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Response of nitrogen levels and plant density on growth, yield and quality of chickpea (*Cicer arietinum* L.)

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Abstract
The present investigations entitled "Response of nitrogen levels and plant density on growth, yield and quality of chickpea (*Cicer arietinum* L.)" was conducted at the student instructional field, department of Agronomy, faculty of Agriculture, AKS University, Satna (M.P.) during the rabi (winter) season of 2021-22 on a sandy loam soil. The experiment consisting of combination of four nitrogen levels (0 kg/ha, 10 kg/ha, 20 kg/ha & 30 kg/ha) and three plant spacing (45.0 x 10.0 cm2, 45.0 x 15.0 cm2 and 45.0 x20.0 cm2). The field experiment was laid out in Randomized Block Design with factorial concept with three replications. The results revealed that among the fertilizer, application of nitrogen @ 30 kg/ha recorded higher growth parameters, yield attributing characters, yield and grain quality compared to rest of the nitrogen levels. Among plant spacing treatments, 45.0 x 10.0 cm2 recorded higher growth parameters, yield attributes, yield and quality character followed by 45.0 x 15.0 cm2 and 45.0 x 20.0 cm2. However, net monetary return and B: C ratio significantly more with 45.0 x 10.0 cm2.From the study it could be concluded that application of nitrogen @ 30 kg/ha relatively performed better for more growth, yield and quality of chickpea. Plant spacing of 45.0 x 10.0 cm2 gave more plant growth, yield and quality.

Keywords: Nitrogen levels, plant density, chickpea, growth, yield and quality

Introduction

Chickpea (*Cicer arietinum* L.) is the most important rabi pulse crop known as "Gram" or "Bengal gram" is most important and premier pulse crop of India. In India, it accounts for more than one third of the area and about 50% of the production of pulses. India accounts for 65% of the world acreage and 67% production of chickpea at present. India is the largest producer, consumer and importer of pulses in the world. Chickpea is a good source of carbohydrates and protein, together constituting about 80% of the total dry seed mass in comparison with other pulses (Chibbar, *et al*. 2010) [5]. Therefore, it is an inexpensive, high-quality source of protein. It is not only an important source of protein in human diets, but it also plays a significant role in maintaining soil fertility, through biological nitrogen fixation. It is also rich in calcium, iron and niacin.

Nitrogen is important nutrient for chickpea, its application to increases the growth and yield of chickpea also required for high productivity. Increase in yield was reported with nitrogen application as basal dose and at post flowering stage. Nitrogen application during the post flowering stage enhanced nitrate reductase activity and yield (Saxena and Yadav, 1975). Nitrogen is essential for crops because it is a key component of chlorophyll, the substance that enables plants to utilize sunlight energy to make sugars from water and carbon dioxide, a process known as photosynthesis. Nitrogen deficiency causes a decrease in development rate, chlorosis, growth stunted and decreases in crop yield (Erman *et al*., 2011) [6]. Nitrogen is considered as most important nutrient for the protein synthesis and can constitute 40-50 of protoplasm of plant cell on dry weight basis and can be a limiting factor under such condition (De, 1993).

One of the main reasons of low yield of chickpea is improper plant- population. Too low and high plant population beyond a certain limit often adversely affects the crop yield. Number of plants per unit area influences plant yield components and ultimately the seed yield. The distance between row and distance between plants within row also manipulate the crop yield as interception of sunlight, intercultural operation etc. play important role in this regard. Bhairappanavar *et al*. (2005) [10] reported that closer spacing of 30 cm X 10 cm established significantly higher stand and highest seed yield. plant density is very important to facilitate aeration and light penetration into plant canopy for optimizing rate of photosynthesis. Improper plant spacing and plant population is the main reason of low yield of chickpea.

Optimum plant density enables to improve the efficiency of individual plant as it associated with root development as well as shoot development. Plant may show better growth and development and give higher yield per plant but may not give maximum yield per unit area because inadequate plant population and improper plant nutrition. Thus, for realizing potential economic yield, the optimum planting geometry with appropriate nutrition is essential

Materials and Methods

The present experiment was conducted during the *rabi* season of 2021-22 at the Student Instructional field, department of Agronomy, Faculty of Agriculture, AKS University, Sherganj, Satna (M.P.). Mean temperature and humidity ranged from 10.20º C (min) to 45.0º C (max) and 87.00% (morning) to 75.00% (evening), respectively. The soil of experimental field was silty clay loam with low level of organic carbon (0.39%), available nitrogen (178.4kg ha^{-1}), available phosphorus (16.8 kg ha^{-1}) and medium level of available potassium (279.50 kg ha^{-1}) having 7.5 pH and 0.14 ds/m EC.

Twelve treatment cobination (N_0S_1, N_0S_2, N_0S_3, N_1S_1, N_1S_2, N_1S_3, N_2S_1, N_2S_2, N_2S_3, N_3S_1, N_3S_2, N_3S_3) of four levels of nitrogen *viz*. $N_{0=}$ 0 kg/ha, $N_{1=}$ 10 kg/ha, $N_{2=}$20 kg/ha and $N_{3=}$30 kg/ha and three spacing *viz*. S_1=45X10 cm, $S_{2=}$ 45X15 cm and $S_{3=}$ 45X20 cm were laid out in Factorial Randomize block Design with three replications. The gross and net plot size was 5 m x 3 m, respectively. The experimental plots were fertilizers as per recommended dose.

The seed of Chickpea, JG-36 variety was obtained from JNKVV, Jabalpur. The chickpea variety was sown as per treatments. As per treatment the crop was sown using seed rate of 80 kg/ ha. Seeds were treated with Bavistin before sowing the seeds to control the seed borne disease. Thereafter, the seed was inoculated with culture, as per treatment. In order to obtain uniform plant height stand, seeds were weighed for each plot separately in small packets for sowing. Sowing was done manually in furrows with the spacing of as per treatment. The crop was sown on 25th October 2021. Sowing was done followed by pre sowing irrigation and then sowing was done as per treatment has retained optimum moisture content. Pre-sowing irrigation was given 7-10 days before sowing. The crop was irrigated two times. The seeds were sown manually at about 5 cm depth followed by irrigation. Required quantity of healthy, bold, unbroken and fully developed seeds were used.

Results and Discussion

Plant height (cm) at 90 DAS

Interaction effect between different levels of nitrogen and plant spacing was found to be significant for variation in plant height at 90 DAS. The treatment combination consisting that application of nitrogen @ 30 kg/ha with narrow plant spacing of 45.0 x 10.0 cm (T_{10}, N_3S_1) produced significantly highest plant height (60.95 cm) as compared to all the remaining treatment combinations and closely followed by 59.89 cm with the treatment combination consisting that application of nitrogen @ 30 kg/ha with plant spacing of 45.0 x 15.0 cm (T_{11}, N_3S_2). Whereas, the lowest plant height (31.50 cm) was noticed under the without application of nitrogen @ 0 kg/ha with wider plant spacing of 45.0 x 20.0 cm (T_3, P_0S_3) treatment combinations.

Number of branches per plant at 90 DAS

The interaction effect between different levels of nitrogen and plant spacing was found to be significant for variation in number of branches per plant at 90 DAS. The treatment combination consisting that application of nitrogen @ 30 kg/ha with wider plant spacing of 45.0 x 20.0 cm (T_{12}, N_3S_3) produced significantly maximum number of branches per plant (11.80) as compared to all the remaining treatment combinations and closely followed by 10.20 with the treatment combination consisting that application of nitrogen @ 30 kg/ha with plant spacing of 45.0 x 15.0 cm (T_{11}, N_3S_2). Whereas, the minimum number of branches per plant (4.53) was noticed under the without application of nitrogen @ 0 kg/ha with narrow plant spacing of 45.0 x 10.0 cm (T_1, N_0S_1) treatment combinations.

Number of pods per plant

The interaction effect between different levels of nitrogen and plant spacing was found to be significant for variation in number of pods per plant. The treatment combination consisting that application of nitrogen @ 30 kg/ha with wider plant spacing of 45.0 x 20.0 cm (T_{12}, N_3S_3)
produced significantly maximum number of pods per plant (38.60) as compared to all the remaining treatment combinations and closely followed by 35.00 with the treatment combination consisting that application of nitrogen @ 30 kg/ha with plant spacing of 45.0 x 15.0 cm (T_{11}, N_3S_2). Whereas, the minimum number of pods per plant (14.60) was noticed under the without application of nitrogen @ 0 kg/ha with narrow plant spacing of 45.0 x 10.0 cm (T_1, N_0S_1) treatment combinations.

Seed index (g)

The interaction effect between different levels of nitrogen and plant spacing was found to be significant for variation in seed index. The treatment combination consisting that application of nitrogen @ 30 kg/ha with wider plant spacing of 45.0 x 20.0 cm (T_{12}, N_3S_3) produced significantly highest seed index (21.10 g) as compared to all the remaining treatment combinations and closely followed by 18.19 g with the treatment combination consisting that application of nitrogen @ 30 kg/ha with plant spacing of 45.0 x 15.0 cm (T_{11}, N_3S_2). Whereas, the lowest seed index (15.71 g) was noticed under the without application of nitrogen @ 0 kg/ha with narrow plant spacing of 45.0 x 10.0 cm (T_1, N_0S_1) treatment combinations.

Grain yield per hectare (q/ha)

The interaction effect between different levels of nitrogen and plant spacing was found to be significant for variation in grain yield per hectare. The treatment combination consisting that application of nitrogen @ 30 kg/ha with narrow plant spacing of 45.0 x 10.0 cm (T_{10}, N_3S_1) produced significantly highest grain yield per hectare (24.08 q/ha) as compared to all the remaining treatment combinations and closely followed by 23.06 q/ha with the treatment combination consisting that application of nitrogen @ 30 kg/ha with plant spacing of 45.0 x 15.0 cm (T_{11}, N_3S_2). Whereas, the lowest grain yield per hectare (10.94 q/ha) was noticed under the without application of nitrogen @ 0 kg/ha with wider plant spacing of 45.0 x 20.0 cm (T_3, N_0S_3) treatment combinations.

Stover yield per hectare (q/ha)

The interaction effect between different levels of nitrogen and plant spacing was found to be significant for variation in Stover yield per hectare. The treatment combination consisting that application of nitrogen @ 30 kg/ha with narrow plant spacing of 45.0 x 10.0 cm (T_{10}, N_3S_1) produced significantly highest stove yield per hectare (39.26 q/ha) as compared to all the remaining treatment combinations and closely followed by 39.15 q/ha with the treatment combination consisting that application of nitrogen @ 30 kg/ha with plant spacing of 45.0 x 15.0 cm (T_{11}, N_3S_2). Whereas, the lowest Stover yield per hectare (28.89 q/ha) was noticed under the without application of nitrogen @ 0 kg/ha with wider plant spacing of 45.0 x 20.0 cm (T_3, N_0S_3) treatment combinations.

Protein content (%)

The interaction effect between different levels of nitrogen and plant spacing was found to be significant for variation in protein content. The treatment combination consisting that application of nitrogen @ 30 kg/ha with wider plant spacing of 45.0 x 20.0 cm (T_{12}, N_3S_3) produced significantly highest protein content (22.67%) as compared to all the remaining treatment combinations and closely followed by 21.68% with the treatment combination consisting that application of nitrogen @ 30 kg/ha with plant spacing of 45.0 x 15.0 cm (T_{11}, N_3S_2). Whereas, the lowest protein content (18.30%) was noticed under the without application of nitrogen @ 0 kg/ha with narrow plant spacing of 45.0 x 10.0 cm (T_1, N_0S_1) treatment combinations.

Return per rupee invested (b: c ratio)

The interaction effect between different levels of nitrogen and plant spacing was found to be significant for variation in B: C ratio. The treatment combination consisting that application of nitrogen @ 30 kg/ha with narrow plant spacing of 45.0 x 10.0 cm (T_{10}, N_3S_1) produced significantly highest B: C ratio (3.90:1) as compared to all the remaining treatment combinations and closely followed by 3.70:1 with the treatment combination consisting that application of nitrogen @ 30 kg/ha with plant spacing of 45.0 x 15.0 cm (T_{11}, N_3S_2). Whereas, the lowest B: C ratio (1.30:1) was noticed under the without application of nitrogen @ 0 kg/ha with wider plant spacing of 45.0 x 20.0 cm (T_3, N_0S_3) treatment combinations.

Table 1: Plant height of chickpea at 90 DAS as influenced by different levels of nitrogen and plant density (cm).

Spacing levels	Nitrogen levels				
	N_0 (0 kg/ha)	N_1 (10 kg/ha)	N_2 (20 kg/ha)	N_3 (30 kg /ha)	Mean
S_1 (45.0 x 10.0 cm)	40.45	52.29	57.96	60.95	52.91
S_2 (45.0 x 15.0 cm)	39.87	52.16	54.94	59.89	51.72
S_3 (45.0 x 20.0 cm)	31.50	47.15	54.04	58.34	47.76
Mean	37.27	50.53	55.65	59.72	

	S. Em±	C.D. (P= 0.05)
Nitrogen levels (N)	1.39	4.07
Spacing levels (S)	1.60	4.69
Interaction (N x S)	0.80	1.66

Table 2: Number of branches per plant of chickpea at 90 DAS as influenced by different levels of nitrogen and plant density.

Spacing levels	Nitrogen levels				
	N_0 (0 kg/ha)	N_1 (10 kg/ha)	N_2 (20 kg/ha)	N_3 (30 kg/ha)	Mean
S_1 (45.0 x 10.0 cm)	4.53	6.40	7.40	8.60	6.73
S_2 (45.0 x 15.0 cm)	5.07	6.67	7.80	10.20	7.43
S_3 (45.0 x 20.0 cm)	5.80	7.00	8.20	11.80	8.20
Mean	5.13	6.69	7.80	10.20	

	S. Em±	C.D. (P= 0.05)
Nitrogen levels (N)	0.63	1.84
Spacing levels (S)	0.72	2.12
Interaction (N x S)	0.36	0.75

Table 3: Number of pods per plant of chickpea as influenced by different levels of nitrogen and plant density.

Spacing levels	Nitrogen levels				
	N_0 (0 kg/ha)	N_1 (10 kg/ha)	N_2 (20 kg/ha)	N_3 (30 kg/ha)	Mean
S_1 (45.0 x 10.0 cm)	14.60	24.47	29.27	32.27	25.15
S_2 (45.0 x 15.0 cm)	15.00	27.60	30.20	35.00	26.95
S_3 (45.0 x 20.0 cm)	15.73	28.33	30.87	38.60	28.38
Mean	15.11	26.80	30.11	35.29	

	S. Em±	C.D. (P= 0.05)
Nitrogen levels (N)	1.29	3.78
Spacing levels (S)	1.49	4.36
Interaction (N x S)	0.74	1.54

Table 4: Seed index of chickpea as influenced by different levels of nitrogen and plant density (g)

Spacing levels	Nitrogen levels				
	N_0 (0 kg/ha)	N_1 (10 kg/ha)	N_2 (20 kg/ha)	N_3 (30 kg/ha)	Mean
S_1 (45.0 x 10.0 cm)	15.71	16.26	17.23	17.73	16.73
S_2 (45.0 x 15.0 cm)	15.90	16.62	17.40	18.19	17.03
S_3 (45.0 x 20.0 cm)	16.05	17.19	17.52	21.10	17.97
Mean	15.89	16.69	17.38	19.01	

	S. Em±	C.D. (P= 0.05)
Nitrogen levels (N)	0.84	2.47
Spacing levels (S)	0.97	2.85
Interaction (N x S)	0.49	1.01

Table 5: Grain yield per hectare of chickpea as influenced by different levels of nitrogen and plant density (q/ha)

Spacing levels	Nitrogen levels				
	N_0 (0 kg/ha)	N_1 (10 kg/ha)	N_2 (20 kg/ha)	N_3 (30 kg/ha)	Mean
S_1 (45.0 x 10.0 cm)	12.47	16.03	17.67	24.08	17.56
S_2 (45.0 x 15.0 cm)	11.33	14.22	17.44	23.06	16.51
S_3 (45.0 x 20.0 cm)	10.94	13.53	16.61	19.97	15.26
Mean	11.58	14.59	17.24	22.37	

	S. Em±	C.D. (P= 0.05)
Nitrogen levels (N)	0.84	2.47
Spacing levels (S)	0.97	2.85
Interaction (N x S)	0.49	1.01

Table 6: Stover yield per hectare of chickpea as influenced by different levels of nitrogen and plant density (q/ha)

Spacing levels	Nitrogen levels				
	N_0 (0 kg/ha)	N_1 (10 kg/ha)	N_2 (20 kg/ha)	N_3 (30 kg/ha)	Mean
S_1 (45.0 x 10.0 cm)	29.80	36.60	38.09	39.26	35.94
S_2 (45.0 x 15.0 cm)	29.75	36.42	37.98	39.15	35.82
S_3 (45.0 x 20.0 cm)	28.89	33.49	37.83	38.67	34.72
Mean	29.48	35.50	37.97	39.03	

	S. Em±	C.D. (P= 0.05)
Nitrogen levels (N)	0.60	1.75
Spacing levels (S)	0.69	2.02
Interaction (N x S)	0.34	0.71

Table 7: Protein content of chickpea as influenced by different levels of nitrogen and plant density (%)

Spacing levels	Nitrogen levels				
	N_0 (0 kg/ha)	N_1 (10 kg/ha)	N_2 (20 kg/ha)	N_3 (30 kg/ha)	Mean
S_1 (45.0 x 10.0 cm)	18.30	19.19	20.92	21.61	20.00
S_2 (45.0 x 15.0 cm)	18.68	19.32	21.05	21.68	20.18
S_3 (45.0 x 20.0 cm)	18.90	19.69	21.39	22.67	20.66
Mean	18.63	19.40	21.12	21.99	

	S. Em±	C.D. (P= 0.05)
Nitrogen levels (N)	0.62	1.81
Spacing levels (S)	0.71	2.09
Interaction (N x S)	0.36	0.74

Table 8: B: C ratio of chickpea as influenced by different levels of nitrogen and plant density

Spacing levels	Nitrogen levels				
	N_0 (0 kg/ha)	N_1 (10 kg/ha)	N_2 (20 kg/ha)	N_3 (30 kg/ha)	Mean
S_1 (45.0 x 10.0 cm)	1.61	2.33	2.65	3.90	2.62
S_2 (45.0 x 15.0 cm)	1.39	1.97	2.60	3.70	2.41
S_3 (45.0 x 20.0 cm)	1.30	1.82	2.44	3.09	2.16
Mean	1.43	2.04	2.56	3.56	

	S. Em±	C.D. (P= 0.05)
Nitrogen levels (N)	0.17	0.49
Spacing levels (S)	0.19	0.57
Interaction (N x S)	0.10	0.20

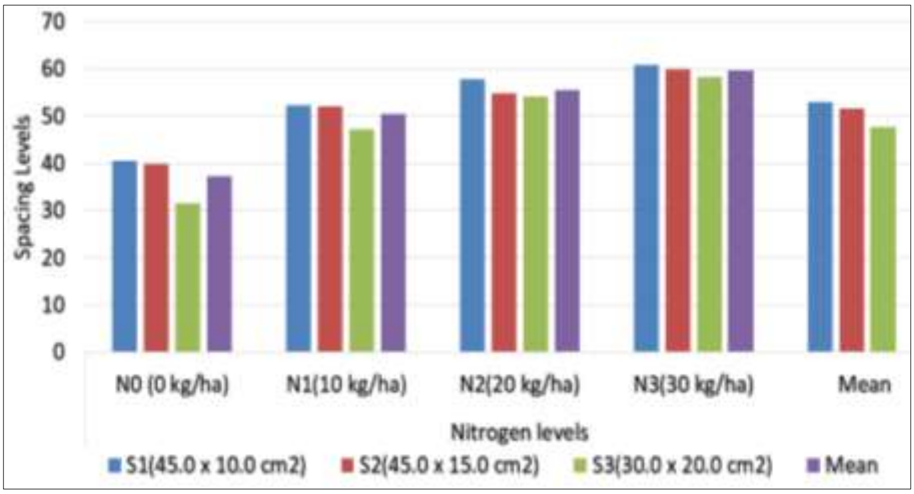

Fig 1: Plant height of chickpea at 90 DAS as influenced by different levels of nitrogen and plant density (cm)

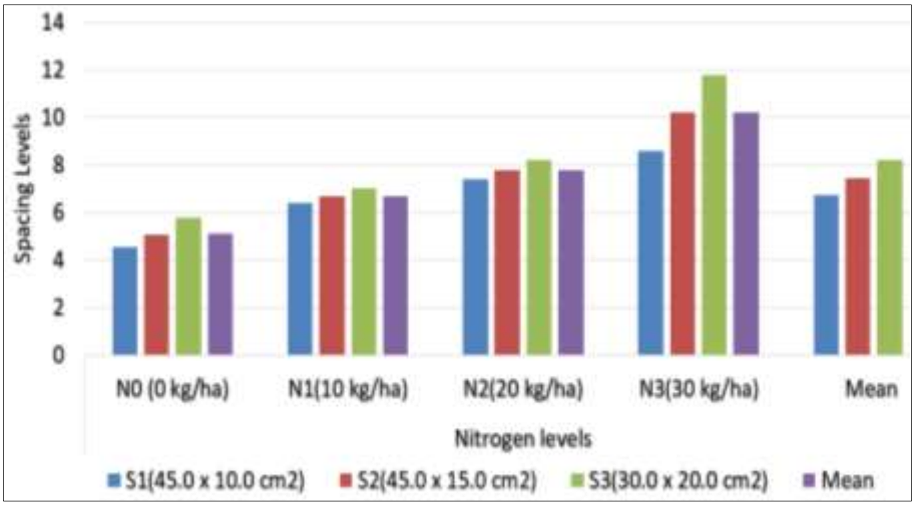

Fig 2: Number of branches per plant of chickpea at 90 DAS as influenced by different levels of nitrogen and plant density

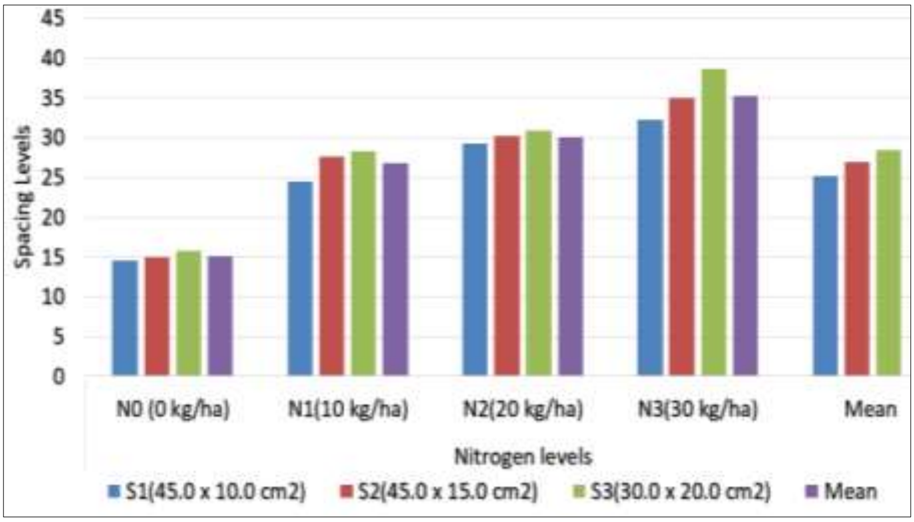

Fig 3: Number of pods per plant of chickpea as influenced by different levels of nitrogen and plant density

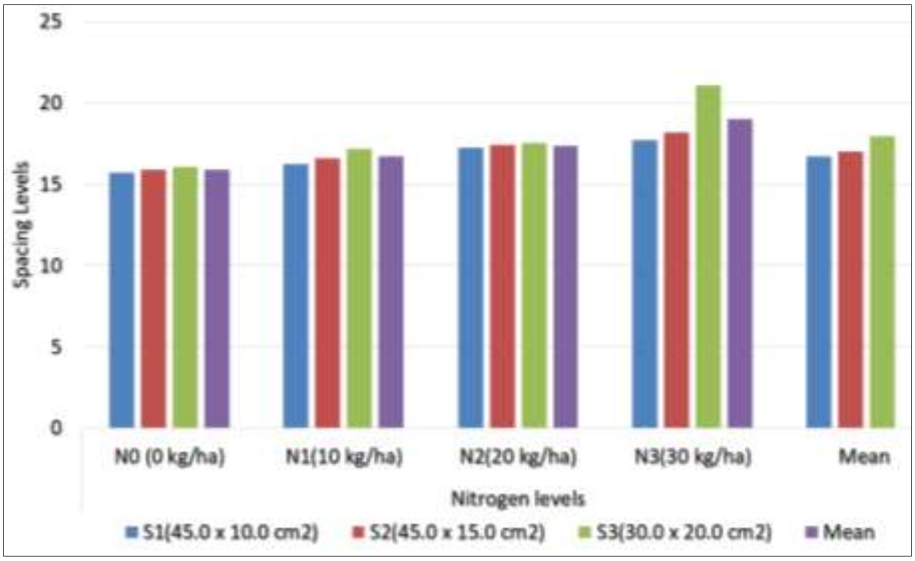

Fig 4: Seed index of chickpea as influenced by different levels of nitrogen and plant density (g)

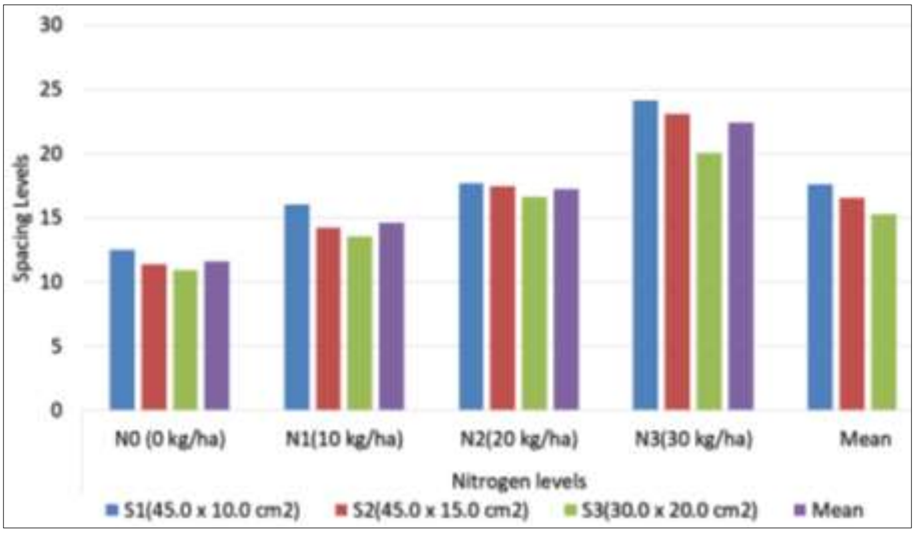

Fig 5: Grain yield per hectare of chickpea as influenced by different levels of nitrogen and plant density (q/ha)

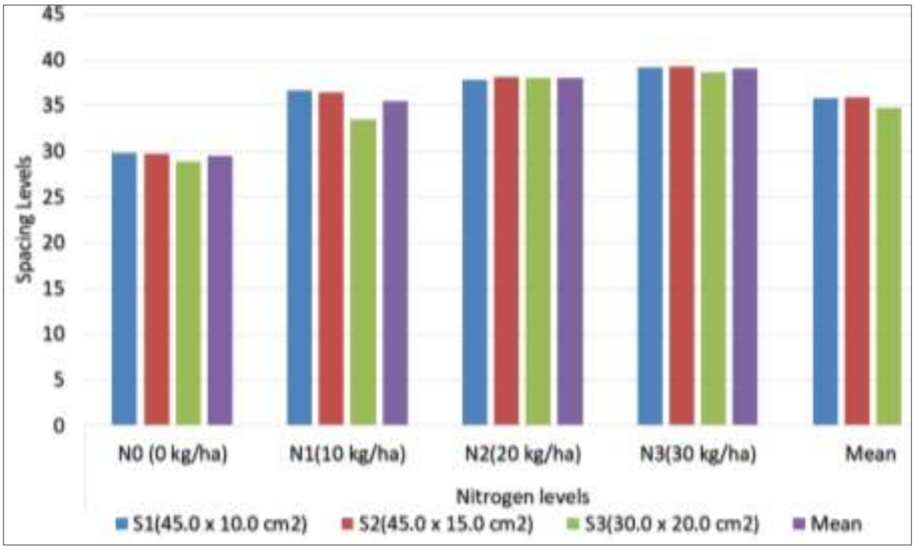

Fig 6: Stover yield per hectare of chickpea as influenced by different levels of nitrogen and plant density (q/ha)

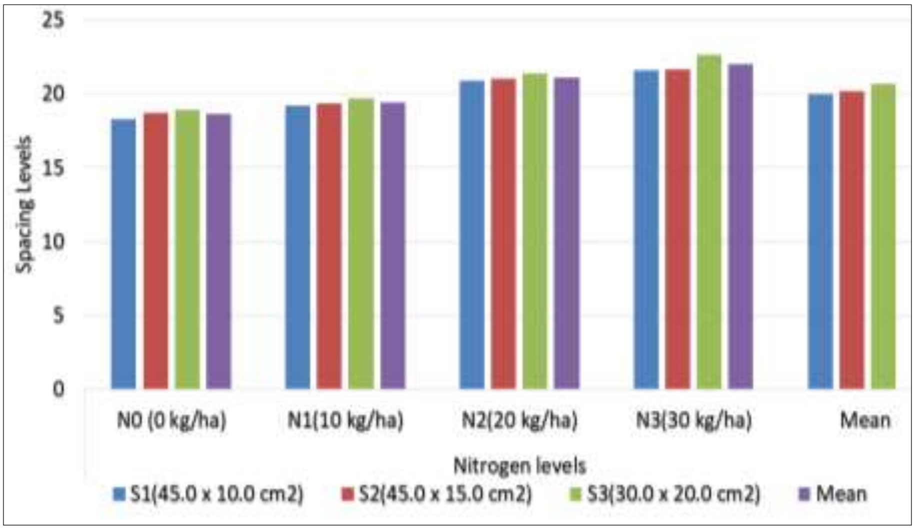

Fig 7: Protein content of chickpea as influenced by different levels of nitrogen and plant density (%)

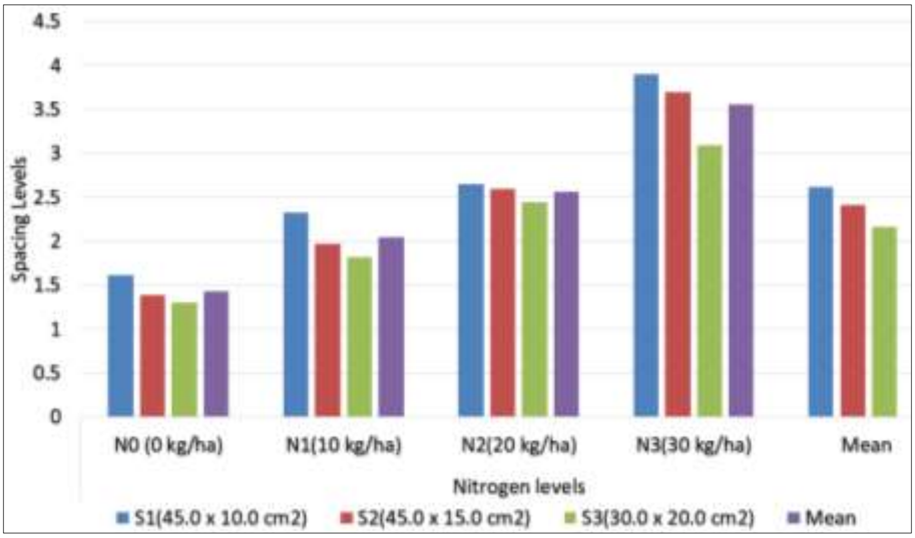

Fig 8: B: C ratio of chickpea as influenced by different levels of nitrogen and plant density

Conclusion

Based upon this experiment it is concluded that application of nitrogen @ 30 kg/ ha and the plant spacing of 45.0 cm x 10.0 cm, recorded the maximum and significantly higher grain yield (24.08 q/ha), gross return (₹ 124331.00 Rs/ha), net returns (₹ 98943.00 Rs/ha) and highest B: C ratio of 3.90: 1. Hence, it can be concluded that plant spacing of 45.0 cm x 10.0 cm under the nitrogen application @ 30 kg/ha obtained B: C ratio >3.90, can be used as a remunerative strategy.
However, these results are only indicative and require further experimentation to arrive at more consistent and final conclusion to be passed on to farmers.

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