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EVALUATION OF THE EFFECT OF COMBINED INORGANIC FERTILIZER AND VERMES-FLUID ON CASSAVA ROOT YIELD

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Abstract
A two-year field trial was conducted at the research farm of National Root Crops Research Institute (NRCRI), Umudike in 2016 and 2017 planting seasons to study the effect of combined inorganic fertilizer and vermes-fluid on cassava root yield. Sixteen treatment combinations laid out as a single factorial experiment in a randomised complete block design (RCBD) with three replications were formed, and TME 419 cassava variety used for the study. The results of the average fresh root yield obtained from the study over the two year period showed that application of the recommended rate of 3-4% of vermes-fluid alone on cassava did not improve yield, rather had a non-significant effect on yield of the control plot and significant effect on the recommended full dose of NPK fertilizer (600kg). A complementary combined application of 75% full dose of NPK fertilizer with 100% of the recommended maximum vermes-fluid concentration (i.e.4%) resulted to an exceptional much higher yield of 57.8t/ha which significantly out-yielded that of the control plot and recommended full dose of NPK fertilizer by 55.2% and 18.70% respectively. This management strategy enhanced reduced application by 25% of NPK fertilizer for cassava production and also with respect to its cost and environmental concern, and is therefore recommended for farmers to adopt for sustainable production.

Keywords: Cassava, Effect, Root, Vermes-fluid and Yield

Introduction
In sub Saharan Africa, Cassava (*Manihot esculenta* Crantz) is the most strategic commodity crop for food security. It is a source of calories in the diets of over 800 million people around the world (Anna Burns *et al.,* 2010). The importance of cassava as a food and industrial crop is tied to its roots since they accumulate starch (approximately 30–60% dry matter), and so, it is considered the second source of starch globally, after maize (FAO, 2013; Halsey *et al.,* 2008). Cassava production is mostly subsistence, predominated by peasant, low income farmers whose production output is considerably low and barely enough for food and income generation (Kawano *et al.,* 2003). Production in Latin America and Asia is characterized by increase in yield per unit area, strongly driven by the demand for dried cassava and starch for livestock feed and industrial applications, whereas increase in land area per hectare is mainly associated with production in Africa, driven by expanding urban markets for food products (FAO, 2013). Cassava has huge potentials for further production increase. Under optimal conditions in experimental stations, fresh root yields of up to 80 t/ha per year and up to 60 t/ha per year under farm conditions are feasible (Kawano *et al.,* 1987). This is still far greater than 20 t/ha per year of the current world average yield (UN, 2015; FAO 2013). Hence there is an urgent need to bridge this yield gap as there is a global booming demand for cassava and cassava products (Jansson *et al.,* 2009), which offers millions of cassava growers in tropical countries the opportunity to intensify production, earn higher income and boost the food supply within and outside the sub-Saharan Africa. Similarly, the world population is estimated to reach 10 billion by the end of 2050 (FAO, 2009). This global population growth will put enormous pressure on cassava and cassava-based products due to production constraints such as declining soil fertility, climate change and limited resources for inputs such as herbicides and fertilizers. Thus, there is every need explore other agro inputs to close the yield gap in cassava root production. Vermes-fluid, an agro chemical derived from earthworm-mediated organic substances is assumed to stimulate increased root yield when used for cassava production. It boosts the production of chlorophyll, which triggers increased photosynthetic rate with high accumulation of organic compounds such as soluble carbohydrate which translates to increased root yield. Vemes-fluid does no harm to the environment unlike chemical fertilizers that contribute significantly

to global warming and climatic change (Smith *et al*., 2007). Recent studies on the use of vermes-fluid on some crops such as potato, tomato, maize, sugar beet etc, have shown that it decreases the chemical fertilizer inputs by 40% and increase yield qualitatively and quantitatively when the recommended concentration range of 3% and 4% per hectare is applied (Cervena and Pecl, 2015). The objective of this study therefore, is to evaluate the effects of vermes-fluid on the root yield of cassava.

Materials and Methods

Field trial was carried out in 2016 and repeated in 2017. A composite auger soil samples were collected at 0 – 20 cm soil depth from the experimental sites in both years before planting. The soil samples were air-dried, ground and mixed together to pass through a 2-mm sieve before it was subjected to physical and chemical analysis using standard analytical methods as described by Udo and Ogunwale (1978). Fifteen different treatment combinations of the recommended rate of inorganic fertilizer for cassava production (600 kg/ha NPK 15:15:15) for low soil fertility class and 100% recommended vermes-fluid application of 4% per hectare for crop production and control without treatment were adopted. A total of 16 treatment combinations laid out as a single factorial experiment in a randomised complete block design (RCBD) with three replications were formed. The 16 treatment combinations are as follows; **NPK 151515: Vermes-fluid, $\mathbf{T_0}$** (0:0), $\mathbf{T_1}$ (25:25), $\mathbf{T_2}$ (25:50), $\mathbf{T_3}$ (50:25), $\mathbf{T_4}$ (50:50), $\mathbf{T_5}$ (25:27), $\mathbf{T_6}$ (75:25), $\mathbf{T_7}$ (100:0), $\mathbf{T_8}$ (0:100), $\mathbf{T_9}$ (50:75), $\mathbf{T_{10}}$ (75:50), $\mathbf{T_{11}}$ (75:75), $\mathbf{T_{12}}$ (75:100), $\mathbf{T_{13}}$ (100:75), $\mathbf{T_{14}}$ (100:100) and $\mathbf{T_{15}}$ (0:75). TME 419 cassava variety was used in the study. After land preparation, the stems were cut into planting stakes planted at a spacing of 1mx1m at the crest of the ridge. The vermes-fluid component of the treatments was foliar applied four times, in each year, at four weeks intervals beginning from 4 WAP each, while the NPK fertilizer was applied at 8 WAP in both years using band method of application. Pre-emergence herbicide (Primextra Gold 650 SC) was used at the rate of 5 litres per hectare using a 15 litres knapsack sprayer. Manuel weeding was carried out using hand held hoe. Other important agronomic protocols were observed to ensure good plant establishment. Data were collected on fresh root yield in tonnes per hectare (t/ha) and estimated from the experimental plot yield (kg/plot). These were further subjected to analysis of Variance (ANOVA) using GENSTAT (2003) to assess significance of treatment effects. Means were compared using Fisher's Least Significant Difference (LSD) at 5% probability level. Metrological data for the 2 years were collected.

Results and Discussion

Results of the soil properties studied at the experimental sites before cropping in both years (2016 and 2017) in Table 1 showed that the soils were predominantly sandy loam in texture, which is suitable for cassava root tuberization. Effective cation exchange capacity (ECEC) was low with high leaching potential, an indication of low nutrient and water holding capacity as observed in the low organic matter (OM) contents, which may negatively affect root yield (Ogunjinmi *et al.,* 2017). The soil pH was moderate (in 2016) but strong (in 2017) with low exchange acidity (EA), and hence there will be no Aluminium (Al) toxicity, therefore cannot limit cassava production since the pH is above the critical level of 4.6 for cassava production (Chew *et al.,* 2008). The total Nitrogen (N) and exchangeable Potassium (K) were low and also was exchangeable (Ca) content but available Phosphorus (Bray-2P) and exchangeable Magnesium (Mg) had levels considered moderate and moderate to high, respectively. This shows that the soils are generally low in fertility with expected responses to supplemental N, P and K fertilization. Base saturation (BS) was high suggesting that the exchange complex is dominated by basic cations, especially Ca2+ and Mg2+. Similarly, the monthly rainfall data during the 2 year growing seasons of experimentation are shown in Table 2. There were no significant year to year variations in seasonal precipitation as recorded during the cassava cropping periods. No substantial variation within the 2 year period in seasonal temperature, relative humidity, solar radiation and sunshine respectively.

Table 1: Physical and chemical properties of soils of the experimental field at NRCRI Umudike in 2016 and 2017

Soil parameters	Soil values	
Physical properties	**2016**	**2017**
Sand (%)	80.60	75.80
Silt (%)	6.70	10.10
Clay (%)	12.70	14.10
Textural class	SL	SL
Chemical properties	**2016**	**2017**
pH (H2O)	5.60	5.1
OM (%)	1.51	1.90
Total N (%)	0.056	0.098
Available Bray-2 P (ppm)	17.70	24.80
K	0.067	0.122
Ca	1.60	2.40
Mg	0.80	1.60
Na	0.272	0.096
Exchange acidity (EA)	0.56	0.96
Effective cation exchange capacity (ECEC)	3.299	5.178
Base saturation (BA) (%)	83.00	81.50
C/N ratio	9:1	11:1

Table 2: 2016 and 2017 metrological data of NRCRI Umudike

2016	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Rainfall (mm)	129	278.4	354.1	268.7	398.2	312.6	273.4	45.0	7.3	51.0	0.0	10.7
Days	8	116	17	16	22	15	7	2	2	2	0	3
Temp Min	23.4	22.7	20.5	20.4	21.7	23	23.1	23.8	20.8	21.6	24.3	23.9
Temp Max	32.5	32.6	30.9	29.6	30.4	30.1	31.1	30.7	33.3	34.1	34.5	34.4
RH	76	81	80	85	87	85	83	82	60	53	76	80
S-Rad	4.9	4.5	5.1	3.2	3.6	3.9	6.2	5.3	6.7	5.5	4.0	4.5
Sunshine	6.2	5.5	3.3	4.2	3.8	4.1	3.3	5.1	6.4	7.2	6.2	5.3
2017												
Rainfall (mm)	188.3	134.2	298.1	493.9	222.4	400.0	184.2	31.0	0.0	0.0	80.1	9.6
Days	8	11	18	21	17	15	15	6	0	0	3	3
Temp Min	24.2	23.6	23.6	23.2	23.6	23.1	23.9	23.6	21.5	22.3	22.1	23.3
Temp Max	35.5	32.2	29.2	28.3	30.1	27.1	30.8	31.8	33.1	34.9	33.7	33.6
RH	79	77	76	89	87	88	90	82	67	65	69	84
S-Rad	4.6	4.6	3.9	2.8	3.4	3.6	4.3	7.0	9.7	5.4	5.1	5.4
Sunshine	5.1	5.3	4.2	3.8	7.4	3.8	4.0	6.5	8.6	6.3	6.1	5.4

The treatment combinations for the recommended rate of NPK 15:15:15 fertilizer (F) and vermes-fluid (V), significant at ($P<0.001$) had effect on the combined cassava fresh root yield in both years (2016 and 2017 respectively) (Fig 1). The root yield in 2016 varied from a minimum of 29.73t/ha in T15 to a maximum of 54.51t/ha in T10. The root yield in T15 was statistically at par ($P>0.05$) with those of T5 and T8, but significantly ($P<0.001$) lower than those obtained in every other treatment including T0 (control), while the maximum root yield in T10 was significantly ($P<0.01$) higher than all others except those obtained when T12 and T7 that received full recommended rate of NPK fertilizer. On the other hand, in 2017, the root yield ranged from a minimum of 32.42 t/ha in T8 to a maximum of 61.11 t/ha in T12. Similarly, the root yield obtained in T8 was less ($P>0.05$) compared to all other treatments except T0, T15 and T1. A maximum root yield of 61.11t/ha (T12) was obtained in the same year and was significantly higher ($P<0.001$) than other treatments except T14. Furthermore, 2017 cropping season recorded a better result than 2016 with average cassava root yield of 45.4t/ha. This could be as a result of better soil nutrition obtained in 2017 than the result of 2016 (Table 1). Differential rainfall pattern during the months of spraying the vermisfluid solution (i.e first 16 weeks after planting) could be a factor as well (Table 2). The yield from all the treatments were considered high (>25t/ha) with T10 and T12 in 2016, and T12, T14 and T2 in 2017, respectively as shown in Fig. 2 with their yields exceeding 50t/ha. This high performance also could be affected by the favourable rainfall pattern in the first 7 months of establishment period of this cassava trial period (Table 2) and probably existence of a suitable textural soil (Table.1). The result is in line with the findings of El-Sharkawy *et al*. (1998) and Agbaje and Akinlosotu, (2004) who reported that beyond 7 months of cassava establishment, moisture stress may not affect the growth of the cassava crop.

Across the 2 years of study, T12 significantly (P<0.001) did better than all other treatments, including those of T14 and T10 that produced exceptionally high yield of 50.91 t/ha and 50.62 t/ha, respectively; and the application of NPK fertilizer at the full dose of 600 kg/ha (T7) and absolute control (T0) by 18.6 and 55.8%, respectively. Best overall, two (2) of the best three (3) yields of 57.76, 50.91 and 50.62 t/ha obtained from T12, T14 and T10 that had 75% of the recommended rate of inorganic (NPK) fertilizer combined with 100% and 50% of the recommended concentration of vermes-fluid, respectively. This implies that cassava farmers could combine at least 50% of the recommended concentration of vermes-fluid (i.e 2%) with 75% of NPK fertilizer (450 kg/ha).

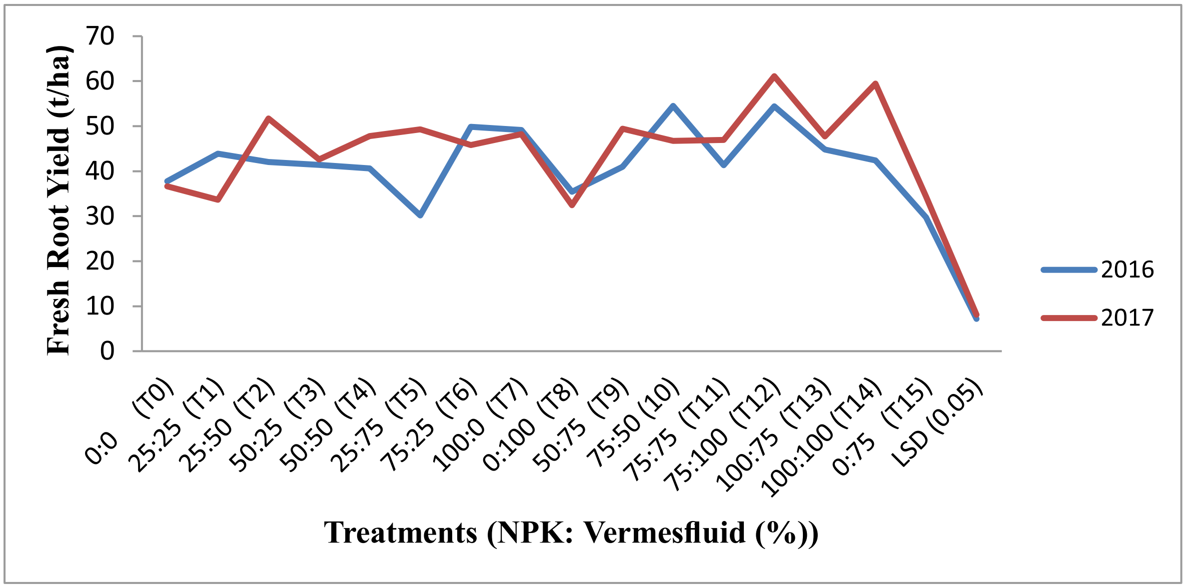

Fig 1: Treatment effect on cassava fresh root yield

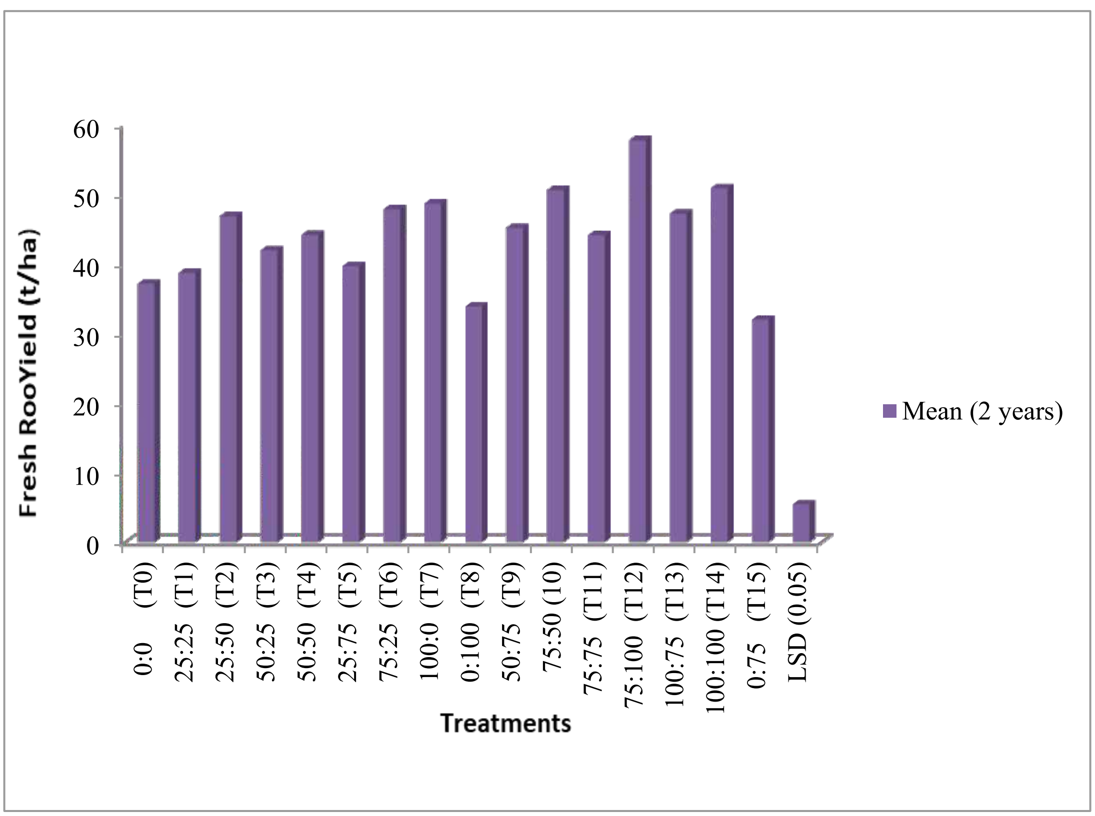

Fig 2: Treatment effect on the mean fresh root yield of cassava in 2016 and 2017

Conclusion

The best three treatments that had best yield results (T12, T14 and T10) in Fig. 2 all had 75% of the recommended rate of inorganic (NPK) fertilizer combined with 100% and 50% of recommended vermis-fluid concentration respectively. This is an indication that cassava could be grown in combination with 50% of the recommended rate of vermis-fluid (i.e. 2%) and 75% recommended rate of NPK (i.e. 450kg/ha). This further shows that application of vermis-fluid at 2-4% reduced the recommended application rate of NPK fertilizer by 25%, implying that vermis-fluid reduced cost of cassava root production sustainably.

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