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Effect of PGPR and PSB on Soil Chemical Properties, Nutrient Status and Microbial Population Changes after Harvest of Irrigated Maize under Varying Levels of Phosphorus

Yasmin Gulnaz[2*], P.S. Fathima[2], Akhilesh Kumar Kulmitra[1], Amlan Ghosh[3] and A.G. Thejesha[4]

[1]Department of Plant Pathology, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh-492012, India
[2]Department of Agronomy, [3]Department of Soil Science and Agricultural Chemistry, [4]Department of Plant Pathology, University of Agricultural Sciences, GKVK, Bangalore-560065, Karnataka, India
**Corresponding author*

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A B S T R A C T

A field experiment was conducted 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% of recommended dose) and various phosphorus biofertilizers and Plant Growth Promoting Rhizosphere (PGPR) and their combinations. The experiment was laid out in RCBD with three replications. The type of soil was sandy loam. The maize hybrid used was NAH-1137. The results revealed that, the application of 75, 100 and 125% of recommended dose of phosphorus fertilizer along with PGPR II (*Pseudomonas fluorescens* + *Bacillus megaterium* + *Azospirillum brasilense)* improved the soil nutrient status as well as biological properties of the soil by increasing the population off beneficial microbe in the soil. The population of free-living N-fixers and phosphate fixers were higher with T_4, T_8 and T_{12}. This has also resulted in increased kernel and straw yield in these treatments.

Introduction

Maize (*Zea mays* L.), the sole cultivated member of the genus Zea and tribe Maydeae is known as the queen of cereals. It is a sturdy, annual, tropical C_4 plant which is photo-insensitive, having its origin in Mexico and Guatemala (Ta and Wieland, 1992) [10]. Maize is a very versatile crop and is cultivated on all the altitudes and fertility conditions making it a remarkable cereal crop having global importance (FAO, 2012)[4].

Maize ranks third in the world after rice and wheat among cereals (FAO, 2012)[4]. It is one of the most traded cereals with a total estimated global production of 885.3 million tons and productivity of 5.22 t ha^{-1}. In India it is mainly grown in Andhra Pradesh, Rajasthan, Madhya Pradesh, Bihar, Uttar Pradesh and Karnataka (FAO, 2012)[4]. India stands 4th in area and 7th in production in the world with an area of 8.78 mha, production of 21.75 mt and productivity of 2.6 t/ha (Anon,

2015)[3]. In India about 28% of maize is used for food purpose, 11% for livestock, 48% as poultry feed, 12% by milling industry and 1% as seed (Anon, 2007)[2]. Accompanied with rice and wheat, maize provides about 30% of the food calories for more than 4.5 billion people in 94 developing countries (Thomas, 2012)[11]. For balancing consumer demand for various end-uses of maize it is critical to improve its productivity. This can be achieved by improving the soil health by reducing the population of disease causing microbes and increasing the beneficial microbes in the soil. These beneficial microbes can also improve the soil nutrient status after the harvest of crop.

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 agro climatic zone VI of Karnataka. The soil of the experimental site was sandy loam with an average particle content of 56.4% coarse sand, 11.6% fine sand, 15.2% silt and 16.8% clay. The soil was neutral in reaction (pH 7.13), organic carbon content was medium (0.59%) with an 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}).

Initially, the soil had a population of 8.16 x 10^2 cfu g^{-1} soil of free living N-fixers, 2.54 x 10^4 cfu g^{-1} soil of phosphate solubilizers, 2.35 x 10^4 cfu g^{-1} soil of cellulose degrading microbes and 3.11 x 10^4 cfu g^{-1} soil of pseudomonads. 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% of nitrogen along with required dose of phosphorus and potassium as basal dose and remaining 50% 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}.

Biofertilizers were applied @ 5 kg ha^{-1} at the time of sowing after incubation with FYM in a ratio of 1:10 of biofertilizers to maize. Also, the biofertilizers 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 population of Azotobacter in the soil samples collected from each plot was calculated by the standard dilution plating technique using Waksman's medium NO. 77. The plates were incubated at 30 ^{0}C for 4-5 days and the number of colonies were counted and expressed as colony forming units (cfu g^{-1} dry soil). Similarly, the population of phosphate solubilizing microorganisms in soil samples collected from each plot was

estimated by the standard dilution plating technique using Sperber's hydroxy apatite medium. The plates were incubated for 4-5 days and those colonies that produced a zone of solubilization around their growth were counted and expressed as colony forming units (cfu g^{-1} dry soil).

The population of cellulose-degrading microbes in the soil samples collected from each plot was enumerated by the standard dilution plating technique using Dubo's cellulose medium. The plates were incubated for 4-5 days and the number of colonies of bacteria and fungi were counted and expressed as colony forming units (cfu g^{-1} dry soil).

The population of pseudomonads in the soil samples collected from each plot was estimated by the standard dilution plating technique using King's B medium for pseudomonads. The plates were incubated at 30 ^{0}C for 3-4 days and the population was expressed as colony forming units (cfu g^{-1} soil).

Results and Discussion

The results of the experiment revealed that soil chemical properties like pH and EC were statistically on par. However, the soil pH and electrical conductivity varied between the treatments from 6.91 to 7.15 and 0.11 to 0.19 dS m^{-1}, respectively. But organic carbon content differed significantly by the influence of PGPR and phosphorus biofertilizers under varying levels of phosphorus. T_8 recorded higher carbon content (0.65 %) which was on par with all other treatments but significantly higher than the control (0.54 %).

The soil nitrogen content measured at harvest differed significantly. The higher soil nitrogen content was recorded with T_8 (181 kg ha^{-1}) which was on par with T_{12} (180.23 kg ha^{-1}) and T_4 (179.33 kg ha^{-1}) and superior over other treatments. Significantly lower soil nitrogen content was obtained with control (165.58 kg ha^{-1}).

The higher soil phosphorus content was recorded with T_{12} (52.70 kg ha^{-1}) which was on par with T_8 (51.08 kg ha^{-1}) and T_4 (51.80 kg ha^{-1}) and superior over control (31.55 kg ha^{-1}) (Fig. 1). The soil potassium content was recorded with T_8 (177.11 kg ha^{-1}) which was on par with T_{12} (172.43 kg ha^{-1}) and T_4 (167.83 kg ha^{-1}) and superior over T_{13} (148.90 kg ha^{-1}).

The improved soil nutrient status is due to the increased mobilization of soil applied and native nutrient by the microbes. The root biomass influenced by PGPR II may also have influenced the nutrient uptake.

The higher N, P and K accumulation is associated with more biomass yield of the plant. The results are in line with the findings of Singh *et al.*, (2016)[8] for NPK uptake of wheat and Singh and Singh (2014)[9] for NPK uptake in chickpea (Table 1).

The microbial population differs significantly during the harvest. The higher population of free living N-fixers was observed with T4, T8 and T12 which was significantly higher than the other treatments. All the treatments involving the use of biofertilizers have significantly increased the population of phosphate solubilisers, cellulose degrading microbes and pseumonads as compared to control.

The increase in N-fixing and P-solubilisers may be due to the external addition of biofertilizers along with FYM. Also higher root biomass and straw yield may have contributed to increased organic matter in the soil as is relevant fron the soil organic carbon content at harvest.

Table.1 Chemical properties and NPK status (kg ha^{-1}) of the soil after harvest as influenced by PGPR and phosphorus bio-fertilizers under varied levels of phosphorus

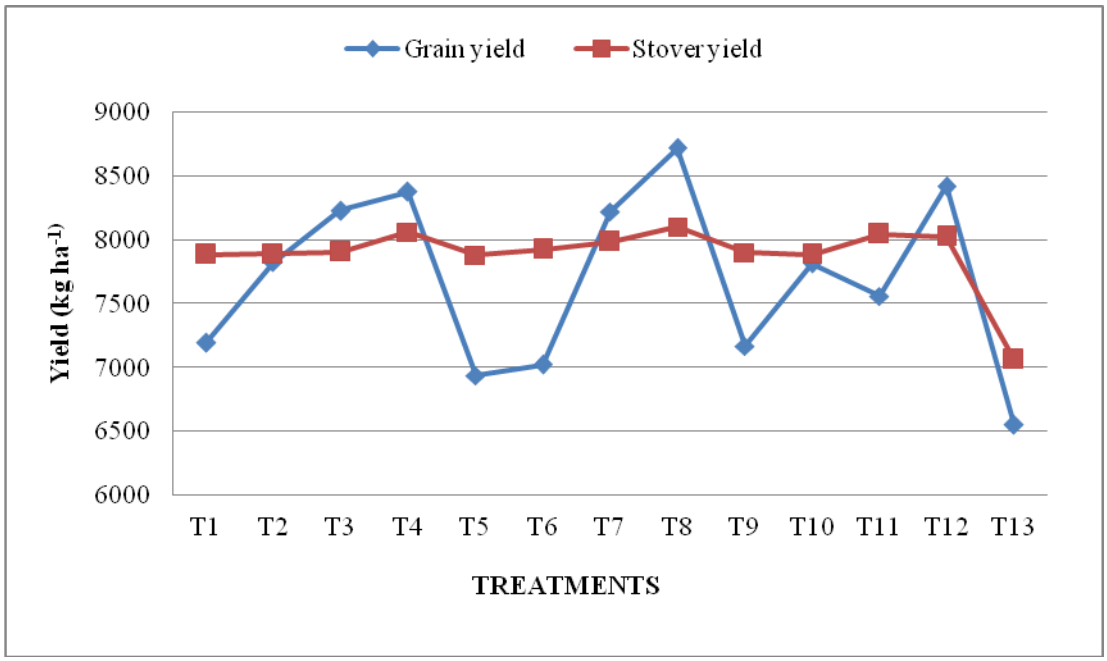
Treatments	pH	EC(dS m^{-1})	OC (%)	N	P_2O_5	K_2O
T_1	7.00	0.12	0.62	166.30	38.27	146.10
T_2	7.05	0.11	0.62	67.70	40.07	150.90
T_3	7.01	0.17	0.63	166.50	39.40	144.93
T_4	7.06	0.13	0.65	179.33	51.80	167.83
T_5	6.91	0.19	0.62	165.58	37.55	155.38
T_6	6.94	0.17	0.62	166.98	39.35	160.18
T_7	7.12	0.13	0.60	165.78	38.68	154.21
T_8	7.15	0.11	0.65	181.65	51.08	177.11
T_9	7.09	0.15	0.61	167.20	39.17	150.70
T_{10}	6.94	0.11	0.62	168.60	40.97	155.50
T_{11}	7.12	0.17	0.60	167.40	40.30	149.53
T_{12}	7.15	0.11	0.65	180.23	52.70	172.43
T_{13}	7.09	0.14	0.54	165.58	31.55	148.90
S.Em ±	0.09	0.03	0.02	3.54	2.07	4.29
CD @ 5%	NS	NS	0.05	10.35	6.04	12.53

PGPR: Plant Growth Promoting *Rhizobacteria*, DAS: Days after sowing, NS: Non Significant

Table.2 Microbial population in the soil after harvest as influenced by PGPR and phosphorus bio-fertilizers under varied levels of phosphorus

Treatments	Free-living N-fixers (cfu x 10^2 g^{-1} soil)	P-solubilisers (cfu x 10^4 g^{-1} soil)	Cellulose degrading microbes (cfu x 10^4 g^{-1} soil)	Pseudomonads (cfu x 10^4 g^{-1} soil)
T_1	8.74	4.74	4.13	6.19
T_2	8.54	4.30	3.60	5.76
T_3	8.94	4.17	3.80	5.63
T_4	10.98	4.47	3.77	5.93
T_5	8.81	4.03	3.66	5.49
T_6	8.61	3.74	3.37	5.19
T_7	9.01	5.02	4.38	6.48
T_8	10.93	5.12	4.42	6.58
T_9	8.34	3.90	3.58	5.28
T_{10}	8.68	4.65	3.82	6.11
T_{11}	8.81	4.52	3.82	5.98
T_{12}	10.76	4.45	3.75	5.91
T_{13}	8.36	2.76	2.48	3.16
S.Em ±	0.26	0.39	0.26	0.39
CD @ 5%	0.75	1.13	0.77	1.12

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



These results are in accordance with the results published by Mikanova *et al.*, (2009)[7], who showed that nitrogen fertilisation in organic form (FYM) increased the counts of *Azotobacter* spp. Further, the phosphorus that is present in soil added through fertilizers is reported to affect the activity of phosphatases (Kiss *et al.*, 1975)[6]. This increased the phosphorus status of soil and improved microbial growth.

The abundance of cellulose degrading microorganisms was significantly higher with the application of FYM compared to all other treatments (Table 2). This could be due to increase in organic matter which serves as carbon source for the growth of cellulose decomposing microorganisms. Similar results have also been obtained by Andreas *et al.*, (2008)[1] who reported that the population densities of cellulolytic bacteria were significantly increased by the manure application in Phaeozem. Further, presence of organic residues have shown that *Serratia marcescens* and *Pseudomonas* sp. were significantly higher and have shown to possess the population of higher cellulolytic activity (Hameeda *et al.*, 2006)[5].

The application of 75, 100 and 125% of recommended dose of phosphorus fertilizer along with PGPR II showed on par soil nutrient status as well as improved microbial population of soil over the control. A consortia of *Bacillus megaterium*, *Pseudomonas fluorescens* and *Azospirillum brasilense* (PGPR II) can be effectively used for maize under irrigated conditions for improving chemical and biological properties of soil.

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References

Andreas, K., Gabriele W, Stephan. Diversity and Activity of Cellulose-Decomposing Bacteria, Isolated from a Sandy and a Loamy Soil after Long-Term Manure Application. Microbiol Ecol. 2008; 55: 512-522.

Anonymous. Annual Reports 2007-08, Directorate of Maize Research, New Delhi. 2007.

Anonymous. Annual Reports 2011-12, Directorate of Maize Research, New Delhi. 2015.

FAO, Agriculture production year book. Food and Agriculture Organization of United Nations, Rome. 2012.

Hameeda, B., Rupela OP, Reddy G, Satyavani K. Application of plant growth-promoting bacteria associated with composts and macrofauna for growth promotion of Pearl millet (*Pennisetum glaucum* L.). Biol. Fert. Soils. 2006; 43: 221-227.

Kiss, S., Dragon BM, Radubes R. Biological significance of enzymes accumulated in soils. Adv. Agron. 1975; 27: 25-87.

Mikanova, O., Ustak, Czako. Soil Utilization of Microbial Inoculation and Compost for Revitalization of Soils. Soil and Water Res. 2009; 4: 126–130.

Singh, M.P., 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. Prog. Agric. 2016; 16(1):83-87.

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 J. Agron. 2014; 59(3):427-432.

Ta, C.T., Wieland RT. Nitrogen partitioning in maize during ear development. Crop Sci. 1992; 32: 443-451.

Thomas, A. Help for developing countries in a world of rising grain prices, CIMMYT. 2012.

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