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Biological and economical feasibility of chickpea (*Cicer arietinum*) + Indian mustard (*Brassica juncea*) cropping systems under varying levels of phosphorus

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ABSTRACT

A study was undertaken by introducing Indian mustard [*Brassica juncea* (L.) Czernj. & Cosson] as an intercrop with chickpea (*Cicer arietinum* L.) in 2 row proportions, viz. 6:2 and 8:2, fertilized with 0, 30, 60 and 90 kg P_2O_5/ha during the winter season of 1998–99 and 1999–2000, to assess the biological and economical feasibility of chickpea + Indian mustard in association under varying levels of phosphorus. Intercropping systems reduced the values of yield attributes and seed yield of chickpea, while reverse was true in case of Indian mustard than sole cropping of chickpea and Indian mustard respectively. Both intercropping systems recorded significantly higher chickpea-equivalent yield, net monetary returns and benefit : cost ratio than its sole cropping. Among the intercropping systems, 8:2 row ratio proved most efficient and profitable system resulting in maximum chickpea-equivalent yield (24.31 q/ha), net monetary returns (Rs 17,101/ha), benefit : cost ratio (2:11) and land-equivalent ratio (1.19). Both chickpea and Indian mustard in sole and intercropping systems responded favourably up to 60 kg P_2O_5/ha only for yield attributes, yield and net monetary returns over no phosphorus and 30 kg P_2O_5/ha. The interaction effects of the factors showed that mean chickpea equivalents responded to P application up to 60 kg/ha in sole stands and up to 90 kg P_2O_5/ha in intercropping systems.

Key words : Intercropping, Chickpea, Indian mustard, Chickpea-equivalent yield, Economic feasibility

Intercropping may be a feasible and viable agronomic practice for stepping up the production of pulses and oilseeds from a unit of land during a cropping period. Plant population and spatial arrangement in intercropping have important effects on the balance of competition between component crops and their productivity. The greatest limitation of increase in productivity of these crops is inadequate supply of fertilizer nutrients. The nutrient mainly phosphorus contributes significantly in enhancing the yield of leguminous crops. Thus, proper application of phosphorus may increase the production and productivity of both chickpea and Indian mustard crop (Enania and Vyas, 1995). Keeping in view, an experiment was undertaken to find out possibility of increasing production of pulses and oilseeds through intercropping system in relation to spatial arrangement of crops and phosphorus fertilization.

MATERIALS AND METHODS

An experiment involving intercropping of Indian mustard with chickpea was conducted in sandy-loam soil of Kanpur, during the winter seasons of 1998–99 and 1999–2000. The soil was slightly alkaline in reaction (pH 7.9 and 7.8), poor in organic carbon (0.40 and 0.45%), low in available N (225 and 248 kg/ha), medium in available P_2O_5 (16.1 and 14.0 kg/ha) and available K_2O (180 and 172 kg/ha).

Treatments consisting of 16 combinations of 4 cropping systems, viz. sole chickpea, sole Indian mustard, chickpea + Indian mustard, chickpea + Indian mustard (6:2) and chickpea + Indian mustard (8:2) row proportion and 4 P levels (0, 30, 60 and 90 kg/ha) applied to the crops were tested in randomized block design and replicated thrice. Crop varieties were 'Udai' and 'Basanti' for chickpea and Indian mustard respectively. Both crops were sown in the last week of October in the 2 years at row distance of 45 cm. The seed rate was 100 and 5 kg/ha for respective crops. All sole crops were fertilized with recommended dose of 20 kg N/ha for chickpea and 120 kg N/ha for Indian mustard. In case of intercropping, the fertilizer dose was adjusted for proportionate area of the crops. Phosphorus was given in basal as per treatment. Full dose of nitrogen was applied chickpea as basal dressing in furrows before sowing. In Indian mustard, nitrogen was applied in 2 equal splits, i.e. 50% basal and 50% top-dressed after first irrigation. The crop-wise harvesting was done at maturity. Chickpea and Indian mustard were harvested on 30 March 1999 and 20 March 1999 during the first year and 2 April 2000 and 24 March 2000 during the second year respectively. Rainfall received during crop period of 1998–99 and 1999–2000 was 18.2 and 11.8 mm respectively. Economics was worked out on the existing market price. Chickpea-equivalent yield was calculated on the basis of support prices of both the crops on pooled basis. The pooled data were computed for different biological indices, viz. land-equivalent ratio and product of relative crowding coefficient, as described by Willey (1979). It was further calculated for competition index as proposed by Donald (1963).

RESULTS AND DISCUSSION

Effect of intercropping

Chickpea: The yield attributes (pods/plant, seed/pod and 1,000-seed weight) and seed yield of chickpea showed significant variation due to planting patterns (Table 1). Higher values of yield attributes were noticed with sole chickpea. This might be due to the fact that Indian mustard endowed with deep-rooted system and vigorous plant growth, offered more competition both under and above ground for growth resources. Secondly, better root growth in sole chickpea facilitated more area for nodule formation, resulting higher yield attributes. Among the intercropping systems, 6:2 row ratio had relatively greater adverse effect on yield attributes of chickpea due to vigorous growth and adverse effect of Indian mustard in association.

The seed yield of chickpea was significantly higher in sole cropping than that recorded in intercropping with Indian mustard under both the planting patterns due to absence of inter-space competition and limited disturbance of habitat. Production of seed yield of intercropped chickpea was reduced by 35.9% and 28.3% under 6:2 and 8:2 row ratio over sole stand of chickpea respectively. Among intercropping treatments, 8:2 row ratio registered significantly higher seed yield of chickpea owing to more plants/unit area and lesser inter-space competition posed by Indian mustard with lesser plant population and shading effect. The results confirm the findings of Sarkar *et al.* (2000).

Indian mustard : All the yield-attributing characters of Indian mustard were higher in intercropped stands with chickpea over its sole cropping (Table 1). Among intercropping patterns, chickpea + Indian mustard grown under 8:2 row ratio had higher values of yield attributes in Indian mustard owing to lesser competition for nutrients, light, space and moisture, and took more advantage of solar radiation. The seed yield of Indian mustard under intercropping system decreased significantly compared to its sole stands might be due to higher plant population (100%) compared to 6:2 and 8:2 planting patterns contributed only 25% and 20% plant stand respectively. Among

Table 1. Yield attributes, seed yield, chickpea-equivalent yield, biological and economical parameters of chickpea + Indian mustard intercropping systems as influenced by varying phosphorus doses (mean of 2 years pooled data)

Treatment	Pods/plant		Seeds/pod		1,000-seed weight (g)		Seed yield (q/ha)		Chickpea equiva-lent yield (q/ha)	Land equiva-lent ratio	Relative crowing co-efficient	Competi-tion index	Cost of cultivation (Rs/ha)	Net monetary return (Rs/ha)	B : C ratio
	Chickpea	Indian mustard	Chickpea	Indian mustard	Chickpea	Indian mustard	Chickpea	Indian mustard							
Cropping system															
Sole chickpea	49.7		1.8		126.7		21.50		21.50				15,897	13,307	1.84
Sole Indian mustard		348.2	-	10.9		4.2		20.30	18.74				13,836	10,529	1.76
Chickpea + Indian mustard (6:2)	40.9	649.5	1.4	11.6	119.6	4.8	13.83	9.31	22.42	1.10	1.52	(-) 0.12	15,308	14,807	1.97
Chickpea + Indian mustard (8:2)	44.2	662.9	1.7	12.1	123.3	5.0	15.42	9.62	24.31	1.19	2.30	(-) 0.16	15,410	17,101	2.11
CD (P=0.05)	1.3	12.9	0.1	0.4	2.7	0.2	0.51	0.26	0.15					1,154	0.11
P (kg/ha)															
0	36.9	489.4	1.2	10.4	113.8	4.0	13.07	11.47	17.74	1.08	1.44	(-)0.16	14,415	9,317	1.65
30	44.4	545.9	1.5	11.4	120.5	4.3	17.00	13.10	21.82	1.15	1.95	(-) 0.15	14,882	14,587	1.98
60	48.5	582.0	1.8	12.1	127.8	5.0	18.68	13.82	23.58	1.16	2.11	(-) 0.12	15,345	16,076	2.05
90	49.9	596.0	1.8	12.2	130.6	5.3	18.92	13.93	23.83	1.17	2.15	(-) 0.13	15,810	15,765	2.00
CD (P=0.05)	1.5	14.9	0.1	0.5	3.1	0.2	0.59	0.30	0.14					1,208	0.13

intercropping treatments, 8:2 row ratio recorded significantly higher seed yield of Indian mustard over 6:2 row proportion might be owing to improvement in yield attributes which also compensated the losses caused by reduction in plant stand (Thakur *et al.*, 2000).

Effect of phosphorus application

Chickpea: The yield attributes (pods/plant, seeds/pod and 1,000-seed weight) and seed yield recorded markedly up to 60 kg P_2O_5/ha only (Table 1). The improvement in yield components might have been owing to better proliferation of roots resulting increased nodulation due to P availability and phosphorus fertilization may be accounted for fovourable influence of P nutrition on promotion of source capacity in legumes (Sarkar *et al.*, 1995). The increase in seed yield with 60 kg P_2O_5/ha over the control and 30 kg P_2O_5/ha was 42.9 and 9.9% respectively.

Indian mustard : The yield attributes of Indian mustard (pods/plant and seeds/pod) showed improvement up to 60 kg P_2O_5/ha only, whereas 1,000-seed weight significantly increased up to 90 kg P_2O_5/ha (Table 1). The improvement in yield attributes by P application could be attributed to better development of plant growth and nutrient translocation favourably affecting the rate of photosynthesis and accumulation of photosynthates. The seed yield markedly increased up to 60 kg P_2O_5/ha only as a result of improved growth, translocation of more photosynthates towards sink and consequent increase in yield-attributing characters. The results are in conformity with the findings of Bhari *et al.* (2000).

Total productivity

Both the intercropping systems showed superiority to sole cropping in total productivity, as evident by chickpea-equivalent yield (Table 1). The higher equivalent yield showed higher biomass production and efficient use of available growth resources under intercropping than sole cropping. However, among the cropping systems, intercropping system involving Indian mustard raised in 8:2 row ratio recorded the maximum chickpea-equivalent yield, providing significantly higher yield 13.1% and 29.7% over sole chickpea and Indian mustard respectively. Sole Indian mustard recorded the lowest chickpea-equivalent yield. The results are in conformity with those of Prasad *et al.* (2000). Chickpea-equivalent yield exhibited an increasing trend with increasing levels of P significantly up to 90 kg/ha, which gave 34.3, 9.2 and 1.1% higher over the control, 30 and 60 kg P_2O_5/ha respectively. It seems to be associated with increased yield of chickpea and Indian mustard both at higher level P.

Biological feasibility

The mean land-equivalent ratio (LER) and relative crowding coefficient (RCC) in 2 years ranged from 1.10 to 1.19 and 1.52 to 2.30, respectively, indicating biological sustainability of intercropping over sole cropping. Chickpea + Indian mustard (8:2) intercropping system recorded the maximum LER of 1.19 and RCC of 2.30 indicating that intercropping though reduced the yield of chickpea by 10.4%, this system as a whole was more productive with yield advantage of 19%. This indicates that intercropping was more efficient in utilizing natural resources than sole cropping of component crops. Competition index (CI) was lower in 8:2 row ratio than 6:2 row ratio system indicating that chickpea + Indian mustard grown in 8:2 row ratio system was found more efficient than chickpea + Indian mustard (6:2) system. Increasing doses of P enhanced LER and RCC up to highest dose of 90 kg P_2O_5/ha with respective value of 1.17 and 2.15, whereas competition index influenced up to 60 kg P_2O_5/ha. It indicates that 90 kg P_2O_5/ha utilized land more efficiently but it faced more crowd and competition among component crops of the system.

Economic viability

The economic feasibility in terms of net monetary return showed that both the intercropping systems gave higher net returns than sole cropping of component crops (Table 1), indicating intercropping a productive and remunerative system of cultivation. However, among the cropping systems, intercropping of chickpea + Indian mustard in 8:2 row ratio fetched higher net monetary return and benefit : cost ratio. Among the P levels, there was steady increase in net returns with increase in P level from 0 kg to 60 kg/ha. There was, however, a marginal reduction in net returns (Rs 311) at highest level of 90 kg P_2O_5/ha over 60 kg P_2O_5/ha and benefit : cost ratio also followed the similar trend with highest value 2.05 at 60 kg/ha P.

Response function

Further, owing to increased availability of P in soil, response of component crops under different cropping systems to phosphorus on seed yield of chickpea and Indian mustard was worked out by fitting response equation and following estimated equations were obtained from seed yield data pooled over 2 years.

Chickpea

Sole chickpea : $Y=17.53+0.1623\ P-0.00106\ P2$

Chickpea + Indian mustard (6:2) : $Y=10.55+0.1371\ P-0.00092\ P^2$

Chickpea + Indian mustard (8:2) : $Y=11.25+0.1743\ P-0.00117\ P^2$

Indian mustard

Sole mustard : $Y=17.79+0.1082\ P-0.00075\ P^2$

Chickpea + Indian mustard (6:2) : $Y=8.28+0.0397\ P-0.00024\ P^2$

Chickpea + Indian mustard (8:2) : $Y=8.39+0.047\ P-0.00028\ P^2$

These equations revealed that response of component crops under various cropping systems to P application was quadratic, indicating operation of the law of diminishing return. The economic dose for maximum seed yield and yield at this dose of both component crops were computed for P application indicated that 23.71, 15.62 and 17.71 q/ha, and 21.64, 9.75 and 10.21 q/ha seed yield of chickpea and Indian mustard were predicted by applying 71.0, 68.0 and 69.0 kg, and 64.0, 56.0 and 61.0 kg P_2O_5/ha under sole and 2 planting patterns, viz. 6:2 and 8:2 row ratios, with 100, 25 and 20% plant population respectively. The maximum response/kg P_2O_5 was 11.64 and 14.94 kg at their corresponding P levels under chickpea + Indian mustard (8:2) intercropping system.

Interaction effects

The interaction effect of cropping system and P levels had significant effect on seed yield of intercropped Indian mustard and chickpea-equivalent yield (Table 2). Sole Indian mustard and intercropped Indian mustard grown in 8:2 row ratio showed significant increase in Indian mustard seed yield with increasing levels of phosphorus up to 60 kg/ha, whereas Indian mustard grown in 6:2 row proportion showed no significant variation in seed yield beyond 30 kg P_2O_5/ha.

Table 2. Seed yield of Indian mustard and chickpea-equivalent yield under different cropping systems as influenced by phosphorus levels (mean of 2 years pooled data)

Cropping system (CS)	P (kg/ha) (P)			
	0	30	60	90
Seed yield of Indian mustard (q/ha)				
Sole Indian mustard	17.75	20.50	21.45	21.50
Chickpea + Indian mustard (6:2)	8.25	9.30	9.75	9.95
Chickpea + Indian mustard (8:2)	8.40	9.50	10.25	10.35
	CS × P			
CD (P=0.05)	0.53			
Chickpea-equivalent yield (q/ha)				
Sole chickpea	17.50	21.50	23.40	23.60
Sole Indian mustard	16.38	18.92	19.80	19.85
Chickpea + Indian mustard (6:2)	18.11	22.58	24.30	24.68
Chickpea + Indian mustard (8:2)	18.95	24.27	26.81	27.20
	CS × P			
CD (P=0.05)	0.29			

Sole stands of chickpea and Indian mustard registered significantly higher mean chickpea-equivalent yield up to 60 kg P_2O_5/ha. However, when 90 kg P_2O_5/ha was applied with chickpea + Indian mustard intercropping system resulted in significantly highest chickpea-equivalent yield. Chickpea + Indian mustard (8:2) system gave significantly maximum chickpea-equivalent yield at application of 90 kg P_2O_5/ha under combined effect.

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