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Assessment of Integrated Soil Fertility Management System on the Growth and Yield of *Abelmoschus esculentus* in a Tropical Alfisol

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Abstract: The combined effect of Poultry manure, Pig slurry and NPK fertilizer as integrated nutrient on soil fertility and on the growth and yield of *Abelmoschus esculentus* (Okra) were examined on a tropical Alfisol, under field conditions at the Teaching and Research Farm of Joseph Ayo Babalola University, Ikeji-Arakeji, Nigeria, in 2014. The experiment was laid in a Randomized Complete Block Design (RCBD) having three replicates of eight treatments. The treatments applied were: i. Poultry droppings (PD) at 5t ha^{-1} ii. Pig slurry (PS) at 5t ha^{-1} iii. NPK 15-15-15 (NPK) at 250kg ha^{-1} iv. Control (CT) v. Poultry droppings and Pig slurry (PDPS) at 2.5 t ha^{-1} eachvi. Poultry droppings and NPK 15-15-15 (PDNPK) at 2.5 t ha^{-1} and 125kg ha^{-1} respectively vii. Pig slurry and NPK 15-15-15 (PSNPK) at 2.5 t ha^{-1} and 125kg ha^{-1} respectively viii. Poultry droppings, Pig slurry and NPK 15-15-15 (PDPSNPK) at 1.67 t ha^{-1}, 1.67 t ha^{-1} and 83.3 kg ha^{-1} respectively. The soil of the experimental site was sampled for analysis before planting and after planting. Growth parameters such as plant's height, stem girth and yield were measured at 3, 4 and 5 weeks after planting (WAP). At 55 days after planting (DAP), the plants were sampled for chlorophyll test and leaf area determination. Data collected were subjected to analysis of variance (ANOVA) and the means were separated using Duncan multiple range test at 5% probability level. The results showed that plant height, stem diameter, leaf area, chlorophyll and yield were significantly influenced by the application of soil fertility replenishment treatments. At 5 weeks after planting (WAP), the plant height recorded were 44.13cm, 53.30cm, 49.46cm, 30.66cm, 53.73cm, 44.80cm, 54.40cm and 45.60cm for PD, PS, NPK, CT, PDPS, PDNPK, PSNPK and PDPSNPK respectively while the yield recorded were 1.33t ha^{-1}, 1.62t ha^{-1}, 1.07t ha^{-1}, 0.40t ha^{-1}, 1.56t ha^{-1}, 1.36t ha^{-1}, 1.86t ha^{-1}, and 1.53t ha^{-1} for PD, PS, NPK, CT, PDPS, PDNPK, PSNPK and PDPSNPK respectively. Combined Pig slurry and NPK 15-15-15 (PSNPK) performed better in most of the growth parameters taken as well as the yield. The post-harvest pH values of the soil indicated that the soil was slightly acidic.
Keywords: Poultry droppings, Pig slurry, NPK Fertilizer, Soil fertility, *Abelmoschus esculentus*, Alfisol

INTRODUCTION

Crop productivity is a major means to break the vicious cycle underlying poverty in Nigeria, but the soil that will enhance the productivity is 'hungry' just like the people living on it. Continual cultivation of land for crop production in order to meet up with food demand and alleviate the poverty of the ever increasing population in the nation had resulted in soil nutrient depletion. Increase use of fertilizer to replenish soil nutrient is therefore a key factor to sustainable crop production in the agricultural system. Inorganic fertilizers has proved to be a way of boosting crop yields per unit area of land but because of the problems inherent with the use such as high cost, imbalance nutrient supply, losses through volatilization, scarcity, soil acidity, inadequate supply of micro and macronutrients, Integrated soil fertility management system (ISFM) have been advocated by FAO and other Researchers [1-7]. ISFM strategies center on the combined use of mineral fertilizers and organic materials to replenish lost soil nutrients, undertaken with the aim of improving the efficiency of fertilizer, optimizing the condition of the soil, with regard to its physical, chemical, biological and hydrological properties, for the purpose of enhancing farm productivity and minimizing land degradation. Ojeniyi [2], established that chemical fertilizers have failed to make necessary impact in tropical agriculture, and particularly emphasized that in Nigeria, sustainable crop production is not possible with dependence on chemical fertilizers alone. The realization of this had spurred up the establishment of organomineral fertilizers manufacturing companies by state governments in Nigeria, especially in the south-west. Though, a good number of studies on the influence of ISFM on different crops have been carried out but literatures on its assessment on *Abelmoschus esculentus* (Okra) are not readily available[4, 8-10].Ayeni*et al*, [5]established that integrated application of poultry manure and NPK fertilizer enhances the performance of

Tomato in derived savanna transition zone of southwest Nigeria. This study is aimed at assessing the effect of integrated soil fertility management system on the growth and yield of Okra.

MATERIALS AND METHODS

Description of Site and Material

The experiment was conducted on the Teaching and Research Field Plot of the College of Agricultural Science of Joseph Ayo Babalola University, IkejiArakeji, Osun State which lies between latitude 7°16' and 7°18' North and longitude 5°09' and 5°11' E. The area is characterized by a tropical climate. The study area is situated in the humid tropical forest zone of Nigeria. It has an annual average rainfall of between 1500mm-1800mm and relative humidity of between 80% - 85% annually. The area is characterized by a bimodal rainfall pattern which starts in late March and ends in late September while the short rainy season extends from September to late November after a dry spell in August. The soil order is a loamy soil and the land has long been subjected to cultivation of arable crops such as maize, cassava, cowpea, vegetables. The experiment was conducted from April-July, 2014.

Seed Source,Seed Bed Preparation, Experimental Design and Layout

The seeds of *Abelmoscus esculentus* used were obtained from National Horticultural Research Institute (NIHORT) in Ibadan, Oyo State, Nigeria. The bed was manually prepared using cutlass and hoes. This was carried out before seedlings transplant.

The experiment was laid out as a randomized complete block design (RCBD) with four treatments and three replicates. The experiment was conducted on a 12m x 25m plot partitioned into twenty-four beds of 3m x 3m separated by buffer of 1.0m wide with plant spacing of 50cm by 50cm. The treatments were:

a. Weathered Poultry dropping (PD) at $5tha^{-1}$.
b. Weathered Pig slurry (PS) at $5tha^{-1}$.
c. NPK 15-15-15 (NPK) at $250kg\ ha^{-1}$.
d. Control (CT).
e. Weathered Poultry dropping + Weathered Pig slurry (PDPS) at $2.5tha^{-1}$ each.
f. Pig dropping+ NPK (PDNPK) at $2.5tha^{-1}$ and $125kg\ ha^{-1}$ respectively.
g. Weathered Pig slurry +NPK (PSNPK) at $2.5tha^{-1}$ and $125kg\ ha^{-1}$ respectively.
h. Weathered Poultry dropping + Weathered Pig slurry + NPK (PDPSNPK)at $1.67tha^{-1}$, $1.67\ tha^{-1}$ and $83.3kg\ ha^{-1}$.

For plot that received poultry manure and pig slurry, the nutrient was incorporated a week before planting while for those plots treated with inorganic fertilizer, the application was carried out a week after germination. For those that receive combined nutrient application, the organic manure component was incorporated during bed preparation and the inorganic fertilizer was applied a week after germination. For combined organic manure application (i.e. poultry droppings and pig slurry), the organic manures were thoroughly mixed and applied during bed preparation while NPK was applied a week after germination. Weeding was done regularly.

DATA COLLECTION & ANALYSIS

Soil Sample Collection and Analysis

Soil sample were collected from the experimental plots at depth of 0-15cm using Soil augerbefore land preparation and repeated at the first, second and third harvests to determine the nutrient status of the soil. The soil samples were air dried, crushed and sieved to pass through a 2 mm sieve after which analysis was carried out. Total nitrogen was analyzed using the macro-kjeldahl procedure; Organic carbon analysis was done using the Walkley and Black procedure [11].The organic matter content was derived by multiplying organic carbon content by 1.72; Soil pH was determined in soil/water ratio of 1:2 using a pH meter with glass electrode [12]; Available phosphorus was by the Bray 1 method; Exchangeable acidity was determined by the titration method, exchangeable K, Ca and Mg were determined by extraction with ammonium acetate at pH 7.0 and the amounts of K, and Ca in the filtrate were determined using a Corning flame photometer with appropriate filter, while Mg was determined by using a Perkin-Elmer Atomic Absorption Spectrophotometer (AAS); Micronutrients: Cu, Zn, Mn and Fe were determined after extraction of the soil sample with 0.1 M HCl and the filtrate read on Perkin-Elmer AAS; and Effective Cation Exchangeable Capacity (ECEC) of the soil samples was determined by the summation of all the cations and the exchangeable acidity.

Proximate Analysis of Poultry Droppings and Pig Slurry

Samples of Poultry Droppings and Pig Slurry used were taken for proximate analysis.

Agronomic Data collection

Plant height and diameter of five randomly selected plants from each treatment were measure during meter rule and veneer caliper respectively at 3, 4 and 5 weeks after planting.

Determination of Leaf Area

The total leaf area of three randomly selected okra plants per plot were taken at 60 days after planting and corresponding leaf area index computed. The leaf area was measured following the procedure of [13, 14] by multiplying the length (L) of a leaf by its widest width (W) and by alpha, where alpha is 0.743- (L x W x 0.743). The leaf area index was computed by dividing the area of okra plant stand by the total land area occupied by single stand [15].

Statistical Analysis

Data were subjected to analysis of variance using the General linear model procedure (GLM) for randomized complete block design (RCBD) in SAS (SAS Institute 2005). Analysis of variance was completed to determine the significance of treatments. Mean separation was done using Duncan's New Multiple Range Test at $P<0.05$.

RESULTS AND DISCUSSION

Results

Pre-planting Physical and Chemical Properties of Soil of the Experimental Site

The soil of the area is slightly acidic and has low percentage of organic carbon (Table 1). Also the total soil nitrogen of the area is low as well as available soil phosphorus. The texture of soil in the area is sandy, clay and loamy. Calcium, magnesium, potassium, and effective cations exchange capacity (ECEC) were low which the value of exchange acidity was fairly high.

Table 1: Pre-planting physico-chemical properties of soil of the Experimental Site

Soil Properties	Values
pH (Water)	5.9
Organic Carbon	0.46
Organic Matter (%)	0.8
Total Nitrogen (%)	0.067
Available P (mg/kg)	3.44
Sand (%)	64.00
Silt (%)	24.00
Clay (%)	12.00
Calcuim (cmol/kg of soil)	0.80
Magnesium (cmol/kg of soil)	0.35
Potassium (cmol/kg of soil)	0.15
Sodium (cmol/kg of soil)	0.17
Exchange acidity (cmol/kg of soil)	1.36
ECEC (cmol/kg of soil)	2.83

Textural class: Sand clay loam. ECEC: Effective cations exchangeable capacity

Chemical Analysis of Poultry Droppings and Pig Slurry

The results in Table 2 show that Pig slurry had the highest values of nitrogen (0.66%) and organic carbon (45.93%) and its pH was slightly acidic (6.3). On the other hand, Poultry dropping has lower nitrogen (0.52%), 45% organic carbon and alkaline pH of 8.4.

Table 2: Chemical Analysis of Poultry droppings and Pig Slurry

Element	Poultry Droppings (PD)	Pig Slurry (PS)
% Nitrogen	0.52^{NS}	0.66^{NS}
% Phosphorus	1.29^{NS}	1.20^{NS}
% Calcium	3.91^{NS}	3.60^{NS}
% Magnesium	0.66^{NS}	0.53^{NS}
% Potassium	0.62^{NS}	0.67^{NS}
% Carbon	45.91^{NS}	45.94^{NS}
% Moisture Content	2.53^{NS}	2.73^{NS}
% pH (H_2O) 1:2	8.4^{*}	6.3^{*}

* Significant at 5%; NS not significant

Effect of Organic manure, NPK fertilizer and Integrated Nutrient on the height and diameter of Okra

There were significant differences among the treatments at ($P \leq 0.05$).At 3weeks after planting (WAP), the control has the least values of height (15.40cm) while the highest value of 36.90cm was recorded at PS plot. All the treatment recorded higher values over the control but there were no significant differences among the treatments.

At 4weeks after planting (WAP) the trend was the same, lowest value was recorded in the control plot while the highest value was recorded in the PS with no significant differences.

At 5weeks after planting (WAP), PDPS recorded the highest values with the least value from control plot. Statistically, there was no significant difference but all yielded better than the control (Table 6).

There were no significant differences in the diameter among the treatments at 3 WAP (Table 4). The least value was recorded in the control plot while the highest value was recorded in the PS plot. At 4 WAP, control plot still gave the least value with the highest value recorded from PS plot.

At 5 WAP, the least value of 0.90cm was recorded from the control plot while the highest value of 1.73cm was recorded from PSNPK plot. There were significant differences in values of diameter recorded from the CT, PSNPK and PDPSNPK, while others show no significant differences.

Table 3: Effect of Organic manure,NPK Fertilizers and Integrated Nutrient on Okra Height (cm)

Treatments	PD	PS	NPK	CT	PDPS	PDNPK	PSNPK	PDPSNPK
3WAP	31.66^{a}	36.90^{a}	25.66^{a}	15.40^{b}	36.00^{a}	26.83^{a}	36.36^{a}	27.66^{a}
4WAP	37.40^{a}	45.80^{a}	36.00^{a}	24.03^{b}	45.26^{a}	36.93^{a}	45.80^{a}	38.60^{a}
5WAP	44.13^{a}	53.30^{a}	49.46^{a}	30.66^{b}	53.73^{a}	44.80^{a}	54.40^{a}	45.60^{a}

Means on the same row followed by the same letter are not significantly different using Duncan New Multiple Range Test at P<0.05.

Table 4: Effect of Organic manure,NPK Fertilizers and Integrated Nutrient on Okra Diameter (cm)

Treatments	PD	PS	NPK	CT	PDPS	PDNPK	PSNPK	PDPSNPK
3WAP	1.03^{a}	1.16^{a}	0.73^{a}	0.40^{b}	0.86^{a}	0.80^{a}	1.06^{a}	0.76^{a}
4WAP	1.32^{ab}	1.46^{a}	1.10^{b}	0.80^{c}	1.13^{b}	1.16^{b}	1.50^{a}	1.06^{b}
5WAP	1.65^{ab}	1.65^{ab}	1.32^{bc}	0.90^{d}	1.37^{abc}	1.34^{abc}	1.73^{a}	1.23^{c}

Means on the same row followed by the same letter are not significantly different using Duncan New Multiple Range Test at P<0.05. Means on the same row followed by different letter are significantly different at P<0.05.

Effect of Organic manure, NPK fertilizer and Integrated Nutrient on Leaf Area

Tables 5 show the value of Leaf Area. The value of leaf area ranges from 1.67cm in control to 3.59cm in plot mulched with PSNPK. There was no significant difference in the leaf area between NPK, PD, PS, PDPS, PDNPK and PDPSNPK plots respectively.

Table 5:Effect of Organic manure, NPK fertilizer and Integrated Nutrient on Leaf Area (LA)

Treatments	PD	PS	NPK	CT	PDPS	PDNPK	PSNPK	PDPSNPK
LA (m^2)	2.52^{ab}	3.59^{a}	2.37^{ab}	1.67^{b}	2.99^{a}	2.65^{ab}	3.30^{a}	3.52^{a}

Effect of Organic manure, NPK fertilizer and Integrated Nutrient on Yield

Tables 6 show the value of Okra yield.The yields of okra were more in plot treated PSNPK with the value of 1.86tha^{-1} while the least value of 0.40tha^{-1} was recorded in control plot. In yield values, there was no significant difference between all the treatment plots except for control plot only (Table 6).

Table 6: Effect of Organic manure, NPK fertilizer and Integrated Nutrient on okra yield (tha^{-1})

Treatment	PD	PS	NPK	CT	PDPS	PDNPK	PSNPK	PDPSNPK
Yield (t ha^{-1})	1.33^{a}	1.62^{a}	1.07^{a}	0.40^{b}	1.56^{a}	1.36^{a}	1.86^{a}	1.53^{a}

Means on the row followed by different letter are significantly different at P<0.05

Post-harvest chemical properties of the soil

The chemical properties of the soil of the experimental site after 1st, 2nd and 3rd harvest are shown in Table 7 below.

Table 7: Post- harvest chemical properties of the soil

	SOIL CHEMICAL PROPERTIES							
TRTHarvest	PH	%OC	% N	(ppm)P	(ppm)Ca	(ppm)mg	(ppm)K	(ppm)Na
CT 1st	6.4	0.84	0.22	25.98	7	1.2	11.4	11.2
2nd	6.88	0.86	0.23	26	6.92	1.22	11.5	11.25
3rd	6.64	0.85	0.21	25.96	6.96	1.18	11.3	11.23
PD 1st	6.6	1.09	0.36	46.36	7.13	1	8.4	7.8
2nd	6.86	1.11	0.34	46.34	7.11	1.01	8.42	7.77
3rd	6.73	1.1	0.3	46.35	7.12	1	8.41	7.78
PS 1st	6.6	0.69	0.18	33.99	7.5	1.2	12.6	8.4
2nd	6.94	0.7	0.2	34	7.47	1.2	12.63	8.43
3rd	6.74	0.69	0.9	34.05	7.49	1.2	12.62	8.42
NPK 1st	6.3	1.03	0.3	24.19	6.88	1.1	13.6	10.6
2nd	6.72	1.04	0.33	24.22	7.1	1.11	13.55	10.57
3rd	6.51	1.03	0.32	24.21	6.99	1.11	13.57	10.59
PDPS 1st	6.6	0.88	0.27	40.17	7.32	1.1	10.5	8.1
2nd	6.9	0.9	0.27	40.17	7.3	1.11	10.53	8.11
3rd	6.7	0.89	0.27	40.17	7.31	1.11	10.52	8.1
PDNPK 1st	6.45	1.05	0.33	35.27	7.01	1.05	11	9.2
2nd	6.79	1.07	0.34	35.28	7.11	1.07	10.99	9.18
3rd	6.62	1.06	0.34	35.28	7.06	1.06	10.99	9.19
PSNPK 1st	6.45	0.85	0.24	29.08	7.19	1.15	13.1	9.5
2nd	6.83	0.86	0.27	29.11	7.28	1.16	13.1	9.51
3rd	6.64	0.86	0.25	29.09	7.24	1.15	13.1	9.5
PDPSNPK 1st	6.5	0.93	0.28	40.51	7.16	1.1	11.53	8.93
2nd	6.84	0.94	0.28	34.85	7.23	1.1	11.54	8.92
3rd	6.67	0.93	0.28	37.68	7.19	1.1	11.54	8.93

DISCUSSION

The texture of the area was sandy clay loam. This may be attributed to the lithology of the parent material. The low values of clay content may also be as a result of lithology of parent materials. Nitrogen, phosphorus, calcium, magnesium and sodium were low in study area. This may be due to over cropping, leaching of soluble cations, soil erosion and lack of proper and management practices in the area. The acidic nature of the soil may be due to the leaching of soluble cations observed in the area as well as distribution of exchangeable acidity. Also, Enwezor*et al*,[17] observed that leaching of Na, K, Ca and Mg were largely responsible for the development of acidity in the soil. The low value of organic matter in the area may be due to continuous cropping without the addition of organic manure as supported by the findings of Sajo*et al.,* [16]. The alkaline nature of poultry droppings might be due to higher calcium content than the pig slurry.

The result of the treatments on the Okra height and diameter are shown in Table 3 and 4 respectively. All the treatments significantly increased the height and diameter compared to the control at all sampling weeks. The highest height was obtained from pig slurry (PS) at 3WAP and 4WAP while the plot treated with pig slurry and NPK (PSNPK) gave the highest at 5WAP. This

trend might be due to higher nutrients released by PS and PSNPK. PS treatment gave the highest diameter at 3WAP, while PSNPK gave the highest at 4WAP and 5WAP which might be connected with nutrient released by the treatment.

The leaf area value was higher in the plots treated with PS, PDPSNPK and PSNPK which might be due to release of higher nutrients necessary for leaf area. This trend which reflected in the yield of Okra corroborated the earlier assertion of leaf area to be essential for stimulation of light interception and photosynthetic production [18].

The Okra yield was higher in PS and PSNPK plots over other treatments, although not significantly higher. This might be due to the supply of greater quantities of needed nutrients as well as improvement of the soil physico-chemical properties [19].

CONCLUSION AND RECOMMENDATION

Conclusion

This study was designed to investigate the effect of different types of organic manure and inorganic manure on okra *(Abelmoschus esculentus*). Data were collected at different growth stages for plant height, diameter, total leaf area and fruit yield. In the treatment, a combined application of 2.5tha^{-1} level of pig slurry (PS) and 125kg ha^{-1}level of NPK 15-15-15 had significantly different effects compared with other treatment for the parameters of growth and yield. Highest mean value was observed with a combined application of 2.5tha^{-1} level of organic manure (PS) and 125kg ha^{-1} level of inorganic manure (NPK 15-15-15). Based on the results of this study, the following conclusion was drawn: Okra grew taller, had bigger diameter, larger leaf area and higher fruit yield at a combined application of 2.5tha^{-1} level of organic manure (PS) and 125kg ha^{-1} level of inorganic manure (NPK 15-15-15).

Recommendations

Integration of organic and inorganic fertilizer is of great importance to soil properties and plant performance, therefore the following are recommended: This work should be repeated and extended tootheragro-ecological zones. Various forms of integration of different types of organic and inorganic fertilizers should be experimented.

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