Assessment of Variation Among Physico-chemical Properties of Soil of Maize as Influenced by Levels of NPK and Vermicompost at Eastern Uttar Pradesh

Abstract

A field experiment was conducted during Zaid season 2022 at the research farm of Department of Soil Science and Agricultural Chemistry, SHUATS, Prayagraj, To Assess the variation among physico-chemical properties of soil, and yield of maize as influenced by levels of NPK and vermicompost at eastern Uttar Pradesh. The soil of the experimental site was sandy loam in texture and is situated at $25^0 24' 30''$ N latitude, $81^0 51' 10''$ E longitude and 98 meter above the sea level .The experiment was laid out in randomized block design with nine 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 physico-chemical properties of soil before sowing and after crop harvest was determined by following 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 mete 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 revealed that The Bulk density, percent pore space, water holding capacity, Ec, organic carbon Available N, P, K of soil was found significant at different levels of 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 Bulk density and particle density of soil was improved under T9(100%NPK ha^{-1}+ 100% Vermicompost ha^{-1}) compared to control and rest of the treatments combination .Bulk density gradually decreased with an increase dose of NPK and vermicompost. Therefore, the integration of organic and inorganic fertilizers resulted in better physico-chemical properties on par compared with sole used of 100%RDF.

Keywords: Vermicompost, NPK, Maize and Prayagraj.

Introduction

Indian agriculture has made tremendous progress after the sixties and The success of agriculture production has been attributed to the widespread use of high yielding varieties. Among several inputs, fertilizers have been the kingpin for the transformation of Indian agriculture from subsistence to surplus. (Nelson *et al.,* 2019) Maize (*Zea mays L*), is the world's third most important cereal crop after wheat and rice. The world production of maize was 967 million metric tons (MMT) and in India its production was 23 MMT in 2013-14. (India maize summit, 2014) It is cultivated with different crop sequence under various agro climatic regions of the country. Hence, it is considered as potential driver of crop diversification under different situations The application of organic manure enhanced the crop yield due to increase in nutrient availability and improvement in soil structure. In the past four decades, global maize production has greatly increased mainly due to application of nitrogen. (FOA, 2018) It imparts vigorous vegetative growth to plant and it produce early growth of maize. Nitrogen governs the utilization of potassium, phosphorus and other elements in maize crops. It has been observed that the maize crop requires regulated and assured supply of nitrogen throughout its growing period right from seedling stage to grain filling stage. (Singh *et al*. 2012) Phosphorus is essential for transformation of energy, metabolism and in respiration of plant and early maturity of maize. Potassium plays important role in formation of protein and chlorophyll and it provide much of osmotic pull that draw water into plant roots. It produces strong stiff straw in maize and reduce lodging in maize crop. It also increases vigor and disease resistance to plant (Singh *et al*., 2010) Organic manures bind the soil aggregates which increased cation exchange capacity, phosphate availability and water holding capacity of soil. They also improved the fertilizer use efficiency, microbial and organic carbon content in the soil. The nitrogen loss was also less in soil due to the application of organic manures (Liu *et al*., 2021). The regular application of inorganic fertilizers along with organic manures helped in controlling the pH and EC of soil as compared to without organic manure application (Han *et al*., 2021). The combination of organic manures with inorganic fertilizers resulted in improvement of soil fertility and available nitrogen status of soil (Han *et al.,* 2021) The combined application of vermicompost with inorganic fertilizers made the availability of nutrients to crop throughout their growth period and it results in improvement of crop yield as well as physical, chemical and biological properties of the soil. By keeping in view this existing scenario, a field experiment conducted to study the variation among physico-chemical properties of soil, Growth and yield of maize as influenced by levels of NPK and vermicompost

Materials and Methods

A field experiment was conducted on maize crop at the research farm of Department of Soil Science and Agricultural Chemistry, SHUATS, Prayagraj, during the year 2022. The climate of this region is typically comes under subtropical belt in the South east of Uttar Pradesh, which experience extremely hot summer and fairly cold winter. The maximum temperature of this area reaches up to $46^0C – 48^0C$ and seldom falls as low as $4^0C – 5\ ^0C$. The relative humidity ranged between 20 to 94 percent. The average rainfall in this area is around 1100 mm annually Experimental site is situated at $25^0 24' 30''$ N latitude, $81^0 51' 10''$ E longitude and 98 meter above the sea level. The maize seed PRMH-9 was sown on 9th of March (2022) and harvested on 15th June. Soil samples were collected prior to the experiment to study the physico- chemical properties of the experimental area. The soil was sandy loam in texture (sand % 62.71, silt % 23.10 and clay % 14.19) medium in available Nitrogen (255.23), medium in available Phosphorus (23.03), medium in Potassium (201.23) and pH is slightly alkaline (7.13) The field was laid out in randomize block design (RBD) which is replicated three (3) times The organic nutrient sources used are Vermicompost whereas the inorganic sources are Urea, single super phosphate (SSP) and Murate of potash (MOP). Nine (9) treatments involving a combination of various nutrients from different sources (organic and inorganic) were used which include: 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 dose of organic fertilizer (vermicompost) used was 5 t/ha and this was uniformly incorporated into the soil before sowing as per treatments in each plot. Furthermore, the recommended dose of inorganic fertilizer (RDF) used was 120:60:40 NPK kg/ha, whereas whole P and K were applied at the time of sowing and N was applied in 3 split doses as 20% at the time of sowing, 40% at 30 days after sowing (DAS) and remaining 40% at the time of tasseling (i.e. at 60 DAS). After crop harvesting the soil samples from field trial were collected from each plot at a depth of 0-15 and 15 -30 cm using a soil auger and samples were air-dried, passed through a 2 mm sieve, and analyzed for determination of soil physico-chemical properties (Bulk density, Particle density, water holding capacity, Percent pore space, pH, Organic carbon , Electrical conductivity Available N, P, k, Electrical conductivity.)

Results and Discussion

The effects of NPK and Vermicompost on soil properties are presented in table. 1.and 2 The results showed that the application of NPK and Vermicompost had a significant effect on 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 value of bulk density was observed inT_9 where NPK and Vermicompost were applied as(@100%NPK+@100%Vermicompost) The main reason of lower bulk density was aggregation of soil particle due to increasing organic matter as well as stability of aggregates. Islam *et al* (2012) Similar results regarding the decrease of bulk density as the effect of addition of organic and inorganic fertilizers in soil were reported by Martens and Franken Berger (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 main reason of lower bulk density was aggregation of soil particle due to increasing organic matter as well as stability of aggregates. Islam *et al* (2012) Similar results regarding the decrease of bulk density as the effect of addition of organic and inorganic fertilizers in soil were reported by Martens and Franken Berger (1992)

Percent pore space

The higher value of percent pore space was observed in T_9 where NPK and Vermicompost were applied as (@100%NPK+@100%Vermicompost) Aggregation of soil particle due to increasing organic matter as well as stability of aggregates, which lead to increase the percent pore space in soil. Islam *et al*. (2012) The soil of the treatments in which NPK and Vermicompost were applied in combination recorded higher percent pore space might be owing to the better soil particle

aggregation, microbial respiration, increased pore space Similar results regarding the increase in infiltration rate as the effect of addition of organic and inorganic fertilizers in soil were reported by 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 in treatment T_9 (@ 100%NPK +@100% Vermicompost) similar results have also been recorded by Bhattacharya *et al.* (2016) Srinivasarao *et al* (2015) the application of NPK fertilizers decreases soil pH due to the acidifying effect of ammonium-based fertilizers.

Generally, the pH tends to be more acidic in the surface layers of soil and more alkaline in the deeper layers. This variation can be attributed to factors such as the accumulation of organic matter, the leaching of nutrients, and the activity of 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 in treatment T_9 (@ 100%NPK +@100% Vermicompost) similar results found that the application of vermicompost significantly increased soil organic carbon levels compared to NPK fertilizer alone or a combination of NPK and vermicompost. However, the combination of NPK and vermicompost resulted in higher crop yields compared to the use of vermicompost or NPK 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 in treatment T_9 (@ 100%NPK +@100% Vermicompost) Similar result found that the combined application of NPK fertilizers and vermicompost significantly increased the available nitrogen content of soil compared to the application of NPK fertilizers alone. A experiment conducted by Singh *et al.* (2012) found that the application of vermicompost along with NPK fertilizers significantly increased the available nitrogen content of soil at different depths in a maize-wheat cropping system in northern India. Another study by Yadav *et al.* (2017) reported that the application of 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 Available phosphorus (24.00 and 20.00) was 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 in treatment T_9 (@ 100%NPK +@100% Vermicompost) Similar result found that the combined application of NPK fertilizers and vermicompost significantly increased the available phosphorus content of soil at all depths compared to the use of NPK fertilizers alone. (Mondal *et al* 2016)

Available Potassium (kg ha^{-1})

The minimum Available Potassium (210.15 and 180.11) was 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 result found that the application of NPK fertilizers and vermicompost significantly increased the available potassium content in the soil of maize crop at different depths. The study found that the application of 150 kg NPK per hectare along with 10 tone of vermicompost per hectare resulted in the highest available potassium content in the soil(Singh *et al* 2015)

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

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. (±)	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 Effect of different levels of NPK and Vermicompost on pH, Electrical conductivity(dSm-^{1})and, Organic carbon (%), of post- harvest soil.

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. (±)	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 Effect of different levels of NPK and Vermicompost on Available Nitrogen (kg ha^{-1}) ,Available phosphorus (kg ha^{-1}), and Available potassium (kg ha^{-1}) of post- harvest soil.

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. (±)	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 current study concluded that all the organic and inorganic fertilizer sources has significant effect on physio-chemical properties of soil of maize Crop. The integration of organic manures with inorganic fertilizer sources found most effective in improving physico-chemical properties of soil as it decreases bulk density, and pH in T_9(@100%NPK +@100%Vermicompost). Effective increase in percentage pore space, water holding capacity, electrical conductivity, percentage organic carbon and available nitrogen, phosphorus and potassium in T_9(@100%NPK +@100%Vermicompost). The present study also indicated that it is not possible to maintain soil fertility and productivity by the sole application of either organic manure or inorganic fertilizer source. To sustain soil fertility and productivity on long term basis, the integration of organic and inorganic is highly recommended.

References

Bhattacharyya, P., Roy, K. S., & Neogi, S. (2016). Effect of integrated nutrient management on soil pH and nutrient status in different depths of soil. Journal of Applied and Natural Science, 8(4), 2043-2049

Fisher, R.A. (1957). The underworld of probability, *the Indian journal of statistics*, 18 (3/4): 201- 210.

FAO. FAO STAT-agriculture database. (2018)

Gupta, R. K. (2013). Effect of organic and inorganic fertilizers on the water holding capacity of sandy loam soil. International Journal of Scientific and Research Publications, 3(2), 1-5.

Gupta, R. K., Singh, Y. V., & Singh, R. K. (2012). Impact of organic and inorganic sources of nutrients on soil organic carbon in maize–wheat cropping system. Current Science, 103(7), 797-803

Han, J., Dong, Y. and Zhang, M. (2021). Chemical fertilizer reduction with organic fertilizer effectively improve soil fertility and microbial community from newly cultivated land in the Loess Plateau of China. Applied Soil Ecology. 165: 103-966

Islam, M.R., Sikder, S., Bahadur, M.M. and Hafiz, M.H.R. (2012). Effect of Different Fertilizer Management on Soil Properties and Yield of Fine Rice Cultivar. Journal of Environmental Science and Natural Resources 5(1): 239–42.

Jackson, M. L. (1958). Soil chemical analysis, Second edition Indian Reprint, prentice hall of India, New Delhi. 498.

Kumar, S., Singh, R., Singh, M., & Kumar, S. (2013). Maize: The queen of cereals. In Emerging Technologies and Management of Crop Stress Tolerance (pp. 273-300).

Kumar, R., Sharma, S. K., & Sharma, V. K. (2016). Effect of vermicompost on soil fertility and crop productivity in maize (*Zea mays* L.). Indian Journal of Agricultural Research, 50(3), 293-297.

Liu M, FHu X, Chen Q, Huang J, Jiao B, Zhang H Li. (2009) Organic amendments with reduced chemical fertilizer promotes soil microbial development and nutrient availability in a subtropical paddy field: the influence of quantity, type and application time of organic amendments. Appl Soil Ecol. 2009; 42:166-175

Mondal, S., Gupta, A., & Sarkar, S. (2016). Effect of NPK and vermicompost on soil properties, yield and nutrient uptake of wheat (*Triticum aestivum* L.) in an inceptisol of West Bengal. Indian Journal of Agricultural Sciences, 86(1), 77-83.

Manjunatha, M. V., Rangaswamy, V., & Jagadeesh, K. S. (2017). Effect of integrated nutrient management on soil physico-chemical properties and yield of maize (Zea mays L.) under rainfed conditions. Journal of Crop and Weed, 13(2), 49-54

Martens, D.A. and Frankenberger, W.T. (1992). Modification in infiltration rates in an organic amended irrigated soil. Agronomy Journal 84(4): 707–17

Nelson, A. R. L. E., Ravichandran, K., and Antony, U. (2019). The impact of the Green Revolution on indigenous crops of India. J. Ethnic Foods 6:8.

Olsen, S. R., Cole, C. V., Watanable, F. S. and Dean, L. A. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *United States Department of Agriculture*, 932.

Prihar, S. S. (1972). Nitrogen and maize production in India. The Journal of Agricultural Science, 79(2), 221-230

Reddy, K. L., & Murthy, M. V. R. (2008). Effect of vermicompost on soil physical properties and maize crop growth. Journal of the Indian Society of Soil Science, 56(4), 417-421.

Subbaih, B. V. and Asija, C. L. (1956). A rapid procedure for the estimation of available nitrogen in soils. *Current sciences*, 25:256-260.

Singh, P., Singh, M., and Singh, R. K. (2021). Influence of nitrogen on growth, yield, and quality of maize (Zea mays L.) under varying planting dates. International Journal of Current Microbiology and Applied Sciences, 10(3), 2281-2293.

Saha, A., Chakraborty, S., Bhadra, B., & Mandal, B. (2020). Effects of potassium fertilization on soil quality parameters, yield, and quality of maize in an Alfisol of West Bengal, India. Communications in Soil Science and Plant Analysis, 51(14), 1847-1862.

Saha, D., & Mandal, B. (2019). Effect of organic and inorganic fertilizers on soil fertility and crop productivity in maize cultivation. Environmental Science and Pollution Research, 26(15), 14948-14960

Srinivasarao, C., Venkateswarlu, B., Lal, R., Singh, A. K., Kundu, S., & Rao, V. U. M. (2015). Long-term effects of nutrient management on soil pH and crop yields in a vertisol. Soil Use and Management, 31(1), 29-39.

Singh S, Sati A, Mishra P. (2010) Soil test based integrated N. P and K prescription for yield target of maize in Mollisol of Uttarakhand. Pant Nagar Journal of Research.;8(2):248-250

Singh, Y. V., Singh, B., & Singh, R. (2012). Integrated use of vermicompost and inorganic fertilizers on soil physical, chemical, and biological properties in maize-wheat cropping system. Communications in soil science and plant analysis, 43(12), 1653-1666.

Singh, A., Sharma, R. K., Singh, S., & Singh, Y. (2014). Response of growth and yield of rice (Oryza sativa L.) to integrated nutrient management in Typic Haplustept soil of Punjab. Indian Journal of Agricultural Sciences, 84(9), 1161-1166

Singh, S.K., Kumar, S., Singh, A.K., Singh, M.K., Singh, R.K. (2015). Effect of nitrogen, phosphorus and potassium levels and vermicompost on growth, yield and nutrient uptake by maize (Zea mays L.). Journal of Applied and Natural Science, 7(2), 816-820.

Toth, S. J. and Prince, A. L. (1949). Estimation of cation exchange capacity and exchangeable Ca, K, and Na content of soil by flame photometer technique. *Soil Science*, 67:439-445.

Walkley, A. and Black, I. A. (1947) Critical examination of rapid method for determining organic carbon in soils, effect of variance in digestion conditions and of inorganic soil constituents. *Soil science*, 632:251.

Wilcox, L. V. (1950) Electrical conductivity Am. water works Assoc. J 42, 775-776.

Yadav, O.P., Gupta, S.K., Rajpurohit, B.S. (2015) Maize in India: current status, and future prospects. The Crop Journal. 2015; 3(4)

Yadav, S. K., Singh, A. K., Singh, Y. V., & Singh, B. (2017). Integrated use of vermicompost and inorganic fertilizers on soil physical, chemical, and biological properties in soybean-wheat cropping system. International Journal of Recycling of Organic Waste in Agriculture, 6(2), 139-149.