Assessment of Variation in Physico-chemical Properties of Maize Soil as Influenced By Levels of NPK, and Vermicompost At Eastern Uttar Pradesh, India

Abstract

A field experiment was carried out throughout Zaid season 2022 on the research farm of the Department of Soil Science and Agricultural Chemistry, SHUATS, Prayagraj, to examine the variations in physicochemical properties of soil and yield of maize, as affected by the levels of NPK and vermicompost in the eastern part of Uttar Pradesh. The soil at the test site was sandy loam in texture and is located at $25^0 24' 30''$ North latitude, $81^0 51' 10''$ East longitude, and about 98 meters above sea level. The experiment was designed in a block-based design that was randomly randomized with nine different treatments T_1@0%NPK ha^{-1} + @0%Vermicompost ha^{-1}, T_2@0%NPK ha^{-1} + @50% Vermicompost ha^{-1}, T_3 @ 0% NPK ha^{-1} + @100% Vermicompost ha^{-1}, T_4 @ 50% NPK ha^{-1} +@ 0% Vermicompost ha^{-1}, T_5 @50% NPK ha^{-1} + @50% Vermicompost ha^{-1}, T_6 @50%NPK ha^{-1} +@100%Vermicompost ha^{-1} , T_7 @ 100% NPK ha^{-1} +@ 0% Vermicompost ha^{-1} , T_8 @ 100% NPK ha^{-1} +@ 50% Vermicompost ha^{-1} , T_9 @ 100%NPK ha^{-1}+ @100% Vermicompost $ha^{-1.}$ which were replicated thrice. The soil's physico-chemical characteristics before sowing and following crop harvest were assessed using standard procedures. Bulk density, Particle density, percent pore space and water holding capacity Was determined by (Muthuval *et al*) pH, Ec and organic carbon was determined by Digital pH meter, Digital EC meter and Walkley and Black method respectively. Available N, P, K was determined by Kjeldhal Method, Colorimetric method and Flame photometric method respectively. The experimental findings showed that the Bulk density, percent of pore space, capacity for holding water, Ec, organic carbon and available N, P, K of soil were found to be significant at various quantities that included NPK and Vermicompost. Post-harvest soil physico-chemical properties (Water holding capacity, percent pore space, Electrical conductivity, organic carbon, Available nitrogen, phosphorus and potassium) were maximum underT_9(100%NPK ha^{-1}+ 100% Vermicompost ha^{-1}) and followed by T_8(100%NPK ha^{-1}+ 50% Vermicompost ha^{-1}). It was also observed that the soil's Bulk and particle density were improved under T_9(100%NPK ha^{-1}+ 100% Vermicompost ha^{-1}) when compared with other control treatments and treatments combinations. Bulk density gradually decreased with an increased dose of NPK and vermicompost. So, integrating inorganic and organic fertilizers has resulted in improved physico-chemical properties compared to the sole use of 100% RDF.

Keywords: Vermicompost, NPK, Maize and Prayagraj.

Introduction

Indian agriculture experienced great strides forward during the 1960s due to widespread adoption of high-yield varieties and effective fertilizer usage, helping transform subsistence farming to surplus farming (Nelson et al. 2019). Following rice and wheat, maize (Zea mays L) has emerged as an influential cereal crop worldwide. 2013-14, India produced 23 million metric tonnes (MMT). The global production of maize is 967 MMT. (India maize summit 2014) It is grown in different sequences depending on the agro-climatic region of the country. It is therefore considered a driver for crop diversification in different situations. Organic manure application improved soil structure and made nutrients available, leading to higher yields in crops. Nitrogen application has been instrumental in the global increase of maize production over the last four decades. Nitrogen supports rapid vegetative growth and early maize development (FOA, 2018) and controls how potassium, calcium and phosphorus are distributed into maize crops - meaning its usage should remain constant from seedling through harvest (Singh *et al*., 2012). Phosphorus is essential to energy transformation, metabolism, respiration and early maturation of maize. Potassium plays an integral part in chlorophyll production, protein formation, and other plant pigment formation; its osmotic force draws water toward plant roots, reduces lodging by producing strong straw, increases plant vigor and increases resistance against disease (Singh *et al*., 2010). The organic manures increase the water-holding capacity of the soil, as well as phosphate availability. Organic manures also increased the efficiency of fertilizer application and the soil's microbial and organic carbon content. Organic manure also reduces soil nitrogen losses (Liu *et al*. 2021). Regular applications of organic manures and inorganic fertilizers help regulate soil pH and EC better than not applying these materials. (Han *et al*., 2021). Combining organic manure with inorganic fertilizers improved soil fertility and nitrogen availability (Han *et al*., 2021). Vermicompost and inorganic fertilizers work together to make nutrients available to crops throughout their growing stage, improving yield, physical, chemical, and biological soil properties. A field study was conducted to understand variations in soil physicochemical properties as impacted by NPK levels and vermicompost levels and analyze variations in maize growth yield and growth as affected by vermicompost application.

Materials and Methods

An experiment in the field was conducted on the maize plant on the research farm of the Department of Soil Science and Agricultural Chemistry, SHUATS, Prayagraj, in 2022. The climate of this region usually falls under the subtropical belt in the southeast region of Uttar Pradesh, which experiences extreme heat in summer and cold winters. The temperature maximum of this region reaches up to 46^0C – 48^0C and rarely drops to 4^0C – 5 ^{0}C. The relative humidity varied from 20-94 percent. The average rainfall for the area is about 1100 mm per year. Experimental site is situated at $25^0 24' 30''$ North latitude, $81^0 51' 10''$ East longitude and 98 meters above sea level. The maize seed PRMH-9 was sown on 9th of March (2022) and harvested on 15th June. Soil samples were taken before the study to analyze the physico-chemical characteristics of the area under study. This soil is sandy-loam with a form (Sand percent 62.71, Silt percent 23.10 and Clay percent 14.19). Medium with the available nitrogen (255.23), Medium with Phosphorus (23.03) and Medium with Potassium (201.23). The pH was a little more alkaline (7.13). The field was designed using the randomized block designs (RBD) and replicated at least three (3) times. The organic sources of nutrients used include Vermicompost, and the inorganic sources include Urea, single super phosphate (SSP), and Murate of Potash (MOP). Nine (9) treatments that involve the use of a mixture of different nutrients from various types of sources (organic and inorganic) were utilized, including: Treatments were T_1 – @0 % NPK ha-^{1} + 0% Vermicompost ha^{-1}, T_2 @ 0% NPK ha^{-1} + 50% Vermicompost ha^{-1} , T_3 @ 0% NPK ha^{-1} + 100% Vermicompost ha^{-1} , T_4 @ 50% NPK ha^{-1} + 0% Vermicompost ha^{-1} , T_5 @ 50% NPK ha^{-1} + 50% Vermicompost ha^{-1} , T_6 @50%NPK ha^{-1} +100%Vermicompost ha^{-1} , T_7 @ 100% NPK ha^{-1} + 0% Vermicompost ha^{-1} , T_8 @ 100% NPK ha^{-1} + 50% Vermicompost ha^{-1} , T_9 @ 100%NPK ha^{-1}+ 100% Vermicompost ha^{-1} . The recommended dosage of organic fertilizer (vermicompost) utilized was 5 t/ha, and it was evenly incorporated into the soil before sowing by the treatment for every plot. Additionally, the recommended dosage of inorganic fertilizer (RDF) utilized was 120:60:40 kg/ha of NPK, in contrast to the total P and K applied before sowing. N was sprayed in three doses divided into 20% at the sowing time. 40% after 30 days following the sowing (DAS) and the remaining 40% after the moment of Tasseling (i.e. at 60 DAS).After harvesting, soil samples from field trials were taken from each plot with an interval between 0-15 cm and 15-30 cm using an auger for soil. They were dried in the air before passing them through a 2mm filter for analysis to assess their physico-chemical characteristics (Bulk density, Particle density, water holding capacity, Percent pore space, pH, Organic carbon , Electrical conductivity Available N, P, k, Electrical conductivity)

Results and Discussion

Tables 1,2, and 3 outline the effects of NPK and Vermicompost fertilizers on soil properties. According to these tables, their applications significantly altered soil properties.

The maximum bulk density (1.27 and 1.32 Mg m^{-3}),Particle density (2.63 and 2.64 Mg m^{-3}) and pH (7.36 and 7.56) was recorded in T-1(@0%NPK+@0%Vermicompost), while the minimum bulk density (1.27 and 1.31 Mg m^{-3}) ,Particle density (2.58 and 2.59 Mg m^{-3}) and pH (7.12 and 7.32) was found in T-9 (@100%NPK+@100%Vermicompost) at 0-15 and 15-30 cm depth. Similarly, the maximum EC (0.41 and 0.29dS m^{-1}), organic carbon (0.47 and 0.44 %), percentage pore space (45.02 and 42.87%), water holding capacity (49.62 and 47.61%), and available nitrogen (281.03 and 279.09 kg ha^{-1}), phosphorus (32.00 and 27.98 kg ha^{-1}), and potassium (210.14 and 180.11 kg ha^{-1}) was found in T-9(@100%NPK +@100%Vermicompost),and the minimum EC (0.32 and 0.21 dS m^{-1}), organic carbon (0.35 and 0.31 %), percentage pore space (39.87 and 37.87 %), water holding capacity (44.02 and 42.23%), and available nitrogen (254.37 and 250.85kg ha^{-1}), phosphorus (24.00 and 20.00 kg ha^{-1}), and potassium (210.14 and 180.11 kg ha^{-1}) was recorded in T-1(control) at 0-15 and 15-30 cm .

Physico-Chemical properties of soil at 0-15 and 15-30cm depth.

Bulk density

The lower bulk density value was observed in T_9, where NPK and Vermicompost were applied as(@100%NPK+@100%Vermicompost). The aggregation and stability of aggregates due to increased organic matter was the main cause of lower bulk density.(Islam *et al* 2012) Martens and Franken Berger reported similar results regarding the decrease of bulk density as the effect of the addition of organic and inorganic fertilizers in the soil. (1992)

Particle density

The lower value of particle density was observed inT_9 where NPK and Vermicompost were applied as(@100%NPK+@100%Vermicompost). The primary reason for the lower bulk density is aggregation in soil particles caused by increasing organic matter and stability of aggregates.Islam *et al* (2012). Martens and Franken Berger reported similar results about reducing bulk density in the soil due to adding organic and inorganic fertilisers. (1992)

Percent pore space

The higher percent value of pore space was observed in T_9 where NPK and Vermicompost were applied as (@100%NPK+@100%Vermicompost) Aggregation of soil particles because of the increase in organic matter and the stability of aggregates results in an increase in the pore size percentage in soil. Islam *et al.* (2012) The soils of the treatment in which NPK and Vermicompost were combined showed higher percentages of pore space. This may be due to greater aggregation of soil particles, the microbial respiration process, and increased pore size. Similar results in relation to the growth in infiltration rate because of the adding of organic and inorganic fertilizers in soil were published in the work of Martens and Franken Berger (1992).

pH

The maximum pH (7.36 and 7.56) was found in T_1-(@ 0%NPK +@0% Vermicompost) at 0-15 and 15-30 cm and the minimum (7.12 and 7.32 was found while treatment of T_9 (@ 100%NPK +@100% Vermicompost) Bhattacharya has also recorded similar results *et al.* (2016). Srinivasarao *et al* (2015) the application of NPK fertilizers decreases soil pH due to the acidifying effect of ammonium-based fertilizers.

Typically, pH levels in soil tend to fluctuate between more acidic in its upper layers and more alkaline ones in its deeper ones due to factors like accumulation of organic matter, leaching of nutrients or microorganism activity. This shift can be explained by several different sources - accumulation of organic material, leaching nutrients through leaching processes, or activity from microorganisms.

Organic Carbon (%)

The minimum Organic carbon (0.35 and 0.31) was found in T_1-(@ 0%NPK +@0% Vermicompost) at 0-15 and 15-30 cm and the maximum (0.47 and 0.44) was found while treatment of T_9 (@ 100%NPK +@100% Vermicompost) Similar results showed that vermicompost application significantly increased soil organic carbon levels compared to NPK alone or the combination of NPK with vermicompost. The combination of NPK with vermicompost led to higher crop yields than using NPK or Vermicompost alone.Kumar *et al* (2019)

Available Nitrogen (kg ha^{-1})

The minimum Available Nitrogen (254.37 and 250.85) was found in T_1-(@ 0%NPK +@0% Vermicompost) at 0-15 and 15-30 cm and the maximum (281.03 and 279.09) was found while treatment of T_9 (@ 100%NPK +@100% Vermicompost) The combined application of NPK fertilizers and vermicompost increased soil nitrogen availability significantly compared to NPK fertilizers applied alone. Singh et al. (2012) experimented and found that applying vermicompost with NPK fertilizers increased soil nitrogen levels at various depths within a maize and wheat cropping system. Another study by Yadav et al. (2017) reported that applying NPK fertilizers along with vermicompost significantly increased the available nitrogen content of soil at different depths in a soybean-wheat cropping system in central India.

Available Phosphorus (kg ha^{-1})

The minimum phosphorus available was (24.00 and 20.00) found in T_1-(@ 0%NPK +@0% Vermicompost) at 0-15 and 15-30 cm and the maximum (32.00 and 27.98) was found while treatment of T_9 (@ 100%NPK +@100% Vermicompost) The combined use of NPK fertilizers and vermicompost increased soil phosphorus content levels at all depths significantly compared to NPK fertilizers used alone.(Mondal *et al* 2016)

Available Potassium (kg ha^{-1})

The minimum Potassium available was (210.15 and 180.11) found in T_1-(@ 0%NPK +@0% Vermicompost) at 0-15 and 15-30 cm and the maximum (230.99 and 197.32) was found in treatment T_9 (@ 100%NPK +@100% Vermicompost) Similar results showed that applying NPK and vermicompost increased the potassium available in the soil for maize crops at different depths. The study showed that applying 150 kg NPK and 10 tons of vermicompost to a hectare of soil resulted in higher potassium content. (Singh *et al* 2015)

Table:-1 Different levels of NPK and Vermicompost effect on Bulk density (Mg m^{-3}), Particle density (Mg m^{-3}), Pore space (%)and Water holding capacity (%) of the soil post- harvest.

Treatment	Bulk density (Mg m^{-3})		Particle density (Mg m^{-3})		Water holding capacity (%)		Percent pore space	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T_1	1.27	1.32	2.63	2.64	39.87	37.87	44.02	42.23
T_2	1.25	1.30	2.61	2.62	40.92	38.97	45.81	43.26
T_3	1.23	1.28	2.59	2.60	42.51	40.98	47.54	45.12
T_4	1.26	1.29	2.62	2.63	40.01	39.01	44.69	43.89
T_5	1.24	1.27	2.60	2.61	41.98	40.56	46.68	44.77
T_6	1.21	1.25	2.58	2.59	44.02	41.97	48.58	46.29
T_7	1.24	1.26	2.61	2.62	41.32	40.77	46.23	45.37
T_8	1.22	1.24	2.59	2.60	42.98	41.67	47.74	46.12
T_9	1.19	1.22	2.58	2.59	45.02	42.87	49.62	47.61
F- test	S	S	NS	NS	S	S	S	S
S.Em. ($\pm$)	0.014	0.017	0.029	0.042	0.628	0.483	0.773	0.698
C.D (P=0.05)	0.043	0.053	0.087	0.128	1.885	2.092	2.32	2.09

Table:-2 Different levels of NPK and Vermicompost effect on pH, Electrical conductivity(dSm-^{1})and Organic carbon (%), of the soil post- harvest.

Treatment	pH(1:2.5)		Electrical conductivity(dSm^{-1})		Organic carbon(%)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T_1	7.36	7.56	0.21	0.32	0.35	0.31
T_2	7.31	7.51	0.24	0.34	0.38	0.32
T_3	7.25	7.45	0.27	0.36	0.42	0.35
T_4	7.32	7.52	0.22	0.33	0.39	0.33
T_5	7.27	7.47	0.25	0.35	0.42	0.37
T_6	7.20	7.40	0.28	0.37	0.44	0.40
T_7	7.27	7.47	0.23	0.34	0.41	0.38
T_8	7.21	7.41	0.26	0.38	0.45	0.41
T_9	7.12	7.32	0.29	0.41	0.47	0.44
F- test	NS	NS	S	S	S	S
S.Em. ($\pm$)	0.O8	0.12	0.773	0.698	0.08	0.12
C.D (P=0.05)	0.23	0.36	2.32	2.09	0.23	0.36

Table:-3 Different levels of NPK and Vermicompost effect on Available Nitrogen (kg ha^{-1}) ,Available phosphorus (kg ha^{-1}), and Available potassium (kg ha^{-1}) of the soil post- harvest.

Treatment	Available Nitrogen (kg ha^{-1})		Available Phosphorus (kg ha^{-1})		Available Potassium (kg ha^{-1})	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T_1	254.37	250.85	24.00	20.00	210.15	180.11
T_2	258.89	256.34	25.00	21.98	212.35	184.21
T_3	265.37	264.27	27.00	23.87	218.25	186.87
T_4	261.87	259.89	26.00	21.11	215.98	183.65
T_5	266.97	265.01	28.00	22.98	221.12	187.65
T_6	272.13	270.97	30.00	25.97	225.17	192.98
T_7	269.87	266.97	29.00	23.67	223.99	190.89
T_8	278.98	275.03	31.00	26.25	228.12	193.75
T_9	281.03	279.09	32.00	27.98	230.99	197.32
F- test	S	S	S	S	S	S
S.Em. ($\pm$)	3.425	2.979	0.510	0.337	4.090	3.280
C.D (P=0.05)	10.270	8.932	1.529	1.010	12.264	9.833

Conclusion

The findings from this research indicate that both organic and inorganic fertilizer sources play an essential role in improving the soil properties of maize crops. Combining organic manures and inorganic sources was most successful at improving these properties by decreasing bulk density and pH values in T_9(@100%NPK +@100%Vermicompost). Effectively increases percent pores capacity for water, electrical conductivity, organic percentage carbon, and available nitrogen, phosphorus and potassium of T_9(@100%NPK +@100%Vermicompost). This study revealed that soil fertility and productivity could not be sustained over the long term by only using organic manure or inorganic sources as fertilizers; instead, incorporating both types is strongly advised to sustain soil health over time.

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