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Effect of Fertilizer Types on Nutrient Uptake and Yield of Cassava in Ondo Southwestern Nigeria Using Farmers' Simulation Method

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ABSTRACT

Many subsistence farmers find it difficult to apply the right dose of fertilizer using conventional Kg/ha or t/ha style of recommendation that are normally interpreted to the farmers by the Agricultural Extension Agents. Two field experiments were conducted to determine the effect of fertilizer types on nutrient uptake and yield of cassava using farmer simulation method at Adeyemi College Agricultural Research Farm in Ondo, southwest Nigeria. There were two sites A and B. NPK 15:15:15, Urea, Single Super Phosphate (SSP), Muriate of Potash (MOP), Wood Ash (WA) and Poultry Manure (PM) were used as treatments. Mineral fertilizers were each applied at 300kg/ha using a beer cap as a measure of the treatment while WA and PM were applied at 10t/ha using an improvised tin can. There was a control experiment without fertilizer application. The treatments were arranged on Randomized Complete Block Design and replicated three times. Compared with control, NPK, MOP, SSP, Urea, PM and WA significantly increased ($p < 0.05$) plant N, P uptake, cassava root yield and plant growth parameters at both locations. Among the treatments, WA recorded the highest Ca, K, Na and Mg uptake. All the treatments significantly increased whole tuber weight, peeled tuber weight and tuber length compared with control in location A and B. The percentage increase in whole tuber weight in location A was in the order of NPK (32%) > WA (24.45%) > PM (21.7%) > SSP (5.98%) > MOP (4.34) > Urea (2.7%) while the order of increase in tuber weight in location B was PM (74.4%)> WA (74%)>NPK (37%)>SSP (6%)>MOP (4%)>Urea (2%).

INTRODUCTION

Many local farmers are of the opinion that cassava can perform well on any type of soil whether fertile or not (Janssens, 2001), even in a depleted soil (Obisesan, 2013). But, the present fertility status of soils in most parts of Nigeria can no longer sustain optimum production of cassava (Adeleye and Ayeni, 2010). They even prefer to grow yams and other arable crops in fertile soils because they believe that cassava can tolerate any type of soils The assertion that cassava will perform well in any type of soil is wrong as the soils of Nigeria are declining very fast in plant nutrients (Ojeniyi, 2008). There is soil degradation and dwindling of the available land needed for growing of arable crops; hence soils are no longer as fertile as they were before. Many farmers also believe that application of mineral fertilizers to cassava may cause tubers deterioration, poor storage, low nutrient quality and increase in puric/hydrocyanic acid; but fertilizer application is unavoidable as a result of nutrients depletion of agricultural soils.

Many subsistence farmers in southwestern Nigeria are not well educated therefore they find it difficult to apply the right dose of fertilizer using conventional Kg/ha or t/ha style of recommendation that are normally interpreted to the farmers by the Agricultural Extension Agents. For example, a matchbox holds about 25g of mineral fertilizer, a teaspoon contains 4g, a tablespoon 16g and a cup holds 250g. It is better to perform experiments that could fit into farmers' system of farming otherwise there would be no or little adoption of the outcome of the research by farmers. Using farmers' simulation method to perform experiments would reduce the error that might have come up as a result of difference in the method adopted for measurement by the researcher and the farmer field. Using the local method of applying the right dose of fertilizer i.e. tin can, bottle cap, matches etc. would go a long way in alleviating farmers' problems of wrong fertilizer use.

Cassava, one of the main tuberous crops of Nigeria is also a major crop in southern Nigeria (FAO, 1996). The importance of cassava cannot be under estimated if the country wants to achieve its objective in optimum food production. Apart from the fact that it is a staple food consumed by the populace (MoAFS, 2012), it can also be used to feed livestock. Starch can also be derived from it and the leaves that fall from the stems add organic matter to the soil. When fully matured, leaves of cassava plant forms canopy that suppresses weed thereby reducing weeding.

Therefore, it is important to investigate the use of locally sourced organic materials, which are cheap, environmentally friendly and probably have long term effect for improving and sustaining the productivity of soils and arable land. This project work focuses on the use of mineral fertilizers such as CAN, NPK, Phosphate, NPK15:15:15 and their combinations, and organic fertilizers to grow cassava as well as to improve fertility of the soil**.** The objective of the research is to compare the effect of selected fertilizer types on nutrients uptake growth and tuberisation of cassava.

MATERIALS AND METHOD

Site Description

This experiment was conducted at the teaching and research farm, Department of Agricultural Science, Adeyemi College of Education, Ondo, Ondo State. The soil was gently sloppy and coarse in texture. The soil used was typically sandy soil. The site was free from shaded trees and had been previously cultivated. The soil was well drained. Soil samples were taken from 0 – 20 cm for nutrients determination before the conduct of the experiments to show the nutrient status of the two locations, soil pH was determined in 1:2 soil/CaCl2., soil OM was determined by the normal dichromate oxidation method (Black, C.A., 1965), total N was determined by Mickrockjedahl method and available P was determined colourimetrically (Bray and Kurtz, 1945). Exchangeable bases were extracted with 1M NH4OAC at pH 7.0. Na and K were determined by flame photometer (Brown and Lilleland, 1958) method while Ca and Mg were read with atomic absorption spectrophotometer.

The land was cleared; all roots, stumps and debris were removed. Ridges were made of 5m x 5m. There was a discard area of 1m apart. The popular varieties of cassava TMS 419 was planted with the stem cutting of 25cm length (Odedina et al., 2015) with a spacing of 1m x 1m in slanting position of angle 45^o.

The experiment was arranged in a randomized complete block design (RCBD) replicated three times. There were seven treatments namely, wood ash (10t/ha), poultry manure (10t/ha), muriate of potash (300kg/ha), NPK 15:15:15 fertilizer (300kg/ha), Single super phosphate fertilizer (300kg/ha), urea fertilizer (300kg/ha) and control. Beer cap was used to apply the mineral fertilizers while tin can was used to apply wood ash and poultry manure into the plots. Poultry manure was cured for two weeks under shade to reduce the toxic effect as a result of heat. Poultry manure and wood ash were applied in ring form two weeks after planting. Cassava spends more than six weeks in soil before maturity, this means, poultry manure would still release enough nutrients to the soil for cassava uptake even without using the conventional method of two weeks before planting.

Two months later urea, NPK, muriate of potash and single superphosphate fertilizers were applied to the base of each of the cassava in ring form on each plot.

Cutlass and hoe were used for weeding at three weeks intervals for seven months till the cassava formed a canopy (Pellet et al., 1997).

Data Collection

Five plants from each plots were randomly selected, tagged and were used for data collection. Data was collected on growth of cassava such as plant height, number of leaves, nodes and main branches. Cassava height was measured with a measuring rule while the number of leaves, nodes and main branches were done by visual counting. Whole tuber size and peeled tuber were each weighed with a weighing machine. Tuber length was determined by a measuring rule.

Plant Nutrient Uptake

Fresh leaves were collected from tagged plants on each plot and transported inside a well labeled paper envelope to the laboratory. The leaves were washed with distilled water, air dried and put inside a hot air oven present to a temperature of 65^0C for about 24hours and dried to a constant weight. The nutrients determined were N, P, K, Ca and Mg. Nutrient uptake was analysed from wet digest of the samples (AOAC, 2000).

Statistical Analysis

Data were subjected to analysis of variance and separated by Duncan Multiple Range Test

Result and Discussion

Table 1 showed the soil properties before the conduct of the experiment. The soil properties showed that the soil was slightly acidic. The soil was deficient in OM, total N and available P. Potassium K, Ca, Mg, Fe, Cu and Zn were adequate for production of cassava in southwestern Nigeria (Adeoye and Agboola, 1985). The OM, N and P status shows that the soil requires additional nutrient from external source for optimum cassava production.

The analysis of the textural class of the soil showed that the soil was sandy loam with high percentage of sand and clay (sand 88.1%, silt 8% and 3.79%). This shows that the soil might be prone to high leaching and erosion that might cause nutrient depletion.

Table 1 Pre-Cropping Soil Chemical Properties

Soil Properties	Location A	Location B
pH	5.6	5.2
OM (%)	2.1	1.97
N (%)	0.12	0.1
P (mg kg-1)	5.79	5.67
Exchange bases (C mol kg-1)		
K	0.17	0.15
Ca	4.13	2.23
Mg	1.45	1.12
Na	1.2	1.1
Micronutrient (mg kg-1)		
Fe	25.98	30.12
Zn	5.99	6.12
Cu	0.6	1.2

Nutrient Composition of Wood Ash, Poultry Manure, N.P.K, Urea, Murate of Potash and Phosphate Fertilizer

Table 2 shows the nutrient composition of the wood ash (WA), poultry manure (PM), NPK, Muriate of Potash (MOP), single super phosphate (SSP) and urea fertilizer. Wood ash and poultry manure contained Ca and Mg which were not present in NPK, MOP, SSP and urea fertilizers. The assertion that wood ash and poultry manure contain plant nutrients was supported by Belay et al. (2001). Urea had the highest amount of N, MOP had the highest K content while SSP had the highest amount of phosphorus.

Table 2: Nutrient Composition of Wood Ash, Poultry Manure, NPK, urea, Murate of Potash and Phosphate Fertilizer

Treatments	Nutrient Composition (%)				
	N	P	K	Ca	Mg
Wood Ash	0.2	1.53	2.69	14.2	2.67
PM	3.5	1.78	1.2	1.21	2.15
NPK	15	15	15	-	-
MOP	-	-	60	-	-
SSP		20			
Urea	46	-	-	-	-

Effect of Fertilizer Types on Nutrient Uptake of Cassava

The data in Table 5 shows the effect of fertilizer types on nutrient uptake by cassava in location A. Relative to control, all the treatments significantly increased (P<0.05) plant N except MOP and SSP. Relative to control, PM, NPK and SSP significantly increased plant P relative to control. Wood ash, PM, NPK and SSP significantly increased plant K. It was observed that only WA and PM significantly increased plant Mg and Ca.

Table 3: Effect of Fertilizer Types on Nutrient Uptake of Cassava in location A

Treatments	N	P	K	Ca	Mg	Na
Control	0.58[b]	0.14[c]	0.34[b]	0.10[c]	0.34[b]	0.03[b]
WA	0.79[b]	0.23[b]	2.87[a]	1.67[a]	1.13[a]	0.17[a]
PM	0.92[ab]	0.45[a]	2.77[a]	1.48[a]	1.02[a]	0.09[b]
NPK	1.09[a]	0.47[a]	2.89[a]	0.71[b]	0.44[b]	0.03[b]
Urea	1.29[a]	0.18[c]	2.15[b]	0.09[c]	0.37[b]	0.03[b]
MOP	0.46[b]	0.19[c]	3.93[a]	0.11[c]	0.33[b]	0.05[b]
SSP	0.59[b]	0.89[a]	2.36[a]	0.08	0.36[b]	0.06[b]

Means with the same letter are not significantly different using Duncan Multiple Range Test

In location B, compared with control, NPK, Urea, WA and PM significantly increased plant N Table 4. The cassava plants that were fertilized with SSP, NPK, PM and WA significantly increased plant P relative to control. The K content in cassava leaves was significant in WA, PM NPK and MOP. The Ca content in cassava leaves was significant in the plants that were treated with WA, PM, MOP and SSP relative to control while Na was only significant in WA and PM Table 4.

Table 4: Effect of fertilizer types on nutrient uptake of cassava in Location B

Treatment	N %	P	K	Ca	Mg	Na
Control	0.32b	0.12b	0.30b	.04c	0.33b	0.03b
WA	0.69a	0.39a	1.92a	1.92a	1.11a	0.39a
PM	0.69a	0.49a	1.82a	1.82aa	1.32a	0.41a
NPK	0.78a	0.45a	1.90a	1.90a	0.47b	0.05b
Urea	0.99a	0.18b	0.42bb	0.42b	0.42b	0.03b
MOP	0.37b	0.16b	1.89a	1.89a	0.39b	0.07b
SSP	0.38b	0.49a	0.41b	0.41b	0.32b	0.07b

Means with the same letter are not significantly different using Duncan Multiple Range Test.

Table 5 below showed the agronomic parameters of cassava fertilized with mineral and organic fertilizers. NPK 15:15:15 fertilizer recorded the highest increase in plant height, number of node, number of main branches and number of plantable stems. Among the fertilizer treatments, MOP recorded the least plant height, number of nodes, number of leaves and number of plantable stems while SSP recorded the least number of leaves.

Table 5: Effect of Fertilizer types on growth parameters and planting materials of cassava in location A

Treatment	Plant height (cm)	No. of nodes /plant	No of leaves /plants	No of main branches/ plant	No of plantable stem/ Plant (25cm)	No of nodes/ Plantable stem 25cm
Control	120b	104.6d	183.6a	3.0a	3.0b	8c
WA	196a	266.3b	117.3c	4.6a	9.44a	16a
PM	195a	226.6c	84.3d	5.0a	8.0ab	13b
NPK	210a	310.0a	156.6b	5.3a	11.2a	20a
Urea	180a	262b	156.6b	5.0a	9.8a	18a
MOP	100b	111.6d	47.6e	3.6a	3.8b	8c
SSP	133ab	305a	15.6f	3.3a	8.2a	17a

Means with the same letter are not significantly different using Duncan Multiple Range Test.

In location B, compared with control, all the treatments significantly increased plant height Table 6. Wood ash, PM. NPK Urea and SSP significantly increased nodes in cassava stem. The number of plantable cuttings were significant in fertilized PM, NPK, Urea and MOP Table 6. All the treatments were significantly higher than the control in the number of nodes in plantable cuttings.

Table 6: Effect of Fertilizer types on growth parameters and planting materials of cassava in location B

Treatment	Plant height (cm)	No. of nodes/ Plant	No of leaves/ plants	No of main branches/ plant	No of stem cutting/ Plant	No of nodes/ Cutting
Control	**72.0d**	95b	**25b**	4.1a	7b	7c
WA	126.3b	103a	62a	6.3a	9b	13a
PM	134.3b	114a	62a	6.4a	15a	14a
NPK	176.3a	115a	68a	6.4a	15a	14a
Urea	161.3a	101a	67a	4.3a	17a	10ab
MOP	114.3c	99b	30b	3.2a	15a	10ab
SSP	100.0c	97ab	37b	5.1a	10a	15a

Means with the same letter are not significantly different using Duncan Multiple Range Test

In Location A, compared with control, all the treatments significantly increased fresh tuber weight, tuber length and peeled tuber weight (Table 7). Among the fertilizer treatments, NPK recorded the highest cassava whole tuber, weight of peeled cassava tuber and tuber length. The increase in whole tuber were NPK>WA>PM>MOP>SSP>Urea.

Table 7: Effect of Fertilizer types on Yield of Cassava location A

Treatment	Whole tuber weight / ha	Weight of peeled cassava tuber/ha	%increase In whole tuber cassava	Tuber length (cm)
Control	18.4c	15.64c	-	9.81c
WA	22.9b	19.44b	24.45	26.93a
PM	22.2b	18.87b	21.7	22.52a
NPK	24.3a	20.64a	32	32.51a
Urea	18.9c	16.06c	2.7	17.77b
MOP	19.2c	16.32c	14,34	20.15ab
SSP	19.5c	16.57c	5.98	15.43b

Means with the same letter are not significantly different using Duncan Multiple Range Test

In location B, compared with control, WA, PM and NPK significantly increased cassava whole tubers and peeled tubers relative to control. The percentage increase in whole tuber weight were in the order PM (74.4%)> WA (74%)>NPK (37)>SSP (6%)>MOP (4%)>Urea (2%). All the treatments significantly increased length of cassava tuber.

Table 8: Effect of fertilizer types on yield of cassava in location B

Treatment	whole tuber/ha	peeled tuber/ha	% Increase in whole tuber	tuber length
Control	10.12c	8.24b	-	16.24c
WA	17.61a	13.27a	74	30.42a
PM	17.00a	14.12a	74.4	31.64a
NPK	14.00b	12.00b	37	26.12b
Urea	10.32c	8.76b	2	20.14b
MOP	10.50c	8.93b	4	21.12b
SSP	10.70c	9.12b	6	37.4a

Means with the same letter are not significantly different using Duncan Multiple Range Test

DISCUSSION

The deficient in OM, N and P of the soil used in the conduct of the experiments in locations A and B shows that the soil required additional nutrients from external source for optimum cassava production. This result on soil fertility is in line with the assertion of Agbede *et al., (*2008),who observed that most of the soils in southwestern Nigeria are low in plant nutrients. The high percentage of sand in the two locations indicates that they might be prone to erosion, leading to deficiency in major nutrients especially the cations beyond the cassava root zone. It was observed that wood ash and poultry manure contained Ca, Mg and Na which were not present in all the mineral fertilizers used in this research. The plants treated with WA and PM might supply more nutrients in proper balance that are needed for optimum production of cassava than the mineral fertilizers that contained either one or two of the nutrients required for cassava production. Excess of N in urea, P in SSP, and K in MOP might cause nutrient antagonism especially in location A leading to nutrients imbalance which might negatively affect crop production. It was observed that the leaves of cassava absorbed more N in the plants treated with urea, more P in the plants treated with SSP and more K in the soil fertilized with MOP. Also, the plant grown with WA recorded the highest Ca and Mg. This shows that cassava plants absorb the nutrients readily available to them. It was also observed that all the treatments recorded P uptake than the control despite the fact that MOP and urea contain no P in their formulation. This might be as a result of the ability of cassava fibrous to absorb P through myccorhization. This assertion agrees with Leo and Vernon’s (2015) statement that, cassava’s fibrous roots usually become infected with native soil mycorrhiza, thus resulting in hyphae formation which help in the uptake and transport of P to the cassava roots.

The better increase in tuber yield of cassava in soil treated with fertilizers input than the control in the two locations might be as a result of nutrients supplied by the fertilizers. The better performance of NPK 15:15:15 fertilizer in increasing tuber weight than the other mineral fertilizers might be the presence of N, P and K in the fertilizer which are primary nutrients that enhance good crop performance. Increase in cassava yield in the soils fertilized with NPK fertilizer is in line with Kamaraj et al. (2008) who reported increase in yield of cassava when NPK fertilizer was applied. The wood ash and PM performed favourably with NPK fertilizer in terms of tuber weight and tuber length.

It was observed in this experiment that there was a sharp difference between location A and B in cassava yield. NPK had the highest increase in cassava tuber yield especially the whole tuber weight and the peeled tuber weight in location A while WA and PM recorded the highest yield in location B this might be as a result of the difference in nutrient status of the two locations. Calcium was high in initial soil of location A while it was low in location B. Cassava plants in location B absorbed more Ca and Mg than any of the nutrient elements used as parameters in this study. Calcium is known to enhance tuberisation while Mg is known to take part in chlorophyll formation. Though there was low yield of cassava in location B yet the percentage increase in whole cassava tuber indicates that WA and PM perform better than NPK fertilizer. The Ca and Mg content present in WA and PM might have compensated for the low soil Ca and Mg of location B. The high tuber yield recorded in cassava fertilized with NPK fertilizer in location A might be the N, P and K present in NPK fertilizer coupled with inherent Ca from the soil because NPK 15: 15: 15 fertilizer has no Ca and Mg in its composition. Ayeni et al., (2010) showed that WA and PM have Ca, Mg and micronutrients which are not present in industrially manufactured NPK fertilizers. The better performance of poultry manure and wood ash might be as a result of slow release of nutrients that meet the vegetative and reproductive cycle of cassava. Organic manures normally mineralise late than mineral fertilisers which are quicker in mineralization in plant nutrients than organic wastes. These experiments show that crops up to six months to one year are expected to benefit from organic manures than mineral fertilisers.

CONCLUSION

Investigation into the use of wood ash, poultry manure, single superphosphate and muriate of potash for cassava production was carried out in Ondo Southwestern Nigeria. The result form the two locations showed that poultry manure and wood ash respond well in the soil that is not fertile.

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