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Effect of Spacing and Biofertilizers on Growth and Yield of Chickpea

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The field experiment was conducted during *rabi* 2022-23, at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of the experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 6.9), low in organic carbon (0.32%), available N (283.93 kg/ha), available P (18.3 kg/ha) and available K (223.5 kg/ha). The experiment was laid out in Randomized Block Design with ten treatments *viz.* T_1: Spacing 20 cm x 15 cm + Uninoculated, T_2: Spacing 20 cm x 15 cm + *Rhizobium*, T_3: Spacing 20 cm x 15 cm + PSB, T_4: Spacing 30 cm x 10 cm + Uninoculated, T_5: Spacing 30 cm x 10 cm + *Rhizobium*, T_6: Spacing 30 cmx 10 cm + PSB, T_7: Spacing 40 cm x 10 cm + Uninoculated, T_8: Spacing 40 cm x 10 cm + *Rhizobium*, T_9: Spacing 40 cm x 10 cm + PSB and T_{10}: Control: 100% RDF each replicated thrice. The results of the experiment obtained that application of *Rhizobium* (20 g/kg seeds) along with the Spacing 30cmx10cm significantly increased the growth parameters *viz.* plant height (46.79 cm), number of nodules (31.93/plant), plant dry weight (22.11 g/plant) and yield parameters *viz.* number of pods per

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plant (36.80), seed index (22.15 g), seed yield (3.44 t/ha) and stover yield (4.28 t/ha). This treatment also showed its positive effect on economics *viz*. gross returns (1,71,834 INR/ha), net returns (1,24,486 INR/ha), B:C (2.63). As the majority of Indian farmers are marginal and poor who cannot afford the use of high cost fertilizers with the result that crops are exposed to nutritional constraints. In such conditions biofertilizers can play an important role in contributing towards soil health and crop productivity. Biofertilizers are a cost effective renewable energy source that plays a crucial role in reducing inorganic fertilizer application and at the same increasing crop yield besides maintaining soil fertility. The optimum spacing for any crop means maintaining uniform and healthy crop stand so as to get optimum yield of crop. The growth and yield of crop is closely related to number of plants per unit area.

Keywords: Rhizobium; PSB; economics; growth parameters; yield parameters.

1. INTRODUCTION

Chickpea [*Cicer arietinum* (L.)], also known as Bengal gram is the most significant *rabi* season pulse crop grown in India. It accounts for around 30% of total acreage and 38% of total production under pulses. Around the world, 15% of the land used for growing different pulses is dedicated to Chickpea. With almost 10 million hectares under cultivation, it is the third pulse crop, fifth legume, and fifteenth grain crop in the world. As a leguminous crop, Chickpeas have root nodules that, with the aid of N-fixing bacteria (*Rhizobium* sp.), fix and use atmospheric nitrogen, enhancing the soil fertility.

Biofertilizers have the potential to significantly improve crop output and soil health. In addition to preserving soil fertility, biofertilizers a low-cost renewable energy source, are essential for decreasing the use of inorganic fertilizers and boosting crop output [1]. When combined with chemical fertilizers and organic manures, biofertilizers increase crop productivity and optimize nutrient usage [2]. Biofertilizers can be applied either via seed treatment or soil application. Seed treatment with biofertilizers also helps to control soil borne pathogenic infection and lowers the risk of host susceptibility to diseases. It also increased the soil available nutrients as well as uptake of nutrients by crop plants.

In order to achieve the highest crop yield, the ideal spacing for every crop entails maintaining a healthy, homogenous plant stand. Plants per unit area have a direct impact on crop growth and output. Improper plant population is one of the key causes of low yield in Chickpea. Crop yield is frequently negatively impacted by too low and excessive plant population after a certain point. In order to maximize the rate of photosynthesis, aeration and light penetration into the plant canopy proper plant spacing in the field is to be opted. Keeping all the facts into consideration the present study entitled “Effect of spacing and biofertilizers on growth and yield of Chickpea” was undertaken with the objectives such as to find out the influence of spacing and biofertilizers on growth and yield of chickpea and also to study the economics of different treatment combinations.

2. MATERIALS AND METHODS

The experiment was carried out during *rabi* 2022-23 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj.The soil was sandy loam in texture, medium in available nitrogen (283.93 kg/ha), available phosphorous (18.3 kg/ha) available potassium (223.5 kg/ha). The experiment was laid out in Randomized Block Design with ten treatments *viz.* T_1: Spacing 20 cm x 15 cm + Uninoculated, T_2: Spacing 20 cm x 15 cm + *Rhizobium*, T_3: Spacing 20 cm x 15 cm + PSB, T_4: Spacing 30 cm x 10 cm + Uninoculated, T_5: Spacing 30 cm x 10 cm + *Rhizobium*, T_6: Spacing 30 cm x 10 cm + PSB, T_7: Spacing 40 cm x 10 cm + Uninoculated, T_8: Spacing 40 cm x 10 cm + *Rhizobium*, T_9: Spacing 40 cm x 10 cm + PSB and T_{10}: Control: 100% RDF each replicated thrice. The experimental field was ploughed thoroughly in order to obtain a fine seed bed for better germination and crop growth. Thinning and gap filling was done 7 DAS and 15 DAS respectively to maintain ideal plant population. Seed inoculation with *Rhizobium* (20 g/kg seeds) and PSB (20 g/kg seeds) was carried out in the following method, the inoculants were mixed with jaggery solution and the required amount of seeds were mixed in the slurry so as to form uniform coating of the inoculants over the seeds. This was done eight hours prior to sowing and the treated seeds were shade dried. The growth parameters were recorded at different intervals *i.e.,* 20, 40, 60, 80 DAS. The plant height was measured with the help of scale from the base of the plant to the tip and recorded accordingly. The dry weight was recorded with the help of weighing balance, the tagged plants were uprooted and oven dried for 24hrs. The number of nodules per plant were counted manually from each tagged plant and the observations were recorded. The yield attributes like number of pods per plant and number of seeds per pod were counted manually, weight of 100 seeds *i.e.,* seed index was observed with the help of digital weighing balance and recorded at the time of harvest and statistically analyzed 120 DAS using ANOVA technique [3].

3. RESULTS AND DISCUSSIONS

3.1 Effect on Growth Attributes

3.1.1 Plant height (cm)

The observations related to growth parameters were presented in Table 1. Results revealed that significantly higher plant height (46.79 cm) was recorded with the application of *Rhizobium* (20 g/kg seeds) along with the Spacing 30 cm x 10 cm and the lowest plant height (39.95 cm) was recorded with adoption of Spacing 20 cm x 15 cm and when the seeds were left uninoculated.

The significantly higher plant height was might be due to plants get sufficient space under optimal spacing for light, air and nutrition for better growth and development. Results were similar to Arun et al*.* [4]. Further, *Rhizobium* and PSB inoculated plants improved photosynthetic efficiency which might have increased the growth. Similar findings were reported by Abisha et al*.* 2022. The biofertilizer inoculation improved the availability of nitrogen, phosphorus and all other major nutrients for enhanced vegetative growth which resulted in increase in plant height in Chickpea. Similar results were obtained by Rabieyan et al*.* [5].

3.1.2 Number of nodules per plant

During 60 DAS, Significantly maximum number of nodules per plant (31.93) was recorded with the application of *Rhizobium* (20 g/kg seeds) along with the Spacing 30 cm x 10 cm. However, the minimum number of nodules per plant (24.93) was observed in Control. *Rhizobium* inoculation resulted in a significant and maximum number of nodules per plant, and the nitrogenase enzyme availability contributed to the rise in nodules per plant of Chickpea. Results were similar to Sathvik et al. [6]. The optimal row spacing also had a significant impact on nodulation due to accumulation of plant nutrition at the rooting zones. This is in accordance with the early findings of Khan et al. [7].

3.1.3 Plant dry weight (g)

The significantly highest plant dry weight (22.113 g/plant) was recorded with application of *Rhizobium* (20 g/kg seeds) along with the Spacing 30 cm x 10 cm. However, application of PSB (20 g/kg seeds) along with the Spacing 30cmx10cm and application of *Rhizobium* (20 g/kg seeds) along with the Spacing 40 cm x 10 cm was found to be statistically at par.

The continuous increase in the dry matter with progressing growth phases was shown to be greater with closer spacing, which maybe because of the higher plant population and nutrients accumulating per unit area than compared to broader spacing. This is in accordance with findings of Varshitha et al*.* [8]. *Rhizobium* and PSB inoculation enhances the availability of nutrients like N and P. Increased nutritional availability led to increase in physiological processes, which in turn improved growth characters and dry matter output, Singh et al*.* 2018. The dry weight increased steadily with advancing growth stages and was found to be maximum at harvest. It was recorded to be highest with spacing 30 cm x 10 cm, which could be due to optimum plant population and accumulation of nutrients per unit area, Sathyamoorthi et al*.* [9].

3.2 Effect on Yield Attributes

3.2.1 Number of pods per plant

The data showed that the number of pods per plant (36.80) was significantly higher with application of *Rhizobium* (20 g/kg seeds) along with the Spacing 30 cm x 10 cm. However, application of PSB (20 g/kg seeds) along with the Spacing 20 cm x 15 cm (36.67) and adoption of Spacing 30cmx10cm along with Uninoculated seeds (35.20) was found to be statistically at par.

Table 1. Effect of spacing and biofertilizers on growth parameters of Chickpea

S. No.	Treatments	Plant height (cm)	Number of nodules/plant	Plant dry weight (g/plant)
1.	Spacing 20 cm x 15 cm + Uninoculated	39.95	25.87	13.397
2.	Spacing 20 cm x 15 cm + Rhizobium	41.87	25.73	20.417
3.	Spacing 20 cm x 15 cm + PSB	40.83	28.20	16.353
4.	Spacing 30 cm x 10 cm + Uninoculated	43.76	28.67	14.660
5.	Spacing 30 cm x 10 cm + Rhizobium	46.79	31.93	22.113
6.	Spacing 30 cm x 10 cm + PSB	45.02	30.13	20.757
7.	Spacing 40 cm x 10 cm + Uninoculated	41.81	27.93	13.120
8.	Spacing 40 cm x 10 cm + Rhizobium	43.61	27.40	20.667
9.	Spacing 40 cm x 10 cm + PSB	42.46	26.60	19.003
10.	Control (RDF- NPK: 20:60:20 kg/ha)	40.68	24.93	14.417
	SEm(±)	0.49	0.52	0.65
	CD (P=0.05)	1.46	1.55	1.94

Table 2. Effect of spacing and biofertilizers on yield attributes and yield of Chickpea

S. No.	Treatments	Pods/plant	Seeds/pod	Seed yield (t/ha)	Stover yield (t/ha)
1.	Spacing 20 cm x 15 cm + Uninoculated	34.80	1.13	2.71	3.46
2.	Spacing 20 cm x 15 cm + Rhizobium	35.13	1.25	2.94	3.76
3.	Spacing 20 cm x 15 cm + PSB	36.67	1.21	3.17	4.05
4.	Spacing 30 cm x 10 cm + Uninoculated	35.20	1.25	2.95	3.75
5.	Spacing 30 cm x 10 cm + Rhizobium	36.80	1.29	3.44	4.41
6.	Spacing 30 cm x 10 cm + PSB	34.13	1.29	3.06	4.28
7.	Spacing 40 cm x 10 cm + Uninoculated	34.20	1.22	2.22	2.80
8.	Spacing 40 cm x 10 cm + Rhizobium	34.73	1.35	2.36	3.00
9.	Spacing 40 cm x 10 cm + PSB	33.20	1.33	2.25	2.85
10.	Control (RDF- NPK: 20:60:20 kg/ha)	35.27	1.22	2.72	3.47
	SEm(±)	0.58	0.03	0.20	0.29
	CD (P=0.05)	1.72	0.10	0.85	0.85

Table 3. Effect of spacing and biofertilizers on economics of Chickpea

S. No.	Treatments	Cost of cultivation (INR/ha)	Gross returns (INR/ha)	Net returns (INR/ha)	B:C
1.	Spacing 20 cm x 15 cm + Uninoculated	47,148	1,35,667	89,519	1.88
2.	Spacing 20 cm x 15 cm + Rhizobium	47,348	1,47,000	99,652	2.10
3.	Spacing 20 cm x 15 cm + PSB	47,328	1,58,500	1,11,172	2.35
4.	Spacing 30 cm x 10 cm + Uninoculated	47,148	1,47,334	1,00,186	2.12
5.	Spacing 30 cm x 10 cm + Rhizobium	47,348	1,71,834	1,24,486	2.63
6.	Spacing 30 cm x 10 cm + PSB	47,328	1,53,167	1,05,839	2.24
7.	Spacing 40 cm x 10 cm + Uninoculated	47,148	1,10,834	63,686	1.35
8.	Spacing 40 cm x 10 cm + Rhizobium	47,348	1,18,000	70,652	1.49
9.	Spacing 40 cm x 10 cm + PSB	47,328	1,12,500	65,172	1.38
10.	Control (RDF- NPK: 20:60:20 kg/ha)	47,148	1,36,000	88,852	1.88

** Data was not subjected to statistical analysis*

3.2.2 Number of seeds per pod

The data revealed that application of *Rhizobium* (20 g/kg seeds) along with the spacing 40 cm x 10 cm recorded maximum number of seeds per pod (1.35), which was found to be significant. However, application of *Rhizobium* (20 g/kg seeds) along with the Spacing 30 cm x 10 cm (1.29) and application of PSB (20 g/kg seeds) along with the Spacing 40 cm x 10 cm (1.33) was found to be statistically at par.

3.2.3 Seed index (g)

The data showed that there was no significant difference among the treatments. However, highest seed index (22.15 g) was recorded with application of *Rhizobium* (20 g/kg seeds) along with the Spacing 30 cm x 10 cm and the lowest seed index (19.52) was observed in Control.

Seed inoculation with *Rhizobium* and PSB significantly enhanced the quantity of pods per plant and seeds per pod. This could be as a result of seed treatment with Rhizobium increasing the root nodulation through improved root development and enhanced nutrient availability. As a result, better flowering, fruiting and pod formation was observed. This is in accordance to findings of Das et al*.* [10]. When sufficient amount of Nitrogen, Phosphorus and all other major nutrients provided to plants, they increase the growth attributes which as a result increases number of pods per plant, number of seeds per pod and seed index. Results are in conformity with Yadav et al*.* [11].

3.3 Effect on yield

3.3.1 Seed yield

The data showed that seed yield (3.44 t/ha) was significantly higher with application of *Rhizobium* (20 g/kg seeds) along with the Spacing 30cmx10cm. However, application of PSB (20 g/kg seeds) along with the Spacing 20 cm x 15 cm + PSB (3.17 t/ha), adoption of Spacing 30 cm x 10 cm along with Uninoculated seeds (2.95 t/ha) and application of PSB (20 g/kg seeds) along with the Spacing 30 cm x 10 cm (3.06 t/ha) was found to be statistically at par.

3.3.2 Stover yield

The application of *Rhizobium* (20 g/kg seeds) along with the Spacing 30 cm x 10 cm recorded significantly higher stover yield (4.28 t/ha). However, application of PSB (20 g/kg seeds) along with the Spacing 20 cm x 15 cm (4.05 t/ha), adoption of Spacing 30cmx10cm along with Uninoculated seeds (3.75 t/ha) and application of PSB (20 g/kg seeds) along with the Spacing 30 cm x 10 cm (4.28 t/ha) was found to be statistically at par.

The sufficient plant population with optimum spacing may have led to higher growth and development along with better utilization of production inputs, which resulted in the maximum yield. The results were similar to Arun et al. [4].

With the use of biofertilizers for seed treatment, factors that contribute to growth and yield increased. This was primarily because there was more N and P available, which led to well developed roots with higher capacity for nitrogen fixation, which improved plant growth and development and also improved photosynthate diversion in sink. Similar results found by Kumari et al. [12] and Meena et al*,* 2006 [13,14].

3.3.3 Harvest index

The harvest index was recorded to be non-significant. However, the highest harvest index (44.18%) was obtained with the adoption of Spacing 40 cm x 10 cm along with Uninoculated seeds. While the lowest harvest index (41.97%) was recorded with the application of PSB (20 g/kg seeds) along with the Spacing 30 cm x 10 cm [15].

3.3.4 Economics

The maximum gross return (1,71,834), net return (1,24,486) and B:C ratio (2.63) was recorded with the application of *Rhizobium* (20 g/kg seeds) along with the Spacing 30 cm x 10 cm.

4. CONCLUSION

The conclusion drawn from the experimental research suggests that the application of *Rhizobium* (20 g/kg seeds) along with the Spacing 30 cm x 10 cm had the most favourable impact on both growth and yield. This treatment resulted in higher plant height, plant dry weight, nodules per plant, pods per plant, seeds per pod, seed yield and stover yield compared to the rest of the treatments. Furthermore. it also generated the maximum gross return, net return and benefit-cost ratio, indicating its economic viability.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Govindrajan K, Thangaraju M. Azospirillum- a potential inoculants for horticultural crops. South Ind. Hort. 2001; 49:223-235.
2. Mahajan A, Choudhary AK, Jaggi RC, Dogra RK., Importance of bio-fertilizers in sustainable agriculture. Farmers' Forum. 2003;3(4):17–19.
3. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research. Wiley, New York; 1984.
4. Arun K, Debbarma V. Effect of spacing and panchagavya on growth and yield attributes of chickpea (*Cicer arietinum* L.). International Journal of Environment and Climate Change. 2022;12(11):2890-2895.
5. Rabieyan Z, Kashani ZF. The effect of irrigation and biofertilizer on seed and yield index on two chickpea (*Cicer arietinum* L.) varieties. Advances in Environmental Biology. 2012;1528-1534.
6. Sathvik D, Debbarma V. Influence of Biofertilizers and Sulphur on Growth and Yield Attributes of Chickpea (*Cicer arietinum* L.). International Journal of Environment and Climate Change. 2022; 12(11):707-713.
7. Khan EA, Aslam M, Ahmad HK, Ayaz M, Hussain A. Effect of row spacing and seeding rates on growth yield and yield components of chickpea. Sarhad J of Agric. 2010;26(2):201-211.
8. Varshitha KM, Singh V, George SG, Singh AC. Effect of Plant Growth Regulators and Spacing on Growth and Yield of Chickpea (*Cicer arietinum* L.). International Journal of Environment and Climate Change. 2022;12(10):614-619.
9. Sathyamoorthi K, Amanullah MM, Somasundram E. Growth and yield of greengram (*Vigna radiate* L. Wiczek) as influenced by increase plant density and nutrient management. International Journal of Agricultural Sciences. 2008;4(2):499-505.
10. Das S, Pareek BL, Kumawat A, Dhikwal SR. Effect of phosphorus and biofertilizers on productivity of chickpea (*Cicer arietinum* L.) in north western Rajasthan, India. Legume Research-An International Journal. 2013;36(6):511-514.
11. Yadav S, Kumar S, Anshuman K, Singh N, Srivastava A. Studies on effect of different biofertilizers on yield and economics chickpea. J Pharm. Innov. 2021;10(4):541-5.
12. Kumari V, Gill R, Singh R, Kumar R. Effect of inorganic, organic and different bio-fertilizers on growth and yield of desi gram (*Cicer arietinum* L.), under Irrigated Conditions; 2022.
13. Gaur AC. Phosphate solubilizing microorganism as biofertilizers. Omega Scientific Publishers, New Delhi. 1990;188.
14. Singh R, Pratap T, Singh D, Singh G, Singh AK. Effect of phosphorus, Sulphur and biofertilizers on growth attributes and yield of chickpea (*Cicer arietinum* L.). Journal of Pharmacognosy and Phytochemistry. 2018;7(2):3871-3875.
15. Singh S. Effects of biofertilizer and phosphorus on growth, yield components and yield of Chickpea (*Cicer arietinum* L.). International Journal of Plant & Soil Science. 2022;34(20):326-331.

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