Pacesetter Organomineral, NPK 15-15-15 Fertilizers and Their Residual Effects on Performance of Cassava

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Abstract: The need to move cassava from poverty alleviator to industrial crop and ensure sustainability in cassava production, necessitated the need for fertilizer application to maximize yield. Applying organomineral fertilizer without adequate recommendations can result in low crop yields compared with potential yields. Using 30 kg pots, experiments were conducted in a completely randomized design to compare the effects of Pacesetter organomineral fertilizer (0, 50, 100, and 150 kg N/ha) and NPK 15-15-15 (400 kg/ha) on the performance of cassava (TMS 30572). Their residual effects were also evaluated. Cassava was planted one hard stem cutting per pot. The data obtained were subjected to analyses of variance with significance level at 5%. Pacesetter organomineral fertilizer (POF) increased cassava plant height, stem diameter, number of leaf and estimated average leaf area with the highest values obtained at 100 kg N/ha. The POF application at 100 and 50 kg N/ha, significantly increased cassava storage root yields compared to 150 kg N/ha or the control. These levels were not significantly different from the effect of NPK on cassava storage root yield. The order of the effects of fertilizers on cassava storage root yield is 100 > 50 > NPK > 0 > 150. Further, 100 kg N/ha POF significantly improved cassava storage root sizes compared to other treatments. Significantly higher top: storage root ratio was observed at 150 kg N/ha treatment compared to 50 or 100 kg N/ha POF treatments. There was no significant residual effect of fertilizers on subsequent cropping. However, the residual effect of 150 and 100 kg N/ha POF were 24.64 % and 9.11 %, respectively higher than the value observed using NPK fertilizer. Hence, 100 kg N/ha is recommended for optimum cassava storage root yield in the area.
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1. Introduction

Cassava or tapioca (Manihot esculenta, Crantz) is an annual tuber crop grown widely in tropical and sub-tropical areas. It can easily thrive in sandy-loam soil with low organic matter, receiving low rainfall and moderate temperatures. It is therefore a cash crop cultivated by small-holder farmers within the existing farming systems in many countries (Wanapat et al., 2000). In Sub-Saharan Africa, cassava root and its derivatives are dominant food responsible for fifty percent of food intake and about 1000 calories per capital per day (Mombo et al., 2016). According to Ojeniyi et.al. (2009), cassava is also an industrial crop.

In Nigeria, cassava is grown throughout the country with estimated production of 54.83 million tons in 2014. The average yield was 7.72 t/ha. Cassava is an easy growing plant and well adapted in poor soils. Due to its adaptability and relatively high productivity, it is a popular crop found on farmer's field. To increase yield in cassava production, there are many factors involved such as cultivars, environmental factors and also good crop management. Despite the ability of cassava to usually grow in poor soil areas, continuously growing the plant can lead to further soil nutrients depletion thereby affecting cassava growth and yield. To overcome this problem, good crop management is important. The application of fertilizer causes significant increases in yields of storage roots as well as starch content (Howeler, 2001a). Hence, cassava production is limited by soil fertility status and this necessitates application of organic and inorganic fertilizers (Ojeniyi et.al., 2009) especially in Southeast Nigeria where scarcity of land militates bush fallowing (Fagbola et al., 1998). Howeler (1991) reported that cassava removes 55 kg/ha N, 132 kg/ha P and 112 kg/ha K from the soil. It is therefore a heavy nutrient miner.

In traditional system, cassava is usually grown without the application of fertilizers. However, to produce high yield, the crop does require large supplies of nutrient, and this requirement can be met through the use of fertilizers. However, due to scarcity and high cost, farmers rarely use chemical fertilizer; rather, they depend on cheap organic sources of nutrients (Ojeniyi et al., 2012). The benefits derivable from the use of organic materials have, however, not been fully utilized in the humid tropics. This is partly because of the large quantities needed to satisfy the nutritional needs of crops, and the high cost of handling and transportation (Adeoye et al., 2005). In the tropical cropping systems, organomineral fertilizer was specifically formulated and encouraged as an alternative to conventional inorganic fertilizers and thus increase land use frequency to approach continuous crop production. These reasons have necessitated research on increasing effectiveness of organomineral fertilizers and develop optimum fertilizer level for maximum cassava yield. This study was therefore aimed at evaluating cassava response to different levels of Pacesetter organomineral fertilizer.

2. Materials and Methods

These experiments were conducted in the open field at Ayepe, Isokan LGA, Osun State, south western Nigeria (latitude 7°17'27.17''N and longitude 4°16'51.62''E). Soil used for planting in the pot experiment was collected from the location and homogenized after passing through 2 mm screen sieve to control for nutrient differences between soils collected at different spots. Sub samples of the soils were taken for laboratory analysis. The samples were analyzed for the following parameters using standard procedures; pH was measured by glass electrode in a 1: 2 soil: water ratio. Exchangeable acidity was determined by the titration method (Page et al., 1982). Exchangeable bases were extracted with neutral ammonium acetate solution buffered at pH 7, while Na and K in the extracts were determined using flame photometer. Calcium and Mg were determined by Atomic Absorption Spectrophotometer (AAS) (Page et al., 1982). Organic matter was determined by wet acid digestion (Walkey and Black, 1934). Total nitrogen was determined by the Kjeldahl digestion method, phosphorus by Bray -1 procedure (Bray and Kutz, 1945). Particle size analysis was by the hydrometer method (Bouyoucos, 1951).

All the pots were filled with 30 kg of the sieved soil at the initiation of the experiment. The treatments were Pacesetter organomineral fertilizer (POF) at 0, 50, 100 and 150 kg N/ha and NPK 15-15-15 at 400 kg/ha. The pots were arranged in a completely randomized design with three replicates. Agronomic data collected monthly for a period of nine months included plant height, stem diameter, number of leaves and estimated average leaf area (LA).

$$LA = 1.933 + 0.907(L \times B) \text{ (Karim et al., 2010)}$$

Where L = length of leaf from middle lobe

B = width of leaf

After 10 months of growth, the following stem characteristics were measured at harvest: plant height, stem diameter, height at jorquette, number of primary shoots, fresh shoot biomass and dry shoot weight. Plant height was measured from the base of the plant to the highest shoot. Also evaluated were the following parameters: total number of tubers per plant, tuber yield per plant, average tuber size and top:storage root weight ratio.

Residual Experiment: The residual influences of fertilizer applications after cropping with cassava were assessed on dry shoot weight of maize at 12 WAP.

All experimental data were subjected to ANOVA and correlation coefficient analysis using SAS. Treatment means were separated using LSD at 5% level of probability.

3. Results

The result of the soil analyses is presented in Table 1. The soil was slightly acidic with a pH of 6.3 and organic carbon of 11.5 g/kg. The soil C/N ratio was 14.74, while the P and K values were 5.83 mg/kg and 0.5 (cmol/kg), respectively. The soil textural class was loamy sand with high fraction of sand.

Table 1, The physical and chemical characteristics of soil used for the experiment

Parameters	Values
pH (H2O)	6.3
Organic carbon (g/kg)	11.5
N (g/kg)	0.78
P (mg/kg)	5.83
C/N ratio	14.74
Exchangeable Bases (cmol/kg)	
Ca	5.2
K	0.5
Mg	2.4
Na	0.6
% Base Saturation	56.1
Soil physical fractions (g/kg)	
Sand	844.0
Silt	80.0
Clay	76.0
Soil texture	Loamy Sand

The chemical properties of the organomineral fertilizer used for the study is presented in Table 2. The organomineral fertilizer used had a C/N ratio of 20.9, while the P, K, Ca and Mg values were 0.23%, 1.01%, 0.64% and 0.23%, respectively.

Table 2, Chemical properties of the organomineral fertilizer used for the study

Properties	Organomineral fertilizer
Nitrogen (%)	1.88
Organic C (%)	39.3
C: N ratio	20.9
Phosphorus (%)	0.23
Potassium (%)	1.01
Calcium (%)	0.64
Magnesium (%)	0.23

The highest plant height at harvest was observed at 100 kg N/ha POF (Table 3). However, this was not significantly different from the lowest value observed in the control. Applying organomineral fertilizer increased stem diameter with increasing level of application, but significant difference was observed among treatments. The 150 kg N/ha POF gave the highest stem diameter at harvest, while the lowest was observed in the control.

Table 3, Influences of fertilizer applications on cassava growth at harvest

Fertilizer	Plant height (cm)	Stem diameter (cm)	No. of leaves	Height at jorquette (cm)	No. of shoots	Fresh shoot biomass (g/pot)	Dry shoot weight (g)
0 kg N	88.33	1.12	119.00	49.67	2.33	108.97	63.20
50 kg N/ha POF	93.00	1.15	156.01	57.33	4.33	208.70	80.27
100 kg N/ha POF	97.00	1.17	168.34	57.67	3.67	262.77	107.40
150 kg N/ha POF	94.67	1.30	119.33	49.33	3.00	321.23	191.70
NPK 15-15-15	95.67	1.23	164.00	45.67	3.00	294.93	153.67
LSD	ns	ns	ns	ns	ns	93.34	87.34

Height at jorquette was highest at 100 kg N/ha, but the value did not differed significantly from the lowest height at jorquette observed in the NPK treated plants. The increase in POF produced an average decrease in number of shoots per plant. Fertilizer application did not have significant effect on number of shoots. However, 50 kg N/ha treatment gave the highest number of shoots, while the control had the lowest value. Applying POF or NPK fertilizer had significant influences on fresh shoot biomass and dry shoot weight in cassava. However, the 150 kg N/ha POF treatment had the highest cassava fresh shoot biomass and dry shoot weights, while the lowest values were observed at 0 kg N.

The influence of POF on number of tuber decreased with increase in POF application. Application of 50 kg N/ha POF significantly increased number of tubers per plant compared to 150 kg N/ha POF (Table 4). All other treatments did not differ significantly from the highest value. Pacesetter organomineral fertilizer application at 100 and 50 kg N/ha, significantly increased cassava storage root yields compared to 150 kg N/ha or the control. These levels were not significantly different from the effect of NPK on cassava storage root. However, 100 kg N/ha POF gave 14.68 % higher storage root difference compared to observed storage root yield at 50 kg N/ha POF. The order of the effects of fertilizers on cassava storage root is 100 > 50 > NPK > 0 > 150. Further, the average size per tuber followed similar trends in response to treatments as cassava storage root yield per pot. Applying 100 kg N/ha significantly improved tuber sizes compared to other treatments. Similarly, NPK treatment significantly improved cassava tuber sizes compared to the control, but not from the 150 or 50 kg N/ha treatments. Significantly higher top: storage root ratio was observed at 150 kg N/ha treatment compared to the other treatments. Applying 50 kg N/ha POF gave the lowest top: storage root ratio.

Residual effects of fertilizers

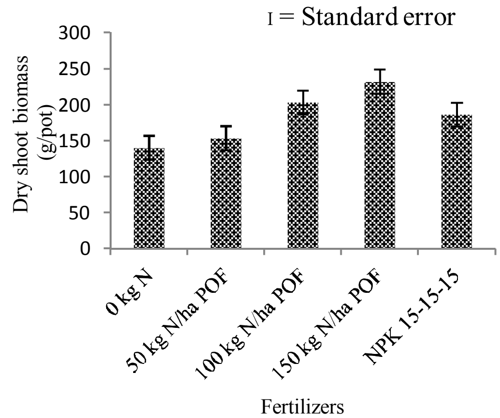

Figure 1, Residual effects of fertilizer applications on maize dry shoot weight

Table 4. Influences of fertilizer application on cassava yield component and yield at harvest

Fertilizer/rate	No. of tubers/plant	Storage root weight (g)	Average tuber size (g/tuber)	Top:Storage root weight ratio
0 kg N	3.00	189.77	63.26	0.57
50 kg N/ha POF	6.33	677.50	107.03	0.31
100 kg N/ha POF	5.00	776.93	155.39	0.34
150 kg N/ha POF	2.00	155.37	77.69	2.07
NPK 15-15-15	5.33	587.00	110.13	0.50
LSD	3.92	440.39	36.40	ns

The residual effects of the application of fertilizers on maize shoot biomass indicated that there was no significant response to the residual of treatments (Figure 1). However, maize shoot biomass increased with increase in POF application. The highest maize shoot biomass was observed at 150 kg N/ha POF, while the least was observed in the control. The residual effect of 150 and 100 kg N/ha POF were 24.64 % and 9.11 %, respectively higher than the value observed using NPK fertilizer.

Cassava plant height was positively and significantly correlated to stem diameter, height at jorquette, number of shoots and nitrogen contents in cassava leaf (Table 5). There was also significant correlation between stem diameter and height at jorquette at harvest and fresh shoot biomass. The correlation between stem diameter and dry shoot weight, and numbers of tubers per plant in cassava leaf were high but not significant. However, a negative correlation between stem diameter and number of shoots per plant was observed. Number of shoots per plant had high correlation with number of tubers and storage root yield in cassava, but these were not significantly correlated. Also, fresh shoot biomass had significantly high correlation with dry shoot weight, storage root yield and cassava tuber size. Dry shoot weight and fresh shoot biomass were similar in their correlation with other parameters observed. The number of tubers was significantly correlated to storage root yield, but negatively correlated to tuber size. The observed storage root yield had high significant ($p < 0.01$) Pearson correlation coefficient with tuber size. Residual cropping was negatively correlated with plant height, plant diameter, fresh shoot biomass, dry shoot weight and number of tubers per plant observed.

Table 5, Correlations of cassava growth parameters, yield related components and yield as influenced by fertilizer application at harvest

	Plant height	Stem diameter	Height at jorquette	Number of shoots	Fresh shoot biomass	Dry shoot weight	Number of tubers	Storage root yield	tuber size
Stem diameter	0.76**								
Height at Jorquette	0.83**	0.55*							
Number of shoots	0.02	-0.25	0.15						
Fresh shoot biomass	0.47	0.56*	0.32	0.11					
Dry shoot weight	0.44	0.51	0.27	0.13	0.96**				
Number of tubers	0.59*	0.43	0.49	0.47	0.37	0.38			
Storage root yield	0.26	0.28	0.23	0.31	0.73**	0.77**	0.62*		
Tuber size	0.10	0.17	0.17	0.19	0.72**	0.73**	-0.09	0.90**	
Residual cropping (maize dry biomass)	-0.21	-0.14	0.07	0.11	-0.11	-0.14	-0.22	0.07	0.23

*, ** = Correlation is significant at the 0.05 and 0.01 level, respectively; n = 15

4. Discussion

The soils textural class (loamy sand) contains clay and silt in adequate proportion to hold enough water for good cassava plant growth and to guard against short duration drought (Howeler and Cadavid, 1983). The values for N, P and K showed the fertility status of the soils to be low when compared to cassava critical levels for optimum production (Howeler, 1989; Putthacharoen et al., 1998). The N content in the POF was a little more than the average for organic fertilizers. This might have resulted from the fortification with mineral fertilizer. However, the N content was inadequate compared to standard organomineral fertilizer as reported by Ayoola and Agboola (2002) and Nottidge et al. (2005). The available P and the exchangeable K were low for cassava as reported by Howeler (2001b) and Umeh and Mbah (2010). The inadequacy of the nutrients in the native soil used, as recommended by Howeler (2001b) has shown that cassava will respond favourably to soil fertility improvement. This was proved by the good response of the cassava growth and yield parameters to all levels of POF and NPK fertilizer application compared to the control treatment.

The plant height increases observed with increase in application levels implies that cassava plants responds to fertilizer application. This is similar to the report of other workers (Obigbesan and Agboola, 1973; Uwah et al., 2013; Edet et al., 2015). However, higher level of N application (above 100kg N/ha POF) did not encourage plant height. This indicated that, there is limit to which cassava plant height can be enhanced by the use of fertilizer. This support Krochmal and Samuels (1970) and Uwah et al. (2013) reports, that there is limit to which higher N application favoured higher plant height. Furthermore, the effect of NPK fertilizer application on cassava plant height did not match the effect of 50 kg N/ha POF neither was it above other POF levels. The positive effects of POF demonstrated in these experiments are in agreement with previous studies (Edet et al., 2013a; Odedina et al., 2015).

The effects of POF on stem diameter indicated increasing level of application improved stem diameter. However, the increased in stem diameter with increase in level of POF application indicated that there was no limit to POF influence on stem diameter. Also, no difference was observed between POF and NPK fertilizer applications. Ayoola and Makinde (2007) also reported that the effect of organomineral fertilizer on stem girth was similar to that obtained from inorganic fertilizer with no significant difference observed.

Fertilizer applications at 50 and 100 kg N/ha POF enhanced the number of leaves obtained compared to that of 0, 150 kg N/ha POF and NPK. These responses observed on number of leaf indicated that 100 kg N/ha was most adequate for optimum cassava leaf production. It was most likely that this is one of the factors that contributed to the final yield observed. The positive effect of fertilizer demonstrated on number of leaf in this experiment is in agreement with previous studies (Howeler, 2001a; Edet et al., 2013a).

In cassava, the main yield components that contribute to storage root yield improvement are determined by storage root number, storage root size and storage root diameter (Ntawuruhunga and Dixon, 2010). Also, character association indicates that petiole length, number of leaves per plant, total leaf area, stem diameter, tuber diameter, plant dry matter content were positively and significantly associated with cassava storage root yield (Ayoola and Adeniyan, 2006; Rao et al., 2015). Similarly, Howeler et al. (1982) reported that higher tuber girth resulted from lesser number of roots for storing the synthesized assimilates. These could be attributed to the competition for nutrients and other growth resources between shoots in plants with more shoots or storage roots. This was supported by El-Sharkawy (2007) and Ikeh et al. (2012) reports that competition for assimilates results in reduction in growth rate and yield of multi-shoot plants. Asare et al. (2009) also observed that the storage root size was inversely related to the number of tuber. These were confirmed in the study as the Pearson correlation showed positive and significant association in storage root yield with fresh shoot biomass, dry shoot weight, number of tubers, tuber size and N concentrations in cassava leaf. Application of the POF at 100 kg N/ha seems to have provided adequate nutrient for the cassava, by showing slightly higher growth values which resulted to higher storage root yield than that of 50 kg N/ha. The relationship between plants top and storage root weight is always of interest to cassava producers when relating response to fertilizers. A low top: storage root weight ratio is desired for production of tubers; a high ratio would indicate poor tuber production despite an abundant growth of leaves and stems (Izumi et al., 1999). The production of tubers was inversely related to the top: storage root weight ratio. The 150 kg N/ha POF gave the highest top: storage root weight ratio. This implied that the rate of application favoured above ground production at the expense of storage root as a result of excess N in the fertilizer. This findings support Izumi et al. (1999) and Howeler (1998) reports. The 100 and 50 kg N/ha POF gave lower top: storage root weight ratio. Thus, these levels of POF applications favoured the production of cassava storage root over the above ground biomass. Similarly, Howeler (1998) reported that cassava storage root production was highest at 100 kg N/ha.

Cassava roots are generally low in the amounts of nutrients removed from the soil compared to those removed by other crops (Howeler, 2001a). However, nutrient removal can be relatively high when yields are high or when stems and leaves are also removed (Howeler, 2001a). Hence, continuous planting of cassava without subsequent addition of nutrients will further decrease soil fertility with time. The residual effect of fertilizer application is therefore of great importance in ensuring good yield from successive croppings. The residual effect of inorganic fertilizer application, although applied at the rate of 60 kg/ha N (400 kg/ha NPK 15-15-15) gave lower cassava storage root yield, suggesting importance of POF over the inorganic fertilizer. Similar result was observed by Edet et al. (2013b), that residual effect of organomineral fertilizer consistently increased growth of cassava compared to inorganic fertilizer. Pacesetter organomineral fertilizer has many benefits over inorganic fertilizer. Nutrients contained in organic manures are released more slowly and are stored for a longer time in the soil, thereby ensuring a long residual effect (Adeoye et al., 2008; Edet et al., 2013b). These explained the reason for the order of maize biomass observed in the residual cropping.

Conclusion: These results indicate that organomineral fertilizer has positive benefit on cassava growth and yield parameters. This benefit increases with increase in organomineral fertilizer levels except at level above 100 kg N/ha. Therefore, 100 kg N/ha is recommended for optimum cassava storage tuber yield.

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