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Competition functions, productivity and economics of chickpea (*Cicer arietinum*)-based intercropping system under rainfed conditions of Bihar plateau

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ABSTRACT

A field experiment was conducted during the winter (*rabi*) season of 1996–97 and 1997–98 at Deochanda Experiment Station, Hazaribagh, to study the productivity of chickpea (*Cicer arietinum* L.)-based intercropping system with cereal, pulses and oilseeds in rainfed uplands of Bihar plateau. Intercropping of chickpea and safflower (*Carthamus tinctorious* L.) in 1 : 1 row ratio proved most efficient system resulting in maximum chickpea-equivalent yield (12.76 q/ha), gross (Rs 10, 846) and net (Rs 5, 346/ha) monetary returns and benefit : cost ratio (1.97). The same treatment also accounted for higher land-equivalent ratio (1.12), area-time equivalent ratio (0.96), monetary advantage (Rs 1, 162/ha) and maximum product of crowding coefficient (K 1.84) with modest competition coefficient (0.31 ; 0.68) which proved the most efficient. Chickpea sown with barley (*Hordeum vulgare* L.) in 1:2 row proportion proved to be inefficient intercropping system with minimum chickpea-equivalent yield (9.84 q/ha) and net monetary returns (Rs 2,758/ha).

Key words : Intercropping, Productivity, Economics, Chickpea, Linseed, Safflower, Barley, *Toria*

The plateau region of Bihar is traditionally a monocropped area due to low irrigation facility and poor water-holding capacity of soil. Intercropping may be a 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. Keeping in view, an experiment was undertaken to augment possibility of increasing production of pulses and oilseeds through intercropping system in relation to crop combination and

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spatial arrangement on rainfed upland of Bihar plateau.

MATERIALS AND METHODS

A field experiment was conducted during winter (*rabi*) season of 1996–97 and 1997–98 at Deochanda Experiment Station, Hazaribagh. The soil of the field is characterized as a typical upland soil (Oxisol). The soil was light textured, highly permeable (24 mm/hr), acidic in reaction (pH 5.6) with 0.35% organic carbon and available P and K contents of 30 and 212 kg/ha respectively. The treatments consisted of 5 sole stands each of chickpea (*Cicer arietinum* L.) cv. 'BR 77', linseed (*Linum usitatissimum* L.) cv. 'T 397', barley (*Hordeum vulgare* L.) cv. 'BR 32', safflower (*Carthamus tinctorious* L.) cv. 'BYL 652', *toria* (*Brassica campestiris* L.) cv. 'BR 32', and intercrop association of chickpea with each linseed, barley, safflower and *toria* in row ratios of 1:1, 1:2 and 2:1. Chickpea, linseed, barley and *toria* were sown in rows 25 cm apart, whereas safflower at 45 cm apart under both sole and intercropped stands. All the crops grown sole were fertilized at their recommended dose, but for the intercropped stands, fertilizers were adjusted according to the proportion of area for each crop component. The crops were sown on 19 October 1996 and 21 October 1997. Rainfall during monsoon season of 1996 and 1997 was 1, 466 and 1,076 mm, respectively, whereas during crop-growth period the rainfall was 219 and 112 mm respectively. The maximum and minimum air temperature, and relative humidity during the crop-growth period ranged from 8.7 to 37.9°C and 48.00 to 80.16% in 1996–97 and from 6.6 to 33.4°C and 45.00 to 78.12% in 1997–98 respectively.

Chickpea-equivalent yield was calculated by converting the grain yield of all the crops into chickpea yield on the basis of existing market price of the crops. Competition functions like land-equivalent ratio (LER), area-time equivalent ratio, competition coefficient (RCC/Kab) (De Wit, 1960) and monetary advantage (MA), were calculated on pooled basis. Gross and net monetary returns were computed using prevailing rates of produce and agro-inputs.

RESULTS AND DISCUSSION

Seasonal effect

In general, the performance of different treatments was better during 1996–97 than during 1997–98, owing to sufficient residual moisture available to crops as well as good amount and well-distributed rainfall during crop-growth period and less occurrence of dry spells. In 1997–98, during crop-growth period, the rainfall was 112 mm with erratic distribution, and a period of nearly 4 months from November to Ferbruary remained almost dry with a little rainfall resulting in reduced growth and poor yield of crops.

Performance of component crops

Sole stands of crops gave higher yield than their intercrop due to absence of interspace competition and limited disturbance of habitat (Table 1). In spatial arrangement of 2:1, the reduction in yield of base crop, in general, was lower as compared to 1 : 1 row ratio because of relatively less inter-row competition posed

Table 1. Grain yield, chickpea equivalent and mean economics of chickpea–based intercropping system

Cropping system	Grain yield (q/ha)				Chickpea-equivalent yield (q/ha)			Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	Benefit : cost ratio
	1996–97		1997–98								
	Main crop	Inter-crop	Main crop	Inter-crop	1996–97	1997–98	Mean				
Sole cropping											
Chickpea	12.83		9.54		12.83	9.54	11.18	5,400	9,503	4,103	1.75
Linseed		10.65		6.12	9.31	5.51	7.41	4,800	6,298	1,498	1.31
Barley		1.665		5.38	12.48	4.18	8.33	4,900	7,080	2,180	1.44
Safflower		12.29		8.24	13.82	9.15	11.49	5,300	9,758	4,458	1.84
Toria		8.49		4.81	10.05	5.35	7.71	5,000	6,553	1,553	1.31
Intercropping :											
Chickpea + linseed (1:1)	7.73	5.34	4.85	3.58	12.40	8.02	10.21	5,100	8,678	3,578	1.70
Chickpea + barley (1:1)	6.06	9.99	4.31	2.55	13.55	6.29	9.92	5,200	8,432	3,232	1.62
Chickpea + safflower (1:1)	6.02	8.52	4.59	4.80	15.60	9.92	12.76	5,500	10,846	5,346	1.97
Chickpea + *toria* (1:1)	7.33	5.40	5.02	2.52	13.40	7.81	10.60	5,300	9,010	3,710	1.70
Chickpea + linseed (1:2)	4.94	7.76	3.48	4.29	11.73	7.28	9.51	5,200	8,109	2,909	1.55
Chickpea + barley (1:2)	298	13.81	3.08	3.30	13.33	5.64	9.48	5,300	8,058	2,758	1.52
Chickpea + safflower (1:2)	3.24	10.52	3.34	5.75	15.07	9.72	12.39	5,650	10,531	4,881	1.86
Chickpea + *toria* (1:2)	4.77	6.83	3.69	3.19	12.45	7.23	9.84	5,450	8,364	2,914	1.53
Chickpea + linseed (2:1)	9.98	3.46	6.54	2.29	13.00	8.57	10.78	5,300	9,163	3,863	1.72
Chickpea + barley (2:1)	7.42	7.25	6.20	1.91	12.85	7.68	10.26	5,350	8,727	3,371	1.63
Chickpea + safflower (2:1)	7.37	5.44	6.42	3.06	13.49	9.81	11.65	5,550	9,902	4,352	1.78
Chickpea + *toria* (2:1)	10.49	3.17	6.57	1.90	14.05	8.68	11.36	5,500	9,656	4,156	1.75
CD (P = 0.05)	0.64		0.57		0.30	0.20					

Market price of grain (Rs/ha) : Chickpea, 800 and 900; linseed, 700 and 800; barley, 600 and 700; safflower, 900 and 10,000; *toria,* 900 and 10,000

by intercrop with lesser plant population. Among the crop components, chickpea and safflower showed lesser reduction in yield in intercropping situation, indicating greater productivity and higher stability of these crops under receding soil-moisture conditions.

Total productivity

The highest total productivity in terms of chickpea-equivalent yield (Table 1) was recorded with chickpea + safflower in 1:1 ratio due to additional advantage of intercrop yield and also higher economic value of intercrop. Lower chickpea equivalent in chickpea + linseed (1 : 2) and chickpea + barley (1 : 2) was due to greater reduction in yield of crop components in mixed stand due to interspecific competition. Sole linseed recorded the lowest mean chickpea equivalent.

Productivity indices

All the intercropping systems except chickpea + linseed in 1:1 row ratio had land-equivalent ratio (LER) greater than 1.00. However, calculated LER did not reflect the superiority of chickpea + *toria* (1:1, 1:2 and 2:1), indicating the need of evaluation on the basis of other criterion. Chickpea + linseed (1:1) system, although showed higher chickpea equivalent but lower land-use efficiency, suggesting to develop a better method of calculation on the efficiency of intercropping systems. Considering lower LER values in intercropping system, it can be derived that intercropping system for dry season on residual moisture hardly increases land-use efficiency (Kumar and Singh, 1987). The relative crowing coefficient (Kab/Kba) revealed any advantage in yield in all of the associations except chickpea intercropped with either barley or safflower in 1:1 and 1:2 ratio respectively. Linseed proved the dominant companion to chickpea, having higher values of crowding coefficient which was further evident from higher competition coefficient (Table 2) in chickpea + linseed system in 1:1 and 1:2 ratios. The products of relative crowding coefficient showed definite yield advantage under all the situations ($K > 1.00$) except chickpea + barley (2:1) which showed yield disadvantage ($K < 1.00$). All the intercropping systems showed area-time equivalent ratio (ATER) less than 1.00 (Table 2), indicating inefficient use of area-time in the systems.

Economic viability

The monetary advantages (MA) based on LER indicated superior economic viability of chickpea + *toria* in 2:1 ratio. Chickpea + safflower and chickpea + linseed in 2:1 gave higher chickpea-equivalent yield but with relatively lower values of monetary advantage. To give a clear picture net monetary return was taken as the criterion. The gross and net monetary returns and benefit : cost ratio values (Table 2) were highest under chickpea + safflower (1:1 row) mainly owing to higher economic production in the system. The highest gross and net returns as well as benefit : cost ratio followed a trend quite different from monetary advantages based on LER because in LER only grain yield were considered. But for working out gross and net returns, the by-product yield being an

Table 2. Competition function and monetary adantages of chickpea-based intercropping systems (mean data of 2 years)

Intercropping system	Land-equivalent ratio (LER)	Relative crowding coefficient		Area-time equivalent ratio	Product of relative crowding coefficient (K)	Competition coefficient		Monetary advantages (Rs/ha)
		Kab	Kba			Ca	Cb	
Chickpea + linseed (1:1)	0.96	1.17	1.29	0.83	1.51	0.47	0.52	–361
Chickpea + barley (1:1)	1.03	0.75	1.67	0.72	1.67	0.42	0.57	245
Chickpea + safflower (1:1)	1.12	0.81	1.84	0.96	1.84	0.31	0.68	1,162
Chickpea + *toria* (1:1)	1.14	1.04	1.31	0.67	1.31	0.44	0.55	1,106
Chickpea + linseed (1:2)	1.09	0.79	1.07	0.79	1.32	0.45	0.53	669
Chickpea + barley (1:2)	1.02	0.71	0.72	0.71	1.17	0.35	0.64	310
Chickpea + safflower (1:2)	1.08	0.97	0.81	0.97	1.8	0.32	0.67	780
Chickpea + *toria* (1:2)	1.13	0.62	1.1	0.62	1.44	0.46	0.53	927
Chickpea + linseed (2:1)	1.07	0.80	1.06	0.8	1.13	0.5	0.47	599
Chickpea + barley (2:1)	1.04	0.74	0.71	0.74	0.94	0.35	0.64	171
Chickpea + safflower (2:1)	1.32	0.86	0.76	0.86	1.05	0.34	0.64	288
Chickpea + *toria* (2:1)	1.14	0.73	1.15	0.73	1.4	0.49	0.5	1,106

Kab and Kba are relative crowding coefficient of main crop and intercrops respectively; Ca and Cb are competition coefficient of main crop and intercrops respectively

important component was also taken into account, as a result this character gave better assessment of the system. Higher productivity and monetary return from intercropping of chickpea and safflower over sole stand of either of the crop under dry conditions was also reported by Singh and Yadav (1992).

The intercropping of chickpea+safflower in 1:1 planting ratio is superior for economic sustainability of cropping system under upland rainfed conditions of Bihar plateau.

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