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Production potential of chickpea (*Cicer arietinum*)-based intercropping systems under irrigated conditions

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ABSTRACT

A field experiment was conducted during 2000–2002 at New Delhi, to evaluate the productivity of chickpea (*Cicer arietinum* L.)-based intercropping systems. The yield of chickpea was adversely affected by intercropping with Indian mustard [*Brassica juncea* (L.) Czernj. & Cosson], barley (*Hordeum vulgare* L., s.l.) and linseed (*Linum usitatissimum* L.). However, the magnitude of reduction was relatively greater in Indian mustard. Further, the yield of chickpea increased as the proportion of chickpea increased in the mixture from 2:1 to 4:1, while reverse trend was noticed in the yield of intercrops. Sole Indian mustard recorded the highest total productivity in terms of chickpea-equivalent yield (CEY), followed by chickpea + Indian mustard (2:1), chickpea + linseed in various row proportions and sole chickpea recorded similar CEY, which was markedly lower than sole barley and linseed and chickpea intercropped with Indian mustard and barley in various proportions, except chickpea + barley in 4:1 row proportion. Among various intercropping systems, chickpea + barley, especially in 2:1 and 3:1 row proportions, showed yield advantages in terms of land-equivalent ratio (LER), while all the sole intercrops and chickpea-based intercropping systems, except chickpea + linseed (4:1) recorded higher income equivalent ratio over sole chickpea. All the intercrops were more competitive and aggressive than chickpea. Based on relative crowding coefficient, chickpea intercropped with barley in all row proportions and with linseed in 3:1 and 4:1 row proportions were the compatible intercropping systems.

Key words : Chickpea, Indian mustard, Barley, Linseed, Intercropping, Competition ratio

Chickpea is the most important winter pulse crop of India grown both under assured irrigation and residual soil moisture conditions. In India, chickpea is cultivated on 6.1 million ha with a production of 5.27 million tonnes. The area under irrigation is 1.77 million ha, i.e. 29.1% of total chickpea area (FAI, 2003). However, chickpea is less remunerative than Indian mustard, linseed, wheat and barley. Hence there is a gradual shift in cropping pattern from sole chickpea to intercropping, and in extreme cases to sole cropping of the later crops. Intercropping of chickpea with Indian mustard (Uttar Pradesh, Rajasthan, Bihar, Haryana and Madhya Pradesh), linseed (Bundelkhand region of Uttar Pradesh, Madhya Pradesh and Maharashtra) and barley (Uttar Predesh and Uttaranchal) are quite popular (GOI, 2000). Since information on comparative performance, competition relations and economics of these systems are lacking, the present study was undertaken.

MATERIALS AND METHODS

A field experiment was conducted during the winter seasons of 2000–2001 and 2001–2002 at New Delhi. The soil was sandy loam containing 0.36% organic carbon, 14.5 kg/ha available P and 168 kg/ha available K, with 7.7 pH. The experiment comprising 13 treatments was conducted in randomized block design replicated thrice, had 4 sole crops (chickpea, Indian mustard, barley and linseed) and 9 combinations of chickpea intercropping with other 3 crops in 2:1, 3:1 and 4:1 row proportions. The crops were sown on 25 October in 2000 and 2 November in 2001, and harvested on 3 April in 2001 and 30 March in 2002. A row spacing of 30 cm was adopted for all the crops with a plant-to-plant spacing of 10 cm in chickpea and linseed and 20 cm in Indian mustard. A seed rate of 100 kg/ha was followed in barley. A common fertilizer dose of 100 kg diammonium phosphate/ha was applied to the crops at the time of sowing. An additional 20 kg N/ha was top-dressed in Indian mustard, linseed and barley on area basis 40 days after sowing. The cultivars used in the study were 'Pusa 256' (chickpea), 'Pusa Jaikisan' (Indian mustard), 'HL 9' (linseed) and 'HBL 276' (barley).

RESULTS AND DISCUSSION

Chickpea

Sole chickpea recorded significantly lower plant height than that recorded in its intercropping with Indian mustard. The tall growing (>1.6 m) Indian mustard posed

competition to chickpea for light and space resulting in taller plants of associated chickpea crop. However, no such variations in plant height of chickpea were noticed when intercropped with barley and linseed. Pods/plant in sole chickpea were significantly more than all intercropping systems in different row proportions, except chickpea + linseed in 3:1 and 4:1 and chickpea + barley in 4:1 row ratio. Chickpea intercropping with Indian mustard resulted in drastic reduction in pods/plant compared with other intercropping systems. This could be attributed to the variations in the magnitude of competition among component crops grown in various proportions. The differences in 1,000-seed weight due to various sole and intercropping systems were not perceptible.

Sole chickpea gave significantly higher biological and seed yield than all the intercropping systems. Among the intercropping systems, the least biological yield was obtained with chickpea + Indian mustard (2:1), which, in turn, was on a par with its 3:1 row proportion intercropping. Chickpea+linseed intercropping system resulted in the highest biological yield, which showed a tendency to increase with increasing row proportion from 2:1 to 4:1. However, the differences between 2:1 and 3:1 and 3:1 and 4:1 row proportions were not marked, but 4:1 row ratio had significantly higher biological yield over 2:1 ratio. The seed yield also followed the similar trend, except that the seed yield in 3:1 and 4:1 row ratios being at par recorded higher yield over that of chickpea + linseed in 2:1 row ratio. In chickpea + barley intercropping, the seed yield increased significantly with increasing proportions of chickpea from 2:1 to 4:1. In chickpea + Indian mustard intercropping, the seed yield in 4:1 row ratio was markedly higher over 2:1 row ratio. More pods/plant coupled with higher population of chickpea in 4:1 row ratio could be the reason for higher seed yield of chickpea (Table 1). In general, the harvest index of chickpea increased with increasing proportion of chickpea in intercropping systems. Intercropping with Indian mustard resulted in significant decline in harvest index compared with sole chickpea. On the contrary, an intercropping of chickpea with barley improved the harvest index and this improvement was marked in 4:1 row ratio of chickpea: barley (36.40) over sole chickpea (25.32). The chickpea + linseed intercropping recorded similar harvest index as that of sole chickpea.

Intercrops

The effects of different row proportions of intercropping were not marked on plant height and yield attributes of intercrops over their sole crops, except in chickpea + Indian mustard intercropping. Chickpea + Indian mustard intercropping in 4:1 row ratio, being at par with row proportions of 3:1 and 2:1, recorded significantly more siliquae/plant than sole Indian mustard. This could be attributed to more space available to individual plants for lateral spread. The biological and seed yields were significantly higher in sole crops than that under intercropping systems mainly because of reduced plant population. The intercropping of chickpea + Indian mustard or barley or linseed in 4:1 row ratio recorded significantly lower biological and seed yields than in 2:1 row ratio, as the population of intercrops was reduced to half in the former case. Besides, marked reduction in biological yield of Indian mustard was also noticed with chickpea + Indian mustard in 3:1 row ratio when compared with 2:1 row ratio. In chickpea + barely intercropping, the seed yield of barley in 3:1 row proportion was distinctly higher than 4:1 row proportion. The variable plant population, growth behaviour of crops and elasticity of individual plants in mixtures of differential species were largely responsible for variations in biological and seed yields of crops. Intercropping with chickpea did not markedly alter the harvest index of intercrops.

Chickpea-equivalent yield

Over the seasons, sole Indian mustard showed significantly higher chickpea-equivalent yield (CEY) than all other sole crops and chickpea-based intercropping systems. Among sole crops, barley and linseed being at par also recorded higher CEY over sole chickpea. Sole chickpea recorded CEY similar to that of chickpea + linseed intercropping system in all row proportions. Among the intercropping systems, chickpea + Indian mustard in 2:1 row ratio had significantly higher CEY over all other treatments, except sole Indian mustard. The differences between intercropping systems in 3:1 and 4:1 row ratios were marked in barley only, where 3:1 row ratio recorded higher CEY over 4:1 row ratio. Similarly, the difference between 2:1 and 3:1 row ratios was significant in chickpea + Indian mustard only, where 2:1 row ratio recorded higher CEY over 3:1 row ratio. Similar trend of results, when chickpea intercropped with Indian mustard and lentil, was observed by Ali and Mishra (2002) and Mishra *et al.* (2001). The differential behavior in CEY was on account of productivity of crops in intercropping systems and their relative market prices.

Land-equivalent ratio and income-equivalent ratio

Intercropping advantage measured in terms of land-equivalent ratio (LER) in intercropping systems revealed that chickpea + barley in all row proportions and chickpea + linseed in 3:1 and 4:1 row proportions were superior to sole chickpea. However, in chickpea + linseed intercropping, the advantage was only marginal. Based on income-

Table 1. Effect of intercropping on growth and yield of chickpea (mean of 2 seasons)

Treatment		Plant height (cm)	Pods/ plant	1,000-grain weight (g)	Biological yield (q/ha)	Seed yield (q/ha)	Harvest index (%)
Sole chickpea		65.8	32.3	187.5	66.2	16.76	25.32
Chickpea + Indian mustard	2:1	76.6	9.5	181.8	13.4	2.04	15.22
Chickpea + Indian mustard	3:1	73.3	14.4	180.6	18.2	2.74	15.06
Chickpea + Indian mustard	4:1	72.3	19.3	187.8	23.5	4.48	19.06
Chickpea + barley	2:1	67.8	22.1	178.7	20.4	6.30	30.88
Chickpea + barley	3:1	64.6	25.2	185.0	27.0	8.41	31.15
Chickpea + barley	4:1	64.1	31.8	190.5	28.3	10.30	36.40
Chickpea + linseed	2:1	66.6	27.4	191.5	43.3	9.51	21.96
Chickpea + linseed	3:1	67.3	31.0	190.5	48.0	12.64	26.33
Chickpea + linseed	4:1	65.7	32.1	191.9	51.8	13.93	26.89
CD (P=0.05)		4.5	2.5	NS	7.0	1.81	5.86

Table 2. Effect of intercropping on growth, yield attributes and yield of intercrops (mean data of 2 seasons)

Treatment		Plant height (cm)	Siliquae panicles or capsules/plant*	Seeds/siliquae or panicle or capsule	1,000-grain weight (g)	Biological yield (q/ha)	Seed yield (q/ha)	Harvest index (%)
Indian mustard		169.2	386.0	14.2	5.37	141.7	33.49	23.63
Chickpea + Indian mustard	2:1	163.7	398.9	14.8	5.87	114.1	27.73	24.30
Chickpea + Indian mustard	3:1	165.2	407.7	14.3	5.56	92.6	22.71	24.53
Chickpea + Indian mustard	4:1	166.9	435.6	14.1	5.71	84.3	19.69	23.36
CD (P=0.05)		NS	40.0	NS	NS	20.5	5.30	NS
Barley		83.4	21.5	50.7	35.51	137.8	53.81	39.05
Chickpea + barley	2:1	81.3	20.6	57.2	35.84	99.7	40.06	40.18
Chickpea + barley	3:1	84.8	21.3	57.5	36.11	85.3	33.97	39.82
Chickpea + barley	4:1	78.2	22.3	58.9	36.43	61.7	23.50	38.09
CD (P=0.05)		NS	NS	NS	NS	25.0	8.73	NS
Linseed		63.3	47.1	6.7	8.80	73.1	21.14	28.97
Chickpea + linseed	2:1	68.4	52.5	6.6	8.86	23.2	7.74	30.71
Chickpea + linseed	3:1	65.5	55.9	6.5	8.97	18.1	5.41	29.89
Chickpea + linseed	4:1	65.4	56.6	6.8	8.98	14.1	4.12	29.22
CD (P=0.05)		NS	NS	NS	NS	8.5	2.50	NS

*In barley, panicles/m row length

equivalent ratio (IER), chickpea intercropping with Indian mustard, barley and linseed had lower IER than their respective sole intercrops, but greater than sole chickpea, except chickpea + linseed in 4:1 row ratio. The IER, in general, declined with increasing proportions of chickpea in intercropping system, i.e. 2:1 to 4:1 (Table 3).

Competition ratio, aggressivity and relative crowding coefficient

All the intercrops were more competitive than chickpea in all row proportions, except chickpea + linseed in 4:1 row proportion, as evident from competitive ratio (CR) values. Among the intercrops too, Indian mustard was highly competitive followed by barley and linseed. With increasing proportions of chickpea in the mixture, the competitiveness of chickpea increased and this increase was so high that in 4:1 row proportion of chickpea + linseed intercropping, chickpea became more competitive than linseed.

The aggressivity of chickpea was negative in all the intercropping systems. The aggressivity (A) of Indian mustard increased with increasing row ratios of chickpea + Indian mustard from 2:1 (2.33) to 4:1 (2.61). However, this increase was noticed in chickpea + barley only up to 3:1 row ratio, beyond which it declined. In chickpea + linseed intercropping system, linseed aggressivity decreased with increasing row ratio from 2:1 (0.54) to 4:1 (0.21).

The intercropping of chickpea and barley at all row ratios and chickpea and linseed in 3:1 and 4:1 row proportions was advantageous, as the product of relative crowding coefficient (K) was >1 and showed the complimentary relationship. The K was, however, the highest in 2:1 row ratio of chickpea + barley and 4:1 row ratio of chickpea + linseed. The intercropping of chickpea + Indian mustard

Table 3. Effect of intercropping on chickpea equivalent yield and competition functions (mean data of 2 seasons)

Treatment		CEY (q/ha)	IER	LER	CR		A		K		
					Chickpea	Intercrop	Chickpea	Intercrop	Chickpea	Intercrop	Product
Chickpea		16.76	1.00	1.00							
Indian mustard		36.41	2.20	1.00							
Barley		24.46	1.45	1.00							
Linseed		22.99	1.38	1.00							
Chickpea + Indian mustard	2:1	33.43	2.02	0.96	0.07	13.57	–2.33	2.33	0.07	9.63	0.67
Chickpea + Indian mustard	3:1	27.43	1.67	0.85	0.08	12.40	–2.50	2.50	0.07	6.32	0.41
Chickpea + Indian mustard	4:1	25.89	1.55	0.86	0.25	8.80	–2.61	2.61	0.09	5.71	0.53
Chickpea + barley	2:1	23.75	1.41	1.13	0.25	3.96	1.69	1.69	0.30	5.83	1.76
Chickpea + barley	3:1	23.24	1.37	1.12	0.26	3.77	–1.86	1.86	0.34	5.14	1.73
Chickpea + barley	4:1	20.52	1.21	1.05	0.35	2.84	–1.42	1.42	0.40	3.10	1.24
Chickpea + linseed	2:1	17.93	1.07	0.94	0.78	1.29	–0.54	0.54	0.66	1.16	0.76
Chickpea + linseed	3:1	18.52	1.11	1.01	0.97	1.02	–0.36	0.36	1.03	1.03	1.06
Chickpea + linseed	4:1	16.78	1.00	1.02	1.07	0.94	–0.21	0.21	1.23	0.97	1.19
CD (P=0.05)		1.76									

A, Aggressivity; CR, competitive ratio; K, relative crowding coefficient; LER, land-equivalent ratio; IER, income-equivalent ratio; CEY, chickpea-equivalent yield

was not advantageous, as evident from the K values<1. Similar results were also reported with respect to CR, A and K values by Mishra *et al.* (2001).

REFERENCES

FAI, 2003. *Fertilizer Statistics,* 2002–2003. The Fertilizer Association of India. pp. III. 13 and 51.

GOI. 2000. *Expert Committee Report on Pulses.* Technology Mission on Oilseeds and Pulses. Department of Agriculture and Cooperation, Ministry of Agriculture, New Delhi, pp. 20–21 and 43–44.

Ali, Masood and Mishra, J.P. 2002. Genotypic compatibility with an interplay of row orientation in gram (*Cicer arietinum*) + Indian mustard (*Brassica juncea*) under irrigated conditions of Indo-Gangetic alluviums. *Indian Journal of Agricultural Sciences* **72**(2) : 97–100.

Mishra, J.P., Ali, Masood and Arya, R.L. 2001. Genotypic compatibility in relation to row ratio in the intercropping of linseed (*Linum usitatissimum*) and gram (*Cicer arietinum*) under rainfed conditions. *Indian Journal of Agricultural Sciences* **71** (6) : 359–362.