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Research Paper

Productivity and economics of field pea (*Pisum sativum*) and baby corn (*Zea mays*) intercropping systems as affected by planting pattern and weed management

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ABSTRACT

A field experiment was conducted during the consecutive winter seasons of 2011–12 and 2012–2013 to find out the effect of planting patterns and weed-management practices on yield attributes, yields and economics of field pea (*Pisum sativum* L.) + baby corn (*Zea mays* L.) intercropping system. The experiment was laid out in a split-plot design, keeping 4 planting patterns as main plot and 4 weed-management practices as subplot with 3 replications. An intercropping of field pea with baby corn reduced the yield attributes of field pea, viz. pods/plant, grains/pod, 1,000-grain weight and grain yield/plant and cobs/plant of baby corn. Sole field pea recorded significantly higher grain (1.85 t/ha) and straw yields (2.90 t/ha) than yield obtained as a component crop in paired maize (30/60 cm) + field pea (2 : 2) and maize + field pea (1 : 1). Baby corn yield was similar in sole, paired (2 : 2) and 1 : 1 planting but significantly higher stover yield of baby corn (3.55 t/ha) was obtained from sole crop than other planting methods. Both the intercropping systems had significantly higher field pea-equivalent yield than sole crop of either field pea or baby corn. Hand-weeding 30 days after sowing (DAS), pre-emergence application of pendimethalin 1 kg/ha and post-emergence application of imazethapyr 50 g/ha (30 DAS) improved all the growth and yield parameters of field pea and baby corn than weedy check. Hand-weeding (30 DAS), pre-emergence application of pendimethalin 1 kg/ha and post-emergence application of imazethapyr 50 g/ha (30 DAS) resulted in significantly higher field pea-equivalent yield than weedy check. The highest gross return (80.71 × 10^3 ₹/ha) and net returns (53.25 × 10^3₹/ha) were obtained under paired maize (30/60 cm) + field pea (2 : 2) and the highest benefit: cost ratio (2.15) was found in sole field pea (30 cm). Hand-weeding (30 DAS) resulted in the maximum value of gross returns (103.42 × 10^3₹/ha), net returns (77.80 × 10^3₹/ha) and benefit: cost ratio (3.04).

Key words: Baby corn, Economics, Field pea, Planting pattern, Weed management, Yield

Intercropping of cereals with pulses is an age-old practice. Pulses can do wonder when intercropped with widely spaced crops like maize, sorghum, pearlmillet, cotton and sugarcane, particularly in Northern India (Punjab, Haryana, Uttar Pradesh, Rajasthan, Bihar). There are evidences that intercropping of short-growing grain legumes with tall cereals give higher productivity than corresponding sole crops (Rao and Willey, 1983). Field pea (*Pisum sativum*), one of the important pulse crops of the winter season, has great potential to contribute to the pulse basket in India. During the recent past, Maize, the queen of cereals, has been used as vegetable where unfertilized young cob is used for cooking purpose, popularly known as baby corn (*Zea mays* L.) (Barod *et al*., 2012). Introduction of baby corn during off-season (winter months), because of its photo- and thermo-insensitiveness will promote nutritive dish of the people and also fetch additional income to farming community. Normally, baby corn is planted in wider rows and a considerable portion of the incident solar radiation remains un-intercepted due to poor canopy development because of its slow growth during the winter season. Slow crop growth during the winter months provide ample opportunity to the growth of weeds. Maintenance of adequate crop cover turns the competition in favour of crop. Intercropping itself has been found helpful in limiting weed population by way of cutting light to

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them. So field pea may be introduced between the rows of baby corn. Intercropping of legumes with maize has been found to give yield advantage owing to efficient utilization of growth resources and maintenance of soil health (Singh *et al.*, 1998). Mishra (2014) reported that maize + field pea intercropping system resulted an extra advantage of 85.6% in terms of maize-equivalent yield over sole maize.

Development of feasible and economically viable intercropping system depends largely on adoption of proper planting pattern as well as weed management. Efficiency of production in intercropping system could be improved by minimizing inter-specific competition between the component crops. Planting pattern alters the space available to individual plant; hence the degree of competition for natural resources becomes variable between component crops. Appropriation of suitable planting pattern is thus, necessary to bring the competition to the minimum level. Pandey *et al.* (1999) at the Vivekananda Parvatiya Krishi Anusandhan Shala (VPKAS), Almora, Uttarakhand, found that soybean yield under paired rows of maize (30/90 cm) + soybean in 2 : 2 row was 46.7% higher than that of maize (45/90 cm) + soybean in 2 : 2 row ratio. Aravinth *et al.* (2011) at the Tamil Nadu Agricultural Univesity (TNAU), Coimbatore, found that different intercrops did not influence the growth parameters (plant height, leaf-area index and dry-matter production) of baby corn. They found that baby corn raised at 60 cm × 5 cm planting geometry produced taller plants, higher leaf area index and more dry matter than that at 45 cm × 25 cm. Weeds are one of the major obstacles that severely affect the productivity and quality of the component crops. Weeds compete with the crop plants for nutrients, moisture and light and thus, reduce the yield considerably. Gopinath *et al*. (2009) revealed that season-long crop-weed competition reduced the green pod yield of garden pea by 74% in 2003–2004 and 93% in 2004–2005 under Indian Himalayas condition. Keeping the above points in view, the experiment was conducted to see the response of field pea and baby corn to planting pattern and weed management in field pea + baby corn intercropping system.

MATERIALS AND METHODS

The experiment was conducted during the winter (*rabi*) seasons of 2011–12 and 2012–13 at Dr Norman E. Borlaug Crop Research Centre, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand (29° N, 79.3° E and 243.84 m above mean sea-level). The maximum temperature during the crop season of 2011–12 and 2012–13 ranged between 17.5 and 36.5°C and 12.0–40.6°C, respectively. The minimum temperature during the same period ranged between 3.7 and 21.5°C and 2.5–23.7°C respectively. A total rainfall of 1.16 mm and 5.44 mm were received during the crop season of 2011–12 and 2012–13 respectively. There was frost in the second fortnight of January during 2012–2013. The soil was sandy loam, high in organic carbon (0.79%), low in available nitrogen (210.6 kg N/ha) and medium in available phosphorus (16.5 kg P/ha) and potassium contents (184.7 kg K/ha) and neutral in soil reaction (*p*H 7.3). The experiment was laid out in a split-plot design with 3 replications. Main plot consisted of 4 planting patterns, viz. sole field pea (30 cm), sole baby corn (45 cm), maize + field pea (1:1) and paired maize (30/60 cm) + field pea (2:2) and sub-plot consisted of 4 weed-management practices, viz. weedy check, hand-weeding at 30 days after sowing (DAS), pre-emergence (PE) application of pendimethalin 1 kg/ha and post-emergence (POE) application of imazethapyr 50 g/ha at 30 DAS. Maize crop was fertilized with 120, 60 and 40 kg/ha of N, P_2O_5 and K_2O through urea, single super phosphate and muriate of potash respectively. Half dose of nitrogen and full dose of P_2O_5 and K_2O were applied basal in all the plots and remaining N was applied at days after sowing as top-dressing. A dose of 18 kg N, 48 kg P_2O_5 and 24 kg K_2O/ha was applied to field pea sole through NPK mixture (12 : 32 : 16) @150 kg/ha as basal. No additional dose of fertilizer to pea was given to intercropping system.

Different observations related to yield and its attributes were recorded following the standard procedures. Land-equivalent ratio (LER) was calculated as:

$$LER = \frac{Y1i}{Y1s} + \frac{Y2i}{Y2s}$$

where Y1i and Y1s are the intercrop and sole crop yields of component 1 and Y2i and Y2s are the intercrop and sole crop yields of component 2 respectively.

Crop-equivalent yield was computed with the help of following formula:

$Y_1P_1 = Y_2P_2$

where Y_1 and Y_2 are the yields of component 1 and 2, respectively, and P_1 and P_2 are the prices of component 1 and 2 respectively.

Cost of cultivation of sole and intercropping system was calculated on the basis of prevailing market price of different inputs like labour, implements, seeds, fertilizers and herbicides, used in cultivation of crops under different treatments. The grain and straw yields of field pea, fresh weight of baby corn and stover yield of maize were computed into gross return on the basis of prevailing local market prices of produce (grain, baby corn and straw/stover). The net return of each treatment was calculated by deducting the cost of cultivation from the gross return of individual treatment. Benefit: cost (B : C) ratio was obtained by dividing the net return by cost of cultivation.

The data collected for various parameters were subjected to analysis by using STPR-1, programme developed by Department of Statistics and Mathematics, College of Basic Science and Humanities, Pantnagar. Comparison of treatment means was done using critical differences (CD) at 5% level of significance.

RESULTS AND DISCUSSION

Field pea

Yield attributes: Sole field pea (30 cm) produced significantly higher pods/plant than both the intercropping systems (Table 1). Possible reasons for higher pods/plant in sole field pea plots might be attributed to no inter-specific competition, more number of pod-bearing branches and better utilization of nitrogen being applied as a starter dose and fixed by root nodule. Shading by the taller component resulted in flower and pod dropping, which ultimately decreased number of pods/plant in intercropping systems. Similar results were reported by Khan *et al.* (2012) and Das *et al.* (2013) in mungbean and soybean when they found higher pods/plant in monoculture as compared to their corresponding intercropping with maize. Among the weed-management practices, hand-weeding (30 DAS) resulted in statistically similar number of pods/plant as PE application of pendimethalin 1 kg/ha. Planting patterns had no significant effect on grains/pod, but hand-weeding (30 DAS) resulted in significantly higher grains/pod than remaining weed-management practices (Table 1). The maximum number of grains/pod in hand-weeding (30 DAS) might be due to less competition from weeds which provides ample space for the crop plants to spread their source (leaves) which trapped solar radiation more efficiently than the remaining treatments resulting in more dry-matter accumulation which is the pre-requisite for better development of yield-attributing characters. Planting patterns and weed-management practices had no significant effect on 1,000- grain weight (Table 1). Sole field pea (30 cm) gave significantly more grain yield/plant than both the intercropping systems. Hand-weeding (30 DAS) recorded the highest grain yield/plant (Table 1).

Grain yield, straw yield and harvest index: On an average, sole field pea yielded 85.3 and 61.4% more grain yield than maize + field pea (1:1) and paired maize (30/60 cm) + field pea (2:2) respectively (Table 1). Higher yield of field pea in the treatments where it was grown alone might be owing to higher planting density, plant height and higher values of yield-attributing characters like pods/plant, grains/pod and grain yield/plant. On an average, hand-weeding (30 DAS), PE application of pendimethalin 1 kg/ha and PoE application of imazethapyr 50 g/ha (30 DAS) resulted in 50.8, 31.6 and 24.0% higher yield over weedy check respectively. The higher grain yield in these treatments could be attributed to improvement in yield components which was the result of lower crop-weed competition, which shifted the balance in favour of crop in the utilization of nutrients, moisture, light and space. The interaction between planting patterns and weed-management practices with respect to grain yield/ha was significant during both the years (Table 2). Sole field pea (30 cm) recorded the highest grain yield which was significantly higher than paired maize (30/60 cm) + field pea

Table 1. Effect of planting patterns and weed-management practices on yield attributes, grain and straw yields and harvest index of field pea (data pooled over 2 years)

Treatment	Pods/plant	Grains/pod	1,000-grain weight (g)	Grain yield/plant (g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)
Planting pattern							
Sole field pea (30 cm)	18.5	5.9	154.4	17.6	1.85	2.90	38.4
Maize + field pea (1:1)	17.4	5.6	152.7	16.9	1.00	2.46	29.0
Paired maize (30/60 cm) + field pea (2:2)	17.6	5.7	151.3	17.0	1.15	2.27	32.4
SEm±	0.2	0.1	4.0	0.2	0.05	0.07	0.9
CD (P=0.05)	0.6	NS	NS	0.6	0.20	0.28	3.2
Weed management							
Weedy	16.5	5.3	150.4	14.9	1.05	2.40	29.5
Hand-weeding (30 DAS)	19.1	6.2	152.2	18.8	1.59	2.70	35.9
Pendimethalin 1 kg/ha (PE)	18.5	5.8	149.7	17.9	1.38	2.52	34.6
Imazethapyr 50 g/ha (PoE, 30 DAS)	17.2	5.7	159.0	17.1	1.30	2.55	33.0
SEm±	0.2	0.1	3.2	0.2	0.04	0.05	0.8
CD (P=0.05)	0.7	0.4	NS	0.5	0.11	0.14	2.3

DAS, Days after sowing; PE, pre-emergence; PoE, post-emergence

(2 : 2) and maize + field pea (1 : 1) under all weed-management practices. Hand-weeding (30 DAS) recorded the highest grain yield under all planting patterns, and the lowest yield was found in weedy check under all planting patterns. On an average, increase in straw yield in sole field pea than maize + field pea (1 : 1) and paired maize (30/60 cm) + field pea (2:2) was 18.0 and 27.9% respectively (Table 1). This was mainly owing to higher plant population in sole planting of field pea. Similar results were reported by Barod *et al*. (2017), who reported significantly higher grain and straw yields in sole crop of pigeonpea and mungbean than their intercropping with pearlmillet. On an average, hand-weeding (30 DAS), PE application of pendimethalin 1 kg/ha and PoE application of imazethapyr 50 g/ha (30 DAS) resulted 12.6, 5.0 and 6.1% higher straw yield over weedy check respectively. The highest harvest index was observed in field pea sole (30 cm) which was significantly higher than both the intercropping systems (Table 1). Oljaca *et al.* (2000) and Das *et al.* (2013) also reported similar results, who observed lower HI of soybean under intercropping system compared to that in sole cropping. Hand-weeding (30 DAS) being at par with PE application of pendimethalin 1 kg/ha), recorded significantly higher harvest index than remaining weed-management practices.

Baby corn

Number of baby cobs/plant: Planting patterns had no significant effect on the number of baby cobs/plant (Table 3). Hand-weeding (30 DAS) resulted in comparatively more number of baby cobs/plant than PE application of pendimethalin 1 kg/ha, PoE application of imazethapyr 50 g/ha (30 DAS) and weedy check.

Baby corn and stover yield: The yield of baby corn under different planting patterns was statistically similar (Table 3). On an average, hand-weeding (30 DAS), PE

Table 2. Interaction between planting pattern and weed management on grain yield of field pea (data pooled over 2 years)

Planting pattern	Grain yield (t/ha)			
	Weedy	Hand-weeding (30 DAS)	Pendimethalin 1 kg/ha (PE)	Imazethapyr 50 g/ha (PoE, 30 DAS)
Sole field pea (30 cm)	1.48	2.21	1.85	1.85
Maize + field pea (1 : 1)	0.79	1.14	1.12	9.57
Paired maize (30/60 cm) + field pea (2 : 2)	0.89	1.41	1.18	1.10
		SEm±	CD (P=0.05)	
Comparison between 2 planting patterns at same weed management		0.06	0.19	
Comparison between 2 weed managements at same planting pattern		0.08	0.26	

DAS, Days after sowing; PE, pre-emergence; PoE, post-emergence

Table 3. Effect of planting patterns and weed-management practices on number of baby cobs/plant, baby corn and stover yields of baby corn, land-equivalent ratio (LER), field pea-equivalent yield and economics (data pooled over 2 years)

Treatment	Baby cobs/ plant	Baby corn yield (t/ha)	Stover yield (t/ha)	LER	Field pea equivalent yield (t/ha)	Cost of cultivation (× 10^3 ₹/ha)	Net returns (× 10^3 ₹/ha)	Benefit: cost ratio
Planting pattern								
Sole field pea (30 cm)	–	–	–	1.00	1.85	18.6	40.0	2.15
Sole baby corn (45 cm)	3.0	0.81	3.55	1.00	1.45	24.3	25.1	1.04
Maize + field pea (1:1)	2.7	0.76	1.59	1.52	2.36	27.5	48.6	1.77
Paired maize (30/60 cm) + field pea (2:2)	2.8	0.78	1.80	1.61	2.54	27.5	53.3	1.95
SEm±	0.05	0.02	0.05	0.02	0.06	–	–	–
CD (P=0.05)	NS	NS	0.21	0.09	0.20	–	–	–
Weed management								
Weedy	2.5	0.54	1.95	1.07	1.51	23.1	43.8	1.91
Hand-weeding (30 DAS)	3.2	0.92	2.59	1.04	2.43	25.7	77.8	3.04
Pendimethalin 1 kg/ha (PE)	2.9	0.90	2.71	1.04	2.23	24.9	71.4	2.87
Imazethapyr 50 g/ha (PoE, 30 DAS)	2.8	0.78	2.02	1.01	2.02	24.2	62.3	2.58
SEm±	0.05	0.02	0.06	0.05	0.04	–	–	–
CD (P=0.05)	0.16	0.05	0.17	NS	0.12	–	–	–

DAS, Days after sowing; PE, pre-emergence; PoE, post-emergence; NS, non-significant

Table 4. Interaction between planting pattern and weed management on baby corn yield (data pooled over 2 years)

Planting pattern	Baby corn yield (t/ha)			
	Weedy	Hand-weeding (30 DAS)	Pendimethalin 1 kg/ha (PE)	Imazethapyr 50 g/ha (PoE, 30 DAS)
Sole baby corn (30 cm)	0.53	1.00	0.90	0.81
Maize + field pea (1:1)	0.50	0.83	0.91	0.81
Paired maize (30/60 cm) + field pea (2:2)	0.58	0.95	0.88	0.71
		SEm±		CD (P=0.05)
Comparison between 2 planting patterns at same weed management		0.03		0.08
Comparison between 2 weed managements at same planting pattern		0.03		0.11

DAS, Days after sowing; PE, pre-emergence; PoE, post-emergence

application of pendimethalin 1 kg/ha and PoE application of imazethapyr 50 g/ha (30 DAS) resulted in 72.6, 67.2 and 45.5% higher baby corn yield over weedy check respectively. The higher baby corn yield in hand-weeding (30 DAS) and herbicide-treated plots was owing to better growth and development of baby corn plants as a result of less competition from weeds for light, water, nutrients, carbon dioxide, etc. as a result of better control of weeds. Interaction between planting pattern and weed management on baby corn yield/ha was significant (Table 4). Hand-weeded (30 DAS) plots gave more baby corn yield under different planting patterns. On an average, sole baby corn gave 123.1 and 97.3% more stover yield over maize + field pea (1 : 1) and paired maize (30/60 cm) + field pea (2 : 2) respectively (Table 3). This was mainly owing to better growth and dry-matter accumulation in sole baby corn. Similar results were reported by Singh *et al.* (2017), who reported reduction in straw yield of associated cereal crop, i.e. barley in an intercropping system with chickpea. Among the weed-management practices, on an average, hand-weeding (30 DAS), PE application of pendimethalin 1 kg/ha and PoE application of imazethapyr 50 g/ha (30 DAS) resulted in 33.3, 39.2 and 3.5% higher stover yield over weedy check respectively. These results confirm the findings of Sinha *et al.* (2001) and Shinde *et al.* (2001), who found that use of herbicides to control weeds resulted in increased plant height, plant population and stover yield.

Land equivalent ratio: Land-equivalent ratio (LER) differed significantly only due to planting pattern (Table 3). Both the intercropping systems had higher LER than sole field pea or baby corn. Yield advantages occurred owing to the development of both temporal and spatial complementarities. The results agreed with the findings of Dahmardeh *et al.* (2010) who reported that LER values were greater in all intercropping systems of maize and cowpea than their sole crops.

Field pea equivalent yield: Both the intercropping systems had higher field pea-equivalent yield than sole planting of either field pea or baby corn (Table 3). This was mainly owing to additional advantage of intercrops yield and higher economic values of intercrops. Field pea-equivalent yield was the highest for hand-weeding (30 DAS) which was followed by PE application of pendimethalin 1 kg/ha, PoE application of imazethapyr 50 g/ha (30 DAS) and weedy check.

Economics

The net returns was higher from both the intercropping systems than sole planting of either field pea or baby corn (Table 3). The highest net return was found in hand-weeded (30 DAS) plots which was followed by PE application of pendimethalin 1 kg/ha, PoE application of imazethapyr 50 g/ha (30 DAS) and weedy check. The highest benefit: cost ratio was found in field pea sole (30 cm) (2.15), which was followed by paired maize (30/60 cm) + field pea (2:2) (1.95), maize + field pea (1:1) (1.77) and sole baby corn (45 cm) (1.04) (Table 3). Hand-weeding (30 DAS) had the highest benefit: cost ratio (3.04) which was followed by PE application of pendimethalin 1 kg/ha (2.87), PoE application of imazethapyr 50 g/ha (30 DAS) (2.58) and weedy check (1.91). Hand-weeding (30 DAS) fetched higher net return (77.80×10^3 ₹/ha) as well as benefit: cost ratio (3.04) which might be owing to higher combined intercrop yield.

It may be concluded that paired maize (30/60 cm) + field pea (2 : 2) proved more remunerative and efficient in terms of land utilization (LER) and yield advantage (field pea equivalent yield) than maize + field pea (1:1) and sole planting of either field pea or baby corn. Hand-weeding (30 DAS) was found more beneficial than PE application of pendimethalin 1 kg/ha, PoE application of imazethapyr 50 g/ha (30 DAS) and weedy check.

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