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Effect of seed treatment with bioagents on growth and yield attributes of chickpea (*Cicer arietinum* L.)

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Abstract

A field experiment was conducted during rabi season of 2025-26 at Crop Research Centre of School of Agriculture, Uttaranchal University, Dehradun (Uttarakhand) “To study the effect of seed treatment with bioagents on growth and yield attributes of chickpea (*Cicer arietinum* L.)”. The experiment consisted of seven treatments with three replications viz. T₁ (control), T₂ (Trichoderma), T₃ (Rhizobium), T₄ (PSB), T₅ (Rhizobium + Trichoderma), T₆ (PSB + Trichoderma) and T₇ (PSB + Rhizobium). Randomized Block Design (RBD) was used to conduct the experiment. The aim of the research was to ascertain the effect of various seed treatment in improving the growth and yield of chickpea. Data on growth parameters and yield attributes were gathered and subjected to statistical analysis. Among the different treatments combination T₃(Rhizobium) recorded the highest plant growth (19.56 cm), number of branches (7.66), T₇(PSB) and T₃(Rhizobium) has the maximum number of dry nodules plant⁻¹ (19.33), (17.66). T₆ (PSB + Trichoderma) has the maximum number of flowers at 60 DAS (30), 90 DAS (49.33), and 100-grain weight of chickpea (24.35). T₅ recorded maximum number of seed pods⁻¹(5.47) Whereas T₇ recorded maximum number of dry weights plant⁻¹ (54.10), Nodules plant⁻¹ (19.33), dry weight of nodules plant⁻¹ (0.07), pods plant⁻¹(53.33) and grain weight (68.48). whereas T₇ (PSB + Rhizobium) recorded the maximum grain yield q/ha, Biomass q/ha and Net return, T₆ (PSB + Trichoderma) has the maximum harvest index and maximum benefit cost ratio and T₅ produced the maximum gross return. It was concluded that seed treatment proved more effective in enhancing the growth and yield of chickpea.

Keywords: Chickpea, PSB, Trichoderma, rhizobium, yield attribute, vegetative growth

Introduction

Chickpea (*Cicer arietinum* L.) belongs to the Fabaceae family and it has (2n=16) chromosome number. Other names for chickpea are Egyptian pea, garbanzo bean, Bengal gram, and gram. There are 34 perennial and 8 annual chickpea species. Chickpea has two main types: “Kabuli,” which are huge, ram-shaped, cream-coloured, and lack anthocyanin pigment, and “Desi,” which are small, angular, dark-coloured, and have anthocyanin pigment on one or more portions. (Lohitha, 2022) ^[8]

India is the world’s largest producer of chickpea (gram/chana), contributing nearly 70% of global production. According to the latest estimates, chickpea production in India during 2025-2026 is projected at about 11.3-11.8 million tonnes, accounting for nearly 45% of the total pulses production in the country. The crop plays an important role in nutritional security due to its high protein content and adaptability to semi-arid regions. Technological advancements, improved varieties, and better nutrient management practices have significantly enhanced chickpea productivity in recent years. (ICAR-IIPR,2025; Ag pulse Analytica, 2025) ^[1, 3]

In India Madhya Pradesh, Rajasthan, Uttar Pradesh, Haryana, Maharashtra, and Karnataka are the main states that cultivate chickpea (*Cicer arietinum* L.), accounting for (60%) of the total land and (90%) of its production. (Meher Scholar *et al.*, 2018) ^[10]

Legume crops are essential to both food security and the sustainability of agro-ecosystems and many other beneficial services, such as biological nitrogen fixation, mitigation of greenhouse emissions, and suppression of weeds and plant diseases. Various varieties of legume crops are a significant source of plant-based food and feed because of their ability to fix atmospheric nitrogen with the help of rhizobia. Legume crops actually play an important part in integrated soil fertility management. This can boost soil fertility and reduce reliance on N-fertilisers in low-

input farming systems. (Janati *et al.*, 2021)^[4].

To boost agriculture production, introducing the right rhizobium into legume crops can enhance nitrogen fixation in the soil. It is also known that phosphate-solubilising bacteria enhance phosphorus uptake, improving agricultural plant growth and yield. Rhizobium and phosphate-solubilising bacteria inoculation together improved chickpea nodulation, growth, and yield metrics (Sharma *et al.*, 2024)^[13].

Seeing the above facts, the present research study entitled “Effect of Seed Treatment with bioagents on growth and Yield attributes of Chickpea (*Cicer arietinum* L.)” was conducted with the following objectives:

1. To evaluate the effect of Rhizobium, phosphate-solubilising bacteria (PSB), and Trichoderma (alone and in different combinations) on seed germination and early seedling Vigor of chickpea (*Cicer arietinum* L.).
2. To assess the influence of bio-inoculants on nodulation characteristics of chickpea, including the number of nodules per plant and nodule dry weight.
3. To study the effect of bio-inoculant treatments on plant growth parameters, phenological stages, yield attributes, seed yield, and economic returns of chickpea.

Materials and Methods

A field experiment was conducted during Rabi 2025-2026 at the School of Agriculture, Uttaranchal University, Prem Nagar, Dehradun, (Uttarakhand). The soil of the experimental field was sandy loam in texture with pH content (5.3), organic carbon content (0.51%), available Nitrogen content (62.72kg/ha), Available phosphorous (62.72kg/ha) whereas available

potassium was 57.6kg/ha. The field experiment was done during the month of November to April where the maximum average temperature was 20.6 °C to 34.2 °C, the minimum average temperature ranged from 3 °C to 12.6 °C, RHI (Relative humidity in the morning) ranged from 82.2% to 66.3%, RHII (Relative humidity in at 2pm) ranged from 43.2% to 82.9%, WS (Wind speed) ranged from 1.2km/ha to 1.9km/ha, BSS (Bright sun shine) ranged from 4hr to 6.1hr, Rain 0mm to 1.8mm, number of rainy days was 3 times which occurred in the month of January, March, and April and EVP (evaporation) ranger from 1.1mm to 5.1mm. This experiment was conducted to assess the effect of seed treatment with bioagents on growth and yield attributes of Desi chickpea (*Cicer arietinum* L.). Before sowing, the seeds were treated with bioagents along with Acacia gum as a sticker to seed. The combination of different treatments was followed as T₁(control), T₂ (Trichoderma), T₃ (Rhizobium), T₄ (PSB), T₅ (Rhizobium + Trichoderma), T₆(PSB + Trichoderma) and T₇(PSB + Rhizobium). The treated seed were then kept for drying in the laboratory for overnight (24 hrs) and used for sowing in the next day. where the seed was taken 50g/kg along with 5g Acacia gum and 5ml of bioagent in each treatment. The experiment was laid out in Randomized Block Design (RBD) with three replications. The observations was recorded on five randomly selected plants per plot for Plant height, number of branches plant⁻¹, number of flowers plant⁻¹, number of pods plant⁻¹, number of seeds pod⁻¹, number of dry nodules plant⁻¹, dry weight of plant⁻¹, grain weight plant⁻¹, 100-grain weight, grain yield (q/ha), biomass yield (q/ha) and harvest index (%), Were recorded on the plot basis.

Table 1: Chemical properties of field soil

S. No	Parameters	Value	Method of estimation
1	Soil pH (1:2:5 soil water suspension)	5.3 to 5.4	Buckman’s pH meter (Jackson 1967) ^[5, 6]
2	EC dSm ⁻¹	0.156 ds/m	Solu bridge method (Piper, 1950) ^[12]
3	Organic carbon (%)	0.51%	Walkley and black (1934) ^[15]
4	Available N (Kg ha ⁻¹)	62.72 kg/ha	Alkaline permanganate method (Subbiah and Asijia, 1956) ^[14]
5	Available P ₂ O ₅ (Kg ha ⁻¹)	0.749	Olsen’s method (Olsen <i>et al.</i> , 1954) ^[11]
6	Available k ₂ O (kg ha ⁻¹)	57.6	Flame photometer (Jackson, 1967). ^[5, 6]

Results and Discussion

Seed treatment in chickpea helps to protect from seed-borne and soil-borne diseases, improved germination percentage, increase nutrient uptake, it also helps to get better nodulation.

The results estimated from the data of present investigation, which was pointed out to asses seed yield, quality parameters and identification of best treatment are presented and discussed.

The result showed the significant difference for mean sum of square at 5% level for all the characters under study among 7 treatments. The present investigation revealed that in the plant height T₃ (Rhizobium) produced the maximum plant height at 30, 60 and 90 DAS (19.56), (26.83) and (41.13) respectively, also T₃(Rhizobium) produced the maximum number of branches at 60 DAS and 90 DAS (7.66), (11.53).

Table 2: Vegetative growth under different seed treatment

T.no	Treatments	Plant height (cm)			Number of branches per plant	
		30 DAS	60 DAS	90 Das	60DAS	90DAS
T1	Control	19.16	27.26	41.2	6.13	8.53
T2	Trichoderma	17.7	25.36	38.53	7.13	8.13
T3	Rhizobium	19.56	26.83	41.13	7.66	11.53
T4	PSB	18.26	25.03	38.06	5.8	8.2
T5	Rhizobium+ Trichoderma	16.96	25.44	40	6.13	10.73
T6	PSB + Trichoderma	18.56	26.06	39.6	5.66	10.33
T7	PSB + Rhizobium	17.96	24.83	38.73	7.53	11.13
C.D (P at 5%)		2.58	3.12	6.034	2.58	2.88
SE(m) ±		0.836	1.011	1.937	0.837	0.934
SE(d)		1.182	1.43	2.739	1.184	1.321
C.V.		7.905	6.78	11.563	22.029	0.371

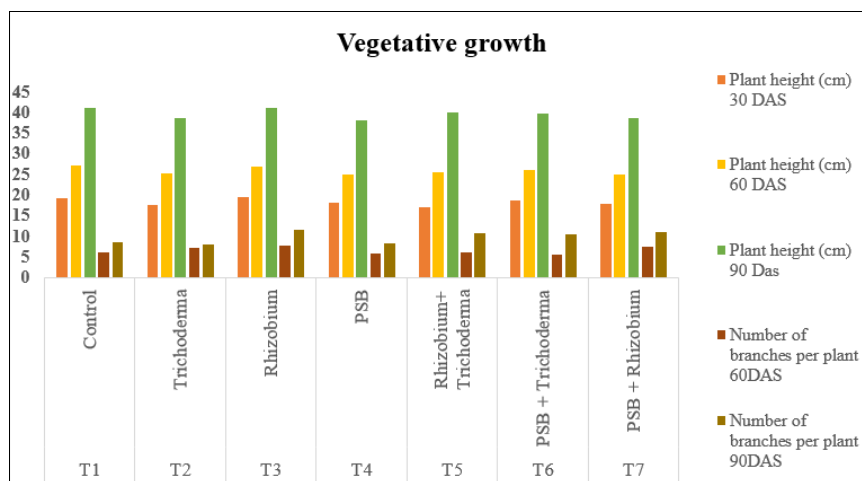


Fig 1: Vegetative growth under different seed treatment

T₆ (PSB + Trichoderma) produced the maximum number of flowers at 60 DAS and 90 DAS (30) and (49.33). T₇(PSB + Rhizobium) produced the maximum number of dry weights

plant¹ (54.10g), number of nodules plant¹(19.33g), number of dry weight of nodules plant¹ (0.07g).

Table 3: Growth parameters of flowers under different treatments

No. T	Treatment	Number of flowers per bed	
		60 DAS	90 DAS
T1	Control	8.33	43.66
T2	Trichoderma	8	33.48
T3	Rhizobium	11	41
T4	PSB	18.33	44.33
T5	Rhizobium + Trichoderma	11.66	36.66
T6	PSB + Trichoderma	30	49.33
T7	PSB + Rhizobium	10	40
C.D. (P at 5%)		15.94	14.86
SE(m) ±		5.172	4.823
SE(d)		7.315	6.82
C.V.		64.427	19.297

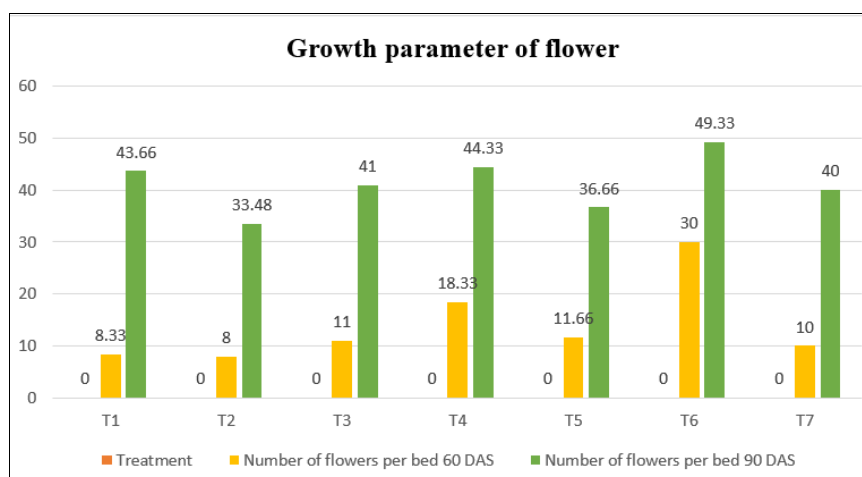


Fig 2: Growth parameters of flower under different seed treatment

Table 4: Yield attributes under different seed treatment

T. No	Treatment.	Dry weight per plant(g)	Nodules per plant	Dry weight (nodules/plant (g))	Pods/plant	Seeds /pod	Grain weight per plant	100-grain weight (Test Weight)	Grain yield (q/ha)	Biomass yield (q/ha)	Harvest index %
T1	Control	46.91	11.33	0.04	44.73	2.04	42.89	20.63	12	43.27	27.73
T2	Trichoderma	47.99	14	0.05	51.53	1.8	59.08	22.74	11.39	44.44	25.62
T3	Rhizobium	51.39	17.66	0.05	46.13	2.04	50.85	22.81	12.62	48.59	25.97
T4	PSB	38.99	15	0.06	52.93	2.04	46.62	21.42	12.91	30.23	42.69
T5	Rhizobium + Trichoderma	51.37	17	0.06	45	5.47	48.12	21.19	12.18	40.71	29.91

T6	PSB + Trichoderma	32.08	15.66	0.06	40.2	2.04	48.52	24.35	16.24	35.84	45.3
T7	PSB + Rhizobium	54.1	19.33	0.07	53.33	2.14	68.48	22.38	17.04	59.11	28.82
Dry weight per plant (g)		Nodules per plant	Dry weight nodules/plant (g)	Pods/plant	Seeds/pod	Grain weight Per plant	100-grain weight (Test Weight)	Grain yield (q/ha)	Biomass yield (q/ha)		
C.D. (P at 5%)	19.28	5.47	0.012	12.57	3.78	22.08	0.006	2.99	11.58		
SE(m) ±	6.257	1.776	0.004	4.08	1.225	7.166	0.002	0.87	3.33		
SE(d)	8.849	2.511	0.005	5.77	1.733	10.134	0.003	1.22	4.71		
C.V.	23.499	19.514	12.377	14.816	84.345	23.83	0.047	16.98	20.43		

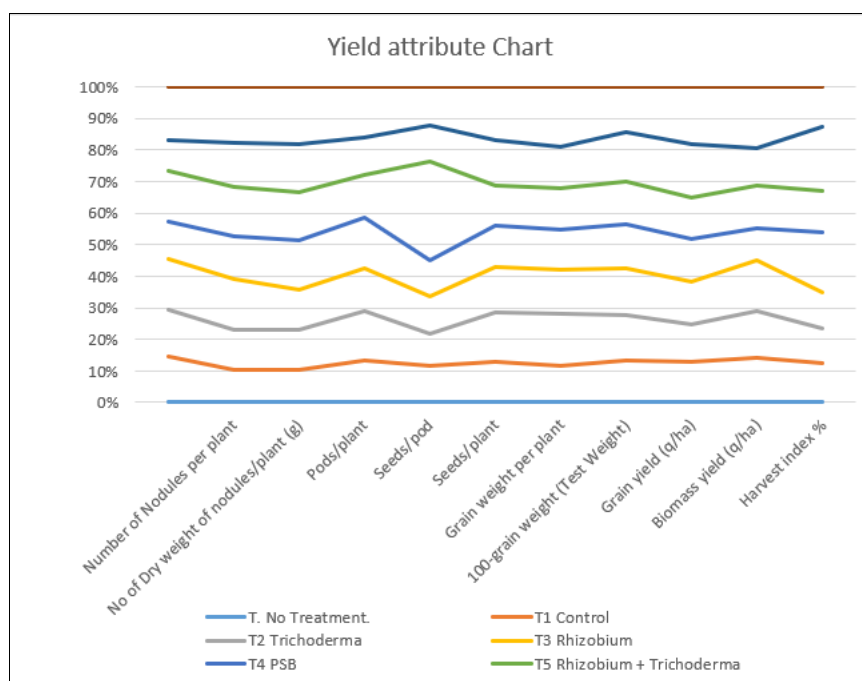


Fig 3: Yield attributes under different seed treatment

In the yield attributes T₇ (PSB + Rhizobium) produced the maximum pods plant⁻¹(53.33), seeds plant⁻¹(291.66), grain weight plant⁻¹ (68.48), biomass yield (59.11q/ha), grain yield (17.04q/ha). T₅ (Rhizobium + Trichoderma) produced the maximum number of seeds pods⁻¹. Whereas T₆ (PSB + Trichoderma) produced the maximum number of 100-grain yield (24.35), harvest Index (45.30%). It also been reported that P. fluorescence and Rhizobium enhance stem height, root length and dry weight. Gupta *et al.* (2011) [2] also claim that application of Rhizobium inoculation, significantly increased nodule number and nodule dry weight compared to the control. (Rhizobium + PSB + Azotobacter) had the biggest effect on, plant height, number of branches, number of seeds per pod, pod count, 100 seed weight, and seed yield. Lohita and Dutta (2022) [8] also reported that application of Rhizobium + PSB + Azotobacter had the biggest effect on pod count, number of seed per pods, seed yield.

After being dry, the harvested chickpea seed was collected for the data analysis. Where the biological yield was analysed. Grain weight plant⁻¹ ranged from 42.89 to 68.48, T₇(PSB +Rhizobium) produced the maximum number of grain weight plant⁻¹ and T₁ (control) was the lowest produced grain weight per plant. And in 100-grain test weight ranged from 20.63 to 22.81 where T₃ (Rhizobium) produced maximum number of (22.81) and T₁(control) produced lowest number (20.63).

The 100-grain weight increased may be due to the more availability of nutrients like nitrogen and phosphorous in the rhizobium and less losses as compared to the broadcast method.

These findings are related to who reported that less losses of fertilizer in band placement. The same result was also reported by Meena *et al.*, (2001) [9] and Kyei Boahen *et al.*, (2002) [7] who state that Rhizobium inoculation significantly increased 100 seed weight yield. Lohita and Dutta (2022) [8] also reported that application of Rhizobium + PSB + Azotobacter had the biggest effect on 100-grain yield.

In grain yield (q/ha) number ranged from 12.00 to 17.04, T₆(PSB + Rhizobium) produced maximum number (17.04q/ha) and T₁ (control) produced the lowest number (12.00q/ha), Biomass yield (q/ha) ranged from 59.11 to 30.23, T₆(PSB + Rhizobium) produced the maximum number (59.11q/ha) and T₄ (PSB) produced lowest number (30.23q/ha). Harvest index ranged from 45.30 to 25.62, where T₆(PSB + Trichoderma) produced maximum number (45.30%) and T₂ (Trichoderma) produced lowest number (25.62%). finding also showed that Rhizobium inoculation increased grain yield.

As per the experiment conducted, the data on economic values showed significant results, the highest cost of cultivation was in T₄ (PSB), Rs 12500/ha, followed by T₆ (PSB + rhizobium), Rs 12437.5/ha. The lowest cost was in T₁ (control), Rs 11500. In Gross return (Rs/ha¹) T₅ (Rhizobium + Trichoderma) produced the maximum gross return of Rs 109650/ha whereas followed by T₇ (PSB + Rhizobium) with gross return of Rs 153400/ha. T₇ (PSB + Rhizobium) gave the maximum net return of Rs 1,40,962.5/ha, whereas T₂ (Trichoderma) had the lowest net return of Rs 90,900/ha.

T₆ (PSB + Trichoderma) gave the maximum B.C (benefit-cost

ratio) of 12.70, followed by T₇ (PSB + Rhizobium) with a B.C (benefit-cost ratio) of 12.33. also reported that application of Rhizobium, PSB and Azotobacter produced the highest gross

return (Rs. 125077.2) and B.C Of (2.69), which was followed by application of Rhizobium+ PSB.

Table 5: Economic ratio under different seed treatment

T. No	Treatments	Cost of Cultivation	Gross return (Rs/ha ⁻¹)	Net return (Rs/ha ⁻¹)	Benefits: Cost (B.C)
T1	Control	11500	108000	96500	9.39
T2	Trichoderma	11650	102550	90900	8.80
T3	Rhizobium	12375	113550	101175	9.17
T4	PSB	12500	116150	103650	9.29
T5	Rhizobium + Trichoderma	12012.5	109650	97637.5	9.12
T6	PSB + Trichoderma	12075	146150	134075	12.70
T7	PSB + Rhizobium	12437.5	153400	140962.5	12.33

Conclusion

The experiment carried out in 2025-2026 revealed that the application of PSB + Rhizobium and PSB + Trichoderma improved the chickpea performance in comparison to all other treatments. Application of PSB, Trichoderma, and Rhizobium remained equivalent in growth, yield attributes and yield. Application of Rhizobium, PSB + Trichoderma increases the number of branches and number of flowers. Combining the seed treatment of Rhizobium + Trichoderma gives the maximum number of seeds per pod. Thus, we can conclude that using a combination of seed treatments is a great method to enhance the soil's properties and chickpea growth, resulting in higher yields and higher net returns.

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