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Yield, quality and economics as influenced by winter maize (*Zea mays*)-based intercropping system in eastern Uttar Pradesh

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ABSTRACT

An experiment was conducted during winter (*rabi*) season of 1994–95 and 1995–96 to evaluate the yield, quality and economics of winter maize (*Zea mays* L.)-based intercropping system under different planting pattern system and fertility level at Kumarganj (Faizabad). Maize grown with lentil (*Lens culinaris* Medikus) was more advantageous than *rajma (Phaseolus vulgaris* L.) and Indian mustard [*Brassica juncea* (L.) Czernj. & Cosson] and gave significantly highest average maize yield (74.0 q/ha), intercrop yield (11.4 q/ha), maize-equivalent yield (104.3 q/ha), uptake of N, P and K (168.9, 23.7 and 158.7 kg/ha), protein content (10%), carbohydrate content (68.7%), gross returns (Rs. 49,672/ha), net returns (Rs 32,571/ha) and benefit : cost ratio (1.91) over other intercropping system owing to minimum competition between crops. The paired planting pattern gave significantly higher yield (91.34 q/ha), uptake of nutrients, contents of protein and carbohydrate and monetary returns as well as income-equivalent ratio (1.48) over alternate planting pattern. Application up to 100% recommended dose of fertilizer to intercrop increased significantly maize, lentil and maize-equivalent yields of 69.5, 11.1 and 93.5 q/ha, uptake of nitrogen, phosphorus and potassium of 159.1, 25.4 and 145.8 kg/ha and content of protein and carbohydrate 10.1 and 70.1%. However, gross returns, net returns and benefit : cost ratio of Rs 47,865/ha, Rs 30,764/ha and 1.80 were significantly increased with increasing up to 50% recommended dose of fertilizer to intercrop. Growth and yield components such as plant height, dry-matter accumulation, leaf-area index, rows/cob, test weight and shelling (%) showed trends similar to yields. The intercropping system when maize was grown with lentil row with 50% recommended dose of fertilizer to intercrop was found to be more profitable.

Key words : Winter maize-based cropping system, Yield, Quality, Economics

In eastern Uttar Pradesh maize has become a well-adapted crop with high yield potential (40–60 q/ha) and the area with the crop has increased tremendously. There is

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ample scope to utilize the vacant wider inter-row spaces of maize during the initial slow growth period of the crop by introducing some compatible crop and adjusting the crop geometry for increased productivity (Singh and Singh, 1993). In recent years, *rajma* has been introduced as a potential winter (*rabi*) crop in the plains of Uttar Pradesh and is finding its place in winter maize-based intercropping system. But their precise agronomy practices has not yet been developed so far. A very few studies have actually considered the response of components crops in determining the optimum dose of fertilizer, particularly when the species respond differently to a particular nutrient. Therefore, to generate information on yield potential of different winter maize intercropping system with different planting patterns and fertility levels, the present study was undertaken.

MATERIALS AND METHODS

The field experiment was conducted during the winter season of 1994–95 and 1995–96 at Agronomy Research Farm, Kumarganj (Faizabad). The treatment consisted of 3 intercropping systems [maize + *rajma* (C_1), maize+lentil (C_2) and maize+ Indian mustard (C_3)], 2 systems of planting pattern [alternate planting (R_1) and paired planting (R_2)] and 3 fertility levels [no additional recommended dose to intercrop (F_0), 50% of recommended dose to intercrop (F_1) and 100% of recommended dose of intercrop (F_2)]. The combinations of intercropping system and planting pattern were assigned to main plots and fertility levels to subplots, replicated thrice in split-plot design. The soil was silty loam in texture, low in organic carbon (0.38%), alkaline in reaction, low in available N (180.2 kg/ha), available P (13.1 kg/ha) and available K (161.2 kg/ha). A fertilizer schedule of 150:60:40, 100:60:40, 80:40:40 and 10:60:40 kg/ha of N:P:K was applied to maize, *rajma*, lentil and Indian mustard respectively. Half dose of N and full dose of P and K were applied basal prior to sowing in furrows opened just by the side and deeper than the seed furrow in all component crops as per treatment. The remaining N for the intercrop (*rajma* or lentil or Indian mustard, was top, dressed after first irrigation, but in case of maize, it was top-dressed in equal splits, one fourth at knee-high stage and rest of tasseling stage. The crop varieties 'DHM 103' of maize, 'PDR 14' of *rajma*, 'T 36' of lentil and 'NDR 8501' of Indian mustard were sown on 4 and 5 November 1994 and 1995 respectively. For sowing, furrows were opened 60 cm apart in alternate row of maize and intercrop and 70 cm and 50 cm apart in paired row of maize and intercrop with the help of *desi* plough and seeds were placed in furrow 5–6 cm deep, maintaining a distance of maize. One set of paired rows of intercrop was sown in 120 cm space vacant space between 2 pairs of maize rows.

RESULTS AND DISCUSSION

Growth and yield components

Maize+lentil intercropping system recorded higher growth and yield components over rest of the intercropping systems (Table 1). Maximum values of growth and yield attributes were recorded in paired planting over alternate planting. This might be due to environmental situation resulting

Table 1. Effect of intercropping, planting pattern and fertility level on growth and yield components of winter maize

Treatment	Plant height (cm)		Leaf-area index		Dry-matter accumulation		Rows/cob		Test weight (g)		Shelling (%)	
	1994–95	1995–96	1994–95	1995–96	1994–95	1995–96	1994–95	1995–96	1994–95	1995–96	1994–95	1995–96
Intercropping												
C_1	112.3	124.3	4.26	4.30	1,722	1,810	14.88	15.56	226	230	80.1	80.4
C_2	120.7	134.3	4.74	4.74	1,842	1,935	16.22	16.50	242	244	82.8	83.1
C_3	110.0	114.6	4.20	4.20	1,619	1,635	14.00	14.44	213	204	74.2	73.2
CD (P=0.05)	2.2	2.7	0.01	0.02	98	117	1.01	1.37	5	5	2.1	1.8
Planting pattern												
R_1	113.4	122.8	4.28	4.33	1,716	1,732	15.00	29.90	226	218	82.3	82.0
R_2	115.3	126.0	4.47	4.49	1,727	1,757	15.88	30.80	231	228	84.1	83.1
CD (P=0.05)	2.2	2.2	0.01	0.01	8	21	0.80	0.82	4	4	0.8	0.5
Fertility level												
F_0	103.2	104.0	4.32	4.36	1,644	1,687	14.67	27.78	206	202	80.2	82.1
F_1	112.3	114.0	4.39	4.42	1,731	1,731	16.78	30.28	230	241	82.9	83.6
F_2	116.2	125.5	4.42	4.48	1,838	1,887	16.90	31.45	242	256	83.1	84.9
CD (P=0.05)	3.4	1.5	0.01	0.02	79	34	0.87	0.67	2	3	0.6	0.4

Treatment details are given in Materials and Methods

in better plant growth. The fertilizer applied at the highest level (100% to intercrop) resulted in higher plant height, leaf-area index dry-matter accumulation, rows/cob, test weight and shelling (%) of winter maize over 50% and no fertilizer applied to intercrop. Similar findings were reported by Sinha *et al.* (1999).

Nutrients uptake by maize

Significant higher uptake of nitrogen, phosphorus and potassium were obtained under maize– lentil intercroping than maize–*rajma* and maize–Indian mustard (Table 2). This increase of NPK uptake by the principal crop of maize raised with legume might be attributed to the substantial role of legume component with respect to transfer of nutrients towards the maize crop.

Significantly higher uptake of nitrogen, phosphorus and potassium by maize was noticed under paired planting pattern compared with alternate planting pattern.

Increasing fertility up to 100% of recommended fertility level increased the total nitrogen, phosphorus and potassium uptake. There were significantly superior to those obtained with other higher fertility level. It was owing to beneficial effect of higher dose of NPK fertilizer. Similar findings were also reported by Prasad and Prasad (1988).

Quality of maize grain

Protein and carbohydrate in maize+lentil of 9.96 and 68.1% in 1994–95 and 10.0 and 69.3% in 1995-96 compared with maize+Indian mustard, while it was at par with maize + *rajma* during both the years (Table 2). Hegde and Saraf (1962) reported similar results.

Increasing levels of fertility increased the protein and carbohydrate content up to 100% of recommended dose to intercrop by 10.1 and 70.9% in first and by 10.0 and 69.2% in second year which were significantly superior to those of 50% of recommended dose to intercrop. The lowest protein and carbohydrate contents of 9.1 and 67.1% in 1994–95 and of 9.2 and 67.1% in 1995–96 were recorded under no- fertility level.

Yields

The maize grain yield and intercrop yield recorded in maize+lentil intercropping system was significantly higher than rest of the intercropping system, owing to minimum competition between crops (Table 3.) The maize yield and intercrop yield were lowest in maize + Indian mustard intercroping system. Association of *rajma* and Indian mustard as an intercrop had more depressing effect on maize production than lentil. The compatibility of lentil as an intercrop with winter maize was also reported (AICMIP, 1979).

Paired planting recorded significantly higher maize grain yield and intercrop yield over alternate planting. These difference may be due to the wider spaced rows utilizing more, natural resouces than narrowly spaced one, and consequently little competition between plants. Application of 100% recommended dose to intercrop significantly increased the maize grain yield of 4.46 and 3.71% and intercrop seed yield of 8.78 and 7.90% over 50% recommended dose to intercrop during 1994–95 and

Table 2. Effect of intercropping, planting pattern and fertility level on nutrient uptake and protein and carbohydrate contents in grain of winter maize

Treatment	Nutrients uptake (kg/ha)						Protien content (g)		Carbohydrates content (%)	
	Nitrogen		Phosphorus		Potassium					
	1994–95	1995–96	1994–95	1995–96	1994–95	1995–96	1994–95	1995–96	1994–95	1995–96
Intercropping										
C_1	149.6	158.8	22.7	22.8	138.8	114.63	9.7	9.8	67.2	67.4
C_2	164.3	173.5	23.6	23.7	154.6	162.80	9.9	10.0	68.1	69.2
C_3	125.5	127.6	20.0	20.1	120.8	119.10	9.3	9.4	67.1	67.1
CD (P=0.05)	0.8	1.0	0.5	0.6	0.7	0.9	0.6	0.5	0.4	0.7
Planting pattern										
R_1	142.6	151.5	21.7	21.8	134.8	140.1	9.5	9.6	67.3	67.4
R_2	145.3	156.4	23.2	23.5	139.9	146.0	9.7	9.7	67.6	67.5
CD (P=0.05)	0.8	1.0	1.3	1.7	2.4	2.1	NS	NS	NS	NS
Fertility level										
F_0	138.6	143.7	21.1	22.1	127.9	133.1	9.1	9.2	67.1	67.1
F_1	149.6	157.8	23.6	24.0	138.9	145.1	9.7	9.6	69.3	68.3
F_2	155.1	163.1	24.8	25.9	144.3	147.21	0.1	10.0	70.9	69.2
CD (P=0.05)	2.9	2.8	1.1	1.9	2.1	1.9	0.4	0.3	1.3	0.7

Table 3. Effect of intercropping, planting pattern and fertility level on yields,maize-equivalent: yield and economics of winter maize and components crops

Treatment	Maize grain yield (q/ha)		Intercrop yield (q/ha)		Maize-equivalent yield (q/ha)		Monetary return (Rs/ha)			Benefit: cost ratio
	1994–95	1995–96	1994–95	1995–96	1994–95	1995–96	Average	Gross	Net	
Intercropping										
C_1	64.68	71.02	7.96	8.23	82.35	89.26	85.81	46,888	27,078	1.37
C_2	70.28	77.72	11.31	11.43	100.43	108.17	104.30	49,672	32,571	1.91
C_3	50.75	52.50	9.12	9.04	68.35	70.41	69.38	33,660	16,811	1.00
CD (P=0.05)	1.71	1.81	0.96	0.58	9.70	9.23	9.47	1,870	946	0.19
Planting pattern										
R_1	61.68	66.57	9.21	9.35	82.84	88.48	85.66	42,431	24,512	1.37
R_2	63.72	68.65	9.49	9.79	84.59	98.08	91.34	44,382	26,463	1.48
CD (P=0.05)	1.42	0.65	0.21	0.34	1.29	1.13	1.21	1,651	1,037	0.05
Fertility level										
F_0	57.83	62.94	6.93	7.12	73.80	78.93	76.37	37,241	17,621	0.90
F_1	6.3.65	68.83	10.08	10.38	86.30	92.02	89.16	47,865	30,764	1.80
F_2	66.62	71.48	11.05	11.21	91.03	96.89	93.36	45,115	28,266	1.68
CD (P=0.05)	1.51	1.60	0.92	0.64	3.27	3.44	3.36	2,138	1,115	0.07

1995–96 respectively. Bhatt and Damor (1985) reported higher yield in maize+groundnut intercropping.

Total productivity

Maize-equivalent yield indicated that intercropping system of maize+lentil recorded significantly higher maize-equivalent yield than maize+*rajma* (Table 3). On an average, maize intercropped with lentil and *rajma* recorded 33.48 and 17.73% higher maize-equivalent yield compared with maize+Indian mustard owing to much higher yields of maize and component crops as well as higher market price of grain legume than that of Indian mustard and *rajma*.

Different planting patterns had significant influence on maize-equivalent yield. Paired planting resulted in significantly higher maize-equivalent yield than alternate planting pattern. Significantly higher maize-equivalent yield was found with 100% of recommended dose of fertilizer than 50% of recommended dose of fertilizer and no-fertility level. The similar results of increase in maize-equivalent yield owing to maize–potato cropping with paired row planting and 100% of recommended dose to intercrop was also reported by Sinha *et al.* (1999).

Economic returns

The gross returns, net returns and benefit : cost ratio were significantly higher in maize + lentil intercroping compared with maize+*rajma* intercropping (Table 3). These difference may be associated for wider differnces in maize and lentil yields in respective cropping systems. Significantly higher gross returns, net returns and benefit : cost ratio were found in paired rows, followed by alternate planting. Application of 50% recommended dose of fertilizer gave significantly higher gross returns, net returns and benefit : cost ratio than no fertilizer treatment. Mishra *et al.* (1994) reported highest net returns under maize+pigeonpea at 60 cm (1:1) intercropping system.

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