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Yield and economics as influenced by winter maize (*Zea mays*) - based intercropping systems in North Bihar

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ABSTRACT

An experiment was conducted during 1991–92 and 1992–93 to evaluate the yield and economics of winter maize (*Zea mays* L.)-based intercropping systems under different fertility and weed-management systems at Pusa (Bihar). Maize grown with potato (*Solanum tuberosum* L.) in normal (1 : 1) and paired row planting (2 : 2) reduced the weed population, their dry weight and increased the weed-smothering efficiency of crop canopy (66.10 and 60.59% respectively). Maize intercropped with potato was more advantageous than French bean (*Phaseolus vulgaris* L.) and significantly improved all the yield attributes as well as yield of component crops and finally recorded significantly higher maize-equivalent yield (12.30 and 12.02 tonnes/ha) than normal (1 : 2) and paired planting (2 : 4) of maize with French bean (9.81 and 9.65 tonnes/ha). On an average, maize intercropped with potato under normal and paired planting systems, recorded 20.69 and 18.89% higher maize-equivalent yield than normal and paired row maize with French bean. Although gross return was more with maize + potato, the net return and net return per rupee investment were higher in maize + French bean. The higher level of fertilizer resulted in significant increase in all the yield attributes and yield of component crops and ultimately the maize-equivalent yield. Net return was significantly higher with 100% fertilizer dose but the net return per rupee of investment was higher with 75% dose. Weedy ecosystem registered a yield reduction of 29.63, 26.79 and 38.85% in maize, potato and French bean respectively. Significantly higher maize-equivalent yield was recorded under hand-weeding and pendimethalin-treated plots than weedy check. Chemical weeding recorded significantly higher net return per rupee of investment.

Key words: Intercropping, Maize, Potato, French bean, Planting pattern, Fertility, Weed management

In North Bihar, winter maize has become a well-adapted crop with high yield potential (40–60 q/ha) and the area under the crop has increased tremendously. There is ample scope to utilize the vacant wider inter-row space of maize during the initial slow growth period of the crop by introducing some compatible crop and adjusting the crop geometry for in-

creased productivity (Singh and Singh, 1993). Potato intercropped in available space between the rows of maize quickly covers the space and smothers the emerging weeds through competition and shading (Pandey and Shukla, 1985). In recent years, French bean has been introduced as a potential winter (*rabi*) crop in Bihar plains and is finding its place in winter maize-based intercropping systems. But their precise agronomy practices has not yet been developed so far. A very few studies have actually considered the response of component crops in determining the optimum dose of fertilizer particularly when the species respond differently to a particular nutrient. Similarly, the nature of the weed problem and measures to combat them have also not been studied for making the system economically viable. Therefore, to generate information on yield potential of different winter maize-based intercropping systems with different planting patterns, fertility levels and weed management, the present study was undertaken.

MATERIALS AND METHODS

The field experiment was conducted during the winter season of 1991–92 and 1992–93 at Tirhut College of Agriculture Farm, Dholi (Muzaffarpur). The treatment consisted of 4 planting geometries, [1 row of potato between 2 normal spaced (60 cm) maize rows (1:1), paired row planting of maize at 30-30-90 cm with 1 paired row of potato in the 90 cm space between 2 maize pairs (2:2), 2 rows of French bean or *rajma* between 2 normal spaced (60 cm) maize rows (1:2) and paired row planting of maize at 30-30-90 cm with 2 paired rows of *rajma* in 90 cm space between 2 pairs (2:4)], 3 fertility levels (50, 75 and 100% recommended dose for component crops), and 3 weed-management practices [weedy check, hand-weeding (35 DAS) and pendimethalin @ 1.0 kg ai/ha as pre-emergence]. The combinations of planting geometry and fertility levels were assigned to main plots and weed management in subplots were replicated thrice in split-plot design. The soil was sandy loam in texture, low in organic carbon (0.48%), alkaline in reaction, low in available N (21 kg/ha), available P (218 kg/ha) and available K (127 kg/ha). A fertilizer schedule of 100 : 60 : 40, 100 : 60 : 80 and 90 : 60 : 0 kg/ha of N, P and K was applied to maize, potato and *rajma*; 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 (potato/*rajma*) was placed by the side of the crop rows after first irrigation but in case of maize, it was top-dressed in equal splits, one-fourth at knee-high stage and rest at tasseling stage. The crop varieties 'Hemant' of maize, 'Kufri Sinduri' of potato and 'PDR 14' of *rajma* were sown on 20 and 18 November 1991 and 1992 respectively.

RESULTS AND DISCUSSION

Weeds

The dominant weed flora recorded in the experimental field was *Cynodon dactylon* (L.) Pers. and *Sorghum halepense* (L.) Pers. among the grasses; and *Cyperus rotundus* (L.) Pers. as sedge. The broad-leaved weeds like *Chenopodium album* L., *Anagallis arvensis* L., *Melilotus alba* L., *Launaea aspleniifolia* Hook. f., *Cannabis sativa* L., *Fumaria parviflora* Lam., *Launaea sarmentosa* (Wild.) Alston, *Lathyrus aphaca* L., *Vicia sativa* L., *Convolvulus arvensis* L. and *Cirsium arvense* L. were also present in high proportion in the field during both the years.

Intercropping of potato was found beneficial from the crop-weed competition point of view as evident from the data on weed density and weed dry weight (Table 2). A significant reduction in weed population and their dry weight was recorded in normal and paired planting of maize in association with potato.

Table 1. Yield attributes (mean data of 2 years) and yield as affected by intercropping system, fertility level and weed management in winter maize, potato and French bean or *rajma*

Treatment	Maize		*Rajma*			Potato		Maize grain yield (tonnes/ha)		*Rajma* grain yield (tonnes/ha)		Potato tuber yield (tonnes/ha)	
	Grains/ cob	1,000-seed weight (g)	Pods/ plant	Seeds/ pod	100-seed weight (g)	Tubers/ hill	Fresh weight of tubers/ hill (g)	1991–92	1992–93	1991–92	1992–93	1991–92	1992–93
Intercropping system													
Maize + potato	349.2	318.5				6.6	187.0	5.02	4.85			14.37	16.78
PR maize + PR potato	227.3	307.2				6.6	182.0	4.91	4.73			14.18	16.16
Maize + *rajma*	328.8	302.3	7.3	2.8	42.2			4.67	4.54	1.33	1.29		
PR maize + PR *rajma*	325.9	296.2	6.9	2.6	41.0			4.54	4.49	1.33	1.26		
CD (P = 0.05)	17.0	15.3	NS	NS	NS	NS	NS	0.36	0.28	NS	NS	NS	0.43
Fertility level													
50% RD of comp. crops	304.2	291.6	6.5	2.4	38.2	5.9	156.1	3.81	4.00	1.08	1.02	11.85	14.17
75% RD of comp. crops	341.8	310.0	7.1	2.8	42.3	6.8	196.2	5.14	4.86	1.41	1.38	15.29	17.40
100% RD of comp. crops	359.8	316.5	7.6	3.0	44.3	7.0	201.2	5.41	5.09	1.51	1.44	15.68	17.81
CD (P = 0.05)	12.7	12.6	0.9	0.3	5.2	0.5	6.1	0.31	0.24	0.10	0.08	0.67	0.53
Weed management													
Weedy check	291.3	284.9	6.2	2.3	37.6	5.3	149.5	3.79	3.62	.97	.89	11.77	13.15
Hand-weeding	359.2	317.8	7.5	2.9	43.1	7.3	204.2	5.29	5.24	1.48	1.46	15.74	18.30
Pendimethalin @ 1.0 kg/ha	355.4	315.4	7.6	2.9	44.0	7.1	199.7	5.26	5.09	1.54	1.50	15.31	17.98
CD (P = 0.05)	9.6	8.8	0.5	0.2	1.7	0.4	5.6	0.17	0.17	0.08	0.05	0.40	0.37

PR, Paired row; RD, recommended dose; comp., component

Table 2. Effect of intercropping systems, fertility levels and weed management on weeds, maize-yield equivalent, net return and net return per rupee investment in maize-based intercropping system

Treatment	Weed count (No./m²)	Weed dry weight (g/m²)	Weed-control efficiency (%)	Maize-yield equivalent (tonnes/ha)		Cost of cultivation (Rs '000/ha)			Net return (Rs '000/ha)			Net return per rupee investment
									Y_1	Y_2	Pooled	
				Y_1	Y_2	Y_1	Y_2	Mean				
Intercropping system												
Maize + potato	7.41	5.84	66.10	13.31	11.30	18.62	19.68	19.15	17.37	18.73	18.05	0.93
PR maize + PR potato	7.51	6.11	60.59	13.09	10.95	18.62	19.68	19.15	16.79	17.55	17.17	0.89
Maize + *rajma*	7.68	6.28	59.22	10.53	9.09	11.21	11.90	11.55	17.48	19.26	18.37	1.56
PR maize + PR *rajma*	7.81	6.49	55.83	10.41	8.96	11.21	11.90	11.55	17.11	18.81	17.96	1.53
CD (P = 0.05)	NS	0.52		0.56	0.29				NS	0.99		0.06
Fertility level												
50% RD of comp. crops	7.47	5.88	64.19	9.59	8.53	14.27	14.85	14.56	11.82	14.32	13.07	0.96
75% RD of comp. crops	7.62	6.21	59.73	12.70	10.63	14.91	15.79	15.35	19.53	20.45	19.99	1.37
100% RD of comp. crops	7.73	6.45	57.36	13.19	11.07	15.56	16.73	16.14	20.20	21.00	20.60	1.35
CD (P = 0.05)	NS	0.45		0.49	0.25				1.33	0.85	0.15	0.07
Weed management												
Weedy check	9.21	8.14		9.33	7.71	14.35	15.23	14.79	11.03	11.19	11.11	0.81
Hand-weeding	6.78	5.08	62.17	13.09	11.33	15.42	16.30	15.86	20.06	22.30	21.18	1.39
Pendimethalin @ 1.0 kg/ha	6.82	5.32	58.69	13.08	11.19	14.97	15.85	14.41	20.47	22.27	21.37	1.48
CD (P = 0.05)	0.45	0.28		0.24	0.24				0.65	0.71	0.61	0.04

Y_1, 1991–92; Y_2, 1992–93

Weed-control efficiency (WCE) of this intercropping system was also higher than normal and paired planting of maize in association with *rajma*. This may be attributed to relatively less space available for the growth of the weeds from the early stage of crop growth and more shading effect due to lateral growth of potato plants between 2 rows of maize.

Fertility levels did not differ much in their weed population. However, application of 100% recommended dose of fertilizer significantly increased the weed dry weight over 50% of the recommended dose but remained statistically at par with 75% dose.

Different weed-control treatments showed marked effect on weed population and their dry-matter accumulation. Hand-weeding (35 DAS) and pendimethalin @ 1.0 kg/ha being at par proved significantly superior to the unweeded control in reducing weed population and weed dry biomass. The maximum WCE was recorded under hand-weeding followed by pendimethalin during both the years. The results confirm the findings of Pandey and Shukla (1985).

Yield attributes

Potato intercropping either in normal or paired planting of maize significantly increased the grains/cob and test weight compared with maize + *rajma* in both the planting patterns.

Fertilizer applied at the highest level(100%) resulted in higher grains/cob and test weight in maize as well as higher number of tubers and their fresh weight/hill in potato. In *rajma* also, pods/plant, seeds/pod and test weight were higher at 100% recommended dose of fertilizer. However, significant increase was observed only up to 75% recommended dose of fertilizer.

Maximum values of the yield-attributing characters were recorded under hand-weeding (35 DAS) and pendimethalin and both of them were equally effective in improving the yield attributes and ultimately the grain yield of maize than unweeded control. This might be due to reduced crop–weed competition and enhancement in most of the crop-growth parameters under the favourable environmental situation resulting in better plant growth (Balyan and Bhan, 1987; Prusty *et al* (1987).

Yield

The intercropping system had significant influence on maize yield (Table 1). Normal planting of maize in association with potato (1 : 1) gave highest maize grain yield, being significantly higher than normal (1:2) and paired row planting (2:4) of maize intercropped with *rajma* but was at par with paired row planting (2:2) of maize with potato. Geometry of maize plants either grown in normal or paired row planting did not significantly affect grain yield of maize or seed and tuber yields of associated crops in any of the years. Association of *rajma* as an intercrop had more depressing effect on maize production than potato. The compatibility of potato as an intercrop with winter maize was also reported by Sinha *et al.* (1994).

Maize grain yield was significantly influenced by fertility levels and weed-management practices. Application of 75% recommended dose of nutrients increased the maize grain yield significantly to 21.93% over 50% recommended dose. Significantly higher grain yield of maize was recorded under hand-weeding and pendimethalin and lowest under unweeded control. Excessive weed growth and severe competition drastically reduced the crop yield under unweeded control, being 25.8 and 28.33% lower than hand-weeding and pendimethalin treatments.

Total productivity

Maize-equivalent yield (Table 2) clearly indicated that intercropping system of normal sown (1:1) and paired (2:2) row maize + potato recorded significantly higher maize-

equivalent yield (12.30 and 12.02 tonnes/ha) than normal (1:2) and paired planting (2:4) of maize (9.81 and 9.68 tonnes/ha) in association with *rajma*. On an average, maize intercropped with potato under normal and paired row planting recorded 20.69 and 18.89% higher maize-equivalent yield compared with normal and paired row maize with *rajma* due to much higher yield of potato compared with latter.

Maize-equivalent yield under 100% recommended dose of nutrients applied to component crops was significantly higher due to increased grain and tuber production by the component crops at the highest level of nutrients. Pre-emergence application of pendimethalin @ 1.0 kg/ha and hand-weeding (35 DAS) gave significantly higher maize-equivalent yield than the weedy check. This was due to higher yield of component crops as a result of reduced crop–weed competition and increased water and nutrient availability.

Net return

In the first year, maximum net return was obtained under normal planting (1:2) of maize intercropped with *rajma*. However, the differences among the various treatments were not significant. In the second year, normal planting of maize (1:2) intercropped with *rajma* recorded maximum net return and was followed by paired row maize (2:4) in association with *rajma* and normal row maize(1:1) intercropped with potato. These 3 intercropping systems were statistically similar but significantly superior to paired row (2:2) maize + potato.

The increase in net profit was more with increase in fertility level from 50 to 75% compared with increase in fertility levels from 75 to 100 % of recommended dose.

The maximum net return was obtained from the plot treated with pendimethalin, followed by hand-weeding.

Net return/rupee investment

The maximum net return/rupee of investment was associated with maize intercropped with *rajma* both under normal and paired planting patterns. This might be due to lower cost of cultivation of *rajma* compared with potato as an intercrop.

Return per rupee investment on nutrient applied to the component crops at 50, 75 and 100% recommended doses were Rs 0.96, 1.37 and 1.35. The level of nutrient beyond 75% recommended dose reduced the return per rupee investment. This was in accordance with the law of diminishing return. Shah *et al.* (1992) also reported similar results. Net return per rupee investment was significantly more with pendimethalin (1.48) than hand-weeding and no weeding due to the lower cost involved under herbicidal treatment.

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