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Effect of different doses of phosphorus and liquid bio-fertilizers on maize in new alluvial zone of West Bengal

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Abstract
A field experiment was conducted during *kharif* season of 2016 and 2017, to evaluate the effect of different doses of phosphorus and liquid bio-fertilizers on maize at District Seed Farm (AB Block), Kalyani, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal on silty clay loam soil having pH 7.25, medium in available N (250.20 kg/ha), high in available P (26.20 kg/ha) and medium in available K (280.12 kg/ha). The experiment was laid down in RBD design with three replication having twelve treatments *viz*. T_1: Control (Recommended N and K), T_2: PSB I, T_3: PSB II, T_4: NPK consortia, T_5: 60 kg P_2O_5/ha, T_6: 30 kg P_2O_5/ha + PSB I, T_7: 60 kg P_2O_5/ha + PSB I, T_8: 30 kg P_2O_5/ha + PSB II, T_9: 60 kg P_2O_5/ha + PSB II, T_{10}: 30 kg P_2O_5/ha + NPK consortia, T_{11}: 60 kg P_2O_5/ha + NPK consortia and T_{12}: 90 kg P_2O_5/ha. In maize field, highest grain yield (12,297 and 11,980 kg/ha), stover yield (14,232 and 13,678 kg/ha), net return (Rs. 1, 10173/- and 1, 38,099/-) and B: C ratio (3.94 and 4.06) were obtained in treatment T_{11} receiving 60 kg P_2O_5/ha + NPK consortia which was followed by T_{10} treatment (30 kg P_2O_5 + NPK consortia) during both the years, respectively. The experimental results revealed that, 60 kg/ha P_2O_5 + NPK consortia was best treatment combination for maize in new alluvial zone of W. B which not only increased maize productivity, net income, supplementing balance nutrition to the maize but also improves the soil health by synthesize/assimilate atmospheric nitrogen, solubilizes phosphate, potash, unavailable micro-nutrient into available form and prevent environmental pollution.

Keywords: Maize, phosphorus, liquid bio-fertilizer, yield, economics

Introduction
Maize (*Zea mays* L.) is one of the major cereal crop and is a versatile crop and ranks third following wheat and rice in world production as reported by Food and Agriculture Organization. Maize is a staple human food, a feed for livestock and raw material for many industrial products. About 59% of the total production is used as feed, while the remaining is used as industrial raw material (17%), food (10%) and other purposes (4%) (Kumar *et al*., 2013) [5]. For increasing the productivity and profitability of maize, farmers are cultivating the crop intensively with the huge use of chemical fertilizers, pesticides, weedicides etc. though these practices are helps to increase the temporary increase the production of crop; deterioration of natural resources (*viz*. land, water and air) is also high input intensive cultivation. Excessive use of chemical fertilizers has been associated with declines in soil physical and chemical properties and crop yield (Hepperly *et al.*, 2009) [4]. Highest productivity of crops in sustainable manner without deteriorating the soil and other natural resources could be achieved only by applying appropriate combination of different organic manner and inorganic fertilizers (Chandrashekara *et al.*, 2000) [1]. One of the most important means to achieve the goals of organic agriculture is to extent the application of biological fertilizers (Obid *et al.*, 2016) [7]. Liquid bio-fertilizer is a special formation containing high number of desired micro-organism with high shelf life, zero contamination, cost effective, better survival on seed and soil, doses is 10 time loss than carried based powder bio-fertilizer and having very high enzymatic activity. These microbial inoculants help in increasing crop productivity through increased biological fixation, increased availability or uptake of nutrients by plants through solubilisation or increased absorption, stimulation of plant growth through hormonal action or antibiosis etc. (Sivamurugan *et al.*, 2018) [10]. It is recognized that neither bio-fertilizers alone nor exclusive application of phosphorus through chemical fertilizers can sustain soil health as well productivity in modern farming where nutrient turn-over in soil plant system is quite high (Gautam *et al*., 2017) [2]. Considering the above facts, the present study was undertaken to evaluate effect of different doses of phosphorus with varied liquid bio-fertilizers on growth, yield attributes, yield and economies of maize in New Alluvial Zone of West Bengal.

Materials and Methods

The experiment was conducted at the District Seed Farm (AB Block), Kalyani, Bidhan Chandra krishi viswaviyalaya, West Bengal (Latitude 22°57/ N, Longitude 88°20/ E and at of 9.75 m above sea level) during *kharif* seasons of 2016 and 2017. The experiment was designed to study the effect of different doses of phosphorus with varied liquid bio-fertilizers on growth, yield attributes, yield and economies of maize. The soil of experiment plots was silty clay loam in texture having pH neutral in reaction (7.32) with medium in organic carbon content (0.54) and medium in available nitrogen, potassium and high in phosphorus content. The experiment was laid out in Randomized Block Design (RBD) and replicated thrice with 12 treatments *viz.* T1: Control (Recommended N and K), T2: PSB I, T3: PSB II, T4: NPK consortia, T5: 60 kg P_2O_5/ha, T6: 30 kg P_2O_5/ha + PSB I, T7: 60 kg P_2O_5/ha + PSB I, T8: 30 kg P_2O_5/ha + PSB II, T9:60 kg P_2O_5/ha + PSB II, T10: 30 kg P_2O_5/ha + NPK consortia, T11: 60 kg P_2O_5/ha + NPK consortia and T12: 90 kg P_2O_5/ha. The liquid bio-fertilizers were applied through seed treatment at the rate of 50 ml per acre. Phosphorus and potash fertilizers were applied as basal as per treatment wise and 1/3th nitrogen fertilizer was applied at the time of sowing and 1/3th+13th at 30 and 45 day after sowing. The maize variety was JKMH 502 sown in second week of June. The spacing of maize was 60X20 cm row to row and plant to plant. At harvesting following characters were measured included: plant height, cob length, cob girth, grain rows/cob, grains/row, 100 seed weight, grain yield and stover yield. The collected data of the two seasons were statistically analysed separately according to the analysis of variance (ANOVA) by using MSTAT-C computer software packages. Mean comparisons were worked out by Ducan's Mutiple Range Test (DMRT) at 5% level of probability according to Gomez and Gomez, 1984 [3].

Results and Discussion

Growth and Yield attributes

Results showed that effect of different phosphorus doses and liquid bio-fertilizers on plant height was significant (Table-1). Among the treatments, T11: 60 kg P_2O_5/ha + NPK consortia recorded highest plant height (230 and 247.30 cm) in 2016 and 2017, respectively which was statistically at par with treatment T10: 30 kg P_2O_5/ha + NPK consortia in 2016. This may be due to prolonged vegetative growth which increased the plant height. Application of different phosphorus doses and bio-fertilizers significantly influenced yield attributing characters. During 2016 and 2017 yield attributes like cob length, 100 seed weight were significantly influenced by different phosphorus rate and bio-fertilizer but cob girth, grain rows/cob and grains per row were not significant. Among the different treatments, T11: 60 kg P_2O_5/ha + NPK consortia recorded highest cob length (24.4 cm and 16.3 cm), cob girth (16.3 and 15.3 cm), grain rows/cob (18.0 and 15.5), grains per row (31 and 31.7) and 100 seed weight (33.8 and 36.3 g) during 2016 and 2017, respectively. This might be due to higher levels of phosphorus and bio-fertilizers which induced the uptake ability of the roots to nutrients and positive increased in the yield parameters because of improving the root system as a source-sink relationship to the reproductive part (shoot), that agree with Sheraz Mahdi *et al.* 2010 [9] and Mohammed *et al*. 2001 [6].

Table 1: Effect of different doses of phosphorus and bio-fertilizers on growth and yield attributes of maize

Treatments	Plant Height (cm)		Cob length (cm)		Cob girth (cm)		Grain rows/cob		Grains/row		100-seed weight (g)	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
T_1	215.7	193.3	20.0	10.8	14.2	14.9	14.0	13.2	29.0	23.6	31.4	25.5
T_2	187.3	199.0	13.7	10.8	12.0	14.1	11.3	14.3	23.7	24.9	28.2	27.8
T_3	191.3	210.7	14.7	13.1	12.1	13.8	10.7	14.1	24.0	26.0	28.6	28.5
T_4	220.3	192.0	21.2	14.1	14.6	14.9	15.3	14.7	28.5	27.8	32.0	**31.0**
T_5	193.3	207.3	16.9	13.8	12.2	14.7	11.3	14.7	24.7	25.8	31.3	28.7
T_6	199.0	209.0	16.3	14.0	12.5	14.4	11.3	14.1	25.0	27.0	29.4	29.3
T_7	204.0	214.0	17.2	16.0	12.7	14.9	12.7	14.7	25.3	27.3	29.9	29.7
T_8	207.3	213.3	18.2	12.8	13.1	14.3	12.7	14.4	26.5	24.7	30.4	30.4
T_9	210.0	221.3	19.1	15.1	13.5	14.3	13.7	14.1	27.0	27.2	30.8	31.2
T_{10}	223.3	216.3	21.3	14.3	15.3	15.0	15.3	14.4	29.5	26.4	32.8	30.7
T_{11}	230.0	247.3	24.4	16.3	16.3	15.3	18.0	15.5	31.0	31.7	33.8	36.3
T_{12}	195.0	219.0	15.5	13.6	12.2	15.3	12.0	14.7	25.0	28.1	27.7	27.7
CD at 5%	17.0	25.5	2.2	2.4	0.7	1.6	2.3	1.5	1.7	5.8	1.8	4.8
Significance	S	S	S	S	S	NS	NS	NS	S	NS	S	S

Yield

The grain yield and stover yield of maize were significantly influence by different doses of phosphorus and bio-fertilizers (Table-2). The highest grain yield (12,297 and 11, 980 kg/ha) and stover yield (14,232 and 13,678 kg/ha) during 2016 and 2017 were obtained with application of 60 kg P_2O_5 + NPK consortia. This might be due to remarkable improvement in growth and yield attributes in response to increasing levels of phosphorus and bio-fertilizers (Paramsivan *et al,* 2011) [8]. A good and optimum supply of Phosphorus and bio-fertilizers are associated with increased root growth due to which plants explore more soil nutrients and moisture which increased plant growth and yield of crop. (Gautam *et al,* 2017) [2].

Economics

Economics of maize during 2016 and 2017, respectively (Table-2) was varied significantly by different treatments. The highest net return (1, 10,173 and 1, 38,099) and B: C ratio (3.94 and 4.06) were found in treatment receiving 60 kg P_2O_5/ha + NPK consortia which was followed by treatment T10 during both the year, respectively. Similar finding was also reported by Sivamurugan *et al*., 2018 [10].

Table 2: Effect of different doses of phosphorus and bio-fertilizers on yield and economics of maize

Treatments	Grain yield (kg/ha)		Stover yield (kg/ha)		Net returns (Rs. /ha)		B:C ratio	
	2016	2017	2016	2017	2016	2017	2016	2017
T_1	10106	6452	12196	8359	80748	56929	2.99	2.30
T_2	6711	8170	8833	10077	46193	82207	2.33	2.86
T_3	6898	7972	8940	9917	48801	79314	2.39	2.79
T_4	10303	7866	12452	9831	89250	77863	3.59	2.76
T_5	7271	7640	9401	9569	50013	68798	2.34	2.38
T_6	7811	7571	9876	9497	57895	71920	2.61	2.58
T_7	8013	9200	10039	11152	58821	96404	2.57	2.83
T_8	8101	8245	10158	10199	61366	82078	2.71	2.80
T_9	9109	9749	11165	11713	71971	100001	2.92	3.07
T_{10}	11295	9405	13332	11295	99649	99355	3.77	3.18
T_{11}	12297	11980	14232	13678	110173	138099	3.94	4.06
T_{12}	7500	9232	9442	11138	51258	89724	2.32	2.70
CD at 5%	208.7	1865.0	199.1	1905.4	2538.4	28019.3	0.07	0.57
Significance	S	S	S	S	S	S	S	S

Conclusion

Based on the results obtained from this study, it could be concluded that the using of 60 kg P_2O_5/ha + NPK consortia are the best treatment combination of maize in new alluvial zone of West Bengal which not only increased maize productivity, net income, supplementing balance nutrition to the maize but also improves the soil health by synthesize/assimilate atmospheric nitrogen, solubilizes phosphate, potash, unavailable micro-nutrient into available form and prevent environmental pollution.

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