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Production Potential and Economic Returns of Bed Planted Chickpea (*Cicer arietinum* L.) as Influenced by Different Intercropping Systems

M.V. Priya, Thakar Singh, K.S. Saini, Sompal Singh[1]

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ABSTRACT

Background: Chickpea (*Cicer arietinum* L.) is the third most important pulse crop produced after dry bean and peas in the world. Amongst pulses, chickpea is the major crop in India but for international market the quality of this crop has to be improved which may be possible by evaluation of different planting techniques. No systematic research and adequate technologies have been reported in Punjab on intercropping of different crops in chickpea. The current study aimed to find out the effect of different intercrops on growth and yield of bed planted chickpea based intercropping systems.

Methods: A field experiment was carried out during the *rabi* season of 2017 and 2018 to evaluate the productivity and economic viability of bed planted chickpea based intercropping systems. The experiment was laid out in a randomized block design consisting of four replications with thirteen treatments.

Result: Results showed that sole chickpea recorded highest seed yield and it was statistically at par with seed yield that obtained under chickpea + oats fodder (2:1), chickpea + oats fodder (4:1) and chickpea + linseed (4:1) intercropping systems. However, oilseed rape and barley as intercrops showed adverse effect on yield and yield attributes of chickpea. Chickpea + oats fodder in 2:1 row ratio recorded highest chickpea equivalent yield of 24.07 and 24.77 q/ha and system productivity of 15.96 and 15.60 kg/ha/day during 2017 and 2018, respectively. Higher net returns (Rs. 63098 and 70924/ha), benefit cost ratio (1.47 and 1.63) and production efficiency (417.9 and 446.1 Rs/ha/day) were also recorded in chickpea + oats fodder (2:1) intercropping system over sole chickpea (Rs. 44862 and 53769/ha and 1.21 and 1.41) during both the years. Chickpea + oats fodder (4:1), chickpea + linseed (2:1) and chickpea + linseed (4:1) also recorded significantly higher chickpea equivalent yield, net returns and benefit cost ratio as compared to sole chickpea.

Key words: Bed planted chickpea, Chickpea equivalent yield, Economic returns, Intercropping system, Production efficiency.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is a foremost pulse crop of semi-arid tropics and grown as winter *rabi* pulse crop in India. Globally, India is the largest producer which accounts for nearly 35 per cent of total pulse production in the world. In India, chickpea is grown over an area of 10560 thousand hectares with about 11379 thousand tonnes production and productivity of 1078 kg/ha (Anonymous, 2018). In Punjab, it was grown on 1.7 thousand hectares with production of 2.0 thousand tonnes and productivity of 1180.0 kg/ha (Anonymous 2019).

Chickpea is a legume crop belonging to the family *Fabaceae*. It is commonly referred as gram or bengal gram or *chana* and also known as king of pulses. It contains 21.1 per cent of protein which helps in eliminating the malnutrition problem in developing countries. Chickpea has the ability to enrich soil and sustains the soil productivity by trapping the atmospheric nitrogen in their root nodules (Ali and Kumar 2005). Through symbiotic nitrogen fixation it can fix up to 80 per cent of its nitrogen requirement (Saraf *et al.,* 1998). Therefore, there is a need to increase area under pulses or to increase the productivity of pulses.

Bed planting in chickpea is a new concept in the cultivation of chickpea. Sowing of chickpea on the bed and intercrops in the ditches will not only protect the chickpea from excess moisture during heavy rains or irrigated conditions but will also decrease the competition between the two crops if any, because of their different rooting depths. Chickpea plays an important role in the cropping systems of subsistence farmers due to its ability to grow under abrasive edaphic factors and arid environments when provided with better low inputs (Verma *et al.,* 2013). Intercropping is defined as growing of two or more dissimilar crops simultaneously on the same piece of land, in a distinct row arrangement using one crop as a base crop to which rows of an additional component crops are added.

Department of Agronomy, Punjab Agricultural University, Ludhiana-141 004, Punjab, India.

[1]Department of Climate Change and Agricultural Meteorology, Punjab Agricultural University, Ludhiana-141 004, Punjab, India.

Corresponding Author: M.V. Priya, Department of Agronomy, Punjab Agricultural University, Ludhiana-141 004, Punjab, India. Email: priya3manchuri@gmail.com

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The advantage of intercropping in crop production in comparison to pure cropping is due to better use of environmental resources (Mahapatra 2011).

In India, chickpea is generally intercropped with wheat, barley, lentil, pea, mustard, linseed, safflower and coriander. Selection of crops for intercropping includes their compatibility with main crop, low competition for resources and ability to produce higher yield (Gharineh and Telavat 2009). The experiment was under taken during *rabi* season of 2017 and 2018 with the objective to find out the effect of different intercrops on chickpea and evaluate the productivity and economic viability of bed planted chickpea based intercropping systems.

MATERIALS AND METHODS

Field experiment was conducted during *rabi season* of 2017 and 2018 at Students' Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana. The soil of the experiment field was loamy sand, having pH (7.0 and 7.1), EC (0.18 and 0.17 dS/m), OC (0.21 and 0.20%), available N (169.3 and 188.1 kg/ha), available P (24.9 and 22.5 kg/ha) and available K (157.3 and 154.5 kg/ha), respectively during both years of study. The experiment was laid out in randomised block design in four replications with thirteen treatments *viz.,* T_1: Chickpea + oats fodder (2:1), T_2: Chickpea + oats fodder (4:1), T_3: Chickpea + linseed (2:1), T_4: Chickpea + linseed (4:1), T_5: Chickpea + barley (2:1), T_6: Chickpea + barley (4:1), T_7: Chickpea + oilseed rape (2:1), T_8: chickpea + oilseed rape (4:1), T_9: Sole chickpea, T_{10}: Sole oats fodder, T_{11}: Sole linseed, T_{12}: Sole barley and T_{13}: Sole oilseed rape. The plant population of chickpea was kept same in all the treatments. The recommended dose of nutrients *viz.,* 15 kg N/ha and 20 kg P_2O_5/ha to chickpea were applied at the time of sowing. Fertilizers were applied on area basis for all treatments to intercrops as per recommendations. Nitrogen, phosphorus and potassium nutrients were applied through urea, single super phosphate and muriate of potash. The varieties taken for sowing were PBG 7 of chickpea, OL 10 of oats fodder, LC 2063 of linseed, PL 807 of barley and GSC 6 of oilseed rape. Sowing of the chickpea and the intercrops was done simultaneously on 10th November during 2017 and on 5th November during 2018.Wheat bed planter was used for 67.5 cm apart spaced bed preparation (bed width was 37.5 cm and furrow width was 30 cm). Sowing of two rows of chickpea was done on the top of each bed and intercrops was sown in the furrows under 2:1 row ratio, whereas four rows of chickpea was sown on two beds and one row of intercrops was sown in furrows after two beds under 4:1 row ratio. All cultural practices were followed as per recommended procedures. The chickpea equivalent yield was computed by converting the yield of intercrop to chickpea yield, based on their market prices. System productivity values in term of kg/ha/day were worked out by total production in an intercropping system divided by total duration of the crops in that system. Gross returns and net returns were also calculated based on market prices of crops during both the years. Production efficiency values in term of per day income (Rs/ha/day) were obtained by net returns of the intercropping system divided by total duration of the crops in that system (Sekhon *et al.,* 2019). The data collected from the experiment was subjected to statistical test by following 'Analysis of variance technique' as suggested by Cochran and Cox (1967) and Cheema and Singh (1991). The critical difference (CD) values at 5% level of probability were computed for making comparison between treatments.

RESULTS AND DISCUSSION

Yield attributes

Intercropping systems did not show any significant effect on yield attributes of chickpea *viz.,* number of primary branches per plant, number of secondary branches per plant and number of seeds per pod during both the years (Table 1). However, the number of seeds per pod and 1000-seed weight was significantly influenced by the different intercropping systems which might be due to the competition for soil moisture, nutrients and solar radiation for chickpea. The highest number of pods per plant and 1000-seed weight were recorded in sole chickpea and it was statistically at par with chickpea + oats fodder (2:1), chickpea + oats fodder (4:1) and chickpea + linseed (4:1) and significantly higher than all other intercropping systems.

Seed yield, haulm yield of chickpea

Sole chickpea recorded significantly higher seed yield (18.61 and 19.86 q/ha) which might be due to no competition effect, higher number of pods per plant and higher 1000-seed weight as compared to other treatments. This system was statistically at par with the seed yield of chickpea obtained under chickpea + oats fodder (2:1), chickpea + oats fodder (4:1) and chickpea + linseed (4:1) systems during both the cropping seasons. The lowest seed yield was recorded under chickpea + oilseed rape in 2:1 row ratio (3.46 and 6.78 q/ha) and followed by chickpea + oilseed rape in 4:1 row ratio (7.24 and 9.95 q/ha) which might be due to the reason that chickpea crop was suppressed by the oilseed rape plants and resulted in less production of pods per plant and shrivelled grains. Highest haulm yield was obtained with sole cropping during both the years. These results corroborated with the results of Singh and Aulakh (2017).

Chickpea equivalent yield (CEY)

Among all the different intercropping systems, chickpea + oats fodder in 2:1 row ratio recorded maximum chickpea equivalent yield (24.1 and 24.8 q/ha) during the cropping seasons of 2017 and 2018, respectively (Table 2). This system was statistically at par with chickpea + oats fodder (4:1), chickpea + linseed (2:1) and chickpea + linseed (4:1) systems but was significantly better than sole chickpea and other intercropping systems during both the cropping seasons. Similar trend was observed with respect to system productivity of different intercropping systems. Higher CEY

Table 1: Yield attributes, seed yield and haul yield of bed planted chickpea as influenced by different intercropping systems.

Treatment	Number of primary branches per plant		Number of secondary branches per plant		Number of pods per plant		Number of seeds per pod		1000-seed weight (g)		Seed yield (q/ha)		Haulm yield (q/ha)	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Chickpea + oats fodder (2:1)	3.9	4.1	10.5	10.7	41.3	42.2	2.0	2.0	153.8	154.5	17.8	18.7	41.3	41.8
Chickpea + oats fodder (4:1)	3.9	4.2	10.3	10.5	41.7	42.3	2.0	2.0	154.0	154.6	18.5	19.7	41.8	40.8
Chickpea + linseed (2:1)	3.8	4.1	10.3	10.5	34.3	34.4	1.8	1.9	147.4	147.5	13.2	12.9	40.5	39.5
Chickpea + linseed (4:1)	3.9	4.0	10.3	10.4	41.0	41.6	2.0	2.0	153.5	154.1	17.5	17.3	41.0	42.0
Chickpea + barley (2:1)	3.9	3.9	10.1	10.3	33.6	34.0	2.1	1.9	144.7	145.2	10.9	11.8	38.9	37.3
Chickpea + barley (4:1)	3.8	3.9	10.2	10.1	37.7	38.0	2.0	2.0	149.5	149.6	16.6	16.8	38.5	38.8
Chickpea + oilseed rape (2:1)	3.5	3.8	9.8	9.8	27.9	28.2	1.8	1.9	134.6	135.9	3.5	6.8	36.4	35.5
Chickpea + oilseed rape (4:1)	3.6	3.9	10.1	9.9	30.2	30.4	2.0	2.0	137.3	137.9	7.2	9.9	36.2	36.3
Sole chickpea	4.1	4.2	10.3	10.7	42.5	42.6	2.1	2.1	154.5	155.2	18.6	19.9	42.2	42.3
CD (P=0.05)	NS	NS	NS	NS	1.90	1.03	NS	NS	1.7	1.3	1.1	2.9	2.4	3.2

Table 2: Seed yield, intercrop yield and chickpea equivalent yield as influenced by different intercropping systems.

Treatment	Seed yield (q/ha)			Intercrop yield (q/ha)			CEY (q/ha)			System productivity (kg/ha/day)		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Mean
Chickpea + oats fodder (2:1)	17.8	18.6	18.2	231.2	217.6	224.4	24.1	24.8	24.4	15.96	15.60	15.78
Chickpea + oats fodder (4:1)	18.5	19.7	19.1	156.9	147.0	152.0	22.8	23.9	23.3	15.10	15.03	15.07
Chickpea + linseed (2:1)	13.2	13.0	13.1	10.4	11.0	10.7	22.7	23.0	22.8	15.03	14.47	14.75
Chickpea + linseed (4:1)	17.5	17.3	17.4	5.4	6.1	5.8	22.5	22.8	22.7	14.90	14.34	14.62
Chickpea + barley (2:1)	11.0	11.8	11.4	19.1	17.4	18.3	17.1	17.2	17.2	11.32	10.82	11.07
Chickpea + barley (4:1)	16.6	16.8	16.7	10.7	9.8	10.3	20.0	19.8	19.9	13.25	12.45	12.85
Chickpea + oilseed rape (2:1)	3.5	6.8	5.1	14.4	12.0	13.2	16.6	17.7	17.1	10.99	11.13	11.06
Chickpea + oilseed rape (4:1)	7.2	9.9	8.6	10.0	9.9	10.0	16.3	19.0	17.6	10.79	11.95	11.37
Sole chickpea	18.6	19.9	19.2	-	-	0.0	18.6	19.9	19.2	12.32	12.52	12.42
Sole oats fodder	-	-	-	628.8	601.3	615.0	17.1	16.9	17.0	12.48	11.90	12.19
Sole linseed	-	-	-	16.0	17.8	16.9	14.6	16.2	15.4	9.67	10.19	9.93
Sole barley	-	-	-	41.1	35.0	38.1	13.2	10.9	12.0	9.64	7.68	8.66
Sole oilseed rape	-	-	-	18.7	20.0	19.3	17.0	18.1	17.6	11.72	11.99	11.85
CD (P=0.05)	1.1	2.9	2.1	-	-	-	2.8	2.7	2.4	-	-	-

CEY = Chickpea equivalent yield.

Table 3: Economics of chickpea based intercropping system as influenced by different intercropping systems.

Treatment	Cost of cultivation (Rs/ha)			Gross returns (Rs/ha)			Net returns (Rs/ha)			B:C ratio			Production efficiency (Rs/ha/day)		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Mean
Chickpea + oats fodder (2:1)	42800	43500	43150	105898	114424	110161	63098	70924	67011	1.47	1.63	1.55	417.9	446.1	432.3
Chickpea + oats fodder (4:1)	42500	43200	42850	100194	110259	105227	57694	67059	62377	1.36	1.55	1.45	382.1	421.8	402.4
Chickpea + linseed (2:1)	42300	43500	42900	99827	106275	103051	57527	62775	60151	1.36	1.44	1.40	381.0	394.8	388.1
Chickpea + linseed (4:1)	42000	43200	42600	98806	105542	102174	56806	62342	59574	1.35	1.44	1.40	376.2	392.1	384.3
Chickpea + barley (2:1)	39000	39500	39250	75144	79575	77360	36144	40075	38110	0.93	1.01	0.97	239.4	252.0	245.9
Chickpea + barley (4:1)	38500	39000	38750	87977	91685	89831	49477	52685	51081	1.29	1.35	1.32	327.7	331.4	329.6
Chickpea + oilseed rape (2:1)	39000	39500	39250	72844	81879	77361	33844	42379	38111	0.87	1.07	0.97	224.1	266.5	245.9
Chickpea + oilseed rape (4:1)	38500	39000	38750	71872	87577	79725	33372	48577	40975	0.87	1.25	1.06	221.0	305.5	264.4
Sole chickpea	37000	38000	37500	81862	91769	86816	44862	53769	49316	1.21	1.41	1.31	297.1	338.2	318.2
Sole oats fodder	33500	34000	33750	75450	78163	76806	41950	44163	43056	1.25	1.30	1.28	306.2	311.0	308.6
Sole linseed	30500	32500	31500	64110	74760	69435	33610	42260	37935	1.10	1.30	1.20	222.6	265.8	244.7
Sole barley	23900	23925	23913	57986	50436	54211	34086	26511	30299	1.43	1.11	1.27	248.8	186.7	217.7
Sole oilseed rape	35000	35500	35250	74640	83832	79236	39640	48332	43986	1.13	1.36	1.25	273.4	320.1	296.7
CD (P=0.05)	-	-	-	7.92	13.1	10.7	8.01	13.1	10.7	0.15	0.33	0.24	-	-	-

and system productivity under chickpea + oats fodder system was due to the fact that oats fodder is a short duration crop and three cuttings was taken for fodder, as a result it showed less competition with chickpea that resulted in comparatively higher seed yield of chickpea. These results were supported by the findings of Torkaman *et al* (2018) and Singh *et al* (2019) who reported higher chickpea equivalent yield in intercropping systems as compared to their sole cropping. However, the lower chickpea equivalent yield was observed in the systems when oilseed rape and barley were taken as intercrops in 2:1 and 4:1 row ratio. This might be due to the poor yield of chickpea associated with these intercrops due to more shading effect.

Economics

Cost of cultivation was higher with chickpea + oats fodder (2:1) than other intercropping systems because of more number of cultural operations and labour charges (Table 3). Among different intercropping systems, there was increase in cost of cultivation in 2:1 row ratio than 4:1 row ratio treatment. Chickpea + oats fodder (2:1) recorded maximum gross returns, net returns and B:C ratio which was statistically at par with chickpea + oats fodder (4:1), chickpea + linseed (2:1) and chickpea + linseed (4:1) systems but significantly higher than all other intercropping systems during both the years. In addition to these systems, B:C ratio was also statistically at par with chickpea + barley (4:1). These results were supported by the findings of Singh *et al* (2017), Meena and Kumar (2017) and Singh *et al* (2019) who also reported higher gross and net returns under different intercropping systems over sole cropping. Lowest gross and net returns were recorded under chickpea + oilseed rape in 2:1 row ratio owing to very poor yield of chickpea under this system due to comparatively more shading effect of oilseed rape.

Production efficiency

Production efficiency in terms of Rs/ha/day followed almost similar trend as in case of net returns. On an average, maximum production efficiency (432.3 Rs/ha/day) was obtained in chickpea + oats fodder (2:1) intercropping system and it was followed by chickpea + oats fodder (4:1), chickpea + linseed (2:1) and chickpea + linseed (4:1) systems. This was mainly attributed to higher level of production and prices of chickpea and linseed. Minimum production efficiency was recorded in chickpea + barley (2:1) among different intercropping system while it was lowest in barley among different sole crops.

CONCLUSION

More attention is required in the pulse production to meet the demands of burgeoning population and the production can be increased through the intercropping systems. From the above research, chickpea can be intercropped with oats fodder and linseed in both 2:1 and 4:1 row ratio and these intercropping systems were advantageous than the sole cropping of chickpea in terms of system productivity, net returns, B:C ratio and production efficiency.

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