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Effect of tank silt and wood ash on physical and physico-chemical properties of coastal sandy soil under groundnut cultivation

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Abstract— *A field experiment was conducted during the rabi season of 2023 on sandy loam soil to study the effect of tank silt and wood ash on soil properties, including physical and physico-chemical properties under groundnut cultivation. The experiment consisted of ten treatments with tank silt, wood ash and* K_2SO_4 *foliar application with different levels of RDK tested in randomized block design (RBD) with three replications. Results indicated that the soil's physical properties were not significantly influenced by the imposed treatments. Among the physico-chemical properties of soil, soil reaction (pH) did not show significant influence from the treatments, whereas, electrical conductivity, cation exchange capacity and organic carbon content were found to be improved due to the application of tank silt and wood ash.*

Keywords— ***Coastal sandy soil, groundnut, tank silt, wood ash***

I. INTRODUCTION

Soil fertility and quality are crucial factors that determine sustainable agricultural productivity, especially in regions with challenging soil types like coastal sandy soils, where groundnut is widely cultivated. Groundnut (*Arachis hypogaea* L.), known as the "king of oil seeds", is an important oilseed and food crop in India, which is also known as peanut or the poor man's almond. It belongs to the family Leguminosae. On a dry seed basis, groundnut seed has 44–56% oil and 22–30% protein. It is also a rich source of minerals (phosphorus, calcium, magnesium and potassium) and vitamins (E, K and B groups). It is reported that the total carbohydrates in groundnut seeds, including both soluble and insoluble carbohydrates, range from 9.5 to 19.0% (Chowdhury *et al*., 2015)

The coastal sandy soils often exhibit poor nutrient retention, low organic matter, and limited water-holding capacity, necessitating innovative soil management strategies. Amendments such as tank silt and wood ash have shown promise in enhancing soil properties, offering a cost-effective and eco-friendly solution for improving agricultural outcomes.

A field experiment was conducted during the rabi season of 2023 on coastal sandy soil to examine the effect of tank silt and wood ash on soil properties, particularly focusing on physical and physico-chemical characteristics under groundnut cultivation. The study employed a randomized block design (RBD) with ten treatments, incorporating combinations of tank silt, wood ash, and K_2SO_4 foliar application at varying levels of Recommended Dose of Potassium (RDK). Each treatment was replicated three times.

II. MATERIALS AND METHODS

The experiment was conducted at Agricultural College Farm, Bapatla under Acharya N G Ranga Agricultural University, Andhra Pradesh, India with TAG-24 variety of groundnut during *rabi* season in 2023-24 in sandy loam soil. The experiment was laid out in randomised block design (RBD) with ten treatments replicated thrice. The groundnut crop was sown under irrigated conditions with a spacing of 30 cm x 10 cm.Nitrogen, phosphorus and potassium were supplied through urea, single super phosphate (SSP) and muriate of potash (MOP). The recommended dose of 40 kg P_2O_5 and 30 kg N ha^{-1} were applied uniformly to all plots. The recommended dose of K_2O @ 50 kg ha^{-1} was applied as per the treatments. Nitrogen was applied in 2 equal splits (1/2 at the time of sowing and the remaining half at 30 DAS). The entire quantity of P and K fertilizers was applied as basal before sowing. Wood ash @ 500 kg ha^{-1} and tank silt @ 6000 kg ha^{-1} were applied to each plot according to the treatments 1 week before the date of sowing. Foliar spraying of 2% K_2SO_4 was done at 35 DAS according to treatment.

Treatment details: T_1 – 100% RDK, T_2 – 75% RDK, T_3 –75% RDK + wood ash, T_4 – 75% RDK + wood ash + K_2SO_4 foliar application at 35 DAS), T_5 – 75% RDK + tank silt, T_6 –75% RDK + tank silt + K_2SO_4 foliar application at 35 DAS, T_7 –50% RDK + wood ash, T_8 – 50% RDK + wood ash + K_2SO_4 foliar application at DAS, T_9 – 50% RDK + tank silt and T_{10} – 50% RDK + tank silt + K_2SO_4 foliar application at 35 DAS.

The physical properties like BD, MC, WHC and Aggregate stability were analyzed by clod method (Dastane 1967), gravimetric method (Rao *et al*., 2017), Keen-Raczkowski method (Piper, 1966), Wet sieving method in Yoder's apparatus (Gupta, 1965). The pH and EC were measured with (1: 2.5- soil: water) potentiometry method given by Jackson (1973). Organic carbon and CEC were estimated by Walkley and Black's (1934) wet digestion method and sodium saturation method (Black, 1965) respectively.

Fisher's method of analysis of variance was followed for analysis and interpretation of the data as suggested by Panse and Sukhatme (1978). The level of significance used in 'F' test at 0.05 level of probability was worked out for significance.

III. RESULT AND DISCUSSION

3.1 Physical properties

The physical properties of soil recorded at the harvest of the crop are presented in Table 1. The findings indicate that the application of tank silt and wood ash did not show any significant effect on the physical properties of the soil. However, a non-significant improvement was observed in physical properties due to the application of wood ash and tank silt.

3.1.1 Bulk density

The findings indicate that the application of tank silt and wood ash didn't show any significant effect on the bulk density of the soil. However, a non-significant reduction is observed in bulk density due to the application of tank silt and wood ash. The range of bulk density in tank silt-added soil was 1.41 Mg m^{-3} to 1.42 Mg m^{-3} and wood ash-added soil was 1.55 Mg m^{-3} to 1.56 Mg m^{-3}. The highest bulk density (1.58 Mg m^{-3} and 1.57 Mg m^{-3}) was observed in the treatment T_1 (100% RDK) and T_2 (75% RDK) which received only inorganic fertilizers. The non-significant effect of tank silt and wood ash on bulk density might be due to the short duration of the experiment. However, a reduction was observed in bulk density due to the application of tank silt and wood ash. Tank silt, characterized by its substantial clay and organic matter content, improves soil structure and reduces bulk density upon application, as documented by Srinivasa *et al*. (2010). This enhancement in soil structure resulting in decreased bulk density has been observed previously in studies by Rao *et al*. (2017) and Degala *et al*. (2018).

The finer texture of wood ash, which can modify pore size distribution and increase soil porosity, particularly in sandy soils, might be the reason for the observed non-significant decrease in bulk density after application of wood ash, as noted by Chirenje and Ma (2002). Similarly, studies by Sartori *et al*. (2007) and Moragues-Saitua *et al*. (2017) have confirmed that the effect of the application of wood ash on bulk density was non-significant as observed in the present study.

3.1.2 Moisture content

According to the results presented in table 1, the application of wood ash and tank silt did not result in a statistically significant change in soil moisture content. However, there was a slight, non-significant increase in moisture content was observed with these treatments. Among the treatments, those involving tank silt application and wood ash application demonstrated a higher moisture content when compared to the treatments received only inorganic fertilizer. There has been an increase of 4.7 to 6.8 % moisture content in tank silt added soil and 1.36 to 3.4 % moisture content in wood ash added soil compared to unamended soil.

This increase in moisture content due to tank silt application can be attributed to the high water-holding capacity and organic carbon content of tank silt (Srinivasarao *et al*., 2013). According to Bhanavase *et al*. (2011), the application of tank silt also increased the clay content in the plough layer, which directly influenced the amount of water available to the soil.

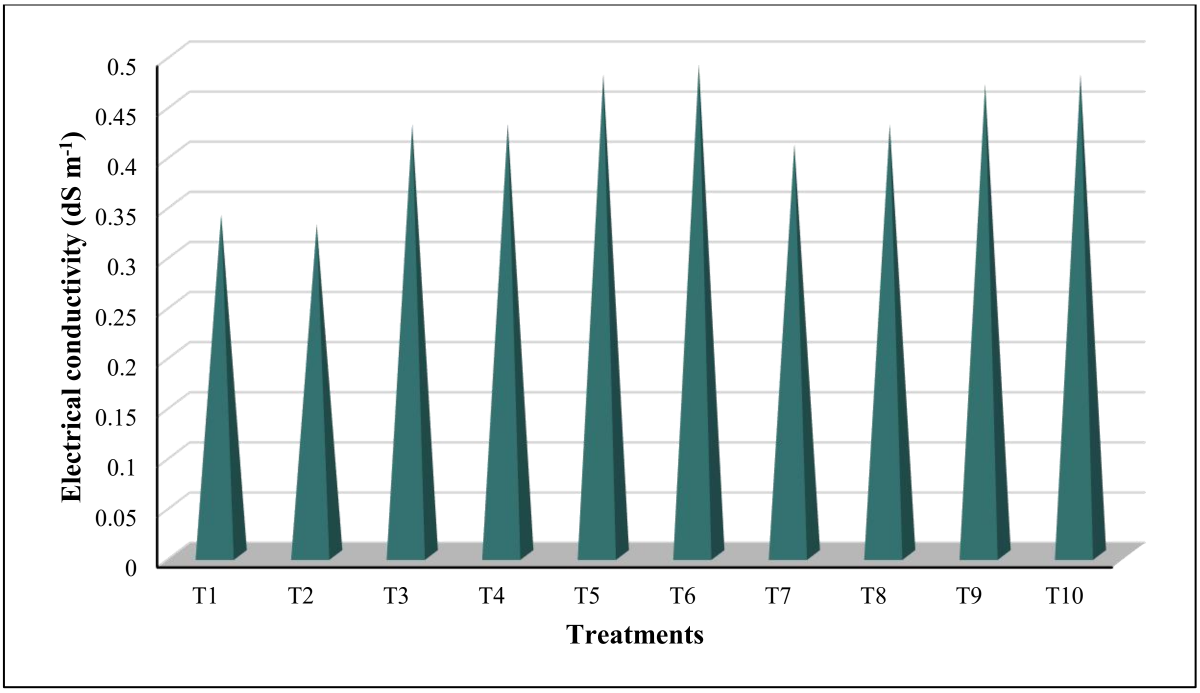

Fig.1 Effect of tank silt and wood ash on electrical conductivity (dS m^{-1}) of soil at harvest of groundnut crop

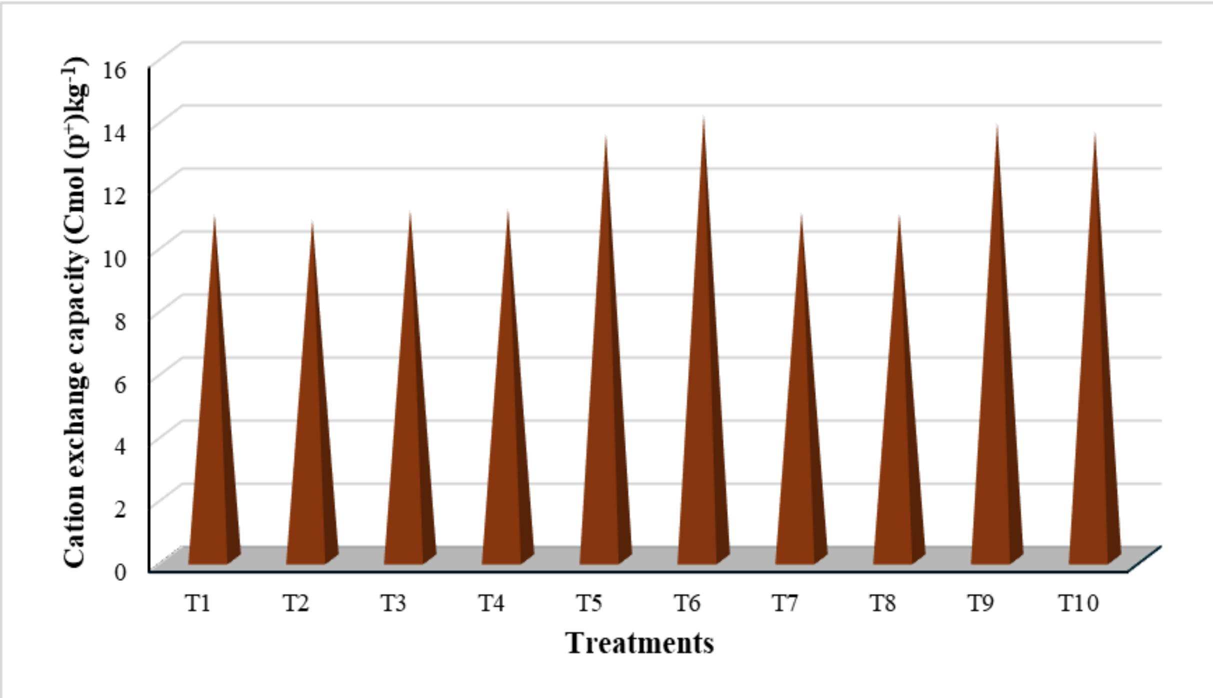

Fig.2 Effect of tank silt and wood ash on cation exchange capacity of soil at harvest of groundnut crop

The treatment of soil with wood ash has been observed to reduce saturated hydraulic conductivity, resulting in a slight increase in soil moisture content. This reduction in hydraulic conductivity is directly related to the decrease in pore diameters caused by the addition of ash, which enables water to remain in the root zones for a longer period when it is most needed. The decrease in saturated hydraulic conductivity was found to be linear across the range of ash application rates used, as reported by Chirenje and Ma (2002). This indicates a consistent relationship between the amount of ash applied and the extent of reduction in hydraulic conductivity, thereby enhancing moisture retention in the soil.

Table 1. Effect of different sources of potassium application on physical and physico-chemical properties of soil at harvest

Treatments	Bulk density (Mg/m^3)	Moisture content (%)	WHC (%)	pH (1:2.5)	EC (dS m^{-1})	CEC (Cmol(p^+)kg^1)	OC(%)
T_1 – 100% RDK	1.58	14.8	17.2	6.56	0.34	10.97	0.47
T_2– 75% RDK	1.57	14.7	17.1	6.57	0.33	10.80	0.46
T_3 – 75% RDK + Wood ash	1.56	15.2	17.4	7.30	0.43	11.10	0.48
T_4 – 75% RDK + Wood ash + K_2SO_4 foliar application at 35 DAS	1.55	15.1	17.5	7.28	0.43	11.14	0.48
T_5 – 75% RDK + Tank silt	1.41	15.4	18.1	7.39	0.48	13.52	0.62
T_6 – 75% RDK + Tank silt + K_2SO_4 foliar application at 35 DAS	1.42	15.7	18.3	7.38	0.49	14.13	0.61
T_7– 50% RDK + Wood ash	1.56	14.9	17.5	7.28	0.41	11.01	0.47
T_8 – 50% RDK + Wood ash + K_2SO_4 foliar application at 35 DAS	1.55	15.2	17.4	7.27	0.43	10.99	0.47
T_9 – 50% RDK + Tank silt	1.41	15.4	18.3	7.39	0.47	13.87	0.60
T_{10} – 50% RDK + Tank silt + K_2SO_4 foliar application at 35 DAS	1.42	15.5	18.2	7.36	0.48	13.61	0.59
S.Em (±)	0.08	0.85	0.85	0.33	0.03	0.52	0.03
CD @ 0.05	NS	NS	NS	NS	0.08	1.56	0.08
CV (%)	9.16	9.69	8.38	8.03	12.09	7.54	8.41

3.1.3 Water holding capacity

The results show that the soil's ability to retain water was not considerably impacted by the addition of wood ash or tank silt. However, compared to treatments with only inorganic fertilizer application, the application of wood ash and tank silt showed a slight improvement in water-holding capacity. This non-significant effect on enhancing water-holding capacity can likely be attributed to the short duration of the experiment being a single-season study.

The water holding capacity ranged from 18.3 % in tank silt-added soil to 17.1 % in soil with the addition of only inorganic fertilizers. There was an increase of 5.8 to 7.0 % of water holding capacity in tank silt-added soil and a 1.7 to 1.8 % increase in wood ash-added soil compared to soil that received only inorganic fertilizer.

The application of tank silt likely increased the soil plasticity due to the high concentration of clay particles with plastic properties present in the tank silt. This increase in plasticity may have also contributed to the observed enhancement in water-holding capacity (Rajeshwar and Ramulu, 2015). Johan *et al*. (2021) previously reported on the impact of wood ash application on the soil's water-holding capacity. Their findings revealed that wood ash particles can clog soil pores by swelling when combined with water, thereby enhancing the ability to retain water.

3.2 Physico-chemical properties

The physico-chemical properties of soil recorded at the harvest of the crop are presented in Table 1. Among the physicochemical properties of soil, soil reaction (pH) was not significantly influenced by the treatments. In contrast, electrical conductivity, cation exchange capacity, and organic carbon content were found to be significantly affected by different treatments and improved due to the application of tank silt and wood ash.

3.2.1 Soil Reaction (pH)

The findings indicate that the application of wood ash and tank silt did not significantly alter soil pH levels at the harvest. There was a slight increase in soil pH in treatments involving both wood ash and tank silt, with pH values ranging from 6.56 to 7.39. The application of tank silt with a pH of 9.1 resulted in a more substantial increase in soil pH compared to wood ash with a pH of 8.5.

Sundaram and Annadurai (2018) also reported similar pH changes in soil due to tank silt application. Soil pH has increased because of the alkaline nature of tank silt, which is the result of the buildup of salt during tank silt development over time (Sankalpa and Kadalli, 2018). Additionally, the application of wood ash raises soil pH also due to its alkaline properties and the buffering capacity of carbonates, particularly calcium carbonate ($CaCO_3$) (Arseneau *et al*., 2021). Wood ash also contains high amounts of calcium and magnesium oxides associated with their hydroxide which can neutralize soil acidity (Bonfim-Silva *et al*., 2021).

3.2.2 Electrical conductivity

The data on electrical conductivity of soil is presented in Fig.1 and Table 1. The electrical conductivity of soil treated with tank silt ranged from 0.47 to 0.49 dS m^{-1}, soil treated with wood ash ranged from 0.41 to 0.43 dS m^{-1}, and soil not treated with either wood ash or tank silt ranged from 0.33 to 0.35 dS m^{-1}.

Rajakumar and Ammal (2016) also observed an increase in electrical conductivity (EC) with the addition of tank silt. This increase was attributed to the nature of tank silt as an erosion product, where soluble compounds are transported and deposited in the tanks. The elevated EC concentrations in tank silt are likely due to this transportation process. Additionally, the application of tank silt may also release organic acids, especially in soils added with organic amendments, leading to a significant release of ions into the soil solution.

Yilmaz *et al*. (2024) corroborate the increase in electrical conductivity (EC) resulting from the application of wood ash. This enhancement in EC is attributed to the presence of cations and soluble salts in the wood ash. According to Khan (2024), by releasing soluble salts and cations present in the wood ash into the soil, it can raise the EC of the soil and contribute to the overall salinity.

3.2.3 Cation Exchange Capacity

The results indicate a significant variation among the treatments at the crop harvest stage. Specifically, the soil treated with tank silt exhibits a substantially higher CEC compared to all other treatments. This highlights the pronounced effect of tank silt on enhancing the soil's cation exchange capacity, distinguishing it from other soil amendments. The information presented here highlights the notable increase in CEC caused by tank silt addition in comparison to wood ash and only inorganic fertilizer addition. Paramasivan and Kumar (2019) reported a similar positive influence of tank silt addition on CEC as seen in our study. Furthermore, Wadne *et al*. (2020) documented a two to threefold increase in soil CEC following the application of tank silt. This increase was attributed to the inclusion of clay content from the tank silt, which is significantly positively correlated with CEC. These findings underscore the substantial role that tank silt, rich in clay, plays in enhancing the soil's cation exchange capacity

3.2.4 Organic Carbon

The data presented in table 1 indicate a significant impact on organic carbon content resulting from the

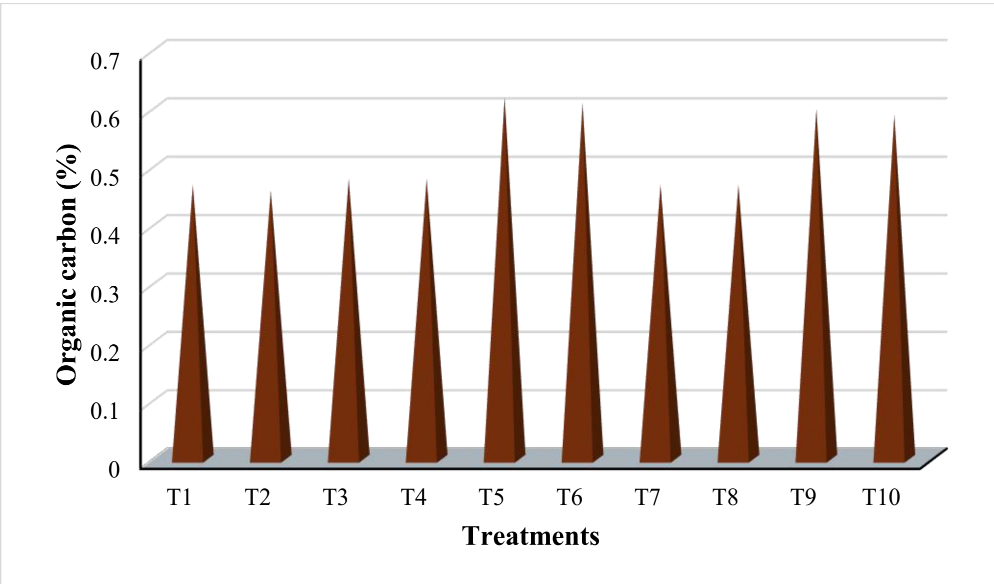

Fig.3 Effect of tanksilt and wood ash on the organic carbon percentage of soil at harvest of groundnut crop

application of tank silt, compared to both unamended soil and soil treated with wood ash. The enhancement in organic carbon content is notably greater in soils amended with tank silt, highlighting its superior efficacy in improving soil organic matter over the other treatments.

The findings emphasize the significant influence of tank silt application in enhancing soil organic carbon content compared to treatments involving wood ash and solely inorganic fertilizers. The observed increase in organic carbon following tank silt application is attributed to the high organic carbon content inherently present in tank silt, as documented by Srinivasa *et al*. (2010) and Adhinarayanan (2017).

IV. CONCLUSION

Application of tank silt and wood ash enhanced the physical and physico-chemical properties of soil. The improvement was non-significant in the case of physical properties, whereas electrical conductivity, cation exchange capacity and organic carbon content showed a significant increase due to various treatments. Electrical conductivity increased due to the application of both tank silt and wood ash. Cation exchange capacity and organic carbon content were increased prominently in treatment with tank silt application.

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