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Effect of biofertilizers in conjunction of phosphorus on growth, yield attributes, yield and economics of maize (*Zea mays* L.)

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Abstract
An investigation was made during *kharif* season of 2016 at M.G.C.G.V., Chitrakoot to see the effect of biofertilizers on maize. It is evident from the results that application of 60 Kg P_2O_5 + NPK consortia proved to be the best treatment as it gave the superior yield attributes *viz*. Cobs/plant (1.20), cob weight (184.92g), seed weight/plant (116.01g), 1000-seed weight (212 g), cob length (20.07 cm) and cob girth (13.35cm); cob yield (11934 kg/ha) grain yield (4990 kg/ha), stover yield (9854 kg/ha), gross returns (Rs. 159555/ha) and net returns (Rs. 136549/ha). Treatment T_2, T_3, T_4, T_5, T_6, T_7, T_8, T_9, T_{11} and T_{12} produced higher grain yield of maize to the tune of 129 kg (1.69%), 193 Kg (5.24%), 373 kg (10.12%), 356 kg (9.66%), 802 Kg (21.76%), 721 Kg (19.57%), 254 Kg (6.89%), 725 Kg (19.7%), 795 Kg (21.57%), 1305 Kg (35.41%) and 458 Kg/ha (12.43%) over control, respectively. Plant population plant height, leaves/plant and dry weight/plant were not affected significantly due to biofertilizer treatments.

Keywords: NPK consortia, P.S.B.-I, PSB-II, grain yield, stover yield, gross returns, net returns

Introduction
Maize (*Zea mays* L.) is one of the important cereal crops next to wheat and rice in the world and in India. In India it is cultivated an area of 8691.2 million hectare with an annual production of 21806.50 million tonne and productivity of 2509 kg/ha. The area of maize is mostly concentrated in Uttar Pradesh. Rajasthan, Madhya Pradesh, Gujrat, Bihar, Karnataka and Himanchal Pradesh. Maize is generally grown in *Kharif* season but it can also be grown during winter and summer seasons. In India about 35 percent maize produced out of which 60 percent in used for human consumption, 25 percent in poultry and cattle feed and 15 percent in food processing like corn flakes, popcorn and in their industries mainly starch, dextrose, corn syrup and corn oil. Green cobs, are roasted and consumed by people with great interest. Several food dishes including 'Chappaties' are prepared out of maize flours. Maize is most versatile emerging crop having high yield potential, wider adaptability and diverse ecologies and adverse environment. Maize crop is highly responsive to fertilizer specially nitrogen, phosphorus and potassium. Nitrogen is essential constituent of proteins, nucleotides, phosphatides, enzymes, Harmons and vitamins etc. Nitrogen is an integral part of chlorophyll which is primary absorber of light energy required for photosynthesis. Phosphorus is needed in capturing and converting the sun energy into useful plant compound. Phosphorus is high mobile in plants, improved crop quality, stimulated root development. Potassium is essential for translocation of water and photo synthesis with in the plant body. The utilization efficiency of applied phosphatic fertilizers is only 15-20 percent. The use of certain biofertilizers me prove beneficial in reducing the cost of fertilizers as well as increasing the availability of unavailable soil phosphorus. Bacteria that acts positively on plant growth and development through direct or indirect mechanism are collectively known as plant growth promoting Rhizobacteria (PGPR). This group includes phosphate solubilizing bacteria (PSB) that convert in soluble phosphate into soluble forms through acidification, chelation, exchange reactions and production of organic acids. They are found in soil but usually not enough in the rhizosphere of plants. Therefore, inoculation of plants at higher concentration of microorganism is essential NPK consortia is a new biofertilizers

particularly inoculation in maize. Thus, present study was under taken.

Materials and Methods

A field experiment was conducted during Kharif, 2016 at Rajaula Agriculture Farm of the Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot District Satna (M.P.). Treatment consisted T_1: Control (100 Kg N + 40 Kg K_2O/ha), T_2: PSB-I with 100 kg N + 40 Kg K2O, T3:P.S.B.-II + 100 Kg + 40 Kg K_2O, T_4: NPK consortia + 100 Kg N + 40 Kg K_2O/ha T_5: 60 Kg P_2O_5/ha T_6: 30 Kg P_2O_5 + PSB-I, T_7: 60 Kg P_2O_5 + PSB-I, T_8: 30 Kg P_2O_5 + PSB-II, T_9: 60 Kg P_2O_5 + PSB-II, T_{10}: 30 Kg P_2O_5 + NPK consortia, T_{11}: 60 Kg Kg P_2O_5 + NPK consortia T_{12}: 90 Kg P_2O_5. Thus 12 treatments were tried in a randomized block design with three replications. The soil of the experimental plot was sandy loam in texture having soil P^H 7.9, organic carbon 0.44%, available nitrogen 214 kg/ha, available phosphorus 55.41 Kg/ha and available potassium 52.49 Kg/ha. The gross plot size was 4.40 m × 3.60m and net plot size was 3.40m × 1.80m. The maize (CV J.M. 216) was sown in furrows 60 cm apart on 23rd July 2016 using 20 Kg seed rate per hectare. Before sowing, as per treatment seeds were inoculated with PSB-I, PSB-II and NPK consortia in recommended procedure. As per treatment crop was fertilized through urea, SSP and muriate of potash of N, P, K, respectively. 50% N was supplied as based and 50% top dressed on August 12, 2016. Phosphorus and potassium were given at sowing in furrows. crop was irrigated once on September 11, 2016 in addition to rainfall of 905 mm in crop duration. The crop was harvested on October 23, 2016. As per recommendation crop was protected from weeds and insect pest. The important growth parameters, yield attributes and yields were recorded. The economics were also calculated as per market rates of input cum operations.

Result and Discussion

Effect on growth parameters

It is clear from Table 1 that plant stand of maize was not affected by treatments because almost equal plant to plant distance was maintained by thinning operation. Plant height, leaves/plant and dry weight/plant were recorded at 20, 40 and 60 DAS which were improved in each successive stages of crop but not differ significantly due to treatment except plant height at harvest stage. At 60 DAS stage the tallest plant of 238.00 cm was recorded under T_{10}: 30 Kg P_2O_5 + NPK consortia. The highest plant height of 245.67 cm at harvest was recorded under 60 Kg P_2O_5 + PSB-II and dry weight/plant at 60 DAS of 48.46 g was recorded under 30 kg P_2O_5 + PSB. -I. Almost similar on numerically higher growth parameters was due to sufficient nitrogen and potash was supplied to control and few other treatments. In other treatments PSB-I, PSB-II and NPK consortia fulfilled the requirement of nutrients in general and nitrogen in particular. Manjoor *et al.* (2017) [8] confirmed these results. PSB improved availability of soil phosphorus as well as inorganic fertilizers.

Effect on yield attributes

Significantly highest cob weight/plant of 184.92 g and seed weight of 116.01 g was observed under T_{11}: 60Kg P_2O_5 + inoculation of NPK consortia followed by T_5: 60 Kg P_2O_5 /ha only and 9: Kg P_2O_5 + inoculation of PSB. -II. 1000-grain weight and cob length (20.39cm) maximum (217.67 g) in T_6: 30 Kg P_2O_5 + PSB-I followed by T_{11}: 60 Kg P_2O_5 + NPK consortia. The remaining yield attributes were found numerically better under treatment of phosphorus and biofertilizers over control plot. The superior yield attributes in biofertilizer treated plots may be due to enhance availability of P and its active involvement in shoot and root growth lead to improvement in plant growth which later boosted yield attributes in general and NPK consortia with 60 Kg P_2O_5 /ha in particular. These results were conformity with the findings of Chaudhary *et al.* (2012) [2], Joshi *et al.* (2013) [4] and Hashim *et al.* (2016) [3].

Effect on yield and harvest index

It is clear from Table 3 that all biofertilizer treated treatment produced significantly higher cob yield, grain yield and stover yield of maize over control. Significantly maximum cob yield of 11934 kg/ha, grain yield (4990 kg/ha) and stover yield 9854 kg/ha was recorded under T_{11}: 60 Kg P_2O_5/ha + NPK consortia followed by T_9: 60 Kg P_2O_5 + inoculation of PSB-II, T_{10}: 30 Kg P_2O_5 + NPK consortia and T_{12}: 90 Kg P_2O_5 /ha. All yield attributes were in trend of cob, grain and stover yield. It was due to beneficial effect of biofertilizers in general and with NPK consortia in particular this increase may be attributed to the auxin production by PSB. Due to enhance availability of P and its active involvement in shoot and root growth later boosted crop yields. NPK consortia produced biologically active substances provide significant amount of available NPK through biological fixation improve photosynthesis and resulting higher yield. These results are agreement with there of Joshi *et al.* (2013) [4], Wani and Ali (2015) [7]. The harvest index was maximum of 35.68% under T_{11}: 60 Kg P_2O_5 + NPK consortia. It was due to higher recovery of grain into total biomass production.

Effect of economics

It is evident from Table 3 that minimum expenditure incurred in cultivation of maize of Rs 20369/ha in control and maximum of Rs 24314/ha under T_{12}: 90 Kg P_2O_5 /ha treatment. This variation was due to additional cost involved in different treatments. The maximum gross returns of Rs. 159555/ha and net returns of Rs. 136549/ha was earned under T_{11}: 60 Kg P_2O_5 + inoculation of NPK consortia treatment followed by T_6: 30 Kg P_2O_5 /ha + inoculation of PSB-I. The gross returns is directly related to grain and stover yield and their sole price. The gross returns trend was similar to grain yield. The net returns are governed by gross returns and cultivation cost which was varied with treatment. Thus, it was similar to gross returns. Chaudhary *et al.* (2012) [2] and Joshi *et al.* (2013) [4] reported higher net returns with the use of biofertilizers in maize. The benefit: Cost ratio as not differed with treatments. Thus, it indicates that all treatments gave almost similar benefit: Cost ratio.

Table 1: Effect of treatments on plant population, plant height (cm), leaves/plant and dry weight (g)/plant of maize

Treatments	Plant stand/ha at harvest	Plant height (cm) at				Trifoliate leaves/plant at			Dry weight/plant (g) at		
		20 DAS	40 DAS	60 DAS	At harvest	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
T_1 control (Rec. N & K)	72194	35.60	175.33	225.67	235.33	7.73	10.00	12.00	1.58	16.55	37.63
T_2 PSB-I + (Rec. N & K)	72194	34.17	170.00	224.67	240.33	7.20	9.47	12.13	1.48	15.87	39.83
T_3 PSB-II	68500	34.87	168.67	217.00	235.00	7.40	9.00	11.53	1.50	14.62	38.00
T_4 NPK consortia	71278	32.70	170.00	228.00	234.67	6.47	9.53	11.73	1.56	16.22	38.41
T_5 60kg P_2O_5/ha	65694	22.87	168.00	228.00	231.00	6.67	8.93	11.87	1.47	14.60	42.92
T_6 30kg P_2O_5/ha + PSB-I	69417	35.93	170.00	235.67	233.67	7.40	9.07	12.27	1.61	16.52	48.46
T_7 60kg P_2O_5/ha + PSB-I	64778	35.07	169.33	228.00	242.33	7.47	9.13	12.13	1.50	15.02	40.73
T_8 30kg P_2O_5/ha + PSB-II	69417	34.53	166.00	230.67	241.00	7.33	9.20	12.47	1.43	15.58	42.54
T_9 60kg P_2O_5/ha + PSB-II	74028	34.33	169.33	230.33	245.67	7.60	8.93	12.20	1.52	12.00	44.13
T_{10} 30kg P_2O_5/ha + NPK consortia	70361	33.80	164.67	238.00	235.67	6.93	8.67	12.33	1.45	15.03	44.84
T_{11} 60kg P_2O_5/ha + NPK consortia	69417	34.07	166.67	225.33	234.00	7.53	9.67	11.40	1.58	16.48	40.84
T_{12} 90kg P_2O_5/ha	69389	35.93	168.00	229.33	233.67	7.53	9.80	11.87	1.46	14.22	43.36
S. Em ≠	3154	3.25	1.90	3.44	3.49	0.40	0.45	0.30	0.09	1.78	2.95
C.D. (P=0.05)	N.S.	N.S.	N.S.	10.09	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. %	8.46	17.96	2.11	2.82	2.76	10.24	9.10	4.75	10.58	21.68	13.16

Table 2: Effect of treatments on yield attributes on maize

Treatments	Cobs/Plant	Cobs weight/ plant (g)	Seed weight/ plant (g)	1000- seed weight (g)	Cob length (cm)	Cob girth (cm)	No. of grain row/cob	Grains/cob	Number of cobs/ha
T_1 control (Rec. N & K)	1.07	137.03	91.31	196.33	16.33	12.99	12.27	336.00	88889
T_2 PSB-I + (Rec. N & K)	1.20	141.86	95.19	203.33	18.70	12.99	12.87	315.13	100000
T_3 PSB-II	1.13	142.15	92.57	196.67	17.80	12.45	12.37	312.48	94444
T_4 NPK consortia	1.13	157.25	97.54	197.67	19.69	12.94	12.73	309.40	94444
T_5 60kg P_2O_5/ha	1.13	165.14	110.24	217.67	20.39	12.53	13.00	314.27	94444
T_6 30kg P_2O_5/ha + PSB-I	1.13	154.37	92.67	209.67	17.97	12.96	13.07	284.53	94444
T_7 60kg P_2O_5/ha + PSB-I	1.07	151.27	88.21	213.33	18.63	12.73	12.47	351.93	88889
T_8 30kg P_2O_5/ha + PSB-II	1.20	148.62	87.69	200.67	18.56	12.51	12.80	334.93	10000
T_9 60kg P_2O_5/ha + PSB-II	1.13	156.39	109.54	200.00	18.50	12.81	13.27	373.27	94444
T_{10} 30kg P_2O_5/ha + NPK consortia	1.07	166.01	91.68	206.33	18.79	12.66	13.33	360.67	88889
T_{11} 60kg P_2O_5/ha + NPK consortia	1.20	184.92	116.01	212.00	20.07	13.35	13.60	355.73	100000
T_{12} 90kg P_2O_5/ha	1.07	155.26	91.43	203.00	16.84	13.49	12.60	256.35	88889
S. Em ≠	0.07	6.70	7.11	4.11	0.73	0.44	0.47	38.14	5660
C.D. (P=0.05)	N.S.	19.64	N.S.	12.06	2.14	N.S.	N.S.	N.S.	N.S.
C.V. %	11.24	8.08	13.66	3.77	7.36	6.40	6.89	21.78	11.24

Table 3: Effect of treatments on grain yield (kg/ha), stover yield (kg/ha), harvest index (%) and economics of maize

Treatments	Cob yield (kg/ha)	Grain yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)	Cost of cultivation (kg/ha)	Gross returns (kg/ha)	Net returns (kg/ha)	Benefit: Cost ratio
T_1 control (Rec. N & K)	7618	3685	8123	31.22	20369	118700	98331	5.83
T_2 PSB-I + (Rec. N & K)	9231	3814	8294	31.48	20421	122738	102317	6.01
T_3 PSB-II	9399	3878	8221	32.05	20420	124578	104158	6.10
T_4 NPK consortia	9292	4058	8959	31.17	20421	130710	110289	6.40
T_5 60kg P_2O_5/ha	8788	4141	8560	32.60	22955	132764	109809	5.78
T_6 30kg P_2O_5/ha + PSB-I	9573	4487	8998	33.33	21713	143625	121912	6.61
T_7 60kg P_2O_5/ha + PSB-I	9837	4406	9353	32.10	23006	141558	118552	7.48
T_8 30kg P_2O_5/ha + PSB-II	9609	3939	8616	31.76	22679	128786	106107	5.68
T_9 60kg P_2O_5/ha + PSB-II	9500	4410	9651	31.29	23006	141975	118969	6.17
T_{10} 30kg P_2O_5/ha + NPK consortia	9867	4480	9130	32.85	22679	143551	120872	6.33
T_{11} 60kg P_2O_5/ha + NPK consortia	11934	4990	9854	35.68	23006	159555	136549	6.93
T_{12} 90kg P_2O_5/ha	11447	4143	8902	31.75	24314	137212	112898	5.65
S.Em ≠	538	203	879	1.06	-	6085	6090	0.45
C.D. (P=0.05)	1577	597	819	N.S.	-	7847	7862	N.S.
C.V. %	10.47	9.05	587	6.20	-	8.40	10.03	13.47

Conclusion

It is concluded that Plant stand of maize was not affected by treatments because almost equal plant to plant distance was maintained by thinning operation. Plant height, leaves/plant and dry weight/plant were recorded at 20, 40 and 60 DAS which were improved in each successive stages of crop but not differ significantly due to treatment except plant height at harvest stage. Significantly highest cob weight/plant of 184.92 g and seed weight of 116.01 g was observed under T_{11}: 60Kg P_2O_5 + inoculation of NPK consortia followed by T_5: 60 Kg P_2O_5 /ha only and 9: Kg P_2O_5 + inoculation of PSB. -II. 1000-grain weight and cob length (20.39cm) maximum (217.67 g) in T_6: 30 Kg P_2O_5 + PSB-I followed by T_{11}: 60 Kg P_2O_5 + NPK consortia. biofertilizer treated treatment produced significantly higher cob yield, grain yield and stover yield of maize over control. Significantly maximum cob yield of 11934 kg/ha, grain yield

(4990 kg/ha) and stover yield 9854 kg/ha was recorded under T_{11}: 60 Kg P_2O_5/ha + NPK consortia followed by T_9: 60 Kg P_2O_5 + inoculation of PSB-II, T_{10}: 30 Kg P_2O_5 + NPK consortia and T_{12}: 90 Kg P_2O_5 /ha. All yield attributes were in trend of cob, grain and stover yield. minimum expenditure incurred in cultivation of maize of Rs 20369/ha in control and maximum of Rs 24314/ha under T_{12}: 90 Kg P_2O_5 /ha treatment. This variation was due to additional cost involved in different treatments.

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