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EFFECT OF DIFFERENT FERTILIZER TYPES ON SOIL PHYSICAL PROPERTIES, GROWTH AND YIELD OF OKRA (*Abelmoschus esculentus* (L.) MOENCH (LD 88-1) IN SOUTHWEST NIGERIA

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Abstract

Residue quality is a huge determinant of how effective different fertilizers are on soil and crop plants. The aims of this study was to compare the effect of different fertilizer types on soil physical properties, growth and yield of okra {Abelmoschus esculentus (L.) Moench (LD 88-1)} in southwest Nigeria. Field experiments were conducted during the cropping seasons of 2012 and 2013 at the Teaching and Research Farm, Federal College of Forestry, Ibadan. The experiment was laid out in a Randomized Complete Block Design with seven treatments replicated three times. The treatments of the experiments were: control (i.e. no fertilizer application), 20 tons ha^{-1} poultry manure, 150 kg ha^{-1} N.P.K 15:15:15, 120 kg ha^{-1} Organomineral fertilizer, 120 kg ha^{-1} N.P.K.MgO (12:12:17 + 2% MgO), 20 tons ha^{-1} poultry manure + 150 kg ha^{-1} N.P.K.15:15:15 and 20 tons ha^{-1} poultry manure + 120 kg ha^{-1} N.P.K.MgO (12:12:17:2%MgO). The results of the study showed that application of fertilizers gave significant (p=0.05) increase in plant height, stem girth, number of leaves, number of branches and yield. At 8 weeks after treatment application (8WATA), 20 tons ha^{-1} poultry manure + 150 kg ha^{-1} NPK 15:15:15 gave the highest values in plant height, stem girth, number of leaves, number of branches and yield of okra. In 2013, application of 20 tons ha^{-1} poultry manure + 150 kg ha^{-1} NPK 15:15:15 had lowest or reduced bulk density (1.47 g/cm^3), increase in total porosity (44.53 %) and gravimetric moisture content (20.93 %) compared to control. This result suggests that incorporation of organic and inorganic fertilizers into cropping systems will increase productivity and yield (t/ha) of okra. Hence, for improvement in soil physical properties and increase yield of okra, application of 20 tons ha^{-1} poultry manure + 150 kg ha^{-1} NPK 15:15:15 may be recommended for the production of okra.

Key Words: *Bulk density, Total Porosity, Growth, Yield, Organic, Organomineral fertilizer*

Introduction

Okra (*Abelmoschus esculentus* (L.) Moench) is one of the most important, popularly cultivated and consumed vegetables in Nigeria and in other temperate/sub-tropical regions or countries of the world. In Nigeria, okra is primarily grown for its green, tender pods and leaves. In advanced and developed countries of the world like United States of America (USA), quantities of pod or fruits are frozen, canned alone or mixed with other vegetables for future use. The fruits are also used as medicine for the treatment of peptic ulcer. The nutrients contained in okra are very important in neutralizing acidic substances. The pod of okra has been reported to be a good source of vitamin, minerals and proteins due to its high lysine content (Savello *et al*., 1980). The fresh fruit has ascorbic acid of 203mg/100g (Keshiro and Ketiku, 1979). Fresh, immature fruits and leaves are also used in preparing soups while the pod contains mucilaginous substance that can be used as plasma replacement or blood volume expander and for the manufacture of paper (Majanbu *et al*., 1985). The mature stem of some varieties contain crude fiber, which is beneficial in increasing intestinal peristalsis (Oyolu, 1986). Okra seeds contain a high content of edible oil and quality protein due to high lysine contents (Savello *et al*., and Tindall, 1993). The crop can also serve as a supplement to cereal-based diets (Al-Wandaw, 1983). In spite of the importance of okra, the production is still limited to small-scale holders due to several identifiable limitations. Declining soil fertility is a major production constraint in Africa, especially in Nigeria, and it is becoming increasingly critical to secure sustainable soil productivity and food security. Okra, like other vegetables has been reported to give good response to difference fertilizer type.

The physical condition of a soil is one of the fundamental factors affecting crop growth, development and yield. This is because; soil physical properties have a very high degree of correlation with crop production and high influence on soil fertility and crop performance (Nnaji, 2009). In order to obtain high crop yield, the soil must have the proper physical properties, and unless the physical nature of soils is improved, a high plant-nutrient-use efficiency may not be achieved (Parr *et al.,* 1986).The physical properties of soil play an important role in influencing plant growth thereby contributing to efficient crop production (Zheljazkov and Warman, 2004). Increasing soil organic matter will enhance aggregation and stability thereby improving soil structure and soil porosity. Stability of aggregates prevents surface sealing and soil erosion, improves water infiltration, and enhances water holding capacity (Martínez-Blanco *et al*., 2013). Intensively cropped soils are prone to deterioration in soil physical properties with the following resultant effects; increased soil bulk density, reduced porosity, low soil water content and reduced soil aggregation. Also, Mehdizale *et al.* (2013) reported that intensive cropping and tillage systems had positive effects on soil physical properties that led to increased bulk density and decreased soil porosity when compared with uncultivated state of the soil.

However, indiscriminate use of inorganic fertilizer leads to nutrient imbalance in soils, causing ill-effect on soil properties. Hence, there is a need to supplement inorganic fertilizers along with the application of organic and bio fertilizers to the maximum possible level. Inorganic fertilizers are easily solubilized

and sometimes the rate of uptake by plants does not correspond with application and this can cause environmental pollution. Therefore, the project objective was to determine alternative fertilizer sources that could be recommended for optimal production of Okra.

Materials and Methods

The experiment was conducted at the Teaching and Research farm (crop section) of the Federal College of Forestry (latitude 07° 23′ N longitude 03° 51′ E), Ibadan, Oyo state Nigeria. The annual rainfall of Ibadan is 1250 mm with a bimodal pattern, wet season of about 8 months, usually between April and October/November, with a brief dry season which starts in most cases in the second half of August. The minimum mean daily temperature of Ibadan is 21.9°C and maximum temperature of 35.5°C.

Land Preparation and Crop Establishment

The field was cleared and tilled manually with cutlass and hoe. The entire field was partitioned into 9 experimental plots each measuring 3 m x 1 m with 1m alley between plots and 2m walkway around the farm. The total land area was 15 m X 17 m (255 m^2). Each experimental unit had fifteen seedlings of okra. The experiment was laid out in a randomized complete block design with seven treatments and three replications. The treatments were: control (i.e. no fertilizer application), 20 tons ha^{-1} poultry manure, 150 kg ha^{-1} N.P.K 15:15:15, 120 kg ha^{-1} organomineral fertilizer, 120 kg ha^{-1} N.P.K.MgO (12:12:17:2%MgO), 20 tons ha^{-1} poultry manure + 150 kg ha^{-1} N.P.K.15:15:15, 20 tons ha^{-1} poultry manure + 120 kg ha^{-1} N.P.K.MgO (12:12:17 + 2% MgO). Okra seeds (variety LD 88-1) used for the experiment were obtained from National Horticulture Research Institute (NIHORT) Ibadan, Oyo state.

Poultry manure, organo-mineral, N.P.K fertilizers were obtained from Ondo state Government Agricultural Development Progamme along Igbatoro road, Akure, Ondo State. Okra seeds (variety LD 88-1) were planted at three seeds per hole and thinned to one per stand with a spacing of 60cm giving a total of 37,037 plants/ha. The fertilizers were applied 3 weeks after planting (WAP) shortly after weeding. The band placement technique was used to apply the fertilizer. Foliar pests of okra were controlled with Cymbush (5ml/10 L water) thrice.

Soil Sampling and Analysis

Surface soil (0-15 cm depth) samples were randomly collected with soil auger from different points on the site, bulked; air dried and sieved using a 2 mm mesh sieve. Fertilizers tested were taken to the laboratory for chemical analysis.

Physical Properties

Particle size distribution was determined using hydrometer method (Gee and Or, 1986). Bulk density was measured by using core method, as described by Blake and Hartage (1986). Total porosity was calculated from bulk density and particle density assumed as 2.65 g/cm^3.

Chemical Properties

Soil pH was determined in a 1:1 soil to water ratio using the Coleman's pH meter (IITA, 1982). Organic carbon was determined by the Walkey and Black procedure (Nelson and Sommers, 1982) while total Nitrogen was determined by the Macrokjeldahl method (Bremner, 1996). Available Phosphorus was extracted by Bray P-1 method (Bray and Kurtz, 1945). Organic matter was estimated as organic carbon x 1.724 (Odu

et al., 1986). Exchangeable cations (Ca, Mg, K and Na) were extracted with 1 N NH4OAC (pH 7) at a soil: extracting solution ratio of 1: 10 for 15 min. The concentrations of Ca and Mg were read on the Atomic Absorption Spectrophotometer while K and Na were read on the Flame Photometer.

Calibration of Fertilizer Application Equipment

The application of accurate amount of the desired of fertilizer is essential to supplying the proper nutrition to okra crop. Proper calibration of application equipment will better ensure that the proper amount of fertilizer is applied. The "1/100 ha" method is applied in the calibration procedures for the fertilizer spreading machine which does not require calibration charts and calculations.

1) Appropriate calibration distance based on row spacing was first determined.

Row Calibration (mm)	Spacing Distance (m)
1219.6	357.63
1168.4	374.03
1117.6	390.44
1066.8	406.84
1016.0	423.25
903.60	439.66
914.50	456.06

2) Fertilizer was collected from the applicator over the calibration distance and weighed the fertilizer.

3) Multiply the amount of fertilizer collected by 100 to obtain the fertilizer application rate (kg/ha). With two outlets per row, the fertilizers were combined to obtain the application rate for each row. However, the fertilizers collected separately from each row to determine the actual rate of each row.

Statistical Analysis

Data collected was analysed statistically using Genstat Statistical Software package and subjected to Analysis of variance. Means were separated using Duncan Multiple Range Test (DMRT) at 5% level of significance.

Results and Discussion

The soils at the experimental site have been classified as an Alfisol (Smyth and Montgomery, 1962) with its distinctive characteristics. The initial characteristics of the soil studied are presented in Table 1. The soil is deficient in total N (0.66 gkg^{-1}), organic carbon (5.85 gkg^{-1}) and available P (5.52 $mgkg^{-1}$) and slightly acidic (5.11). This is below the critical range (Adeoye and Agboola, 1985, Akinrinde, *et al*., 2005), thus indicating poor soil fertility not suitable without the addition of external input for growing of okra. The soil is however sufficient in exchangeable bases with sandy loam textural class. The chemical composition of poultry manure and organomineral fertilizer used is as shown in Table 2.

Effect of different fertilizer types on the plant height and stem girth of okra

The effect of different fertilizer types on the plant height and stem girth of okra is as presented in table 3. Plant height increases appreciably across treatments. Plant height differed significantly (p=0.05) across treatments between 2^{nd} and 6^{th} week after treatment application (2 and 6 WATA). At the 8th week after treatment application, there were no significant differences across treatments. Plant height ranged from 55.22cm in the control plot to 66.27cm in the plot where 20 tons/ha poultry manure + 1 50kg/ha NPK15:15:15 was applied. Stem girth also increased appreciably across treatments. Stem girth differed significantly (p=0.05) across treatments between the 2^{nd} and 4^{th} weeks after treatment application. However, stem girth did not differ

significantly between the 6th and 8th weeks after treatment application. Stem girth ranged from 1.42cm in the control plot to 1.64cm at 8 WATA in the plot where 20 tons/ha poultry manure + 150kg/ha NPK15:15:15 was applied.

Effect of different fertilizer types on the number of leaves and number of branches of okra

The effect of different fertilizer types on the number of leaves and number of branches of okra is as presented in table 4. Number of leaves increased appreciably across treatments but did not differ significantly (p=0.05) throughout the experiment. Number of leaves ranged from 12 in the control plot to 17 in the plot where 20 tons/ha poultry manure + 150 kg/ha NPK 15.15.15 was applied at 8WATA. Similar trend was also observed in the number of branches produced by okra. Number of branches ranged from 1 in the control plot to 3 in the plot where 5 tons/ha poultry manure + 150 kg/ha NPK 15.15.15 was applied.

Effect of different fertilizer types on yield of okra

The effect of different fertilizer types on yield of okra in 2012 and 2013 is as presented in table 5. Okra yield increases appreciably and differed significantly (p=0.05) across treatments. Among the seven treatments, 20 tons/ha poultry manure + 150 kg/ha NPK 15.15.15 (56.85 and 91.09 kg ha^{-1}) had the highest yield followed by 120 kg/ha NPKMgO 12:12:17:2%MgO (44.85 and 83.82 kg ha^{-1}) and least by control plot (37.20 and 40.00 kg ha^{-1}).

Effects of different fertilizer types on selected soil physical properties

Gravimetric moisture content

Effect of fertilizer types on gravimetric moisture content, bulk density and total porosity of soil is as presented Table 7. Gravimetric moisture content was not influenced by fertilizer types in 2012, but 20 tons/ha poultry manure + 150 kg/ha NPK 15.15.15 treated plot had the highest moisture content. While, in 2013, 20 tons/ha poultry manure + 150 kg/ha NPK 15.15.15 treated plot had significantly higher moisture content (20.93 %) and increase in total porosity (44.53 %) compared to control plot. However, incorporation of fertilizers reduced bulk density (1.47 g/cm^3) compared to control plot.

Discussion

In this study, all treatments encourage growth of okra except the control i.e. no fertilizer application. It could be observe from the result obtain that there was an increase in plant height, stem girth, number of leaves, number of branches and yield. The result showed that application of different types of fertilizer significantly influenced the growth and yield of okra. The results are also in agreement with the findings of Nehra *et al*. (2001), Sanwal *et al*. (2007) and Makinde *et al*. (2010) who also observed an increase in the growth and yield of amaranthus as a result of application of organic, organomineral and N.P.K fertilizers. Organic and organomineral fertilizers were found to increase yield of maize and vegetable such as pepper, tomato, okra, melon and Amaranthus significantly (Ojeniyi and Adejobi, 2002; Ipinmoroti, 2003; Fagbola and Dare, 2003; Olowokere, 2004; Makinde 2007; Adeoye *et al*., 2008; Akanni and Ojeniyi, 2008; Ojeniyi *et al*., 2009). Babatola *et al*. (2002) reported that increasing level of NPK 20:10:10 was observed to increase growth and yield of okra in an okra/sweet corn intercrop.

Conclusion and Recommendation

The result showed that organic, inorganic and organomineral fertilizers have effect on physical properties of soil, growth and yield of okra (*Abelmoshus esculentus* (L.) Moench) in southwest Nigeria. Over the years, Synthetic fertilizers (chemical fertilizers) such as NPK have been used and this is because it has been mineralized and is seen to give a quicker result unlike organic fertilizers such as compost, mulches and farm yard manure (FYM), which takes a longer time to give maximum yield of crops. The reason why farmers do not appreciate organic fertilizers is because the yield from organic manure treated soil during the first season of application is not usually encouraging as the time it takes for the organic matter to rejuvenate the soil is longer. The organic fertilizers compete well and in subsequent years of farming on the same land, they can have better yield, and also maintain the soil physical properties such as moisture content, bulk density and total porosity. The NPK combination with the organic based fertilizer may give an excellent outcome on the growth and yield of Okra. It could be observed from the results obtained that there was an increase in plant height, stem girth, number of leaves, number of branches and yield. Application of 20 tons/ha poultry manure + 150kg / ha N.P.K15:15:15 gave the highest plant height.

Farmers should be educated on the use of organic based fertilizer such as compost, farm yard manure and green manure to improve their soil which will in turn give rise to a better performance on the growth and yield of the crop planted. The use of this organic based fertilizer also promotes good health as there are no residues of chemicals on the crops grown. Therefore, it can be concluded and recommended that for improvement in soil physical properties and increase yield of okra, application of 20 tons ha^{-1} poultry manure + 150 kg ha^{-1} NPK 15:15:15 fertilizer can be used by farmers to increase okra yield production.

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Table 1: Soil properties at the experimental site

Soil parameters	Content in soil
pH 1:1(H_2O)	6.11
Total nitrogen (N) (g kg^{-1})	0.66
Available phosphorus(P) (mg kg^{1})	5.52
Soil Organic Carbon (SOC) (g kg^{-1})	5.85
Exchangeable cations (Cmol Kg^{1})	
Potassium (K)	0.54
Calcium (Ca)	2.39
Magnesium (Mg)	1.28
Sodium (Na)	0.21
Extractable Micronutrients (Mg kg^{-1})	
Mn	302.0
Fe	265.0
Cu	3.39
Zn	1.2
Particle size distribution (g kg^{-1})	
Sand	780.00
Silt	100.00
Clay	120.00
Textural class	Sandy Loam

Table 2: Chemical properties of poultry manure and Organomineral fertilizer used

Parameter	Poultry Manure Content	Organomineral fertilizer value
pH (H_2O)	9.60	7.8
Organic carbon (g/kg)	22.94	30.43
Total Nitrogen (g/kg)	33.30	44.00
Phosphorus (mg/kg)	59.83	11.89
Potassium (cmol/kg)	7.80	6.80
Calcium (cmol/kg)	12.56	6.50
Magnesium (cmol/kg)	1.58	10.80

Table 3: Effect of different fertilizer types on plant height (cm) and stem girth (cm) of okra

Treatments	Weeks after treatment application			
	2	4	6	8
	Plant height (cm)			
Control	28.67^{c}	40.11^{c}	41.44^{c}	55.22^{a}
20 tons/ha Poultry Manure	40.61^{ab}	52.61^{b}	54.83^{b}	57.17^{a}
150 Kg/ha NPK15:15:15	39.06^{abc}	53.56^{ab}	59.11^{ab}	65.00^{a}
120 kg/ha OMF	40.89^{ab}	58.67^{ab}	59.28^{ab}	60.39^{a}
120 Kg/ha NPKMgO	36.89^{abc}	54.50^{ab}	55.55^{b}	55.72^{a}
20 tons/ha poultry manure + 150Kg/ha NPK15:15:15	46.72^{a}	62.50^{a}	64.56^{a}	66.27^{a}
20 tons/ha poultry manure + 120 Kg/ha NPKMgO	32.44^{bc}	53.83^{ab}	53.89^{b}	58.94^{a}
	Stem girth (cm)			

Control	0.99[b]	1.23[b]	1.23[a]	1.42[a]
20 tons/ha Poultry Manure	1.12[ab]	1.32[ab]	1.41[a]	1.44[a]
150 Kg/ha NPK15:15:15	1.42[a]	1.44[a]	1.47[a]	1.52[a]
120 kg/ha OMF	1.29[ab]	1.42[ab]	1.43[a]	1.47[a]
120 Kg/ha NPKMgO	1.37[ab]	1.45[ab]	1.47[a]	1.54[a]
20 tons/ha poultry manure + 150 Kg/ha NPK 15:15:15	1.45[a]	1.51[a]	1.53[a]	1.64[a]
20 tons/ha poultry manure + 120 Kg/ha NPKMgO	1.30[ab]	1.43[a]	1.46[a]	1.46[a]

Means followed by the same letter in each column for each parameter are not significantly different from each other by DMRT at 5% level of probability.

Table 4: Effect of different fertilizer types on number of leaves and number of branches of okra

Treatments	Weeks after treatment application			
	2	4	6	8
	Number of leaves			
Control	9[a]	11[a]	12[a]	12[a]
20 tons/ha Poultry Manure	12[a]	12[a]	12[a]	15[a]
150 Kg/ha NPK15:15:15	10[a]	11[a]	12[a]	13[a]
120 kg/ha OMF	12[a]	12[a]	14[a]	15[a]
120 Kg/ha NPKMgO	11[a]	12[a]	14[a]	14[a]
20 tons/ha poultry manure + 150Kg/ha NPK15:15:15	12[a]	12[a]	13[a]	17[a]
20 tons/ha poultry manure + 120 Kg/ha NPKMgO	12[a]	14[a]	15[a]	16[a]
	Number of branches			
Control	1[a]	1[a]	1[a]	1[a]
20 tons/ha Poultry Manure	1[a]	2[a]	2[a]	2[a]
150 Kg/ha NPK15:15:15	2[a]	2[a]	2[a]	2[a]
120 kg/ha OMF	2[a]	2[a]	2[a]	2[a]
120 Kg/ha NPKMgO	2[a]	2[a]	2[a]	2[a]
20 tons/ha poultry manure + 150Kg/ha NPK15:15:15	2[a]	2[a]	3[a]	3[a]
20 tons/ha poultry manure + 120 Kg/ha NPKMgO	2[a]	2[a]	2[a]	2[a]

Means followed by the same letter in each column for each parameter are not significantly different from each other by DRMTat 5% level of probability

Table 5: Effect of different fertilizer types on yield (Kg/ha) of okra

Treatments	2012	2013
Control	37.20[a]	40.00[a]
20 tons/ha Poultry Manure	39.50[a]	72.07[bc]
150 Kg/ha NPK15:15:15	41.34[a]	82.65[de]
120 kg/ha OMF	39.06[a]	78.98[cd]
120 Kg/ha NPKMgO	44.85[ab]	83.82[e]
20 tons/ha poultry manure + 150Kg/ha NPK15:15:15	56.85[ab]	91.09[e]
20 tons/ha poultry manure + 120 Kg/ha NPKMgO	38.92[a]	67.88[b]

Means followed by the same letter in each column for each parameter are not significantly different from each by DRMT at 5% level of probability.

Table 6: Effect of different fertilizer types on the pod proximate composition of okra

Treatment	% Moisture content	% Fat	% Fibre	% Protein	% Ash	% Carbohydrate
Control	88.09	1.44	4.3	3.11	2.21	0.85
20 tons/ha Poultry Manure	88.87	1.10	5.83	3.36	0.71	0.13
150 Kg/ha NPK15:15:15	79.65	1.21	8.01	4.31	2.79	4.03
120 kg/ha OMF	78.23	1.14	7.41	6.54	3.45	3.23
120 Kg/ha NPKMgO	80.75	1.09	8.09	3.94	1.79	4.34
20 tons/ha poultry manure + 150Kg/ha NPK15:15:15	84.71	0.99	5.77	4.6	1.17	2.76
20 tons/ha poultry manure + 120 Kg/ha NPKMgO	88.65	0.67	5.94	3.38	1.1	0.26

Table 7: Effects of fertilizer types on typical physical properties of soil

Treatment	Gravimetric moisture (%)		Bulk density (g/cm^3)		Total porosity (%)	
	2012	2013	2012	2013	2012	2013
Control	7.66a	9.82b	1.54ab	1.73a	41.88ab	34.72ab
20 tons/ha Poultry Manure	7.96a	9.50b	1.62a	1.66ab	38.86b	37.36ab
150 Kg/ha NPK15:15:15	7.27a	8.65b	1.47b	1.68ab	44.53a	36.60ab
120 kg/ha OMF	8.38a	5.55b	1.47b	1.72a	44.53a	35.09b
120 Kg/ha NPKMgO	8.18a	10.19b	1.51ab	1.71a	43.02ab	35.47ab
20 tons/ha Poultry manure + 150Kg/ha NPK15:15:15	8.60a	20.93a	1.42b	1.47b	46.42a	44.53a
20 tons/ha poultry manure + 120 Kg/ha NPKMgO	8.20a	9.50b	1.46b	1.65ab	44.91ab	37.74ab