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Research Paper

Effect of planting pattern and fertility level on hybrid maize (*Zea mays*) + legume intercropping system under dryland condition

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ABSTRACT

A field experiment was conducted in rainy (*kharif*) seasons of 2011 and 2012, to assess the effect of planting pattern and fertility level on maize (*Zea mays* L.) with blackgram [*Vigna mungo* (L.) Hepper] and soybean [*Glycine max* (L.) Merril]-based intercropping system under dryland conditions in alluvial soil of Vatanasi, Uttar Pradesh. Among the planting patterns tested, blackgram proved the best intercrops for maize-based planting pattern compared to soybean. In maize condition, maize paired row (50/100 cm) + blackgram (2:1) significantly increased growth, yield attributes and yield. However, intercropping of blackgram and soybean recorded the maximum yield with maize-paired row (50/100 cm) + intercrops (2:2), owing to higher plant population of intercrops compared to other planting pattern, except yield attributes. In case of fertility level, maize with 100% recommended dose of fertilizer (RDF) + intercrops with 100% RDF recorded the maximum growth, yield attributes and yield, during both the years of investigation. Finally, maize paired row with 2 rows of blackgram intercropping with 100% RDF of both main and intercrops, proved to be the best combination by recording the maximum land-equivalent ratio, maize-equivalent yield, net returns and benefit: cost ratio. Maize with positive aggresivity factor acted as a dominant crop component in overall treatments.

Key words: Blackgram, Economics, Intercrops, Maize, Paired row, Sole crops, Soybean, Uniform row

Since maize is a widely spaced crop, inter-row space could profitability be utilized for legumes. Maize–legume intercropping system, besides increasing productivity and profitability also improves soil health, conserves soil moisture and increases total out turn. In recent years, the area under hybrid maize has increased tremendously in northern parts of the country. Being a potential crop in India, maize occupies an important place as a source of human food (25%), animal feed (12%), poultry feed (49%), industrial products mainly as starch (12%) and (1%) each in brewery and seed (Dass *et al*., 2008). 'HQPM 1' is the first yellow grain QPM single-cross hybrid, which is particularly responsible for enhancing lysine and tryptophan content of maize endosperm protein. Intercropping of legumes with maize is a recognized practice for economizing the use of nitrogenous, phosphate fertilizers and increasing the productivity and profitability per unit area and time. The present study was therefore conducted to evaluate planting pattern and fertility level in maize-based intercropping systems.

MATERIALS AND METHODS

The field study was conducted during the rainy season (*kharif*) season of 2011 and 2012 at the research farm of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh (India). The experimental soil was Gangetic alluvial with *p*H 7.26. It was moderately fertile, being low in available organic carbon (0.36%) as well as available N (202.5 kg/ha) and medium in available phosphorus (23.7 kg/ha) as well as available potassium (233.4 kg/ha). The experiment was laid out in split-plot design, comprising 6 planting patterns of maize-based intercropping in additive series, i.e. maize uniform row (75 cm) + blackgram (1:1), maize uniform row (75 cm) + soybean (1:1), maize paired row (50/100 cm) + blackgram (2:1), maize paired row (50/100 cm) + soybean (2:1), maize paired row (50/100 cm) + blackgram (2:2), maize paired row (50/100 cm) + soybean (2:2) in main plots and

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3 different doses, i.e. 100% recommended dose of fertilizer (RDF) for maize + 0% RDF for intercrops, 100% RDF for maize + 50% RDF for intercrops and 100% RDF for maize + 100% RDF for intercrops in subplots. Four additional plots of sole maize uniform and paired 'HQPM 1', sole blackgram 'T 9' and sole soybean 'PS 1024' were taken for the estimation of yield, aggresivity and land-equivalent ratio. Thus, all the total 22 [(6 main plots × 3 subplots) + 4 additional plots] treatment combinations were replicated thrice. In sole as well as in intercropping system, maize crop was sown at a row spacing of 75 cm in uniform planting and row spacing of 50 cm in paired planting with plant-to-plant distance of 20 cm. However, in sole blackgram and soybean, closely sowing was done at a row spacing of 30 cm. The plant-to-plant distance of blackgram and soybean was maintained at 10 cm by 1 thinning 15 days after sowing (DAS). In general, the weather conditions were less congenial during the first year than the second year of experimentation (equally distribution of rainfall in 2012 over the 2011) and consequently resulted in slightly lower crop yield in the former. The total rainfall received during crop season (July–October) was 874.9 mm in 2011 and 608.2 mm in 2012. Economics was worked out on the existing market price.

Maize-equivalent yield, crop-growth rate, aggressivity and land-equivalent ratio were calculated by standard methods.

RESULTS AND DISCUSSION

Growth

Maize: Of the different planting patterns, maize paired row (50/100 cm) + blackgram (2:1) resulted in the highest dry-matter accumulation/plant at harvesting stage; it was significantly superior to the maize uniform row with intercrops at harvest stage of crop growth. However, maize paired row (50/100 cm) + blackgram (2:1) were statistically at par to all maize paired row with intercrops, during both the years. Amongst different fertility level, maize with 100% recommended dose of fertilizer (RDF) + intercrops with 100% RDF revealed the maximum dry-matter accumulation/plant, which was at par with maize with 100% RDF + intercrops with 50% RDF to maize with intercrops at harvesting stage. Crop-growth rate (CGR) is the gain in dry-matter production on a unit of land in a unit of time and indicated that it's declined drastically after 75 days after sowing (DAS) till maturity. However, effect of planting pattern and fertility level on crop-growth rate did not show any significant variation in 75 DAS–at harvesting during both the years. However, on the mean basis higher values of dry-matter accumulation and crop growth rate were noticed with sole maize.

Intercrops: The effect of planting pattern on dry-matter accumulation/plant and number of branches/plant were non-significant at harvesting stage in both the years. The maximum dry-matter accumulation/plant and branches/plant were recorded with maize paired row (50/100 cm) + intercrops (2:1) compared other planting pattern. In fertility level, dry-matter accumulation/plant and branches/plant were recorded significantly with maize with 100% RDF + intercrops with 100% RDF, which was at par with maize with 100% RDF + intercrops with 50% RDF. On the mean basis, dry-matter accumulation/plant and branches/plant of blackgram and soybean were higher in sole stands over their intercropped stands.

Yield attributes and grain yield

Maize: Maize paired row (50/100 cm) + blackgram (2:1) gave significantly higher grains/cob and grain yield over the maize uniform row (75 cm) + intercrops (1:1). However, the grain yield of maize in intercropping of maize paired row (50/100 cm) + blackgram (2:1) was statistically at par with all maize paired rows with intercrops in treatments. On the sole crop mean basis, grain yield in maize paired sole cropping was slightly higher than maize uniform (2.58%). In treatments and sole crop of maize lower reduction in grain yield of paired row compared with uniform row might be due to more space, light penetration and more uptake of nutrients (Sarkar *et al*., 2003). In fertility level, the best performance in respect of grain yield was recorded with maize with 100% RDF + intercrops with 100% RDF treatment, which was at par with maize with 100% RDF + intercrops with 50% RDF during both the years (Table 2).

Intercrops: The agro-climatic condition of Eastern Uttar Pradesh is favourable for maize with balckgram intercropping cultivation in *kharif* season, compared to maize with soybean intercropping systems. The effect of planting pattern on grains/pod in blackgram was non-significant, but statistically significant in soybean both the years. Grains/pod in soybean, the treatment of maize paired row (50/100 cm) + soybean (2:1) was found significantly superior to entire maize planting pattern (Table 2). In fertility level, the treatment of maize with 100% RDF + intercrops with 100% RDF recorded significantly higher grains/pod, being at par with maize with 100% RDF + intercrops with 50% RDF, during both the years. The grain yield of intercrops under maize intercropping system, maize paired row (50/100 cm) + intercrops (2:2) was found significantly superior to other treatments of both the years, owing to higher plant population (40%) in maize paired row (50/100 cm) + intercrops (2:2) compared to maize (75 cm) + intercrops (1:1, 33%) and maize paired row (50/100 cm) + intercrops (2:1, 10%). Maize with 100% RDF + intercrops with 100% RDF gave the maxi-

mum grain yield and showed its significant superiority to maize with 100% RDF + intercrops with 50% RDF and maize with 100% RDF + intercrops with 0% RDF. On the mean basis, grain yield in sole (blackgram and soybean) crops was higher than the intercrops, owing to treatment-wise minimum population of blackgram and soybean in intercrops.

Maize-equivalent yield

Maize paired row (50/100 cm) + blackgram (2:2) showed the best performance for maize-equivalent yield, (MEY) followed by maize paired row (50/100 cm) + blackgram (2:1) and maize uniform (75 cm) + blackgram (1:1) compared to all planting patterns with soybean intercropping systems and sole crops (Table 2). This increase was mainly owing to additional yield advantage of blackgram intercropping as well as higher market price of grain blackgram than that of soybean and maize grain. The improvement in yield could be owing to the synergistic effect of maize and blackgram association. The highest MEY was recorded when maize received 100% RDF + intercrops received 100% RDF and the next was maize with 100% RDF + intercrops with 50% RDF). These results are in accordance with findings of Meena *et al.,* (2006).

Aggresivity

Maize with positive aggresivity factor was aggressive under both the planting patterns in intercropping and among fertility level acted as a dominant crop component, but blackgram and soybean with negative aggresivity factor was aggressive under all planting patterns as well as fertility levels in intercropping acted as a dominated crop (Table 3). Aggresivity values were greater than zero in both planting patterns and fertility level in intercropping systems, indicating yield advantage over sole maize. The results are in conformity with those of Sarkar *et al*. (2003).

Land-equivalent ratio

Maize paired row (50/100 cm) + blackgram (2:2) revealed the maximum land-equivalent ratio, followed by maize uniform row (75 cm) + blackgram (1:1) and paired row (50/100 cm) + soybean (2:2), reflecting their superiority among all the intercropping patterns. Nedunchezhiyan (2007) also reported higher LER value with greater yam-based intercropping system. Maize with 100% RDF + intercrops with 100% RDF exhibited maximum LER. The lowest LER was recorded under the maize with 100% RDF + intercrops with 0% RDF (Table 3).

Economics

Significantly highest net returns and benefit: cost ratio

Table 1. Effect of planting pattern and fertility level on growth parameters of maize with blackgram and soybean (mean data of 2 years)

Treatment	Dry matter accumulation (g/plant)			CGR (g/plant/day)	Branches/plant	
	Maize	Blackgram	Soybean	75 days–at harvest	Blackgram	Soybean
Planting pattern (MU/MP)						
Maize (75 cm) + blackgram (1:1)*	278.1	17.7	–	4.02	4.0	–
Maize (75 cm) + soybean (1:1)*	269.5	–	15.0	3.93	–	3.0
Maize (50/100 cm) + blackgram (2:1)**	293.5	18.6	–	4.14	4.4	–
Maize (50/100 cm) + soybean (2:1)**	290.6	–	16.5	4.11	–	3.3
Maize (50/100 cm) + blackgram (2:2)**	286.5	18.4	–	4.06	4.2	–
Maize (50/100 cm) + soybean (2:2)**	281.2	–	15.7	4.03	–	3.2
SEm±	4.2	0.8	0.5	0.07	0.13	0.12
CD (P=0.05)	13.3	NS	NS	NS	NS	NS
Fertility level (F)						
Maize + intercropping (RDF)						
100% + 0%	276.4	16.4	14.0	4.00	3.7	2.8
100% + 50%	284.5	18.4	16.1	4.06	4.3	3.2
100% + 100%	288.9	19.9	17.3	4.09	4.6	3.5
SEm±	2.9	0.6	0.4	0.05	0.08	0.11
CD (P=0.05)	8.5	1.8	1.4	NS	0.24	0.35
Sole (mean)						
Maize (75 cm)*	286.5	–	–	4.10	–	–
Maize (50/100 cm)**	293.8	–	–	4.15	–	–
Blackgram	–	19.5	–	–	4.7	–
Soybean	–	–	17.4	–	–	3.3

*Uniform row; **paired row; RDF, recommended dose of fertilizer

Table 2. Effect of planting pattern and fertility level on yield attributes and yields of maize with blackgram and soybean (mean data of 2 years)

Treatment	Grains/cob and pod			Grain yield (t/ha)			Maize-equivalent yield (t/ha)
	Maize	Blackgram	Soybean	Maize	Blackgram	Soybean	
Planting pattern (MU/MP)							
Maize (75 cm) + blackgram (1:1)*	345	4.3	–	5.95	0.168	–	6.53
Maize (75 cm) + soybean (1:1)*	325	–	2.8	5.85	–	0.162	6.16
Maize (50/100 cm) + blackgram (2:1)**	373	4.7	–	6.28	0.111	–	6.65
Maize (50/100 cm) + soybean (2:1)**	362	–	3.4	6.19	–	0.099	6.38
Maize (50/100 cm) + blackgram (2:2)**	357	4.5	–	6.15	0.212	–	6.86
Maize (50/100 cm) + soybean (2:2)**	345	–	2.9	6.03	–	0.210	6.38
SEm±	8	0.16	0.07	0.08	0.007	0.006	0.11
CD (P=0.05)	25	0.63	0.29	0.26	0.027	0.025	0.34
Fertility level (F)							
Maize + intercropping (RDF)							
100% + 0%	336	4.0	2.6	5.96	0.109	0.104	6.24
100% + 50%	354	4.6	3.1	6.09	0.168	0.157	6.51
100% + 100%	364	4.9	3.4	6.18	0.214	0.210	6.73
SEm±	5	0.10	0.08	0.05	0.007	0.006	0.08
CD (P=0.05)	15	0.30	0.24	0.15	0.020	0.019	0.23
Sole (mean)							
Maize (75 cm)*	357	–	–	6.19	–	–	6.19
Maize (50/100 cm)**	382	–	–	6.35	–	–	6.35
Blackgram	–	4.9	–	–	0.804	–	–
Soybean	–	–	3.3	–	–	0.909	–

*Uniform row; **paired row; RDF, recommended dose of fertilizer

Table 3. Effect of planting pattern and fertility level on biological feasibility (mean basis) and economical parameter of maize-based intercropping system (mean data of 2 years)

Treatment	Aggresivity			Land-equivalent ratio	Net returns ($\times 10^3$ ₹/ha)	Benefit: cost ratio
	Maize	Blackgram	Soybean			
Planting pattern (MU/MP)						
Maize (75 cm) + blackgram (1:1)*	1.50	-1.50	–	1.18	74.0	3.57
Maize (75 cm) + soybean (1:1)*	1.53	–	-1.53	1.12	68.2	3.32
Maize (50/100 cm) + blackgram (2:1)**	1.07	-1.07	–	1.13	76.5	3.69
Maize (50/100 cm) + soybean (2:1)**	1.13	–	-1.13	1.09	72.2	3.52
Maize (50/100 cm) + blackgram (2:2)**	1.40	-1.40	–	1.24	79.4	3.75
Maize (50/100 cm) + soybean (2:2)**	1.44	–	-1.44	1.18	72.7	3.49
SEm±	–	–	–	–	1.42	0.07
CD (P=0.05)	–	–	–	–	4.47	0.21
Fertility level (F)						
Maize + intercropping (RDF)						
100% + 0%	1.45	-1.44	-1.46	1.07	70.4	3.47
100% + 50%	1.34	-1.32	-1.37	1.16	74.1	3.57
100% + 100%	1.24	-1.21	-1.27	1.24	77.0	3.64
SEm±	–	–	–	–	0.80	0.04
CD (P=0.05)	–	–	–	–	2.35	0.12
Sole (mean)						
Maize (75 cm)*	–	–	–	1.0	69.5	3.47
Maize (50/100 cm)**	–	–	–	1.0	71.7	3.55
Blackgram	–	–	–	1.0	18.6	1.87
Soybean	–	–	–	1.0	5.3	1.23

*Uniform row; **paired row; RDF, recommended dose of fertilizer

were found with maize paired row (50/100 cm) + blackgram (2:2), which were at par with maize paired row (50/100 cm) + blackgram (2:1) and maize uniform row (75 cm) + blackgram (1:1). However, the minimum net returns and benefit: cost ratio were recorded in all planting patterns with soybean and sole crops (Table 3). A higher economic returns was recorded in intercropping of blackgram, owing to additional yield advantage as well as higher market price of blackgram compared to maize and soybean. Similar results were obtained by Rana *et al*. (2006). Among the fertility level, the highest net returns and benefit: cost ratio were obtained from maize with 100% RDF + intercrops with 100% RDF, which was at par with maize receiving 100% RDF + intercrops receiving 50% RDF in case of benefit: cost ratio. Shrivastava *et al*. (1996) also recorded almost similar finding in legumes crops. The minimum net returns was recorded in when the maize receive 100% RDF + intercrops receive 0% RDF benefit: cost ratio being 3.47.

Maize paired row and maize uniform row with intercropping of blackgram with fertility level of maize with 100% RDF + intercrop with 100% RDF is biologically and economically efficient system for dryland of Gangetic alluvial soil in Eastern Uttar Pradesh.

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