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Assessing The Influence Of Organo-Mineral Fertilizers In Enhancing Soil Properties And Okra (Abelmoschus Esculentus L. Moench) Productivity In Abraka, Delta State.

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Abstract
The study assessed the influence of formulated organo-mineral fertilizers on soil physico-chemical properties and okra (Abelmoschus esculentus L. Moench) productivity for two years in Abraka, Delta State. Six treatments - control (T_1), NPK15:15:15 (T_2), compost+NPK (T_3), compost+N (T_4), compost+PK (T_5) and sole compost (T_6) were applied. Clemson spineless okra variety was used to test the effectiveness of the fertilizers. Sawdust, wood shavings, rice bran, poultry droppings, pig dung and cattle dung were used to prepare compost which was used to formulate fertilizers at a ratio of 4:1 (compost: mineral fertilizer). NPK15:15:15 applied at the rate of 250kg/ha, organo-mineral fertilizers at 6ton/ha and sole compost at 10tons/ha were arranged in a randomized complete block design (RCBD) replicated three times. Okra growth parameters and yield were collected from two weeks after sowing while soil samples were collected at harvest for routine analysis. Collected data were subjected to analysis of variance using R project for statistical computing to determine treatment effects. Comparison of treatment means was carried out using the T-HSD (Turkey's Honestly Significant Difference at $P<0.05$). Results indicated no significant differences in soil pH, organic matter, total nitrogen, available phosphorus and exchangeable cations due to fertilizer effects. However, high pH was obtained from T_5 and T_6 (4.98), total N from (0.21%), available P from T_3 (22.70mg/kg), organic matter from T_6, Ca (4.40cmol/kg), Mg (1.40cmol/kg) and K (0.15cmol/kg) from T_4. Sole compost and T_4 consistently enhanced plant height, number of leaves and leaf area while T_6 produced the highest okra yield (0.99tons/ha). These parameters were higher in plots containing organic inputs, an indication that application of organo-mineral fertilizers offers sustainable strategy for improving soil fertility and boosting okra yield in tropical sandy soils.
Keywords: *Assessing, influence, organomineral fertilizers, soil properties and okra productivity.*

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I. Introduction

Agriculture is a crucial sector of the global economy that provides a range of economic, social and environmental benefits and its productivity is fundamental in food security and economic development. Interestingly, these to a great extent, rely on the nature of soil and its management practices. The rise in human population has led to increased food production to meet his food need leading to more pressure on the available fertile land. The pressure has led to decrease in soil fertility status because lands are no longer given enough time to recover their loss fertility through natural means of fallow systems. It is therefore necessary that fertilizers be added to boost their fertility for optimum crop growth and yield. Inorganic fertilizers have often been used to improve soil fertility because its nutrients are released immediately they are applied with precise nutrient composition. However, farmers have realized that constant use of inorganic fertilizers result to soil acidity which diminishes phosphate intake and lead to inhibition of crop growth (Kotschi, 2015). Again, the price of inorganic fertilizers has risen so high in recent times that most farmers could not afford them.

Fertilizers derived from the combination of organic materials with mineral nutrients are called organo-mineral fertilizers. Okra cultivation requires nitrogen, phosphorus, potassium, calcium, sodium and sulphur for growth and development and these nutrients are specific in function as well as must be supplied to plants at the right time and quantity (Molik *et al*., 2016).

Organomineral fertilizers have shown great potentials in improving soil fertility and crop yields in different locations. In Ethopia, application of organo-mineral fertilizers significantly increased growth and yield of cabbage (McKonnen *et al*., 2020). Again, at the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso in 2005 and 2006 cropping seasons, application of organo-mineral fertilizer influenced the growth, yield, quality and nutritional content of okra (Olaniyi *et al*., 2010). Okra is highly nutritious and has high economic and industrial values leading to its high demand. Okra cultivation in Abraka could be a good source of income for the farmers if soil fertility can be improved. Hence, farmers' financial status could be improved through the use of organo-mineral fertilizers to boost soil nutrients for optimum performance of okra in Abraka area of Delta State. Though, many researches have been carried out on okra yield in Abraka, unfortunately, there is little information on the use of organo-mineral fertilizers on okra production. Soils of Delta State are highly weathered therefore, they are low in fertility (Ojobor *et al*., 2021). The natural reserve of plant nutrients in the soils are highly depleted and only little proportion is made available for plant use. It is on this ground that fertilizer application has become imperative to supplement the available soil supply. Hence, the study assess the influence of organo-mineral fertilizers on soil properties and yield of okra in Abraka, Delta State.

II. Materials And Methods

The research was a field experiment carried out in the Teaching and Research Farm, , Abraka located between latitude 5°79'9" and 5°80'6" North and longitude 6°12'3" and 6°12'6" East for two years. Abraka has annual rainfall range of 2000 – 3000mm, a mean temperature of 31°C, relative humidity of 60% - 90% (Umeri *et al*., 2017). The soils are predominantly made up of sand materials with a few interactions of clay and silt, the sands are commonly fine to coarse grained and poorly cemented with sub-angular to well-rounded grains (Ofomola, *et al*., 2017). Abraka also lies within the tropical rainforest zone that is made up of different species of trees, shrubs and grasses.

The experiment was a Randomized Complete Block Design (RCBD) replicated 3 times. The treatments were 6 types of fertilizers which were Control (T_1), NPK15:15:15(T_2), NPK+compost (T_3), N+compost (T_4), PK+compost (T_5) and Sole compost (T_6) with clemson spineless variety of okra as test crop. Compost was prepared from saw dust, wood shavings, rice bran, poultry droppings, pig dung and cattle dung. Organo-mineral fertilizers were formulated by adding inorganic fertilizer to the prepared compost at a ratio of 4:1 compost:mineral fertilizer. A composite soil sample for initial soil properties analysis was taken from the experimental area measuring 10.2m x 15.0m. Two seeds of okra per hole were planted at the spacing of 60cm x 40cm on a plot size of 3m x 2m. Organo-mineral fertilizers were applied at the rate of 6 tons per hectare (3.6kg per plot), inorganic fertilizer was applied at 250Kg per hectare (0.15Kg per plot) while the sole compost was applied at 10 tons per hectare (6Kg per plot).

Plant data were taken at 2 to 10 weeks after sowing. Plant height (cm) was measured from ground level to the last leaf tip using a meter rule; leaf area (cm^2) was measured by multiplying the length and width of the leaf with a factor of 0.62 (Jazuli, 2019); Number of leaves per plant was taking by counting the total number leaves of the tagged plants. Yield parameter was taken at harvest by measuring the okra weight per plot. Soil samples were collected from each plot at the end of harvest for routine analysis with the use of soil auger at the depth of 0 – 15cm. A total of 18 soil samples were collected at the end of each planting season. Soil samples collected were subjected to air drying after which soil aggregate were crushed using a porcelain mortar and pestle. The crushed samples were made to pass through a 2mm sieve to obtain suitable soil samples for analysis.

Particle size distribution was determined by the hydrometer method (Gee and Or, 2002). Organic carbon was determined by rapid dichromate wet oxidation method (Olowoake, *et al*., 2015) and converted to organic matter by multiplying it with 1.724. Soil pH was determined in a 1:1 soil to water suspension using a pH meter. Available phosphorus was determined using the Bray P-1 extracting solution method (Anderson and Ingram, 1993). Total nitrogen was measured in a macro Kjeldahl digestion and distillation apparatus (Brookes, *et al*,, 1985). Exchangeable bases of the samples were extracted with 1.0M NH_4OAC (ammonium acetate) at pH 7.0 and Potassium and Sodium in the solution were measured by the flame photometer while Calcium and Magnesium were determined by EDTA (Ethylenediaminetetraacetic Acid) titration (Thomas, 1982). Exchangeable acidity was determined by successive leaching of soil with 1N KCl using 1:10 soil: solution ratio and the amount of exchangeable hydrogen and aluminum in the leachate will be determined by titration procedure of Maclean (1982). Effective cation exchange capacity was taken as sum of exchangeable bases and exchangeable acidity. Analysis of micro nutrients (copper, zinc, iron and manganese) was performed using atomic absorption spectrophotometry (Khan *et al*., 2023).

All collected data were subjected to analysis of variance using the R project for statistical computing (Ludecke *et al*., 2021). Comparison of means was carried out using the T-HSD (Turkey's Honestly Significant Difference at $P<0.05$).

III. Results And Discussion

Physico-chemical properties of experimental site prior to planting

Results of the physico-chemical properties of the experimental sites before planting are shown in Table 1. Abraka soil was sandy loam and moderately acidic having pH of 5.4. Organic matter and organic carbon were both moderate (2.38% and 1.38%), respectively. Total nitrogen was low (0.20%) while available P was within the optimal range (23.40mg/kg). Exchangeable bases were low (4.40cmol/kg, 0.80cmol/kg, 0.20cmol/kg and

0.30cmo/kg) for Ca^{2+}, Mg^{2+}, K^{+} and Na^{+} respectively. The exchangeable acidity was moderate (0.88cmol/kg). The soil had moderate nutrient holding capacity with ECEC of 6.28cmol/kg and high base saturation of 85.98%. Soil extractable Zn^{2+}, Mn^{2+}, Cu^{2+} and Fe^{2+} were low (0.04mg/kg, 0.05mg/kg, 0.07mg/kg and 0.02mg/kg) respectively.

The Abraka soil was sandy loam in texture as a result, they were well drained and easy to till. The high proportion of sand could be associated with the quartz parent materials from which the soils are formed. Nature of parent material has been found to influence development and characteristics of soils (Umeri, *et al*., 2017). The acidic nature of the soils could be as a result of soil texture and high amount of rainfall that occurs in the area which could lead to leaching of exchangeable bases beyond the root zone of the plant. In high rainfall areas, essential base-forming cations are leached from the soil, leaving behind acidic hydrogen and aluminum ions (Brady and Weil, 2014). Abraka soil though having sandy loam texture had moderate amount of organic matter. This might have resulted from the topography of the area which is low-lying with minimal elevation thereby reducing the impact of water erosion. Gentle slopes and flat areas enhance infiltration and deposition of water, promoting deeper soil development and higher fertility resulting from accumulation of organic matter and sediments.

Table 1: Physico-chemical Properties of Experimental Sites before application of Treatments

Parameter	Value
Particle size distribution	
Sand (%)	75.00
Silt (%)	11.00
Clay (%)	14.00
Textural class	Sandy loam
pH(H_2O)	5.4
Organic carbon (%)	1.38
Organic matter (%)	2.38
Total Nitrogen (%)	0.21
Available Phosphorus (mg/kg)	23.40
Exchangeable calcium (cmol/kg)	4.40
Exchangeable Magnesium (cmol/kg)	0.80
Exchangeable Potassium (cmol/kg)	0.20
Exchangeable Sodium (cmol/kg)	0.30
Exchangeable acidity (cmol/kg)	0.88
Effective Cation Exchange Capacity (cmol/kg)	6.82
Base saturation (%)	85.92
Extractable Zinc (mg/kg)	0.04
Extractable Manganese (mg/kg)	0.05
Extractable Copper(mg/kg)	0.07
Extractable Iron (mg/kg)	0.02

Total nitrogen was low in line with the report of Ekpe *et al*., (2017) which noted that total N of tropical soils is generally low. The low soil nitrogen could be associated with the leaching of NO_3^- due to high amount of rainfall in the area. Soil available phosphorus was moderate while exchangeable cations were low. This is in line with the report of Akpovwovwo (2014) which stated that the soils of the humid tropics are known to suffer multiple deficiencies of nutrients and by implication having low productivity. Result also indicated micronutrients though required in little quantity were low. Micronutrients have the same agronomic importance as macronutrients and play vital roles in the growths of plant (Nazif *et al*., 2006). The low micronutrient may be as a result of soil pH and organic matter content, adsorptive surfaces and other physical, chemical and biological conditions in the root zone and is influenced by their distribution within the soil profile and other soil characteristics (Jiang, 2009).

Soil physico-chemical properties after application of treatments

The results of soil texture showed highest sand content in T_5 (72.73%), lowest sand in T_2 (70.90%), highest silt in T_4 (13.47%), least silt in T_5 (11.23%) and the highest clay was obtained from T_2 (16.67%) while the least was observed in T_4, T_5 and T_6 (15.80%). It demonstrated that the organic component of organo-mineral fertilizers can improve soil structure and aggregation which directly depend on soil particle size and organic matter content. This report align with that of Yang *et al*., (2023) which stated that fertilizer with manure improved soil structure and fertility than fertilizer alone. T_5 and T_6 having the highest pH (4.98) is an indication that the compost contained in an organo-mineral fertilizer had the potential to buffer soil especially in the absence of mineral nitrogen while low pH exhibited by T_4 (4.77) may be due to nitrogen-based fertilizer (urea) added to the compost. This report corroborate the report of Guo *et al*., (2010) which stated that further analysis showed that recent soil acidification in China has resulted mainly from high N-fertilizer inputs and the uptake and removal of base cations by plants. Organic substitution has been recognized as an effective approach to alleviate soil acidification caused by excessive ammonium-based fertilizer application (Wang, *et al*., 2018). The highest total N obtained from T_4 and T_6 (021%) higher than T_1 (0.18%) and T_2 (0.20) highlighted the direct contribution of mineral nitrogen and mineralization of organic matter which releases nitrogen gradually to the soil. T_3 gave the highest available P (22.70mg/kg) which may be attributed to the combination of NPK and compost enhancing P availability through microbial activity while the least available P obtained from T_2 (21.17mg/kg) was due to P fixation in acidic soil without organic inputs. The highest organic matter (1.40%) obtained from T_6 and the least organic carbon and organic matter (0.61%) and (1.05%) respectively seen in T_1 is an indication that compost enhances soil organic matter level and improve soil fertility. This is in line with the report of Adugna (2016) which stated that one efficient way to increase soil organic matter level is compost application produced especially from biomass wastes.

Exchangeable cations (Ca, Mg and K) were highest in T_4 (4.40cmol/kg, 1.40cmol/kg and 0.15cmol/kg) respectively demonstrated that the combination of compost and mineral N has the potential to enhance nutrient release. This is in line with the report of Adekiya *et al*. (2020) which asserted that different organic sources of soil amendment increase soil organic matter, nitrogen, phosphorus, potassium, calcium and magnesium significantly ($p<0.05$) with respect to the control. The exchangeable cations were lowest in T_1 and T_2 due to absence of organic inputs in them. The exchangeable highest sodium reported in T_2 (0.35col/kg) could have resulted from impurities in mineral fertilizer while the least Na level (0.32com/kg) in T_3 and T_6 may be attributed to the presence of compost that enhanced the release of Ca, Mg and K which improve ionic balance in the soil. Soils treated with organic amendments show apparent increases of available macronutrients (P, K, Ca and Mg) (Angelova *et al*., 2013). T_1 having highest exchangeable acidity was due to the absence of amendment which could have neutralize the natural soil acidity while the least exchangeable acidity observed in T_6 (1.10cmol/kg) demonstrates the potential of compost to displace acidic cations from the soil system thereby reducing soil acidity. ECEC was highest in T_4 (7.47cmol/kg) and the least was observed in T_2 (6.21cmol/kg) among treated plots. This highlights the potential of the combination of mineral N and compost to improve cation exchange capacity. Base saturation of the soil followed the same trend as ECEC with T_4 having the highest base saturation (83.33%) and the least was obtained from T_2 (79.96%) indicating improved nutrient retention of T_4 and T_2 being less fertile.

Table 2a: Soil physico-chemical properties after application of treatments

Treatment	Sand (%)	Silt (%)	Clay (%)	pH	N (%)	P (mg/kg)	OC (%)	OM (%)	Ca	Mg	K	Na	EA	ECEC	BS (%)
									← cmol/kg →						
T1	72.17ᵃ	11.93ᵃ	16.40ᵃ	4.83ᵃ	0.18ᵃ	22.18ᵃ	0.61ᵃ	1.05ᵃ	3.40ᵃ	1.07ᵃᵇ	0.10ᵃ	0.33ᵃ	1.27ᵃ	6.20ᵃ	79.31ᵃ
T2	70.90ᵃ	12.43ᵃ	16.67ᵃ	4.93ᵃ	0.20ᵃ	21.17ᵃ	0.72ᵃ	1.24ᵃ	3.82ᵃ	0.87ᵇ	0.10ᵃ	0.35ᵃ	1.24ᵃ	6.21ᵃ	79.96ᵃ
T3	71.23ᵃ	12.80ᵃ	16.13ᵃ	4.80ᵃ	0.20ᵃ	22.70ᵃ	0.65ᵃ	1.12ᵃ	3.73ᵃ	1.00ᵃᵇ	0.12ᵃ	0.32ᵃ	1.12ᵃ	6.29ᵃ	81.67ᵃ
T4	70.90ᵃ	13.47ᵃ	15.80ᵃ	4.77ᵃ	0.21ᵃ	22.45ᵃ	0.70ᵃ	1.21ᵃ	4.40ᵃ	1.40ᵃ	0.15ᵃ	0.33ᵃ	1.20ᵃ	7.47ᵃ	83.33ᵃ
T5	72.73ᵃ	11.23ᵃ	15.80ᵃ	4.98ᵃ	0.19ᵇ	22.17ᵃ	0.74ᵃ	1.28ᵃ	3.87ᵃ	1.13ᵃᵇ	0.14ᵃ	0.34ᵃ	1.21ᵃ	6.70ᵃ	81.79ᵃ
T6	71.73ᵃ	13.07ᵃ	15.80ᵃ	4.98ᵃ	0.21ᵃ	22.16ᵃ	0.81ᵃ	1.40ᵃ	3.67ᵃ	1.27ᵃᵇ	0.12ᵃ	0.32ᵃ	1.10ᵃ	6.48ᵃ	80.29ᵃ

Means with same alphabet(s) on the same column and under the same heading are not significantly different at $P<0.05$ level of probability using T-HSD.

Table 2b: Soil micronutrients after application of treatments

Treatment	Zn (mg/kg)	Mn (mg/kg)	Cu (mg/kg)	Fe (mg/kg)
T1	0.92^{ab}	0.31^{a}	0.15^{a}	0.29^{ab}
T2	1.07^{a}	0.25^{a}	0.28^{a}	0.46^{a}
T3	0.70^{ab}	0.09^{a}	0.07^{a}	0.30^{ab}
T4	0.71^{ab}	0.16^{a}	0.11^{a}	0.41^{a}
T5	0.61^{b}	0.23^{a}	0.12^{a}	0.06^{b}
T6	0.67^{ab}	0.26^{a}	0.14^{a}	0.34^{ab}

Means with same alphabet(s) on the same column and under the same heading are not significantly different at $P<0.05$ level of probability using T-HSD.

Extractable Zn which was highest in T_2 (1.07mg/kg) may be due to solubility of Zn in slightly acidic soil while P_5 having the least extractable Zn may have resulted from its competition with P making Zn less soluble in the soil. T_1 with the highest Mn (0.31mg/kg) is an indication that unbuffered natural acidic nature of the soil favoured Mn solubility while the presence of organic matter in T_3 helped to reduce extractable Mn (0.09mg/kg). Cu and Fe which were highest in T_2 with values 0.28mg/kg and 0.46mg/kg respectively is linked to mineral fertilizer and acidic condition that can enhance their solubility in the soil. The least extractable Cu and Fe obtained from T_6 (0.07mg/kg) and T_5 (0.06mg/kg) respectively is likely due to their immobilization in the presence of organic matter. Application of compost may result in different amount of bioavailable forms of soil micronutrients due to the nature of soil and characteristic of compost. The availability of soil micronutrients in different soil orders depends upon the soil mineralogy, topography, climatic conditions and cropping sequences (Dhaliwal *et al*., 2022).

Influence of organomineral fertilizers on plant height, leaf area, number of leaves and yield of okra

Results showed significant differences ($P<0.05$) in plant height at 2WAS, 8WAS and 10WAS while at 4WAS and 6WAS indicated no significant difference ($P<0.05$) (Table 3). The highest plant heights was obtained from T_6 at all sampling periods while the least at 2WAS was observed in T_1, T_2 and T_5. At 4WAS – 10WAS, T_2 had the lowest plant height among treated plots T_4 and T_6 had the highest. Table 3 showed significant differences ($P<0.05$) in leaf area at 4WAS, 6WAS and 8WAS while leaf area at 2WAS and 10WAS indicated no significant differences ($P<0.05$). The highest leaf area was obtained from T_6 at 2WAS and 4WAS while at 6WAS - 10WAS, the highest leaf areas were obtained from T_4. The least were obtained from T_2 among treated plots at 6WAS-10WAS. No significant differences ($P<0.05$) in number of leaves at all sampling periods except at 8WAS (Table 3). At 2WAS and 4WAS, the highest number of leaves per plant were obtained from T_6. At 6WAS - 10WAS, T_4 gave the highest number of leaves per plant. At 2WAS, T_1 – T_5 had the lowest number of leaves while at 4WAS T_2 gave the lowest. From 6WAS – 10WAS, the least were obtained from T_1. Results showed significant differences ($P<0.05$) in yield of okra. The highest yield was seen in T_6 (0.99tons/ha) while the lowest yield was observed in T_2 (0.35tons/ha) among treated plots.

Table 3: Influence of organomineral fertilizers on plant height, leaf area, number of leaves and yield of okra

Treatment		2WAS			4WAS			6WAS			8WAS			10WAS		Yield
	PH(cm)	LA(cm^2)	NL	PH(cm)	LA(cm^2)	NL	PH(cm)	LA(cm^2)	NL	PH(cm)	LA(cm^2)	NL	PH(cm)	LA(cm^2)	NL	Ton/ha
T_1	4.62^{b}	4.0^{a}	3.00^{a}	9.71^{a}	23.07^{b}	5.96^{a}	17.28^{a}	55.83^{b}	6.46^{a}	24.18^{b}	93.25^{b}	9.17^{ab}	27.09^{c}	108.51^{a}	10.96^{a}	0.28^{c}
T_2	4.62^{b}	3.98^{a}	3.00^{a}	9.47^{a}	32.28^{b}	4.82^{a}	17.99^{a}	65.60^{b}	6.83^{a}	25.80^{ab}	120.59^{ab}	9.79^{b}	29.36^{bc}	128.66^{a}	11.71^{a}	0.35^{c}
T_3	4.61^{b}	4.32^{a}	3.00^{a}	11.15^{a}	36.66^{ab}	5.33^{a}	19.89^{a}	111.34^{a}	6.96^{a}	28.52^{ab}	175.42^{a}	10.50^{ab}	32.01^{ab}	209.74^{a}	12.28^{a}	0.67^{bc}
T_4	4.88^{ab}	4.24^{a}	3.00^{a}	10.62^{a}	36.75^{ab}	5.29^{a}	21.32^{a}	120.73^{a}	7.96^{a}	30.08^{a}	182.14^{a}	11.67^{a}	34.69^{a}	219.03^{a}	13.33^{a}	0.70^{ab}
T_5	4.66^{b}	3.84^{a}	3.00^{a}	10.87^{a}	27.66^{b}	4.96^{a}	18.81^{a}	76.27^{ab}	6.46^{a}	27.57^{ab}	123.71^{ab}	9.55^{b}	31.24^{ab}	144.31^{a}	11.58^{a}	0.66^{c}
T_6	5.15^{a}	5.17^{a}	3.08^{a}	12.47^{a}	56.80^{a}	5.42^{a}	20.79^{a}	102.71^{a}	6.83^{a}	28.84^{ab}	170.19^{a}	10.00^{b}	31.84^{ab}	189.09^{a}	11.83^{a}	0.99^{a}

Means with same alphabet(s) on the same column and under the same heading are not significantly different at $P<0.05$ level of probability using T-HSD.

The improved performance in plant height and leaf area observed in T_6 at the early growth stage is probably due to better soil structure and nutrient release leading to higher vegetative growth. The combination of compost and N fertilizers (T_4) and sole compost (T_6) supporting vegetative growth during the mid and late growth stages highlights the role of nitrogen and organic matter in plant development. This is in line with the observation of Law-Ogbomo and Ojeniyi (2013) which declared that organic manures are best for Okra although the crop responds to NPK with high analysis of N. The highest yield (0.99 tons/ha) obtained from T_6 followed by T_4(0.70ton/ha) and the least recorded in T_2(0.39 ton/ha) is an indication that fertilizers containing organic inputs effectively enhance okra output while the control and NPK15:15:15 without organic inputs under performed in all parameters measured. This align with the assertion of Oladipo *et al*., (2005) which declared that maintenance of organic matter is the basis of sustainable crop production in Nigeria and other tropical countries

IV. Conclusion

The study highlighted the importance of organomineral fertilizers in enhancing both soil health and okra productivity in Abraka, Delta State. Combining compost and inorganic fertilizers or use of sole compost improved soil pH, organic matter, nutrient availability and cation exchange capacity. The amendments also enhanced plant height, leaf area, number of leaves and most critically, okra yield. The T_6 produced the highest yield followed by T_4 while T_2 under-performed in terms of yield indicating the limitations of mineral fertilizers.

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