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PRODUCTIVITY OF SUMMER LEGUME FORAGES INTERCROPPED WITH MAIZE AS AFFECTED BY MIXED CROPPING IN DIFFERENT SOWING TECHNIQUES

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ABSTRACT

This study was conducted during 2003 and 2004 to study the influence of mixed cropping on forage yield and quality. Three summer forage legumes viz. clusterbean, cowpea and ricebean were intercropped with maize in different sowing techniques such as broadcast with blended seed of maize and legume, line sowing with blended seed of maize and legume and line sowing in alternate rows of maize and legume. The experiment was laid out in randomized complete block design with four replications. Highest green forage yield of 13.31 t ha^{-1} was obtained from cowpea intercropped with maize in 30 cm spaced lines in alternate rows. This treatment combination also increased the leaf area index of 1.88 and 2.49 during the first and second year of study, respectively leading to improvement in nutritive value as evidenced by its protein contents, compared to other legume intercrop combinations. In conclusion, to get better yield of quality fodder, forage maize should be intercropped with forage legumes, preferably cowpea, under the planting pattern of 30 cm spaced lines in alternate rows.

Key words: Clusterbean, cowpea, ricebean, intercropping, planting pattern, forage maize.

INTRODUCTION

Livestock production is an integral and indispensable component of farming system in Pakistan. It contributes more than 30% of the Pakistan GNP. According to Livestock Census, there is 154.1 million livestock population in the country providing dietary requirements, like milk, butter, cheese, meat etc. to millions of people (Govt. of Pakistan, 2009a). The human population of the country is increasing day by day and resulting in increased requirements for milk and milk products. At present 2.36 million hectares of land is under fodder crops with annual production of 53.61 million tons of fodder (Govt. of Pakistan, 2009b)). The area under fodder crops can not be increased at the expense of food crops. However, increased productivity and quality of fodder is pre-requisite for an efficient and productive livestock industry.

Fodder is the cheapest form of feed for animals. The fodder production in the country is primarily through primitive and traditional ways which does not meet fully the fodder requirement both in terms of quantity and quality, the animals are thus undernourished. Shortage of fodder production is the major factor responsible for low animal productivity in the country. The average forage yield of fodders in Pakistan is 22.6 t ha^{-1} (Govt. of Pakistan, 2009b) which is far very low than the potential. This is primarily due to substandard methods of cultivation, poor crop stand, malnutrition and lack of high yielding varieties. However substantial potential for increasing the fodder supply of balanced quality exists in the country. Forage yield and its quality can be improved by improved production technology (Chittapur *et al.*, 1994).

Intercropping of forage legumes with forage maize not only improves the nutritive value of fodder but also help in maintaining the soil fertility (Berg, 1990). For Instance, Ibrar *et al*. (2002) reported beneficial effects of legumes intercropped in maize on soils with low fertility as legumes fix atmospheric nitrogen (N) besides meeting their own N requirements. This eventually helps in meeting the N needs of cereals partially. Intercropping being a unique system in tropical and subtropical regions is particularly popular among small farmers. Tripathy *et al.* (1997) reported improvement in forage yield and crude proteins from maize-cowpea intercropping. Similarly Patel and Rajagopal (2001) reported increase in green forage yield with maize and cowpea grown in 5:2 row was 9.69 and 17.31%. However the highest value of land equivalent ratio was recorded when maize and clusterbean were grown in 3:2 row. Ayisi *et al.* (2001) obtained higher yield of intercropped sorghum when the component crops were arranged in alternate rows at 0.90 m spacing, the over all land use efficiency, assessed by the land equivalent ratio was improved by 11%. However there is dearth of knowledge on the sequential arrangement of forage legumes intercropped with forage maize. This study was therefore, undertaken to determine the yield and quality response of forage legumes intercropped with maize in different sowing techniques

MATERIALS AND METHODS

The study was carried out at Agronomic Research Farm, University of Agriculture, Faisalabad, Pakistan to evaluate the yield and quality of forage legumes intercropped with maize following different sowing arrangements during the autumn season of the year 2003 and 2004 in the field when the previous crop was wheat. Experimental soil was sandy clay loam with 0.042% organic matter, 7.15 ppm available phosphorus and 198 ppm available potassium. The study comprised of broadcast with blended seed of maize + clusterbean (I_1S_1), drill sowing with blended seed of maize + clusterbean in 30 cm apart rows (I_1S_2), drill sowing of maize in 30 cm apart rows and intercropped with clusterbean. (I_1S_3), broadcast with blended seed of maize + rice bean (I_2S_1), drill sowing with blended seed of maize + rice bean in 30 cm apart rows (I_2S_2), drill sowing of maize in 30 cm apart rows and intercropped with ricebean (I_2S_3), broadcast with blended seed of maize + cowpea (I_3S_1), drill sowing with blended seed of maize + cowpea in 30 cm apart rows (I_3S_2) and drill sowing of maize in 30 cm apart rows and intercropped with cowpea (I_3S_3). The experiment was quadruplicated in a randomized complete block design with a net plot size of 3.6 m x 9 m. Seeding rates of 100, 50, 20 and 30 kg ha^{-1} for maize, clusterbean, ricebean and cowpeas was used, irrespective to sowing techniques. Mean maximum temperature during the growing season of crop ranged between 39.2°C in July and 38.5°C in mid September in 2003, and the corresponding values were 40.2°C and 39.0°C for 2004. Solar radiations receipts changed considerably during the growing seasons of both the years and consistently higher radiations values prevailed in 2004. Relative humidity ranged between 70-75 in both the years. Comparatively low rainfall was received in 2003 than 2004. Fertilizers were applied at 150-100-100 kg NPK ha^{-1} using urea, di-ammonium phosphate and murate of potash as sources, respectively. The experiment received four irrigations in all. The crop was harvested in 3rd week of October. Data on various plant parameters like stand density, LAI, forage and dry matter yield at harvest were collected by using the standard procedures. For stand density total number of plants were counted in one meter length of three randomly selected rows in each plot and then average per square meter was computed. Leaf area index (LAI) was calculated as the ratio of crop leaf area to land area (Watson, 1947). For green forage yield all the crop plants in each plot were harvested, 60 days after sowing and weighed separately with the help of a spring balance and then forage yield was converted into t ha^{-1}. For the purpose of dry matter yield, ten randomly selected plants from each plot were chopped with the help of a hand fodder cutter and then thoroughly mixed. Thereafter, a sample of 100 g was taken from each lot and dried in an oven at 80°C to a constant weight. Samples were reweighed and then dry matter percentage was calculated as under:

$$\text{Dry weight (\%age)} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

Thereafter, dry matter percentage calculated in each treatment was used for converting the fresh fodder yield into dry matter yield per plot and then converted into t ha^{-1}.

Various quality parameters such as crude protein, crude fiber, ether extractable fat % and ash % in legumes were estimated in the chemical laboratory by using the standard procedures as recommended by A.O.A.C (1990).

Data collected were analyzed statistically using analysis of variance technique to differentiate the effects of treatment and their interaction using MSTAT-C statistical computer package. Treatment means were compared using LSD test at P =0.05 level (Steel *et al*., 1997).

RESULTS AND DISCUSSION

A) Yield and yield parameters

Stand density of legumes at harvest: The stand density at harvest is potential yield component in forage crops. The year effect on final stand density per square meter of associated legumes was significant. The stand density per square meter was higher during the 2nd year than the preceded year.

Both the interactive and individual effects of maize + legume mixed cropping and sowing techniques on stand density at harvest were significant during both years (Table 1). During the 1st year, significantly the maximum stand density (35 m^{-2}) was recorded for clusterbean grown in alternate rows with maize (I_1S_3) followed by clusterbean grown by broadcast with blended seed of maize + clusterbean (I_1S_1). Similar stand density per square meter was recorded for ricebean sown by broadcast or in lines with blended seed of maize + ricebean (I_2S_1 and I_2S_2). The difference between I_1S_2 and I_2S_3 was also significant, the former showing higher stand density than the latter. By contrast, significantly the minimum stand density (15 m^{-2}) was recorded for cowpea sown in lines with blended seed of maize + cowpea (I_3S_2). Almost the same trend was exhibited during the 2nd year with the minimum stand density of 17 m^2 for cowpea sown in lines with blended seed of maize + cowpea (I_3S_2) (Table 1). Since sowing the component crops in alternate did not exert much shading effect on each other and thus resulted in the maximum stand density m^{-2} of the associated legumes. The year effect on final stand density per square meter of legumes was significant. The stand density per square meter was

higher during the 2nd year than the preceded year (Table 1).

Leaf area index of legumes: There was a significant year effect on leaf area index of legume intercrops. The leaf area index was higher during the second year than the preceded year because of better growth of the legumes due to more favorable weather conditions prevailing during the second year than the previous year. The individual as well as interactive effects of mixed cropping and sowing techniques on leaf area index at harvest of intercropped legumes was significant during each year (Table 1). Significantly highest leaf area index (1.88) was recorded for cowpea sown in alternate rows with forage maize (I_3S_3) followed by that grown by broadcast with blended seed of maize + clusterbean (I_1S_3) and I_2S_3 producing LAI of 1.66 and 1.55 respectively. Contrarily, the minimum LAI (0.66) was recorded for ricebean planted in lines with blended seed of maize + ricebean (I_2S_2) which was at par with I_1S_2 (0.66) and I_3S_2 (0.71). Similar trend prevailed during the 2nd year of study with the maximum LAI (2.49) for cowpea grown in alternate rows with maize (I_3S_3). The minimum LAI (0.84) was recorded for ricebean sown in lines with blended seed of maize + ricebean (I_2S_2) which was similar to I_1S_2 and I_3S_2 treatment combinations. The periodic LAI development depicted in Table 1.1 reveal that LAI values of different legumes sown with different techniques were non significant till 15 and 30 DAS each year and thereafter different treatment combinations resulted in significant differences among themselves. In 2003, maximum LAI at 45 DAS were obtained in cowpea grown in alternate rows with maize (I_3S_3), followed by cluster bean grown in alternate rows with maize (I_1S_3). This, in turn, was followed by I_2S_3 and I_3S_1 treatment combinations, which showed similar LAI. Almost similar trend was recorded on LAI development of legumes at 45 DAS, in the second year experiment. This is attributed to differential competition of the component plant species for different environmental and soil resources.

Green forage yield of legumes: The year effect on forage yield of associated legumes was significant. The green forage yield was higher by 1.1 t ha^{-1} during the second year than the previous year. The interactive and main effects of mixed cropping and sowing techniques on green forage yield of associated legumes were significant in both the years (Table 1). The highest green forage yield of 12.22 t ha^{-1} was recorded for cowpea sown in alternate rows with forage maize (I_3S_3) followed by that grown by broadcast with blended seed of maize + cowpea (I_3S_1) and I_3S_2 producing forage yield of 10.96 and 9.98 t ha^{-1},respectively. By contrast, the minimum forage yield of 4.24 t ha^{-1} was recorded for ricebean grown in lines with blended seed of maize + ricebean (I_2S_2) which was at par with I_2S_1 producing forage yield of 4.49 t ha^{-1}. The difference between I_1S_1 and I_1S_3 was also non-significant. The same trend was exhibited during the second year with the maximum forage yield of 14.41 t ha^{-1} for cowpea grown in alternate rows with maize (I_3S_3) against the minimum of 3.89 t ha^{-1} for ricbean planted in lines with blended seed of maize + ricebean (I_2S_2). These results are in line with Ayisi *et al.* (2001), Ibrar *et al.* (2002) and Rana *et al.* (2001).

Dry matter yield of legumes: The year effect on dry matter yield of associated legumes was significant which was relatively higher during the second year than the preceded year. Both the interactive and individual effects of mixed cropping and sowing techniques on dry matter yield of associated legumes were significant in both years (Table 1). The maximum dry matter yield (2.039 t ha^{-1}) was obtained from cowpea grown in alternate rows with maize (I_3S_3) followed by that sown by broadcast with blended seed of maize and cowpea (I_3S_1) and I_3S_2 which produced dry matter yield of 1.806 and 1.555 t ha^{-1}, respectively. By contrast, the lowest dry matter yield of 0.644 t ha^{-1} was recorded for ricebean grown in lines with blended seed of maize + ricebean (I_2S_2) which was at par with I_2S_1 (0.668 t ha^{-1}). The same trend prevailed during the second year of study. Similar results were reported by Hussain *et al.* (1999) and Azim *et al.* (2000) who reported a significant increase in biomass of fodder in which maize and cowpea were intercropped at seed ratio of 7:3.

B) Forage quality

Crude protein percentage in legumes: There was a significant year effect on crude protein content of legume forage which was relatively higher during the first year than the second year. Crude protein percentage in different associated forage legumes was affected significantly both by the interaction and main effects of mixed cropped and sowing techniques in both the year (Table 2), During the first year, although cowpea grown in alternate rows with maize (I_3S_3) accumulated similar crude protein to cowpea sown by broadcast with blended seed of maize + cowpea (I_3S_2) or that sown by broadcast with blended seed of maize + clusterbean (I_1S_1) or I_1S_2 and I_1S_3 showing protein content of 19.43, 19.60, 19.45 and 19.20 %, respectively. By contrast, the lowest crude protein content (14.10%) was recorded for ricebean sown by broadcast with blended seed of maize + ricebean which was at par with that sown in lines with blended seed of maize + rice bean (I_2S_2) showing protein content of 14.24 percent. On the contrary, during the 2nd year, although the highest crude protein content (19.96%) was recorded for cowpea grown in line with blended seed of maize + cowpea (I_3S_2) but was statistically at par with I_3S_3 and I_3S_1. Similarly, the difference among I2S1, I2S2 and I2S3 was non-significant and were preceded by I_1S_1, I_1S_2 and I_1S_3. However, the lowest crude protein content (13.32%) was recorded for ricebean grown in lines with blended seed of maize + ricebean (I_2S_2). On the whole,

crude protein percentage was higher in clusterbean followed by cowpea compared to the minimum in ricebean in the year 2003 as against 2004 in which cowpea recorded more protein percentage than clusterbean. Similar findings were reported by Tripathy *et al.* (1997).

Crude fiber percentage in legumes: The year effect on crude fiber content of associated legumes was significant which was relatively higher during the first year than the succeeding year. The individual as well as the interactive effects of mixed cropping and seeding techniques on crude fiber content of associated legumes were significant during the first year (Table 2). Among the combined treatments, the highest crude fiber content (35.40%) was recorded in clusterbean sown in alternate rows with maize (I_1S_3) followed by that grown in lines with blended seed of maize + clusterbean (I_1S_2) which was at par with I_1S_1 showing crude fiber content of 33.87 and 33.85%, respectively. By contrast, the lowest crude fiber content (27.91%) was recorded in cowpea seeded in lines with blended seed of maize + cowpea (I_3S_2) preceded by I_3S_3 (28,92%) and I_3S_1 (29.64%), both being at par with each other. The crude fiber content in ricebean under the three seeding techniques were statistically the same which varied from 31.35 to 31.83%. On the contrary, during the 2nd year, the main effects of sowing technique and the interaction of mixed cropping x sowing techniques on crude fiber content of legumes were non-significant while the main effects of associated legumes were significant. The highest crude fiber content (35.15%) was recorded in clusterbean followed by ricebean (29.46%) compared to lowest (27.62%) in cowpea. These results are in agreement with those of Azim *et al.* (2000).

Ether extractable fat percentage in legumes: The year effect on ether extractable fat in legumes forage was significant which was relatively higher in first year than the succeeding year.

Table 1: Stand density m^{-2}, Leaf area index, Green forage yield, and Dry matter yield of legumes at harvest as affected by mixed cropping with maize in different sowing techniques

Treatment combinations	Stand density m^{-2}		Leaf area index (LAI)		Green forage yield (t ha^{-1})		Dry matter yield (t ha^{-1})	
	Ist year	2nd year	Ist year	2nd year	Ist year	2nd year	Ist year	2nd year
a)Intercrops								
I_1 (Clusterbean)	32.3 *A*	36.3 *A*	1.17 *B*	1.48 *B*	8.08 *B*	9.33 *B*	1.073 *B*	1.374 *B*
I_2 (Ricebean)	27.7 *B*	30.0 *B*	1.08 *C*	1.40 *C*	4.63 *C*	4.46 *C*	0.697 *C*	0.788 *C*
I_3 (Cowpea)	16.3 *C*	18.3 *C*	1.30 *A*	1.64 *A*	11.06 *A*	13.29 *A*	1.800 *A*	2.175 *A*
LSD	0.441	0.373	0.03	0.04	0.374	0.271	0.037	0.046
b)Sowing techniques								
S_1(Broadcast with blended seed)	25.0 B	28.0 B	1.18 B	1.41 B	7.97 B	9.05 B	1.168 B	1.388 B
S_2(Line sowing with blended seed	24.0 C	26.6 C	0.68 C	0.87 C	7.07 C	8.14 C	1.052 C	1.291 C
S_3(Line sowing in alternate rows)	27.3 A	30.0 A	1.70 A	2.24 A	8.73 A	9.88 A	1.349 A	1.659 A
LSD	0.441	0.373	0.03	0.04	0.374	0.271	0.037	0.046
Interaction (Intercrops x Sowing techniques)								
I_1S_1	32 b	36 b	1.19 c	1.39 e	8.46 d	9.22 e	1.032 c	1.276 e
I_1S_2	30 c	37 c	0.67 g	0.89 g	6.97 e	8.62 f	0.957 f	1.164 f
I_1S_3	35 a	39 a	1.66 b	2.17 b	8.81 d	10.13 d	1.229 d	1.682 d
I_2S_1	27 f	30 c	1.05 f	1.29 f	4.49 g	4.41 f	0.668 h	0.772 h
I_2S_2	27 f	29 f	0.66 g	0.84 g	4.24 g	3.89 i	0.644 h	0.726 h
I_2S_3	29 d	31 d	1.55 c	2.06 c	5.16 f	5.09 g	0.780 g	0.856 g
I_3S_1	16 g	18 h	1.31 d	1.55 d	10.96 b	13.53 b	1.806 b	2.115 b
I_3S_2	15 h	17 i	0.71 g	0.88 g	9.98 c	11.92 c	1.555 c	1.983 c
I_3S_3	18 c	20 g	1.88 a	2.49 a	12.22 a	14.41 a	2.039 a	2.428 a
LSD	0.765	0.646	0.06	0.07	0.647	0.470	0.065	0.079
Year mean	25.4 B	28.2 A	1.18 B	1.51 A	7.92 B	9.02 A	1.190 B	1.446 A

Any two means not sharing a letter differ significantly at $P \leq 0.05$.

Both the interactive and main effects of mixed cropping and seeding technique on ether extractable fat percentage of associated legumes forage was significant during the first year (Table 2). The highest fat percentage

(2) was recorded in cowpea grown in alternate rows with maize (I_3S_3) followed by that grown by broadcast with blended seed of maize + cowpea (I_3S_1) which was at par with I_3S_2 showing fat content of 1.85 and 1.84%, respectively. Contrarily, the minimum fat percentage (1.55%) was estimated in ricebean sown by broadcast with blended seed of maize + ricebean (I_2S_1) proceeded by I_2S_2 (1.58%). However, similar fat percentage was recorded for I_1S_1, I_1S_3 and I_2S_3 which amounted 1.62%. By contrast, in 2004 the interactive effect of mixed cropping and sowing techniques on fat percentage was non-significant. While the individual effects of mixed cropping and seeding techniques was significant. Significantly the highest fat percentage (1.78%) was found in cowpea forage followed by clusterbean (1.53%) against the minimum of 1.51% in ricebean forage. Among the seeding techniques the legumes sown in alternate rows with maize exhibited significantly the highest fat percentage (1.65%) followed by that sown by broadcast with blended seed of maize + legumes (1.60%) compared to the lowest (1.57%) that grown in alternate rows with blended seed of maize + legumes.

Ash percentage in legumes: Both the interaction and main effects of sowing techniques on ash percentage of associated legumes were non-significant. However, the ash percentage on an average varied from 9.90 to 11.52 %. The year effect was also found to be non significant (Table 2).

Table 2: Crude protein, Crude fibre, Ether extractable fat and Ash (%age) of legumes at harvest as affected by mixed cropping with maize in different sowing techniques

Treatment combinations	Crude protein (%age)		Crude fibre (%age)		Ether extractable fat		Ash (%age)	
	Ist year	2nd year	Ist year	2nd year	Ist year	2nd year	Ist year	2nd year
a)Intercrops								
I_1 (Clusterbean)	19.42*A*	18.86 *B*	34.37 *A*	35.15*A*	1.61 *B*	1.53 *B*	10.57*AB*	10.51
I_2 (Ricebean)	14.39*C*	13.44 *C*	31.52 *B*	29.46*B*	1.58 *C*	1.51 *C*	9.90 *B*	10.37
I_3 (Cowpea)	19.11*B*	19.82 *A*	28.82 *C*	27.62*C*	1.85 *A*	1.78 *A*	11.64 *A*	11.13
LSD	0.247	0.248	0.454	0.263	0.02	0.02	1.34	NS
b)Sowing techniques								
S_1(Broadcast with blended seed)	17.41B	17.21^{NS}	31.77 A	35.14^{NS}	1.67 B	1.60 B	10.76^{NS}	10.77
S_2(Line sowing with blended seed	17.71A	17.50	31.04 B	29.45	1.67 B	1.57 C	10.69	10.57
S_3(Line sowing in alternate rows)	17.80A	17.40	31.90 A	27.62	1.70 A	1.65 A	10.65	10.67
LSD	0.247	NS	0.454	NS	0.02	0.02	NS	NS
Interaction (Intercrops x Sowing techniques)								
I_1S_1	19.60 a	18.47 d	33.85 b	35.07	1.62 c	1.153	10.53	10.82
I_1S_2	19.45 a	19.25 bc	33.87 b	35.01	1.60 d	1.50	10.65	10.44
I_1S_3	19.20 a	18.88 cd	35.40 a	35.35	1.62 c	1.57	10.53	10.27
I_2S_1	14.10 d	13.60 e	31.83 c	29.55	1.55 f	1.50	9.96	10.24
I_2S_2	14.42 d	13.32 e	31.35 c	29.19	1.58 e	1.47	9.86	10.35
I_2S_3	14.82 c	13.41 e	31.38 c	29.61	1.62 c	1.54	9.87	10.52
I_3S_1	18.52 b	19.57 ab	29.64 d	27.31	1.85 b	1.78	11.80	11.25
I_3S_2	19.43 a	19.96 a	27.91 e	27.85	1.84 b	1.73	11.54	19.91
I_3S_3	19.37 a	19.93 a	28.92 d	27.70	1.87 a	1.83	11.56	11.23
LSD	0.428	0.135	0.787	NS	0.01	NS	NS	NS
Year mean	17.64 A	17.37 B	31.57 A	30.74 B	1.68 A	1.61 B	10.70	10.67

Any two means not sharing a letter differ significantly at $P \leq 0.05$. NS= Non significant

Conclusion: So on the basis of results it was concluded that productivity of summer legume forages especially cowpea can be improved through intercropping with maize sown in 30 cm apart rows. This was also resulted in more protein contents than rest of the legumes forages.

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