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# Phosphorus Solubilizing Bacteria (PSB) in combination with different Fertilizer sources to enhance yield performance of chickpea

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**Abstract:** The chickpea (*Cicer arietinum* L.) is an edible legume having high protein and is one of the most important cultivated pulse crop. As compared to consumption of country, the production of chickpea is very low which can be enhanced by managing nutrients requirement of the crop. To evaluate the effect of Phosphorus Solubilizing Bacteria (PSB) along with different fertilizer sources, a field experiment was carried out at Cereals and Pulses Section, Agronomic Research Institute, Faisalabad during Rabi 2018-19. The study was conducted in Randomized complete block design (RCBD), replicated thrice and having plot size of 9 m × 3 m. Five Fertilizer treatments ($T_1$= Recommended NP @ 32:85 kg ha$^{-1}$, $T_2$= Seed treatment of PSB + Recommended NP, $T_3$= FYM @ 3.5 t ha$^{-1}$, $T_4$= Seed treatment of PSB+ FYM @ 3.5 t ha$^{-1}$ and $T_5$= FYM @ 3.5 t ha$^{-1}$ + Remaining P from SSP) were evaluated. Data regarding yield and yield contributing factors was recorded by using standard procedures and were analyzed statistically using Fisher's technique of analysis of variance and treatment's means were compared by using Least Significant Difference (LSD) test. The results revealed that seed inoculation of PSB with different fertilizers significantly enhanced the yield and yield components of chickpea. Seed treatment of PSB+ Recommended NP ($T_2$) significantly resulted in maximum plant height (53.66 cm), No. of branches per plant (4), No. of grains per pod (1.58), No. of pods per plant (36.66), 100- seed weight (18.48 g) and grain yield (1852 kg ha$^{-1}$) which is 6.62%, 8.11%, 10.49%, 15.79%, 12.48% and 15.37% respectively over treatment where only Recommended NP @ 32: 85 kg ha$^{-1}$ ($T_1$) was applied. Seed inoculation of PSB + FYM @ 3.5 t ha$^{-1}$ application also enhanced the yield and yield components over treatment $T_3$ (FYM @ 3.5 t ha$^{-1}$) and $T_5$ (FYM @ 3.5 t ha$^{-1}$ + Remaining P from SSP). That increase was 8.13%, 5.56%, 5.85% and 17.42% for plant height, No. of branches per plant, 100-seed weight and grain yield respectively over $T_3$ and 17.74%, 2.70%, 6.70%, 9.58%, 3.67% and 12.54% for plant height, No. of branches per plant, No. of grains per pod, No. of pods per plant, 100-seed weight and grain yield respectively over $T_5$. However, all the parameters were found significantly lower in all treatments than $T_2$. It was found that seed treatment of PSB along with fertilizer application at the time of sowing enhances yield and yield contributing factors of chickpea.

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**Keywords:** Chickpea; Farm yard manure; Inoculant; Phosphorus solubilizing bacteria, FYM= Farm Yard Manure, NP= Nitrogen: Phosphorus, SSP= Single Super Phosphate

## Introduction

Chickpea (*Cicer arietinum* L.) is an important rabi pulse crop. It is an edible legume which contains high protein and is one of the earliest pulse crop being cultivated (Namvar and Sharifi, 2011). During 2018-19 chickpea was grown on an area of 944 thousand hectares with total production of 438 thousand tonnes (Pakistan bureau of statistics, 2018-19) with an average yield of 1155kg ha$^{-1}$ in Pakistan. In Pakistan this crop is grown on marginal lands and less importance is being given to fertilizer inputs by the farmers. Several type of organic materials have been reported as source of suitable soil amendments and as an alternate source for soil fertilization which in turn increases yield of crop and improves nutrient availability to plant and increases uptake from the soil. (Makinde and Ayoola, 2010). Among different fertilizer sources microbial inoculants are healthy, cost effective, ecofriendly, and easily available source of plant nutrients due to their significant role in nitrogen fixation and phosphorus solublisation. (Banerjee, 2005). Phosphorus is an important macro-nutrient required by the plants. The status of soil P is influenced by a number of factors which include soil type, temperature, other environmental conditions as well as various crop management practices (Funga et

al., 2016). Biofertilizer show a dynamic and positive effect on crop yield and nutrient uptake by the plant from the soil. There is a difference in biofertilizer performance among different crops out of which climate, soil biodiversity, soil fertility and soil C:N ratio are major contributing factors it. Thus, the need biofertilizers for nutrient uptake is an important factor in many soils. P levels are considered to be influenced by activity of micro-organisms and thus effectiveness of biofertilizers. Especially phosphate-solubilizing bacteria and AMF are expected to be affected by P levels. Biofertilizer plays a significant role in minimizing the use of synthetic fertilizer by fixing atmospheric nitrogen and increasing P availability to the crop (Selvakumar et al., 2012). The aim of this experiment was to examine the role of PSB in combination with inorganic and organic nutrient sources on grain yield of chickpea

**Material and Methods**

The research experiment was conducted at Cereals and Pulses Section, Agronomic Research Institute, Faisalabad during Rabi 2018-19. The experiment was designed in Randomized Complete Block Design having 4 replications consisting of net plot size 9 m x 3 m. The study comprised of five treatments in which microbial inoculant Phosphorus Solubilizing Bacteria was tested under the same input level of synthetic fertilizer (Urea, SSP 18%) and organic fertilizers (Farm Yard Manure @ 3.5 t $ha^{-1}$) along with the non-inoculated control.

Chickpea variety Noor-2013 was sown maintaining Row to Row distance of 60 cm. Soil samples were analyzed for its various physical and chemical properties (Table 1). Seedbed was prepared by cultivating the soil twice upto the depth of 12 cm followed by one planking. Kabuli chickpea cultivar Noor-2013 was used @ 75 kg $ha^{-1}$. Seed was treated with fungicide before sowing. In treatments where Bio-fertilizer was to be applied seed was treated @ 4 packets/ 10kg Phosphorus solubilizing Bacteria inoculant prior to sowing. Farm Yard Manu @ 3.5 t $ha^{-1}$ was applied in the field 20 days before sowing after getting it analyzed for NPK (0.96%, 0.54%, 0.8% respectively). All the Urea and SSP was applied at the time of sowing. First irrigation was applied 50 days after sowing. Hand weeding was done twice, first at 30 days after sowing and second 70 days after sowing. All other agronomic practices were kept uniform.

The plants were harvested at maturity and yield contributing parameters i.e. plant height, No. of branches, number of pods per plant, number of grains per pod were recorded on 10 randomly selected plants in each plot. 100-grain weight was recorded from each replication. At maturity crop from each plot was harvested, tagged, bundled, dried in the sun and threshed manually. Grain yield from each plot was weighed separately and converted into t ha-1. Harvesting was done when pods reached 80% maturity. The collected data was analyzed using Fisher's analysis of variance technique wand the difference among treatment means were compared using least significant difference (LSD) test at 5% probability level (Steel et al., 1997)

**Table-1 Pre-sowing soil mechanical and Chemical properties of experimental site**

| Soil Character | Value (2018-19) |
|---|---|
| EC | 1.49 mS/cm |
| Soil pH | 7.42 |
| Organic Matter | 0.63 % |
| Available N | 0.03 % |
| Available P | 8.7 ppm |
| Available K | 220 ppm |
| Saturation | 32 % |
| Texture | Loam |

**Results**

**Plant Height (cm):**

The analysis of variance showed that the different fertilizer amendments had significant difference on the plant height. Maximum plant height 53.66 cm was recorded in treatment where Seed Treatment with PSB + Recommended dose of synthetic fertilizer NP @ 32:85 kg/$ha^{-1}$ was applied which is 6.61 % higher than 50.33 cm plant height from Recommended NP @ 32: 85 kg $ha^{-1}$ (T1), followed by 48.66 cm Plant height obtained from seed inoculation with PSB + FYM @ 3.5 t $ha^{-1}$ which is 15.06 % higher than treatment where only FYM @ 3.5 t $ha^{-1}$ was applied while minimum plant height 41.33 cm was observed in treatment where FYM @ 3.5 t $ha^{-1}$ + Remaining P from SSP was used.

**Plant Population:**

The analysis of variance exhibited that the different fertilizer amendments statistically had no significant difference on the plant population however, Maximum plant population 21 was observed in treatment where Seed Treatment with PSB + Recommended dose of synthetic fertilizer was used which was also at par (19.6) with treatment where PSB+ FYM@ 3.5 t $ha^{-1}$ was applied.

**No. of branches/ plant:**

The analysis of variance showed that the fertilizer amendments had significant effect on number of branches per plant. According to data in (table 2) Maximum No. of branches/ plant (4) were recorded when Seed Treatment with PSB + Recommended dose of synthetic fertilizer NP @ 32:85 kg/$ha^{-1}$ was applied, followed by treatment where PSB+ FYM@ 3.5 t $ha^{-1}$ was applied while minimum number of branches (3.6) were recorded where Farm Yard Manure @ 3.5 t $ha^{-1}$

was applied and that was statistically at par with treatment where FYM@ 3.t ha$^{-1}$ + remaining P from SSP was applied.

**No. of Grains/pod:**

The analysis of variance showed that the fertilizer amendments had significant difference on the number of grains per pod. Maximum no. of Grains/pod (1.58) were recorded when Seed Treatment with PSB + Recommended dose of synthetic fertilizer NP @ 32:85 kg/ha$^{-1}$ was applied and was statistically alike with $T_1$, $T_3$ and $T_4$, while minimum No. Grains/pod (1.33) were recorded where FYM @ 3.5 t ha$^{-1}$ + Remaining P was supplemented using SSP.

**No. of Pods/plant:**

The analysis of variance showed that the fertilizer amendments had significant effect on the No. of pods/plant. Maximum No. Pods/plant (36.66) were recorded when Seed Treatment with PSB + Recommended dose of synthetic fertilizer NP @ 32:85 kg/ha$^{-1}$ was applied which is 13.64% greater than the (31.66) no. of pods/plant in un- inoculated NP @ 32:85 kg/ha$^{-1}$ application. While minimum No. of pods/plant (31.33) were recorded where FYM @ 3.5 t ha$^{-1}$ + Remaining P was supplemented using SSP was used which is 9.58% lesser than the 34.33 no. of pods/plant in treatment where inoculated seed along FYM @ 3.5 t ha$^{-1}$ was applied.

**100-Seed Weight (g):**

The analysis of variance showed that the fertilizer amendments had effect on the 100- seed weight. Maximum 100-seed weight (18.48) was recorded when Seed Treatment with PSB + Recommended dose of synthetic fertilizer NP @ 32:85 kg/ha$^{-1}$ was applied, followed by treatment $T_4$ (PSB+ FYM @ 3.5 t ha$^{-1}$) while minimum 100-Seed Weight (16.43) was recorded where NP @ 32:85 kg/ha$^{-1}$ (Recommended) was applied.

**Grain yield (kg ha$^{-1}$):**

The analysis of variance showed that the fertilizer amendments had significant effect on the grain yield. Maximum Grain yield (1852 kg ha$^{-1}$) was recorded when Seed Treatment with PSB + Recommended dose of synthetic fertilizer NP @ 32:85 kg ha$^{-1}$ was applied and was statistically at par with $T_4$ (PSB+ FYM @ 3.5 t ha$^{-1}$) while minimum Grain yield (1419.7 kg ha$^{-1}$) was recorded when Farm Yard Manure @ 3.5 t ha$^{-1}$ was applied.

**Discussion:**

Increase in plant height might be attributed to the better availability of phosphorus to chickpea plants by use of PSB. Findings of Singh et al., (2014) also confirm the results as they stated the increase in plant height by the use of bio-fertilizers in combination with organic fertilizers attributed to better supply of nutrients. Balachandran et al., (2005) also found that the increase in plant height was due to use of bio fertilizer in combination with synthetic fertilizer.

Increase in number of branches per plant may also be attributed to better nourishment of crop due to better availability of Phosphorus with use of PSB. Better nutrient availability leads to better crop growth and improved crop stand. Chauhan and Raghav (2017) also reported the increased uptake of phosphorus in plant with the application of PSB in chickpea.

Pramanik and Bera, (2012) revealed from their study that inoculation of biofertilizers showed positive effect on chickpea crop. The inoculation with Rhizobium + PSB + VAM significantly improved the yield parameters such as plant height, number of pods /plant, weight of pods /plant, number of grains /plant, test weight, grain yield, stalk yield and harvest index. Kumawat et al., (2013) concluded that seed inoculation of black gram with PSB, had distinctly enhanced the seed yield, biological yield, net returns, B:C ratio as compared to seed inoculation with alone Rhizobium and control. Bahadur and Tiwari, (2014) also confirmed that mungbean inoculated with Rhizobium and PSB showed significant response to all growth and yield parameters.

Pramanik and Bera, (2012) reported that inoculation of bio-fertilizers exhibited positive results on number of pods formation in chickpea. Inoculation led to overall increase in chlorophyll content, nitrogen and phosphorus content of plant as compared to un-inoculated (control) treatment Bhattacharjee and Sharma, 2012.

Increase in 100-seed weight is attributed to more nutrient accumulation in seed, more photosynthates accumulation due to better photosynthesis under better nutrient availability with the use of PSB. Ramana et al., (2010) reported that French bean recorded significantly higher 100 seed weight, due to combined effect of application of 75% RDF + VAM @ 2 kg/ha + PSB @ 2.5 kg ha$^{-1}$.

Increased seed yield was obtained in organic manures combination with biofertilizers application (Rhizobium and PSB) and it must have attributed to the effect of growth hormones like IAA and cytokinins produced by Rhizobium which stimulated root morphology. This in turn, would have improved assimilation of plant nutrients and thus seed yield. The phosphate solubilizing bacteria increase the availability of phosphorus to the plants and its greater uptake. The present results are in collaboration with the findings of Rajkhowa et al., (2017) also concluded that the increased microbial population in the soil resulted in higher greengram yield. Khandelwal et al., (2012) and Balachandran et al., (2005). Inoculation enhances plant growth, grain and biomass yield in chickpea (Funga et al., 2016; Khaitov et al., 2016; Tena et al., 2016).

On the basis of results it is concluded that PSB should be applied with recommended dose of fertilizer for better and enhanced yield. PSB can also be added with organic fertilizer for better yield while producing organically.

**Table-2: Effect of different Nutrient sources on yield and yield contributing factors of chickpea**

| Treatments | Plant Height (cm) | Plant Population/$m^2$ | No. of branches/ plant | No. of Grains/pod | No. of Pods/plant | 100-Seed Weight (g) | Grain yield (kg $ha^{-1}$) |
|---|---|---|---|---|---|---|---|
| **T1= NPK @ 32:85:0 kg/$ha^{-1}$ (Recommended)** | 48.66 ab | 20 | 3.7 bc | 1.43 ab | 31.66 b | 16.43 e | 1605.3 bc |
| **T2= Seed Treatment with PSB + Recommended dose of synthetic fertilizer** | **53.66 a** | 21 | **4.0 a** | **1.58 a** | **36.66 a** | **18.48 a** | **1852 a** |
| **T3= Farm Yard Manure @ 3.5 t $ha^{-1}$** | 45 bc | 20 | 3.6 c | 1.44 ab | 34.33 ab | 17.10 d | 1419.7 c |
| **$T_4$= Seed Treatment with PSB + Farm Yard Manure @ 3.5 t $ha^{-1}$** | 50.33 ab | 19.6 | 3.8 b | 1.42 ab | 34.33 ab | 18.10 b | 1667 ab |
| **T5= FYM @ 3.5 t $ha^{-1}$ + Remaining P from SSP** | 41. 33 c | 20 | 3.7 bc | 1.33 b | 31.33 b | 17.46 c | 1481.3 bc |
| **LSD value @ 0.05** | 5.467 | | 0.177 | 0.170 | 3.20 | 0.358 | 201.06 |

**Table-3 Analysis of Variance (ANOVA) Table of yield and yield contributing factors of Chickpea (Mean Sum of Squares MSS)**

| SOV | d.f | Plant height (cm) | Plant Population | No. of Branches/plant | Grains/Pod | Pods/plant | 100-seed weight | Grain yield (Kg $ha^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| **Treatments** | 4 | 66.8218** | 0.76667* | 0.73333* | 0.02406* | 14.5000* | 1.96351** | 85871** |
| **Replication** | 2 | 0.7302 | 0.46667 | 0.86667 | 0.00186 | 5.0667 | 4.9838 | 26699 |
| **Error** | 8 | 0.7353 | 0.96667 | 0.53333 | 0.00823 | 2.9000 | 0.3630 | 91223 |
| **Total** | 14 | 274.630 | 11.7333 | 8.93333 | 0.16576 | 91.333 | 9.1411 | 488107 |

SOV= Source of Verification, d.f= degree of freedom

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