



**USE OF FORMULATED FERTILIZERS FOR SOIL CHEMICAL PROPERTIES  
IMPROVEMENT AND OKRA (*Abelmoschus esculentus* L. Moench) YIELD IN  
IBUSA, DELTA STATE**

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**ABSTRACT**

The study evaluated the use of formulated fertilizers for soil chemical properties improvement and okra (*Abelmoschus esculentus* L. Moench) yield for two years in Ibusa, Delta State. The treatment consisted of six fertilizers (control (T<sub>1</sub>), NPK 15:15:15 fertilizer (T<sub>2</sub>), organic + NPK (T<sub>3</sub>), organic + N (T<sub>4</sub>), organic + PK (T<sub>5</sub>) and sole organic (T<sub>6</sub>)), while Clemson spineless okra variety was used to test the effectiveness of the fertilizers. Sawdust, rice bran, wood shavings, pig dung, cattle dung and poultry droppings were the materials used for organic fertilizer preparation. The organic and inorganic fertilizers were used to formulate the organo-mineral fertilizers at a ratio of 4:1 and 250kg/ha of NPK15:15:15 was applied, the organo-mineral fertilizers and organic manure were applied at 6tons/ha and 10tons/ha respectively. Randomized complete block design replicated three times was used for the study. Okra growth and yield parameters were measured from 2WAS-10WAS and soil samples were collected at harvest for routine analysis. Data collected were subjected to analysis of variance with R project for statistical computing to determine the treatment effects and means comparison was done with Turkey's Honestly Significant Difference at P<0.05. Results showed that, the highest soil pH was obtained from T<sub>6</sub> (5.80) and N from T<sub>4</sub> (0.20%) in 2024 whereas P from T<sub>3</sub> (23.30mg/kg) in 2023 and OM from T<sub>6</sub> (1.98%) in 2024. T<sub>3</sub> had the highest ECEC (8.87cmol/kg), T<sub>6</sub> produced the highest okra yield(5.68ton/ha) that was closely followed by T<sub>4</sub> (5.32tons/ha) in 2024, This is an indication that either organic or organo-mineral fertilizers could sustainably improve soil fertility and boost okra yield in tropical areas.

**Keywords:** Formulated, Fertilizers, Soil, Properties, Okra, Yield

**INTRODUCTION**

Increasing demand for sustainable agriculture has encouraged developmental interest in alternative soil fertility management practices which balances productivity with environmental conservation. Tropical soils by nature and their mode of formation are very fragile and easily degraded. Therefore, there is need for effective soil management in order to derive maximum benefit from the soil both in short and long runs. Soil fertility determines the overall soil productivity and it is the ability of the soil to provide essential nutrients in the right amount to plants for their growth and development. There has been a decrease in soil fertility as a result of pressure on land for agriculture and other uses. It is therefore necessary that fertilizers be added to soils to boost soil fertility for optimum crop growth and yield. Inorganic fertilizers often used to improve soil fertility status because of their immediate release of nutrients to the soil as soon as they come in contact with moist soil lead to soil acidity that can reduce phosphate uptake by crops and inhibit crop growth. Organo-mineral fertilizers are derived from the combination of organic materials with mineral nutrients. Organo-mineral fertilizer with its organic matter content improves soil structure, helps the soil to retain nutrients thereby controlling leaching and nutrients runoff, stimulates microbial activities and provide balanced nutrient supply for plant growth (Nair *et al.* 2019).

Okra is an important vegetable crop cultivated in Delta State for its economic and nutritional value but its productivity is often affected by soil fertility decline. The use of mineral fertilizer by farmers is limited because of scarcity, high costs and basic disadvantages in apparent inability to substantially redress the physical fragility and chemical deterioration of the soil (Adeniyi and Ojeniyi, 2005). Therefore, the use of organic and organo-mineral fertilizers holds promise for sustainable okra production and this will boost the financial status of okra farmers in the area. Ibusa



represents a typical humid tropical environment with intense rainfall and highly weathered soils prone to nutrient leaching and organic matter depletion. Though many studies have been carried out on the influence of organo-mineral fertilizers on soil properties and okra production, there is little information on the use of organo-mineral fertilizers in Ibusa soils. Understanding the role of organic and organo-mineral fertilizers on soil properties and okra yield is essential for its recommendation for farmers. This study, therefore, investigates the effects of organic and organo-mineral fertilizers on soil chemical properties, growth, and yield of okra in Ibusa, Delta State.

## **MATERIALS AND METHODS**

### **Study Area**

The study was carried out in Delta Agricultural and Rural Development Authority (DARDA), Ibusa during the 2023 and 2024 cropping seasons. The experimental area is located between latitude 6°18'56" - 6°18'59" North and longitude 6°63'09" - 6°67'50" East. Ibusa is characterized by intense annual rainfall of 184.96cm - 240.98cm, a mean temperature of 24.46°C -31.91°C, mean monthly sunshine hour range of 7.31 – 11.02 and average relative humidity range of 44.80% - 85.88% (NiMet, 2017). The vegetation is of the rainforest zone made up of trees, shrubs and grasses of various species. The area is undulating and the soils are classified as sandy loam, Kaolinitic Haplustalf of the Kaolinite order (Egbuchua, 2012).

### **Treatment and Experimental Design**

The experiment was a Randomized Complete Block Design (RCBD) replicated 3 times. Six fertilizer treatments - control (T<sub>1</sub>), NPK 15:15:15 fertilizer (T<sub>2</sub>), organic + NPK (T<sub>3</sub>), organic + N (T<sub>4</sub>), organic + PK (T<sub>5</sub>) and sole organic (T<sub>6</sub>) were applied while Clemson spineless okra variety was used to test the effectiveness of the fertilizers. Sawdust, rice bran, wood shavings, pig dung, cattle dung and poultry droppings were materials used for the organic fertilizer preparation. Organo-mineral fertilizers were formulated by adding inorganic fertilizer to the prepared organic fertilizer at a ratio of 4:1 organo-mineral fertilizer. Two seeds of okra per hole were planted at the spacing of 60cm x 40cm on experimental plot of 2mx3m. 250kg/ha, 6tons/ha and 10tons/ha of NPK15:15:15, organo-mineral fertilizers and organic fertilizer were applied respectively.

### **Soil Sampling and Analysis**

A composite soil sample for initial soil properties analysis was taken from the experimental area (10.2m x 15.0m). Eighteen (18) soil samples were collected from 0 – 15cm in each plot after harvest to determine the nutrient contents of the soil. The samples were prepared by air drying at room temperature, crushed with mortar and pestle and samples finally made to pass 2mm sieve in order to get suitable particles for analysis. The samples were analyzed at the university of Ibadan with laid down procedures (IITA, 1979)

### **Data Collection**

Plant height was taken with meter rule from the ground level to the tip of the last leaf, leaf area was determined by multiplying leaf length and width with a factor of 0.62 (Jazuli, 2019) and number of leaves per plant was taking by counting the total number of leave of the tagged plant from 2 weeks after sowing – 10 weeks after sowing. Yield was taken at harvest by measuring the okra weight per plot.

### **Statistical Analysis**

Data collected were subjected to analysis of variance with the use of R project for statistical computing (Ludecke *et al.* 2021) and means were compared with aid of Turkey's Honestly Significant Difference at P<0.05.

## **RESULTS AND DISCUSSION**

### **Pre-planting Soil Analysis**

The results showed the soil to be strongly acidic and the acidic nature could be as a result of texture and rainfall pattern in the area which could leached exchangeable bases beyond the level that could be accessible to plant root. This had been confirmed by Brady and Weil (2014) that basic cations are leached whereas leaving acidic hydrogen and aluminum ions in top soils in high rainfall



areas. The soil was also low in organic carbon, total nitrogen though available phosphorus was moderate.

**Table 1:** Physico-chemical Properties of Soils of Experimental Site before Planting

Parameter	Value
Particle Size Distribution (%)	
Sand	76.00
Silt	9.00
Clay	15.00
Textural class	Sandy loam
pH (H <sub>2</sub> O)	4.6
Organic Matter (%)	1.50
Organic Carbon (%)	0.87
Total Nitrogen (%)	0.17
Available Phosphorus (mg/kg)	21.60
Exchangeable Calcium (cmol/kg)	3.60
Exchangeable Magnesium (cmo/kg)	0.80
Exchangeable Potassium (cmo/kg)	0.17
Exchangeable Sodium (cmo/kg)	0.31
Exchangeable acidity (cmo/kg)	1.04
Effective Cation Exchange Capacity (cmo/kg)	5.93
Base Saturation (%)	82.40
Extractable Zinc (mg/kg)	0.11
Extractable manganese (mg/kg)	0.39
Extractable Iron (mg/kg)	0.02
Extractable Copper (mg/kg)	2.05

The results from Table1 also indicated that soil micronutrients (zinc, manganese and iron) were very low. 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).

#### **Effects of Fertilizers on Soil Physico-chemical Properties at Ibusa during 2023 and 2024 Planting Seasons**

The results obtained from the effects of fertilizers on soil texture suggested that inorganic fertilizers may not have altered soil texture while the combination of organic and inorganic fertilizers improved soil texture by increasing silt and clay fractions through soil aggregation. Soil pH was highest in T<sub>6</sub> (5.70) in 2024 and the least was obtained from T<sub>2</sub> (4.17) in 2023 indicating that manure alone or in combination with inorganic fertilizer can neutralize soil acidity while sole dependence on inorganic fertilizers could increase soil acidity. This report is in line with Banuwa *et al.* (2020) which stated that mineralization of manure releases basic cations which are alkalinitic in nature and that continuously application increases soil pH. The T<sub>4</sub> which had the highest nitrogen content (0.20%) and the least obtained from T<sub>2</sub> (0.17%) in 2024 highlight the effects of combination of organic and inorganic amendment on nitrogen availability. The T<sub>3</sub> was reported to have the highest P (23.30mg/kg) in 2023 and the least was obtained from T<sub>4</sub> (20.03mg/kg) showing the ability of combined manure with NPK fertilizer improve available phosphorus. This align with the report of Hashim *et al.* (2023) which stated that highest values of available soil phosphorus were recorded when  $\frac{2}{3}$  of NPK fertilizer was applied with compost.

Manure with nitrogen alone was not adequate to increase phosphorus due to the presence of mineral nitrogen without corresponding mineral P in T<sub>4</sub>. This is in line with Liu *et al.* (2019) which asserted that elevated nitrogen deposition in humid tropical regions may aggravate phosphorus (P) deficiency in forest on highly weathered soil found in these regions. The highest organic carbon and organic matter contents, (1.15%) and (1.98%) respectively were obtained from T<sub>6</sub> in 2024. This underscored the importance of manure in improving soil organic carbon and organic matter which are important components of a fertile soil. T<sub>2</sub> had the least soil organic carbon and organic matter (0.67%



and 1.15%) among treated plots in 2024 due to absence of organic amendment. The highest calcium content was obtained from T<sub>3</sub> (5.73cmol/kg) in 2023 and the least value was reported in T<sub>2</sub>(2.93cmol/kg) in 2024. It was also observed that T<sub>6</sub> had the highest Mg(1.60cmol/kg) and K(0.17cmol/kg) in 2023 and 2024 respectively while the least Mg(0.80cmol/kg) was seen in T<sub>1</sub> in 2023 and the least K(0.09cmol/kg) was obtained from T<sub>2</sub> in 2023 an indication that organic amendment enhances the availability of essential cations. The highest exchangeable Na observed in T<sub>5</sub> (0.37cmol/kg) in 2023 and the least in T<sub>6</sub> (0.28cmol/kg) in 2024 was due to fertilizer input composition, and cation exchange dynamics. T<sub>5</sub> applied without mineral N might have lowered microbial biomass thereby reducing sodium immobilization through microbial activity while manure improved soil structure and permeability over time which resulted in more leaching of Na in T<sub>6</sub> during the second planting season.



**Table 2a:** Effects of Fertilizers on Soil Physico-chemical Properties at Ibusa during 2023 and 2024 Planting Seasons

Treatment	Sand (%)	Silt (%)	Clay (%)	pH	N (%)	P (%)	OC (%)	OM (%)	Ca	Mg	K	Na cmol/kg	EA	ECEC	BS (%)
<b>2023</b>															
T <sub>1</sub>	73.13 <sup>a</sup>	11.40 <sup>a</sup>	15.47 <sup>a</sup>	5.23 <sup>a</sup>	0.19 <sup>a</sup>	23.07 <sup>a</sup>	0.45 <sup>a</sup>	0.78 <sup>a</sup>	4.80 <sup>a</sup>	0.93 <sup>a</sup>	0.11 <sup>a</sup>	0.37 <sup>a</sup>	1.12 <sup>a</sup>	7.439 <sup>a</sup>	84.60 <sup>a</sup>
T <sub>2</sub>	73.47 <sup>a</sup>	11.07 <sup>a</sup>	15.80 <sup>a</sup>	4.17 <sup>a</sup>	0.18 <sup>a</sup>	22.30 <sup>a</sup>	0.65 <sup>a</sup>	1.11 <sup>a</sup>	4.67 <sup>a</sup>	1.47 <sup>a</sup>	0.09 <sup>a</sup>	0.32 <sup>a</sup>	1.23 <sup>a</sup>	7.76 <sup>a</sup>	84.00 <sup>a</sup>
T <sub>3</sub>	72.13 <sup>a</sup>	11.40 <sup>a</sup>	16.80 <sup>a</sup>	4.96 <sup>a</sup>	0.17 <sup>a</sup>	23.30 <sup>a</sup>	0.50 <sup>a</sup>	0.85 <sup>a</sup>	5.73 <sup>a</sup>	1.47 <sup>a</sup>	0.11 <sup>a</sup>	0.33 <sup>a</sup>	1.23 <sup>a</sup>	8.87 <sup>a</sup>	86.16 <sup>a</sup>
T <sub>4</sub>	73.13 <sup>a</sup>	11.40 <sup>a</sup>	15.47 <sup>a</sup>	5.17 <sup>a</sup>	0.18 <sup>a</sup>	21.13 <sup>a</sup>	0.53 <sup>a</sup>	0.92 <sup>a</sup>	5.33 <sup>a</sup>	1.33 <sup>a</sup>	0.14 <sup>a</sup>	0.35 <sup>a</sup>	1.28 <sup>a</sup>	8.44 <sup>a</sup>	84.57 <sup>a</sup>
T <sub>5</sub>	70.80 <sup>a</sup>	12.40 <sup>a</sup>	16.80 <sup>a</sup>	5.60 <sup>a</sup>	0.17 <sup>a</sup>	22.47 <sup>a</sup>	0.74 <sup>a</sup>	1.28 <sup>a</sup>	4.93 <sup>a</sup>	1.07 <sup>a</sup>	0.14 <sup>a</sup>	0.37 <sup>a</sup>	1.12 <sup>a</sup>	8.27 <sup>a</sup>	84.94 <sup>a</sup>
T <sub>6</sub>	72.47 <sup>a</sup>	11.40 <sup>a</sup>	16.13 <sup>a</sup>	4.90 <sup>a</sup>	0.18 <sup>a</sup>	22.20 <sup>a</sup>	0.58 <sup>a</sup>	0.99 <sup>a</sup>	5.20 <sup>a</sup>	1.60 <sup>a</sup>	0.12 <sup>a</sup>	0.36 <sup>a</sup>	0.99 <sup>a</sup>	7.62 <sup>a</sup>	87.96 <sup>a</sup>
<b>2024</b>															
T <sub>1</sub>	71.93	11.93 <sup>ab</sup>	16.33 <sup>a</sup>	5.17 <sup>a</sup>	0.16 <sup>c</sup>	21.97 <sup>a</sup>	0.55 <sup>b</sup>	0.95 <sup>b</sup>	2.00 <sup>c</sup>	0.80 <sup>b</sup>	0.10 <sup>c</sup>	0.31 <sup>a</sup>	0.93 <sup>a</sup>	4.15 <sup>d</sup>	77.35 <sup>c</sup>
T <sub>2</sub>	72.53	11.93 <sup>b</sup>	16.20 <sup>a</sup>	5.70 <sup>a</sup>	0.17 <sup>c</sup>	21.23 <sup>a</sup>	0.67 <sup>b</sup>	1.15 <sup>b</sup>	2.93 <sup>bc</sup>	0.93 <sup>ab</sup>	0.11 <sup>c</sup>	0.31 <sup>a</sup>	0.91 <sup>a</sup>	5.20 <sup>cd</sup>	82.62 <sup>abc</sup>
T <sub>3</sub>	70.73	12.87 <sup>ab</sup>	16.93 <sup>a</sup>	5.40 <sup>a</sup>	0.19 <sup>ab</sup>	22.23 <sup>a</sup>	0.90 <sup>ab</sup>	1.55 <sup>ab</sup>	3.73 <sup>ab</sup>	1.07 <sup>ab</sup>	0.13 <sup>b</sup>	0.29 <sup>ab</sup>	1.04 <sup>a</sup>	6.27 <sup>abc</sup>	83.38 <sup>ab</sup>
T <sub>4</sub>	73.00	11.67 <sup>ab</sup>	15.33 <sup>a</sup>	5.70 <sup>a</sup>	0.20 <sup>a</sup>	20.03 <sup>a</sup>	0.85 <sup>ab</sup>	1.46 <sup>ab</sup>	4.69 <sup>a</sup>	1.20 <sup>a</sup>	0.14 <sup>b</sup>	0.28 <sup>ab</sup>	0.96 <sup>a</sup>	7.25 <sup>ab</sup>	86.76 <sup>ab</sup>
T <sub>5</sub>	71.07	13.13 <sup>a</sup>	16.13 <sup>a</sup>	5.70 <sup>a</sup>	0.17 <sup>b</sup>	21.40 <sup>a</sup>	0.74 <sup>b</sup>	1.28 <sup>b</sup>	3.27 <sup>bc</sup>	0.93 <sup>ab</sup>	0.14 <sup>b</sup>	0.28 <sup>ab</sup>	1.01 <sup>a</sup>	5.66 <sup>bcd</sup>	82.13 <sup>bc</sup>
T <sub>6</sub>	71.60	13.07 <sup>ab</sup>	15.67 <sup>a</sup>	5.80 <sup>a</sup>	0.19 <sup>ab</sup>	21.15 <sup>a</sup>	1.15 <sup>a</sup>	1.98 <sup>a</sup>	5.07 <sup>a</sup>	1.20 <sup>a</sup>	0.17 <sup>a</sup>	0.18 <sup>b</sup>	0.91 <sup>a</sup>	7.58 <sup>a</sup>	87.88 <sup>a</sup>

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:** Effects of Fertilizers on Soil Micronutrients at Ibusa during 2023 and 2024 Planting Seasons

Treatment	Zn	Mn	Cu	Fe
	← mg/kg →			
<b>2023</b>				
T <sub>1</sub>	0.22 <sup>a</sup>	0.12 <sup>a</sup>	0.03 <sup>a</sup>	0.27 <sup>a</sup>
T <sub>2</sub>	0.38 <sup>a</sup>	0.30 <sup>a</sup>	0.03 <sup>a</sup>	0.48 <sup>a</sup>
T <sub>3</sub>	1.17 <sup>a</sup>	0.35 <sup>a</sup>	0.11 <sup>a</sup>	0.49 <sup>a</sup>
T <sub>4</sub>	0.12 <sup>a</sup>	0.83 <sup>a</sup>	0.30 <sup>a</sup>	0.39 <sup>a</sup>
T <sub>5</sub>	0.15 <sup>a</sup>	0.38 <sup>a</sup>	0.31 <sup>a</sup>	0.35 <sup>a</sup>
T <sub>6</sub>	0.35 <sup>a</sup>	0.35 <sup>a</sup>	0.09 <sup>a</sup>	0.18 <sup>a</sup>
<b>2024</b>				
T <sub>1</sub>	0.22 <sup>a</sup>	0.14 <sup>a</sup>	0.03 <sup>a</sup>	0.29 <sup>a</sup>
T <sub>2</sub>	0.38 <sup>a</sup>	0.30 <sup>a</sup>	0.04 <sup>a</sup>	0.50 <sup>a</sup>
T <sub>3</sub>	0.18 <sup>a</sup>	0.36 <sup>a</sup>	0.12 <sup>a</sup>	0.50 <sup>a</sup>
T <sub>4</sub>	0.13 <sup>a</sup>	0.84 <sup>a</sup>	0.31 <sup>a</sup>	0.40 <sup>a</sup>
T <sub>5</sub>	0.16 <sup>a</sup>	0.39 <sup>a</sup>	0.32 <sup>a</sup>	0.37 <sup>a</sup>
T <sub>6</sub>	0.37 <sup>a</sup>	0.30 <sup>a</sup>	0.10 <sup>a</sup>	0.19 <sup>a</sup>

Means with same alphabet(s) on the same column and under the same heading are not significantly different at P<0.01 level of probability using T-HSD.

The least exchangeable acidity (0.96cmol/kg) was obtained from T<sub>6</sub> in 2024, an indication that manure could ameliorate soil acidity, manure applications contribute basic cations that neutralize hydrogen ion in the soil, thereby reducing exchangeable acidity (Agegnehu *et al.* (2016). The highest ECEC obtained from T<sub>3</sub>(8.87cmol/kg) in 2023 and the least from T<sub>2</sub>(5.20cmol/kg) in 2024 in addition to highest base saturation in T<sub>6</sub> (87.98%) in 2023 and T<sub>2</sub> having the least base saturation (82.62%) among treated plots in 2024 is an evidence that manure and its combination with inorganic fertilizers can enhance soil nutrient holding capacity and improve overall soil fertility. The addition of manure to inorganic fertilizer was found to have a considerable impact on the amount of available phosphorus and potassium (Hashim *et al.* 2023).

Extractable micronutrients (Zn, Mn, Cu and Fe) with different variations is an indication that the fertilizer combination influenced their dynamics in different ways. Zn was highest in T<sub>2</sub> (0.38mg/kg) in both seasons and least in T<sub>4</sub> (0.12mg/kg) in 2023. This may be due to the application of NPK which could enhance the pool of available Zn in acidic soil making it more soluble. This is contrary to the report of da Silva *et al.* (2024) which asserted that Zn solubility reduced after addition of phosphate fertilizers due to the formation of sparingly soluble precipitates, decreasing Zn availability to crop. T<sub>4</sub> gave rise to the highest Mn (0.84mg/kg) in 2024 and the least was obtained from T<sub>1</sub> (0.12mg/kg) in 2023 which could be attributed to presence of compost in the nitrogen fertilizer that through accumulation over time had increased Mn availability through chelation and microbial activity while the absence of organic or inorganic amendment had resulted in reduced content of Mn in T<sub>1</sub>. This observation is in line with the report of Samiei and Bostani (2016) which stated that by increasing manure application, DTPA-extractable Mn concentrations and existing amounts in five different soil fractions increased, which the lowest and highest concentration in all studied forms were observed in control and 6 ton/ha manure treatments respectively. Again extractable Cu highest in T<sub>5</sub> (0.32mg/kg) in 2024 demonstrated the influence of manure on soil structure and microbial activity that could lead to immobilization of Cu while T<sub>1</sub> and T<sub>2</sub> in 2023 and 2024 with the least extractable Cu (0.03mg/kg) resulted from lack of organic amendments in T<sub>1</sub> and T<sub>2</sub>. T<sub>6</sub> had the least extractable Fe (0.18mg/kg) while T<sub>2</sub> and T<sub>3</sub> with the highest value (0.50mg/kg) may be attributed to the presence of mineral N-fertilizer in T<sub>2</sub> and T<sub>3</sub> that could enhance soil activity thereby making Fe more available in the soil while organic matter could form complexes of F-organic matter that can reduce its availability. The use of nitrogen fertilizer supplement in soil slightly alleviated the Fe decrease caused by organic fertilizers (Liu *et al.* 2023).





### **Effect of Fertilizers on Growth and Yield Characters of Okra at Ibusa during 2023 and 2024 Planting Seasons**

Plant height showed no significant difference ( $P < 0.05$ ) at both planting seasons.  $T_6$  had the highest plant height at 2WAS while the lowest was obtained from  $T_5$  in 2024 and 2023 respectively. At 4WAS, the highest plant height was obtained from  $T_6$  (16.75cm) while the least was obtained from  $T_2$  (13.04cm) in 2024. The highest plant height was seen in  $T_6$  (26.75cm) in 2024 while the lowest plant height was observed in  $T_2$  (21.55cm) in 2023 at 6WAS. At 8WAS and 10WAS,  $T_6$  had the highest plant height (53.17cm and 54.72cm respectively) in 2024 while the least was seen in  $T_2$  (30.56cm and 32.11cm) respectively during 2023 among treated plots (Table 3).

Effect of fertilizers on leaf area indicated no significant differences ( $P < 0.05$ ) in all sampling periods for 2023 and 2024 planting seasons except at 4WAS and 6WAS in 2024 planting season. At 2WAS,  $T_3$  produced the highest leaf area (34.12cm<sup>2</sup>) in 2024 while the least was obtained from  $T_1$  (7.66cm<sup>2</sup>) in 2023. At 4WAS, the highest leaf area was observed in  $T_6$  (133.92cm<sup>2</sup>) in 2024 while the least leaf area was noticed in  $T_1$  (45.18cm<sup>2</sup>) during 2023. The highest and lowest leaf area were obtained from  $T_3$  (201.62cm<sup>2</sup>) and  $T_2$  (106.43cm<sup>2</sup>) respectively in 2024 at 6WAS among treated plots (Table 3). At 8WAS and 10WAS during 2023 planting season, the highest leaf area was seen in  $T_4$  (317.87cm<sup>2</sup> and 379.64cm<sup>2</sup>) respectively while the least was obtained from  $T_1$  (210.80cm<sup>2</sup> and 256.66cm<sup>2</sup>) respectively. Effect of organo-mineral fertilizer on number of leaves per plant showed significant differences ( $P < 0.05$ ) at 2WAS, 4WAS and 6WAS 2023 and in all sampling periods in 2024 (Table 3). At



**Table 3:** Effects of Fertilizers on Plant Height, Leaf area, Number of leaves and Yield of okra in Ibusa during 2023 and 204 Planting Seasons

Treatment	2 WAS			4 WAS			6 WAS			8 WAS			10 WAS			Yield (ton/ha)
	PH(cm)	LA(cm <sup>2</sup> )	NL	PH (cm)	LA (cm <sup>2</sup> )	NL	PH (cm)	LA (cm <sup>2</sup> )	NL	PH (cm)	LA (cm <sup>2</sup> )	NL	PH (cm)	LA (cm <sup>2</sup> )	NL	
<b>2023</b>																
T <sub>1</sub>	5.30 <sup>a</sup>	7.66 <sup>a</sup>	4.00 <sup>a</sup>	11.98 <sup>a</sup>	45.18 <sup>a</sup>	6.08 <sup>a</sup>	21.82	126.94 <sup>a</sup>	7.59 <sup>a</sup>	30.16 <sup>a</sup>	210.80	12.17 <sup>b</sup>	30.16 <sup>c</sup>	256.66 <sup>a</sup>	16.75 <sup>c</sup>	2.67 <sup>a</sup>
T <sub>2</sub>	5.34 <sup>a</sup>	8.19 <sup>a</sup>	4.00 <sup>a</sup>	13.25 <sup>a</sup>	81.10 <sup>a</sup>	7.25 <sup>a</sup>	21.55	172.45 <sup>a</sup>	9.92 <sup>a</sup>	30.56 <sup>a</sup>	252.18 <sup>a</sup>	14.50 <sup>ab</sup>	32.11 <sup>bc</sup>	311.81 <sup>a</sup>	19.00 <sup>b</sup>	3.15 <sup>a</sup>
T <sub>3</sub>	5.50 <sup>a</sup>	8.71 <sup>a</sup>	4.00 <sup>a</sup>	13.78 <sup>a</sup>	85.51 <sup>a</sup>	7.58 <sup>a</sup>	23.03	187.79 <sup>a</sup>	9.58 <sup>a</sup>	32.86 <sup>a</sup>	275.77 <sup>a</sup>	13.75 <sup>ab</sup>	34.75 <sup>ab</sup>	332.77 <sup>a</sup>	19.00 <sup>b</sup>	3.48 <sup>a</sup>
T <sub>4</sub>	5.57 <sup>a</sup>	8.63 <sup>a</sup>	4.00 <sup>a</sup>	15.76 <sup>a</sup>	76.05 <sup>a</sup>	8.08 <sup>a</sup>	24.86	200.57 <sup>a</sup>	10.42 <sup>a</sup>	34.77 <sup>a</sup>	317.87 <sup>a</sup>	15.83 <sup>a</sup>	36.89 <sup>a</sup>	379.64 <sup>a</sup>	21.24 <sup>a</sup>	4.62 <sup>a</sup>
T <sub>5</sub>	5.17 <sup>a</sup>	7.76 <sup>a</sup>	4.00 <sup>a</sup>	13.85 <sup>a</sup>	63.74 <sup>a</sup>	6.92 <sup>a</sup>	22.83	163.12 <sup>a</sup>	8.75 <sup>a</sup>	32.00 <sup>a</sup>	248.42 <sup>a</sup>	14.08 <sup>ab</sup>	33.54 <sup>abc</sup>	308.31 <sup>a</sup>	18.50 <sup>bc</sup>	2.73 <sup>a</sup>
T <sub>6</sub>	5.82 <sup>a</sup>	9.29 <sup>a</sup>	4.00 <sup>a</sup>	14.91 <sup>a</sup>	68.20 <sup>a</sup>	6.92 <sup>a</sup>	23.96	186.07 <sup>a</sup>	9.08 <sup>a</sup>	32.93 <sup>a</sup>	289.27 <sup>a</sup>	13.33 <sup>ab</sup>	34.62 <sup>ab</sup>	335.62 <sup>a</sup>	18.75 <sup>bc</sup>	4.68 <sup>a</sup>
<b>2024</b>																
T <sub>1</sub>	6.43 <sup>a</sup>	15.16 <sup>a</sup>	3.00 <sup>a</sup>	13.23 <sup>a</sup>	62.00 <sup>ab</sup>	4.33 <sup>a</sup>	23.24 <sup>a</sup>	106.36 <sup>b</sup>	9.33 <sup>a</sup>	42.75 <sup>a</sup>	101.60 <sup>a</sup>	9.42 <sup>a</sup>	37.11 <sup>a</sup>	72.96 <sup>a</sup>	3.83 <sup>a</sup>	2.53 <sup>c</sup>
T <sub>2</sub>	6.47 <sup>a</sup>	14.54 <sup>a</sup>	3.00 <sup>a</sup>	13.04 <sup>a</sup>	59.20 <sup>b</sup>	4.58 <sup>a</sup>	23.04 <sup>a</sup>	106.43 <sup>b</sup>	9.58 <sup>a</sup>	40.14 <sup>a</sup>	118.88 <sup>a</sup>	8.83 <sup>a</sup>	37.84 <sup>a</sup>	97.72 <sup>a</sup>	7.75 <sup>a</sup>	3.03 <sup>bc</sup>
T <sub>3</sub>	7.76 <sup>a</sup>	34.12 <sup>a</sup>	3.00 <sup>a</sup>	15.88 <sup>a</sup>	133.57 <sup>a</sup>	5.08 <sup>a</sup>	25.89 <sup>a</sup>	201.62 <sup>a</sup>	9.67 <sup>a</sup>	49.17 <sup>a</sup>	113.10 <sup>a</sup>	13.42 <sup>a</sup>	51.05 <sup>a</sup>	91.82 <sup>a</sup>	12.25 <sup>a</sup>	4.06 <sup>abc</sup>
T <sub>4</sub>	8.19 <sup>a</sup>	23.92 <sup>a</sup>	3.00 <sup>a</sup>	16.48 <sup>a</sup>	98.95 <sup>ab</sup>	5.33 <sup>a</sup>	26.51 <sup>a</sup>	152.54 <sup>ab</sup>	10.08 <sup>a</sup>	50.92 <sup>a</sup>	131.06 <sup>a</sup>	11.08 <sup>a</sup>	51.81 <sup>a</sup>	118.16 <sup>a</sup>	9.83 <sup>a</sup>	5.32 <sup>ab</sup>
T <sub>5</sub>	7.09 <sup>a</sup>	24.27 <sup>a</sup>	3.00 <sup>a</sup>	14.58 <sup>a</sup>	99.84 <sup>ab</sup>	4.83 <sup>a</sup>	24.58 <sup>a</sup>	152.61 <sup>ab</sup>	10.00 <sup>a</sup>	44.08 <sup>a</sup>	124.10 <sup>a</sup>	9.75 <sup>a</sup>	45.48 <sup>a</sup>	100.78 <sup>a</sup>	8.42 <sup>a</sup>	3.12 <sup>abc</sup>
T <sub>6</sub>	8.37 <sup>a</sup>	32.61 <sup>a</sup>	3.00 <sup>a</sup>	16.75 <sup>a</sup>	133.92 <sup>a</sup>	5.00 <sup>a</sup>	26.75 <sup>a</sup>	194.15 <sup>a</sup>	10.17 <sup>a</sup>	53.17 <sup>a</sup>	139.76 <sup>a</sup>	10.08	54.72 <sup>a</sup>	118.19 <sup>a</sup>	8.92 <sup>a</sup>	5.68 <sup>a</sup>

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.





T2WAS, the number of leaves per plant were the same (3.00) for all fertilizer treatments during 2023 and 2024 planting seasons. The highest number of leaves at 4WAS was obtained from T<sub>5</sub> and T<sub>6</sub> (6.92) in 2023 while the least was obtained from T<sub>2</sub> (4.58) among treated plots in 2024. At 6WAS, the highest and least number of leaves was seen in T<sub>6</sub> (10.17) in 2024 and T<sub>1</sub> (7.59) in 2023 planting season respectively. At 8WAS and 10WAS the highest number of leaves was seen during 2023 in T<sub>4</sub> (15.83 and 21.24) respectively for both sampling periods while the least number of leaves was obtained from T<sub>2</sub> (8.83 and 7.75) respectively in 2024.

The highest and lowest yield were obtained from T<sub>6</sub> (5.68tons/ha) in 2024 and T<sub>1</sub> (2.67tons/ha) in 2023 respectively. At early growth stage (2WAS), plant height and leaf area performed better in 2024 than in 2023. However, the number of leaves per plant were higher at 2WAS in 2023 than in 2024. The superior performance may be attributed to favourable environmental conditions such as soil fertility and climatic factors. The highest plant height observed in T<sub>6</sub> (8.37cm) and highest leaf area recorded in T<sub>4</sub> (34.12cm<sup>2</sup>) in 2024 suggests the importance of manure and integration of manure and nitrogen fertilizer in enhancing soil nutrient supply leading to better growth performance. At mid-growth stages (4WAS-8WAS), the highest plant height and leaf area obtained from T<sub>6</sub> (16.75cm and 133.92cm<sup>2</sup>) respectively in 2024 while the highest number leaves was recorded in T<sub>4</sub> (8.08) in 2023 pointed to the fact that organic inputs can improve okra growth. Leaf area began to decline as soon as fruiting commenced in 2024. This may be due to the plant diverting its nutrient from vegetative growth to flower and fruit development. As soon as pod is formed in the okra plant, the greater amount of photosynthetic material moves to the pod depending on the species and environmental conditions (Oyewole, 2014). At 10WAS, the highest yield was recorded in T<sub>6</sub> (5.68tons/kg) which was followed by T<sub>4</sub> (5.32tons/ha) in 2024. The least yield was obtained from T<sub>2</sub> (3.03tons/ha) in 2024 among treated plots suggesting the absence of organic inputs leading to yield reduction.

## CONCLUSION AND RECOMMENDATION

The study indicated that integrating manure and inorganic fertilizer or sole manure can improve the physico-chemical properties of soil, mitigate soil acidity and improve nutrient retention. Manure promoted higher organic matter and enhanced base saturation. Though, early growth parameters showed variable responses, yield performance was consistently superior under manure based treatments with sole manure having the highest yield followed by manure+N in both seasons confirming the fertilizer used can offer a viable and sustainable approach for maintaining soil fertility and increasing okra yield.

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