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Effect of PGPR and PSB on the quality of irrigated maize under varying levels of phosphorus

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Abstract
A field experiment was conducted during *kharif*, 2015 at College of Agriculture, V. C. Farm, University of Agricultural Sciences, Bengaluru. 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 Rhizobacteria (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 protein content and grain phosphorus content in maize.

Keywords: biofertilizers, pgpr, phosphorus and psb

Introduction
Maize (*Zea mays* L.) is cultivated globally being one of the most important cereal crops and most widely distributed crops of the world. It is cultivated in tropics, sub-tropics and temperate regions. Tremendous choice is available as regard to varieties maturing in 85 days to more than 200 days with variability in seed colour and texture etc, hence it is an extremely versatile crop of the world.
The importance of corn in the food chain is continuously growing and this trend is being recognized by locally and internationally. In fact other than its food and feed uses, corn is now renewable source of energy which used as raw material for ethanol production. With this economic development corn is no longer just a commodity it is commerce. Because of its immense potentiality for adoption, high yield and nutritive value, it is known as 'King of crops' and 'Queen of cereals'.
Maize occupies third place in the world after rice and wheat among cereals. It is one of the most traded cereals with an estimated total global production of 885.3 million tons with a productivity of 5.22 t/ha. In India it is mainly grown in Andhra Pradesh, Rajasthan, Madhya Pradesh, Bihar, Uttar Pradesh and Karnataka (FAO, 2012) [7]. India ranks 4th in area and 7th in production in the world with an acreage of 8.78 mha, production of 21.75 mt and productivity of 2.6 t/ha (Anon, 2011) [4].
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) [3]. 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]. To counter the problem of malnutrition of the increasing population, it is critical to improve the qualitative aspects of the crop. This can be achieved by improving essential nutrient content and proximate content in maize with the help of micro-organisms.

Material and Methods
A field experiment was conducted at Department of Agronomy, College of Agriculture, V.C. Farm, UAS, Bengaluru 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}). The field experiment was laid out in RCBD with three replications 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}.

Seed moisture content

A required sample of matured seeds were taken. The seeds were dried by using oven at 60°C more than 8 hours. The moisture content of the seed was determined by heating at 110°C for 24 hours in an oven and seed moisture was determined by the procedure described by AOAC (1990) [5].

Protein content

Protein content was determined by estimating the grain nitrogen content by Kjeldahl method and multiplying 6.25 to the estimated nitrogen content.

Protein content= N content X 6.25

Fat content

The fat content was determined by hexane extraction (submersion) method given by Thiex *et al.*, 2003 [10].

Seed phosphorus content-

The Phosphorus content was calculated by Di acid digestion and vanadomolybdate method (Piper, 1966) [9].

Results and Discussions

The proximate content of maize seed *viz.*, seed moisture content, seed protein content, fat content and grain phosphorus content as influenced by PGPR and phosphorus biofertilizers under varying levels of phosphorus are presented in the Table 1. Seed moisture content and fat content were statistically on par. However, they varied between the treatments from 23.18 per cent to 24.56 per cent and 3.69 per cent to 3.81 per cent respectively.

Application of 75 per cent of recommended dose of phosphorus fertilizer along with PGPR II recorded superior protein content (8.43 %) and grain phosphorus content (0.427 %) which was on par with the application of 100 per cent and 125 per cent of recommended dose of phosphorus fertilizer along with PGPR II and significantly higher than the application of 100 per cent recommended dose of phosphorus. The fat content of maize was not significantly affected by the treatments. The increased availability of nitrogen and phosphorus increased the nitrogen accumulation and ultimately reflected on the development of protein and grain phosphorus content. This result has been confirmed by Afzal and Bano (2008) [1] for seed phosphorus content in wheat and Akbari *et al.* (2011) [2] for protein and oil content in sunflower. Biofertilizers also improves the increase of irrigated maize (Table 2). The significant improvement in the yield could be due to application of biofertilizers to the root zone which led to increased nutrient supply, thereby favouring higher uptake of nutrients and production of improved growth parameters which resulted in higher kernel and stover yield of maize over the control. These results were also in line with Kushare *et al.* (2009) [8] for grain and straw yield in maize and Chinnusamy *et al.* (2006) [6] for the number of productive tillers per plant, number of filled grains per panicle, test weight, grain and straw yield in rice.

Table 1: Proximate content of kernels as influenced by PGPR and phosphorus biofertilizers under varied levels of phosphorus

Treatments	Moisture content (%)	Protein content (%)	Fat content (%)	Grain P content (%)
T_1: 75% Rec. P + *Bacillus megaterium*	24.18	6.65	3.77	0.316
T_2: 75% Rec. P + *Pseudomonas fluorescens*	23.75	7.49	3.71	0.391
T_3: 75% Rec. P + PGPR-I (*P. fluorescens* + *B. megaterium)*	23.61	7.61	3.75	0.392
T_4: 75% Rec. P + PGPR-II (*P. fluorescens* + *B.megaterium* + *Azospirillum brasilense)*	23.91	8.43	3.77	0.427
T_5: 100% Rec. P + *Bacillus megaterium*	23.47	6.67	3.75	0.316
T_6: 100% Rec. P + *Pseudomonas fluorescens*	23.18	7.51	3.74	0.392
T_7: 100% Rec. P + PGPR-I	24.46	7.62	3.74	0.393
T_8: 100% Rec. P + PGPR-II	24.56	8.44	3.79	0.429
T_9: 125% Rec. P + *Bacillus megaterium*	24.10	6.67	3.77	0.315
T_{10}: 125% Rec. P + *Pseudomonas fluorescens*	23.96	7.51	3.78	0.391
T_{11}: 125% Rec. P + PGPR-I	23.90	7.63	3.72	0.392
T_{12}: 125% Rec. P + PGPR-II	23.76	8.66	3.73	0.428
T_{13}: 100% Recommended Phosphorus (Rec. P) (Control)	23.26	6.15	3.63	0.260
S.Em ±	0.45	0.20	0.04	0.012
CD @ 5%	NS	0.59	NS	0.036

Table 2: Yield of maize as influenced by PGPR and phosphorus biofertilizers under varied levels of phosphorus

Treatments	Per cent increase over control	Per cent increase over control
T_1: 75% Rec. P + *Bacillus megaterium*	9.88	11.65
T_2: 75% Rec. P + *Pseudomonas fluorescens*	12.78	11.68
T_3: 75% Rec. P + PGPR-I (*P. fluorescens* + *B. megaterium)*	26.90	11.92
T_4: 75% Rec. P + PGPR-II (*P. fluorescens* + *B. megaterium* + *Azospirillum brasilense)*	27.92	14.15
T_5: 100% Rec. P + *Bacillus megaterium*	6.00	11.57
T_6: 100% Rec. P + *Pseudomonas fluorescens*	7.20	12.25
T_7: 100% Rec. P + PGPR-I	25.53	13.08
T_8: 100% Rec. P + PGPR-II	33.21	14.70
T_9: 125% Rec. P + *Bacillus megaterium*	9.98	11.86
T_{10}: 125% Rec. P + *Pseudomonas fluorescens*	19.43	11.65
T_{11}: 125% Rec. P + PGPR-I	15.59	13.86
T_{12}: 125% Rec. P + PGPR-II	28.90	13.69
T_{13}: 100% Recommended Phosphorus (Control)	-	-
S. Em ±	2.15	1.57
CD @ 5%	6.27	4.59

Conclusion

The application of 75, 100 and 125% of recommended dose of phosphorus fertilizer along with PGPR II showed on par protein content and seed phosphorus content over the control. A consortia of *Bacillus megaterium*, *Pseudomonas fluorescens* and *Azospirillum brasilense* (PGPR II) can be effectively used for improving the quality of maize under irrigated conditions.

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