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Productivity and profitability of chickpea + linseed intercropping system as influenced by spatial arrangement of crops in Semi-arid Eastern Plain Zone of Rajasthan

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ABSTRACT

A field experiment was conducted during three consecutive rabi seasons of 2015-16, 2016-17 and 2017-18 at research farm of Rajasthan Agricultural Research Institute, Durgapura, Jaipur on a sandy loam soil to identify the suitable row ratios of chickpea and linseed under intercropping situation and their effect on productivity and profitability. The present experiment comprising eight treatments viz sole crops of chickpea and linseed and six intercropping systems of chickpea + linseed in 3:1, 4:1, 5:1, 3:2, 4:2 , 5:2 row ratio. The results revealed that maximum pooled chickpea equivalent yield (2072 kg ha^{-1}), mean gross return (Rs.109934), net return (Rs. 82404) and B:C ratio (3.40) and LER (1.17) was recorded under chickpea +linseed in 5:1 row ratio. The pooled mean increases in chickpea equivalent yield due to 5:1 row ratio and 5:2 row ratio were 15.95 and 21.03 percent and 12.93 and 17.87per cent, respectively over sole chickpea and sole linseed .The least pod damage (13.94 %) was observed in 3:2 row ratio which was statistically at par with 4:2, 5:2 and these were significantly superior over row ratios of 3:1, 4:1, 5:1 and sole chickpea.

Keywords **:** Chikpea, intercropping, linseed, productivity and profitability

Chickpea (*Cicer arietinum* L.) is one of the most important pulse crops in India and preferred as an important constituent of Indian vegetarian diet. In Rajasthan, it is grown on an area of about 1.55 million ha producing about 1.41 tons with the productivity of 911 kg ha^{-1} (Anon., 2016-17). This crop is also an integral part of cropping system for sustainable agricultural production. In spite of its multifarious advantages, its productivity is poor due to several biotic and abiotic factors. While the linseed is cultivated only in 34.9 thousand ha producing 38.93 thousand tons with an average productivity of 1114 kg ha^{-1} (Anon., 2016-17). Cultivation of linseed (*Linum ussitatisimum* L.) is gaining momentum due to increase in awareness among urban population about their health. Both these crops may form a perfect combination for improving their productivity and profitability. Intercropping offers an excellent opportunity in sustaining their production through the best use of available resources and inputs by minimizing competition and by providing a barrier to the entry of many biotic pests. Intercropping system has some of the potential benefits such as increased productivity per unit area per unit time, high profitability, improvement in soil fertility, efficient use of resources and reducing damage caused by pests, diseases and weeds (Ghosh *et al*., 2006). Different intercrops and their spatial arrangement in intercropping have important effect on competition between component crops and their growth (Sarkar *et al.,* 2000). Keeping in view, the present study was undertaken to select an appropriate row ratio of chickpea + linseed system under irrigated conditions of semi-arid eastern plain zone of Rajasthan and to evaluate their effect on yield, pod damage and economics.

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MATERIALS AND METHODS

A field experiment was conducted during three consecutive *rabi* seasons of 2015-16, 2016-17 and 2017-18 at the research farm of Rajasthan Agricultural Research Institute, Durgapura, Jaipur (26^0 51′ N, 75^0 47′ E and 390 m altitude) to identify the suitable row ratios of chickpea and linseed under intercropping situation and their effect on productivity and profitability. The experimental site falls in the Semi-Arid Eastern Plain Zone of Rajasthan (III-A), characterized by cold winters and hot summers. Occurrence of frost (below ^{0}C) during December/ January in winter season is quite common. The average annual rainfall of zone is 529 mm of which about 90 per cent is received during later half of June to September with erratic distribution over time and space. The soil type of the experimental site was sandy loam with sand (86.8%), silt (5.6%), clay (7.6%), pH 7.8, 0.17 % organic carbon and 139.2, 36.6 and 238.0 kg ha^{-1} available N, P_2O_5 and K_2O, respectively. The present experiment comprising eight treatments *viz* sole crops of chickpea and linseed and six intercropping systems of chickpea + linseed in 3:1, 4:1, 5:1, 3:2 , 4:2 , 5:2 row ratio and these were evaluated in Randomized Block Design with three replications. Field preparation included one deep ploughing by 2 cross harrowing followed by planking. The crops, chickpea (RSG 973) and linseed (Parvati) were sown on first week of November during all the three years of experimentation using geometry of 30 x10 cm. For accommodating component crops in intercropping treatments replacement series was used. The experimental crops were fertilized as per the recommendation dose of chickpea (Base crop) @ 20 kg N + 40 kg P_2O_5 ha^{-1} and whole amount of N and P_2O_5 was applied as basal at the

time of field preparation. Crop was raised under irrigated condition and a total of two irrigations were applied at critical growth stages. Crop protection measures were followed as and when required. Both chickpea and linseed were harvested manually at about 10 cm above the ground level and were kept for sun drying for some days in field and after threshing the bundles from each plot, the grains were cleaned, dried and weighed. The grain yield was expressed in kg ha^{-1}. The yield was used to compute land equivalent ratio (LER) using the methodology as suggested by Willey (1979). Per cent pod damage was recorded from five randomly selected plants per plot by counting total number of pods and damage pods. The net returns of each treatment were calculated by deducting the total cost of cultivation from gross returns of respective treatments and the benefit: cost ratio was calculated by dividing the net returns with total cost of cultivation.

All data recorded were analyzed with the help of analysis of variance (ANOVA) technique (Gomez and Gomez, 1984) for RBD. The least significant test was used to decipher the effects of treatments at 5% level of significance ($P<0.05$).

RESULTS AND DISCUSSION

Effect of different row ratios on productivity and LER

The individual and well as chickpea equivalent yield were significantly influenced by various intercropping ratios (Table 1 and 2). The highest chickpea equivalent yield (2173 ,2202 ,1841 kg ha) was recorded under chickpea+ linseed in 5:1 row ratio(T_5) closely followed by 5:2 row ratio (T_8) and 4:1 row ratio (T_4) during all the years of experimentation. Similarly maximum pooled chickpea equivalent yield (2072 kg ha) was recorded under chickpea+ linseed in 5:1 row ratio(T_5) closely followed by 5:2 row ratio(T_8) and were statistically at par with all the treatments of intercropping and significantly superior over sole chickpea (T_1) and sole linseed (T_2). The pooled mean increases in chickpea equivalent yield due to planting of chickpea+ linseed in 5:1 row ratio (T_5) and 5:2 row ratio(T_8) were 15.95 and 21.03 per cent and 12.93 and 17.87 per cent , respectively over sole chickpea (T_1) and sole linseed (T_2). Further, all the intercropping systems proved significantly superior in terms of pooled LER values over sole crops of chickpea and linseed. The maximum LER (1.17) was recorded under 5:1 row ratio which was significantly superior over rest treatments followed by 5:2 row ratio (1.14). The higher productivity under the treatments which contain higher proportion of chickpea (5:1 and 5:2) over other planting ratio might be due the fact that a legume has the ability to fix atmospheric N and recycle the soil P for the component crop. Besides, better soil health with higher proportion of legume in intercropping may enhance uptake of macro and micro nutrient thus nutrients plays a critical role in enhancement of crop productivity. The increases in chickpea equivalent yield under intercropping systems could be attributed to favourable microclimatic conditions which favoured better crop growth and ultimately yield. The significantly higher system productivity of chickpea+ linseed intercropping by 43.4 per cent over that of sole chickpea was also recorded by Ahlawat and Gangaiah (2010). Hossain *et al.* (2000) and Singh and Pandey (2002) also observed better performance of chickpea when intercropped with linseed over sole chickpea.

Effect of different row ratio on pod damage

Percent pod damage due to *Helicoverpa* in chickpea crop was significantly influenced by various intercropping ratios of chickpea and linseed (Table 3). All the intercropping systems proved significantly superior in terms of reduction in percent pod damage due to *Helicoverpa* compared to sole crops of chickpea. Results revealed that chickpea when intercropped with linseed, the least per cent pod damage due to *Helicoverpa* (13.94) was observed in 3:2 row ratio which was statically at par with 4:2 (T_7), 5:2 (T_8) and these were significantly superior over 3:1(T_3), 4:1(T_4), 5:1(T_5) and sole chickpea (T_1). Whereas the maximum per cent pod damage due to *Helicoverpa* was observed in sole chickpea (28.53). The pooled mean reduction in percentage pod damage due to *Helicoverpa* through planting of chickpea+ linseed in 3:2 row ratio (T_5) was 51.14, 29.52 ,33.30 and 34.52 per cent , respectively over sole chickpea (T_1), 3:1 (T_3), 4:1 (T_4) and 5:1 (T_5) intercropping systems. The reduction in per cent pod damage might be due to intercropping with non host plant, which may alter the micro climate and crop canopy. The result confirms the findings of Prasad and Kumar (2002), Suhas *et al.* (2014) and Kumar *et al.* (2017).

Effect of different row ratio on economics

The maximum mean gross, net returns and B:C ratio (Rs. 109934 ha^{-1}, Rs. 82404 ha^{-1} and 3.40) were was recorded under chickpea+ linseed in 5:1 row ratio (T_5) closely followed by 5:2 row ratio (T_8) and 4:1 row ratio (T_4) during all the years of experimentation. Whereas the minimum mean gross, net returns (Rs. 80499 ha^{-1}, Rs. 59465 ha^{-1}) were obtained under treatment under sole linseed (T_2). The planting of chickpea + linseed in 5:1 row ratio (T_5) enhanced the gross return by 36.57, 12.13 and 10.79 per cent and net return by 38.58, 15.08 and 16.41per cent and B: C ratio by 6.25, 9.32 and 18.47 per cent over sole linseed, sole chickpea and 3:2 row ratio, respectively.

Our results from 2 year study demonstrated that cultivation of chickpea + linseed under 5:1 or 5:2 row

Table 1: Effect of spatial arrangement on yield of chickpea and linseed

Treatments	Chickpea								Linseed							
	Seed yield (kg ha^{-1})				Straw yield (kg ha^{-1})				Seed yield (kg ha^{-1})				Straw yield (kg ha^{-1})			
	2015-16	2016-17	2017-18	Pooled	2015-16	2016-17	2017-18	Pooled	2015-16	2016-17	2017-18	Pooled	2015-16	2016-17	2017-18	Pooled
T_1 Sole chickpea	1843	1959	1559	1787	3241	3355	2770	3122	-	-	-		-	-	-	-
T_2 Sole Linseed	-	-	-	-	-	-	-	-	1355	1280	1057	1231	2871	2864	2521	2752
T_3 Chick + Lin (3:1)	1436	1484	1186	1369	2529	2662	2122	2438	462	413	341	405	1041	1026	831	966
T_4Chick + Lin (4:1)	1552	1625	1291	1489	2690	2806	2373	2623	413	389	301	368	936	897	729	854
T_5Chick + Lin (5:1)	1643	1759	1402	1601	2875	3009	2425	2770	388	359	270	339	893	857	666	805
T_6 Chick + Lin (3:2)	1231	1319	1028	1193	2206	2333	1771	2103	571	532	459	521	1258	1261	1072	1197
T_7 Chick + Lin (4:2)	1309	1400	1125	1278	2329	2454	1958	2247	559	511	417	496	1243	1175	973	1130
T_8 Chick + Lin (5:2)	1468	1580	1275	1441	2624	2817	2213	2551	478	423	346	416	1000	972	925	966
SEm (±)	**59**	**70**	**56**	**15**	**99**	**97**	**96**	**20**	**27**	**0.21**	**0.20**	**21**	**54**	**062**	**77**	**28**
LSD (0.05)	**183**	**218**	**175**	**46**	**308**	**301**	**296**	**61**	**85**	**67**	**63**	**64**	**169**	**194**	**238**	**89**

Table 2: Effect of spatial arrangement on chickpea equivalent yield and economics

Treatments	Chickpea equivalent yield(kg ha^{-1})				Gross return (Rs. ha^{-1})				Net returns (Rs. ha^{-1})				B:C ratio				Pooled LER
	2015-16	2016-17	2017-18	Pooled	2015-16	2016-17	2017-18	Mean	2015-16	2016-17	2017-18	Mean	2015-16	2016-17	2017-18	Mean	
T_1 Sole chickpea	1843	1959	1559	1787	97297	120600	76222	98040	74272	94075	46472	71606	3.23	3.55	2.56	3.11	1.00
T_2 Sole Linseed	1848	157	1718	1712	84184	86064	71248	80499	64234	66114	48048	59465	3.22	3.31	3.07	3.20	1.00
T_3 Chick + Lin (3:1)	2066	199	1740	1932	104590	119795	81048	101811	80425	92130	49918	74158	3.33	3.33	2.6	3.09	1.09
T_4 Chick + Lin (4:1)	2116	2102	1780	1999	107490	126336	83777	105868	83400	98746	52747	78298	3.46	3.58	2.7	3.25	1.13
T_5 Chick + Lin (5:1)	2173	2202	1841	2072	110880	132487	86436	109934	86825	104932	55456	82404	3.61	3.81	2.79	3.40	1.17
T_6 Chick + Lin (3:2)	2010	1972	1773	1918	100728	116099	80849	99225	75853	87724	48784	70787	3.05	3.04	2.52	2.87	1.09
T_7 Chick + Lin (4:2)	2071	2026	1803	1967	104012	120855	82867	102578	79062	92405	50702	74056	3.17	3.25	2.51	2.98	1.12
T_8 Chick + Lin (5:2)	2119	2099	1837	2018	107356	126298	85480	106378	82481	97923	53415	77940	3.32	3.45	2.67	3.15	1.14
SEm (±)	**67**	**74**	**66**	**50**	**-**	**-**			**-**	**-**		**-**	**-**	**-**		**-**	**0.01**
LSD (0.05)	**204**	**226**	**200**	**154**	**-**	**-**			**-**	**-**		**-**	**-**	**-**		**-**	**0.02**

Table 3: Effect of spatial arrangement of crops in chickpea + linseed system on *Helicoverpa armigera* (Hubner) incidence in chickpea

Treatments	Pod damage (%)			
	2015-16	**2016-17**	**2017-18**	**Pooled**
Sole chickpea	23.12 (28.73)	24.55 (29.70)	20.10 (26.64)	22.82 (28.53)
Sole Linseed	—	—	—	—
Chickpea +Linseed (3:1)	11.37 (19.64)	10.90 (19.28)	11.79 (20.09)	11.46 (19.78)
Chickpea + Linseed (4:1)	12.25 (20.48)	12.86 (21.01)	12.57 (20.75)	12.73 (20.90)
Chickpea + Linseed (5:1)	14.61 (22.46)	12.27 (20.49)	13.57 (21.60)	13.18 (21.29)
Chickpea + Linseed (3:2)	6.31 (14.54)	5.82 (13.94)	4.37 (12.05)	5.80 (13.94)
Chickpea + Linseed (4:2)	6.70 (15.00)	6.60 (14.89)	6.29 (14.54)	6.57 (14.85)
Chickpea + Linseed (5:2)	7.77 (16.17)	8.18 (16.64)	8.84 (17.30)	8.48 (16.93)
SEm (±)	0.92	0.81	0.81	0.76
LSD (0.05)	2.68	2.36	2.35	2.22

Note: Figures in parenthesis are angular transformed values

ratio resulted in significant improvement in the productivity and profitability with least pod damage in chickpea. Therefore, intercropping of chickpea with linseed under 5:1 or 5:2 row ratio can be advocated as sustainable strategy for enhancing productivity and profitability of chickpea growers in semi-arid condition.

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