EVALUATION OF FERTILIZER AMENDMENTS ON THE GROWTH PARAMETERS OF TWO VARIETIES OF MAIZE (*Zea mays*) IN SOIL POLLUTED WITH CASSAVA PROCESSING EFFLUENT

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ABSTRACT
Experiment was conducted in the green house of the Department of Agricultural Technology, Oyo State College of Agriculture and Technology, Igboora to investigate the impact of fertilizer amendments on the performance of two varieties of maize in a soil associated with cassava processing effluent. The treatment include the control (no fertilizer application), Cow Dung (CD), Poultry Manure (PM), Compost (CMP) applied at the rate of 5 and 10 t ha^{-1}, respectively and NPK 16:16:16 fertilizer applied at the rate of 50 and 100 kg ha^{-1}. The experiment was laid out in completely randomized design (CRD) with three replicates. Two varieties of maize, Oba-Super-2 and SUWAN-1 were grown inside the green house buckets for six weeks. The experiment was carried out twice. Parameters were taken on stem height, stem girth, number of leaves, leaf area, fresh shoot weight and shoot dry matter yield. Application of CMP at 5 t ha $^{-1}$ gave the highest plant height of 61.50 cm while PM at 5 t ha $^{-1}$ gave 74.53 cm for variety 1(Oba Super 2) and variety 2 (SUWAN-1), respectively after 6 weeks of planting. The highest number of leaves was observed in CMP at 5 and 10 t ha $^{-1}$ for the two varieties of maize. However, application of NPK 16:16:16 either at 50 or 100 kg ha^{-1} gave the highest dry matter yield. Compost application either at 5 or 10 t ha $^{-1}$ could be used as fertilizers in soils associated with cassava processing effluent while SUWAN-1 maize variety appeared to be more tolerant than Oba-Super-2 in this situation. This study shows that organic fertilizer could be an excellent soil amendment able to supply nutrients for plant development even in soils affected by cassava processing effluent.

Keywords: Maize, Growth, Fertilizer Amendments, Cassava Processing Effluent.

INTRODUCTION

Cassava (*Manihot esculenta*) is a staple food crop in many areas of the tropics and capable of producing high yields under condition of low fertility and rainfall (IITA, 2008). The leaves of cassava are consumed as vegetable in some African countries and they contain appreciable amount of protein, vitamin A and C (FAO, 2010). Current estimate shows that the dietary calories equivalent per capital consumption of cassava in the country amounts to about 238 kcal (Cock, 1985). This is derived from the consumption of *gari*, chips, or flour fermented pastes and/or for fresh roots (FAO, 2008).

Cassava processing generates solid and liquid residues that are hazardous in the environment (Cumbana *et al*., 2007). The two important biological wastes that may cause damage to the environment are derived during cassava processing and they are the cassava peels and the liquid effluent squeezed out of the fermented parenchyma mash (Oboh, 2006). The peels are usually discharged on land or water as wastes and allowed to rot in the open thus resulting in health and environmental hazards. Liquid effluents contain many nutrients, suitable to increase soil fertility as opposed to the water carried by them, which is pollutant to the environment (Horsfall *et al*., 2006). Compounds that are generally toxic to living organisms will also at toxic concentrations prevent germination as well as inhibit growth. Continuous discharge of the effluent into the soil for a long period of time leads to the extinction of some bacteria and fungi types that were originally available in the soil. In Southern Nigeria, Cassava mill effluent has increased dramatically due to increase in cassava production as cassava milling is one of the major industries and the mills effluent is capable of causing pollution to arable land, fresh water and soil around the mill. Soils that have continually received cassava mill effluent over minimum period of 5 years had no vegetation has been reported by Akpan *et al*. (2011) and this could cause detrimental effects to the environment at large. Therefore, remediation of soils contaminated with cassava effluents has become imperative. However, there is little or no information on the effects of some organic and inorganic soil amendments in a soil contaminated with cassava processing effluent. Therefore, the objective of this study is to determine the impact of fertilizer amendments on two varieties of maize grown on a soil affected by cassava processing effluents in Igboora, Nigeria.

MATERIALS AND METHODS

Location

The study was carried in the Department of Agricultural Technology green house of the Oyo State College of Agriculture Igboora (Latitude 7.40^0N and Longitude 3.30^0 E, 27.5m above sea level) in the derived savannah eco zone of Oyo State, South Western Nigeria.

Soil sampling

Prior to cropping, surface samples (0-15cm depth) were collected from a site affected with cassava processing effluent (CPE) for the green house experiment. The sample was bulked to form a composite sample, which was air dried and sieved using a 2 mm sieve. A portion was kept for the soil analysis while the rest was weighed into buckets for the pot experiment.

Soil analysis

Soil pH (1:2) in water was determined by glass electrode pH meter (IITA, 1979). Organic carbon was determined by chromic acid oxidation method (Walkley and Black 1934). Total N was by the regular macro kjeldahl procedure. Available p was determined by Bray P-1 method and P content determined colorimetrically from spectrophotometer using ammonium molydate method (Bray and Kurtz, 1945). Exchangeable bases (Ca, Mg, K and Na) were extracted using 1N neutral ammonium acetate solution. Sodium and potassium in the extract was determined using flame photometer, while calcium and magnesium were determined using atomic absorption spectrophotometer (AAS). Available zinc was determined using AAS after extraction in 1N HCI solution. Particle size analysis was by hydrometer method (Bouyoucos, 1945). The percent sand, silt and clay of the soil were used to determine the textural class using USDA textural triangle.

Experimental design

The experiment was laid out in a completely randomized design (CRD) with three replications. The treatments include Control (no fertilizer application), Cow Dung (CD), Poultry Manure (PM), Compost (CMP) applied at the rate of 5 and 10 t ha^{-1}, respectively and NPK 16:16:16 fertilizer applied at the rate of 50 and 100 kg ha^{-1}. Each pot contains 5kg of soil thoroughly mixed with the fertilizers. All the organic fertilizers were applied two weeks before planting for mineralization to take place. The test crop, maize varieties (Oba-Super-2 and SUWAN-1) were sown into each bucket and later thinned to one per pot ten days after planting (DAP). Planting operation of watering and weeding were carried out. The maize plant was grown for 6 weeks inside the greenhouse buckets twice.

Agronomic data collected

Agronomic parameters were taken on plant height using a meter rule, stem girth by vernier caliper and number of leaves by direct counting at 2, 4, and 6 weeks after planting (WAP). Fresh shoot weight and dry matter yield were measured by sensitive weighing balance in the laboratory. Leaf area was estimated using LxB of the leaves.

Data analysis

All the data collected were subjected to analysis of variance (ANOVA), using DSAASTAT ver. 1.101 statistical package (Onofri, 2007) and treatment means separated using Duncan Multiple Range Test (DMRT) at 5% level of probability.

RESULTS

Chemical and Physical properties of the soil used for the experiment

The chemical and physical properties of the soil used for the experiment are presented in Table 1. The result of the analysis shows that the soil is slightly acidic with a pH value of 6.87. The result also shows that the organic carbon (15.3g kg^{-1}) is high. The exchange site of the soil is dominated by sodium ions (Na^+). The total Nitrogen (N) is also very low but very high in phosphorus (P) value. The high amount of P in this soil may be linked to the impact of cassava processing effluent as cassava tubers are known to be rich in P. The Lead (Pb) value of the soil is 13.0 mg kg^{-1}, while Cadmium (Cd) is 1.0 mg kg^{-1}. The HCN value is 0.65 mg kg^{-1}. The soil can be classified as sand based on the physical analysis of 85.80 % sand, 8.50 % silt, and 5.70 % clay.

Table 1: Chemical and Physical properties of the soil used for the experiment

Property	Value
pH	6.87
Exchangeable bases (mg kg^{-1})	
Ca	7.16
Mg	4.77
Na	10.34
K	6.15
Al(cmol kg^{-1}	0.03
ECEC (cmol kg^{-1}	99.9
Base saturation (%)	
Total N (%)	0.13
Organic carbon (g kg^{-1})	15.3
P(mg kg^{-1})	56.25
Fe (mg kg^{-1})	362.3
Cu (mg kg^{-1})	1.55
Zn (mg kg^{-1})	15.1
Mn (mg kg^{-1})	140.05
Cd (mg kg^{-1})	1.00
Pb (mg kg^{-1})	13.00
HCN (mg kg^{-1})	0.65
Sand (%)	85.80
Silt (%)	8.50
Clay (%)	5.70

Chemical properties of cow dung (CD), poultry manure (PM) and compost (CMP) used for the experiment

The chemical properties of organic manure used for the experiment are given in Table 2. The pH of (PM) and (CD) are 7.4 and 7.95, respectively. The organic carbon for CMP, PM, CD ranges from 50.9-167 g kg^{-1}. CMP is very high in total Nitrogen (N) with a value of 19.2 g kg^{-1}. Poultry manure is very high in phosphorus (P) with a value of 18.42 mg kg^{-1}. All the organic manures contain Iron (Fe), copper (Cu) and zinc (Zn). Cadmium (Cd) and Lead (Pb) were not detected in the three manures.

Table2: Chemical properties of cow dung (CD), poultry manure (PM) and compost (CMP) used for the experiment

Properties	Compost	Poultry manure	Cow Dung
pH	-	7.4	7.95
O.C (%)	16.7	7.865	5.09
Phosphorus (mg kg $^{-1}$)	7.84	18.42	19.41
Total N (%)	1.92	0.39	0.32
Exchangeable bases (cmol kg^{-1})			
Potassium	6.80	1.12 (%)	3.53 (%)
Calcium	0.43	2.49 (%)	1.28 (%)
Magnesium	11.87	0.64 (%)	0.66 (%)
Sodium	14.80	1.25 (%)	4.2 (%)
Exchangeablemicronutrient (mg kg^{-1})			
Iron	9.73	236.1	245.2
Copper	75.00	22	19
Zinc	2.05	142	83
Mn	16.00	301	352
Cd	-	ND	ND

*ND- NOT DETECTED

First Cropping

Table 3: Effect of fertilizer amendments on the height of maize (cm)

TRT	2 WAP		4 WAP		6 WAP	
	VAR 1	**VAR 2**	**VAR 1**	**VAR 2**	**VAR 1**	**VAR 2**
Control	9.57 a	9.50 ab	22.50 bc	22.76 ab	53.27 ab	52.94 b
CD 5t/ha	10.40 a	7.60 b	27.23 a	23.10 ab	56.00 ab	63.07 ab
CD 10 t/ha	8.70 ab	8.50 ab	25.30 ab	23.33 ab	57.57 ab	53.1 b
PM 5t/ha	9.50 a	10.17 ab	24.87 ab	26.47 ab	61.50 a	56.17 b
PM 10 t/ha	9.97 a	12.30 a	23.63 ab	30.67 a	53.20 ab	63.60 ab
CMP 5t/ha	9.43 a	8.20 ab	22.73 bc	25.07 ab	60.27 a	74.53 a
CMP 10 t/ha	9.27 ab	8.20 ab	26.00 ab	23.03 ab	53.53 ab	60.87 ab
NPK 50kg/ha	5.20 c	9.63 ab	11.10 d	19.03 b	41.50 b	70.13 ab
NPK 100 kg/ha	6.97 bc	10.10 ab	19.67 c	23.23 ab	44.33 ab	68.00 ab

*Means followed by the same letter within the column are not significantly different at 5% level of probability using DMRT
Control=no fertilizer application, CD= Cow Dung, PM=Poultry Manure, CMP= Compost
VAR 1=Oba Super 2,VAR 2 =SUWAN-1

The effects of the fertilizer amendments on the height of the two varieties of maize during the first planting are presented in Table 3. The result shows that the plant height increased with the weeks of planting. It was observed that pots that received CMP at 5 t ha $^{-1}$ gave the highest plant height of 61.50 cm while application PM at 5 t ha $^{-1}$ gave 74.53 cm for variety 1(Oba Super 2) and variety 2 (SUWAN-1), respectively after 6 weeks of planting. These results were significantly higher than that of all other treatments including the control at 5% level of probability.

Table 4: Effect of fertilizer amendments on the stem girth of maize plant (cm)

TRT	2 WAP		4 WAP		6 WAP	
	VAR 1	VAR 2	VAR 1	VAR 2	VAR 1	VAR 2
Control	0.57 abc	0.44 abc	1.39 abc	1.15 ab	1.59 ab	1.15 c
CD 5t/ha	0.43 abc	0.53 ab	1.70 a	1.40 a	1.70 ab	1.20 c
CD 10 t/ha	0.47 abc	0.43 bc	1.57 ab	1.20 ab	1.70 ab	1.50 abc
PM 5t/ha	0.53 abc	0.57 a	1.53 abc	1.27 ab	1.43 b	1.33 abc
PM 10 t/ha	0.60ab	0.53 ab	1.37 abc	1.40 a	1.80 a	1.63 ab
CMP 5t/ha	0.53 abc	0.53 ab	1.27 bc	1.13ab	1.50 ab	1.23 bc
CMP 10 t/ha	0.67 a	0.40 c	1.20 c	1.43 a	1.53 ab	1.73 a
NPK 50kg/ha	0.40 bc	0.40 c	1.20 c	0.80 b	1.60 ab	1.47 abc
NPK100kg/ha	0.33 c	0.47 abc	1.40 abc	1.17 ab	1.57 ab	1.43 abc

*Means followed by the same letter within the column are not significantly different at 5% level of probability using DMRT
Control=no fertilizer application, CD= Cow Dung, PM=Poultry Manure, CMP= Compost
VAR 1=Oba Super 2,VAR 2 =SUWAN-1

The result in Table 4 shows the influence of fertilizer application on the stem girth of the maize varieties during the first planting. At week 4, it was observed that application of application of CD at 5 t ha $^{-1}$ gave the highest value of 1.70 cm which was significantly higher than all other treatments including the control for Oba-Super-2 variety. However, application of PM (1.43 cm) and CMP (1.40 cm) at 10 t ha $^{-1}$ was superior to other treatments for SUWAN-1 variety of the maize after 4 weeks of planting. Similarly, pots treated with CMP and PM at 10 t ha $^{-1}$ gave the highest value of 1.80 and 1.73 cm for Oba-Super-2 and SUWAN-1 maize varieties, respectively at 6 WAP.

Table 5: Effect of fertilizer amendments on number of leaves of maize plant

	2 WAP		4 WAP		6 WAP	
TRT	VAR 1	VAR 2	VAR 1	VAR 2	VAR 1	VAR 2
Control	5.44ab	4.57a	8.33 abc	6.78 b	11.11a	7.99 c
CD 5t/ha	4.67abc	5.67a	10.00 a	8.33 ab	12.00 a	11.33 a
CD 10 t/ha	5.33abc	5.00a	8.667 abc	8.00 ab	12.33 a	11.00 a
PM 5t/ha	6.00a	5.67a	8.00 bc	9.67 a	11.33 a	12.33 a
PM 10 t/ha	5.00abc	5.67a	9.00 ab	8.33 ab	13.00 a	10.67 ab
CMP 5t/ha	5.33abc	6.00a	7.33bc	8.00 ab	12.00 a	8.33 bc
CMP 10 t/ha	4.33bc	5.33 a	8.00bc	8.00 ab	10.67 a	11.33 a
NPK 50kg/ha	4.00c	4.67a	5.00d	7.67 ab	10.00 a	12.00 a
NPK100kg/ha	4.33bc	5.67a	7.00c	8.00 ab	10.33a	10.00 abc

Means followed by the same letter within the column are not significantly different at 5% level of probability using DMRT
Control=no fertilizer application, CD= Cow Dung, PM=Poultry Manure, CMP= Compost
VAR 1=Oba Super 2,VAR 2 =SUWAN-1

The effects of the fertilizer amendments on the number of leaves for the two varieties of maize are presented in Table 5. Expectedly, the number of leaves for both varieties of maize increased with weeks of planting. However, after 6 weeks of planting, there was no significant difference among the treatments for Oba-Super-2 variety even though the number of leaves obtained in pots that received CMP at 10 t ha $^{-1}$ (13) was the highest. On the other hand, application of CMP at 5 t ha $^{-1}$ to SUWAN-1 gave the highest number of leaves (12.33). This value was significantly (P= 0.05) higher than that of the control (8.0). The highest number of leaves observed in pots that received CMP either at 5 or 10 t ha $^{-1}$ for the two varieties of maize may be attributed to the high nitrogen content of CMP compared to other manure sources used in this experiment.

Table 6: Effect of fertilizer amendments on leaf area (cm^2)

	2 WAP		4 WAP		6 WAP	
TRT	**VAR 1**	**VAR 2**	**VAR 1**	**VAR 2**	**VAR 1**	**VAR 2**
Control	34.33ab	35.89a	227.33 ab	210.33 a	447.44a	362.33bc
CD 5t/ha	45.33ab	46.00a	299.00 a	216.67 a	477.67a	222.67c
CD 10 t/ha	38.67ab	33.00a	262.67 a	228.00 a	506.67a	430.00ab
PM 5t/ha	40.33a	41.00a	270.67 a	283.00 a	447.33a	490.33ab
PM 10 t/ha	35.67ab	47.33a	218.00 ab	259.00 a	465.67a	529.33a
CMP 5t/ha	37.00 ab	38.33a	256.00 a	227.67 a	384.00a	391.33ab
CMP 10 t/ha	44.33a	38.67a	246.33a	281.33a	458.67a	491.00ab
NPK 50kg/ha	20.00c	24.33a	140.00b	262.33a	385.00a	390.00ab
NPK100kg/ha	26.00bc	36.00a	218.33ab	269.67a	214.66b	476.67ab

Means followed by the same letter within the column are not significantly different at 5% level of probability using DMRT
Control=no fertilizer application, CD= Cow Dung, PM=Poultry Manure, CMP= Compost
VAR 1=Oba Super 2,VAR 2 =SUWAN-1

Table 6 shows the effects of fertilizer amendments on the leaf area of the maize varieties planted during the first planting. After 6 weeks of planting, application of CD at 10 t ha $^{-1}$ gave the highest leave area (506.67 cm^2) for Oba Super 2, but this value is not significantly different from the control. On the contrary, pots treated with CMP at 10 t ha $^{-1}$ gave the highest leave area (529.33 cm^2) for SUWAN-1 variety at 6 WAP. This value was significantly higher than the control (362.33 cm^2) even at 5 % level of probability.

Table 7: Effect of fertilizer amendments on fresh shoot weight and dry shoot weight (g plant^{-1}) of maize plant

TRT	**FW**		**DW**	
	VAR 1	**VAR 2**	**VAR 1**	**VAR 2**
Control	191.71 ab	168.32 a	1.03 b	2.00 a
CD 5t/ha	216.83 a	193.53 a	1.17 b	1.93 a
CD 10 t/ha	219.50 a	186.23a	0.97 b	1.97 a
PM 5t/ha	216.83 a	181.87 a	0.80 b	1.82 a
PM 10 t/ha	219.67 a	223.83 a	1.13 b	2.24 a
CMP 5t/ha	174.23ab	193.97 a	1.30 b	1.97 a
CMP 10 t/ha	141.57 b	236.57 a	1.03 b	2.48 a
NPK 50kg/ha	135.60 b	242.40 a	1.30 b	2.39 a
NPK 100 kg/ha	159.87 ab	199.50 a	1.93 a	2.10 a

Means followed by the same letter within the column are not significantly different at 5% level of probability using DMRT
Control=no fertilizer application, CD= Cow Dung, PM=Poultry Manure, CMP= Compost
VAR 1=Oba Super 2,VAR 2 =SUWAN-1

The effects of the fertilizer amendments on the fresh shoot weight and dry matter yield for the two maize varieties during the first planting are presented in Table 7. The highest value of 219.67 g plant^{-1} was obtained from pots that received 10 t ha^{-1} of CMP for Oba-Super-2 variety. This value was higher than the fresh shoot weight obtained from pots that received no fertilizer (191.71 g plant^{-1}). However, there was no significant difference among the treatments with SUWAN-1 variety even though application of NPK 16-16-16 at 50 kg ha^{-1} gave the highest fresh shoot value of 242.40 g plant^{-1}.

The results also show that application of NPK 16-16-16 at 100 kg ha^{-1} gave the highest value of dry matter yield (1.93 g plant^{-1}) which was significantly higher than all other treatments including the control (1.03 g plant^{-1}) for Oba-Super-2 variety. Similarly, pots that received NPK 16-16-16 at 50 kg ha^{-1} gave the highest dry matter yield (2.39 g plant^{-1}) for SUWAN-1 variety. This yield value is not significantly different from other treatments.

DISCUSSION

In this study, increases in some properties of cassava effluent polluted soils with corresponding decrease in plant height and dry matter yield of cereals used as experimental plants are consistent with results obtained for *Zea mays* by other workers (Ogboghodo *et al*., 2006). The rise in pH of the soils, the workers suggested, accounted for the nutrient unavailability for growth of plant and increases in some of soil properties were implied to have accounted for increased number of microorganisms which, in turn, may have fixed these micronutrients in their cells or in the soil. In this study, like others (Ogboghodo *et al*., 2006) the pH of the soils polluted with cassava effluent increased towards neutrality. Cereals like *Zeamays* and *Sorghumbicolor* have been reported to grow successfully under a pH range 5.5-8.0 and 5.0-8.5, respectively (Onwueme and Sinha, 1991), therefore, inhibition of germination and growth of these cereals may not have been due to the observed pH increase in the soil in this study.The pH value recorded in this study is slightly higher than the values reported by Osakwe (2012).High amount of sodium has been observed in cassava effluent by Olorunfemi *et al.* (2007). Presence of heavy metals in soils receiving cassava mill effluent has been reported by Adewumi *et al.* (2016). Similarly, high amount of Fe has been reported for soils that have received cassava processing effluent by Osakwe (2012).

The observed high growth parameters shown inthe application of Compost (CMP) and poultry manure (PM) could be attributed to the high level of nitrogen in the two organic materials compared to that of cow dung (CD). In the same vein, tallest maize plant observed in SUWAN-1 compared to Oba-Super-2 suggests that SUWAN-1 maize variety may have ability to tolerate cassava mill effluent in the soil. This result is in accordance with the findings of Ikpe *et al*. (2009) and Olorunfemi *et al*. (2008) that the cassava effluent has negative impact on the growth and biomass parameters studies as there was a significant decrease in biomass in *Zea mays* and *Pennisetum americanum* compared to unpolluted soil. Also the presence of some heavy metals in the cassava effluent in this study may as well partly account for the inhibition of germination and growth of the cereals as reported by Olorunfemi *et al*. (2008) hence the soil amendment practice to add either organic or inorganic fertilizer will allow the availability of nutrients to the plant for its growth and development.

CONCLUSION

The experiment has revealed that fertilizer application could aid the growth and yield of maize in soils that have received cassava processing effluent. The use of CMP in this experiment showed that it has ability to ameliorate the effect of cassava mill effluent on maize growth than other treatments used. Similarly, SUWAN-1 maize variety appeared to be resistant to the effects of cassava mill effluent as it performed better than Oba-Super-2 maize variety in nearly all the parameters considered in this experiment. This study shows that organic fertilizer could be an excellent soil amendment able to supply nutrients for plant development even in soils affected by cassava processing effluent.

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