

Original Research Article

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Effect of NPK Levels and Micronutrients with and without Liquid Biofertilizer on Physico-Chemical Properties of Soil in Maize

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ABSTRACT

A field study was conducted on the “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” 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 T₁₉[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)] bulk density (1.17 Mg m⁻³ during 2018, 1.11 Mg m⁻³ during 2019), particle density (2.32 Mg m⁻³ during 2018, 2.49 Mg m⁻³ during 2019), pore space (47.54 % during 2018, 48.87 % during 2019), water holding capacity (39.75 % during 2018, 39.95 % during 2019), Soil texture (58, 30, 12 % sand, slit, clay during 2018 and 2019), Soil colour (10 YR 6/3 pale brown and 10 YR 4/3 dark brown during 2018 and 2019), pH 6.99 during 2018, 7.67 during 2019, EC (0.87 dSm⁻¹ during 2018, 0.80 dSm⁻¹ during 2019), organic carbon (0.35 % during 2018, 0.50 % during 2019), available nitrogen (290.87 kg ha⁻¹ during 2018, 317.58 kg ha⁻¹ during 2019), available phosphorus (22.39 kg ha⁻¹ during 2018, 22.28 kg ha⁻¹ during 2019), available potassium (291.94 kg ha⁻¹ during 2018, 269.52 kg ha⁻¹ during 2019), available zinc (0.84mg kg⁻¹ during 2018, 0.85 mg kg⁻¹ during 2019), available manganese (5.35mg kg⁻¹ during 2018, 5.66 mg kg⁻¹ during 2019) as compared to T₀ (absolute control).

Keywords

Maize, NPK,
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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). 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). Maize grain contains

about 70% carbohydrate, 10% protein, 4% oil, 2.3% crude fiber, 10.4% albuminoides, 1.4% ash (Choudhary, 1993). 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). 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 as sulphur 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). 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). P is involved in almost all biochemical pathways as a component part of energy carrier compounds, ATP and ADP (Khalil, 2003). Six micronutrients *i.e.*, Mn, Fe, Cu, Zn, B and Mo are known to be required for all higher plants (Welch, 1995). 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 protectants 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). Bio-fertilizers benefiting the crop production are *Azotobacter*, *Azospirillum*, blue green algae, *Azolla*, P-solubilizing

microorganisms, mycorrhizae and rhizobium (Selvakumar *et al.*, 2009). 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).

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°24'30" N latitude, 81°51'10" E longitude 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°C-48°C and seldom falls as 4°C – 5°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°C and the maximum is to be 39.94°C. The minimum humidity was 57.70% and maximum was to be 75.37%.

Results and Discussion

Bulk density (Mg m^{-3})

The result of data were decrypted in Table 1 and Fig. 1 showed that maximum bulk density (Mg m^{-3}) of soil were found in treatment T₁₉ [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)] (1.17 Mg m⁻³ during 2018, 1.11 Mg m⁻³ during 2019), in comparison with control (T₁) *i.e.* 1.14 Mg m⁻³ during 2018, 1.15 Mg m⁻³ during 2019 while the minimum values of the result were found in treatment T₀ (absolute control) respectively. These treatments were statistically at par with each other with the treatment (T₁₈) *i.e.*, 1.14 Mg m⁻³ during 2018 and 1.13 Mg m⁻³ during 2019 respectively, the mean value of bulk density of soil (Mg m^{-3}) was found significantly different. It was also observed that the bulk density of soil was gradually increased with increasing the dose of NPK levels. The effect of NPK levels and micronutrient with and without liquid bio-fertilizer was also found significant. Because the presence of NPK levels and micronutrient with and without liquid bio fertilizers in optimum amount increases bulk density of soil. It contains higher amount of sand, silt and clay particle. As indicated enrichment of fine fractions *i.e.*, silt and clay a part from the retention of dissolved O.M. leading to change in physical properties of soil. (Motior *et al.*, 2011, Kumar *et al.*, 2015, Jayprakash *et al.*, 2005, Kumar *et al.*, 2019)

Particle density (Mg m^{-3})

The result of data decrypted in Table 1 and Fig. 1 observed maximum particle density

(Mgm^{-3}) of soil were found 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})] (2.32 Mgm^{-3} during 2018, 2.49 Mgm^{-3} during 2019) was minimum values of the result were found in treatment T_0 (absolute control) which was 2.27 Mgm^{-3} during 2018 & 2.48 Mgm^{-3} during 2019 respectively, These treatments were statistically at par with the treatment (T_{18}) *i.e.* 2.16 Mgm^{-3} during 2018 and 2.62 Mgm^{-3} during 2019 respectively, the mean value of particle density of soil (Mgm^{-3}) was found significantly different. It was also observed that the particle density of soil was gradually increased with the effect of NPK levels and micronutrient with and without liquid bio-fertilizer on particle density of soil was also found significant. (Motior *et al.*, 2005; Kumar *et al.*, 2015; Jayprakash *et al.*, 2005; Kumar *et al.*, 2019)

Pore space (%)

The result of data decrypted in Table 1 and Fig.1 showed maximum pore space (%) of soil in 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})] (47.54 % during 2018, 48.87 % during 2019) while the minimum values of the result were found in treatment T_0 (absolute control) which was 38.32 % during 2018 and 38.98 % 2019 respectively.

These treatments are statistically at par with each other and on par with the treatment (T_{18}) *i.e.*, 46.49 % during 2018 and 47.49 % during 2019 respectively, Bulk density and pore space were recorded maximum in INM practice and recommended dose of NPK levels and micronutrient with and without liquid bio-fertilizer. (Kumar *et al.*, 2019, Motior *et al.*, 2005, Kumar *et al.*, 2015, Jayprakash *et al.*, 2005)

Water holding capacity (%)

The result of data showed in Table 1 and Fig. 1 observed maximum water holding capacity (%) of soil found in 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})] 39.75 % during 2018, 39.95 % during 2019 while the minimum values of the result were found in treatment (T_0) absolute control which was 30.57 % during 2018 and 30.27 % 2019 respectively. These treatments were statistically at par with the treatment (T_{18}) *i.e.*, 39.62 % during 2018 and 39.56 % during 2019 respectively. (Kumar *et al.*, 2015) Water holding capacity of soil was found significantly different. It was also observed that the pore space of soil was gradually increased with an increase in dose of NPK levels and micronutrient and liquid Biofertilizer. The effect of NPK levels and micronutrient and liquid Biofertilizer on water holding capacity of soil was also found significant (Motior *et al.*, 2005; Kumar *et al.*, 2015; Jayprakash *et al.*, 2005; Kumar *et al.*, 2019).

Soil texture

The result of data showed in Table 1 and observed Soil Texture (%) found in 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})] 58, 30, 12 % sand, slit, clay during 2018 and 2019 while the minimum values of the result were found in treatment (T_0) absolute control which was 60, 35, 5 % during 2018 and 2019 respectively. (Motior *et al.*, 2005, Kumar *et al.*, 2015, Jayprakash *et al.*, 2005, Kumar *et al.*, 2019)

Soil colour

The result of data showed in Table 1 and observed Soil Colour found in 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)] 10 YR 6/3 pale brown and 10 YR 4/3 dark brown during 2018 and 2019 while the minimum values of the result were found in treatment (T₀) absolute control which was 10 YR 7/3 very pale brown and 10YR 5/4 yellowish brown during 2018 and 2019 respectively. (Motior *et al.*, 2005, Kumar *et al.*, 2015, Jayprakash *et al.*, 2005, Kumar *et al.*, 2019)

Soil pH (1:2.5) w/v

The result of data decrypted in Table 2 and depicted in Fig. 2 showed that the maximum pH (1:2) w/v were found in treatment T₁₉ [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)] 6.99 during 2018, 7.67 during 2019 while the minimum values of the result were found in treatment (T₀) absolute control which was 6.69 during 2018 and 6.84 during 2019 respectively. Application of NPK fertilizer, micronutrient fertilizers and liquid Bio-fertilizers is one of the most important approaches on improving soil physical-chemical characters and maize grain using hybrid variety K-25 (Kanchan). These results indicated that the soil bulk densities were increased, whereas the soil porosity, field capacity and values of pH were increased by NPK levels and micronutrient with and without liquid bio-fertilizer at different stages. (Singh *et al.*, 2017, Gupta *et al.*, 2018, Kumar *et al.*, 2015, Masih *et al.*, 2005, Kumar *et al.*, 2019)

Soil electrical conductivity (dSm⁻¹)

The data depicted in Table 2 and Fig. 2 showed that the maximum electrical Conductivity (dSm⁻¹) were found significantly high in treatment T₁₉ [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)] (0.87 dSm⁻¹ during 2018, 0.80 dSm⁻¹

during 2019 while the minimum values of the result were found in treatment T₀ (absolute control) which was 0.83 dSm⁻¹ during 2018 and 0.82 dSm⁻¹ during 2019 respectively. Table 2 depicted that the mean value of EC (dS m⁻¹) of soil was found non-significant of different levels of NPK. It was also observed that EC of soil were gradually increased with increasing dose of NPK levels and micronutrient with and without liquid Bio-fertilizer. The effect NPK levels and micronutrient on EC of soil was also found non-significant (Masih *et al.*, 2018, Singh *et al.*, 2017, Kumar *et al.*, 2015).

Organic carbon (%)

Usually, in sandy loam soils, organic matter content is low. Based on research studies during the course of two years, it has come with output that, the organically treated plot including bio-fertilizer and NPK levels, marked significantly higher organic carbon content and it varied from 0.31 to 0.96, 0.37 to 1.02 and 0.34 to 0.99 %, respectively, during 2018, 2019. The result of data depicted in Table 2 and Fig. 2 showed maximum organic carbon (%) were found in treatment T₁₉ [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)] (0.35 % during 2018, 0.50 % during 2019) while the minimum values of the result were found in treatment (T₀) absolute control which was 0.26 % during 2018 and 0.29 % during 2019 respectively. These treatments were statistically at par with the treatment (T₁₈) *i.e.*, 0.33 % during 2018 and 0.56 % during 2019 respectively, the mean value of organic carbon (%) of soil was found significant of different levels of NPK and micronutrient. It was also observed that organic carbon (%) of soil was gradually increased with increasing dose of NPK. effect NPK levels and micronutrient with and without liquid bio-fertilizer on organic carbon (%) of soil was

found significantly (Masih *et al.*, 2018, Gupta *et al.*, 2018, Kumar *et al.*, 2015, Kumar *et al.*, 2019)

Available nitrogen (Kg ha⁻¹)

The nitrogen has its major significant role in completion of crop life cycle. In contrast, by using different amount of NPK levels, micronutrient with and without liquid bio-fertilizers on sandy loam soil, the research work was conducted on maize crop during the two years. The observational studies after analyzed soil samples from respective field, integral effect of organics and inorganics found highest available N source. The available N among the treatment's ranges from 121.05 to 290.87 and 121.06 to 317.58 kg ha⁻¹, respectively, observed data during 2018 and 2019 were presented in the Table 2 and described in Fig. 2. In clarity, treatment T₁₉ [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)] (290.87kg ha⁻¹ during 2018, 317.58 kg ha⁻¹ during 2019)while the minimum values of the result were found in treatment (T₀) absolute control which was 121.05 kg ha⁻¹ during 2018 and 121.06 kg ha⁻¹ during 2019 respectively. These treatments were statistically at par with the treatment (T₁₈) *i.e.*, 253.17 kg ha⁻¹ during 2018 and 311.29 kg ha⁻¹ during 2019 respectively. (Meena *et al.*, 2018 (ac), Gupta *et al.*, 2018, Ruth *et al.*, 2018, Bharath *et al.*, 2017(a), Singh *et al.*, 2017). Increase in available N observed under organically treated plot, which might be due to mineralization effect of organic sources (Tabassum *et al.*, 2010). It might be also due to the favorable soil conditions provided by NPK and liquid Biofertilizer addition might have helped in mineralization of additional soil N leading to build-up of higher available N and improved soil fertility (Santhy *et al.*, 1998; Sarin *et al.*, 1991; Kumar, 2014; Davari *et al.*, 2012; Essan and Lattief, 2014).

Available phosphorus (Kg ha⁻¹)

The available P is the most limiting factor in sandy loam soil. However, it exists as an inorganic orthophosphate ion in soil having direct relationship with plant growth and development through regulation of protein synthesis. On the basis of research studies during two years, it has come with output that, the organically treated plot including liquid bio-fertilizer and NPK-levels, marked significantly highest available P in soil and it varied from 10.16 to 22.39 and 12.24 to 22.28 kg ha⁻¹, respectively, during 2018 and 2019 were presented in the Table 2 and described in Fig. 2. In clarity, treatment T₁₉ [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)] (22.39kg ha⁻¹ during 2018, 22.28 kg ha⁻¹ during 2019) while the minimum values of the result were found in treatment (T₀) absolute control which was 10.16kg ha⁻¹ during 2018 and 12.24kg ha⁻¹ during 2019 respectively. These treatments were statistically at par with the treatment (T₁₈) *i.e.*, 21.49 kg ha⁻¹ during 2018 and 22.24kg ha⁻¹ during 2019 respectively, the highest available P in NPK levels and micronutrient with and without liquid bio-fertilizer treated plot resulted, might be due to effective solubilizations of native P in the soil through the release of various organic acids by Liquid bio-fertilizer. On another side it might be influenced by release of carbon dioxide (CO₂), which plays a dominant role in enhancing the P availability, during the decomposition of organic matter which forms carbonic acids, solubilizing certain primary minerals (Singh and Wanjari, 2007). In addition, bio-fertilizer could have maintained P reserve fairly at high level by forming a protective cover on sesquioxide's and this facilitates reduction in the P-fixing capacity of soil. (Meena *et al.*, 2018; Gupta *et al.*, 2018; Ruth *et al.*, 2018; Bharath *et al.*, 2017; Singh *et al.*, 2017).

Available potassium (Kg ha⁻¹)

The available K in soil is readily absorbed by the crop plant, as it held on the clay particles exchange sites. However, it exists as exchangeable form in soil having direct relationship with plant growth and development through regulation of protein and starch synthesis and also acts as energy unit for plants. On the basis of research during the two years, it has come with output that, the organically treated plot having higher clay content, having higher persistence in soil including liquid bio-fertilizer and NPK levels, marked significantly highest available K in soil and it varied from 145.83 to 291.94 and 196.52 to 269.52 kg ha⁻¹, respectively, during 2018, 2019 are presented in the Table 2 and described in Fig. 2. Among various treatment T₁₉ [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)] (291.94kg ha⁻¹ during 2018, 269.52 kg ha⁻¹ during 2019) while the minimum values of the result were found in treatment (T₀) absolute control which was 145.83kg ha⁻¹ during 2018 and 196.52kg ha⁻¹ during 2019 respectively. These treatments are statistically at par with the treatment (T₁₈) *i.e.*, 284.49 kg ha⁻¹ during 2018 and 258.34 kg ha⁻¹ during 2019 respectively, the higher amount of available K in the micronutrient and liquid bio-fertilizer treated plot might have resulted, due to the fact on its application pronounced increased cation exchange capacity in soil, which is mainly capable of holding large amount of exchangeable K. Further, it helped in releasing exchangeable K from non-exchangeable pool. It could also ascribe due to the reduction in K-fixation and release of K from reserved non-exchange site, which is held between inter lattice layer of clay or due to the interaction of organic matter with clay besides the direct addition of K to available pool of the soil (Kher and Minhas, 1991; Gupta *et al.*, 2018; Ruth *et al.*, 2018; Bharath *et al.*, 2017; Singh *et al.*, 2017).

Available sulphur (kg ha⁻¹)

The available sulphur is becoming recognized as the fourth macro-nutrient element in soil, as it readily absorbed by the crop plant in sulphate form, which pronounced more in organic state of a soil. However, it has direct relationship with plant growth in the formation of chlorophyll. On the basis of research studies during the two years, the outcome of the result says that, the organically treated plot including liquid bio-fertilizer and NPK-levels, marked significantly highest available sulphur in soil and it varied from 9.66 to 12.66 and 9.09 to 12.84 kg ha⁻¹, respectively, during 2018 and 2019 are presented in the Table 2 and described in Fig. 2. Alike other treatment, T₁₉ [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)] (12.66kg ha⁻¹ during 2018, 12.84 kg ha⁻¹ during 2019) while the minimum values of the result were found in treatment (T₀) absolute control which was 9.66kg ha⁻¹ during 2018 and 9.09kg ha⁻¹ during 2019 respectively.

These treatments are statistically at par with the treatment (T₁₈) *i.e.*, 12.20 kg ha⁻¹ during 2018 and 12.65 kg ha⁻¹ during 2019 respectively, Primarily, the increase in available sulphur was due to use of single superphosphate (SSP) as a source of P, which contains appreciable amount of sulphur. In addition to this, the highest available sulphur in organic treatment might be attributed to mineralization of available NPKS nutrients from liquid bio-fertilizer, another reason might be that, the suitable soil conditions under organic sources might have promoted for mineralization of nutrients and leading to build-up higher NPKS (Agarwal *et al.*, 2010 and Ravankar *et al.*, 2005; Meena *et al.*, 2018; Gupta *et al.*, 2018; Ruth *et al.*, 2018; Bharath *et al.*, 2017; Singh *et al.*, 2017).

Table.1 Effect of NPK levels and micronutrient with and without liquid bio-fertilizer on physical properties of Soil 2018 and 2019

Treatments	Bulk Density (Mg m ⁻³)		Particle Density (Mg m ⁻³)		Pore space (%)		Water holding capacity (%)		Percentage of sand, silt and clay (%)				Percentage of sand, silt and clay (%)	
	2018	2019	2018	2019	2018	2019	2018	2019	Sand	Silt	Clay	Soil texture	Dry	Wet
T ₁	1.14	1.15	2.27	2.48	38.32	38.98	30.57	30.27	60	35	5	Sandy loam	10 YR 7/3 very pale brown	10YR 5/4 yellowish brown
T ₂	1.14	1.15	2.68	2.62	39.44	40.68	31.75	31.68	60	30	10	Sandy loam	10 YR 7/4 very pale brown	10 YR 5/3 brown
T ₃	1.2	1.13	2.64	2.56	40.62	40.76	31.89	31.75	62	32	6	Sandy loam	10 YR 3/3 pale brown	10 YR 4/4 dark yellowish brown
T ₄	1.18	1.11	2.49	2.56	40.62	40.95	32.02	31.95	58	30	12	Sandy loam	10 YR 6/3 pale brown	10 YR 4/2 dark brown
T ₅	1.15	1.05	2.47	2.85	40.77	41.1	32.15	32.42	60	30	10	Sandy loam	10 YR 6/4 light yellowish brown	10 YR 3/3 dark brown
T ₆	1.14	1.11	2.32	2.62	41.51	41.8	32.18	32.72	55	35	10	Sandy loam	10 YR 6/3 pale brown	10 YR 4/3 dark brown
T ₇	1.15	1.11	2.43	2.63	41.85	41.84	32.84	33.25	58	35	7	Sandy loam	10 YR 7/3 very pale brown	10 YR 4/4 dark yellowish brown
T ₈	1.13	1.13	2.62	2.62	41.89	42.51	33.42	33.65	55	36	9	Sandy loam	10 YR 6/4 light yellowish brown	10 YR 5/4 yellowish brown
T ₉	1.15	1.09	2.64	2.53	42.51	42.52	33.51	34.01	55	38	7	Sandy loam	10 YR 6/3 pale brown	10 YR 4/3 dark yellowish brown
T ₁₀	1.14	1.11	2.43	2.49	42.52	42.56	34.51	35.12	55	36	9	Sandy loam	10 YR 3/3 pale brown	10 YR 4/4 dark yellowish brown
T ₁₁	1.18	1.13	2.28	2.73	42.53	42.83	35.42	35.72	57	35	8	Sandy loam	10 YR 6/3 pale brown	10 YR 4/2 dark brown
T ₁₂	1.18	1.11	2.36	2.62	42.53	43.17	36.55	36.36	55	35	10	Sandy loam	10 YR 6/4 light yellowish brown	10 YR 3/3 dark brown
T ₁₃	1.14	1.13	2.16	2.56	42.89	43.28	37.05	36.89	58	35	7	Sandy loam	10 YR 3/3 pale brown	10 YR 4/4 dark yellowish brown
T ₁₄	1.17	1.11	2.32	2.52	43.28	43.83	37.29	37.39	55	36	9	Sandy loam	10 YR 7/3 very pale brown	10TR 5/4 yellowish brown
T ₁₅	1.15	1.13	2.32	2.4	43.83	44.54	38.15	37.75	55	35	10	Sandy loam	10 YR 7/4 very pale brown	10 YR 5/3 brown
T ₁₆	1.18	1.13	2.28	2.49	44.28	44.95	38.82	38.66	56	32	11	Sandy loam	10 YR 3/3 pale brown	10 YR 4/4 dark yellowish brown
T ₁₇	1.14	1.11	2.36	2.73	44.56	45.23	39.08	38.73	60	30	10	Sandy loam	10 YR 6/3 pale brown	10 YR 4/2 dark brown
T ₁₈	1.14	1.13	2.16	2.62	46.49	47.49	39.62	39.56	62	32	6	Sandy loam	10 YR 6/4 light yellowish brown	10 YR 3/3 dark brown
T ₁₉	1.17	1.11	2.32	2.49	47.54	48.87	39.75	39.95	58	30	12	Sandy loam	10 YR 6/3 pale brown	10 YR 4/3 dark brown
	NS	NS	NS	NS	S	S	S	S						
	-	-	-	-	1.623	1.537	1.873	1.874						
	-	-	-	-	3.279	3.108	3.786	3.789						

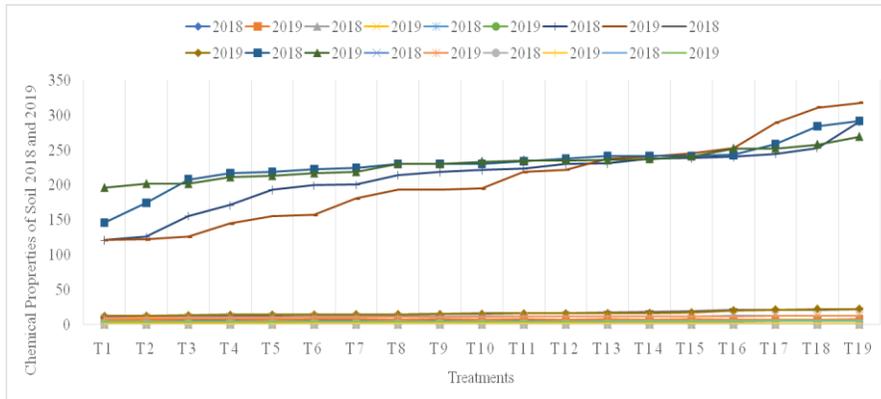
Table.2 Effect of NPK levels and micronutrient with and without liquid bio-fertilizer on chemical properties of Soil 2018 and 2019

Treatments	P ^H (1:2.5) w/v		Electric conductivity (dSm ⁻¹)		Organic carbon (%)		Available Nitrogen (kg ha ⁻¹)		Available Phosphorous (kg ha ⁻¹)		Available Potassium (kg ha ⁻¹)		Available sulphur (kg ha ⁻¹)		Available Zinc (mg kg ⁻¹)		Available Manganese (mg kg ⁻¹)	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
T ₁	6.69	6.84	0.83	0.82	0.26	0.29	121.05	121.06	10.16	12.24	145.83	196.52	9.66	9.09	0.62	0.65	3.94	4.14
T ₂	6.84	6.62	0.79	0.83	0.27	0.3	125.77	122.05	12.2	12.51	174.14	202.15	9.84	9.85	0.63	0.68	4.04	4.2
T ₃	6.78	7.76	0.84	0.86	0.29	0.33	155.64	125.77	12.29	13.21	207.75	202.15	10.58	9.94	0.65	0.72	4.16	4.23
T ₄	6.85	7.79	0.85	0.87	0.34	0.3	170.92	144.64	12.9	13.86	217.11	211.5	10.94	10.16	0.65	0.73	4.19	4.24
T ₅	6.95	6.79	0.83	0.82	0.42	0.31	193.37	155.64	13.36	14.12	218.94	213.34	10.94	10.38	0.66	0.73	4.2	4.3
T ₆	6.75	7.75	0.8	0.85	0.42	0.36	199.47	157.27	13.86	14.17	222.7	217.11	11.09	10.66	0.69	0.75	4.24	4.31
T ₇	6.92	7.91	0.82	0.89	0.4	0.39	200.31	180.8	14.12	14.6	224.6	218.94	11.1	10.85	0.71	0.75	4.29	4.33
T ₈	6.67	6.81	0.84	0.87	0.39	0.47	214.29	193.37	14.58	14.72	230.22	230.25	11.16	10.92	0.71	0.75	4.29	4.41
T ₉	6.91	7.77	0.82	0.85	0.39	0.36	218.47	193.37	14.84	14.92	230.22	230.26	11.34	11.15	0.72	0.76	4.3	4.44
T ₁₀	6.76	6.8	0.83	0.81	0.41	0.31	221.6	194.94	15.94	15.26	230.26	233.96	11.34	11.36	0.73	0.76	4.35	4.47
T ₁₁	6.88	7.64	0.8	0.79	0.42	0.26	223.05	218.45	16.19	15.84	233.96	235.83	11.36	11.55	0.74	0.78	4.36	4.48
T ₁₂	6.93	6.83	0.76	0.82	0.45	0.31	230.18	221.6	16.59	15.94	237.7	235.84	11.54	11.85	0.75	0.78	4.39	4.5
T ₁₃	6.61	7.85	0.85	0.87	0.41	0.39	231.11	237.41	17.51	16.18	241.44	235.87	11.65	11.91	0.76	0.79	4.4	4.59
T ₁₄	6.84	6.78	0.8	0.82	0.41	0.4	237.41	240.54	18.32	16.53	241.45	237.7	11.65	12.06	0.77	0.8	4.41	4.6
T ₁₅	6.85	7.71	0.78	0.8	0.41	0.36	238.47	245.25	18.99	17.28	241.46	241.46	11.74	12.22	0.77	0.81	4.5	4.61
T ₁₆	6.88	6.88	0.81	0.8	0.27	0.49	240.54	253.12	21.33	20.16	243.31	252.61	12.16	12.35	0.79	0.81	4.59	5.25
T ₁₇	6.93	6.93	0.79	0.76	0.29	0.62	244.82	289.28	21.38	21.26	258.33	252.63	12.17	12.46	0.82	0.81	5	5.43
T ₁₈	6.61	6.61	0.82	0.85	0.33	0.56	253.17	311.29	21.49	22.24	284.49	258.34	12.2	12.65	0.83	0.81	5.01	5.64
T ₁₉	6.99	7.67	0.87	0.8	0.35	0.5	290.87	317.58	22.39	22.28	291.94	269.52	12.26	12.84	0.84	0.85	5.35	5.66
	NS	NS	NS	NS	S	S	S	S	S	S	S	S	S	S	S	S	S	S
	-	-	-	-	0.027	0.103	54.346	74.187	2.604	1.926	25.956	9.843	0.026	0.0321	0.022	0.03	0.178	0.159
	-	-	-	-	0.556	0.208	109.856	149.962	5.265	3.893	52.467	19.897	0.053	0.0649	0.047	0.063	0.361	0.323

Fig.1 Effect of NPK levels and micronutrient with and without liquid bio-fertilizer on physical properties of Soil2018 and 2019



Fig.2 Effect of NPK levels and micronutrient with and without liquid bio-fertilizer on chemical properties of Soil2018 and 2019



Available zinc (mg kg⁻¹)

Available zinc in the soil has its synergetic effect with available zinc in estimated soil samples from the experimental plot. Addition to this, zinc showed positive response with micronutrient treated plots in combination of liquid bio-fertilizers and NPK levels; this is happened when sandy loam soil is treated especially with micronutrient, as helps increasing clay content of soil by means of holding zinc in cheated form for longer time. Hence, leaching cannot take place. Outcome of the result from the two years says that, the organically treated plot including liquid bio-fertilizer and NPK levels, marked significantly highest. Available zinc in soil

and it varied from 0.62 to 0.84 and 0.65 to 0.85 mg kg⁻¹, respectively, during 2018 and 2019 are presented in Table 2 and described in Fig. 2. The results further showed that, organically treated plots marked highest available zinc in the treatments T₁₉ [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)] (0.84mg kg⁻¹during 2018, 0.85 mg kg⁻¹during 2019) while the minimum values of the result were found in treatment (T₀) absolute control which was 0.62 mg kg⁻¹ during 2018 and 0.65 mg kg⁻¹ during 2019 respectively. These treatments are statistically at par with the treatment (T₁₈) i.e., 0.83 mg kg⁻¹during2018 and 0.81 mg kg⁻¹ during 2019 respectively, as we know, zinc is known to

form relatively stable chelates with organic legends, in order to minimize their susceptibility with regard to adsorption, fixation and precipitation. Hence, the highest available zinc might have obtained in organic amended plots. On other side, amount of nutrients added, reaction time in soil, rate of extraction by roots, nature and amount of clay minerals, micronutrient content are the governing factors could have responded well with transformation of zinc in soils. (Jat, *et al.*, 2014, Subehia, *et al.*, 2011, Mishra *et al.*, 2019, Gupta *et al.*, 2018, Kumar *et al.*, 2017, Saad *et al.*, 2017, Singh *et al.*, 2016)

Available manganese (mg kg⁻¹)

The most often occurring wide spread deficiency in sandy loam soils because of highly immobile complex nature of an element. Similar phenomenon was noticed that of available Manganese content in soil, where manganese availability has also gone down gradually on addition of organic matter by formation of manganese complexes, as described in the experiment. The data pertaining to manganese availability in soil showed that, significant variation existed among the different treatments. The range of available manganese was ranged from 3.94 to 5.35 and 4.14 to 5.66 mg kg⁻¹, respectively, during 2018, 2019, are presented in the Table 2 and depicted graphically in Fig. 2. In contrast, from various treatment, T₁₉ [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)] (5.35mg kg⁻¹during 2018, 5.66 mg kg⁻¹during 2019) while the minimum values of the result were found in treatment (T₀) absolute control which was 3.94 mg kg⁻¹ during 2018 and 4.14 mg kg⁻¹ during 2019 respectively. These treatments are statistically at par with the treatment (T₁₈) *i.e.*, 5.01 mg kg⁻¹during 2018 and 5.64 mg kg⁻¹during 2019 respectively. (Longchamp *et al.*, 2016, Gyanendra *et al.*, 2015, Singh *et al.*, 2016)

In conclusion the present investigation, it was apparent that application of N and P fertilizer in treatment T₁₉ [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)] was found on physical and chemical parameters of soil such as bulk density, particle density, % pore space, water holding capacity, Soil texture, Soil colour, EC, pH, organic carbon, available NPKS and available micronutrient (Zn, Mn) than other treatment combinations. %pore space, pH and EC are non-significant. Thus it can be concluded that different levels of N and P fertilizer improved soil available nutrient, increased soil available nitrogen, phosphorus, potassium and electrical conductivity. However, pH of soil increased and also among the treatments T₁₉ recorded the best treatment which increased the availability of nutrient and influenced on physical properties of soil.

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