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Effect of organic and inorganic sources of nutrients on soil properties in alluvial soils of the Agra region

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Abstract

This field experiment, conducted over two rabi seasons (2023–24 and 2024–25) at R.B.S. College, Bichpuri, Agra (India), evaluated the impact of integrated nutrient management (INM) combining inorganic fertilizers (RDF: recommended dose of fertilizers) with sulphur (S) and zinc (Zn) on post-harvest soil properties in sandy loam alluvial soil. The experiment was layout in randomized block design with nine treatments of T1 - 100 % RDF, T2 - 75 % RDF + Sulphur, T3 - 75 % RDF + Zinc, T4 - 75 % RDF + Vermicompost, T5 - 75 % RDF + Sulphur + Zinc + Vermicompost, T6 - 50 % RDF + Sulphur, T7 - 50 % RDF + Zinc, T8 - 50 % RDF + Vermicompost and T9 - 50 % RDF + Sulphur + Zinc + Vermicompost with three replications. The study found that applying 75% recommended dose of fertilizers (RDF) + Sulphur + Zinc + Vermicompost (T5) significantly improved soil organic carbon, available nutrients (N, P, K, S, Zn), and other properties compared to other treatments. Application of T5: @ 75% RDF + Sulphur + Zinc + Vermicompost recorded significantly higher EC, pH, soil organic C, available nitrogen, phosphorus, potassium, sulphur and zinc over T6: 50% RDF + Sulphur treatment. Similarly, the increase in soil organic C, available nitrogen, phosphorus, potassium, sulphur and zinc 17.0, 23.1, 39.1, 19.0, 29.9 and 25.9% with the application of T5: 75% RDF + Sulphur + Zinc + Vermicompost compared to T6: 50% RDF + Sulphur.

Key words: INM, SOC, Nitrogen, Phosphorus, Potassium, Sulphur, Zn

Introduction

The alluvial soils of the Agra region are vital for agricultural productivity, but their fertility and sustainability are challenged by intensive farming practices. Inorganic fertilizers provide rapid nutrient availability, boosting crop yields, but long-term use can degrade soil health by reducing organic carbon, impairing soil structure, and contributing to environmental pollution. Organic amendments, such as farmyard manure, compost, and green manures, offer a sustainable alternative by enhancing soil organic carbon, improving water retention, and promoting beneficial microbial activity. This study investigates the effect of integrating organic and inorganic nutrient sources on soil properties in the alluvial soils of the Agra region, aiming to identify balanced nutrient management practices that sustain soil health and productivity.

Materials and Methods

The field experiments were conducted at the Agricultural Research farm of R.B.S. College Bichpuri, Agra located in semi arid or gray steppe arid region of South-Western Uttar Pradesh during two consecutive rabi seasons of 2023-24 and 2024-25 on sandy loam soil. The soil had EC 0.28 dSm^{-1},

pH 8.2, organic carbon 4.6 g kg^{-1}, available N 190.6, P 13.8 and K 218.6 kg ha^{-1}. The soil had $CaCl_2$ extractable sulphur content of 14.2 kg ha^{-1} and DTPA extractable zinc 0.59 mg kg^{-1}. The experiment was laid out in randomized block design with three replications. The treatments were comprised of T1 - 100 % RDF, T2 - 75 % RDF + Sulphur, T3 - 75 % RDF + Zinc, T4 - 75 % RDF + Vermicompost, T5 - 75 % RDF + Sulphur + Zinc + Vermicompost, T6 - 50 % RDF + Sulphur, T7 - 50 % RDF + Zinc, T8 - 50 % RDF + Vermicompost and T9 - 50 % RDF + Sulphur + Zinc + Vermicompost.

Soil sampling and analysis

Soil samples were collected during 2023 from the plow layer (0-20 cm depth) from the experimental plot after the crop harvest. These samples were partitioned and passed through standard prescribed sieves for further use in a different kind of analysis. The soil samples that passed through the 0.2-mm sieve were used for estimating soil organic carbon. For the rest of the soil quality parameters such as chemical (pH, EC), available N, P, K, S, and Zn parameters, soil samples that passed through 2-mm sieves were used. Soil pH and EC were measured in a 1:2 soil/water suspension (Richards, 1954), organic carbon by wet oxidation with sulfuric acid (H_2SO_4) + potassium dichromate ($K_2Cr_2O_7$) (Walkley and Black, 1934), available N by alkaline-$KMnO_4$ oxidizable N method (Subbiah and Asija, 1956), available P by 0.5 M sodium bicarbonate ($NaHCO_3$) extraction method (Olsen et al., 1954), available K (Hanway and Heidel, 1952) , available sulfur by 0.15% $CaCl_2$ (Williams and Steinbergs, 1959), and Available Zn by DTPA method (Lindsay and Norvell, 1978).

Results and discussion

EC and pH

The application of T5 (75% RDF + Sulphur + Zinc + Vermicompost) resulted in a significantly higher EC value of 0.35 dSm^{-1}, compared to T6 (50% RDF + Sulphur) which had an EC value of 0.28 dSm-1. Although T5 recorded a higher pH value of 8.51, the difference was not significant compared to T6 (pH 8.20). These findings are consistent with the results of (Sharma et al. 2022 and 2024).

Soil organic carbon

The soil organic carbon (SOC) content increased significantly across treatments, with T5 (75% RDF + Sulphur + Zinc + Vermicompost) recording the highest SOC content of 5.08 g/kg, representing a 17.0% increase compared to T6 (50% RDF + Sulphur) which had the lowest SOC content of 4.35 g/kg. The SOC content in other treatments was: T4 (4.96 g/kg), T9 (4.89 g/kg), T8 (4.79 g/kg), T3 (4.71 g/kg), T2 (4.60 g/kg), T1 (4.55 g/kg), and T7 (4.49 g/kg). These results are consistent with the findings of (Sharma et al. 20217, 2022 and 2024) and Bhama et al. (2017).

Available Nitrogen

The available nitrogen content in soil was significantly influenced by the nutrient management treatments. The highest available nitrogen content was recorded in T5 (75% RDF + Sulphur + Zinc + Vermicompost) with 222.4 kg/ha, representing a 23.1% increase compared to T6 (50% RDF + Sulphur) which had the lowest available nitrogen content of 180.6 kg/ha. The available nitrogen content in other treatments was: T4 (215.2 kg/ha), T9 (210.6 kg/ha), T8 (204.9 kg/ha), T3 (199.3 kg/ha), T2 (195.5 kg/ha), T1 (191.6 kg/ha), and T7 (186.5 kg/ha). These findings are in agreement with the results of (Sharma et al. 2022 and 2024) and Bhama et al. (2017).

Available Phosphorus

The available phosphorus content in soil increased significantly across treatments, with T5 (75% RDF + Sulphur + Zinc + Vermicompost) recording the highest available phosphorus content of 20.4 kg/ha, representing a 38.8% increase compared to T6 (50% RDF + Sulphur) which had the lowest available phosphorus content of 14.7 kg/ha. The available phosphorus content in other treatments was: T4 (19.4 kg/ha), T9 (18.7 kg/ha), T8 (17.9 kg/ha), T3 (17.4 kg/ha), T2 (16.5 kg/ha), T1 (15.9 kg/ha), and T7 (15.3 kg/ha). These findings are consistent with the results of (Sharma et al. 2022 and 2024) and Indoria et al. (2024).

Available Potassium

The available potassium content in soil increased significantly across treatments, with T5 (75% RDF + Sulphur + Zinc + Vermicompost) recording the highest available potassium content of 244.3 kg/ha, representing a 19.0% increase

Table 1: Effect of organic and inorganic sources of nutrients on EC, pH, SOC, available N, P, K, S and Zn in alluvial soil of Agra region

Treatments	EC (dS/m)	pH	SOC (g/kg)	N (kg/ha)	P (kg/ha)	K (kg/ha)	S (kg/ha)	Zn (mg/kg)
T1	0.29	8.24	4.55	191.6	15.9	221.0	14.3	0.58
T2	0.30	8.28	4.60	195.5	16.5	224.2	14.8	0.59
T3	0.31	8.30	4.71	199.3	17.4	227.9	15.1	0.60
T4	0.35	8.44	4.96	215.2	19.4	240.2	16.5	0.66
T5	0.35	8.51	5.08	222.4	20.4	244.3	17.1	0.68
T6	0.28	8.20	4.35	180.6	14.7	205.3	13.1	0.54
T7	0.29	8.22	4.49	186.5	15.3	216.1	14.0	0.56
T8	0.32	8.37	4.79	204.9	17.9	232.9	15.3	0.62
T9	0.33	8.43	4.89	210.6	18.7	236.2	15.7	0.64
SEm±	0.020	0.12	0.14	7.45	1.04	9.17	0.62	0.02
CD @ 5%	0.042	NS	0.30	15.37	2.15	18.93	1.28	0.05

compared to T6 (50% RDF + Sulphur) which had the lowest available potassium content of 205.3 kg/ha. The available potassium content in other treatments were: T4 (240.2 kg/ha), T9 (236.2 kg/ha), T8 (232.9 kg/ha), T3 (227.9 kg/ha), T2 (224.2 kg/ha), T1 (221.0 kg/ha), and T7 (216.1 kg/ha). These findings are consistent with the results of (Sharma et al. 2022 and 2024).

Available Sulphur

The available sulphur content in soil increased significantly across treatments, with T5 (75% RDF + Sulphur + Zinc + Vermicompost) recording the highest available sulphur content of 17.1 kg/ha, representing a 30.5% increase compared to T6 (50% RDF + Sulphur) which had the lowest available sulphur content of 13.1 kg/ha. The available sulphur content in other treatments were: T4 (16.5 kg/ha), T9 (15.7 kg/ha), T8 (15.3 kg/ha), T3 (15.1 kg/ha), T2 (14.8 kg/ha), T1 (14.3 kg/ha), and T7 (14.0 kg/ha). These findings are consistent with the results of (Sharma et al. 2022 and 2024).

Available Zinc

The available zinc content in soil increased significantly across treatments, with T5 (75% RDF + Sulphur + Zinc + Vermicompost) recording the highest available zinc content of 0.68 mg/kg, representing a 25.9% increase compared to T6 (50% RDF + Sulphur) which had the lowest available zinc content of 0.54 mg/kg. The available zinc content in other treatments were: T4 (0.66 mg/kg), T9 (0.64 mg/kg), T8 (0.62 mg/kg), T3 (0.60 mg/kg), T2 (0.59 mg/kg), T1 (0.58 mg/kg), and T7 (0.56 mg/kg). These findings are consistent with the results of (Sharma et al. 2022 and 2024), Munna, et al. (2020) and Indoria et al. (2024).

Conclusion

The study revealed that the application of T5 (75% RDF + Sulphur + Zinc + Vermicompost) was the most effective treatment in improving soil fertility and nutrient availability. The integrated use of organic and inorganic sources of nutrients can be recommended for sustainable soil management and crop production. The findings of this study can be used to develop nutrient management strategies that enhance soil health and fertility.

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