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The Pharma Innovation

**ISSN (E): 2277- 7695**
**ISSN (P): 2349-8242**
**NAAS Rating: 5.23**
TPI 2021; 10(4): 541-545

www.thepharmajournal.com
Received: 21-02-2021
Accepted: 24-03-2021

**Sandeep Yadav**
Department of Soil Science and Agricultural Chemistry, ANDUAT, Ayodhya, Uttar Pradesh, India

**Suresh Kumar**
Department of Soil Science and Agricultural Chemistry, ANDUAT, Ayodhya, Uttar Pradesh, India

**Kumar Anshuman**
Department of Soil Science and Agricultural Chemistry, ANDUAT, Ayodhya, Uttar Pradesh, India

**Nandan Singh**
Department of Soil Science and Agricultural Chemistry, ANDUAT, Ayodhya, Uttar Pradesh, India

**Anurag Srivastava**
Department of Soil Science and Agricultural Chemistry, ANDUAT, Ayodhya, Uttar Pradesh, India

**Corresponding Author:**
**Sandeep Yadav**
Department of Soil Science and Agricultural Chemistry, ANDUAT, Ayodhya, Uttar Pradesh, India

# Studies on effect of different biofertilizer on yield and economics of chickpea

**Sandeep Yadav, Suresh Kumar, Kumar Anshuman, Nandan Singh and Anurag Srivastava**

## Abstract
A field study was carried out at Instructional Farm Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.) during *Rabi* season 2017-2018 to evaluate effect of different bio-fertilizers on growth, yield attributes and yield of chickpea (*Cicer arietinum* L.). The experiment was comprised with eight treatments ($T_1$) Control + RDF 100%, ($T_2$) *Azotobacter,* ($T_3$) *Rhizobium*, ($T_4$) Phosphorus solubilizing bacteria (PSB), ($T_5$) *Rhizobium* + PSB, ($T_6$) *Rhizobium* + *Azotobacter*, ($T_7$) *Azotobacter* + PSB, ($T_8$) *Rhizobium* + PSB + *Azotobacter*. The result revealed that among all the treatments, *Rhizobium* + PSB + *Azotobacter* ($T_8$) treatment recorded maximum growth attributes, yield and yield attributes which is closely followed by $T_5$ (*Rhizobium* + PSB). Application of *Rhizobium* + PSB+ *Azotobacter* also exhibited maximum values of gross return, net returns and benefit cost ratio.

**Keywords:** Bio fertilizers, *Rhizobium*, azotobacter, PSB, chickpea

## Introduction
Chickpea (*Cicer arietinum*) belong to 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 pulses production (Pooniya *et al.* 2015) [8]. Chickpea contains 21.1% protein, 61.5 per cent carbohydrate, 4.5% fat. It is also rich in calcium, iron and niacin. It is used for human consumption as well as for feeding to animals. In UP its total area is 6.11 lakh ha, production 6.84 lakh tones and productivity 1120 kg ha$^{-1}$. (Pulse revolution from food to nutritional security 2017-2018). In the current scenario, sustainability of agriculture has become a major issue of global concern as the intensive use of chemical inputs show adverse impact on the environment and the soil fertility (Laranjo *et al.* 2014, Verma *et al.* 2014) [7, 16]. Leguminous crops have a unique property of maintaining and restoring soil fertility as well as conserving and improving physical properties of soil by virtue of their deep root system which enables them to efficiently utilize applied as well as residual soil nutrients. Biofertlizers could play a crucial role by fixing the atmospheric nitrogen for the crops or by increasing the availability of phosphorus and other nutrients to the crops. Nitrogen phosphorus and are the major nutrients required for increasing yield potential. They are renewable source of fertilizers and a promising source of essential plant nutrients and growth promoting substances. The combined inoculation of Rhizobium and PSB was well studied in increasing nodulation in legume crops and increasing yield by making available the phosphorus from soil. Complex reactions with symbiotic and free living microorganisms are necessary and normal for healthy crop growth. Rhizobium inoculation helps to improve nodulation, plant growth and grain yield. Rhizobium-inoculated crop produces a 10–12% higher grain yield than a crop that has not been inoculated. Application of PSB has also been found to improve chickpea yield (Saad and Sharma 2001) [12]. The combined use of Rhizobium and PSB was found to be more beneficial than the sole application of Rhizobium in chickpea (Singh and Ali 2003) because both inoculants together provide the chickpea with nitrogen and phosphorus (Gull *et al*. 2004) [3]. The present study was done to study to evaluate the influence of bio fertilizers on growth and yield of chickpea.

## Materials and Methods
A field experiment was conducted at Instructional Farm of the ANDUAT, Kumarganj, Ayodhya (U.P.), during rabi of 2017-18 to evaluate the effect of different combination of

biofertilizers on nutrient uptake and soil fertility under chickpea. The chickpea cultivated variety Radhey that is 150 days duration variety was sown at 30cm x 10cm spacing with 4m x 3m plot size under subtropical region of Indo Gangetic plains with an average annual rainfall of 1250 mm. The soil of experimental field was clay in texture, alkaline in reaction (pH 8.2 to 8.5). Low in available N (185.00 kg $ha^{-1}$), Zn (0.49 ppm) medium in $P_2O_5$ (18.20 kg $ha^{-1}$) high in $K_2O$ (225.36 kg $ha^{-1}$) S (13.19 kg $ha^{-1}$) and low in organic carbon (3.5 g $kg^{-1}$) respectively. All treatments were randomly allocated and replicated three times in a randomized block design was adopted for the experimentation. The experiment was comprised with eight treatments ($T_1$) Control + RDF 100%, ($T_2$) *Azotobacter,* ($T_3$) *Rhizobium,* ($T_4$) Phosphorus solubilizing bacteria (PSB), ($T_5$) *Rhizobium* + PSB, ($T_6$) *Rhizobium* + *Azotobacter*, ($T_7$) *Azotobacter* + PSB, ($T_8$) *Rhizobium* + PSB + *Azotobacter*. Soil sample were collected after harvest of the crop from each plots. Soil pH and EC were determined by following Chopra and Kanwar (1991). Soil organic carbon was determined by Walkley and Black (1934) rapid titration procedure. Soil available N was determined following Subbiah and Asija (1956). Available P was determined by Olsen *et al.* (1954) method. Available K was determined by following Jackson (1973). Plants from 1 m row length were uprooted from sample rows of each plot at 30, 60, and 75 days after sowing (DAS) and at harvest. After removal of root portion, the samples were first air dried for some days and finally dried in an electric oven at 70 °C and recorded the dry matter yield. The number of nodules per plant was counted at 30, 60, 75 DAS. For this, five plants were selected randomly in sample rows of each plot and uprooted carefully. The effective root nodules were counted to record average number of nodules per plant. The fresh weight of nodules was weighed just after the removal from the plant root and dry weight were recorded after oven dried root nodules. The data recorded on various parameters were subjected to statistical analysis following analysis of variance technique and were tested at 5% level of significance to interpret the significant differences.

## Result and Discussion
### Growth parameters
#### Plant height
The plant height recorded at 30, 60, 75 DAS and at harvest stage (Table-1) of crop were revealed that the maximum plant height at 30, 60, 75 DAS and at harvest respectively recorded with the application of biofertilizer along with RDF100% treatment $T_8$ (*Rhizobium* + PSB + *Azotobacter*) followed by $T_5$ (*Rhizobium* + PSB) which was statistically at par with the $T_3$ (*Rhizobium*), $T_6$ (*Rhizobium* + *Azotobacter*) and $T_4$ (Phosphorus solubilizing bacteria). It is apparent from the data that the plant height increases with the all treatment combination. The application of biofertilizer along with RDF (100%) enhanced the plant height. The maximum plant height was recorded with the different combination of biofertilizer along with RDF (100%). The maximum plant height were recorded with the application of treatment $T_8$ (Rhizobium, PSB and Azotobacter). The combination of different biofertilizer and RDF 100% enhanced the nutrient availability and encourage the plant height. The biofertilizer inoculation enhanced the nitrogen, phosphorus and all other major nutrient for enhanced the vegetative growth and thus the plant height may be increase with the application of biofertilizer. Similar results are also reported by Rabieyan *et al*. (2011) [11] Beg and Singh (2009) [2].

#### Number of branch per plant
The data (Table-1) pertaining to number of branches $plant^{-1}$ at 30, 60, 75 DAS. The number of branches $plant^{-1}$ increased with the application of RDF100% along with biofertilizer (*Rhizobium* + PSB + *Azotobacter*). The maximum number of branches $plant^{-1}$ (7.10, 11.30, 13.20) at 45, 60, and 75 DAS respectively was recorded in treatment $T_8$ (*Rhizobium* + PSB + *Azotobacter*) followed by $T_5$ (*Rhizobium* + PSB) which was statistically at par with the treatments $T_3$ (*Rhizobium*), $T_6$ (*Rhizobium* + *Azotobacter*) and $T_4$ (Phosphorus solubilizing bacteria).The number of branches depend upon the vegetative growth and more vegetative growth prefer more plant height and thus, due to the tall plant the number of branches increases. The combination of chemical fertilizer (RDF 100%) along with biofertilizer increases the availability of essential nutrient which affect the vegetative growth and hence due to the more vegetative growth the number of branches increased. The application of different biofertilizer enhances the number of branches per plant. The PSB convert the insoluble form into soluble form and provide the P to the plant for their essential growth. Biofertilizer is essential constituent of plant cell and is also helpful in increasing the different growth character. PSB increase the solubility of phosphorus which increased the availability of phosphorus resulted in sufficient formation of photosynthesis which promote the metabolic activity, accelerates cell division and formation of meristematic tissue, due to this reason there might be enhancement in the number of branches $plant^{-1}$. The present findings are in concurrence with the findings of Hussain *et al.* (2011) [5].

#### Number of nodule per plant
The number of nodule $plant^{-1}$ recorded at 30, 60, 75 DAS that the number of nodule $plant^{-1}$ increased with the application of RDF100% along with bio-fertilizers (*Rhizobium,* PSB and *Azotobacter*). The maximum number of nodule $plant^{-1}$ was recorded with $T_8$ (*Rhizobium* + PSB + *Azotobacter*) followed by $T_5$ (*Rhizobium* + PSB) which was statistically at par with the treatments $T_3$ (*Rhizobium*), $T_6$ (*Rhizobium* + *Azotobacter*) and $T_4$ (Phosphorus solubilizing bacteria). It is apparent from the data that the number of nodules increased under the $T_8$ (RDF100% Rhizobium, PSB and azotobacter) significantly over control. Number of nodule $plant^{-1}$ increased with the different biofertilizer along with RDF 100%. The application of biofertilizer like Rhizobium, PSB also increased the number of nodules considerably in comparison to control. The inoculation of rhizobium and PSB enhance the microbial population in legume crop and form higher number of nodule per plant. The activity of microorganism increased in legumes crop due to rhizobium and PSB and this inoculation of Rhizobium and PSB increased the number of nodule per plant. The increase in nodulation was highest with the $T_8$ (Rhizobium, PSB and RDF 100%). Similar results are also reported by Tagore *et al.* 2014 [15].

#### Fresh and dry weight of root nodule $plant^{-1}$
Fresh and dry weight of nodule $plant^{-1}$ at 30, 60, 75 DAS the fresh weight of nodule $plant^{-1}$ increase with the application of RDF100% along with bio-fertilizers (*Rhizobium*, PSB and *Azotobacter*). The maximum fresh and dry weight of nodules at 30, 60, 75 DAS respectively was recorded in treatment $T_8$ (*Rhizobium* + PSB + *Azotobacter*) followed by $T_5$ (*Rhizobium*

+ PSB) which was statistically at par with the treatments $T_3$ (*Rhizobium*), $T_6$ (*Rhizobium* + *Azotobacter*) and $T_4$ (Phosphorus solubilizing bacteria). Fresh and dry weight of root nodules improved with the application of different biofertilizer along with RDF 100% (Table-2). The application of $T_8$ (RDF 100% Rhizobium, PSB and azotobacter) increases the fresh and dry weight of root nodule plant$^{-1}$ compare to control. The inoculation of Rhizobium and PSB increases the availability of enzymes and vitamins in soil and due to this enzyme activity the number of microbial population increases and this increased population of bacteria, and actinomycetes recharge the soil with conditioner. The inoculation of Rhizobium and PSB works as a soil conditioner which enhance the nutrient availability. PSB helps in nodule formation because PSB increases the phosphorus availability and this available phosphorus ha direct role in biological nitrogen fixation in legumes which ultimately increase the activity of microorganism and this increased microorganism which help in nodule formation. Sufficient amount of nodule formation increases the weight of nodule. The increases in fresh and dry weight of root nodule were highest in treatment $T_8$ (Rhizobium, PSB and azotobacter). Similar results are also reported by Singh *et al.*, (2007) [13].

**Yield attributes and yield**

**Number of pods plant$^{-1}$ & seeds pod$^{-1}$ and test weight**

The number of pods plant$^{-1}$ increased with the application of RDF 100% along with bio-fertilizers (*Rhizobium*, PSB and *Azotobacter*). The maximum number of pods plant$^{-1}$ (42.75) was recorded in treatment $T_8$ (*Rhizobium* + PSB + *Azotobacter*) followed by $T_5$ (*Rhizobium* + PSB) which was statistically at par with the treatments $T_3$ (*Rhizobium*), $T_6$ (*Rhizobium* + *Azotobacter*) $T_4$ (Phosphorus solubilizing bacteria) and $T_7$ *Azotobacter + PSB.* Data on number of pods plant$^{-1}$ and number of seeds pod$^{-1}$ significantly influenced by the application of different biofertilizer and RDF 100%. The $T_8$ (Rhizobium, PSB and azotobacter and RDF 100%) have significant effect on number of pods plant$^{-1}$ and number of seeds pod$^{-1}$ is affected by the number of branches and vegetative growth of plant. When sufficient amount of nitrogen, phosphorus and all other major nutrient provided to the plant they increase the growth parameter which increases the number of pods plant$^{-1}$ and seed pod$^{-1}$.

Data presented in Table-3 given in the prospect further revealed that the inoculation of Rhizobium and PSB increase the test weight significantly improved the test weight of grain as comparison to rest of the treatment. The increases in test weight were highest with the treatment $T_8$ (RDF 100%, Rhizobium, PSB and azotobacter) Similar results are also reported by Zaman *et al.* 2011 [18] and Yasari *et al.* 2007 [17].

**Seed yield, and straw yield**

The seed yield increased with the application of RDF 100% along with bio-fertilizers (*Rhizobium,* PSB and *Azotobacter*). The maximum seed yield was recorded with treatment $T_8$ (*Rhizobium* + PSB + *Azotobacter*) followed by $T_5$ (*Rhizobium* + PSB) which was statistically at par with the treatments $T_3$ (*Rhizobium*), $T_6$ (*Rhizobium* + *Azotobacter*) $T_4$ (Phosphorus solubilizing bacteria) and $T_7$ *(Azotobacter* + PSB) Data pertaining to seed and straw yield as influenced by various treatments indicated that seed yield of chickpea increased significantly with the inoculation of Rhizobium and PSB (Table-3). The $T_8$ (RDF 100% Rhizobium, PSB and azotobacter) had the significant effect on seed yield, straw yield and harvesting index. The inoculation of Rhizobium and PSB enhance the phosphorus availability and this available phosphorus enhances the number of seed yield straw yield and harvest index. The increases in harvest index were highest with the biofertilizer along with RDF 100%. The crop having the more harvest index which has more seed yield. Similar results are also reported by Gupta *et al*. 2006 [4].

**Economic**

The maximum cost of cultivation was computed (Table-4) under the application of $T_8$ (Rhizobium, PSB and azotobacter) followed by $T_5$ (Rhizobium + PSB). The minimum cost of cultivation in control $T_1$ RDF 100%). Highest net return was recorded under treatment $T_8$ (RDF 100%, Rhizobium, PSB and azotobacter). Maximum gross return (Rs125077.2) was computed in $T_8$ (Rhizobium, PSB and azotobacter) followed by $T_5$ (Rhizobium + PSB). The minimum gross return (Rs 100452) was noted in control $T_1$ (RDF 100%). net returns (Rs 91212.0) was estimated under $T_8$ (Rhizobium, PSB and azotobacter) followed by $T_5$ (Rhizobium + PSB). The minimum net return (Rs. 67181.8) was estimated in control $T_1$ (RDF 100%) and cost benefit ratio (2.69) was computed in treatment in $T_8$ (Rhizobium, PSB and azotobacter) followed by $T_5$ (Rhizobium + PSB). The minimum cost benefit ratio was computed under control $T_1$ (RDF 100%). The treatment $T_8$ (Rhizobium, PSB and azotobacter) was found significant in higher values of net returns and benefit cost ratio, which might be due to the higher grain and stover yield. Similar results were found by Swaminathan *et al*. (2007) [14] and Prabhu *et al*. (2010) [9].

**Conclusion**

On the basis of present investigation, it may be concluded that application of RDF 100% along with biofertilizers (*Rhizobium*, PSB and *azotobacter*) significantly increases the growth and yield parameters *viz.* plant height, number of branches per plant, number of nodules per plant, number of seed per pod, test weight (100 seed weight) seed yield and straw yield. The highest seed and straw yield was recorded with the application of $T_8$ (100% RDF, *Rhizobium*, PSB and *azotobacter*). So, to get better yield and higher economic benefit from chick pea productions farmers are suggested to use the combination of, *Rhizobium*, PSB and *azotobacter.*

**Table 1:** Effects of bio-fertilizer on growth attributes of chickpea

| Treatments | Plant height (cm) | | | | Number of branch plant$^{-1}$ | | |
|---|---|---|---|---|---|---|---|
| | 45 DAS | 60 DAS | 75 DAS | At harvest | 45 DAS | 60 DAS | 75 DAS |
| $T_1$ Control + RDF100% | 17.60 | 23.60 | 32.30 | 42.20 | 5.80 | 7.30 | 9.00 |
| $T_2$ *Azotobacter* | 18.10 | 24.90 | 32.90 | 44.70 | 6.20 | 8.20 | 10.90 |
| $T_3$ *Rhizobium* | 19.60 | 26.50 | 35.80 | 47.00 | 6.60 | 8.80 | 11.60 |
| $T_4$ Phosphorus solubilizing bacteria | 18.40 | 26.00 | 34.20 | 46.30 | 6.40 | 8.30 | 11.10 |
| $T_5$ *Rhizobium* + PSB | 20.40 | 27.90 | 38.40 | 48.90 | 6.90 | 9.10 | 12.00 |
| $T_6$ *Rhizobium* + *Azotobacter* | 19.70 | 27.40 | 36.80 | 46.20 | 6.70 | 9.05 | 11.90 |
| $T_7$ *Azotobacter* + PSB | 19.00 | 26.20 | 35.90 | 45.10 | 6.50 | 8.50 | 11.30 |
| $T_8$ *Rhizobium* + PSB + *Azotobacter* | 20.90 | 28.80 | 39.40 | 50.10 | 7.10 | 10.30 | 13.20 |
| SEm± | 0.88 | 0.82 | 1.32 | 1.71 | 0.24 | 0.33 | 0.42 |
| CD at 5% | 2.69 | 2.50 | 4.01 | 5.19 | 0.73 | 1.01 | 1.42 |

**Table 2:** Effects of bio-fertilizer on number and weight of nodule of chickpea crop

| Treatments | Number of nodule plant$^{-1}$ (mg) | | | Fresh weight of nodule plant$^{-1}$ (mg) | | | Dry weight of nodule plant$^{-1}$ (mg) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | 60 DAS | 75 DAS | 30 DAS | 60 DAS | 75 DAS | 30 DAS | 60 DAS | 75 DAS |
| $T_1$ Control (RDF100%) | 7.60 | 12.10 | 9.00 | 352.00 | 375.63 | 286.80 | 70.10 | 80.00 | 65.05 |
| $T_2$ *Azotobacter* | 8.10 | 13.25 | 10.15 | 364.00 | 384.63 | 303.60 | 76.20 | 90.05 | 70.00 |
| $T_3$ *Rhizobium* | 9.00 | 13.46 | 11.10 | 373.00 | 406.88 | 340.20 | 85.00 | 100.10 | 80.10 |
| $T_4$ Phosphorus solubilizing bacteria | 8.85 | 12.96 | 10.85 | 370.00 | 387.81 | 259.80 | 81.20 | 96.20 | 77.20 |
| $T_5$ *Rhizobium* + PSB | 9.80 | 14.45 | 12.14 | 448.00 | 485.63 | 403.20 | 91.15 | 110.00 | 88.10 |
| $T_6$ *Rhizobium* + *Azotobacter* | 9.28 | 13.89 | 11.87 | 420.00 | 459.38 | 378.00 | 88.57 | 105.20 | 81.00 |
| $T_7$ *Azotobacter* + PSB | 8.90 | 13.71 | 11.38 | 376.00 | 380.50 | 302.40 | 83.50 | 102.00 | 78.10 |
| $T_8$ *Rhizobium* + PSB + *Azotobacter* | 9.30 | 15.10 | 12.50 | 490.00 | 531.56 | 441.00 | 96.11 | 120.50 | 90.50 |
| SEm± | 0.33 | 0.50 | 0.41 | 14.95 | 16.08 | 13.05 | 3.11 | 3.70 | 2.90 |
| CD at 5% | 1.05 | 1.53 | 1.25 | 45.32 | 48.76 | 39.57 | 9.42 | 11.23 | 8.80 |

**Table 3:** Effects of bio-fertilizer on yield attributes and yield of chickpea crop

| Treatments | Yield attributes | | Yield (q/ha) | | Test weight (g) |
|---|---|---|---|---|---|
| | No. of pod plant$^{-1}$ | No. of seed pod$^{-1}$ | Seed | Straw | |
| $T_1$ Control (RDF100%) | 37.00 | 1.28 | 18.10 | 28.05 | 17.50 |
| $T_2$ *Azotobacter* | 37.25 | 1.30 | 19.06 | 29.73 | 18.30 |
| $T_3$ *Rhizobium* | 41.15 | 1.50 | 20.70 | 32.70 | 19.00 |
| $T_4$ Phosphorus solubilizing bacteria | 39.75 | 1.49 | 19.90 | 31.24 | 18.35 |
| $T_5$ *Rhizobium* + PSB | 42.00 | 1.52 | 21.63 | 35.04 | 19.25 |
| $T_6$ *Rhizobium* + *Azotobacter* | 41.50 | 1.51 | 20.86 | 33.58 | 19.10 |
| $T_7$ *Azotobacter* + PSB | 40.00 | 1.50 | 20.56 | 32.89 | 18.40 |
| $T_8$ *Rhizobium* + PSB + *Azotobacter* | 42.75 | 1.55 | 22.06 | 38.60 | 19.35 |
| SEm± | 1.79 | 0.05 | 0.75 | 1.21 | 0.69 |
| CD at 5% | 4.52 | 0.14 | 2.26 | 3.67 | NS |

**Table 4:** Economic analysis of various treatment combinations

| Treatments | Cost of cultivation (Rs.ha$^{-1}$) | Gross income (Rs.ha$^{-1}$) | Net return (Rs.ha$^{-1}$) | Benefit cost ratio |
|---|---|---|---|---|
| $T_1$ Control (RDF100%) | 33265.2 | 100452 | 67181.8 | 2.01 |
| $T_2$ *Azotobacter* | 33415.2 | 105895.2 | 72480.0 | 2.16 |
| $T_3$ *Rhizobium* | 33415.2 | 115254 | 81838.8 | 2.44 |
| $T_4$ Phosphorus solubilizing bacteria | 33415.2 | 110682 | 76965.0 | 2.30 |
| $T_5$ *Rhizobium* + PSB | 33715.2 | 120954.6 | 87239.4 | 2.58 |
| $T_6$ *Rhizobium* + *Azotobacter* | 33715.2 | 116521.2 | 82806.0 | 2.45 |
| $T_7$ *Azotobacter* + PSB | 33715.2 | 114721.2 | 81006.0 | 2.40 |
| $T_8$ *Rhizobium* + PSB + *Azotobacter* | 33865.2 | 125077.2 | 91212.0 | 2.69 |

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