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Contribution of Cereal-Legume Association to the Yield and Grain Quality of Cereals

Abdur Rashid[a]*, Himayatullah[b] and Rahmatullah Khan[a]
[a]Arid Zone Research Institute, Ratta Kulachi, Dera Ismail Khan, Pakistan
[b]Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan

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Abstract. A study on the mixed cereal-legume cultivation in different planting patterns was undertaken for two consecutive years. The aim was to investigate the contribution of the association of legumes towards yield and grain quality of cereal crops. The data indicated that the association of legumes in different planting pattern with sorghum affected the yield and grain quality of sorghum. During both the years of study, the double row strips (30/90 cm) planting pattern significantly increased the grain yield of sorghum, as compered with single rows (60 cm apart) and triple row strips (30/120 cm). The grain yield of sorghum decreased when sorghum was associated with mungbean or guar, but the additional harvest of intercrops increased the total productivity. The difference in grain yield between the treatment means of interaction was non-significant. 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 grain protein content (respectively, 9.41% and 9.34%) of sorghum, as compared with single row planting pattern (protein content of 9.19%). Sorghum grain protein content of 9.51 and 9.49% produced in association with mungbean was significantly more than the grain protein content of sorghum alone or sorghum grown in the association with guar during 1999 and 2000, respectively. Increase in grain protein content of sorghum, when associated with mungbean, was attributed to the N transfer from companion mungbean to sorghum. It may be concluded from the results obtained that sorghum + mungbean association in the double row strips (30/90 cm) planting pattern can efficiently utilize the available resources to improve the grain quality and overall production of sorghum-based cropping system.

Keywords: *Sorghum bicolor,* crop planting pattern, cereal-legumes association, grain yield, sarghum protein content

Introduction

Intercropping of cereals-legumes has become a common practice in the developing countries. Traditionally, this system of farming aims to avoid the risk of crop failure, to meet diversified needs of the farmer family, and to increase total productivity from the small piece of land-holdings. Research findings have revealed that the mixed cropping of cereals-legumes not only increases the overall productivity, but also reduce soil erosion, improves the declining level of soil fertility, and results in sufficient supply of nitrogen to the companion crops or at the least improved residual nitrogen carryover to the next crop. Zougmore *et al.* (2000) reported that sorghum-cowpea intercropping not only doubled the grain yield, but also reduced run off by 20-30%, as compared to a sorghum mono- culture. Ibrahim *et al.* (1987) reported that soybean can fix 60-168 kg of atmospheric nitrogen to the soil per year. Pal and Shehu (2001) studied the direct and residual contribution of legumes to the yield and nitrogen uptake of maize crop and found that all the legume crops contributed to the yield and N uptake of maize, when either intercropped with the legume or grown after legumes as the sole crop. Direct transfer of N from the nodulating soybean, lablab bean, green gram and black gram to the intercropped maize crop was 29.9-30.1, 23.8-29.2, 19.7-22.1 and 18.4-18.6 kg N/ha, 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, respectively. Hussain *et al.* (1999) revealed that sowing of sorghum in double row strips with legumes as intercrops gave the highest fresh and dry matter yield, as compared to sole sorghum cultivation. Shievay and Singh (2000) indicated maximum N uptake by maize crop when maize was grown in association with ‘urd’ bean than the N uptake by the sole maize crop.

Legumes, being a rich and cheaper source of proteins, can be grown successfully as intercrops in the cereal-based cropping system. Intercropping not only increases total productivity as equivalent yield, but also contributes a considerable portion of proteins in human diet and animal feeds (Annonymous, 1990). Malik *et al*. (1998) reported that in the intercropping of mungbean and maize crop, the yield of component crops tended to decrease, but the total yield of intercropping pattern was higher than sole cropping of either crop. Munir *et al.* (2004) indicated that wheat-gram intercropping under 4, 6, 8 and 10 rows of wheat strips increased wheat yield

*Author for correspondence; E-mail: drrashid_azri@yahoo.com

equivalent by 39.94, 9.48, 5.80 and 5.90%, respectively, over sole cropping of wheat. Singh and Balyan (2000) indicated that the intercropping system gave significant increase in total productivity (sorghum equivalent) over sole sorghum cropping. It was noted that alternate rows at 30 cm planting was the best combination to achieve higher grain yield of the intercropped species (guar and black gram). Similarly, Goswami *et al*. (1999) found that soybean : sorghum (2 : 2) intercropping system produced the highest equivalent yield, as compared to mono-crop of either species. Sherma *et al.* (2000) also reported that sorghum + soybean (30/90 cm) paired row planting pattern with two rows of soybean gave 38-124% higher yield than the other cropping patterns of component crops. 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).

Sorghum being a multipurpose crop has a great scope to accommodate legume species as intercrops without resorting to extra inputs and loosing its yield potential. The overall objective of this study was to improve agricultural productivity and to meet the nutritional demands of the increasing demographic pressure in Pakistan.

Materials and Methods

Present study was conducted at the Arid Zone Research Institute, Dera Ismail Khan, Pakistan, during 1999 and 2000. The primary aim was to determine the effect of legume association on the yield and grain quality of a cereal crop (sorghum). The intercropping system included: (i) sole sorghum crop; (ii) sorghum + mungbean intercrops; and (iii) sorghum + guar intercrops in three different planting patterns of single rows (60 cm apart) double row strips (30/90 cm), and triple row strips (30/120 cm) of sorghum. The space between the rows in a strip was 30 cm. All the components of crop, including the major crop (sorghum) and legumes as intercrops, were seeded @ 20 kg/ha, each on the same day of sorghum sowing. Soil characteristics of the experimental field are presented in Table 1.

Table 1. Physical and chemical properties of the cropping soil taken at the depth of 0-30 cm

Chemical properties	
pH	8.2
Electrical conductivity (dS m^{-1})	2.7
Organic matter (%)	0.75
Total nitrogen (%)	0.035
Available phosphorus (ppm)	56.9
Extractable potassium (ppm)	102
Physical properties	
Sand (%)	11.5
Silt (%)	37.2
Clay (%)	51.3

The experiment was laid out in the randomized complete block design, with four replications per treatment. The plot size was 4 x 3.6 m. In total, 90-60 kg/ha NP was applied. Nitrogen was applied in three equal splits @ 30 kg/ha. The first dose of nitrogen (30 kg/ha) was applied to the whole experimental plot uniformly with full dose of phosphorus at the time of land preparation. The second and third dose of nitrogen were applied to sorghum crop only with 15 days interval after 30 days of sowing during both the years of study. In all, four irrigations were applied. Thinning was carried out twice to obtain the optimum plant stand and weeds were removed manually. Furadon granules @ 25 kg/ha were applied to sorghum crop only before heading for control of stem borer. Ten plants from each treatment of the legume species (mungbean and guar) were carefully uprooted at flowering and washed in pot to count the number of nodules/plant individually, and then averaged. The nodules of individual plants of each species in a treatment were weighted on electric balance and averaged to record fresh weight of nodules/plant. For the collection of grain yield data, full plot of sorghum and intercrops were harvested at the time of maturity. The harvested crops were tied in small bundles and put under sunlight for drying in an open space for about a week. The sun-dried bundles were threshed manually and the grain yield data were recoded. The grain protein content was determined by micro-Kjeldahl method (AOAC, 1984). The collected data were analyzed statistically using Duncan's multiple range (DMR) test (Steel and Torrie, 1984).

Results and Discussion

The data obtained indicated that planting pattern and legume association significantly affected the grain yield of sorghum during both the years of study (Table 2). During 1999, the highest grain yield of 5.94 ton/ha, irrespective of the legume species involved in the association, was obtained from the double row strips planting pattern as compared to single rows (60 cm apart) and triple row strips (30/120 cm) planting pattern of sorghum. The yield of single rows (5.65 ton/ ha) and triple row strips (5.53 ton/ha) planting pattern also differed significantly. Similarly, grain yield of sorghum, irrespective of the legume species involved in the association, obtained in the double row strips (30/90 cm) planting pattern, was also higher than the other planting patterns of sorghum during

2000. This increase in the grain yield of sorghum, grown in the double row strips (30/90 cm) planting pattern, may be attributed to the maximum penetration of light and efficient use of other inputs such as nutrients and moisture by the crop. These results are in agreement with those reported by Jafar *et al.* (1988) showing that the maize crop gave higher grain yield in double row strips (30/90 cm) planting as compared to other planting patterns.

The data further indicated that the association of legumes significantly decreased the grain yield of sorghum. In 1999, the sole sorghum crop, irrespective of the planting pattern, showed higher grain yield of 5.91 ton/ha, as compared to grain yield of sorghum associated with mungbean (5.69 ton/ ha), or guar with the grain yield of 5.52 ton/ha. Similarly, in the year 2000, grain yield of the sole sorghum crop was more than the grain yield of sorghum associated with mungbean and guar. Malik *et al*. (2002) recorded similar increase in grain yield of sole wheat crop than the intercropped treatments of wheat. The mode of interaction between planting pattern and the association of legumes, as compared with the grain yield of sorghum, was non-significant during both the years of study.

The data on grain protein content of sorghum (Table 3) indicated that the grain quality of sorghum was not affected by the planting pattern during 1999. During the second year of study (2000), however, the data showed that the modified planting pattern had significantly increased the grain protein content of sorghum, whereas double row strips planting pattern produced protein-rich grains of sorghum having protein content of 9.41%, followed by triple row strips planting pattern with protein content of 9.34%. These results are in agreement with the findings of Himayatullah (1991), who obtained significant increase in the grain protein content of maize when the crop was grown in paired row strips (30/90 cm) as compared to single rows of maize.

The results of the association of legumes showed significant effect on the grain quality of sorghum during both the years of study. During 1999, mungbean association significantly increased the grain protein content of sorghum (9.51%), which was more than the sorghum associated with guar (9.30%), or sorghum grown alone having grain protein content of 9.19%. During the second year of study (2000), the grain protein content of sorghum (9.49%) similarly increased with mungbean association, as compared to other treatments. This increase in the grain protein content of sorghum was attributed to the N-transfer from companion legume (mungbean) to the non-legume sorghum crop. These results are in agreement with those reported by Pal and Shehu (2001). They noted similar increase in the maize grain protein contents when legumes and maize were cultivated in an intercropping system.

The interacting effect of planting pattern and legume association was found to be non-significant in terms of the grain protein content of sorghum during both the years of study. However, the data indicated that sorghum + mungbean association in double row strips (30/90 cm) planting pattern produced highest quality sorghum grains during both the years. Shievay and Singh (2000) obtained similar results in the case of maize + 'urd' bean cropping in paired row planting pattern. The results of the present study of two years suggest that sorghum-mungbean association in the planting pattern of double row strips (30/90 cm) can improve the quality of sorghum grains to produce nutritious feed and fodder for livestock as compared with the mono-cropped sorghum. The data

Table 2. The effect of association of legumes (mungbean/guar) on the grain yield (ton/ha) of sorghum in different planting patterns

Planting pattern	Grain yield (ton/ha) during 1999				Grain yield (ton/ha) during 2000			
	legume association				legume association			
	sorghum alone	sorghum + mungbean	sorghum + guar	average*	sorghum alone	sorghum + mungbean	sorghum + guar	average*
Single rows (60 cm spaced)	ns	5.59	5.51	5.65 [b]	ns	5.45	5.41	5.52[b]
Double row strips (30/90 cm)	6.12	5.98	5.71	5.94 [a]	5.93	5.82	5.69	5.78[a]
Triple row strips (30/120 cm)	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

* = mean values followed by the same letter do not differ significantly at 5% level of probability; ns = non- significant; LSD = least significant difference

given in Table 4 support these observations. It may be noted that mungbean showed the highest number and fresh weight of nodules per plant, which indicates that more atmospheric nitrogen may have been fixed and released to the companion sorghum as compared to other treatments.

The data presented in Table 4 further show that irrespective of the planting pattern, the highest number and fresh weight of nodules/plant were produced by mungbean than guar in association with sorghum during both the years of study. Moreover, the number and fresh weight of nodules/plant of legumes increased when the distance between the sorghum strips was increased. This suggests that in the case of wider space between the sorghum strips, legumes utilized the environmental resources such as CO_2, O_2, N_2, moisture, temperature and light more efficiently, which resulted in higher number and fresh weight of nodules/plant. This in turn resulted in greater release of nitrogen, showing positive effect on the growth of sorghum.

Table 3. The effect of association of legumes (mungbean/guar) on the protein content (%) of grains of sorghum grown in different planting patterns

Planting pattern	Grain protein content (%) during 1999				Grain protein content (%) during 2000			
	legume association				legume association			
	sorghum alone	sorghum + mungbean	sorghum + guar	average*	sorghum alone	sorghum + mungbean	sorghum + guar	average*
Single rows (60 cm spaced)	9.10	9.48	9.30	9.29	9.08	9.35	9.15	9.19^{b}
Double row strips (30/90 cm)	9.28	9.53	9.35	9.39	9.25	9.58	9.40	9.41^{a}
Triple row strips (30/120 cm)	9.18	9.52	9.25	9.32	9.13	9.55	9.35	9.34^{a}
Average	9.19^{b}	9.51^{a}	9.30^{b}		9.15^{c}	9.49^{a}	9.30^{b}	LSD
0.133	ns	0.103	0.095					

*= mean values followed by the same letter do not differ significantly at 5% level of probability; ns = non-significant; LSD = least significant difference

Table 4. The number and fresh weight (g) of nodules/plant* produced in the legume (mungbean/guar)-sorghum intercropping farming system

Planting pattern	1999 Cropping			2000 Cropping		
	legume association			legume association		
	sorghum + mungbean	sorghum + guar	average	sorghum + mungbean	sorghum + guar	average
a. Number of nodules/plant						
Single rows (60 cm spaced)	23.75	11.75	17.75^{c}	20.25	12.00	16.13^{c}
Double row strips (30/90 cm)	30.10	14.25	22.13^{b}	21.00	13.75	17.35^{b}
Triple row strips (30/120 cm)	36.50	16.25	26.38^{a}	30.75	17.00	23.88^{a}
Average	30.08^{a}	14.08^{b}		24.00^{a}	14.25^{b}	
LSD	4.456	3.83	7.468	6.421		
b. Fresh weight of nodules/plant						
Single rows (60 cm spaced)	2.09	0.91	1.50^{b}	1.88	0.33	1.11^{b}
Double row strips (30/90 cm)	2.13	1.07	1.60^{ab}	2.11	0.52	1.32^{ab}
Triple row strips (30/120 cm)	2.31	1.37	1.84^{a}	2.22	1.11	1.67^{a}
Average	2.18^{a}	1.12^{b}		2.07^{a}	0.65^{b}	
LSD	0.346	0.297	0.426	0.366		

*= mean values followed by the same letter do not differ significantly at 5% level of probability; LSD = least significant difference

Table 5. Yield of mungbean and guar as intercrops in sorghum based cropping

Planting pattern	Grain yield (ton/ha) during1999 legume association			Grain yield (ton/ha) during 2000 legume association		
	mungbean + sorghum	guar + sorghum	average	mungbean + sorghum	guar + sorghum	average
Single rows (60 cm spaced)	0.343	0.355	0.349 [b]	0.300	0.330	0.315 [b]
Double row strips (30/90 cm)	0.440	0.462	0.451 [a]	0.395	0.399	0.397 [a]
Triple row strips (30/120cm)	0.444	0.472	0.458 [a]	0.400	0.408	0.404 [a]
Average	0.409	0.430		0.365	0.379	
LSD	ns	0.095	ns	0.033		

* = mean values followed by the same letter do not differ significantly at 5% level of probability; ns = non-significant; LSD = least significant difference

Data on the yield of mungbean and guar showed that the grain yield of mungbean and guar, irrespective of the planting pattern, was non-significant during 1999 and 2000 (Table 5). The yield data of intercrops, irrespective of the legume species was significantly affected by the planting pattern during both the years of study. The yield of intercrops obtained in double and triple row strips planting pattern was significantly more than the grain yield of 0.349 ton/ha, obtained in 60 cm spaced single rows of sorghum in 1999. During the second year of study, the yield of intercrops in double and triple row strips planting pattern similarly increased as compared with the yield of single rows (0.315 ton/ha). This increasing trend in yield of intercrops in the double and triple row planting pattern may be attributed to the greater interception of light and aeration in the wider spaces of sorghum. The interaction between planting pattern and the legume intercrops was non-significant.

The findings of this study revealed that the grain yield and quality of sorghum can be improved by mungbean association in modified planting pattern of double row strips (30/90 cm). This technique of sowing may prove useful for the better realization of land and crop productivity per ha. This will in turn contribute to improving the life styles of agrarian societies.

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