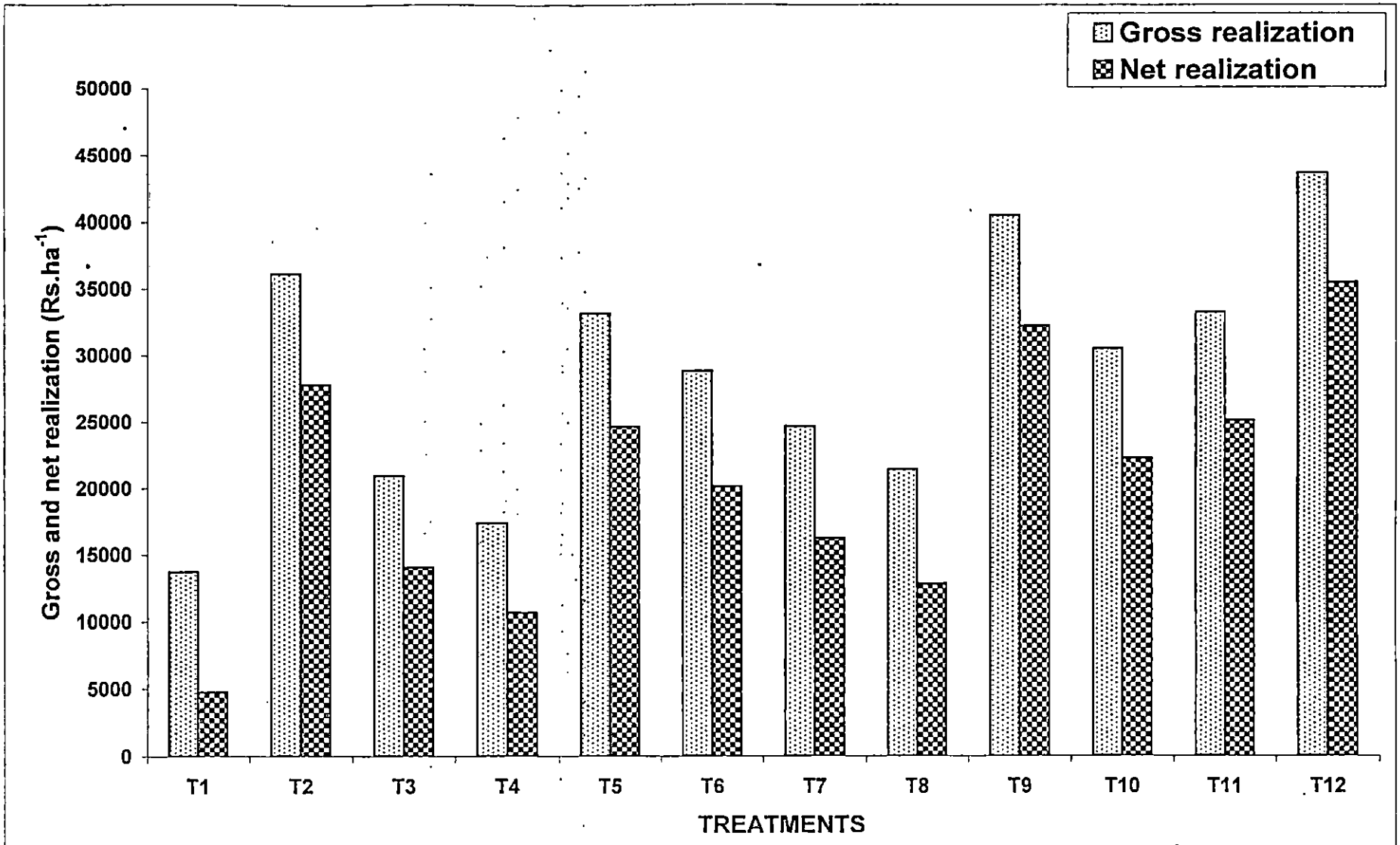

Fig. 6 : Effect of cereals with legumes intercropping systems on gross and net realization ($Rs.ha^{-1}$)

Economical analysis revealed that maximum gross realization of Rs.43,655 ha^{-1} was secured from the intercropping of pearlmillet and clusterbean in 2:1 row ratio and the lowest gross realization (Rs.13718 ha^{-1}) was recorded with sole sorghum (T_1).

Significantly, the highest net return of Rs.35,476 ha^{-1} was obtained by treatment T_{12} (Pearlmillet + clusterbean in 2:1 row ratio) over rest of the treatments. Whereas, sole sorghum (T_1) recorded significantly the lowest net return of Rs.4,747 ha^{-1}.

4.4.3 Benefit : Cost ratio (BCR)

The data regarding the effect of cereals with legumes intercropping systems on benefit : cost ratio are presented in Table 17.

The data indicated that the maximum benefit : cost ratio (4.33) was recorded in the intercropping system involving pearlmillet and clusterbean in 2:1 row ratio. The lower benefit : cost ratio value (0.52) was recorded under sole sorghum (T_1). However, intercropping of pearlmillet and cowpea in 1:1 row ratio (T_9) and sole pearlmillet (T_2) also performed better with benefit : cost ratio of 3.92 and 3.35, respectively.

4.4.4 Land Equivalent Ratio (LER)

The data regarding the effect of cereals with legumes intercropping systems on land equivalent ratio are presented in Table 17 and graphically illustrated in Fig. 7 and their analysis of variance are furnished in Appendix III.

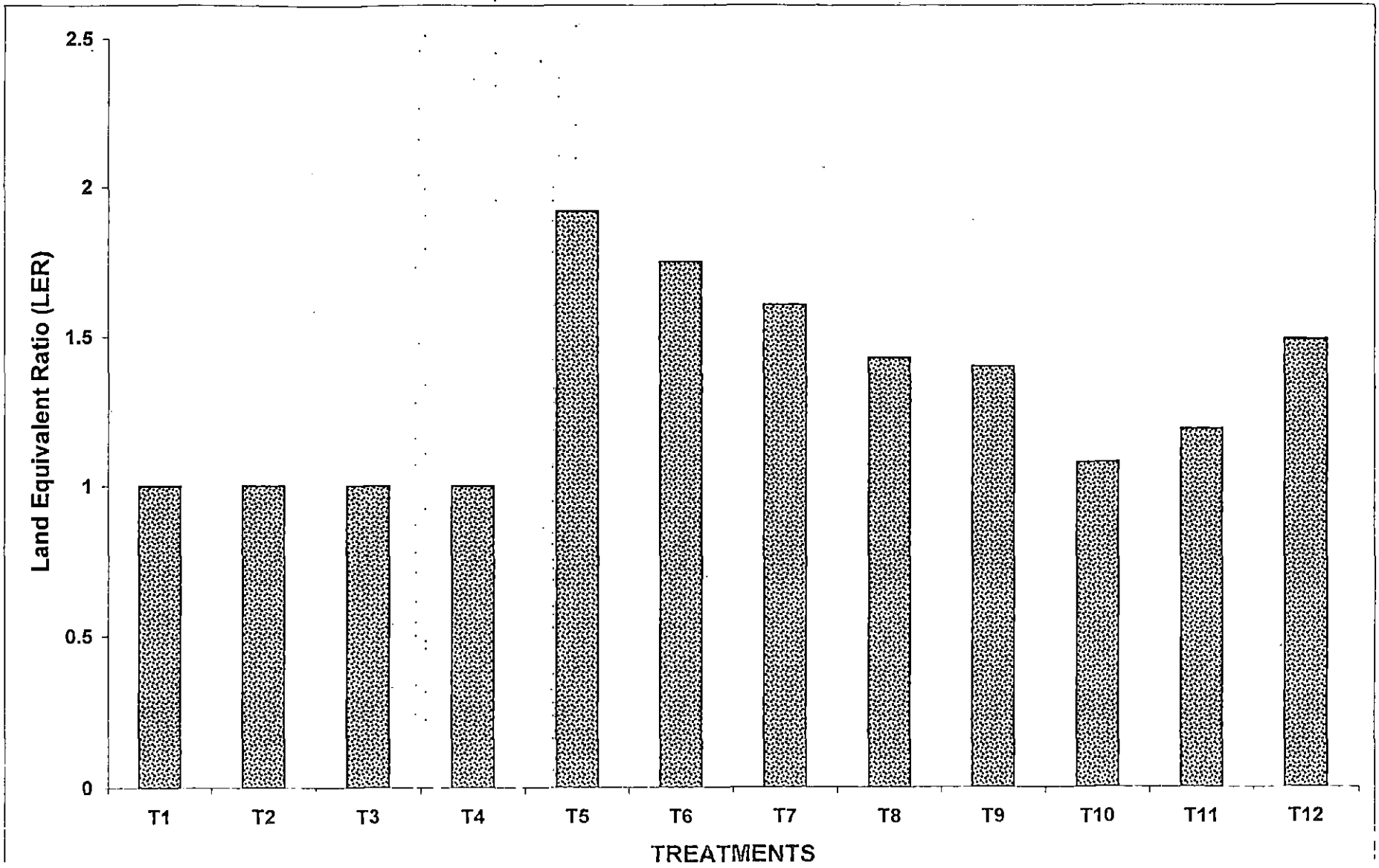

Fig. 7 : Effect of cereals with legumes intercropping systems on land equivalent ratio

A perusal of data indicated that intercropping systems had exhibited their effect on LER. All the intercropping systems recorded more than 1.00 LER value as compared to sole crops thus, it indicates greater biological efficiency of the system. Higher value of LER was found in intercropping of sorghum and cowpea in 1:1 row ratio (1.92) than that found in rest of the treatments. Intercropping of sorghum and cowpea in 2:1 row ratio (1.75), sorghum and clusterbean in 1:1 row ratio (1.61) and pearlmillet and clusterbean in 2:1 row ratio (1.49) recorded 75, 61 and 49 per cent higher LER as compared to sole cropping of sorghum and pearlmillet. Among the different intercropping systems, lower value of LER (1.08) was recorded with treatment T_{10} (Pearlmillet + Cowpea in 2:1 row ratio).

DISCUSSION

V DISCUSSION

The present study aimed to evolve profitable intercrop and suitable row ratio, where by a farmer can harvest maximum yield (*i.e.*, as much as sole crop) and as much additional intercrop yield as possible. To achieve it, two main crops *viz.*, sorghum, pearlmillet and two intercrops *viz.*, cowpea, clusterbean were intercropped at 1:1, 2:1 row ratios and compared with sole cereal crops and sole intercrops. During the course of presenting the experimental results, many significant variations among different treatments were reported. In this chapter, it is contemplated to discuss the variations observed in growth parameters and yield under the influence of different treatments. It has been attempted to establish 'effect and cause relationship' based on the results of the present investigation duly supported by available evidences and relevant literature.

The meteorological data recorded during experimental period indicated that, in general, the weather conditions were observed more or less normal for satisfactory growth and development of crops. Hence, whatever variations observed due to the different treatments exercised in the experiment are discussed hereunder :

5.1 Effect of intercropping on growth parameters

5.2 Effect of intercropping on green forage and dry matter yields

5.3 Effect of intercropping on crude protein and crude fibre contents

5.4 Effect of intercropping on pearlmillet green forage equivalent yield, economics and LER

5.1 EFFECT OF INTERCROPPING ON GROWTH PARAMETERS

A perusal of data presented in Table 9 revealed that the higher plant population was recorded under both sole crops *i.e.,* sorghum and pearlmillet due to the fact that satisfactory plant population were maintained in sole cropping systems whereas, reduction in plant population was observed due to different row ratios maintained in intercropping systems.

It was observed from the Table 10 that plant height of cereal crops and legume crops were not affected significantly at both cuts of sorghum, pearlmillet and a single cut of cowpea and clusterbean. It might be due to dwarf and compact habit of intercrops. However, taller plants of pearlmillet on the basis of mean was recorded by treatment T_{12} (Pearlmillet + Clusterbean 2:1 row ratio). In general, when cowpea and clusterbean were intercropped with pearlmillet in 1:1 and 2:1 row ratios, plant of pearlmillet were significantly taller than that recorded in rest of the treatments of sorghum. This might be due to development of better complementary relationship. This results are also in conformity with those reported by Anjeneyulu *et al.* (1982), Khateek (1997), Ghosh (2002) and Dadhich and Gupta (2005).

The plant height of cowpea and clusterbean at both row ratios was higher in intercropping systems when these crops were sown with pearlmillet or sorghum. This might be due to shedding effect of taller plants of pearlmillet or sorghum on legumes resulted into elongation of their main stem.

The data presented in Table 11 regarding the effect of different intercropping systems on number of tillers per plant of cereal crops *viz.,* sorghum and pearlmillet was affected significantly. However, the maximum number of tillers per plant of pearlmillet was observed under treatment T_{12} (Pearlmillet + Clusterbean 2:1 row ratio) but was remained at par with treatments T_9 (Pearlmillet + Cowpea 1:1 row ratio) and treatment T_2 (Sole pearlmillet) and treatment T_{11} (Pearlmillet + Clusterbean 1:1 row ratio) on mean basis.

Number of tillers per plant of sorghum and pearlmillet were reduced in intercropping system in comparison of their respective sole cropping systems. This might be due to the competition offered by intercrops for natural sources during 1st cut of cereal crops. The intercrops were harvested with 1st cut of cereal crops. Hence more space, moisture and solar radiation were available to cereal crops in intercropping systems after 1st cut of cereal crops. Due to this, more number of tillers per plant of sorghum and pearlmillet were recorded in intercropping systems than their respective sole crop during 2nd cut. During both cuts of cereal crops more number of tillers per plant were recorded in pearlmillet than sorghum. This might be due to very good regeneration ability of pearlmillet as compared to sorghum. Similar results were obtained by Singh (1992), Khateek (1997), Ghosh (2002) and Dadhich and Gupta (2005).

The data presented in Table 11 regarding the effect of different intercropping systems on number of branches of cowpea and clusterbean was not affected significantly. Number of branches per plant of cowpea and

clusterbean were reduced in intercropping systems as compared to their respective sole crop which perhaps due to the fact that competition offered by main crops (Sorghum and Pearlmillet) for natural resources, resulted in poor development of intercrops and also due to less space available for horizontal spread of plants and intraspecific competition for solar radiation. These results are in corroborating with findings of Singh (1992) and Khateek (1997).

A perusal of data given in Table 12 showed that the effect of intercropping systems on leaf : stem ratios of sorghum and pearlmillet was not significant during both cuts and on mean basis. The leaf : stem ratios were observed higher in intercropping systems as compared to sole crops. The leaf : stem ratio of pearlmillet was higher in treatment T_{10} (Pearlmillet + Cowpea 2:1 row ratio) during 1st, 2nd cut and on mean basis. In legume crops, the leaf : stem ratio of cowpea was higher in treatment T_5 (Sorghum + Cowpea 1:1 row ratio) however, the effect was not significant.

5.2 EFFECT OF INTERCROPPING ON GREEN FORAGE AND DRY MATTER YIELDS

It was observed from the data given in Table 13 that significantly the highest green forage yield recorded by sole pearlmillet during 1st, 2nd cut and in total of two cuts which could be attributed to higher plant densities in sole crops. Intercropping of pearlmillet and clusterbean in 2:1 row ratio (T_{12}) had 5.62 per cent lower forage yield as compared to sole pearlmillet in total of two cuts. This might be due to lower plant density of pearlmillet and also higher

competition offered by clusterbean for natural resources. Yadav and Solanki (2002) found similar results in case of sole pearlmillet.

Sole cowpea recorded the highest green forage yield during single cut of legume crops *viz.*, cowpea and clusterbean. Overall the highest total green forage yield was recorded by treatment T_{12} (Pearlmillet + Clusterbean 2:1 row ratio). It recorded 14.32 per cent higher green forage yield than sole pearlmillet. The higher yield in intercropping system might be due to the better utilization of sunlight, moisture and nutrients. These results are also in agreement with the findings of Mishra (1964), Keshwa and Singh (1992) and Gupta and Meena (1995).

The performance of pearlmillet was better might be attributed to its tillering habit and plant height over sorghum.

Dry matter yield (Table 14) was significantly affected by different cropping systems. Significantly the highest dry matter yield was observed in sole pearlmillet during 1st, 2nd cut and total of two cuts of cereal crops which could be attributed to higher plant population in sole cropping system. Treatment T_2 was at par with treatment T_{12}. Intercropping of pearlmillet and clusterbean in 2:1 row ratio (T_{12}) produced 5.35 per cent less dry matter yield than that of sole pearlmillet (T_2) in total of two cuts. This might be due to lower plant density of pearlmillet and also competition offered by clusterbean for natural resources.

Dry matter yield of intercrops were also reduced in intercropping systems in comparison to their respective sole cropping systems. Such variations could be ascribed due to decrease in plant densities and also reduction in number of branches, when grown as intercrop in pearlmillet or sorghum. Higher competition among main crops and intercrops for natural resources like moisture, nutrient and sunlight may also resulted in poor dry matter yields of intercrops.

Total dry matter yield was significantly influenced by different cropping systems. The highest dry matter yield was recorded by treatment T_{12} (Pearlmillet + Clusterbean 2:1 row ratio) followed by treatment T_9 (Pearlmillet + Cowpea 1:1 row ratio). These treatments T_{12} and T_9 recorded 19.48 and 9.95 per cent higher dry matter yield than sole pearlmillet, respectively. Similar results were also obtained by Mishra (1964) and Singh (1992).

5.3 EFFECT OF INTERCROPPING ON CRUDE PROTEIN AND CRUDE FIBRE CONTENTS

The crude protein content (%) was differed significantly by cereals with legumes intercropping systems in individual cut and mean of all the cuts (Table 15).

Crude protein content of pearlmillet was significantly higher in sole pearlmillet and in its intercropping systems than the treatments of sorghum during 1st and 2nd cuts of cereal crops. Between the intercrops, sole clusterbean and in its intercropping systems recorded significantly higher crude protein contents. On the mean basis, treatment T_4 (Sole clusterbean) was superior to

the rest of the treatments. Similar results were also observed by Roat *et al.* (1990). Both legume crops as inter crops in pearlmillet at both row ratios produced higher crude protein than the treatments of sorghum. The reason for superior quality forage may be that cowpea and clusterbean being legumes fixing atmospheric nitrogen could have increased the availability of nitrogen which might have been utilised by pearlmillet for its growth and ultimately increased green forage yield and crude protein content.

Crude fibre content was significantly affected by cereals with legumes intercropping systems in individual cut and mean of all cuts (Table 16).

Crude fibre content (%) of sorghum was significantly recorded higher in sole sorghum and in its intercropping systems than the treatments of pearlmillet during 1st cut of cereal crops. During 2nd cut, treatments T_1 (Sole sorghum) and T_7 (Sorghum + Clusterbean 1:1 row ratio) being at par and recorded significantly higher crude fibre content than rest of the treatments. In a single cut of legume crops, sole cowpea and its intercropping systems recorded higher crude fibre contents than the treatments of clusterbean.

On the mean basis, treatment T_1 (Sole sorghum) recorded the highest crude fibre content (34.61 %). It was at par with treatments T_6, T_3, T_5, T_{10}, T_7 and T_8. Similar results were also obtained by Singh *et al.* (2005).

5.4 EFFECT OF INTERCROPPING ON PEARLMILLET GREEN FORAGE EQUIVALENT YIELD, ECONOMICS AND LER

Apart from the competitive effects, prevailing price become an additional important factor in choosing the components of intercropping

system. Thus, the yields of intercrops and sorghum were converted in to pearlmillet green forage equivalent yield and added both the converted yields. The rest treatments of intercrop yields were also converted in to pearlmillet green forage yield and added with pearlmillet green forage yield (Table 17 and Fig. 5).

The pearlmillet green forage equivalent yield was 20.98 and 12.20 per cent higher with treatment T_{12} (Pearlmillet + Clusterbean 2:1 row ratio) and treatment T_9 (Pearlmillet + Cowpea 1:1 row ratio) over sole pearlmillet (T_2). This might be due to more yield of pearlmillet, clusterbean and cowpea, resulted in the higher pearlmillet green forage equivalent yield.

The data on LER (Table 17 and Fig. 7) indicated that 92 per cent higher yield advantage were found in treatment T_5 (Sorghum + Cowpea 1:1 row ratio) over sole crop of sorghum (T_1). This yield advantage in intercropping may be possible due to combined effect of better utilization of soil moisture, light and nutrients by component crops having differential rooting pattern, canopy distribution and nutrient requirement in intercropping system. These results are also in agreement with the findings of Tripathi *et al.* (1987) and Desale *et al.* (2002) in intercropping of sorghum and soybean in 2:1 row ratio.

The highest net realization was observed in treatment T_{12} (Pearlmillet + Clusterbean 2:1 row ratio). It was 27.62 per cent higher as compared to sole pearlmillet. Whereas, the highest BCR values were observed in the same treatment T_{12} (Pearlmillet + Clusterbean 2:1 row ratio) and in treatment T_9 (Pearlmillet + Cowpea 1:1 row ratio) are in order of 4.33 and 3.92,

respectively. Looking to the economics, treatment T_{12} (Pearlmillet + Clusterbean 2:1 row ratio) gave higher net realization and Benefit : Cost ratio over other intercropping systems and all sole crops. This might be due to higher pearlmillet green forage equivalent yield. These results are also corroborated with the findings as reported by Waghmare *et al.* (1982), Waghmare and Singh (1982) and Manoharan and Subramanian (1993).

Plate I: At the time of first cut

Plate II: At the time of first cut

Plate III: At the time of single cut

Plate IV: At the time of single cut

Plate V: At the time of first cut

SUMMARY AND CONCLUSION

VI SUMMARY AND CONCLUSION

An experiment was conducted on loamy sand soil at Agronomy Instructional Farm, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar to study the effect of "Forage production potential under cereals and legumes intercropping systems" during *kharif* season of 2005. A field experiment was conducted with twelve treatments in randomized block design with four replications.

The results obtained with respect to treatment effects presented in the fore-said chapters are summarized hereunder :

[1] The plant heights of cereal and legume crops were not significantly influenced with different intercropping systems. Maximum plant heights of pearlmillet and clusterbean were recorded by treatment T_{12} (Pearlmillet + Clusterbean 2:1 row ratio).

[2] Significantly higher number of tillers per plant recorded by treatment T_2 (Sole pearlmillet) during 1st cut and treatment T_{12} (Pearlmillet + Clusterbean 2:1 row ratio) during 2nd cut and mean of both cuts.

Number of branches per plant of legume crops was not significantly influenced with different intercropping systems. However, higher number of branches was recorded by treatment T_4 (Sole clusterbean).

[3] The leaf : stem ratios of cereal and legume crops were not significantly influenced by various intercropping treatments. T_{10} (Pearlmillet + Cowpea 2:1 row ratio) recorded maximum leaf : stem ratio of cereal

crops and T_5 (Sorghum + Cowpea 1:1 row ratio) recorded maximum leaf : stem ratio of legume crops.

[4] Significantly higher green forage yield was recorded by treatment T_2 (Sole pearlmillet) during 1st, 2nd and total of two cuts of cereal crops and treatment T_3 (Sole cowpea) recorded higher yield during single cut of legume crops.

Overall significantly the highest total green forage yield was recorded by treatment T_{12} (Pearlmillet + Clusterbean 2:1 row ratio). It was 14.32 per cent higher than T_2 (Sole pearlmillet).

[5] Significantly higher dry matter yield was recorded by treatment T_2 (Sole pearlmillet) during 1st, 2nd and total of two cuts of cereal crops. During a single cut of legume crops the highest dry matter yield was recorded by T_4 (Sole clusterbean).

Overall significantly higher total dry matter yield was recorded by treatment T_{12} (Pearlmillet + Clusterbean 2:1 row ratio). It was 19.48 per cent more than treatment T_2 (Sole pearlmillet).

[6] The crude protein content was significantly higher by treatment T_2 (Sole pearlmillet) during 1st cut. Treatment T_{12} (Pearlmillet + Clusterbean 2:1 row ratio) recorded significantly higher crude protein content during 2nd cut of cereal crops. T_4 (Sole clusterbean) recorded higher crude protein content under legume crops. On the mean data basis, significantly higher crude protein content was recorded by T_4 (Sole clusterbean).

[7] The crude fibre content was significantly the highest observed with treatments T_1, T_7 and T_8 during 1st cut of cereal crops. Treatment T_1 (Sole sorghum) recorded significantly the highest crude fibre content during 2nd cut of cereal crops. In a single cut of legume crops, treatment T_6 (Sorghum + Cowpea 2:1 row ratio) recorded the highest crude fibre content. On the mean data basis, significantly the highest crude fibre content recorded by T_1 (Sole sorghum).

[8] The pearlmillet green forage equivalent yield was found significantly higher when pearlmillet was intercropped with clusterbean at 2:1 row ratio (T_{12}) than rest of the treatments except treatment T_9.

[9] All intercropping systems received more than 1.00 value of LER. Significantly higher value of LER was recorded by T_5 (Sorghum + Cowpea 1:1 row ratio).

[10] The maximum net realization (Rs.35,476 ha^{-1}) and BCR (4.33) were recorded in treatment T_{12} (Pearlmillet + Clusterbean 2:1 row ratio) followed by treatment T_9 (Pearlmillet + Cowpea 1:1 row ratio) with net realization (Rs.32,263 ha^{-1}) and BCR (3.92).

CONCLUSION :

The results indicated that intercropping of pearlmillet with clusterbean in 2:1 row ratio was distinctly superior over sole crops and rest of all the intercropping systems and securing maximum total green forage yield, total dry matter yield and found most profitable by realizing the highest green forage equivalent yield, net return and benefit : cost ratio.

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* Original not seen.

APPENDICES

Appendix I : Analysis of variance for various growth parameters

Source of variation	d.f.	Mean square values											
		Plant height (cm) plant^{-1}				Number of tillers plant^{-1}			No. of branches plant^{-1}	Leaf : Stem ratio			
		Main crops sorghum, pearlmillet			Intercrop cowpea, clusterbean	Main crops sorghum, pearlmillet			Intercrop cowpea, clusterbean	Main crops sorghum, pearlmillet			Intercrop cowpea, clusterbean
		1st cut	2nd cut	Mean	Single cut	1st cut	2nd cut	Mean	Single cut	1st cut	2nd cut	Mean	Single cut
Replication	3	13.85	238.89	71.19	163.87	0.31	0.25	0.052	0.49	0.00	0.01	0.01	0.01
Treatment	9	305.12	639.13	445.44*	53.87	13.82*	34.04*	22.84*	0.30	0.02	0.01	0.01	0.01
Error	27	145.34	311.41	139.97	175.92	0.17	0.41	0.10	0.36	0.01	0.00	0.01	0.00

* Significant at 5 per cent.

Appendix II : Analysis of variance for yields and quality characters

Source of variation	d.f.	Mean square values													
		Green forage yield q ha^{-1}				Dry matter yield q ha^{-1}				Crude protein content (%)			Crude fibre content (%)		
		Main crops sorghum, pearlmillet			Intercrop cowpea, clusterbean	Main crops sorghum, pearlmillet			Intercrop cowpea, clusterbean	Main crops sorghum, pearlmillet		Intercrop cowpea, clusterbean	Main crops sorghum, pearlmillet		Intercrop cowpea, clusterbean
		1st cut	2nd cut	Total	Single cut	1st cut	2nd cut	Total	Single cut	1st cut	2nd cut	Single cut	1st cut	2nd cut	Single cut
Replication	3	572.67	105.95	968.43	776.75	54.68	52.03	128.27	14.08	0.09	0.21	0.11	0.74	0.81	0.46
Treatment	9	12713.31*	14945.28*	54733.06*	7952.64*	204.67*	256.33*	855.75*	174.23*	0.82*	1.65*	4.04*	2.80*	3.39*	4.64*
Error	27	383.29	467.41	1077.09	399.07	28.75	30.04	69.73	18.80	0.19	0.25	0.51	0.84	0.72	0.69

* Significant at 5 per cent.

Appendix III : Analysis of variance for yields and quality characters, pearlmillet green forage equivalent yield, LER and net realization

Source of variation	d.f.	Mean square value						
		Green forage yield (q ha^{-1})	Dry matter yield (q ha^{-1})	Crude protein content (%)	Crude fibre content (%)	Pearlmillet green forage equivalent yield (q ha^{-1})	LER	Net realization (Rs.ha^{-1})
Replication	3	1080.71	69.01	0.38	1.02	15054762.15	0.01	3461422.72
Treatment	11	62820.40*	2237.82*	82.94*	697.17*	609946338.42*	0.39*	335355591.36*
Error	33	1308.04	59.95	0.47	1.49	17617984.44	0.00	3867301.51

* Significant at 5 per cent.

Appendix IV : Cost of cultivation and inputs taken into consideration for calculation of economics

Sr. No.	Particulars		Rate (Rs.Unit^{-1})
1.	Tractor cultivation charge		200 hr^{-1}
2.	Urea		255 bag^{-1}
3.	Single super phosphate		160 bag^{-1}
4.	Seed price :		
	(i)	Sorghum	20 kg^{-1}
	(ii)	Pearlmillet	20 kg^{-1}
	(iii)	Cowpea	25 kg^{-1}
	(iv)	Clusterbean	20 kg^{-1}
5.	Irrigation charge		400 irrigation^{-1}
6.	Man and woman labour		50 day^{-1}
7.	Pair of bullock + Labour charge		120 day^{-1}
8.	Green forage price :		
	(i)	Sorghum	0.75 kg^{-1}
	(ii)	Pearlmillet	0.75 kg^{-1}
	(iii)	Cowpea	1.0 kg^{-1}
	(iv)	Clusterbean	1.0 kg^{-1}
9.	Supervision charge		10 %
10.	Interest on working capital		12 %

CERTIFICATE

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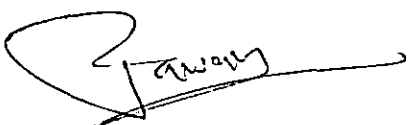

[PAWAN KUMAR PAREEK]

Place : SARDARKRUSHINAGAR
Date : 14th December, 2006.