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Nutrient Management in Maize (*Zea mays* L.) through Varying NP Level and Bio-fertilizers

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ABSTRACT

An on-farm trial was conducted during *rabi* seasons of 2013-14 and 2014-15 at the farmer's field on pre-selected different locations of Muzaffarpur district of North Bihar considering farmers as replication in order to assess the nutrient management in maize (*Zea mays L.*) crop through varying N, P level and bio-fertilizers. The results revealed that significant impact on grain yield, straw yield, biological yield, harvest index and economics as well as soil fertility status. The grain yield, biological yield and harvest index were obtained significantly highest in the treatment *i.e.* N_{100}-P_{60}-Azotobactor+PSB as compared to N_{100}-P_{75} + only *Azotobacter* and N_{120}-$P_{75}K_{50}$ (RDF) as well as control, where K_2O was applied 50 kg ha^{-1} invariably in all the treatments. The maximum net return and B:C ratio was found in N_{100}-P_{60} along with *Azotobacter* + PSB over N_{100}-P_{75} + *Azotobacter* and RDF. However, the application of *Azotobacter* and PSB with N_{100}-P_{60} was registered net positive balance status in soil in relation to available nitrogen and phosphorus over initial soil status. Hence, application of bio-fertilizers improved fertility status of the soil in sustainable manner.

KEYWORD

azotobactor, bio-fertilizer, grain yield, harvest index, miaze, PSB

INTRODUCTION

Maize (*Zea mays L.*)is the most important food grain crop after wheat and rice and considered a promising option for diversifying agriculture andoccupies an important place due to its large production potential and its utilization as food, feed and industrial raw material. It has grown in a wide range of environments, extending from extreme semi-arid to sub-humid and humid regions in *Kharif* and *rabi* seasons. India contributes enhanced production with an accelerated growth of 42.3 million MT in 2017-18, mainly due to increasing demand for feed from livestock and poultry sectors (PJTSA, 2018). In Bihar, Maize is grown in an estimated total area of 7.21 lakhs ha with the total production and productivity is 38.46 lakhs MT and 53.35 kg ha^{-1}, respectively (Directorate of Statistics and Evaluation, 2017). Literature indicates that, there were deficiencies of micronutrients in most of the farmer's fields due to continuous and regular use of conventional NPK fertilizers because of lack of required plant nutrients for sustaining the desired crop productivity with minimum deleterious effect on soil health environment and depletion of natural nutrient supply in cultivated areas (Jadav *et al.*, 2018).The synthetic fertilizers application has harsh effects on the human health due to the loss of soil quality and contamination of underground water (Rajasekaran *et al.*, 2012). The above issue of recommended dose of fertilizers needs upgradations to use balance application of vital micronutrients specific to crop which enhance quality and yields of crop.

Bio-fertilizer is a substance contains effective living micro-organisms, which colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or the availability of primary nutrient and/or growth stimulus to the target crop, when it is applied to seeds, plant surfaces and soil (Vessey, 2003 and Ahmad, 2006). Application of bio-fertilizers *viz. Azotobacter* and PSB (Phosphorous Solubilizing Bacteria) provides the nitrogen and phosphorous, respectively. Azotobacter has vital physiological characteristic having its ability to fix nitrogen, protect the roots from other pathogens present in the soil whereas phosphate is available in soil in insoluble form, and an important primary plant nutrient which helps root formation, plant growth and thereby its productivity. The use of microbial symbiont within the plants intended to reduce chemical fertilizers supply even the possible dose can be reduced to zero (Naserirad *et al.*, 2011). Microorganisms as a bio-fertilizer is attributed to its role in accelerating the mineralization processes of organic matter and helping the release of nutrients resulting in enhancing the utility values of soil organic matter contents and cations exchange capacity (Yadav, 1999). Therefore, bio-fertilizers are gaining importance as they are eco-friendly, nonhazardous and nontoxic products (Bashan *et al.*, 2004 and Sharma *et al*, 2007).

Keeping above mentioned facts and figures in perspective, the present investigation wasconducted to study the effect of integration of *Azotobacter* and phosphorus solubilizing bacteria in supplementation of nutrient demand like NP of Maize (*Zea mays L.*) on yield, and nitrogen and phosphorus status of soil.

MATERIALS AND METHOD

The on-farm trial was conducted during *Rabi* seasons of 2013-14 and 2014-15 under supervision of Krishi Vigyan Kendra, Muzaffarpur (Bihar) on randomly pre-selected 10 farmers' fields as replication and each replication had the plot size of 300

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m^2. The experiment was confined in Saraiya block, Muzaffarpur district that lies 26.03° N latitudes and 85.14° E longitudes at an altitude of 161m above mean sea level that comes under the part of Indo-Gangetic North-West Alluvial plain of Bihar. The area has categorized as tropical humid to sub-humid climate and having average annual rainfall is 1234 mm with average temperature is 25.30°C and relative humidity is 67 percent. The present experiment comprises of four treatments *viz.* T_0-Control, T_1-: N120:P75: K_{50} (RDF), T_2-N_{100}:P_{75}: K_{50}:*Azotobactor* and T_3 - N_{100}:P_{60}: K_{50}+*Azotobactor*+ phosphorus solubilizing bacteria (PSB). Data recorded during experimental period were analyzed statistically in a Randomized Block Design (RBD). Prior to layout the plot under the trial, soil samples were collected from each farmers' field separately and analyzed for available nitrogen by alkaline potassium permanganate method (Subbiah and Asija, 1956), available phosphorus was extracted using the method of 0.5 M $NaHCO_3$ extractable colorimetric method (Olsen *et al.*, 1954) and available potassium was measured by shaking the required amount of soil sample with 1 N NH_4OAc (pH 7.0) solution (1:5 soil: solution ratio) for 5 minutes by (Jackson, 1973) method. All the selected experimental plots were received fertilizers as per treatment. Invariably, according to treatments, full dose of phosphorus and potassium applied as basal while nitrogen was applied in three splits *i.e.* 50 percent basal, 25 percent each at 45 and 60 DAS. Before sowing, seed was treated with *Azotobacter* and phosphorus solubilizing bacteria (PSB) @ 20 gm per kg seed each. The harvest index (HI) was accounted as presented in equation (1)

$$HI = (\text{Economical yield} / \text{Biological yield}) \times 100 \quad (1)$$

The collected data of the *kharif* and *rabi* seasons were statistically analyzed separately according to the analysis of variance (ANOVA). Mean comparisons had worked out at 5% level of significance (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Different treatments significantly enhanced thegrain, straw, biological yields and harvest index (%) of maize crop by the application of N_{100}:P_{60}+*Azotobactor* + Phosphorussolu-bilizing bacteria (Table 1). The significantly higher yields (5495 and 5625 kg ha^{-1}) were obtained with the application of N_{100}:P_{60}+*Azotobactor*+phosphorus-solubilizing bacteria followed by treatment N_{100}:P_{75}+ *Azotobactor* and N_{120}:P_{75}: K_{50} (RDF), whereas minimum values of aforesaid characters were observedin Control (T_0) in both the years.This enhancement was due to simultaneous use of chemical and bio-fertilizers (Beyranvand *et al.*, 2013 and Umesha *et al.*, 2014).

Though, the treatment T_3(N_{100}:P_{60}: K_{50}+*Azotobactor*+ phosphorus solubilizing bacteria) showed statistically superior over T_2(N_{100}:P_{75}: K_{50}:*Azotobactor*) and $T_1$$N_{120}$:$P_{75}$: K_{50} (RDF) in both the years for grain yield, straw yield, biological yield and HI (%). This may be due to release ofmineralized nutrients by biological fertilizersthat are easily available to the plants and result in higher N uptake by grain (Nagassa *et al.*, 2005 and Krey *et al.*, 2013). They suggested that grain yield, biomass yield and harvest index were increased with combined application of biological and inorganic fertilizer which promote incorporation of organic residues which significantly enhance the uptake of nitrogen and phosphorus by plants which facilitate the transfer of nutrient elements to the grains and straw.

Table1: Effect varying level of N, P and bio-fertilizers on yield attributes of maize

Treatments	Yield attributes (kg ha^{-1})											
	Grain			Straw			Biological			Harvest index (%)		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
T_0 :(Control)	4850	4650	4750	6213	6263	6238	11063	10913	10988	42.93	42.62	42.78
T_1:N_{120}:P_{75}:K_{50} (RDF)	5075	5135	5105	6507	6547	6527	11587	11682	11635	43.84	43.94	43.89
T_2:N_{100}:P_{75}:K_{50} :Azotobactor	5250	5300	5275	6615	6685	6650	11865	11985	11925	44.25	44.22	44.24
T_3:N_{100}:P_{60}:K_{50} :Azotobactor +PSB	5495	5625	5560	6746	6806	6776	12246	12431	12338	44.92	45.25	45.09
SEm±	24	48	23	25	35	27	40	54	36	0.24	0.28	0.15
C D (P=0.05)	83	169	81	86	123	95	140	189	127	0.83	0.99	0.52

Nitrogen and Phosphorus Status of Soil

The finding revealed that different treatments significantly influenced by N and P along with bio-fertilizer (Table 2) in maize crop. The use of bio-fertilizers as seed treatment registered net positive balance over initial but it was lower than use chemical fertilizer only during both the years of experiment. Further, there is a net positive gain of available nitrogen and phosphorus as compared with rest treatments *i.e.* T_1 and T_0 and on the other hand, net loss of available nitrogen and phosphorus were observed in treatment T_0 (Control) invariably both the years of trial. Positive effect of bio-fertilizer may have resulted from its ability to increase the availability of phosphorus and other nutrients especially under the specialty of the calcareous nature of the soil. It indicates that use of *Azotobacter* and phosphorus solubilizing bacteria (PSB) together in the present trial were cumulatively translated into net gain of available nitrogen and phosphorus. Bio-fertilizers provides nutrient supply like nitrogen and phosphorous through their activities in the soil or rhizosphere and makes them available to the plants on the soil (Singh and Rai, 2003).

Table 2: Effect varying level of N, P and bio-fertilizers on nitrogen and phosphorus status of soil

Treatments	Post. harvest status						Net change (net gain/loss)			
	Available Soil Nitrogen ($kg\ ha^{-1}$)			Available Soil Phosphorus ($kg\ ha^{-1}$)			Available Soil Nitrogen ($kg\ ha^{-1}$)		Available Soil Phosphorus ($kg\ ha^{-1}$)	
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	2013-14	2014-15
T_0 : (Control)	198.55	198.65	198.60	24.78	24.80	24.79	-1.85	-1.05	-1.12	-0.70
T_1:N_{120}:P_{75}:K_{50} (RDF)	200.43	200.45	202.44	25.40	25.44	25.42	0.03	0.75	-0.06	-0.46
T_2:N_{100}:P_{75}:K_{50}:Azotobactor	208.35	208.38	208.37	25.55	25.57	25.56	7.95	8.68	-0.07	-0.33
T_3:N_{100}:P_{60}:K_{50}:Azotobactor+PSB	209.12	209.25	209.19	27.25	27.26	27.26	8.72	9.55	1.75	1.36
SEm±	0.26	0.31	0.21	0.03	0.14	0.07	-	-	-	-
C D (P=0.05)	0.91	1.08	0.72	0.10	0.47	0.25	-	-	-	-

Initial status of available soil nitrogen ($kg\ ha^{-1}$); 200.40 and 199.70 in 2013 and 2014; Initial status of available phosphorus ($kg\ ha^{-1}$) 25.90 and 25.50 in 2013 and 2014.K_2O was applied 50 $kg\ ha^{-1}$ invariably in all the treatment.

Economics

The maximum net returns (Rs. 53350.00 and Rs.35800.00 ha^{-1}) were recorded with treatment N_{100}:P_{60} + *Azotobactor*+ phosphorus-solubilizing bacteria (Table 3), which were followed by treatment N_{100}:P_{75}+ *Azotobactor* and N_{120}:P_{75}: K_{50} (RDF). Among all the treatments, maximum B:C ratio was obtained under treatmentT_3 followed by T_2 and T_1. The markedly higher production and reduction in cost of cultivation due to curtailing the nitrogen and phosphorus dose.This mainly due to maximum yield produced under this level which overcome the cost of bio fertilizer and benefited more (Dwivedi *et al.*, 2015 and Tomar *et al.*, 2017).

Table 3: Effect varying level of N, P and bio-fertilizers on economics of maize

Treatments	Cost of cultivation (Rs. ha^{-1})		Gross return (Rs. ha^{-1})		Net return (Rs. ha^{-1})		B:C Ratio	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
T_0 : (Control)	19810	20000	53350	55800	33540	35800	2.69	2.79
T_1 :N_{120}:P_{75}:K_{50} (RDF)	18999	19000	55880	60600	36881	41600	2.94	3.16
T_2:N_{100}:P_{75}:K_{50}:Azotobactor	18758	18750	57750	63300	38992	44550	3.07	3.37
T_3:N_{100}:P_{60}:K_{50}:Azotobactor+PSB	18028	18000	60500	67500	42472	49500	3.35	3.75

CONCLUSION

Integration of bio-fertilizerswith chemical fertilizers considered as important approach for integrated nutrient management. A simultaneous mixture has been given the highest crop yield and found beneficial to the environment and move towards attaining sustainability without depleting soil fertility.The finding shown that application of bio-fertilizerdecrease 25-30 percent dose of nitrogen and phosphorus, respectively. Therefore, it will be beneficial to make intensive efforts for diffusion and large scale promotion for adoption of these types of technologies not only in Muzaffarpur district but also in other parts of Bihar. As a result, the productivity of maize in Bihar may be increased on the one hand, but soil fertility may also be restored on the other hand. Consequently, these technologies may be served as a base to enhance socio-economic conditions of the farmers in general and particularly to the small and marginal farmers by augmenting the production per unit area on sustainable manner.

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