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Growth and Yield of Two Varieties of Okra (Abelmoschus esculentus (L). Moench) as affected by Potassium Fertilizer Sources

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Abstract
Wastes arising from poultry production and oil palm processing mill have constituted environmental hazard in South-West, Nigeria. The use of these wastes as soil organic amendments can be a way of managing the wastes thus reducing the menace of pollution caused by indiscriminate dumping of these wastes especially poultry manure. The effects of four agricultural wastes as sources of potassium fertilizers on growth and yield of two varieties of okra (*Abelmoschus esculentus (*L*). Moench*) were assessed in a pot experiment at the Teaching and Research Farm, Ekiti State University, Ado-Ekiti. Treatments consisted of poultry manure (PM), palm oil mill effluent (POME) at 8t/ha each, muriate of potash (MP) applied at 20kg/ha and no fertilizer (NF) as control as well as two varieties of okro TAE-38 and Clemson spineless (NHA_e (47-4). The experiment was laid out in a randomized complete block design (RCBD) in three replicates. Twenty four pots were filled with 25kg top soil each. Data of growth and yield parameters; plant height, number of leaves, leaf area, number of pods, length of pods and fresh weight of pods were measured. The results revealed that poultry manure significantly ($P<0.05$) gave highest plant height of 92.7cm, highest number of pod (18.3) which is 52 and 35% over POME and 89% over NF respectively. POME gave highest fresh pod weight of 23.7g/plant. Maximum yield of 3.3t/ha was obtained with application of poultry manure. The result have shown that organic sources POME and PM could be used as a substitute for K which increase the productivity of the soil in okro production and thereby reduce the pollution caused by these wastes.
Keywords: Growth, poultry manure, potassium fertilizer sources, Oil palm mill effluent.

1. Introduction

Fertilizer use has been a long time event in Nigeria. In spite of its use, crop yield is not increasing correspondingly, which reflect low fertilizer use efficiency (FUE) Ogunniyi, (2012). There are some problems related to the use of chemical fertilizers which includes inadequate supply, adulteration and high cost (Ahmed, 2006), and the continuous use-pollution effect in the environment (Ojeniyi, 2007). However, improving soil fertility without resorting to mineral fertilizer is to use agric and agro-industrial residues as soil organic amendment. Most of the organic fertilizer materials are waste or bi-products of other agricultural crops and animals which are used to augment the soil nutrient status, the biological and physical conditions of the soil. Palm oil mill effluent (POME) is one of the major waste products generated from processing fresh fruit bunch (FFB) in palm fruit processing mills and poultry litter is generated by birds in poultry production. In oil palm mill about 22% of FFB processed into oil end up as POME which contains 30– 40% K_2O and it has enormous potentials as soil amendment and animal feed improvement (Binder *et al.,* 2002). It could be used as source of potassium. Also, poultry litter contain high amount of nutrient especially N, P and K which are needed for plant growth.

Discharging these by-products on the lands may results in environmental pollution and might deteriorate the soil environment. There is an urgent need for a sound and efficient management strategy in a way that will help to conserve the environment and check the deterioration of air, water and soil quality.

Potassium (K) is an essential plant nutrient that plays an important role in plant growth and development. Some specific roles of K in the plant include osmoregulation, internal cation/anion balance, enzyme activation, proper water relations, photosynthate translocation, and protein synthesis. Tolerance of external stress, such as frost, drought, heat, and high light intensity is enhanced with proper K nutrition. Its role is also well documented in photosynthesis, increasing enzyme activity, improving synthesis of protein, carbohydrates and fats, translocation of photosynthates, enabling their ability to resist pests and diseases (Mehdi *et al.,* 2007). It is very essential for vigorous plant growth, disease resistance, fruit and vegetable flavor development, and general plant function.

The use of poultry manure as a means of maintaining and increasing soil fertility has been reported (Ojeniyi *et al.,* 2003, Ojeniyi, 2007 and Ewulo 2010). Manure when efficiently and effectively used, ensures sustainable crop productivity by immobilizing nutrients that are susceptible to leaching. Nutrients contained in poultry manures are released more slowly ensuring longer residual effects, improved root development and higher crop yields (Abou El Magd *et al*., 2005). Manures are usually applied at higher rates and they give residual effects on the growth and yield of succeeding crops (Makinde and Ayoola, 2008). Improvements of environmental conditions as well as the need to reduce cost of fertilizing crops are reasons for advocating use of organic materials as source of K (Bayu *et al.,* 2006).

Okra (*Abelmoschus esculentus (L) Moench*) belongs to the family Malvacea, a flowering plant, originating from tropical and sub-tropical Africa, and it is natural to West Africa (Tindall, 1983). It is one of the important crops cultivated in Nigeria (Alimi, 2005). It is a leading fruit in the Nigerian market on the basis of land area, production and value (Taylor, 1996). Okra is mainly cultivated for its 'pods' which are cooked and eaten in Nigeria. Okra is a good source of vitamins, minerals, calories and amino acid found in seeds and compares favorably with those in poultry eggs and soya bean (Schipper, 2000). Young fruits can be eaten raw and serves as soup thickener. Okra commands a high market price in Nigeria markets, because it features daily in the diets of most Nigerians (Akinfasoye and Nwanngumma, 2005).

Okra plants need N, P and K for optimum growth and yield, and also fertilizer requirements differ based on variety, soil and other conditions. These nutrients must be supplied at the right time and in the right quantity. The use of manure, especially poultry droppings and other agricultural by-product for crop production has helped to improve agricultural practice in West African countries.

Nigeria agriculture is faced with the challenge of increasing efficiency in agricultural productivity. Therefore, the use of Poultry manure and palm oil mill effluent as potassium fertilizer sources can therefore be a sustainable means of disposing these products and also increase crop production. This will involve adequate supply of essential crop nutrients, which will be the critical link between productions of food to meet today's need and long term agricultural sustainability. Generally, fertilizer recommendation for most of the fruits and vegetable grown in Nigeria has been reported (NIHORT, 1986; Ayodele, (1993). Also, intense research studies had been carried out on the effect of K fertilizer rates on various crops, except sources of K. Because of this exception, this study was done to evaluate the use of palm oil mill effluent and poultry manure as sources of K on growth and yield characters of two varieties of okra.

2. Materials and Methods

2.1 Location of Experiment.

The study was conducted at the Teaching and Research Farm, Ekiti State University, Ado-Ekiti. Ado-Ekiti (long. 7º47'N and lat. 5º13'E) is located in the dry forest zone and experiences a warm sub-humid tropical climate with long term mean annual rainfall of 1,367 mm received in 112 days between March and November. The soil of the study site has been identified as an Alfisols of the basement complex, highly leached and with low to medium organic matter content (Fasina *et al.,* 2005). The site had previously been cultivated to some arable crops such as maize, cassava, cocoyam, yam and melon before it was left to fallow for some years.

2.2. Soil Sampling and Analysis

Before sampling, ten core soil samples randomly collected from 0-15 cm top-soil were bulk to form a composite. Samples were air dried, crushed and allowed to pass through a 2mm sieve. Particle size distribution was carried out by the Hydrometer method, while soil pH in soil solution ratio 1:2 in 0.01M CaCl2. Soil organic carbon was determined by the Walkey and Black (1934) dichromate oxidation method. Total N was determined by the micro-kjeldahl digestion method as described by Bremner and Mulvaney, (1982). Available P was determined by Bray and Kurtz (1955) extraction method as described by IITA, (1979); Exchangeable bases were extracted with neutral 1M NH40AC at a soil solution ratio of 1:10 and measured by flame photometry. Magnesium was determined with an atomic absorption spectrophotometer. Exchange acidity was determined by titration of 1M KCl extract against 0.05M NaOH to a pink end point using phenolphthalein as indicator (McLean, 1982).

2.3. Planting Material Preparations.

Twenty – five (25) kilogram top soil were weighed into pots and watered to equilibrate. The pots were punctured at the base to ensure proper aeration and drainage. Poultry manure (PM) was collected fresh from the poultry section of the Teaching and Research Farm, Ekiti State University, Ado-Ekiti, and air-dried to reduce ammonium (NH_4) content. Then application was done two (2) weeks before planting in order to ensure decomposition of the organic manure before planting.

2.4. Experimental Design and Treatments

The experiment was laid out in a randomized complete block design in three replicates. The treatments consisted of poultry manure (PM), palm oil mill effluent (POME), each at 8t/ha, muriate of potash (MP) at 60kg/ha and no fertilizer (NF) as control. Three seeds of NHAe 47-4 and TAE-38 varieties were sown in plastic pot (50x20x40cm) containing 25kg top soil and later thinned to two seedlings per stand at one week after germination. There were five (5) sampling times, at two-week intervals starting from 2 weeks after planting (WAP).

2.5 Data Collection

Data were collected on growth parameters of okro in each pot. Plant height was measured from soil level up to the tip of highest leaf with a meter rule. Number of leaves was done by visual counting. Leaf area was determined non-destructively from its relationship with the length of the mid-rib using a linear equation (Asif, 1977). The estimated regression equation between leaf area (Y) and leaf length (X) is: Y= -386.93 +40.56X (r= 0.91) (Olasantan and Salau, 2008). Yield parameter included number of pods, length of pods and fresh weight of pods and yield.

2.6. Data Analysis

All data collected was subjected to analysis of variance (ANOVA) using the statistical analysis system (SAS, 2006), and the differences between means separated using Duncan's Multiple Range Tests (DMRT) at 5% level of probability.

3. Results and Discussion

3.1. Physical and Chemical Properties of Soil, Poultry manure and Oil palm mill effluent Used

The physical and chemical properties of the soil, poultry manure and oil palm mill effluent used for the study are presented in Table 1. The soil used was a well -drained loamy soil with pH of 5.8. The total N was 0.26g/kg and the available P was 6.40mg/kg, exchangeable bases; Na, Ca, Mg, and K were 0.56, 0.68, 1.74 and 0.32cmol/kg respectively. Exchangeable acidity and effective CEC was 0.12 and 3.42cmol/kg. The poultry manure used had a total N of 3.16g/kg, available phosphorus 0.36g/kg, exchangeable bases; Ca, Mg, Na and K were 7.89, 0.96, 0.35 and 1.69cmol/kg respectively. The oil palm mill effluent had a total N of 2.50g/kg, available P of 2.35mg/kg, exchangeable bases; Ca, Mg, and K were 0.94, 1.57, 1.26, cmol/kg respectively.

3.2. Effects of potassium (K) sources and okra varieties on plant height

The effect of potassium (K) sources and okra varieties on plant height of okra (*Abelmoschus esculentus*) is presented in Table 2. Poultry manure gave the highest values of 92.7cm in plant height at 10 WAP. The increase was such that poultry manure gave 52% increase over the POME and 35% increase over muriate of potash (MP). The significant increase in plant height is an indication that okra plants were able to utilize the nutrients in the fertilizer material (Odeleye *et al*., 2005). The superiority of poultry manure (PM) over other treatments could also be attributed to the increase in N and K concentrations of the PM source. Majanbu *et al*., (1986) had shown that N and K are the most important nutrients that okra required for proper growth and pod production. The result is consistent with the findings of Ojeniyi *et al*. (2007) who reported significant increase in plant height and yield from poultry manure application. Singh *et al*., (1998) also reported an increase in plant height of okra due to the application of K and stated that it plays an important role in promoting vegetative growth by enhancing cell division and cell elongation in okra. There was also significant effect between the two varieties. Improved variety (47-4) gave a significant increase over TAE-38 variety.

3.3. Effects of potassium (K) sources and okra varieties on number of leaves

The effect of potassium (K) sources and okro varieties on number of leaves of okra (*Abelmoschus esculentus*) is indicated in Table 3. Highest number of leaves (11.83) was recorded in PM at 10 WAP which gave 20% increase relative to the control (5.83). Irrespective of K sources, the number of leaves increased as growth period increased. However, there was no significant different in number of leaves between POME and MP at 10WAP. The reason for lower number of leaves in muriate of potash (MP) compared with poultry manure (PM) can be attributed to its chloride ions which have an effect in increasing water content of plant thereby decreasing dry matter contents. This result is consistent with the findings of Hari *et. al.,* (2007), who reported that application of higher rates of MP does not increase number of leaves, but the leaf area was affected.

3.4. Effect of fertilizer sources and varieties on the number of pods and length of pods

The effect of fertilizer sources and varieties on the number of pods of okra at 8WAP is indicated in Table 5. The highest numbers of pods (18.33) was recorded in PM which is 19, 65, 89% increase relative to POME, MP and control respectively. The significant increase observed in the number of pods might be attributed to the mobility of photosynthetates from the source to sink according to Ananthi *et al*., (2004). Similar observations were made by Singh *et al*., (1998) and Mandal *et al*., (1998) in tomato fruits. Number of pod in improved variety (47-4) was higher than TAE-38. Maximum length of pod (8.23cm) was recorded in MP while the least value 6.77cm was obtained in control plot (Table 5). However, there was no significant different between PM and POME application. The non-significant effect of K sources on pod length may be due to the effects of these sources of organic manure in enhancing vegetative growth. The nutrients supplied by the different organic manure sources might have been diverted to development of the vegetative growth. Also, the amount of nutrients already present in the soil may contribute to this phenomenon. This is in agreement with the findings of Akhtar *et al*., (2010), who reported that, the application of muriate of potash at 100kgK/ha affected the marketable yield as well as the yield components. This was attributed to the positive effect of availability of adequate amount of nutrient for plant use.

3.5. Effects of K sources and varieties on the weight of pods and yield of okro

The result from the effects of K sources and varieties on the weight of pods of okra showed that there was significant difference amongst the treatments. POME gave the highest fresh pod weight 23.67g/plant while the least (16.2g/plant) was obtained from the control. There was no significant different between PM and MP. The percentage increase in POME is 46% relative to the control plot. The low yield recorded when muriate of potash (MP) was applied could be attributed to the chloride ions which have recognized effect in increasing water content of plant and decreasing dry matter content, according to Hari *et al*.,(2007). The increase in fruit weight from application of POME could be as a result of higher dry matter production and chlorophyll content coupled with higher nutrient uptake, which makes assimilates got synthesized, and translocate to fruits and thereby increased the yield. There was varietal difference in term of pod weight, improved variety 47-4 gave significant ($p<0.05$) increase over TAE-38. The increase was such that 47-4 gave 23% increase over TAE-38 variety.

The effect of K sources and varieties on yield is presented in Table 5. The highest fruit yield value of 3.30t/ha was observed in PM treated pot. The yield obtained from PM was 13, 25 and 70% increase over POME, MP and NF respectively. There was no significant different between POME and MP. However, the reason for low yield in application of MP could be attributed to the lower retention of moisture by inorganic fertilizer as reported by Owen, (2008), who indicated that synthetic fertilizers do not have good characteristics in aggregating soil particles. As a result, pods produced by inorganic fertilizer gave relatively lower yield than those applied with organic sources.

3.6. Effects of K sources on the nutrient status after harvest

At the final harvest, soil pH generally increased from 5.8 to a range of 6.0 - 6.8, and was 6.8 due to treatment with POME (Table 6). Application of fertilizer sources increased soil pH. This is consistent with the report of Akande *et al.,* (2003) that application of organic materials could ameliorate slightly acidic tropical soil to improve crop production. The highest N content, 0.16%, was from application of poultry manure. There was significant increase in Ca, Mg, Na ank K contents with application of PM and POME relative to no fertilizer plots while K and Mg were reduced due to application of MP.

4. Conclusion

The results revealed that poultry manure gave highest plant height and highest number of pod. POME gave highest fresh pod weight while the highest yield was obtained with application of poultry manure. These organic sources POME and PM could be used as a source of K in okro production and thereby reduce the menace of pollution caused by these wastes.

Table 1. Physical and Chemical Compositions of the soil, poultry manure and oil palm mill effluent used for the experiment.

Parameters	Soil value	Poultry manure	POME
pH (H_2O)	5.8	7.50	8.02
E.C	3.0	-	-
Organic matter (%)	1.09	1.28	-
Total N (g/kg)	0.26	3.16	2.05
Available P (mg/kg)	6.40	0.36	2.35
Exchangeable K (mg/kg)	0.32	1.69	1.26
Na (mg/kg)	0.56	0.35	2.23
Ca (mg/kg)	0.68	7.89	0.94
Mg (mg/kg)	1.74	0.96	1.57
Exchange acidity (mg/kg)	0.12	-	-
CEC	4.86	-	-
Sand (g/kg)	758	-	-
Silt (g/kg)	154	-	-
Clay (g/kg)	88	-	-
Textural class	Sandy loam	-	-

Table 2. Effect of Potassium (K) sources and varieties on plant height of Okra.

Treatments	Weeks after planting				
	2	4	6	8	10
Fertilizer types					
NF(Control)	5.60b	13.48b	29.17ab	30.78d	51.20b
PM	8.08a	16.40a	38.05a	66.38a	92.65a
POME	6.67ab	10.00c	21.98b	38.02c	44.27b
MP	6.48ab	15.88ab	35.62a	54.93b	59.33b
Mean	6.71	13.94	31.21	47.53	61.86
SE±	0.43	1.28	1.65	1.58	2.14
Varieties					
TAE-38	7.32a	12.22b	25.05b	45.96a	50.73b
NHAe47-4	6.10b	15.66a	36.32a	53.10a	68.99a
Mean	6.71	13.84	30.69	49.53	59.86
SE±	0.20	0.23	1.42	2.53	3.21

Means with the same letter(s) are not significantly different (P<0.05) at 5% level of probability by DMRT. NF-no fertilizer, PM-poultry manure, POME-palm oil mill effluent, MP- muriate of potash

Table 3. Effect of potassium (K) sources and varieties on the number of leaves of Okra.

Treatments	Weeks after planting				
	2	4	6	8	10
Fertilizer types					
NF	3.83a	5.17b	5.50b	5.00b	5.83b
PM	3.67a	8.50a	10.00a	10.50a	11.83a
POME	3.17a	4.83b	6.17b	7.27b	7.17ab
MP	3.67a	5.83b	7.20ab	7.33ab	8.33ab
Mean	3.59	6.08	7.22	7.78	8.29
SE±	0.27	0.33	1.29	2.33	3.26
Varieties					
TAE-38	4.33a	6.08a	7.33a	7.12a	8.83a
NHAe47-4	3.83a	6.08a	7.50a	6.83a	7.75a
Mean	4.08	6.07	7.42	6.98	8.29
SE±	0.01	0.03	0.29	0.33	1.26

Means with the same letter are not significantly different at 5% level of probability by DMRT. NF-no fertilizer, PM-poultry manure, POME-palm oil mill effluent, MP- muriate of potash.

Table 4. Effect of potassium (K) sources and varieties on leaf area (cm^2) of Okra.

Treatments	Weeks after planting				
	2	4	6	8	10
Fertilizer types					
NF (Control)	223c	280b	380.2c	405c	574c
PM	246b	357a	432b	558a	783a
POME	217bc	383a	417b	542a	717b
MP	324a	383a	488a	533b	733b
Mean	253	350	429.3	507.0	701.8
SE±	20.3	18.2	26.1	28.6	39.6
Varieties					
TAE-38	423a	508a	626a	681a	724b
NHAe47-4	363a	418a	550a	678a	775a
Mean	393	463	588	680	750
SE±	27.3	32.1	32.6	37.6	40.3

Means with the same letter are not significantly different at 5% level of probability by DMRT. NF-no fertilizer, PM-poultry manure, POME-palm oil mill effluent, MP- muriate of potash.

Table 5. Effect of K sources and varieties of okra on yield and yield components of Okra.

Treatments	Number of pod	Pod Length (cm)	Fresh pod weight (g)	Yield (t/ha)
Fertilizer types				
NF(Control)	9.67d	6.77c	16.20c	1.93c
PM	18.30a	7.84b	20.52b	3.30a
POME	15.30b	8.13b	23.67a	2.92b
MP	10.31c	9.23a	21.32b	2.63b
Mean	13.40	7.99	20.43	2.45
SE±	3.41	0.08	0.57	0.06
Varieties				
TAE-38	23.60b	6.17b	20.42b	2.71b
NHAe47-4	28.70a	9.23a	22.60a	3.64a
Mean	26.2	8.04	21.50	3.18

Means with the same letter are not significantly different at 5% level of probability by DMRT. NF-no fertilizer, PM-poultry manure, POME-palm oil mill effluent, MP- muriate of potash.

Table 5. Chemical properties of the soil at the end of harvest.

Fertilizer Types	pH	% C	% N	Av. P	Exchangeable Cations				Ex. Acidity	CEC
					(Cmol/kg)					
					Ca	Mg	K	Na	H^+	
Initial	5.80		0.26	6.40	0.68	1.74	0.32	0.02	0.12	2.76
NF	5.70a	0.58a	0.12b	5.24c	0.83a	0.61c	0.37a	0.05a	0.16a	2.49b
PM	6.70 a	0.67a	0.16a	22.64a	0.97a	1.89a	0.35a	0.09a	0.16a	3.30a
POME	6.80a	0.60a	0.17a	19.48a	0.86a	0.74b	0.38a	0.03a	0.14a	1.86c
MP	6.10a	0.62a	0.08c	15.22b	0.91a	0.56d	0.28a	0.06a	0.15a	1.92 c
Mean	6.34	0.67	0.11	15.65	0.89	0.95	0.35	0.06	0.15	2.39

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