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RESEARCH PAPER

Comparative study of PSB and NPK consortia affecting the yield attributes of hybrid maize

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Abstract : The experiment was conducted during *Kharif* season of 2016 for analyzing the response of different biofertilizers and varying doses of fertilizers on yield attributes of hybrid maize at Agronomy Main Research Farm, Orissa University of Agriculture and Technology Bhubaneswar. The experiment was laid out in a randomised block design replicated thrice with 12 treatment combinations. Among the different liquid biofertilizer treatment combinations, the combined application of NPK consortia + RDF (T_{11}) resulted in maximum cob length (22.2 cm), grain weight cob^{-1} (194.49 g), and other yield attributing characters at harvest. Similarly, application of 60 Kg P_2O_5 ha^{-1}+ NPK consortia along with recommended doses of N and K, produced maximum grain yield (6.51 t ha^{-1}) which was at par with T_{12}, T_{10} and T_9 and superior to all other biofertilizer management practices. Thus, under the same level of nutrients, NPK consortia proved to be the best followed by PSBII and PSBI among the three biofertilizers used for inoculation of maize seeds. This might be due to presence of all types of biofertilizers (N fixing- *Azotobacter,* P solubilising- *Burkholderia,* K solubilising- *Bacillus*) bacteria in NPK consortia. Combined application of inorganic source of nutrient and biological fertilizer gave the highest crop yield in this study.

Key Words : Rhizobacteria, Consortia, Inoculants, Soil fauna, PSB, Biofertilizer, Inorganic

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INTRODUCTION

Maize is an important staple food for human being and quality feed for animals. It plays a key role in crop diversification strategy in place of upland paddy. The major maize growing states are Karnataka, Madhya Pradesh, Maharashtra, Bihar and Rajasthan. Being "the queen of cereals" it is the third major cereal crop next to rice and wheat in the world. Hybrid maize is a heavy feeder and more responsive to nutrients and the required amount of nutrients may be supplied through organic manures and inorganic fertilisers to grow it and to maintain soil fertility on a sustained manner. Supplementing a heavy feeder crop with chemical fertilizers will not only deteriorate the quality of the crop but also degrade the soil qualitative traits.

Meeting the rising demand of food, keeping our environment safe and healthy should be our ultimate goal. But in contrast, the growers have added chemicals haphazardly into our mother soil. Attaining higher

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production at one go through chemicals would definitely degrade our soil. Instead, organic nutrient sources such as bio-fertilizers must be brought into use because of their cost effectiveness and environment friendly nature. The bio fertilizers are known to solubilise the residual nutrient content in the soil and make them available for plants. In this way, they act as enhancers of nutrient availability. These microbes are naturally found in the soil fauna, but their populations are quite minimal to support higher crop yield. Their population is artificially multiplied for the same purpose. These may be either soil inoculants or seed inoculants. Seeds are primed with liquid biofertilizers and after some time lapse, they are sown in the field. Rhizosphere activity allows the transformation, mobilisation and solubilisation of nutrients from a limited pool in the soil and subsequent uptake of essential nutrients by plants to achieve crop genetic potential (Hisinger *et al*., 2011). The phosphate solubilising bacteria (PSB) are rhizobacteria that convert insoluble phosphates into soluble forms through acidification, chelation, exchange reactions and production of organic acids (Rodriguez and Fraga, 1999). NPK consortia is liquid microbial inoculants in which N-fixing, P-solubilizing and K-mobilizing microbes are clubbed together.

MATERIAL AND METHODS

Field experiment was conducted during *Kharif* season of 2016 in the Agronomy Main Research Farm, OUAT, Bhubaneswar situated at 20015' N latitude and 85052' E longitude at about 65 km away from Bay of Bengal at an elevation of 25.9 m above mean sea level (MSL). During the experimentation, cumulative rainfall was 713.6 mm, while mean maximum and minimum temperature of 32.1^{0}C and 26.4^{0}C, respectively. The soil of the experimental site was sandy loam with sand 82.7%, silt 7.7% and clay 9.6% and pH 5.23, organic carbon 0.67%, low in available N (151.15 kg ha^{-1}), high in available P (62.5 kg ha^{-1}) and low in available K (101.92 kg ha^{-1}). The experiment was laid out in a randomised block design replicated thrice with 12 treatment combinations *viz.,* T_1-Control(No P),T_2-PSB I *(Pantoea agglomerans)*, T_3-PSB II *(Burkholderia cepacia)*, T_4-NPK consortia (N fixing- *Azotobacter,* P solubilising-*Burkholderia,* K solubilising- *Bacillus)*, T_5-60 kg P_2O_5 ha^{-1}, T_6-30 kg P_2O_5 ha^{-1}+ PSB I, T_7-60 kg P_2O_5 ha^{-1}+ PSB I, T_8-30 kg P_2O_5 ha^{-1}+ PSB II, T_9-60 kg P_2O_5 ha^{-1}+ PSB II, T_{10}-30 kg P_2O_5 ha^{-1}+ NPK consortia, T_{11}-60 kg P_2O_5 ha^{-1}+ NPK consortia, T_{12}-only 90 kg P_2O_5 ha^{-1} Both N and K were applied in all treatments as per recommendation. NPK consortia contains 10^9 cfu/ml of nitrogen fixing *(Azotobacter),* P solubilising (*Burkholderia cepacia*) and K-solubilising (*Bacillus* sp.) whereas PSB I is Phosphate solubilising bacteria containing *Pantoea agglomerans* and PSB II is Phosphate solubilising bacteria containing *Burkholderia cepacia.* The seeds of maize variety P3501 were sown in each plot of 20m^2 size. The weeds were eliminated from each plot by hand weeding. Standard procedures were adopted for recording the data on various growth and yield parameters. Data collected were statistically analyzed by using Fisher's analysis of variance technique.

RESULTS AND DISCUSSION

The relevant results of the research has been given in the Table 1. Under the same level of nutrients, NPK consortia proved to be the best followed by PSBII and PSBI among the three biofertilizers used for inoculation of maize seeds. Plants inoculated with NPK consortia and supplied with 60 Kg P_2O_5 ha^{-1} + recommended N and K (T_{11}) resulted in maximum cob length (22.2 cm) and cob girth (15.79cm) The maximum number of rows cob^{-1} (15.75) was registered in T_{11} treatment which was at par with T_5 (15.27) which was supplied with inorganic source of nutrients only (N+ 60 kg P_2O_5 ha^{-1} + K). Under same level of nutrient management *i.e* (N+ 60 kg P_2O_5 ha^{-1} + K), inoculation by NPK consortia yielded highest number of grains row^{-1} in general. The maximum value (38) was observed in plants grown with RDF of N, P and K + NPK consortia (T_{11}) which was closely followed by treatments receiving the maximum dose of chemical fertilizer alone (T_{12}). The maximum number of total grains per cob was recorded in plants inoculated with NPK consortia and supplied with 60 kg P_2O_5 ha^{-1}

Table 1: Yield attributing characters and yield of hybrid maize as influenced by different nutrient management practices

Treatments	Grain weight cob^{-1}(g)	Test weight(g)	Cob length (cm)	Cob girth (cm)	No. of rows cob^{-1}	No. of grains row^{-1}	No. of grains cob^{-1}	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index(%)
T_1- Control(No P)	151.05	305.75	19.8	14.37	13.43	34.80	467.65	4.24	7.96	34.17

combined with inorganic source of recommended N and K; whereas the least number was reported in control treatment (T_1). The highest grain weight per cob was registered in the treatment receiving 60 kg P_2O_5 ha^{-1} + NPK consortia + recommended N and K and was superior to all other treatments whereas the least grain weight per cob was recorded in the treatment without bio-fertilizer and inorganic supplement (T_1).

The maximum test weight (383.47g) was noticed in the treatment (T_{11}) when NPK consortia inoculated seeds were sown and applied with recommended N, P and K through chemical fertilizer which closely resembled T_{12} treatment (371.26 g) with application of recommended N and K along with 90 kg P_2O_5 ha^{-1} through fertilizers only. Application of 60 kg P_2O_5 ha^{-1} + NPK consortia + recommended N and K. The same treatment gave the maximum grain yield of 6.51 t ha^{-1} being at par with T_{12}, T_{10} and T_9. The treatment without phosphorus source (T_1) marked the lowest grain yield (4.24 t ha^{-1}). Similar to the grain yield, the stover yield was also recorded highest in T_{11} treatment which was at par with T_{12}, T_{10} and T_9. The lowest stover yielding treatment was T_1 (Control/no P) which reduced stover yield by 28.9% as compared to highest yielding treatment $T_{11.}$ Combined application of recommended dose of (N, P and K) chemical fertilizer with NPK consortia recorded highest harvest index value (37.18%) whereas the lowest harvest index(34.17%) was noticed when no phosphorus was applied (T_1).

Of the total grain weight in maize, 20 to 30 % comes from the dry matter accumulated during pre flowering stage and 70 to 80 % during post flowering stage. The sink is composed of cob length, grains row^{-1}, cob diameter, and number of grains cob^{-1} and their weight. All these factors have been found to be markedly influenced by the genotype and supplementation of nutrients during period of study.

The treatments which were supplied with single type of biofertilizer in combination with inorganic fertilizers did not responded as high as that of the consortia applied treatments under the same level of nutrient management. The probable reason behind this may be involvement of all types of biofertilizer source in consortia *i.e.* N-fixing, P-solubilizng and K-mobilizing bacteria. Also, there must be definite addition of recommended dose of the chemical fertilizer in order to raise the efficiency of biofertilizers being used.

The yield attributing characters like cob length, cob girth, number of rows cob^{-1}, number of grains row^{-1}, number of grains cob^{-1}, grain weight cob^{-1} and test weight are directly responsible for increasing the grain yield. Significant increase in the yield of hybrid maize can be traced back to the significant increase in the yield components. Among the yield components grain weight

Table 2: Different nutrient management practices

Treatments	Grain weight cob^{-1}(g)	Test weight (g)	Cob length (cm)	Cob girth (cm)	No. of rows cob^{-1}	No. of grains row^{-1}	No. of grains cob^{-1}	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)
T_1- Control(No P)	151.05	305.75	19.8	14.37	13.43	34.80	467.65	4.24	7.96	34.17
T_2-PSB I	170.85	323.00	21.2	14.86	14.55	35.33	514.30	5.62	9.85	34.71
T_3-PSB II	172.63	326.90	21.9	14.93	13.63	36.67	507.11	5.68	10.52	35.13
T_4-NPK consortia	175.90	334.43	21.1	14.90	14.77	35.67	546.36	6.12	10.55	35.01
T_5-60 kg P_2O_5 ha^{-1}	179.65	328.88	21.0	15.23	15.27	34.47	526.01	5.90	10.67	35.73
T_6-30 kg P_2O_5 ha^{-1} + PSB I	178.33	343.33	22.0	15.00	14.69	36.80	540.43	5.89	10.57	35.82
T_7-60 kg P_2O_5 ha^{-1} + PSB I	183.69	352.67	20.6	15.12	15.09	36.40	549.05	6.07	10.67	36.63
T_8-30 kg P_2O_5 ha^{-1} + PSB II	188.45	347.00	21.1	14.99	14.63	34.07	498.45	6.08	10.69	36.33
T_9-60 kg P_2O_5 ha^{-1} + PSB II	187.51	354.40	20.3	15.06	13.61	35.80	487.29	6.18	10.79	36.98
T_{10}-30 kg P_2O_5 ha^{-1} + NPK consortia	188.50	357.80	20.4	15.48	14.57	37.07	534.02	6.23	10.8	36.83
T_{11}-60 kg P_2O_5 ha^{-1} + NPK consortia	194.49	383.47	22.2	15.79	15.75	38.00	561.86	6.51	11.2	37.18
T_{12}-90 kg P_2O_5 ha^{-1}	190.94	371.26	21.2	15.49	14.72	37.20	558.85	6.47	10.9	37.02
S.E.±	5.07	4.16	0.47	0.27	0.22	0.69	12.86	0.13	0.18	0.01
C.D. (P=0.05)	14.85	12.21	1.37	0.79	0.63	2.02	37.73	0.39	0.52	0.02

plant^{-1} and number of grains cob^{-1} exerted greater influence on the grain yield of hybrid maize. Among all the bio-fertilizer management practices, the treatment with recommended dose of N, P and K along with NPK consortia (T_{11}) recorded higher values of the both characters whereas treatment fertilised with recommended dose of N and K but no P (T_1) showed the least values. This trend was also followed by other yield parameters. The results are in agreement with the findings of Umesha *et al.* (2014); Kalhapure *et al.* (2013); Azimi *et al*. (2013); Eugene *et al.* (2013) and Yazdani *et al*. (2009). Eugene *et al.* (2013) reported a combination of inorganic fertilizer and biological fertilizer gave the highest crop yield in his study. Also chemical fertilizer combined with biological fertilizer was beneficial to the environment because of the decreased use of chemical fertilizer and use of organic inputs can move to side sustainable agriculture, increase efficiency and decrease use of water.

According to Fathi *et al.* (2012), biological nitrogen and phosphorous fertilizers increased the number of kernel rows per ear of corn, test grain weight and grain yield of maize which also supports the study of Panwar *et al.* (2006); Hameeda *et al.* (2006) and Sani *et al.* (2007).The cob weight obtained (207.63 g) was also maximum in the treatment having recommended dose of NPK + *A. chroococcum* + *B. megaterium*+ *P. fluorescence* + enriched compost (Umesha *et al.,* 2014).

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