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Response of row spacing, bio-fertilizer and nitrogen levels on yields and economics of chickpea (*Cicer aritenium* L.) under central plain zone of Uttar Pradesh

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Abstract
A field experiment was conducted during two consecutive years of rabi 2014-15 and 2015-16 at Soil Conservation and Water Management farm of the C. S. Azad University of Agriculture and Technology, Kanpur to find out the response of row spacing, bio-fertilizer and nitrogen levels on yields i.e. seed yield, stover yield, harvest index and economics of chickpea crop. The treatments comprised of 2 row spacing i.e. 40 cm and 60 cm, 3 bio-fertilizer i.e. *Rhizobium leguminosarum* culture (seed coating @ 20 g kg^{-1} seed),Phosphate solubilizing bacteria (PSB) @ 2.5 kg ha^{-1} in soil and *Rhizobium leguminosarum* + Phosphate solubilizing bacteria (PSB) and 3 nitrogen level i.e. 10 kg ha^{-1}, 20 kg ha^{-1} and 30 kg ha^{-1} in Split plot design with 3 replications. Results obtained in regarded to yields and economics showed that the 40 cm row spacing produced significantly higher yield in both the years on pooled basis recorded seed yield (14.22 q ha^{-1}), stover yield (20.20 q ha^{-1}), harvest index (41.16%), gross return₹75593 ha^{-1}, net return ₹56972 ha^{-1} and B.C. ratio 1:3.07. Among the bio-fertilizer the performance of dual inoculation of *Rhizobium leguminosarum* culture + PSB was the best & have recorded significantly superior seed yield (14.33 q ha^{-1}), stover yield (19.15 q ha^{-1}), harvest index (42.48%), gross return ₹76047 ha^{-1}, net return ₹ 58225 ha^{-1} and B.C. ratio 1:3.27. However nitrogen level @ 30 kg ha^{-1} recorded significantly higher on seed yield (14.83 q ha^{-1}), stover yield (19.97 q ha^{-1}), harvest index (42.83%), gross return ₹78728 ha^{-1}, net return ₹60994 ha^{-1} and B.C. ratio1:3.44. Nitrogen levels 30 kg ha^{-1} was found superior in all respect as compared to other treatments combinations.

Keywords: Phosphate solubilizing bacteria (PSB), *Rhizobium leguminosarum* culture, split plot design (SPD), harvest index (HI), cost of cultivation gross & net return and cost: benefit ratio

Introduction
Pulse crops have a specific importance for the vegetarian population of our country because pulses are the major source of protein. However, due to population explosion and low productivity of pulse crops, per capita availability of pulses is consistently decreasing and availability of pulses per day is only 47g as against the minimum requirement of 104 g as recommended by nutritional experts of World Health Organization. Food legumes are of prime importance in human diet and animal feed contributing the major source of vegetable protein. They are an economic source of not only protein but of carbohydrate, minerals and β -complex vitamins particularly in vegetarian diet. On an average, pulses contain 20-25 per cent of protein in their dry seeds, which is almost 2.5-3.0 times the value normally found in cereals. Thus, the food legumes ensure nutritional security to the poor masses of the country.

Chickpea is one of the most widely cultivated pulse crops of India. It is the most important crop of *rabi* season which occupies an area of 8.52 million hectares in the country with an annual production of 8.83 million tonnes and productivity of 10.36 q ha^{-1}. In U.P., it is grown an area of 6.0 lakh hectares with an annual production and productivity of 6.8 lakh tonnes and 11.19q ha^{-1}. The major pulses producing states are Madhya Pradesh (43.16%), Maharashtra (13.14%), Rajasthan (14.46%) and Uttar Pradesh (7.65%), which together accounts for 72 per cent. Madhya Pradesh ranks first in area, production and productivity, while Maharashtra ranks second and Uttar Pradesh ranks sixth in respective order (Anonymous, 2014) [2].

Bio-fertilizers are microbial inoculants of selective microorganisms like bacteria, algae, fungi already existing in nature. They may help in improving soil fertility by way of accelerating biological nitrogen fixation from atmosphere, solubilization of the insoluble nutrients already present in soil, decomposing plant residues, stimulating plant growth and production. The process is slow, consumes less energy and provides Cheep nutrient to agriculture without polluting the nature. The seed inoculation with *Rhizobium* increases nodulation, influences seed yield and economies the input cost of fertilizers to some extent and protects against chances of soil deterioration and environmental pollution caused by heavy use of chemical fertilizers. The efficient strains of *Rhizobium* can fix about 90 kg of nitrogen per hectare in one season and enrich soil nitrogen (Gupta and Prasad, 1982) [9].

Chickpea is grown in many tropical, sub-tropical and temperate regions of the world and one of the most important pulse crops of India due to its multiple functions in the traditional farming system. Row spacing is also one of the important factors which ultimatly effect nutrient uptake growth and yield of plant. Increases in spacing decreases the total population, but with more nutrition to the individual plant grows better and yield more and vice-verse.

Materials and Methods

A field experiment was conducted on response of row spacing, bio-fertilizer and nitrogen levels on yields and economics of chickpea at Soil Conservation and Water Management Farm, Department of Soil Conservation and Water Management of Chandra Shekhar Azad University of Agriculture & Technology, Kanpur which is situated in the alluvial tract of Indo - Gangetic plains in central part of Uttar Pradesh between 25º 26’ to 26º 58’ North latitude and 79º 31’ to 80º34’ East longitude at an elevation of 125.9 m above mean sea level. The average annual rainfall is 800 mm, a major portion of which is received during the monsoon season from the last week of June to first week of October. The treatments comprised of 2 row spacing i.e. 40 cm and 60 cm, 3 bio-fertilizer *i.e. Rhizobium leguminosarum* culture (seed coating @ 20 g kg^{-1} seed), Phosphate solubilizing bacteria (PSB) @ 2.5 kg ha^{-1} in soil and *Rhizobium leguminosarum* + Phosphate solubilizing bacteria (PSB) and 3 nitrogen level i.e. 10 kg ha^{-1}, 20 kg ha^{-1} and 30 kg ha^{-1} in Split plot design with 3 replications. Recommended uniform dose 60 + 20+ 20 with 3 replications and 18 treatments the analysis of variance of the data was worked out on the basis of the Split Block Design, as explained by Cochran and Cox (1957) [5].

Results

1. Seed yield

The data pertaining to the seed yield (q ha^{-1}) of chickpea have been given in Table-1 showed that response of row spacing clearly indicate marked variation among them, where 40 cm row spacing treatment produced significantly highest seed yield on pooled basis (14.22) q ha^{-1} of chickpea however 60 cm row spacing recorded to be the lowest seed yield (11.91) q ha^{-1} during both the years. Bejandi *et al*. (2012) [4] noted that the effects of plant densities on seed yield were found significant. The lowest values for time of maturity and the highest values for plant height were observed at 45 plants m^{-2}. The maximum the highest seed yield of chickpea was recorded at 45 plants m^{-2} similar findings Farjam *et al*. (2014) [6].

Effect of bio-fertilizer also varied remarkably in respect of seed yield of chickpea. Significantly higher seed yield recorded on pooled basis in rhizobium culture + PSB (14.33) q ha^{-1}. However lowest seed yield in rhizobium culture treatment during recorded (11.53) q ha^{-1} during both the years. Asad and Vafa (2011) [3] study also showed that the occurrence of *Azospirillum* or *Azotobacter* inoculants in the treatment composition caused an expressive improvement in seed yield and plant biomass similar findings Pramanik and Bera (2012) [11].

Similarly nitrogen levels also showed marked variation in respect of seed yield. Significantly higher seed yield was recorded under N 30 kg/ha nitrogen levels treatment gave (14.83) q ha^{-1} over other nitrogen levels during both the years. Goyal *et al*. (2010) [8] reported that higher fertility level produced significantly higher values of growth and yield attributes, seed and straw yield of Kabuli chickpea (*Cicer arietinum* L.) compared to lower fertility level were similar findings Ali *et al*. (2013) [1].

2. Stover yield

The data pertaining to the stover yield (q ha^{-1}) of chickpea have been given in Table -1 showed that response of row spacing clearly indicate marked variation among them, where 40 cm row spacing treatment produced significantly highest stover yield on pooled basis (20.20) q ha^{-1} of chickpea however 60 cm row spacing recorded to be the lowest stover yield on pooled basis (15.87) q ha^{-1} during both the years. Bejandi *et al.* (2012) [4] noted that the effects of plant densities on stover yield were found significant. The lowest values for time of maturity and the highest values for plant height were observed at 45 plants m^{-2}. The maximum the highest seed yield of chickpea was recorded at 45 plants m^{-2} similar findings Farjam *et al.* (2014) [6].

Effect of bio-fertilizer also varied remarkably in respect of stover yield of chickpea. Significantly higher stover yield on pooled basis recorded in rhizobium culture + PSB (19.15) q ha^{-1} however lowest stover yield in rhizobium culture treatment during (16.50) q ha^{-1} respectively during both the years. Asad and Vafa (2011) [3] showed that the occurrence of *Azospirillum* or *Azotobacter* inoculants in the treatment composition caused an expressive improvement in seed yield similar findings Pramanik and Bera (2012) [11].

Similarly nitrogen levels also showed marked variation in respect of stover yield. Significantly higher stover yield was recorded under N 30 kg/ha nitrogen levels treatment (19.97) q ha^{-1}. However lowest stover yield recorded on pooled basis in N 10 kg nitrogen levels (15.75) q ha^{-1}. Application of 30 kg/ha nitrogen level superior other treatment during both the years with pooled. Goyal *et al*. (2010) [8] reported that higher fertility level produced significantly higher values of seed and straw yield of Kabuli chickpea (*Cicer arietinum* L.) compared to lower fertility level with similar findings Ali *et al*. (2013) [1].

Table 1: Effect of row spacing, bio-fertilizer and nitrogen levels on seed, stover yield q ha^{-1} and harvest index (%) of chickpea during 2014-15 & 2015-16.

Treatment	Seed yield q ha^{-1}			Stover yield q ha^{-1}			Harvest index (%)		
	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
Row spacing									
40 cm	15.74	12.71	14.22	21.98	18.42	20.20	41.81	40.50	41.16
60 cm	13.16	10.65	11.91	17.39	14.36	15.87	42.83	42.45	42.64
SE(d)	0.38	0.39	0.39	0.42	0.42	0.42	0.41	0.38	0.39
C.D. (P=0.05)	0.86	0.87	0.87	0.94	0.94	0.93	0.91	0.86	0.88
Bio – fertilizer									
Rhizobium culture (seed coating @20g/kg seed)	12.68	10.37	11.53	17.86	15.13	16.50	41.55	40.66	41.11

PSB @2.5 kg/ha in soil	14.73	11.95	13.35	20.18	16.75	18.47	42.22	41.61	41.92
Rhizobium culture+ PSB	15.93	12.72	14.33	21.02	17.27	19.15	43.19	42.17	42.48
SE(d)	0.47	0.48	0.48	0.52	0.52	0.52	0.50	0.47	0.48
C.D. (P=0.05)	1.06	1.08	1.06	1.15	1.16	1.15	1.11	1.04	1.07
Nitrogen levels- kg ha^{-1}									
10	12.18	9.94	11.06	17.04	14.45	15.75	41.57	40.54	41.06
20	14.74	11.87	13.31	20.10	16.68	18.40	42.17	41.47	41.82
30	16.42	13.23	14.83	21.91	18.02	19.97	43.22	42.43	42.83
SE(d)	0.55	0.54	0.54	0.61	0.57	0.58	0.59	0.53	0.56
C.D. (P=0.05)	1.14	1.11	1.12	1.26	1.17	1.20	1.22	1.07	1.15

3. Havest index

The data pertaining to the harvest index (%) of chickpea have been given in Table -1 showed that response of row spacing clearly indicate marked variation among them, where 40 cm row spacing treatment produced significantly highest harvest index (%) recorded on pooled basis (42.64) q ha^{-1} of chickpea however 60 cm row spacing recorded to be the lowest harvest index recorded (41.16) q ha^{-1} during both the years. Bejandi *et al.* (2012) [4] noted that the effects of plant densities on seed yield were found significant. The lowest values for time of maturity and the highest values for plant height were observed at 45 plants m^{-2}. The maximum the highest harvest index of chickpea was recorded at 45 plants m^{-2} similar results Farjam *et al.* (2014) [6].

Effect of bio-fertilizer also varied remarkably in respect of harvest index (%) of chickpea. Significantly maximum harvest index recorded in rhizobium culture + PSB recorded on pooled basis (42.48) q ha^{-1} however lowest harvest index in rhizobium culture treatment recorded (41.11) q ha^{-1} respectively during both the years. Asad and Vafa (2011) [3] showed that the occurrence of *Azospirillum* or *Azotobacter* inoculants in the treatment composition caused an expressive improvement in seed yield and plant biomass similar findings Pramanik and Bera (2012) [11].

Similarly nitrogen levels also showed marked variation in respect of harvest index in (%). Significantly higher harvest index was recorded under N 30 kg/ha nitrogen levels treatment (42.83) q ha^{-1}. However lowest harvest index in N 10 kg nitrogen levels recorded on pooled basis (41.06) q ha^{-1}. Application of 30 kg/ha nitrogen level superior other treatment during both the years with pooled. Goyal *et al.* (2010) [8] reported that higher fertility level (30 kg N + 60 kg P_2O_5 + 30 kg K_2O + 20 kg S ha^{-1}) produced significantly higher values of growth and yield attributes, seed and straw yield of Kabuli chickpea (*Cicer arietinum* L.) compared to lower fertility level (20 kg N + 40 kg P_2O_5 + 20 kg K_2O + 20 kg S ha^{-1}) similar findings Ali *et al.* (2013) [1].

II. Economics

The data pertaining to economics of chickpea cultivation was studied in terms of cost of cultivation, gross return, net return and benefit: cost ratio (B.C.) which has been furnished under main effects in Table 2.

Cost of cultivation

1. Common cost

Common cost of cultivation in all treatments under row spacing, bio fertilizer and nitrogen levels of chickpea common cost as mean basis ₹ 12570 ha^{-1} during both years with pooled for growing of crop.

2. Total cost of cultivation

It is apparent from the results that row spacing, bio fertilizer and nitrogen levels applied in respect of total cost of cultivation per hectare of chickpea during both the years on mean basis (Table 3 to 5). Results reveals that total cost of cultivation was recorded maximum under the plots receiving 40 cm row spacing of ₹ 18617 ha^{-1} followed by 60 cm row spacing of ₹ 16717 ha^{-1}.

Table 2: Effect of row spacing, bio fertilizer and nitrogen levels of chickpea on economics during the both years (mean) pooled

Treatment	Cost of cultivation (₹ ha^{-1})					Gross return (₹ ha^{-1})			Net return (₹ ha^{-1})	Cost: benefit ratio
	Common Cost	Variable cost			Total	By seed	By stover (straw)	Total		
		Row spacing	Bio-fertilizer	Nitrogen levels						
Row spacing										
40 cm	12570	5625	300	123	18617	74477	2204	75593	56972	1:3.07
60 cm	12570	3750	275	123	16717	62363	1731	63233	46511	1:2.79
Bio fertilizers										
Rhizobium culture	12570	4688	125	123	17505	60386	1801	61303	43794	1:2.50
PSB	12570	4688	300	123	17680	69874	2014	70889	53206	1:3.01
Rhi.+PSB	12570	4688	438	123	17817	75000	2087	76047	58225	1:3.27
Nitrogen levels kg ha^{-1}										
10	12570	4688	288	63	17608	57931	1719	58806	41197	1:2.34
20	12570	4688	288	121	17665	69693	2006	70704	53034	1:3.00
30	12570	4688	288	184	17729	77636	2177	78728	60994	1:3.44

Bio fertilizer in respect of total cost of cultivation per hectare of chickpea during both the years with mean results reveals that total cost of cultivation recorded maximum under the plots receiving bio fertilizer rhizobium culture +PSB of ₹ 17817 ha^{-1} followed by PSB of ₹ 17680 ha^{-1} during two years. The lowest total cost of cultivation was recorded under the treatment with application of rhizobium culture of ₹ 17504 ha^{-1} cost during both the years on pooled basis. Gangwar and Dubey (2012) [7] reported that study the effect of dual bio-inoculants significantly higher on economics of chickpea i.e. net income in chickpea genotypes. Amongst the bio-inoculants, Rhizobium + phosphorus-solubilizing bacteria (PSB) recorded the highest the highest net income of ha^{-1} similar finding Srinivasulu *et al.* (2015) [13].

It is clear from the data that sources of Nitrogen levels applied to crop had significant response among the treatments in respect of total cost of cultivation during both the years with mean basis (Table 5). It is apparent from the results that total cost of cultivation increased with increasing dose of nitrogen levels. Application of 30 kg nitrogen recorded maximum total cost ₹ 17729 ha^{-1}. Further, data revealed that applied dose of 20 kg recorded total cost of cultivation ₹17665 ha^{-1}. Minimum total cost of cultivation ₹ 17608 ha^{-1} was recorded under 10 kg nitrogen levels during both the on pooled basis.

2. Gross and net return

It is apparent from the results that row spacing, bio fertilizer and nitrogen levels applied significantly in respect of gross and net returns per hectare of chickpea during both the years and on mean basis (Table 3 to 5). Results reveals that gross and net return was recorded maximum under the plots receiving 40 cm row spacing ₹ 75593 ha^{-1} gross return and ₹ 56972 ha^{-1} net return followed by 60 cm row spacing ₹ 63233 ha^{-1} gross return and net return ₹ 46511 ha^{-1} the both years. Mansur *et al.* (2006) [10] reported that interaction on growth parameters of chickpea net returns [Rs.35603 ha^{-1}] was recorded with application of 50 kg P_2O_5 ha^{-1} to ICCV-2 at 3.33 lakhs/ha plant density. Similar results Tiwari and Tripathi (2014) [14].

Bio fertilizer significantly in respect of gross and net returns per hectare of chickpea during both the years with mean results reveals that gross and net return was recorded maximum under the plots receiving bio fertilizer rhizobium culture +PSB ₹ 76047 ha^{-1} gross return and net return ₹ 58225 ha^{-1} followed by PSB ₹ 70889 ha^{-1} gross return and net return ₹ 53206 ha^{-1} respectively. The lowest gross and net return was recorded under the treatment with application of rhizobium culture of ₹ 61303 ha^{-1} gross return and ₹ 43794 ha^{-1} net returns during both the years with mean basis respectively. Raj *et al.* (2014) [12] reported that study the effect of dual bio-inoculants significantly higher on economics of chickpea i.e. net income in chickpea genotypes. Amongst the bio-inoculants, Rhizobium + phosphorus-solubilizing bacteria (PSB) recorded the highest the highest net income ha^{-1} similar finding Srinivasulu *et al.* (2015) [13].

It is clear from the data that sources of Nitrogen levels applied to crop had significant response among the treatments in respect of gross and net return during both the years and on pooled basis (Table - 5). It is apparent from the results that gross and net return increased with increasing dose of nitrogen levels. Application of 30 kg nitrogen recorded maximum gross return ₹ 78728 ha^{-1} and net return of crop ₹ 60994 ha^{-1}. Further, data revealed that 20 kg nitrogen recorded gross return of crop ₹ 70704ha^{-1} and net return of crop ₹ 53034 ha^{-1}. However minimum gross return ₹ 58806 ha^{-1} and net return of crop₹ 41197 ha^{-1} were recorded under lowest level of nitrogen during both the seasons and on pooled basis. Mansur *et al.* (2006) [10] recorded net returns [Rs. 35603 ha^{-1}] and B:C ratio [3.18] with application of 50 kg P_2O_5 ha^{-1} to ICCV -2 variety of chickpea Similar finding Tiwari and Tripathi (2014) [14].

3. Benefit: cost ratio

It is apparent from the results that row spacing, bio fertilizer and nitrogen levels showed their response in respect of B.C. ratio of chickpea during both the years of mean basis Table - 31. Results reveals that cost benefit ratio under the 40 cm row spacing in 1:3.07 followed by 60 cm 1:2.79 B.C ratio in 60 cm row spacing both the years on mean basis. Mansur *et al.* (2006) [10] reported that interaction on growth parameters of chickpea B:C ratio [3.18] was recorded with application of 50 kg P_2O_5 ha^{-1} to ICCV-2 at 3.33 lakhs/ha plant density. Similar results Tiwari and Tripathi (2014) [14].

Bio fertilizer significantly response to B.C. ratio was recorded maximum under the treatment of bio fertilizer rhizobium culture + PSB in B.C. ratio 1:3.17 followed by PSB in B.C. ratio 1:3.01 during both the years on mean basis. The lowest B.C. ratio was recorded under the treatment rhizobium culture in B.C. ratio 1:2.5 during both the years on mean basis. Gangwar and Dubey (2012) [7] reported that study the effect of dual bio-inoculants significantly higher on economics of chickpea i.e. net income in chickpea genotypes. Amongst the bio-inoculants, Rhizobium + phosphorus-solubilizing bacteria (PSB) recorded the highest the highest net income of ha^{-1}. Similar finding Srinivasulu *et al.* (2015) [13].

It is clear from the data that sources of Nitrogen levels applied to crop had significant variations among the treatments in respect of B.C. ratio as recorded on mean basis Table- 31. It is apparent from the results that the application of 30 kg ha^{-1} nitrogen recorded maximum B.C. ratio 1:3.44. Further, data revealed that of 20 kg ha^{-1} nitrogen levels recorded B.C. ratio 1:3.0 and minimum B.C. ratio 1:2.5 was recorded under N 10 kg ha^{-1} nitrogen levels during both the on mean basis. Mansur *et al.* (2006) [10] recorded net returns [Rs.35,603 ha^{-1}] and B:C ratio [3.18] with application of 50 kg P_2O_5 ha-1 to ICCV -2 variety of chickpea similar finding Tiwari and Tripathi (2014) [14].

Conclusion

Yields of crop *i.e.* seed, stover yield and harvest index were significantly increased with increasing row spacing, bio fertilizer Rhizobium culture + PSB and nitrogen levels 30 kg ha^{-1}as compared to other treatments. Economics practices registered higher net return over other treatments. The highest return was observed with the application of 30 kg nitrogen levels recorded maximum gross return ₹ 82878$ha^{-1}$and net return ₹ 65700 ha^{-1} with B:C ratio 1:3.81. Overall consideration of results it can be concluded that in the case of nitrogen levels 30 kg ha^{-1} was found superior in all respect as compared to other combinations of fertility management. So, it may be recommended that growing of chickpea in *rabi* season was found most suitable and remunerative in central plain zone of Uttar Pradesh with 40 cm row spacing, Rhizobium culture + PSB bio-fertilizer and with applied 30 kg nitrogen levels.

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