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Production potential and monetary advantage of winter maize (*Zea mays*) -based intercropping systems under irrigated conditions in central Uttar Pradesh

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ABSTRACT

A field experiment was carried out during winter (*rabi*) seasons of 2003–04 and 2004–05 at Kanpur to find out the production potential and economic viability of winter maize (*Zea mays* L.) intercropped with potato (*Solanum tuberosum* L.), Indian mustard [*Brassica juncea* (L.) Czernj. & Cosson], *toria* (*Brassica campestris* var. *toria*), pea (*Pisum sativum* L. sensulato), linseed (*Linum usitatissimum* L.) and wheat (*Triticum aestivum* L. emend. Fiori & Paol.) for central plain zone of Uttar Pradesh. Values of land equivalent ratio (LER) and area-time equivalent ratio (ATER) with all the intercropping systems were greater indicating advantage in yield, land-use efficiency and monetary return/unit time and space over the respective monocultures. All the intercrops with maize recorded significantly higher maize-equivalent yield than the sole crop. Intercropping of maize with potato was more advantageous than the other intercrops. Maize + potato appeared to be biologically the most efficient and economically viable system giving the highest maize grain yield (6 091 kg/ha), maize-equivalent yield (13 792 kg/ha), production efficiency (276.1%), land equivalent ratio (2.14), area-time equivalent ratio (1.91), monetary advantage (Rs 39 017) and net realization (Rs 32 369/ha), followed by maize + pea. Indian mustard, *toria* and wheat were found non-compatible with winter maize.

Key words: *Brassica campestris* var. toria, *Brassica juncea*, Indian mustard, Intercropping, Linseed, *Linum usitatissimum*, Maize, Monetary advantage, Pea, *Pisum sativum*, Potato, *Solanum tuberosum*, *Toria*, *Triticum astivum*, Wheat, *Zea mays*

Maize (*Zea mays* L.) is now one of the important crops of winter season because of its higher yield compared with wheat, oilseeds and pulses. Its yield is almost double that of rainy season maize, and is also more than that of the summer crops. In Uttar Pradsh, it has become popular day-by-day due to its high yield potential and the area with the crop has increased tremendously from 4.1 thousand hectares in 2005–06 to 30.0 thousand hectare in 2006–07 with the production of 13.7 thousand tonnes to 47 thousand tonnes (DMR 2008). The winter (*rabi*) crop sown October–November makes little growth till mid-February, leaving enough scope for intercropping during the period. It is planted in rows 60 cm apart and takes first 3 months to pick up the growth. In view of such eco-situation, there is an 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 crops to get more productivity as well as net returns from a unit of land. Improvement in maize yield due to association of legumes, higher productivity and net returns from intercropping combinations have also been reported by Patra *et al.* (2000) and Singh and Kumar (2002). The advantages obtained from different crops with maize in intercropping vary according to the growth habit and nature of intercrop which requires thorough investigation. Hence, present study were undertaken to generate information on best suited intercropping system of winter maize under central plain zone of Uttar Pradesh.

MATERIALS AND METHODS

An investigation was carried out during the winter (*rabi*) seasons of 2003–04 and 2004–05 at the University field conditions at Kanpur. The soil was sandy loam alluvial type, low in organic carbon (0.55%), and available nitrogen (116.8 kg/ha), medium in available phosphorus (18.8 kg/ha) and available potassium (130 kg/ha) with *p*H 7.6. There were 13 treatment combinations comprising 7 sole crops, viz maize (*Zea mays* L.), potato (*Solanum tuberosum* L.), Indian mustard [*Brassica juncea* (L.) Czernj. & Cosson], *toria* (*Brassica campestris* var. *toria*), pea (*Pisum sativum* L. sensulato), linseed (*Linum usitatissimum* L.) and wheat

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(*Triticum aestivum* L. emend. Fiori and Paol.), and 6 intercropping combinations were tried in randomized block design with 3 replications. 'Sharadmani' maize, 'Chipsona 2' potato, 'Kanti' Indian mustard, 'Bhawani' *toria*, 'Azad P 1' pea, 'T 397' of linseed and 'PBW 343' wheat were sown on 1 and 20 November in 2003 and 2004, respectively. Maize was sown at a spacing of 60 cm in rows. One row each of potato and Indian mustard, 2 rows each of *toria*, pea, linseed and wheat was accommodated in between 2 rows of maize in additive series. In intercropping, potato was planted on ridges 60 cm apart and maize was sown at the base of the potato ridges. The plant-to-plant distance in potato was 15 cm, in Indian mustard 20 cm and in *toria* 10 cm, whereas in maize it was 25 cm.

Recommended package of practices was followed to raise the healthy crop. Maize was fertilized with 120 kg N, 60 kg P and 40 kg K, while 150 kg N, 80 kg P and 100 kg K; 120 kg N, 60 kg P and 60 kg K; 80 kg N, 40 kg P and 40 kg K; 20 kg N and 60 kg P; 80 kg N and 40 kg P; and 150 kg N, 75 kg P and 75 kg K/ha were applied to potato, Indian mustard, *toria*, pea, linseed and wheat, respectively, in both sole and intercrops. In intercropping, the crops received the fertilizers on the basis of proportionate area under each crop. Full recommended doses of P and K along with one-third N to maize, 50% N to potato, Indian mustard, *toria* and wheat, and full N to pea and linseed was applied as basal to all the crops in sole as well as intercropping system. Remaining two-third N to winter maize was top-dressed in 2 equal splits at knee high and tasseling stages. Rest 50% N was applied at earthing to potato and after first irrigation to both Indian mustard and *toria* crops. However, to wheat crop, remaining N was applied in 2 equal splits at tillering and ear-emergence stages. Fertilizer requirement of all the crops was met through urea, super phosphate and muriate of potash. Maize-equivalent yield and economics of production were calculated on the basis of minimum support prices of component crops for the main produce and prevailing market prices for the inputs. Production efficiency values were obtained by maize-equivalent yield of systems divided by yield of sole maize crop multiplied by 100. Different competition indices were calculated as suggested by Willey (1979).

RESULTS AND DISCUSSION

Yield of component crops

Maize grain yield was significantly influenced by different intercrops in combination (Table 1). Association of potato and pea significantly increased the grain yield of maize by 22.0 and 7.2%, respectively, compared with the sole cropping of maize due to increase in yield attributing characters, viz cobs/plant, cob girth and grain weight/cob. Among intercropping systems, maize planted with potato recorded the highest mean grain yield of 6 091 kg/ha resulting about 22 and 14% higher than the sole maize and maize + pea system. It might be owing to short duration, provides better moisture condition, better aeration, weed free situation etc. Patra *et al.* (2000) also reported similar observations. However, Indian mustard, *toria* and wheat intercropping with maize caused 32.3, 44.7 and 37.4% reduction in yield of maize. The lower yield may be attributed to the crowding effect as a result of higher plant density per unit area, resulting in increased intra-row competition, and shading effect and exhaustive growth in Indian mustard and *toria* intercropping, resulting in reduced yield attributes, viz cobs/plant, cob girth and grain weight/cob. Patra *et al.* (2000) and Bharti *et al.* (2007) also recorded drastic reduction in grain yield of maize due to intercropping of wheat, Indian

Table 1. Effect of intercropping systems on yield components, production potential and economics of winter maize (pooled data of 2 years)

Treatment	Cobs/ plant	Cob girth (cm)	Grain weight/ cob	Grain yield of component crops (kg/ha)		Maize-equivalent yield (kg/ha)	Production efficiency (%)	Net return (Rs/ha)	Net profit/ rupee of investment (Rs/Re)
				Maize	Intercrops				
Sole maize	1.31	12.91	78.23	4 992		4 992	100.0	7 801	0.38
Sole potato					22 377	8 411	168.4	15 005	0.51
Sole Indian mustard					1 637	4 993	99.7	13 207	1.24
Sole *toria*					899	2 918	58.0	6 479	0.72
Sole pea					1 686	5 143	103.0	17 510	1.68
Sole linseed					972	2 967	59.4	6 585	0.71
Sole wheat					4 448	5 266	105.4	17 576	1.07
Maize + potato (1: 1)	1.42	13.48	101.13	6 091	20 485	13 792	276.2	32 369	0.76
Maize + Indian mustard (1: 1)	1.11	11.17	58.85	3 379	1 251	7 195	143.8	14 693	0.60
Maize + *toria* (1: 2)	1.12	10.83	60.63	2 762	765	5 239	104.6	5 611	0.25
Maize + pea (1: 2)	1.37	13.19	90.08	5 350	1 283	9 263	185.4	27 679	1.16
Maize + linseed (1: 2)	1.23	12.70	72.10	4 663	810	7 134	142.9	16 524	0.72
Maize + wheat (1: 2)	1.13	11.89	60.53	3 121	3 065	6 768	135.5	15 088	0.58
SEd±	0.03	0.11	2.64	127	150	185		897	0.04
CD (*P*=0.05)	0.07	0.24	5.45	263	303	373		1 838	0.09

mustard and *toria*.

Maize decreased the yield of all intercrops compared with their respective sole crop (Table 1). More inter and intra-plant competition and lower density of intercrops might be responsible for such reduction. Patra *et al.* (2000) and Bharti *et al.* (2007) also made similar observations. There was maximum mean reduction of 30.8% in the grain yield of wheat, followed by pea (24.1%) and Indian mustard (23.9%) probably due to long duration and shade susceptibility of wheat and pea.

Total productivity and production efficiency

The maize-equivalent yield of all the intercropping systems was significantly higher than their respective sole crop yields except with maize + *toria*, where it was yielded on par to sole maize yield (Table 1). However among the intercropping systems, maize + potato significantly recorded the highest maize-equivalent yield (13 792 kg/ha) compared with the sole maize (4 992 kg/ha). It was mainly due to 22% increase in maize yield and additional advantage due to intercrop yield, followed by maize + pea intercropping system. However, maize + *toria* recorded the lowest maize-equivalent yield due to exhaustive growth of *toria*, showing poor compatibility with maize, resulting reduction in maize yield (2 230 kg/ha) and *toria* yield (1.34 kg/ha) compared with respective sole crops. These results are in conformity with those of Bharti *et al.* (2007).

Intercropping systems were more efficient than their respective sole crops of both the components and production efficiency ranged from 4.6 to 176.2% over the sole maize (Table 1). However, among the intercropping systems, maize + potato combination seemed to be more productive, followed by maize + pea system recording 176.2 and 85.4% higher production over the sole maize, respectively.

Net returns

Maize + potato intercropping system fetched higher net return values of Rs 32 369/ha, followed by maize + pea (Rs 27 679/ha) system than the sole stands of respective crops as well as other intercropping combinations (Table 1). This might be due to difference in maize yield and additional yield of intercrop, which resulted in higher net returns under these intercropping systems than in sole winter maize. This finding is in close conformity with those of Bharti *et al.* (2007). Among intercropping systems, maize intercropped with pea earned the highest net profit/rupee of investment (1.16), followed by maize intercropped with potato (0.76). The minimum net return and net profit/rupee of investment were recorded in maize + *toria* intercropping system, perhaps due to relatively lower maize-equivalent yield.

Intercropping indices

Land equivalent ratio (LER) and area-time equivalent ratio (ATER) of all the intercropping systems were greater than unity indicating higher land-utilization efficiency and yield advantage over the respective monocultures (Table 2). The highest mean values of LER (2.14) and ATER (1.91) were recorded in maize + potato intercropping system, followed by maize + pea (1.83 LER and 1.73 ATER) system. Maize + potato also accomplished the highest land equivalent coefficient (LEC) values (1.12), followed by maize + pea (0.81). This was possible owing to greater temporal complementarily. These results are in accordance with the findings of Sinha *et al.* (1999) and Patra *et al.* (2000). However, maize + wheat recorded the lowest values of LER (1.32) and LEC (0.43), whereas maize + *toria* obtained the lowest ATER (1.17) values.

Intercropping systems were more remunerative than sole cropping (Table 2). Maize + potato recorded the highest monetary advantage (Rs 39 017/ha), followed by maize + pea (Rs 22 354/ha) and maize + linseed (Rs 16 437) due to higher land-equivalent ratio and value of combined produce in intercrops. Maize + *toria* intercropping fetched the minimum monetary advantage which may be attributed to the lower value of combined intercrop yield.

Thus, intercropping of winter maize + potato in additive series with 1:1 row ratio proved highly productive, biologically efficient and remunerative system, followed by maize + pea in 1: 2 row ratio over either of the sole crops as well as other intercropping combinations for irrigated conditions of central plain zone of Uttar Pradesh.

Table 2 Effect of intercropping on land-equivalent ratio, land-equivalent coefficient, area-time equivalent ratio and monetary advantages (pooled data of 2 years)

Treatment	Land equivalent ratio	Land equivalent coefficient	Area-time equivalent ratio	Monetary advantages (Rs/ha)
Sole maize	1.00	0.00	1.00	0.0
Sole potato	1.00	0.00	1.00	0.0
Sole Indian mustard	1.00	0.00	1.00	0.0
Sole *toria*	1.00	0.00	1.00	0.0
Sole pea	1.00	0.00	1.00	0.0
Sole linseed	1.00	0.00	1.00	0.0
Sole wheat	1.00	0.00	1.00	0.0
Maize + potato (1: 1)	2.14	1.12	1.91	39 017
Maize + Indian mustard (1: 1)	1.43	0.51	1.29	11 584
Maize + *toria* (1: 2)	1.41	0.47	1.17	8 010
Maize + pea (1: 2)	1.83	0.81	1.73	22 354
Maize + linseed (1: 2)	1.76	0.77	1.66	16 437
Maize + wheat (1: 2)	1.32	0.43	1.25	8 641
SEd±	0.05	0.04	0.04	925
CD (*P*=0.05)	0.10	0.09	0.09	1 909

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