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Effect of Seed Treatment with Bioinoculants on Seed Yield and Quality Parameters in Chickpea (*Cicer arietinum* L.)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The field experiment**,** was conducted during *Rabi* 2022 at the field experimental center, Department of Genetics and Plant Breeding, SHUATS, Prayagraj, (U.P). The soil of the experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.36%), available N (171.48 kg/ha), available P (15.2 kg/ha) and available K (232.5 kg/ha). The experiment was laid out in Randomized Block Design with thirteen treatments including control which were replicated thrice. The treatments are as follows, T0- Control, T1 - *Bacillus subtilis* – 20 g/kg seeds, T2 – Rhizobium – 20 g/kg seeds, T3 – P.S.B – 20 g/kg seed, T4 - *T. harzianum* – 20 g/kg seed, T5 - *T. viridae* – 20 g/kg seed, T6 – *B. subtilis* + Rhizobium – (10 g + 10 g/kg seed), T7 - Rhizobium + P.S.B – (10 g + 10 g/kg seed), T8 - P.S.B + *T. harzianum* – (10 g + 10 g/kg seed), T9 – *T. harzianum* + *T. viridae* – (10 g + 10 g/kg seed), T10 - *T. viridae* + *B. subtilis* – (10 g + 10 g/kg seed), T11 - *B. subtilis* + Rhizobium + P.S.B – (10 g + 10 g+10 g/kg seed), T12 - P.S.B + T. *harzianum* +

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T, viridae – (10 g + 10 g+10 g/kg seed) respectively. The experiment results revealed that seeds treated with T7 – Rhizobium + P.S.B – 10 g + 10 g gave better than other treatments *viz*, days for 50% flowering (60.00), Days to 50% pod setting (75.00) and has matured earlier (99.00), Plant height (74.90 cm), number of pods per plant (52.33), number of seeds per pod (3.00), Seed yield per plot (522.80 g), Biological yield per plot (613.58), Seed index (32.24 gm). Were recorded significantly higher compared to other treatments.

Keywords: Chickpea; Bacillus subtilis; rhizobium; P.S.B; T. harzianum; T. viridae.

1. INTRODUCTION

Chickpea is also known by the names Chana, Gram and Bengal Gram. Chickpeas come in two forms: whole seed and split seed (dal), Flour may be used to make various types of snacks. Chickpeas are consumed by variety of ways, including as flour, dal, crushed or whole grain cooked or parched, green grain and the leaf as a vegetable. Seeds that have sprouted offer therapeutic properties. (Source: www.chickpea.org).

"The chickpea crop is highly self-pollinated. Chickpeas have two types which are well recognized viz. The Desi type with small and brown seeds accounts for nearly 90% area and the Kabuli type with bold and cream-coloured seeds is grown in around 10% area. Almost 90% of the chickpea crop is cultivated rain-fed mostly on receding soil moisture and on marginal lands. The origin of this genus Cicer is from South-eastern Turkey which later spread to the other parts of the world. It is well adapted to relatively cooler climates. The largest area of adaptation is in the Indian subcontinent". (Source: icrisat.org).

"The most important pulse crops of India are Chickpea, Red gram, Green gram, Black gram, Cowpea etc. Among them, Chickpea (*Cicer arietinum* L.) is the third most important food legume which is grown on 10.42 m ha with 12.60 million ton production (des.delhigovt.nic.in 2020-21).It is the premier pulse crop of the Indian subcontinent. India is the largest chickpea producer and consumer also. India is the largest pulse-producing nation in the world". (Source: icrisat.org). Chickpeas (*Cicer arietinum* L.) belongs to the family Leguminaceae. It is widely cultivated in India, Australia, Pakistan, Turkey, Myanmar and Ethiopia. It is an important cool season pulse crop and is also called Bengal gram. In terms of pulse production, India contributes about 25% to the total global pulse production and contains 21.1% protein, 61.5 per cent carbohydrate, and 4.5% fat. It is also rich in calcium, iron and niacin. It is used for human consumption as well as for feeding animals.

"Rhizobium is a group of Gram-negative aerobic rods, motile, when young have bipolar, subpolar or peritrichous flagella. Symbiotic nitrogen fixation by Rhizobium in legumes contributes substantially to total biological nitrogen fixation. The roots of mung bean bear nodules can fix atmospheric nitrogen via symbiotic association with the bacterium Rhizobium" [1]. Although native Rhizobium is present in soil not all of them are capable of forming nodules. Some strains are highly effective in this respect while others are partially or completely effective. It is reported that natural flora gradually loses its efficiency. Hence artificial inoculation with tested effective strains should be taken up as a comparative means, of cheap insurance for obtaining optimum yield [2,3].

Biofertilizers improve nutrient supply, environment friendly, non-bulky and most importantly cost effective. Therefore, there is strong need to have complementary use of available source to plant nutrient including biofertilizer along with mineral fertilizers for maintenance of soil productivity. The present trial was conducted to study the "effect of seed treatment with bioinoculants on seed yield and quality parameters in chickpea (*Cicer arietinum* L.)".

2. MATERIALS AND METHODS

The present research was made to identify the effect of seed priming of different kinds on seed quality parameters of chickpeas and to find suitable seed priming methods for chickpeas. The experiment was laid out in Randomized Block Design with thirteen treatments including control which were replicated thrice in rabi 2022. The treatments are as follows, *Bacillus subtilis*, *Rhizobium*, Phosphate Solubilizing Bacteria, *Trichoderma harzianum, Trichoderma viridae*. The chickpea seeds were primed with different priming agents in different concentrations and intensities for a given duration. After priming seeds were dried to initial moisture content at room temperature. After that the primed seeds were used to grow under field conditions and Row-to-row spacing of 30 cm and plant-to-plant spacing of 10 cm are generally used, which give a plant population of about 33 plants per m^2.

3. RESULTS

3.1 Pre – Harvest

1. **Plant Height:** Minimum plant height at 90 DAS was exhibited by treatment T0 [control] (65.50), while maximum plant height was recorded in treatment T7 – *Rhizobium* + P.S.B – 10 g + 10 g - (74.90), followed by, T11 – *B. subtilis* + *Rhizobium* + P.S.B – 10 g + 10 g +10 g- (72.00) and T12 - P.S.B + *T. harzianum* + *T. viridae* – 10 g + 10 g +10 g- (71.00) were significantly higher than other significant treatments, as reported in Table 2.
2. **Days to 50% Pod Setting:** Minimum Days to 50% pod setting was exhibited by treatment T7 – *Rhizobium* + P.S.B –10 g + 10 g- (60.00) while maximum Days to 50 % pod setting was recorded in treatment T0 [control] (80.00), followed by T1 – *Bacillus subtilis* –20 g/kg seed (78.00) was significantly higher than other significant treatments.
3. **Days to 50% Flowering:** The minimum Days to 50% flowering was exhibited by treatment T7 – Rhizobium + P.S.B –10 g + 10 g- (75.00) while maximum Days to 50% flowering was recorded in treatment T0 [control] (95.00), followed by T1 – *Bacillus subtilis* –20 g/kg seed (91.00) was significantly higher than other significant treatments.
4. **Days to Maturity:** Minimum Days to maturity were exhibited by treatment T7 – Rhizobium + P.S.B –10 g + 10 g- (99.00) while maximum Days to maturity were recorded in treatment T0 [control] (118.00), followed by T1 – *Bacillus subtilis* –20 g/kg seed (115.00) was significantly higher than other significant treatments.

3.2 Post - Harvest

1. **Number of Pods per Plant:** Minimum number of pods per plant was exhibited by treatment T0 [control] (44.33), while the maximum number of pods per plant was recorded in treatment T7 – Rhizobium + P.S.B – 10 g + 10 g - (52.33), followed by, T11 – *B. subtilis* + Rhizobium + P.S.B – 10 g + 10 g+10g (51.33) and T12 - P.S.B + *T. harzianum* + *T. viridae* – 10 g + 10 g+10 g - (50.67) were significantly higher than other significant treatments, as reported in Table 3.
2. **Number of Seeds per Pod:** Minimum number of seeds per pod was exhibited by treatment T0 [control] (1.00), while maximum number of seeds per pod was recorded in treatment T7 – Rhizobium + P.S.B – 10 g + 10 g - (3.00), followed by, T11 – *B. subtilis* + *Rhizobium* + P.S.B – 10 g + 10 g +10 g(2.00) and T12 - P.S.B + *T. harzianum* + *T. viridiae* – 10 g + 10 g+ 10 g - (2.00) were significantly higher than other significant treatments
3. **Seed Yield per Plot:** Minimum seed yield per plot was exhibited by treatment T0 [control] (393.80 gm), while maximum seed yield per plot was recorded in treatment T7 – *Rhizobium* + P.S.B – 10 g + 10 g - (522.80 gm), followed by, T11 – *B. subtilis* + *Rhizobium* + P.S.B – 10 g + 10 g+10 g (504.40 gm) and T12 - P.S.B + *T. harzianum* + *T. viridae* – 10 g + 10 g + 10 g- (495.60 gm) were significantly higher than other significant treatments.
4. **Biological Yield:** Minimum biological yield per plot was exhibited by treatment T0 [control] (484.58 gm), while maximum biological yield per plot was recorded in treatment T7 – *Rhizobium* + P.S.B – 10 g + 10 g - (613.58 gm), followed by, T11 – *B. subtilis* + *Rhizobium* + P.S.B – 10 g + 10 g + 10 g(595.18 gm) and T12 - P.S.B + *T. harzianum* + *T. viridae* – 10 g + 10 g+ 10 g - (586.38 gm) were significantly higher than other significant treatments, as reported in Table 4.
5. **Seed Index:** Minimum seed index was exhibited by treatment T0 [control] (25.47 gm), while maximum seed index was recorded in treatment T7 – Rhizobium + P.S.B – 10 g + 10 g - (32.24 gm), followed by, T11 – *B. subtilis* + *Rhizobium* + P.S.B – 10 g + 10 g+ 10g (31.00 gm) and T12 - P.S.B + *T.harzianum* + *T. viridae* – 10 g + 10 g+ 10 g - (30.56 gm) were significantly higher than other significant treatments.

4. DISCUSSION

Application of *Brady rhizobium japonicum* increased soybean seed and nitrogen uptake. The increase in nitrogen uptake due to *Rhizobium* inoculation was mainly due to a significant increase in nodulation, which resulted in a higher accumulation of N due to atmospheric N2 fixation.

The higher assimilation of nitrogen might have resulted in higher biomass production thus resulting in higher uptake of N. Higher uptake of N, P and K by soybean crop correspondence to higher biomass production by the crop Gajbhiye et al. [4]. Whereas, seed inoculation with *Rhizobium spp., Bacillus subtilis* and *Bacillus megaterium*, especially dual and triple combinations, may substitute costly N, P fertilizers in chickpea production as reported by Elkoca et al. [5] reported inoculation of *Bradyrhizobium japonicum* + *Bacillus subtilis* was significantly increased seed yield of Chickpea. Similarly, previous studies also showed that dual inoculations significantly increased grain yield as compared with single inoculation of individual organisms in soybean [6]: Patra et al. [7] reported inoculation of *Bacillus spp*. and of rhizobial strain maximum increase grain yield. PGPR (*Bacillus*) have been shown to greatly improve the productivity and quality of many legumes, when co-inoculated with rhizobia.

Bullied et al. [8] reported that *Bacillus spp*. enhance the phosphorus and potassium contents of many plants. Among the plant growth-promoting traits, IAA production by the bacterium has a cascading effect on plant development due to its ability to influence root growth and biomass, which in turn affects nutrient uptake [9]. Indole-3-acetic acid is implicated in signalling between microorganisms and plants [10] leading to stimulation of cell division, initiation of lateral and adventitious roots [11], cell enlargement (Salisbury, 1994) and results in elongation of stems and roots. Results of the present investigation about enhanced nutrient uptake by soybean due to Bacillus spp. inoculation with *B. japonicum* conform with those of Bullied et al. [8].

Table 1. Analysis of variance for effect of seed treatments on chickpea (*Cicer arietinum* L.)

Characters	Mean sum of squares		
	Replications (d. f = 2)	**Treatments (d. f = 12)**	**Error (d. f = 24)**
Plant height at 90 DAS	3.081	21.321*	4.686
Days to 50% flowering	2.000	115.423*	1.600
Days to 50% Pod setting	3.962	107.5*	4.641
Days to maturity	1.275	102.23*	4.729
Number of pods per plant	3.564	18.786*	1.119
Number of seeds per pod	0.025	1.807*	0.025
Seed yield per plot	63.322	4386.3*	155.32
Biological yield per plot	249.33	4386.3*	186.98
Seed index	0.2905	11.471*	0.6067

Table 2. Influence of *Bacillus subtilis, Rhizobium*, P.S.B, T*. harzianum, T. viridae* on plant height, days to 50% pod setting, days to 50% flowering, days to maturity

Treatment	Plant height	Days to 50% pod setting	Days to 50% flowering	Days to maturity
T0 – Control	65.50	95.00	80.00	118.00
T1	65.70	91.00	78.00	115.00
T2	69.70	83.00	68.00	107.00
T3	68.80	84.00	69.00	108.00
T4	67.10	88.00	73.00	112.00
T5	66.90	89.00	74.00	113.00
T6	69.80	82.00	67.00	106.00
T7	74.90	75.00	60.00	99.00
T8	70.70	79.00	64.00	103.00
T9	68.20	86.00	71.00	110.00
T10	67.70	86.00	71.00	110.00
T11	72.00	76.00	61.00	100.00
T12	71.00	78.00	63.00	102.00
SE m (±)	1.24	1.24	0.73	1.25
CV	3.13	2.56	1.82	2.01

Table 3. Influence of *Bacillus subtilis*, *Rhizobium*, P.S.B, *T. harzianum*, *T. viridae* on number of pods per plant, number of seeds per pod, seed yield per plot

Treatment	Numbers of Pods per Plant	Numbers of Seeds per Pod	Yield per Plot
T0 – Control	44.33	1.00	393.80
T1	44.33	1.33	414.60
T2	48.33	2.00	477.00
T3	47.67	2.00	466.60
T4	46.67	1.00	434.20
T5	46.33	1.00	425.20
T6	48.00	2.00	484.40
T7	52.33	3.00	522.80
T8	49.67	2.00	492.00
T9	47.00	2.00	453.80
T10	46.33	1.00	448.40
T11	51.33	3.00	504.40
T12	50.67	3.00	495.60
SE (m)	0.61	0.09	7.19
CV	2.22	8.55	2.69

Table 4. Influence of *Bacillus subtilis*, rhizobium, P.S.B, *T. Harzianum*, *T. viridae* on biological yield, seed index

Treatment	Biological yield per plot (gm)	Seed index (gm)
T0 – Control	484.58	25.47
T1	505.38	26.51
T2	567.78	29.63
T3	557.38	29.11
T4	524.98	27.49
T5	515.98	27.04
T6	575.18	30.00
T7	613.58	32.24
T8	582.78	30.38
T9	544.58	28.47
T10	539.18	28.20
T11	595.18	31.00
T12	586.38	30.56
S Em (±)	7.89	0.44
CD (p=0.05)	2.47	2.69

Higher uptake of N, P and K by soybean crop correspondence to higher biomass production by the crop Gajbhiye et al. [4]. Whereas, seed inoculation with *Rhizobium spp*., *Bacillus subtilis* and *Bacillus megaterium*, especially dual and triple combinations, may substitute costly N, P fertilizers in chickpea production as reported by Elkoca et al. [5] Increase phosphorus uptake in the present investigation can be explained on the bases of results of these workers.

5. CONCLUSION

It is concluded from the present study that the seeds of Chickpea *(Cicer arietinum L.*) were treated with (T7) Rhizobium + P.S.B – 10 g + 10 g showed significant increase in seed yield per plant (26.14 g) followed by T11 – *B. subtilis* + *Rhizobium* + P.S.B – 10 g + 10 g+ 10 g (25.22 gm)appication of both rhizobium and Phosphate and solubilizing bacteria helps in keeping agricultural production at a sustainable level. It reduces the cost of agricultural production and also improves the soil health. Findings are based on research done in one season in Prayagraj (Allahabad) U.P. Further trails may be required for considering it for the recommendation.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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