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Effect of NPK levels and micronutrients with and without liquid biofertilizer on plant nutrient uptake of Maize

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Abstract
A field study was conducted on the “Effect of NPK Levels and Micronutrients with and without Liquid Bio-fertilizer on Soil Health and Yield Attributes of Maize (*Zea Mays* L.)” Cv. K-25” at the Soil Science & Agricultural Chemistry Research Farm, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during *Kharif* season 2018 and 2019. The soil of experimental area falls in order *Inceptisol* and soil texture was sandy loam. The result showed that in treatment T_{19}[140:80:50 NPK kg ha^{-1} + Zn (20 kg ha^{-1}) and Mn (25 kg ha^{-1}) + *Azotobacter* (200 ml ha^{-1})+ PSB (200 ml ha^{-1})] nitrogen uptake in maize grain & stem (34.86 & 68.44 kg ha^{-1}during 2018, 52.89 & 63.65 kg ha^{-1}during 2019), phosphorus uptake in maize grain & stem (25.16 & 11.87 kg ha^{-1}during 2018, 24.11 & 20.51 kg ha^{-1}during 2019), potassium uptake in maize grain & stem (20.16 & 89.22 kg ha^{-1}during 2018, 19.73 & 86.27 kg ha^{-1}during 2019), zinc uptake in maize grain & stem(5.10 & 5.98 kg ha^{-1}during 2018, 5.24 & 5.96 kg ha^{-1}during 2019), manganese uptake in maize grain & stem(7.58 & 7.24 kg ha^{-1}during 2018, 6.78 & 6.85 kg ha^{-1}during 2019) as compared to T_0 (absolute control).

Keywords: Maize, liquid-bio-fertilizer, nutrient uptake

Introduction
Maize is an important cereal crop which ranks the third after wheat and rice in the world. Maize is grown widely in many countries of the world (Onasanya *et al*., 2009) [16]. Maize which is botanically called (*Zea mays* L) belongs to the family *Gramineae*. Maize is one of the world's leading crops cultivated over an area of 139 million hectares with the production of about 600 million tonnes of grain. USA leads the largest area, followed by Brazil, china, Mexico and India. It is grown in almost all states of India occupying an area of 6.3 million hectares with the production and productivity of 11.3 million tonnes and 1.9 million tonnes per hectares respectively (Kumar *et al*., 2007) [11]. Maize grain contains about 70% carbohydrate, 10% protein, 4% oil, 2.3% crude fiber, 10.4% albuminoides, 1.4% ash (Choudhary, 1993) [3]. Along with this, it is rich in vitamin A, vitamin E, nicotinic acid, riboflavin and contains fairly high phosphorus than rice and sorghum. Its fodder and hay contain 7-10% protein, 15-36% fiber, 2.09-2.62% ether extract, 0.42-0.70% calcium, 0.28-0.29% phosphorus, 0.45% magnesium, 1.34% potassium and 56% carbohydrate, therefore, it has very nutritive fodder and hay. Besides food grain, fodder and feed, it has prime importance in textile, starch and big industries (Rai, 2006). Maize is also known as “Queen of cereals” and kind of fodder maize has been usually considered as poor man's crop and occupying the place in the rich communities due to its multifarious use as industrial food and feed crops (Suke *et al*., 2011) [23]. Fertilizer plays an important role in increasing the maize yield and their contribution to economy is very high. Balanced and optimum use of nitrogen, phosphorus and potassium as well Assulphur fertilizer plays a pivotal role in increasing the yields of cereals. Though the yield potential of our present varieties is high enough, but it has not been explored fully due to some production constraints. Among the limiting factors; proper level and ratio of nitrogen and phosphorus are prime importance. Maize is a highly potential crop in Mudhol area (Ghataprabha Left Bank Canal) of Bagalkot district in North Karnataka. Nitrogen is a vital plant nutrient and a major determining factor required for maize production. It is very essential for plant growth and makes up 1-4% of dry matter of the plants. Nitrogen is essential constituent of protein and is present in many other compounds of great physiological

importance in plant metabolism. Nitrogen is called a basic constituent of life (Singh *et al*., 2010) [22]. Phosphorus has a great role in energy storage and transfer and closely related to cell division and development of maize. Phosphorus is a constituent of nucleic acid, phytin and phospho-lipid. Phosphorus compound acts as energy within plants. Phosphorus is essential for transformation of energy, in carbohydrate metabolism, in fat metabolism, in respiration of plant and early maturity of maize.

Micronutrient play an active role in the plant metabolic process starting from cell development to respiration, photosynthesis, chlorophyll formation, enzyme activity, hormones synthesis, nitrogen fixation etc. The micronutrients are going to play a major protective role in bringing stability and sustainability in food production. The role of macro (NPK) and micronutrients (Zn & Mn) is crucial in yields. Nitrogen is a primary constituent of proteins and thus all enzymes (Raun and Johnson, 1999) [19]. P is involved in almost all biochemical pathways as a component part of energy carrier compounds, ATP and ADP **(**Khalil, 2003) [9]. Six micronutrients *i.e*., Mn, Fe, Cu, Zn, B and Mo are known to be required for all higher plants (Welch, 1995) [24]. These have been well documented to be involved in photosynthesis, N- fixation, respiration and other biochemical pathways (Marschner and Romheld, 1991).

Liquid bio-fertilizers are special liquid formulation containing not only the desired beneficial microorganisms and their biological secretions, but also special cell Protestants or substances that encourage the formation of dormant spores or cysts for longer shelf life and tolerance to adverse conditions. Bio-fertilizers include mainly the nitrogen fixing, phosphate solubilizing and plant growth promoting microorganisms. Biofertilizer is a natural input that can be applied as a complement to, or as a substituent of chemical fertilizer in sustainable agriculture (Ebrahimpour *et al.,* 2011) [5]. Bio-fertilizers benefiting the crop production are *Azotobacter, Azospirillum,* blue green algae, Azolla, P-solubilizing microorganisms, mycorrhizae and rhizobium (Selvakumar *et al.,* 2009) [21]. Among the bio-fertilizers, *Azotobacter* represents the main group of heterotrophic, non-symbiotic, gram negative, free living nitrogen-fixing bacteria. They are capable of fixing an average 20 kg N/ha/year. The genus *Azotobacter* includes 6 species, with A. chroococcum most commonly inhabiting in various soils all over the world (Mahato *et al*., 2009) [12].

Materials and Methods

The present study entitled "Effect of NPK Levels and Micronutrients with and without Liquid Biofertilizer on Soil Health and Yield Attributes of Maize (*Zea mays* L.) Cv. K-25"comprise of a field experiment which was carried out at the Soil Science& Agricultural Chemistry Research Farm, Sam Higginbottom University of Agriculture Technology and Sciences Prayagraj during *Kharif* season 2018 and 2019, which is located at 25^{0}24'30'' N latitude, 81^{0}51'10" Elongitude and 98m above the mean sea level. The detail of the experimental site, soil and climate is described in this chapter together with the experimental design, layout plan, cultural practice and techniques employed for the parameters. The area of Prayagraj district comes under subtropical belt in the South East Uttar Pradesh, which experience extremely hot summer and fairly winter. The maximum temperature of the location reaches up to 46^{0}C-48^{0}C and seldom falls as 4^{0}C – 5^{0}C. The relative humidity ranged between 20 to 94 percent. The average rainfall in this area is around 1100mm annually. It comes under subtropical climate receiving the mean annual rainfall of about 1100mm, major rainfall from July to end of September. However, occasional precipitation was also not uncommon during winter. The winter months were cold while summer months were very hot and dry. The minimum temperature during the crop season was to be 27.1 ^{0}C and the maximum is to be 39.94 ^{0}C. The minimum humidity was 57.70% and maximum was to be 75.37%.

Results and Discussion

Nitrogen uptake by maize grain & stem (kg ha^{-1})

Based on the different treatments opted, the nitrogen uptake in maize grain & stem showed significant response in addition with micronutrient, liquid bio-fertilizer and NPK-levels are presented in the Table 1 described in Fig. 1 Thus, it found highest uptake of nitrogen in maize grain and stem was significantly higher in treatment T_{19} [140:80:50 NPK kg ha^{-1} + Zn (20 kg ha^{-1}) and Mn (25 kg ha^{-1}) + *Azotobacter* (200 ml ha^{-1})+ PSB (200 ml ha^{-1})] (34.86 & 68.44 kg ha^{-1}during 2018, 52.89 & 63.65 kg ha^{-1}during 2019) while the minimum values of the result were found in treatment (T_0) absolute control which was 13.22 & 43.97 kg ha^{-1}during 2018 and 22.49 & 31.58 kg ha^{-1} during 2019 respectively. These treatments are statistically at par with the treatment (T_{18}) *i.e.*34.36 & 67.26 kg ha^{-1}during 2018 and 39.49 & 48.59 kg ha^{-1}during 2019 respectively. The nitrogen uptake by maize grain and straw increased significantly with the increasing levels of fertilizers in combination with micronutrient and liquid bio-fertilizers, which mainly attributed to solubilization of native nutrients present in soil, chelation of complex intermediate organic molecules produced during decomposition of added liquid bio-fertilizer, their mobilization and accumulation of different nutrients in different plant parts. The results are in agreement with the findings given by Gyanendra, *et al.*, 2015 [8], Gawade *et al*., 2017 [7], Patil *et al*., 2017 [18], Kumar *et al*., 2017 [10], Meena *et al.,* 2015 [14].

Phosphorus uptake by maize grain & stem (kg ha^{-1})

The uptake of phosphorus in maize grain & stem found highest with application of micronutrient, liquid bio-fertilizer and NPK-levels, are presented in the Table 1and described in Fig. 1. Thus, it proved prominent in the treatment T_{19} [140:80:50 NPK kg ha^{-1} + Zn (20 kg ha^{-1}) and Mn (25 kg ha^{-1}) + *Azotobacter* (200 ml ha^{-1})+ PSB (200 ml ha^{-1})] (25.16 & 11.87 kg ha^{-1}during 2018, 24.11 & 20.51 kg ha^{-1}during 2019) while the minimum values of the result were found in treatment (T_0) absolute control which was 13.75 & 4.20 kg ha^{-1}during 2018 and 13.16 & 10.53 kg ha^{-1} during 2019 respectively. These treatments were statistically at par with the treatment (T_{18}) *i.e.*23.19 & 10.95 kg ha^{-1}during 2018 and 22.16 & 18.85 kg ha^{-1}during 2019 respectively. The reason might be due to the cumulative effect of liquid bio-fertilizer and graded doses of nitrogen progressively increases phosphorus uptake by plants significantly. The results are in agreement with the findings given by Agrawal, *et al.*, 2004, Gawade *et al*., 2017 [7], Patil *et al*., 2017 [18], Kumar *et al*., 2017 [10], Meena *et al.,* 2015 [14].

Potassium uptake by maize grain & stem (kg ha^{-1})

Among various treatments, the combination of micronutrient, liquid bio-fertilizer and NPK-levels, significantly showed higher result, are presented in the Table 1 described in Fig. 4.4.6 and 4.4.6. Thus, the treatment T_{19} [140:80:50 NPK kg ha^{-1} + Zn (20 kg ha^{-1}) + Mn (25 kg ha^{-1}) + *Azotobacter* (200 ml ha^{-1})+ PSB (200 ml ha^{-1})] (20.16 & 89.22 kg ha^{-1}during

2018, 19.73 & 86.27 kg ha^{-1}during 2019) while the minimum values of the result were found in treatment (T_0) absolute control which was 11.86 & 46.35 kg ha^{-1}during 2018 and 10.71 & 46.26 kg ha^{-1} during 2019 respectively. These treatments were statistically at par with the treatment (T_{18}) *i.e.*19.95 & 81.36 kg ha^{-1}during2018 and 19.40 & 81.26 kg ha^{-1}during 2019 respectively. The increased uptake of K by maize grain and stem might be due to the release of K from the K bearing minerals by forming complexing agents and organic acids from the plant roots may accelerate the decomposition of organic minerals. Similar results were observed by Sawarkar *et al.*, 2013. The important reason which holds good in nutrient uptake (NPK) by maize crop in treatment combination with micronutrient, liquid bio-fertilizer and NPK-levels, might be due to association of *Azotobacter* &PSB with crop improvement, which plays a significant role in secretion of ammonia in the rhizosphere in the presence of root exudates, which helps in modification of nutrient uptake by the plants (Narula and Gupta, 1986). The increase in nutrient uptake with respect to NPK, might be due to synergetic effect of an increasing available NPK concentration in the soil, and improved soil structure for higher uptake of nutrients. The results are in agreement with the findings given by Gawade *et al.*, 2017 [7], Patil *et al.*, 2017 [18], Kumar *et al.*, 2017 [10], Meena *et al.*, 2015 [14], Manna, *et al.*, 2001.

Zinc uptake by maize grain & stem (kg ha^{-1})

Among various treatments, the combination of micronutrient, liquid bio-fertilizer and NPK-levels, significantly showed higher result, are presented in the Table 2 described in Fig. 2. Thus, the treatment T_{19} [140:80:50 NPK kg ha^{-1} + Zn (20 kg ha^{-1}) + Mn (25 kg ha^{-1}) + *Azotobacter* (200 ml ha^{-1})+ PSB (200 ml ha^{-1})] (5.10 & 5.98 kg ha^{-1}during 2018, 5.24 & 5.96 kg ha^{-1}during 2019) while the minimum values of the result were found in treatment (T_0) absolute control which was 2.25 & 3.38 kg ha^{-1}during 2018 and 2.89 & 2.27 kg ha^{-1} during 2019 respectively. These treatments were statistically at par with the treatment (T_{18}) *i.e.*4.85 & 5.82 kg ha^{-1}during2018 and 5.09 & 5.92 kg ha^{-1}during 2019 respectively. The results are in agreement with the findings given by Mousavi *et al.*, 2013 [15], Brahma *et al.*, 2012, Paramasivan *et al.*, 2010 [17].

Manganese uptake by maize grain & stem (kg ha^{-1})

Among various treatments, the combination of micronutrient, liquid bio-fertilizer and NPK-levels, significantly showed higher result, are presented in the Table 2 described in Fig. 2. Thus, the treatment T_{19} [140:80:50 NPK kg ha^{-1} + Zn (20 kg ha^{-1}) + Mn (25 kg ha^{-1}) + *Azotobacter* (200 ml ha^{-1})+ PSB (200 ml ha^{-1})] (7.58 & 7.24 kg ha^{-1}during 2018, 6.78 & 6.85 kg ha^{-1}during 2019) while the minimum values of the result were found in treatment (T_0) absolute control which was 2.93 & 2.86 kg ha^{-1}during 2018 and 2.85 & 2.26 kg ha^{-1} during 2019 respectively. These treatments were statistically at par with the treatment (T_{18}) *i.e.*, 7.48 & 6.59 kg ha^{-1}during2018 and 6.21 & 6.48 kg ha^{-1}during 2019 respectively. The results are in agreement with the findings given by Mousavi *et al.*, 2013 [15], Brahma *et al.*, 2012, Paramasivan *et al.*, 2010 [17].

Table 1: Effect of NPK levels and Micronutrient with and without liquid bio-fertilizer on Plant Macro Nutrient uptake of Maize 2018 and 2019

	Nitrogen Uptake (Kg ha^{-1})				Phosphorous Uptake (Kg ha^{-1})				Potassium uptake (Kg ha^{-1})			
	Grain	**Stem**	**Grain**	**Stem**	**Grain**	**Stem**	**Grain**	**Stem**	**Grain**	**Stem**	**Grain**	**Stem**
	2018	2018	2019	2019	2018	2018	2019	2019	2018	2018	2019	2019
T_1	13.22	43.97	22.49	31.58	13.75	4.2	13.16	10.53	11.86	46.35	10.71	46.26
T_2	14.23	44.2	25.29	32.01	13.92	4.24	13.85	10.67	11.95	46.56	12.1	46.35
T_3	16.23	44.92	25.59	34.32	14.16	4.31	14.05	10.84	12.25	46.79	12.71	46.66
T_4	18.17	45.26	28.27	36.05	14.47	4.55	14.16	11.09	12.35	47.15	13.04	47.06
T_5	19.27	45.94	28.49	38.15	15.33	4.65	15.22	11.7	13.28	47.34	13.71	47.15
T_6	21.36	46.27	28.88	39.67	15.66	4.72	15.33	11.98	13.85	48.68	13.93	48.23
T_7	24.21	47.35	32.65	40.05	16.75	4.88	16.28	12.65	14.16	48.92	14.04	48.66
T_8	26.55	51.19	33.22	40.28	16.87	4.92	16.66	12.75	14.26	50.16	14.18	50.06
T_9	28.67	63.1	33.67	40.47	17.15	5.19	17.27	13.12	15.85	50.65	14.37	50.26
T_{10}	29.78	63.12	34.6	40.48	17.74	5.64	17.36	13.56	15.91	61.86	14.44	61.36
T_{11}	31.76	63.22	35.19	43.84	18.45	5.86	18.17	14.15	16.83	62.37	15.15	62.16
T_{12}	32.39	64.63	35.46	44.19	18.91	5.92	18.39	14.48	16.95	63.17	16.11	63.07
T_{13}	32.49	64.75	35.69	45.04	19.27	6.12	19.08	14.87	17.76	64.28	16.17	64.17
T_{14}	32.86	65.18	36.45	45.17	19.35	7.42	19.15	15.3	17.86	65.68	16.18	64.9
T_{15}	33.16	65.23	37.49	45.85	20.65	8.13	20.26	16.48	18.77	66.17	16.23	66.13
T_{16}	33.33	66.81	37.78	46.22	20.77	9.64	21.1	16.78	18.91	67.28	16.87	67.18
T_{17}	33.74	67.1	37.89	47.08	21.74	10.76	21.35	17.52	19.46	79.17	17.27	79.09
T_{18}	34.36	67.26	39.49	48.59	23.19	10.95	22.16	18.85	19.95	81.36	19.4	81.26
T_{19}	34.86	68.44	52.89	63.65	25.16	11.87	24.21	20.51	20.16	89.22	19.73	86.27
	S	S	S	S	S	S	S	S	S	S	S	S
	0.153	3.617	5.715	6.924	0.209	0.041	0.641	0.641	0.032	0.03	1.539	0.106
	0.309	7.312	11.557	13.997	0.423	0.083	1.296	1.296	0.065	0.061	3.113	0.214

Table 2: Effect of NPK levels and micronutrient with and without liquid bio-fertilizer on Plant Micro Nutrient uptake of Maize2018 and 2019

	Zinc uptake (kg ha^{-1})				Manganese uptake (kg ha^{-1})			
	Grain	**Stem**	**Grain**	**Stem**	**Grain**	**Stem**	**Grain**	**Stem**
	2018	2018	2019	2019	2018	2018	2019	2019
T_1	2.25	3.38	2.89	2.27	2.93	2.86	2.85	2.26
T_2	2.57	3.51	3.17	3.43	3.1	2.95	2.96	2.35
T_3	2.93	3.62	3.36	3.61	3.24	3.4	3.18	3.15
T_4	3.17	3.74	3.36	3.85	3.32	3.42	3.27	3.17
T_5	3.42	3.82	3.37	3.97	3.32	3.98	3.35	4.16

T_6	3.5	4.39	3.59	4.26	3.54	4.08	3.41	4.17
T_7	3.56	4.53	3.66	4.55	3.7	4.15	3.55	4.17
T_8	3.65	4.62	3.73	4.65	3.84	4.63	3.76	4.23
T_9	3.67	4.68	3.77	4.75	3.95	4.71	3.86	4.38
T_{10}	3.74	4.69	3.87	4.85	4.4	4.73	4.24	4.43
T_{11}	3.75	5.08	4.01	4.95	4.46	4.94	4.32	4.65
T_{12}	3.87	5.21	4.11	5.06	4.73	4.95	4.36	4.67
T_{13}	4.01	5.45	4.12	5.17	4.8	5.22	4.46	5.17
T_{14}	4.14	5.5	4.29	5.25	5.48	5.62	4.87	5.35
T_{15}	4.28	5.58	4.34	5.36	6.66	5.72	5.07	5.67
T_{16}	4.29	5.8	4.43	5.66	7.37	5.95	5.22	5.85
T_{17}	4.71	5.81	4.85	5.88	7.4	6.02	5.28	6.37
T_{18}	4.85	5.82	5.09	5.92	7.48	6.59	6.21	6.48
T_{19}	5.1	5.98	5.24	5.96	7.58	7.24	6.78	6.85
	S	S	S	S	S	S	S	S
	0.462	0.058	0.567	0.023	0.502	0.215	0.106	0.024
	0.934	0.117	1.147	0.045	1.0158	0.555	0.214	0.049

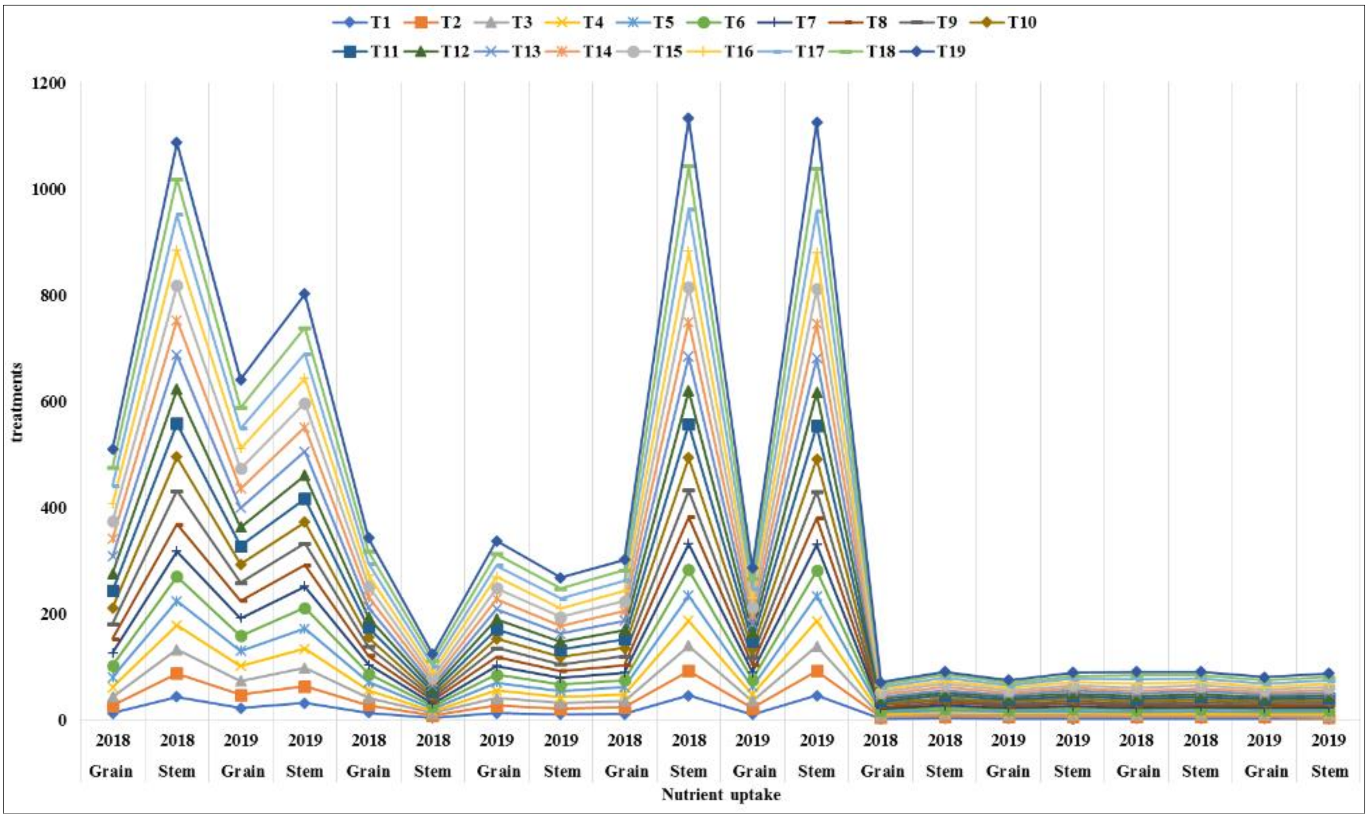

Fig 1: Effect of NPK levels and micronutrient with and without liquid bio-fertilizer on Plant Macroand Micro Nutrient uptake of Maize2018 and 2019

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