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Research Paper

Effect of row ratio and phosphorus fertilizer in chickpea (*Cicer arietinum*) and mustard (*Brassica juncea*) intercropping system

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ABSTRACT

A field experiment was conducted during *rabi* season of 2007–09 at Hamirpur, Uttar Pradesh to evaluate 5 cropping systems and 4 phosphorus levels in chickpea {*Cicer arietinum* (L.)} and mustard {*Brassica juncea* (L.) Czern. & Coss} intercropping systems. Sole chickpea and mustard gave highest seed yield. Among intercropping, 6:3 row ratio produced significantly the highest seed yield of chickpea (1.10 t/ha) followed by 4:2 row ratio (0.99 t/ha). Chickpea grain equivalent yield (1.55 t/ha) and LER (1.32) were recorded the highest under 6:3 row ratio followed by 4:2 row ratio (1.46 t/ha and 1.26, respectively). Seed yield of chickpea, mustard and chickpea grain equivalent yield increased with increasing levels of phosphorus upto 60 kg P_2O_5/ha. Protein content in chickpea seed was recorded the highest in sole stand. Maximum net profit of ₹31,450/ha and B:C ratio of 2.48 was recorded in 6:3 row ratio intercropping. Increasing levels of phosphorus increased seed yield, protein content in chickpea seed, oil content in mustard seed, net profit, and B:C ratio significantly up to 60 kg P_2O_5/ha. It is thus concluded that intercropping of chickpea and mustard in 6:3 row ratio with 60 kg P_2O_5/ha is better combination for higher productivity.

Key words: Chickpea, Indian mustard, Intercropping, Land equivalent ratio, Phosphorus, Row ratio

Pulses and oilseeds are more remunerative than cereals under rainfed condition. Chickpea is an important crop of rainfed areas in Bundelkhand zone of Uttar Pradesh. Indian mustard is also grown on sizeable area, but in mixed stand with chickpea, lentil and/or linseed crop, where yields are very poor because of improper plant stand of component crops and fertilizer nutrition. Prasad *et al.* (1997) observed higher productivity of chickpea when intercropped with Indian mustard. This system not only stabilized chickpea production but also increased the cropping intensity and land utilization efficiency. The success of intercropping system depends mainly on suitable population of component crops in proper row adjustment so that competition between them may be minimized. Proper fertilization of component crops is also essential to exploit their yield potential. Research information on those two important aspects of chickpea + Indian mustard intercropping is lacking particularly for silty loam (*Parwa*) soil of Bundelkhand region of Uttar Pradesh. Therefore, the present study was undertaken on row proportions and phosphorus requirement of chickpea + Indian mustard intercropping system.

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MATERIALS AND METHODS

The field experiment was conducted during *rabi* seasons of 2007–09 at Research Farm Brahmanand Post Graduate College, Rath, Hamirpur, Uttar Pradesh at 25° 50°’ north latitude and 79° 7°’ east longitude. The soil of experimental site was silty loam in texture, slightly alkaline in nature (pH 7.8) having 0.53% O.C., 237.6 kg/ha available N, 25.27 kg/ha available P_2O_5 and 202 kg/ha available K_2O. The rainfall of 9.6 and 16.0 mm was received during crop seasons of 2007–08 and 2008–09, respectively. The experiment was laid out in 3 times replicated split plot design with 20 treatment combinations having 5 cropping systems (Sole chickpea (CP), sole Indian mustard (IM), CP+M in 2:1, 4:2 and 6:3 row proportions) in main–plots and 4 phosphorus levels (0, 30, 60, 90 kg P_2O_5/ha) in sub–plots. Intercropping was done in replacement series. Chickpea ‘Radhey’ and Indian mustard ‘Vardan’ were sown at recommended seed in sole cropping, whereas the seed quantity varied according to the area occupied by the crops in intercropping system. A uniform dose of 18 kg N/ha in chickpea and 60 kg N/ha in

Indian mustard was applied at the time of sowing on the basis of actual area occupied by each crop. Sowing was done in rows 40 cm apart in each case on 3 November, 2007 and November 2008. The observations were recorded on growth and yield attributes, actual yield of component crops, chickpea equivalent yield (CEY) and land equivalent ratio (LER). The CEY was worked out by converting the yield of mustard into the yield of chickpea on the basis of prevailing market price of the crops. LER of the system was calculated by using the formula given by Willey (1979). Seed protein was worked out by multiplying N content in seed with constant factor 6.25. The estimation of oil was done by Intermittent extraction's method using petroleum ether as solvent (Joslyn, 1970). The net returnd was calculated by deducting the total cost of cultivation from the gross returns of each treatment. The B:C ratio was calculated by dividing gross return by cost of cultivation of each treatment. Phosphorus use efficiency was calculated with the formula (PUE) = (yield of treated plot–yield of control plot)/applied P_2O_5 kg per ha.

RESULTS AND DISCUSSION

Growth characters

In chickpea, number of branches/plant and dry matter/plant were recorded significantly higher in sole stand than intercropping. However, dry weight of nodules/plant was the highest in 6:3 row ratio of CP+M. In mustard, number of branches and dry matter/plant were recorded the highest in 4:2 row ratio of CP+M intercropping followed by 6:3 row ratio. Plant height of chickpea or mustard was influenced by cropping systems significantly. However, mustard plant height showed increase in intercropping treatments over sole stand numerically (Table 1). Reduction in branches and dry matter/plant of chickpea in intercropping system might be due to shading effect of mustard on chickpea. Better growth of mustard in intercropping might be due to reduced plant competition within the community. Increasing levels of phosphorus increased plant height, number of branches/plant and dry matter/plant of chickpea and mustard both significantly up to 60 kg P_2O_5/ha (Table 1). Dry weight of root nodules in chickpea also increased significantly up to 60 kg P_2O_5/ha. It might be due to increased availability of phosphorus to plants at higher rate of application, which improved the cell division and development through proper carbohydrate metabolism and respiration resulting better growth of chickpea and mustard. These results corroborate to the findings of Tripathi *et al.* (2005).

Yield attributes

In chickpea, number of pods/plant, seed weight/plant and harvest index were recorded significantly the highest

Table 1. Effect of intercropping and phosphorus levels on growth characters and yield attributes of chickpea and Indian mustard in intercropping system (Poled data of two years)

Treatment	Chickpea characters								Indian mustard characters							
	Plant height (cm)	Number of branches/ plant	Dry weight of nodules/ plant (mg)	Dry weight/ plant (g)	Pods/ plant	1,000–seed weight (g)	Seed weight/ plant (g)	Harvest index (%)	Plant height (cm)	Branches/ plant	Dry weight/ plant	Siliquae/ plant	Seeds/ siliqua	1,000–seed weight (g)	Seed weight/ plant (g)	Harvest index (%)
Intercropping system																
Sole chickpea	76.8	28.1	195.9	34.9	27.0	185.3	8.5	39.9	–	–	–	–	–	–	–	–
Sole mustard	–	–	–	–	–	–	–	–	137.7	24.0	47.7	322.0	12.2	4.2	7.7	21.8
CP+M (2:1)	77.2	23.3	202.7	30.1	24.8	187.0	7.5	32.2	139.3	32.2	68.0	446.8	14.1	4.3	10.8	23.1
CP+M (4:2)	77.4	23.5	210.2	30.2	25.2	186.6	7.6	35.3	140.7	35.5	75.1	505.8	14.2	4.4	12.3	22.7
CP+M (6:3)	77.4	23.9	222.1	30.7	25.7	186.0	7.7	36.7	142.2	34.1	72.3	475.0	14.2	4.4	11.5	22.5
SEm±	1.4	0.4	3.9	0.5	0.4	0.7	0.2	0.2	2.0	0.6	1.3	9.2	0.1	0.4	0.2	0.1
CD (P=0.05)	NS	1.4	11.9	1.6	1.3	NS	0.5	0.6	NS	1.9	4.1	28.4	0.2	0.1	0.5	0.4
Phosphorus (kg/ha)																
0	73.6	19.2	162.4	26.0	21.7	183.2	6.3	35.1	130.9	27.9	56.8	362.6	12.8	4.0	8.4	21.9
30	77.0	24.0	206.2	30.7	25.3	185.4	7.6	37.1	138.1	30.6	63.8	425.6	13.7	4.3	10.1	22.4
60	79.9	27.8	229.0	34.4	27.9	187.4	8.6	37.0	143.6	32.9	69.6	465.7	14.0	4.5	11.4	22.8
90	78.1	27.9	233.3	34.7	27.8	188.8	8.7	36.0	147.4	34.5	72.9	495.7	14.3	4.6	12.3	23.0
SEm±	1.5	0.6	5.7	0.7	0.6	0.9	0.3	0.3	2.9	0.8	1.6	11.1	0.1	0.4	0.3	1.5
CD (P=0.05)	4.1	1.7	15.9	1.9	1.7	2.6	0.7	0.7	7.9	2.3	4.5	30.6	0.3	0.1	0.7	0.5

in sole crop (Table 1). Among intercropping, significant variation was not observed in yield attributes, but intercropping reduced pods/plant, seed weight/plant and harvest index significantly compared with sole chickpea. These reductions might be due to intensified interspecific competition for light offered by mustard plants. In mustard crop, number of siliquae/plant, seeds/siliqua, test weight and seed weight/plant recorded highest in intercropping of CP+M in 4:2 row ratio. The intercropping in 6:3 and 2:1 row ratios of CP+M also recorded significantly higher values of yield attributes over sole mustard. The higher values of yield attributes in intercropping systems may be ascribed to the low inter and intra–specific competition as compared to sole mustard, where each plant faced more competition particularly for upper ground growth resources. Almost similar results have been reported by Tripathi *et al.* (2005) and, Kumar and Singh (2006). The yield attributes of chickpea (Pods/plant, seeds/plant and seed weight/ plant) and mustard (siliquae/plant, seeds/ siliqua, test weight and seed weight/plant) increased with increasing levels of phosphorus significantly up to 60 kg P_2O_5/ha. These improvements in yield attributes of chickpea and mustard owing to P fertilization may be accounted for favourable influence of P nutrition on promotion of source capacity in legumes and oilseeds. These results are in accordance to the findings of Tripathi *et al.* (2005) and; Kumar and Singh (2006).

Productivity

Seed yield of chickpea and mustard was the highest in their sole stands (Table 2). It was associated with higher plant population per unit area in sole stand of both crops. Among intercropping, chickpea produced significantly the highest seed yield under 6:3 row ratio of CP+M intercropping. These seed yields might be attributed to various yield attributes of chickpea, which also behaved in similar manner. In case of mustard, 4:2 row ratio being at par with row ratio of 6:3 of CP+M intercropping, produced significantly higher seed yield than 2:1 row ratio of CP+M intercropping. Such yields are attributed to yield attributes of mustard. These results confirm the findings of Kumar and Singh (2006).

Further, analysis of seed yield showed that in intercropping systems, plant stand of chickpea was 66.7 per cent of sole chickpea, but seed yield produced 61.5, 72.3 and 79.8% in 2:1, 4:2 and 6:3 ratios of CP+M intercropping on the basis of pooled data. These figures shows that chickpea had the yield advantage of 5.6% in 4:2 and 13.1% in 6:3 row ratio of intercropping, respectively, while 2:1 row ratio gave a yield loss of 5.2%. Similarly in mustard 33.3% plant stand of sole mustard, was maintained in intercropping systems, seed yield advantages were worked out as 14.1, 21.0 and 18.7% in 2:1, 4:2 and 6:3 row ratios of CP+M intercropping, respectively. These results clearly indicate that mustard crop was more benefited in CP+M intercropping.

Total productivity of intercropping system in form of chickpea equivalent yield was recorded the highest in 6:3 row ratio of CP+M closely followed by 4:2 row ratio of CP+M, while lowest in sole mustard (Table 2). It might be attributed to higher seed yield of chickpea in 6:3 row ratio and that of mustard in 4:2 row ratio of CP+M intercropping. The intercropping of CP+M in 2:1 row ratio could not produce even at par with sole chickpea thus proved to be non advantageous. Kumar and Singh (2006) also observed similar results.

Table 2. Effect of intercropping and phosphorus levels on yield of chickpea and Indian mustard, chickpea equivalent yield (t/ha), net returns and B:C Ratio of intercropping system (Poled data of two years)

Treatment	Chickpea yield (t/ha)		Mustard yield (t/ha)		Chickpea seed equivalent (t/ha)	Net returns ($\times10^3$ ₹/ha)	B:C ratio
	Seed	Stover	Seed	Stover			
Intercropping System							
Sole chickpea	1.37	2.07			1.37	24.68	1.89
Sole mustard			1.13	4.05	0.87	16.15	1.52
CP+M (2:1)	0.85	1.78	0.54	1.78	1.26	23.97	1.87
CP+M (4:2)	0.99	1.82	0.62	2.08	1.47	29.36	2.31
CP+M (6:3)	1.10	1.89	0.59	2.02	1.55	31.45	2.48
SEm±	0.02	0.03	0.01	0.05	0.03	0.86	0.05
CD (P=0.05)	0.07	0.10	0.04	0.15	0.08	1.28	0.08
Phosphorus (kg/ha)							
0	0.89	1.64	0.55	1.98	1.05	18.35	1.55
30	1.09	1.85	0.68	2.40	1.29	24.82	2.03
60	1.19	2.02	0.79	2.70	1.44	28.63	2.28
90	1.15	2.05	0.85	2.86	1.44	28.46	2.2
SEm±	0.03	0.05	0.02	0.08	0.03	0.72	0.05
CD (P=0.05)	0.09	0.13	0.06	0.22	0.08	1.98	0.14

The seed yield of both chickpea and mustard increased significantly due to phosphorus application up to 60 kg P_2O_5/ha. It might be attributed to various yield attributes of both component crops. It may be ascribed to assimilation and translocation of more photosynthates towards sink at higher level of phosphorus application. These results may be supported by the findings of Kumar and Singh (2006).

System productivity

It was computed much higher in 6:3 and 4:2 row ratios of CP+M intercropping as compared to 2:1 row ratio, which attain LER just above sole cropping (Fig. 2). The reason may be explained that in 6:3 or 4:2 row ratios of CP+M intercropping, component crops particularly mustard utilized environmental resources more efficiently and increased proportionate yield by larger margin than the area allotted. LER was increased slightly with P application over control, but increased P rates had no remarkable effect on LER. It might be associated with more efficient utilization of P by component crops in intercropping system. These results confirm the findings of Tripathi *et al.* (2005).

Phosphorus use efficiency

Phosphorus use efficiency was calculated in terms of seed yield with per unit of fertilizer P_2O_5 application. The effect of intercropping on phosphorus use efficiency is shown in fig. 3. The results indicate that, sole chickpea and mustard recorded the highest phosphorus use efficiency of 7.63 and 6.29 kg seed with per kg applied P_2O_5, respectively, however, in intercropping system phosphorus use efficiency increases with increase population in the planting ratio and highest was achieved (6.09 kg seed with per kg applied P_2O_5) in 6:1 ratio. In case of mustard, phosphorus use efficiency increases with increasing population of chickpea and mustard in the system, the maximum phosphorus use efficiency was recorded (3.42 kg seed with per kg applied P_2O_5) in 4:2 ratio. The results revealed that lower PUE was seen at higher P rates and the maximum PUE of 6.7 and 4.5 kg seed with per kg applied P_2O_5 were observed with 30 kg P_2O_5/ha in chickpea and mustard, respectively.

Seed quality

Protein content in chickpea seed and oil content in mustard seed were not affected by intercropping systems, however protein content in chickpea seed was found significantly higher in sole stand than in 2:1 row ratio of CP+M intercropping only in pooled analysis. Oil content in mustard seed did not influence significantly in different intercropping systems. Similar results have been reported by Singh and Yadav (1992) in chickpea and by Chand and Tripathi (2005) in Indian mustard.

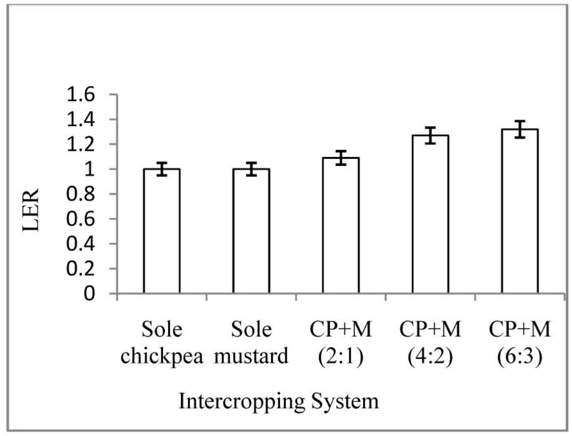

Fig. 1. Effect of intercropping on land equivalent ratio (LER)

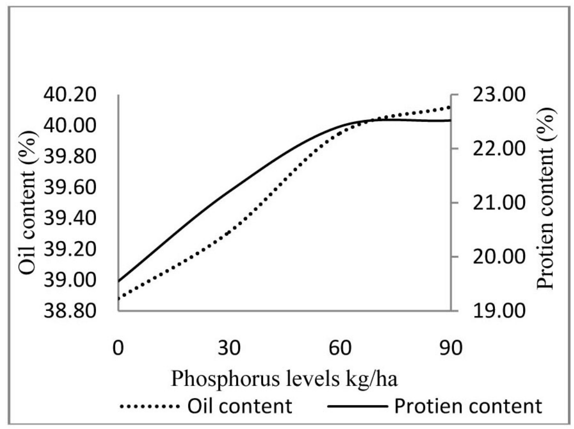

Fig. 2. Effect of phosphorus levels on oil content in mustard and protien content in chickpea

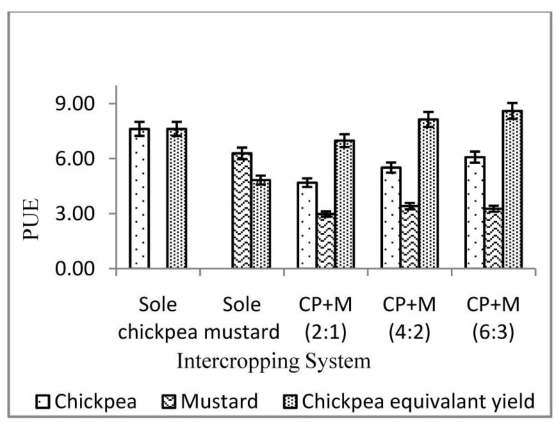

Fig. 3. Effect of intercropping on phoshphorus use efficiency (PUE) kg seed/kg applied P_2O_5

Protein content in chickpea seed and oil content in mustard seed increased with increasing levels of phosphorus significantly up to 60 kg P_2O_5/ha (Fig. 2). It might be due to more uptake of N in chickpea because of better nodulation at higher levels of P application. Singh *et al.*

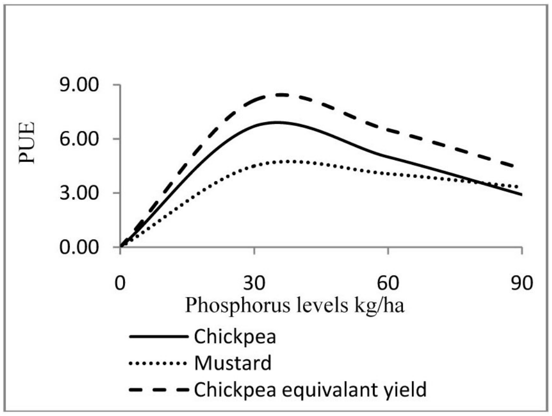

Fig. 4. Effect of phosphorus on phoshphorus use efficiency (PUE) (kg seed/kg applied P_2O_5)

(1997) also reported that application of P significantly increased the uptake of N in chickpea by 30–40% at 60 kg P_2O_5/ha over control. Oil content of mustard influenced significantly with increase in phosphorus levels and produced highest oil content with highest dose of 60 kg P_2O_5/ha. Increase in seed oil content of mustard may be ascribed because it is a constituent of phospholipids and is essential for its synthesis (Maraghatham and Challambudu, 2000).

Economics

Net returns and benefit: cost ratio were recorded the highest with CP+M intercropping in 6:3 row ratio and lowest in sole mustard (Table 2). On pooled basis of two years results, CP+M intercropping in 6:3 row ratio earned maximum net profit of ₹31,450/ha, which was found 7.1, 27.4, 32.7 and 94.7% higher than the net returns values of CP+M intercropping in 4:2 row ratio, sole chickpea, CP+M intercropping in 2:1 row ratio and sole mustard. Better performance of 6:3 and 4:2 row ratios of CP+M intercropping might be associated with higher seed yield of component crops in case of various economic parameters of the system. Kumar and Singh (2006) also reported similar results. Net return and B:C ratio increased with increasing P levels significantly up to 60 kg P_2O_5/ha (Table 2). These might be attributed to higher seed production of both component crops with increasing P levels in a similar way. These results are in accordance to the findings of Kumar and Singh (2006).

In general, it was concluded that environmental resource consumption, including photo synthetically active radiation, moisture and nutri-ents, was better in intercropping system than sole crops, suggesting that intercrop components have 'complementarities effect' in environmental resource obtaining, which is result of different morphological and physiological char-acteristics of intercrop components. More environmental resource consumption in chickpea + mustard intercropping in 6:3 ratio fertilized with 60 kg P_2O_5/ha resulted higher productivity and profitability.

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