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**Yasmin Gulnaz**
Department of Agronomy, University of Agricultural Sciences, GKVK, Bangalore, Karnataka, India

**Fathima PS**
Department of Agronomy, University of Agricultural Sciences, GKVK, Bangalore, Karnataka, India

**Denesh GR**
Department of Agronomy, University of Agricultural Sciences, GKVK, Bangalore, Karnataka, India

**Akhilesh Kumar Kulmitra**
Department of Plant Pathology, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

**Shivraj Kumar HS**
Department of Agronomy, University of Agricultural Sciences, GKVK, Bangalore, Karnataka, India

**Correspondence**
**Yasmin Gulnaz**
Department of Agronomy, University of Agricultural Sciences, GKVK, Bangalore, Karnataka, India

# Effect of Plant Growth Promoting Rhizobacteria (PGPR) and PSB on root parameters, nutrient uptake and nutrient use efficiency of irrigated maize under varying levels of phosphorus

**Yasmin Gulnaz, Fathima PS, Denesh GR, Akhilesh Kumar Kulmitra and Shivrajkumar HS**

## Abstract
A field experiment was conducted to know the effect of Plant Growth Promoting Rhizobacteria (PGPR) and PSB on root parameters, nutrient uptake and nutrient use efficiency of irrigated maize under varying levels of phosphorus during *kharif,* 2015 at College of Agriculture, V. C. Farm, University of Agricultural Sciences, Bangalore. The experiment comprised of thirteen treatments consisting of three levels of phosphorus (75, 100 and 125 per cent of recommended dose) and various phosphorus bio-fertilizers and Plant Growth Promoting *Rhizosphere* (PGPR) and their combinations. The experiment was laid out in RCBD with three replications. The soil type was sandy loam. The maize hybrid NAH-1137 was used. The results revealed that, the application of 75, 100 and 125 *per cent* of recommended dose of phosphorus fertilizer along with PGPR II (*Pseudomonas fluorescens* + *Bacillus megaterium* + *Azospirillum brasilense*) increased the root parameters *viz.,* root length, root volume and root biomass as well as yield over control. The kernel yield was significantly higher over control in all the treatments involving bio-fertilizers except with the application of 75, 100 and 125 per cent of recommended dose of phosphorus fertilizer along with *Bacillus megaterium*. Application of 75 per cent of recommended dose of phosphorus fertilizer along with PGPR II recorded high nutrient uptake as well as nutrient use efficiency. A combination of both PSB and N-fixing bacteria (PGPR II) has improved the root growth and yield in maize than PGPR I (*P. fluorescens* + *B. megaterium*).

**Keywords:** PGPR, Phosphorus, PSB, RCBD

## Introduction
Maize (*Zea mays* L.) is a crop having high yield potential and called by the name queen of cereal crop. The area and production of maize in India is 9.4 million ha and 23 million tones, respectively [2]. The crop is mainly cultivated for commercial purpose with various uses *viz.,* food, feed for livestock, and also used as a raw material in starch, ethanol, paper and other industries. Hence crop is having huge demand from diversified sectors. Maize is an important cereal in many developed and developing countries of the world but low soil phosphorus content is a constraint to production of maize. Deficiency of phosphorus is responsible for small ears in maize due to crooked and missing rows as kernel twist [5]. Also P fertilization enhances competition ability of maize with weeds like velvetleaf [1]. Bio-fertilizers are capable of making the nutrient available to the plants. So bio-fertilizers are the basic need for the sustainability of a production system. The role and importance of bio-fertilizers in sustainable crop production has been reported by several research workers [11]. Several researchers have examined and reported the ability of different bacterial species to solubilise insoluble inorganic phosphate compounds such as tricalcium phosphate, dicalcium phosphate, hydroxyapatite and rock phosphate. The phosphate solubilizers belongs to bacterial genera *Pseudomonas, Bacillus, Burkholderia, Achromobacter, Aerobacter, Flavobacterium and Erwinia*. There are considerable populations of phosphate solubilising bacteria in the soils of plant rhizospheres [6].

## Materials and Methods
A field experiment was conducted at Department of Agronomy, College of Agriculture, V.C. Farm, UAS, Bangalore during *kharif*, 2015. It falls under the region III and agro climatic zone VI (Southern Dry Zone) of Karnataka.

The experimental soil was sandy loam in texture with an average particle content of 56.4 per cent coarse sand, 11.6 per cent fine sand, 15.2 per cent silt and 16.8 per cent clay. The soil was neutral in reaction (pH 7.13), organic carbon content was medium (0.59 per cent) with a electrical conductivity of 0.19 $dSm^{-1}$. The soil was low in available nitrogen (219.70 kg $ha^{-1}$), medium in available phosphorus (41.61 kg $ha^{-1}$) and medium in available potassium (227.20 kg $ha^{-1}$). The field experiment with three replications was laid out in RCBD with the following treatments: $T_1$ (75% Rec. P + *Bacillus megaterium*), $T_2$ (75% Rec. P + *Pseudomonas fluorescens*), $T_3$ [75% Rec. P + PGPR-I (*P. fluorescens* + *B. megaterium*)], $T_4$ [75% Rec. P + PGPR-II (*P. fluorescens* + *B. megaterium* + *A. brasilense*)], $T_5$ (100% Rec. P + *B. megaterium*), $T_6$ (100% Rec. P + *P. fluorescens*), $T_7$ (100% Rec. P + PGPR-I), $T_8$ (100% Rec. P + PGPR-II), $T_9$ (125% Rec. P + *B. megaterium*), $T_{10}$ (125% Rec. P + *P. fluorescens*), $T_{11}$ (125% Rec. P + PGPR-I), $T_{12}$ [125% Rec. P + PGPR-II) and $T_{13}$ (100% Recommended Phosphorus(Rec. P) (Control)].

The recommended dose of fertilizer is 150 kg N, 75 kg $P_2O_5$ and 40 kg $K_2O$ $ha^{-1}$. For treatments $T_1$, $T_2$, $T_3$ and $T_4$, 75% of the required $P_2O_5$ was applied and for treatments $T_9$, $T_{10}$, $T_{11}$ and $T_{12}$, 125% of the required quantity of $P_2O_5$ was applied. The fertilizers were applied as per package of practices i.e. 50 per cent of nitrogen along with required dose of phosphorus and potassium as basal dose and remaining 50 per cent of N was applied in two splits as top dressing at 25 and 45 DAS. Zinc was applied at the rate of 10 kg $ha^{-1}$ through $ZnSO_4$ and boron was applied in the form of borax at the rate of 2 kg $ha^{-1}$. Bio-fertilizers were applied @ 5 kg $ha^{-1}$ at the time of sowing after incubation with FYM in a ratio of 1:10 of bio-fertilizers to maize. Also, the bio-fertilizers were combined in a ratio of 1:1 of *P. fluorescens* to *B. megaterium* for $T_3$, $T_7$ and $T_{11}$ and in 1:1:1 ratio of *P. fluorescens* to *B. megaterium* to *A. brasilense* for $T_4$, $T_8$ and $T_{12}$.

The root length was observed at 30, 60 and 90 DAS. Five plants were taken at random and were pulled out without causing damage to the roots. The root zone areas were initially saturated to allow easy pulling of the plants. The roots were then washed in running water and the root length was measured using a scale and is expressed in centimeters. The root volume was measured by water displacement method and expressed in $cm^3$ $plant^{-1}$. Five plants were selected randomly from bulk plot and used for recording root biomass at 30, 60, 90 DAS. The roots were separated and initially dried under sun followed by oven drying at 65℃. The mean of the dried samples were recorded and expressed as g $plant^{-1}$.

Stover, cob sheath, rind and kernels collected at harvest were analyzed for nitrogen, phosphorus and potassium. Plant samples ground into a fine powder using a mixer grinder after oven drying at 65±5 ºC and then used for analysis using standard methods. The concentration of N, P and K, in maize plant were multiplied by total dry matter of leaves, stem and kernel yield at harvest to obtain uptake of N, P and K expressed as kg $ha^{-1}$. The nutrient use efficiencies for primary nutrients were calculated by using the following formula:

$$\text{Nutrient use efficiency} = \frac{\text{Kernel yield (kg ha}^{-1}\text{)}}{\text{Total fertilizer applied (kg ha}^{-1}\text{)}}$$

**Statistical Analysis and interpretation of data**

The analysis and interpretation of the data was done using the Fisher's method of analysis of variance technique as given by Panse and Sukhatme (1967). The level of significance used in F and t test was at 5% probability. Wherever 'F' test was found significant, 't' test was used to estimate critical differences among various treatments [6].

**Results and Discussion**

The results of the experiment revealed that root parameters of maize *viz.*, root length, root volume, root biomass at 30, 60 and 90 DAS (Table 1) were significantly higher with the application of 75, 100 and 125 per cent of recommended dose of phosphorus fertilizer along with PGPR II and superior over application of 100 per cent recommended dose of phosphorus. The increased root length and biomass could be a result of increased cell elongation and multiplication due to enhanced nutrient uptake of plants following inoculation with PSB. It can also be attributed to the production of plant growth promoting substances in the vicinity of roots by PSB and enhanced uptake of nitrogen due to nitrogen fixation by *Azospirillum*. The results are in agreement with the findings of Ravikumar *et al.* [8] for root length, number of roots and root biomass in rice and Hameeda *et al.* [3] for root length in maize. The kernel yield was significantly higher over control in all the treatments involving bio-fertilizers except $T_1$, $T_5$ and $T_9$. The stover yield was significantly higher over control in all the treatments involving bio-fertilizers (Fig. 1). The improved yield may be attributed to the increased grain filling due to enhanced nutrient uptake and increased photosynthesis. These results were also in conformity with Kushare *et al.*[4] for grain and straw yield in maize and for number of productive tillers per plant, number of filled grains per panicle, test weight, grain and straw yield in rice.

**Table 1:** Root parameters of maize as affected by PGPR and PSB under varying levels of phosphorus

| Treatments | Root length (cm) | | | Root volume (cc) | | | Root biomass (g) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS |
| $T_1$ | 14.30 | 26.07 | 46.96 | 3.40 | 11.78 | 26.65 | 4.43 | 27.79 | 60.48 |
| $T_2$ | 15.70 | 28.57 | 49.46 | 3.56 | 12.37 | 27.90 | 4.43 | 27.80 | 60.95 |
| $T_3$ | 16.17 | 29.83 | 50.73 | 3.23 | 12.57 | 27.11 | 4.45 | 28.32 | 61.28 |
| $T_4$ | 18.53 | 32.57 | 53.46 | 4.17 | 12.54 | 29.08 | 4.57 | 28.63 | 63.65 |
| $T_5$ | 14.60 | 26.67 | 47.36 | 3.72 | 12.53 | 27.06 | 4.43 | 27.83 | 60.75 |
| $T_6$ | 15.07 | 27.63 | 48.53 | 3.84 | 12.43 | 27.30 | 4.43 | 27.93 | 60.81 |
| $T_7$ | 15.43 | 27.33 | 48.26 | 3.90 | 12.57 | 27.44 | 4.45 | 28.26 | 61.41 |
| $T_8$ | 18.63 | 32.42 | 53.32 | 4.24 | 12.88 | 31.72 | 4.57 | 28.77 | 64.48 |
| $T_9$ | 15.17 | 27.83 | 48.73 | 3.31 | 10.81 | 29.31 | 4.43 | 27.93 | 60.25 |
| $T_{10}$ | 15.57 | 28.63 | 49.53 | 3.23 | 11.60 | 30.77 | 4.43 | 28.07 | 60.35 |
| $T_{11}$ | 16.07 | 29.63 | 50.53 | 3.62 | 12.08 | 31.24 | 4.45 | 28.32 | 61.41 |
| $T_{12}$ | 19.13 | 32.42 | 53.32 | 4.07 | 12.73 | 31.89 | 4.58 | 28.87 | 64.31 |
| $T_{13}$ | 12.83 | 23.20 | 44.10 | 4.36 | 12.44 | 31.62 | 4.34 | 26.68 | 57.45 |
| S.Em± | 0.33 | 0.40 | 0.35 | 0.26 | 0.38 | 0.63 | 0.02 | 0.12 | 0.61 |
| CD @ 5% | 0.97 | 1.18 | 1.03 | 0.76 | 1.10 | 1.83 | 0.07 | 0.36 | 1.78 |

The readily available and adequate quantity of nutrients in accordance with growth are very much important in many physiological processes controlling growth and development in plants. $T_4$ recorded on par nitrogen, phosphorus and potassium uptake (231.06, 69.79 and 139.26 kg $ha^{-1}$ respectively) with $T_8$ and $T_{12}$ which was significantly higher than the control (205.00, 58.40 and 90.32 kg $ha^{-1}$ respectively). $T_4$ also recorded on par nitrogen and potassium use efficiency with $T_8$ and $T_{12}$ which was significantly higher than the control. Significantly higher phosphorus use efficiency was recorded with $T_4$ over control. The increased soil availability of nutrients due to the increased mobilization of soil applied and native nutrient by the microbes has caused the increased uptake of nutrients. The root biomass influenced by PGPR II may also have influenced the nutrient uptake. The higher uptake of nutrient as well as higher nutrient use efficiency may be attributed to the higher availability of nutrient as well as higher root growth due to the use of bio-fertilizers. The higher N, P and K accumulation is associated with more biomass yield of the plant. The results are in accordance with the findings of Singh *et al.* [9] for NPK uptake of wheat and Singh and Singh [10] for NPK uptake in chickpea.

**Table 2:** Nutrient uptake and nutrient use efficiency of maize as affected by PGPR and PSB under varying levels of phosphorus

| Treatments | Nutrient uptake (kg $ha^{-1}$) | | | NUE (kg $kg^{-1}$) | | |
|---|---|---|---|---|---|---|
| | N | P | K | N | P | K |
| $T_1$ | 213.00 | 66.07 | 109.12 | 47.95 | 127.87 | 179.82 |
| $T_2$ | 216.10 | 68.17 | 116.56 | 52.17 | 139.11 | 195.62 |
| $T_3$ | 218.30 | 66.70 | 116.24 | 54.87 | 146.31 | 205.74 |
| $T_4$ | 231.06 | 69.79 | 139.26 | 55.86 | 148.97 | 209.48 |
| $T_5$ | 209.77 | 66.17 | 109.36 | 46.25 | 92.50 | 173.44 |
| $T_6$ | 204.30 | 67.37 | 112.24 | 46.82 | 93.63 | 175.56 |
| $T_7$ | 214.90 | 67.97 | 113.68 | 54.81 | 109.62 | 205.54 |
| $T_8$ | 226.40 | 69.80 | 140.88 | 58.12 | 116.25 | 217.96 |
| $T_9$ | 210.60 | 63.67 | 103.36 | 47.78 | 76.45 | 179.19 |
| $T_{10}$ | 214.50 | 67.57 | 112.72 | 52.09 | 83.34 | 195.33 |
| $T_{11}$ | 215.00 | 68.07 | 113.92 | 50.40 | 80.65 | 189.01 |
| $T_{12}$ | 216.40 | 69.80 | 117.68 | 56.13 | 89.81 | 210.50 |
| $T_{13}$ | 205.00 | 58.40 | 90.32 | 43.69 | 87.39 | 163.85 |
| S.Em± | 3.85 | 1.88 | 2.24 | 1.54 | 2.83 | 5.76 |
| CD @ 5 % | 11.23 | 5.48 | 6.53 | 4.48 | 8.25 | 16.81 |

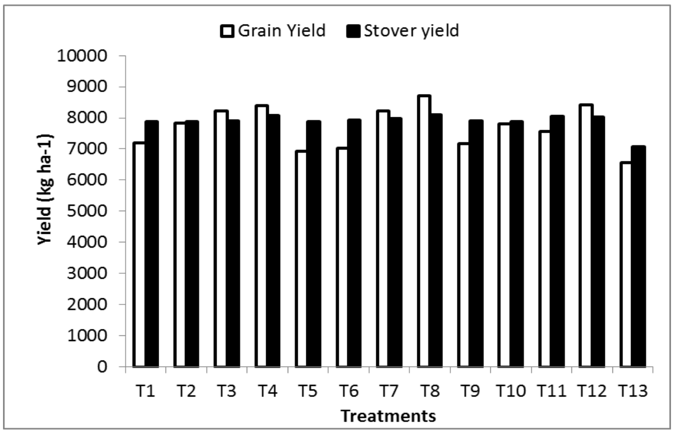


**Fig 1:** Effect of PGPR and PSB on yield of maize under varying levels of phosphorus

## Conclusion

The application of 75, 100 and 125 per cent of recommended dose of phosphorus fertilizer along with PGPR II showed on par root parameters as well as improved nutrient uptake of the crop over the control. A consortia of *Bacillus megaterium, Pseudomonas fluorescens* and *Azospirillum brasilense* (PGPR II) can be effectively used for maize under irrigated conditions with a reduction of use in chemical phosphorus fertilizer to the tune of 25 per cent.

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## References

1. Aghaie P, Kazemeini SA, Majd R, Alebrahim MT. Role of phosphorus in maize (*Zea mays* L.) competitiveness against Velvet leaf (*Abutilon theophrasti*). International Journal of Agronomy and Plant Production. 2013; 4(9):2323-2329.
2. Anonymous. Hand book of agriculture. ICAR Publications, New Delhi, India. 2015, 156-161.
3. Hameeda B, Harini G, Rupela OP, Wani SP, Reddy G. Growth promotion of maize by phosphate solubilizing bacteria isolated from composts and macrofauna. Microbiology Research. 2008; 163:234-242.
4. Kushare BM, Kushare YM, Sandhan VS. Effect of N and P levels and bio-fertilizers on growth and yield of wheat under late sown irrigated conditions. International Journal of Agricultural Science. 2009; 5(2):424-427.
5. Masood T, Gul R, Munsif F, Jalal F, Hussain Z, Noreen N *et al*. Effect of different phosphorus levels on the yield and yield components of maize. Sarhad Journal of Agriculture. 2011; 27(2):167-170.
6. Panse VG, Sukhatme PV. Statistical methods for agricultural workers. ICAR, Publ., New Delhi, 1967, 359.
7. Raghu K, Macrae IC. Occurrence of phosphate-dissolving micro-organisms in the *rhizosphere* of rice plants and in submerged soils. J Appl. Bacteriol. 2000; 29:582-586.
8. Ravikumar S, Shanthy S, Kalaiarasi A, Sumaya M. The Biofertilizer Effect of Halophilic Phosphate Solubilising Bacteria on *Oryza sativa.* Middle-East Journal of Scientific Research. 2014; 19(10):1406-1411.
9. Singh MP, Kumar P, Kumar A, Kumar R, Diwedi A, Gangwar S. *et al*. Effect of NPK with biofertilizers on growth, yield and nutrient uptake of wheat (*Triticum aestivum* L.) in western Uttar Pradesh condition.

Progressive Agriculture. 2016; 16(1):83-87.

10. Singh U, Singh B. Effect of basal and foliar application of diammonium phosphate in cognizance with phosphate-solubilising bacteria on growth, yield and quality of rainfed chickpea (*Cicer arietinum*). Indian Journal Agronomy. 2014; 59(3):427-432.
11. Wani SP, Lee KK. Microorganisms as biological inputs for sustainable agriculture in Organic agriculture (Thampan, P.K.ed.), Peekay Tree Crops Development Foundation, Cochin, India. 1995, 39-76.