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Forage production potential and economics of maize (*Zea mays*) with legumes intercropping under various row proportions

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ABSTRACT

A field experiment was conducted during the summer season of 2006 and 2007 at Sabour, Bihar to assess the production potential and economic viability of intercropping of forage maize (*Zea mays* L.) with cowpea [*Vigna unguiculata* (L.) Walp.], rice bean [*Vigna umbellata* (Thumb) ohwi and ohashi] and clusterbean [*Cyamposis tetragonaloba* (L.) Taub.] under four row proportions, viz. 1:1, 1:2, 2:1 and 2:2. Intercropping of maize and cowpea in the row proportion 2: 2 recorded significantly higher total green fodder (43.2 t/ha), dry matter (9.6 t/ha) and crude-protein yield (1.1 t/ha) as well as net returns (Rs 16,104/ha) and benefit : cost ratio (1.84) compared with the other treatments except maize + rice bean planted in the ratio 2:2. The association of maize and cowpea in row ratio 2:2 also showed the highest land-equivalent ratio (1.84) and relative crowding coefficient (7.08), followed by maize + rice bean in 2:2 ratio. Among the component crops, maize was more competitive and aggressive than legume intercrops. However, maize intercropped with cowpea and rice bean both in row proportion 2:1 was found to be a compatible intercropping system with lower values of aggressivity (0.01) and competition ratio (1.03). Thus intercropping of forage maize with cowpea or rice bean both in 2:2 row ratio are the biologically and economically sustainable intercropping systems.

Key words: Economics, Forage, Intercropping, Legumes, Land-equivalent ratio, Maize, Relative crowding coefficient

Supply of forage is inadequate in the country not only in terms of quantity but also quality wise as well. The availability of green fodder becomes scarce during lean periods of May-June. Intercropping of cereals and legumes appears to be one of the feasible approaches for increasing the herbage yield, utilization of land efficiently and providing stability to production (Verma *et al.*, 2005). Maize (*Zea mays* L.) is an ideal forage crop, possessing quick growing and high-yielding ability during summer season and can be fed to the cattle at any stage of growth, as there is no problem of hydrocyanic acid or oxalic acid poisoning to cattle. Intercropping of maize with legumes is more productive and remunerative (Pandey *et al.*, 2003; Kumar *et al.*, 2005) compared with their sole crops. The type of intercrop and spatial arrangement in intercropping have important effects on the balance of competition between the component crops and their productivity (Sarkar and Pal, 2004). Hence to get the best results, a rational approach is required for agronomic information on appropriate row proportion of forage maize and legumes in an intercropping system. The information on intercropping of forage maize with legumes is not adequate for summer season in alluvial plains of Bihar. Therefore this study was undertaken to assess the production potential and economics of different intercropping systems of maize with legumes at different row proportions during summer season.

MATERIALS AND METHODS

The experiment was conducted during summer season of 2006 and 2007 at Bihar Agricultural College Farm, Sabour, Bihar. The soil was sandy loam, having pH 7.3, low in organic C (0.42%) and available N (186.0 kg/ha), and medium in available P (12.2 kg/ha) and K (189.6 kg/ha). The treatments consisted of sole crops of maize (*Zea mays* L.), cowpea [*Vigna unguiculata* (L.) Walp.], rice bean [*Vigna umbellata* (Thumb) ohwi and ohashi] and clusterbean [*Cyamposis tetragonoloba* (L.) Taub.], and 12 intercropping systems of maize with each cowpea, rice bean and clusterbean in row ratios of 1:1, 1:2, 2:1 and 2:2 (Table 1). Sixteen treatments were laid out in randomized block design with three replications. Seed rate for each intercropping system was calculated on the basis of ratio

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indicating the number of rows of each component crop. Forage maize cv 'African Tall' and forage legumes, viz. cowpea cv 'EC 4216', rice bean cv 'Bidhan1' and cluster bean cv 'Bundel Guar 2', were sown 30 cm apart in different row ratios as per treatments in the second week of April and harvested in the second week of June during both the years. The seed rates for maize, cowpea, rice bean and clusterbean were 40, 30, 30 and 25 kg/ha, respectively. Recommended doses of 80 kg N+ 17.2 kg P + 16.6 kg K/ha in maize and 20 kg N + 21.5 kg P/ha in legume crops were applied in the form of urea, diammonium phosphate and muriate of potash, respectively as per row ratio of the component crops in the intercropping systems. The results of both the years were pooled and analysed statistically. The plant samples were oven-dried and the dry matter and crude-protein yields of the component crops were calculated by multiplying the dry-matter content to green fodder yield and protein content to dry-matter yield, respectively. The economics of different crops and crop combinations were computed on the basis of prevailing market rates of green fodder and inputs. For assessing the economic viability of the system, different competition indices were calculated as described by Willey (1979).

RESULTS AND DISCUSSION

Forage yield

Total green-fodder yields in all the intercropping systems were higher in 2006 than in 2007. The crop received 42.2 mm more rainfall during 2006, which provided favourable condition for growth and development of maize crop. However, the trends of various intercropping systems for green-fodder yield were similar during both the years. Green-fodder yield of maize in the intercropping was higher wherever the legumes yields were lower and *vice versa*. Maize in association with clusterbean gave comparatively higher yields than those in association with cowpea and rice bean. Variation in maize yield due to its association with different legumes might have been due to variation in their green-fodder yields.

Green-fodder and dry-matter yields were significantly affected by different intercropping treatments (Table 1). The total green fodder (43.2 t/ha) and dry-matter yields (9.6 t/ha) were the highest under maize + cowpea in 2:2 row ratio and significantly superior to the other intercropping systems except maize + rice bean planted in the ratio 2:2. The increase in total green-fodder and dry-matter yields with maize + cowpea in 2:2 row proportion was 22.7 and 11.5%, respectively compared with sole maize. In general, forage yield of the component crops, viz. maize + cowpea, maize + rice bean, and maize + clusterbean in intercropping decreased comparison with their respective sole stands. This decrease was compensated by contribution of both in total intercrop yield. Maximum contributions of cowpea in total green fodder and dry matter yields were 42.5 and 36.4% under intercropping of maize in the row ratio 1:2, followed by maize + cowpea intercropping system in 2:2 row proportion. The increase in total green fodder and dry matter yields in the intercropping systems might be owing to better utilization of space and light interception along with nutrient contribution of leguminous fodder to the cereal. Kumar *et al.* (2005) also reported beneficial effect of intercropping of maize and cowpea in the ratio 2:2 on green fodder and dry-matter yields.

Crude-protein yield

The influence of intercropping of maize with cowpea, rice bean and clusterbean was clearly evident in the total crude-protein yield of the system (Table 2). The highest total crude protein yield (1.10 t/ha) was recorded with maize + cowpea (2:2), which showed statistical parity with maize + rice bean (2:2) intercropping and these intercropping systems proved significantly superior to the rest of the systems. Intercropping of maize + cowpea in the ratio 2: 2 gave 52.6 and 38.6% higher crude-protein yield than sole stands of maize and cowpea, respectively. It was closely followed by intercropping of maize + rice bean in row ratio 2:2. The difference in crude-protein yield in all the treatments was noticed mainly due to variation in dry-matter yield of maize and cowpea or rice bean. The intercropping system with more number of legume rows recorded higher crude-protein yield. However, the total crude protein yield in intercropping system was the reflection of contribution from both the component crops. The contribution of cowpea and rice bean in total crude protein yield was 54.6 and 50.2% under intercropping of maize in the row ratio 1:2. Krishna *et al.* (1998) also reported pronounced effect of intercropping of forage legumes with cereals on crude-protein yield.

Economic viability

Intercropping of maize with cowpea, rice bean and clusterbean at different row ratios gave significantly higher net returns than their sole stands (Table 2). There was 116 to 194% increase in the net returns compared with sole maize under all the intercropping situations. The intercropping of maize with cowpea in 2:2 ratio gave the maximum net returns (Rs 16,104/ha) and benefit : cost ratio (1.84), followed by maize + rice bean in row proportion 2:2 (Rs 15,319/ha and 1.71, respectively). Maize in association with cowpea and rice bean in 1:2 ratio being at par, earned significantly higher net returns than the remaining intercropping systems. Among the intercropping systems, maize in association with clusterbean gave comparatively lower net returns than those in association with cowpea and rice bean. However, maize and clusterbean grown in 1:1 ratio recorded the lowest profitability. Patel and Rajgopal (2001) also reported monetary advantage with intercropping of forage legumes with maize.

Biological feasibility

Intercropping of maize resulted in LER more than 1, indicating intercropping advantage (Table 3). Intercropping of maize with cowpea, followed by maize with rice bean in 2:2 row proportion showed greater biological efficiency of the system, having LER values 1.45 and 1.38, respectively. These LER values showed that to produce a yield combined mixture by growing sole stands would require 45 and 38% more land, respectively. This yield advantage owing to intercropping might be attributed to the combined effect of better utilization of natural resources

Table 1. Green fodder and dry-matter yields (t/ha) of forage maize-based intercropping systems during summer season

Treatment	Green-fodder yield (t/ha)									Mean dry-matter yield (t/ha)		
	2006			2007			Mean					
	Main	Intercrop	Total	Main	Intercrop	Total	Main	Intercrop	Total	Main	Intercrop	Total
Maize (sole)	36.2		36.2	34.2		34.2	35.2		35.2	8.52		8.52
Cowpea (sole)		22.8	22.8		24.8	24.8		23.8	23.8		4.44	4.44
Rice bean (sole)		22.3	22.3		23.5	23.5		22.9	22.9		4.17	4.17
Clusterbean (sole)		19.7	19.7		21.5	21.5		20.6	20.6		4.03	4.03
Maize + cowpea (1:1)	24.6	12.4	37.0	21.6	14.0	35.6	23.1	13.2	36.3	5.59	2.46	8.05
Maize + cowpea (1:2)	22.4	15.4	37.8	20.4	16.2	36.4	21.4	15.8	37.2	5.16	2.95	8.11
Maize + cowpea (2:1)	29.6	9.0	38.6	27.8	10.2	38.0	28.7	9.6	38.3	6.95	1.81	8.76
Maize + cowpea (2:2)	27.9	15.8	43.7	25.7	17.0	42.7	26.8	16.4	43.2	6.49	3.08	9.57
Maize + rice bean (1:1)	25.6	10.5	36.1	22.8	12.1	34.9	24.2	11.3	35.5	5.84	2.04	7.88
Maize + rice bean (1:2)	23.8	13.2	37.0	21.6	14.2	35.8	22.7	13.7	36.4	5.39	2.47	7.86
Maize + rice bean (2:1)	28.4	8.4	36.8	27.2	9.2	36.4	27.8	8.8	36.6	6.73	1.59	8.32
Maize + rice bean (2:2)	26.9	15.2	42.1	24.9	16.0	40.9	25.9	15.6	41.5	6.25	2.81	9.06
Maize + clusterbean (1:1)	28.6	5.5	34.1	27.0	6.3	33.3	27.8	5.9	33.7	6.71	1.14	7.85
Maize + clusterbean (1:2)	27.6	7.4	35.0	24.8	8.2	33.0	26.2	7.8	34.0	6.32	1.51	7.83
Maizc + clusterbean (2:1)	32.2	4.2	36.4	30.0	4.8	34.8	31.1	4.5	35.6	7.43	0.86	8.29
Maize + clusterbean (2:2)	28.2	8.4	36.6	27.0	8.8	35.8	27.6	8.6	36.2	6.68	1.65	8.33
SEm±			0.84			0.68			0.71			0.17
CD (P=0.05)			2.45			2.05			2.25			0.50

Table 2. Crude-protein yield and economics of forage maize-based intercropping systems (mean data of 2 years)

Treatment	Crude-protein yield (t/ha)			Cost of cultivation (x 10^3 Rs/ha)	Net returns (x 10^3 Rs/ha)	Benefit : cost ratio
	Main	Intercrop	Total			
Maize (sole)	0.72		0.72	9.31	8.29	0.89
Cowpea (sole)		0.80	0.80	8.24	8.42	1.02
Rice bean (sole)		0.76	0.76	7.79	8.24	1.10
Clusterbean (sole)		0.75	0.75	7.48	6.94	0.93
Maize + cowpea (1:1)	0.47	0.44	0.92	8.78	12.01	1.37
Maize + cowpea (1:2)	0.44	0.54	0.99	8.51	13.25	1.56
Maize + cowpea (2:1)	0.59	0.32	0.91	9.04	12.03	1.33
Maize + cowpea (2:2)	0.55	0.55	1.10	8.78	16.10	1.84
Maize + rice bean (1:1)	0.50	0.38	0.87	8.55	11.46	1.34
Maize + rice bean (1:2)	0.46	0.46	0.92	8.15	12.79	1.57
Maize + rice bean (2:1)	0.58	0.30	0.87	8.92	11.14	1.25
Maize + ricc bcan (2:2)	0.54	0.52	1.06	8.55	15.32	1.71
Maize + cluster bean (1:1)	0.57	0.21	0.78	8.40	9.63	1.15
Maize + cluster bean (1:2)	0.54	0.28	0.82	7.95	10.62	1.34
Maize + cluster bean (2:1)	0.63	0.16	0.79	8.86	9.84	1.11
Maize + cluster bean (2:2)	0.57	0.31	0.87	8.40	11.42	1.36
SEm±			0.02		0.24	0.03
CD (P=0.05)			0.06		0.74	0.09

Selling price of green fodder (Rs/t): Maize, 500; legumes, 700

Table 3. Biological parameters of forage maize-based intercropping system (mean data of 2 years)

Treatment	LER	Competitive ratio		Relative crowding coefficient			Aggressivity	
		Maize	Intercrop	Maize	Intercrop	Product	Maize	Intercrop
Maize + cowpea (1:1)	1.21	1.20	0.83	1.91	1.24	2.37	0.11	- 0.11
Maize + cowpea (1:2)	1.27	1.85	0.54	3.10	0.99	3.07	0.36	- 0.36
Maize + cowpea (2:1)	1.24	1.03	0.98	1.69	1.35	2.28	0.01	- 0.01
Maize + cowpea (2:2)	1.45	1.10	0.91	3.19	2.22	7.08	0.04	- 0.04
Maize + rice bean (1:1)	1.18	1.41	0.71	2.20	0.97	2.13	0.20	- 0.20
Maize + rice bean (1:2)	1.24	2.13	0.47	3.63	0.75	2.72	0.34	- 0.34
Maize + rice bean (2:1)	1.17	1.04	0.96	1.85	1.25	2.31	0.01	- 0.01
Maize + rice bean (2:2)	1.38	1.16	0.86	2.78	2.13	5.92	0.03	- 0.03
Maize + clusterbean (1:1)	1.08	2.72	0.37	3.35	0.40	1.34	0.50	- 0.50
Maize + clusterbean (1:2)	1.12	3.89	0.26	5.82	0.30	1.75	0.55	- 0.55
Maize + clusterbean (2:1)	1.10	2.00	0.50	3.79	0.56	2.12	0.23	- 0.23
Maize + clusterbean (2:2)	1.20	1.86	0.54	3.66	0.72	2.64	0.18	- 0.18

than sole cropping of companion crops, resulting in higher productivity per unit area. Kumar *et al.* (2005) also reported higher LER value with maize and legume intercropping.

Intercropping of maize + legume at all row proportions proved advantageous, as the product of relative crowding coefficient (RCC) was more than 1 and showed the complementary relationship. The product of RCC was however, the highest (7.08) in the row ratio 2:2 of maize + cowpea, followed by that of maize + rice bean (5.92) grown in the same proportion. This might be owing to better utilization of land with the component crops, which recorded higher productivity of the component crops. The association of maize with clusterbean showed lower values of RCC, mainly due to low yields of clusterbean. Forage maize in combination with legumes in the ratio 1:2 was more competitive than all the intercropping systems, as this proportion had higher competitive ratios and aggressivity factors (Table 2). However, maize was more competitive and aggressive when grown in association with clusterbean, having higher values of both aggressivity and competitive ratio, but it was least competitive with cowpea and rice bean with lower values of aggressivity and competitive ratio both at 2:1 proportion. The increase in number of rows of legumes increased the competition between maize plants and thereby resulted in dominance power of legumes.

It was concluded that intercropping of forage maize with cowpea or rice bean both in 2:2 row ratio are biologically and economically sustainable intercropping systems for summer season.

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