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EFFECT OF LEGUME INTERCROPPING ON SORGHUM PRODUCTION

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Intercropping is the most prevalent farming system in the developing countries to intensify and sustain the farm productivity. A research experiment on the legumes intercropping in sorghum based farming system was conducted to study the effect of legumes on the production of sorghum. The data revealed that legumes intercropping has a substantial effect on the growth and grain yield of sorghum. Data on maturity period of sorghum indicated that planting pattern had no consistent effect on the maturity of sorghum crop. However, legumes intercropping showed non-significant effect on the days taken to maturity by sorghum. Moreover, planting pattern and legumes intercropping had significantly affected the number of grains panicle^{-1} of sorghum. Double row strips planting pattern and sole sorghum gave significantly more number of grain panicle^{-1} compared to other treatments. In both the years of study, double row strips planting pattern significantly increased the grain yield of sorghum than single rows and triple row strips planting pattern. The grain yield of sole sorghum was significantly more than the grain yield of sorghum associated with mung bean or guar. Moreover, in the first year of study, protein content of sorghum grain was not significantly affected by the planting pattern but in the second year of study, double and triple row strips planting pattern significantly increased the protein content than single rows planting pattern having a protein content of 9.19%. Sorghum grain protein content of 9.51 and 9.49% produced in the association of mungbean during 1999 and 2000, respectively was significantly more than the grain protein content of sole sorghum or sorghum grown in the association of guar. The interaction between planting pattern and legume intercropping as regards protein content of sorghum grain was non-significant.
Key words: *Sorghum bicolor,* planting pattern, legumes intercropping, grain yield, protein content, Pakistan

INTRODUCTION

Intercropping of cereal-legumes culture is widely practiced by small farmers in tropical and sub-tropical regions of the world (Finlay, 1974). Traditionally this system of cropping aimed to avoid dependence on a single crop, obtain a variety of products from the same piece of land, improve efficiency of the available resources (labour etc;) and increase farm income from small holdings. However, scientific background of this concept showed that mixtures of cereals-legumes is usually opted for coping with problems of soil erosion, declining level of soil organic matter, nitrogen availability to the companion or subsequent crop in addition to the extra yield of intercropped legumes from the same piece of land and time. Moreover, conventional methods of farming do not allow free working of the inter-tillage devices for intercropping and intercultural practices for hoeing and weed control. In contrast, modified advanced planting pattern has great potential to accommodate more than one crop at a time and increase total productivity per unit area without using too many extra inputs. Mixed cropping with legumes, viz. green gram, black gram, cowpeas, cluster bean and velvet bean helps to increase protein content in the associated crop of sorghum (Anonymous, 1962). Chan (1971) observed that Lucerne crop began transferring nitrogen to Fescue plants after 6 weeks of growth and continued up to 18 weeks stage. During this period, the total transfer was 4.9 to 5.8 percent of the total N fixed by the Lucerne. Power *et al.* (1986) revealed that sowing of sorghum in double row strips with legume as intercrops gave the highest dry matter accumulation and highest uptake of NPK was observed by the intercropped sorghum as compared to sole sorghum. Ofosubudu *et al.* (1995) studied soybean cultivars under mono or mixed cropping with sorghum and found that total N accumulated by sorghum component in association with soybean was greater than that of mono crop. Similarly, Khushwaha and Chandel (1997) recorded maximum protein yield of sorghum under soybean plus sorghum system than sole sorghum. Maximum N uptake by maize crop was reported when maize was grown in the association of urdbean than the N uptake by sole maize (Shivay and Singh, 2000). Pal and Sheshu (2001) studied the direct and residual contribution of legumes to the yield and nitrogen uptake of maize and found that all the legume crops contributed to the yield and N uptake of maize either intercropped with the legume or grown after legumes as a sole crop. Direct transfer of N from the nodulating soybean, lablab bean, green gram and black gram to the intercropped maize was 29.9-30.1, 23.8-29.2, 19.7-22.1 and 18.4-18.6 kg N ha^{-1}, respectively. The transfer of residual N from these legumes to the succeeding maize crop was 18.4-20.9, 19.5-29.9, 12.0-13.7 and 9.3-10.3 kg ha^{-1}, respectively. Ayisi *et al.* (2001) reported maximum grain yield of intercropped sorghum when component crops were arranged in

alternate rows at wider spacing (90 cm) than in a narrow spacing (45 cm). Similarly, Singh and Balyan (2000) indicated that the intercropping systems registered significant increase in total productivity (sorghum equivalent) over sole sorghum. It was added that alternate rows at 30 cm planting was the best combination to achieve higher yield of the intercropped species (guar and black gram). The objectives of this study were to investigate the feasibility of legumes intercropping in sorghum based farming system of D.I. Khan.

MATERIALS AND METHODS

An experiment was conducted at the Arid Zone Research Institute, D.I.Khan during 1999 and 2000 to investigate the impact of legumes intercropping on the growth of sorghum. The treatments comprised single rows 60 cm apart, double row strips (30/90 cm) and triple row strips (30/120 cm) planting of sorghum with and without legumes as intercrops. Sorghum variety "PARC-SS-II", mung bean "MN-92" and guar "DK-3" were seeded @ 20 kg ha^{-1} each, during both the years of study. The intercrops (mungbean and guar) were planted on the same day of sorghum sowing. The experiment was conducted in a Randomized Complete Block Design with four replications maintaining a plot size of 4 x 3.60 m.

Fertilizer dose of 60 kg ha^{-1} phosphorus and 90 kg ha^{-1} nitrogen was applied in the form of Single Super Phosphate (SSP) and urea, respectively. Nitrogen was divided in three equal doses. The first dose of nitrogen (30 kg ha^{-1}) was applied to whole experimental plot uniformly with full dose of phosphorus at the time of sowing on 22nd and 26th of June, 1999 and 2000, respectively. The second dose of nitrogen was applied on 21st and 25th of August and third dose was applied on fifth and ninth of September during 1999 and 2000, respectively. Hand weeding was done to keep the crop free of weeds. Furadon granules @ 25 kg ha^{-1} were applied to sorghum crop only for control of stem borer. At maturity, the whole plot of sorghum and intercrops were harvested and tied into small bundles for sun drying for about a week time. The sun-dried bundles were threshed manually and data collected were analyzed statistically at 5% level of probability. Means were separated using Duncan's Multiple Range (DMR) test (Steel and Torrie, 1984).

RESULTS AND DISCUSSION

The data revealed that planting pattern had significantly affected the maturity of sorghum crop during 1999 (Table 1). Double row strips (30/90 cm) planting pattern took maximum number of days (104.4) to maturity followed by single rows conventional planting with non-significant difference. This suggested that double row strips (30/90 cm) planting pattern might have provided better environment, which increased vegetative growth and ultimately the days taken to maturity by sorghum. In contrast, the effect of planting patterns on the days taken to maturity was non-significant during 2000. The data further indicated that legumes intercropping did not effect the sorghum maturity. Similarly, the interaction between planting patterns and legumes intercropping as regards to maturity of sorghum was also found non-significant in both the years of study.

Table I. Days taken to maturity by sorghum as affected by planting pattern and legumes intercropping at AZRI D.I.Khan.

Planting pattern (P)	1999				2000			
	Legume intercropping (A)				Legume intercropping (A)			
	A_0	A_1	A_2	Average	A_0	A_1	A_2	Average
P_1	104.0	103.3	104.0	103.7 [a]	109.0	108.5	108.2	108.5
P_2	104.5	104.3	104.5	104.4 [a]	107.5	107.0	108.2	107.9
P_3	103.2	102.3	103.0	102.8 [b]	108.5	107.5	108.0	108.0
Average	103.9	103.3	103.8		108.3	108.0	108.1	
LSD	NS			0.832	NS			NS

P_1 = 60 cm spaced single rows
P_2 = 90 cm spaced double row strips (30/90 cm)
P_3 = 120 cm spaced triple row strips (30/120 cm)
*Means having different letter differ significantly at P<0.05

A_0 = Sorghum alone
A_1 = Sorghum+mungbean
A_2 = Sorghum+guar
**NS: Non-significant.

The data depicted in the Table II showed that the planting pattern and legumes intercropping had significantly affected the number of grains $panicle^{-1}$ of sorghum in both the years of study. In 1999, double row strips (30/90 cm) planting pattern had significantly increased the number of grains $panicle^{-1}$ than single

rows conventional planting and triple row strips (30/120 cm) planting pattern of sorghum. Double row strips (30/90 cm) planting pattern gave 2173 grains panicle^{-1} compared to 2116 and 2103 grains panicle^{-1} obtained in single rows and triple row strips planting pattern, respectively. This increase in number of grains panicle^{-1} obtained from double row strips planting pattern might be attributed to the efficient use of environmental resources (light, aeration etc) and other inputs like fertilizer and moisture. These results are in line with the findings of Himayatullah (1991), who reported similar increase in grains number cob^{-1} of maize grown in the double rows planting pattern. The same trend was observed in the year 2000 except that triple row strips (30/120 cm) planting pattern significantly decreased the number of grains panicle^{-1} than single rows conventional planting. This decrease in the number of grains panicle^{-1} produced in the triple row strips planting pattern might be the result of mutual shading effect and plants competition for nutrients etc. due to close spaces among the plants.

pattern and legume intercropping (PXA) was found non-significant in both the years of study.

The data (Table-III) showed that grain yield of sorghum was significantly affected by planting pattern in both the years of study. During 1999, highest grain yield of 5.94 t ha^{-1} was obtained from double row strips planting pattern showing 5 and 7% increase over single rows (60 cm apart) and triple row strips (30/120 cm) planting of sorghum, respectively. The yield of single rows (5.65 t ha^{-1}) and triple row strips (5.53 t ha^{-1}) planting pattern also differed significantly. Similar trend was observed in the yield data recorded during 2000. Increase in grain yield of sorghum grown in the double row strips (30/90 cm) planting pattern might be attributed to the maximum number of grains panicle^{-1} and efficient use of the available resources by the crop. These results were supported by Himayatullah (1991) indicating that maize gave maximum grain yield in double row strips (30/90 cm) planting as compared to single rows (60 cm apart) planting of maize. The data further revealed that legumes intercropping also

Table II. Number of grains panicle^{-1} of sorghum as affected by planting pattern and legumes intercropping at AZRI, D.I. Khan

Planting pattern (P)	1999				2000			
	Legume intercropping (A)				Legume intercropping (A)			
	A_0	A_1	A_2	Average	A_0	A_1	A_2	Average
P_1	2146	2113	2089	2116 [b]	2119	2088	2069	2092 [b]
P_2	2185	2130	2130	2173 [a]	2147	2125	2104	2125 [a]
P_3	2152	2107	2049	2103 [b]	2113	2054	2025	2064 [c]
Average	2167 [a]	2135 [b]	2089 [c]		2126 [a]	2089 [b]	2066 [c]	
LSD	22.00			21.05	18.50			17.44

P_1 = 60 cm spaced single rows
P_2 = 90 cm spaced double row strips(30/90 cm)
P_3 = 120 cm spaced triple row strips (30/120 cm)
*Means having different letter differ significantly at P<0.05

A_0 = Sorghum alone
A_1 = Sorghum+mungbean
A_2 = Sorghum+guar
**NS: Non-significant.

Data further indicated that legumes intercropping had significantly decreased the number of grains panicle^{-1} of sorghum compared to sole sorghum. In 1999, sole sorghum produced maximum number of grains panicle^{-1}(2167) compared to sorghum grown in the association of mungbean and guar produced 2135 and 2089 grains panicle^{-1}, respectively. Similar trend was noted in the year 2000. This decrease in number of grain panicle^{-1} of sorghum associated with legume might be the result of competition for inputs by legumes grown with sorghum. These findings were supported by Himayatullah (1991) who recorded similar decrease in number of grains cob^{-1} of base crop when associated with intercrops. The interaction between planting

significantly affected the grain yield of sorghum in both the years. In 1999, sole sorghum produced significantly more grain yield (5.91 t ha^{-1}) than sorghum associated with mung bean or guar. The same trend of increase in grain yield of sole sorghum was observed in the year 2000. This suggests that association of legume have a determintal effects on plant growth due to competition for light, moisture and nutrients which ultimately reduced the grain yield of associated sorghum. Malai and Muthasankaranarayanan (1999) recorded similar increase in grain yield of sole sorghum than intercropped one. The interaction between planting pattern and legumes intercropping as regards grain yield of sorghum was non-significant in both the years of study.

Table III. Grain yield (t ha^{-1}) of sorghum as affected by planting pattern and legumes intercropping at AZRI D.I. Khan

Planting pattern (P)	1999				2000			
	Legume intercropping (A)				Legume intercropping (A)			
	A_0	A_1	A_2	Average	A_0	A_1	A_2	Average
P_1	5.85	5.59	5.51	5.65 [b]	5.69	5.45	5.41	5.52 [b]
P_2	6.12	5.98	5.71	5.94 [a]	5.93	5.82	5.69	5.78 [a]
P_3	5.76	5.49	5.33	5.53 [c]	5.65	5.37	5.12	5.38 [c]
Average	5.91[a]	5.69 [b]	5.52 [c]		5.76 [a]	5.55 [b]	5.38 [c]	
LSD	0.120			0.113	0.121			0.105

P_1 = 60 cm spaced single rows
P_2 = 90 cm spaced double row strips(30/90 cm)
P_3 = 120 cm spaced triple row strips (30/120 cm)
*Means having different letter differ significantly at P<0.05

A_0 = Sorghum alone
A_1 = Sorghum+mungbean
A_2 = Sorghum+guar
**NS: Non-significant.

Grain protein content data of sorghum (Table IV) indicated that planting pattern had showed non-significant effect on the quality of sorghum grain during 1999. Whereas in 2000 the data showed that double row strips (9.41%) and triple row strips (9.34%) planting pattern had significantly increased the grain protein content of sorghum than single rows. These results are in accordance with the work of Himayatullah (1991) who reported significant increase in the grain protein content of maize when crop was grown in paired row strips (30/90 cm) as compared to single rows (60 cm apart) planting of maize.

The data further revealed that legumes intercropping had significantly increased the grain protein content of sorghum in both the years. In the first year of study, mungbean intercropping significantly increased the grain protein content (9.51%) of sorghum than sorghum associated with guar (9.30%) and sorghum grown alone (9.19%). Almost similar increase in grain protein content of sorghum was observed in the second year of study. This might be attributed to the N-transfer from companion legumes to the non-legume sorghum crop. These results are in line with the work of Power *et al.* (1986), Ofosubudu *et al* (1995) and Pal and Sheshu (2001). They reported similar benefits when legumes were grown as intercrops in sorghum and maize based cropping system.

The interaction between planting pattern and legumes intercropping was found non-significant at all the levels of interaction with regards to grain protein content of sorghum during both the years of study. However, it is clear from the Table IV that highest grain protein

Table IV. Grain protein content (%) of sorghum as affected by planting pattern and legumes intercropping at AZRI D.I.Khan.

Planting pattern (P)	1999				2000			
	Legume intercropping (A)				Legume intercropping (A)			
	A_0	A_1	A_2	Average	A_0	A_1	A_2	Average
P_1	9.10	9.48	9.30	9.29	9.08	9.35	9.15	9.19 [c]
P_2	9.28	9.53	9.35	9.39	9.25	9.58	9.40	9.41 [a]
P_3	9.18	9.52	9.25	9.32	9.13	9.55	9.35	9.34 [b]
Average	9.19[c]	9.51[a]	9.30[b]		9.15[c]	9.49[a]	9.30[b]	
LSD	0.133			NS	0.103			0.095

P_1 = 60 cm spaced single rows
P_2 = 90 cm spaced double row strips (30/90 cm)
P_3 = 120 cm spaced triple row strips (30/120 cm)
*Means having different letter differ significantly at P<0.05

A_0 = Sorghum alone
A_1 = Sorghum+mungbean
A_2 = Sorghum+guar
**NS: Non-significant.

content of 9.53 and 9.58% was observed when sorghum was grown in double row strips (30/90 cm) planting pattern with two rows of mung bean as intercrops between the sorghum strips during 1999 and

2000, respectively. These results were supported by Shivay and Singh (2000) who reported maximum N uptake by maize under paired row (45/90 cm) planting pattern of maize + urdbean. The findings of this experiment revealed that sorghum-mungbean intercropping in the planting pattern of double row strips (30/90 cm) improved the grain quality of sorghum than mono cropped or intercropped sorghum in the pattern of single rows (60 cm apart) or triple row strips (30/120 cm) planting pattern of sorghum under climatic condition of D.I.Khan, Pakistan.

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