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Effect of amended soil using different fertilizer applications on phenology of Cassava in Edo State South-South Nigeria

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Abstract. *Three experimental fertilization treatments of fertigation (FERT), Nitrogen-Phosphorus-Potassium (NPK), and poultry organic fertilizer (ORG) were applied on a cassava (TMS 30573) cultivation at the rate 300 kg/ha for NPK and ORG, while fertigation was injected at 1.5 litres/minutes. The results were compared with the control and unfertilized field using the same cassava cultivar. The results from the four treatments indicated that the cassava phenological development significantly responded to fertilizer applications. At 183-day after planting (DAP), the plant height under FERT was higher than NPK, OGR and CON by 19.0 cm, 60 cm and 80 cm. Conversely, under ORG, the leaf emergency (*le*) steady increased to 42 leaves at 183 DAP, whereas NPK reached peak (*le*) at 161 DAP and dropped to 41 at 183 DAP. Also, under the FERT and CON, le dropped to 38 and 33 leaves at 183 DAP. The rate of leaf death (*ld*) is significant at P<0.001 under fertigation, NPK and ORG, while insignificant under control treatment. Projected cassava yield per hectare estimated from phenological and morphological development indicated that ORG showed high possibility of producing cassava yield increase of 2.5 tons/hectare over FERT, 3.2 tons/hectare, 4.8 tons/hectare under NPK and CON respectively.*

Keywords*: Cassava-TMS 30573, Fertilization, Phenological development, Cassava yield, Treatment*

1. Introduction

Cassava is one of the most important crops due to its large chain value addition. Several food items as garri, funfun, pupuru are a by-product of cassava. Manihot esculenta Crantz is also an essential calorie for human and animal well-being. [1] indicated that cassava is the third important calories source after rice and rice mostly in tropical countries. Also, the crop is increasingly used in the pharmaceutical and beer industries [9]. The global population explosion and an emerging increase in cassava usage as direct and indirect consumption, drug and beer manufacturing have greatly increased the demand for the crop. The study of [1] revealed that cassava's demand has tremendously increased due to its wide range of uses. Presently, three is a large gap between the cassava yield and population growth in Nigeria. Conversely, an average cassava yield of 22.0 tons/ha is not sustainable to attain intended cassava yield potential.

Having established an existence between a large cassava yield gap and a growing population, it is important to increase its production to reduce possible deficits, improve food security and economic growth. The finding from the study of Hillock (2014) showed that global cassava's yield represents 46% and 36% over the African continent. Despite that Nigeria is the largest cassava importing, most of the cassava importing regions in Nigeria have been experiencing a reduction in yield per hectare due to nutrient depletion, prevailing weather conditions, and farm management. However, all the factors attributed to cassava yield per hectare could be achieved by choosing and planting a cassava stem variety suitable for a given agro-ecological zone regarding climate (temperature, rainfall e.t.c), nutrients, and pest resistance. Also, agronomic and farm practices are very imperative to achieving improved cassava yield. [3] reported that cassava yield could be increased by planting suitable cassava varieties and application of the required amount of fertilizer

Constant cultivation without fertilizer application will likely lead to nutrient depletion and low cassava yield. Amendment of nutrient-depleted soils is commonly achieved through the use of fertilizers as NPK, Urea, and organic manures both from plants and animals. [8] observed over Sub-Saharan Africa that cassava yield increase with fertilizer application. It is important to determine the rate, amount, and type of fertilizer to use in response to soil type and condition. Also, the information on the soil analysis is significant to fertilizer application. [4] revealed that nitrogen (N) and potassium (K) are the major nutrients required for cassava yield. 4R Nutrient Stewardship principle is recommended to be used in applying fertilizer for cassava cultivation.

Hence, this study aims to evaluate and compare the phenological development of cassava under three fertilizer treatments (URE fertigation, NPK, organic manure) with the control treatment. The results obtained will be useful to select appropriate fertilizer for optimum cassava yield in Edo State, Nigeria.

2. Materials and Methods.

2.1. Site description

Field experiments were carried out at the Teaching and Demonstration of Auchi Polytechnic, Auchi located at latitude 7.0465^{0}N and longitude 6.2701^{o}E. The soil has a high percentage of sand with low fertility due to continuous cultivation and erosion. Auchi is located within a tropical savanna climate with annual average precipitation and air temperature of 1,205 mm and 28^{0}C. The highest and lowest dry period is February and July with a maximum temperature of 38^{o}C and 29^{o}C.

2.2. Land preparation

The vegetation on the area (trees and grasses) was removed using Axe, cutlass, hoe, and motor saw. The area was tilled mechanically using plough and harrow. While the marking out (the division into treatment plots) was done using measuring tape and pegs. A cassava variety of TMS 30573 was planted on the 18th March 2021. The cassava stake of 26 cm long was manually planted on the ridge's crest at a spacing of 2 m.

2.3. Experimental design

The design of the experiment was 4 * 4 randomized complete block design with three replications. The size of each plot is a 4 m * 6 m and contained 6 rows of 6 m length with a planting distance of 2 m. A total of four (4) plots including a control treatment were constructed. The plant was fertilized with NPK at a dose of 15:15: 15 at the rate of 300 kg/ha after two months of a plantation at plot A, while fertigation of NPK (15:15: 15) was done at 1.5 litres per minute on plot B. Organic manure was used to plot C before tillage at the rate of 300 kg/ ha. Hence, plot D is the control treatment where no form of soil amendment was carried out. Each of the plots was subjected to the same supplementary water application of 5 mm for every three (3) days interval for plant germination and establishment. The rate of germination was determined 40 days after planting. The germination rate was 80% in plot A, 100% in plot B, 80% in plot C, and 75% in plot D. The weeding activities were carried out using convection and application of herbicide (Force Up). Cassava phenological development (plant height, plant width, leaf emergency, leaf death) was measured every five days over each of the plots. Statistical metrics of ANOVA and T-test were used to compare different treatments on the cassava growth parameter. Signal 1.0 version was used for the smart plot of the phenological parameter. The least significant difference (LSD) and multiple range test (DUNCAN) were used to compare the mean at a 1% confidence interval. Some of the field activities were shown in plates 1-4.

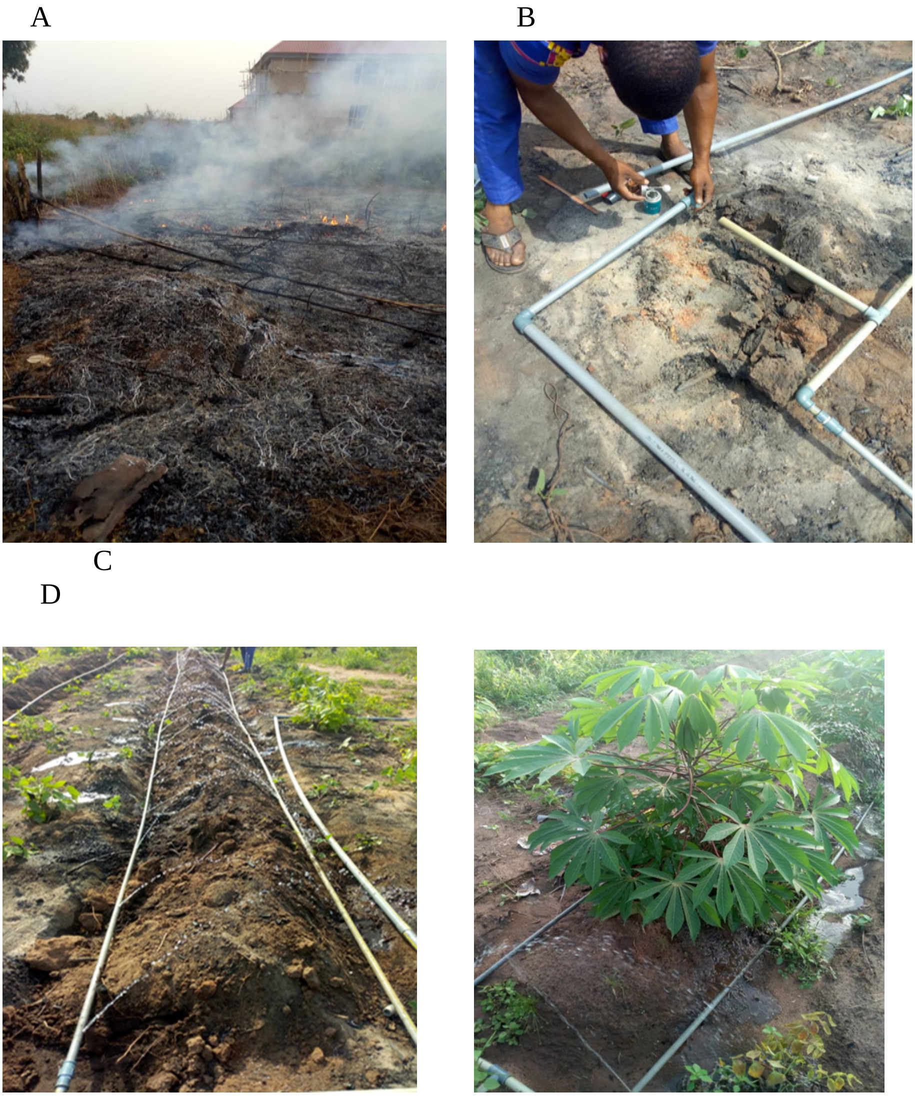

Plate 1: Land clearing (A), Installation of irrigation system (B), Operation of irrigation system (C) and Growing cassava plant (D).

3. Results and Discussion

3.1 Cassava germination

The germination of planted cassava stake was observed at exactly 20 days after the day of planting. The survival and germination showed that plot A recorded a 100% germination rate (GR), while plots B, C, and D indicated GR of

80%, 75%, and 80% respectively. A similar finding was obtained by [3] revealed that MKUC 34-114-106 cassava cultivar had survival and GR of 95.4% and 96.7%.

3.2. Cassava phenology under soil amendment

The growth parameters of cassava were measured at 25 days after planting (DAP) across the plots. The plant height (Ph) increased suddenly with solid NKP, fertigation, and organic manure while under control treatment, the Ph started to increase at 69 DAP. Average plant of 160.0 cm was obtained in plot B (fertigation), 141.0 cm in plot A (Solid NPK fertilizer), 100.0 cm at plot C (organic manure), and 80 cm under control treatment at 183 DAP as shown in Fig 1a. The finding revealed that the plant growth response abruptly to fertigation and NPK soil amendments. The control treatment could be attributed to the depletion in the soil nutrient due to its continuous cultivation. However, the steady development of cassava phenology under organic manure could be best be explained by the long period required for the decomposition processes. The finding is similar to the study of [5] which revealed that under fertigation or any soil amendment to improve soil nutrients may improve the yield of cassava.

Conversely, the developmental pattern took different dimensions for the leaf emergency and death. Le abruptly increased with the NPK treated plot (A) and got to the peak of 48 leaves at 161 DAP and dropped to 41 leaves at 183 DAP. Fertigation treatment also showed a similar pattern with the highest Le of 38 leaves at 183 DAP. A close observation of the organic manure treated plot indicated a steady increase in Le in the number of leaf emergencies from 40 DAP to 42 leaves at 183 DAP whereas the Le recorded showed a low increase compared to organic manure treatment with the highest leaf emergency of 33 leaves at 183 DAP (Fig. a-c). Hence, it is obvious that fertilization has a significant effect on cassava phenological development. [6;7] showed that fertilization has significant effects on phenological and morpho-physiological stages by cassava. Therefore, the absence of fertilization of plot D (Control) could be attributed to low leaf emergency. Fig. 1d shows that the lowest death rate (LDR) occurred at treatment at peak leaf (*ld*) at 25 leaves at 183 DAP, while ld of 40 leaves was estimated at 183 DAP at plot A (Organic manure) and B (fertigation) the ld was at 37 and 35 leaves at 183 DAP respectively.

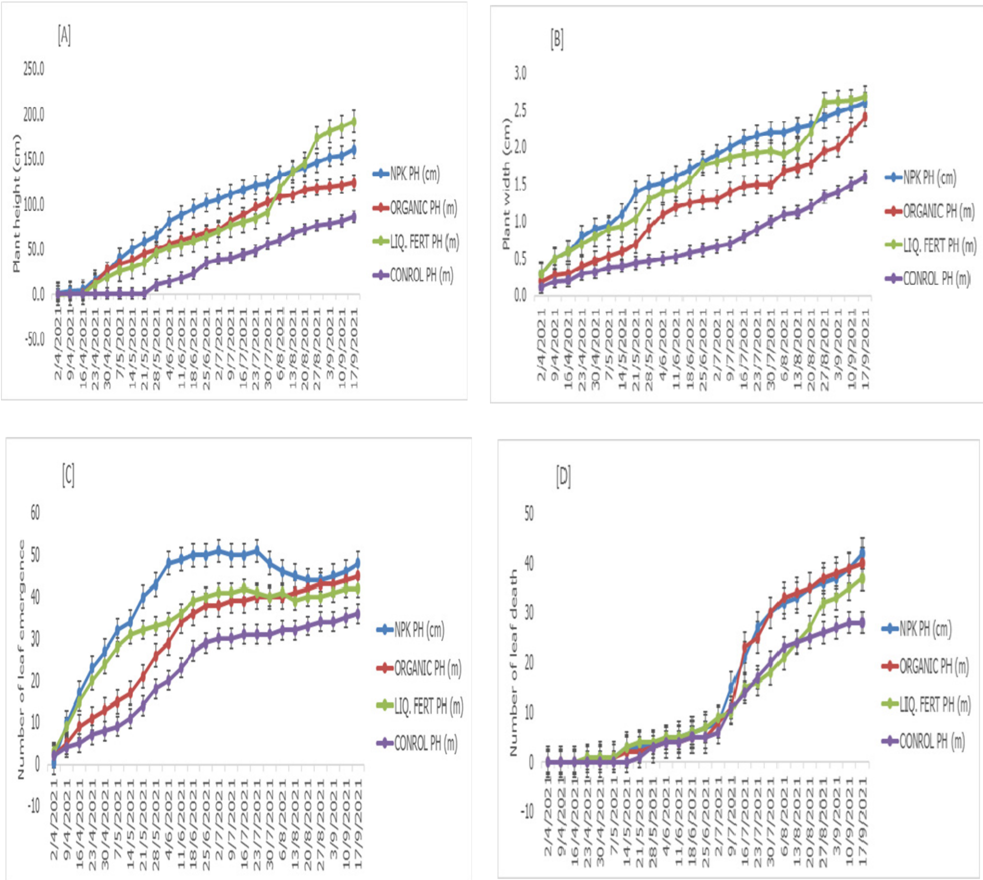

Figure 1. Cassava phenological development-plant height (a), plant width (b), leaf emergency (c), and leaf death (d).

3.3. Cassava growth trend

The result in Table 1 presents statistical metrics of the cassava phenological development (PD) under regime fertilized and unfertilized treatments. PD such as plant height (Ph), plant width (PW), and leaf emergency (Le) are significant with the control treatment at P> 0.001. However, under the fertigation treatment, Ph, Le, and Ld are significant at P<0.001, while Ph and Pw are significant at P<0.001 but insignificant with leaf emergency and plant width. All the growth parameters (Ph, Le, Ld) indicated a highly significant level at 1% under organic treatment except plant width (PW) at P> 0,023 respectively.

Table 1 Statistical metrics for experimental treatments

Treatments	Phenology	Mean	Median	Variance	Std. Dev.	Std. Error	T-Test	Sign
Control	Plant height (Ph)	40.5	40.0	879.8	29.6	6.47	6.26	*0.001
	Plant width (Pw)	0.7	0.6	0.2	0.4	0.07	9.36	*0.001
	No of leaves (Le)	20.3	25.0	166.7	12.9	2.44	8.31	*0.001
	Leaf death (Ld)	9.6	4.5	117.5	10.8	2.05	4.76	0.001
Fertigation	Plant height (Ph)	91.3	76.0	3178.9	56.4	12.31	7.43	0.001
	Plant width (Pw)	4.1	1.9	57.2	7.5	1.43	2.86	0.001
	No of leaves (Le)	32.4	37.0	117.3	10.8	2.00	15.90	*0.001
	Leaf death (Ld)	13.8	9.5	153.7	12.4	2.30	5.90	*0.001
Fertilizer-NPK	Plant height (Ph)	101.3	111.0	159.0	39.9	8.70	12.10	*0.001
	Plant width (Pw)	5.6	2.0	145.0	12.1	2.28	2.46	0.207
	No of leaves (Le)	39.5	45.0	184.6	13.5	2.60	15.40	0.001
	Leaf death (Ld)	17.9	11.5	277.4	16.6	3.00	5.70	*0.001
Organic Fertilizer	Plant height (Ph)	80.9	81.0	1040.7	32.3	7.03	11.50	*0.001
	Plant width (Pw)	4.6	1.3	102.9	10.1	1.92	2.40	0.023
	No of leaves (Le)	30.3	37.0	175.7	13.2	2.50	12.10	*0.001
	Leaf death (Ld)	17.1	9.5	255.9	15.9	2.02	5.6	*0.001

3.4. Physiological dynamic of cassava under different treatment

Plant width (Pw) and plant height (Ph) under all the treatments indicated a positive and strong relationship. Under plot A (NPK treatment), the coefficient of determination (R2) is 0.8806, while in plots B, C, and D, the R^2 values are 0.9545, 0.9156, and 0.9146. Generally, fertilization improved plant growth and this implies that increases in plant height also led to increases in plant width, leaf area index (LAI), and storage root yield. Hence, it is clear that cassava yield prediction from the phenological relationship indicated that organic manure fertilizer may likely produce the largest cassava yield per hectare based on the analysis in Fig.2. The finding is similar to the study of [10;11] that revealed organic fertilizer has essential nutrients like zinc which is responsible for chlorophyll production, protein synthesis, and enzyme components which simulates plant growth and yield.

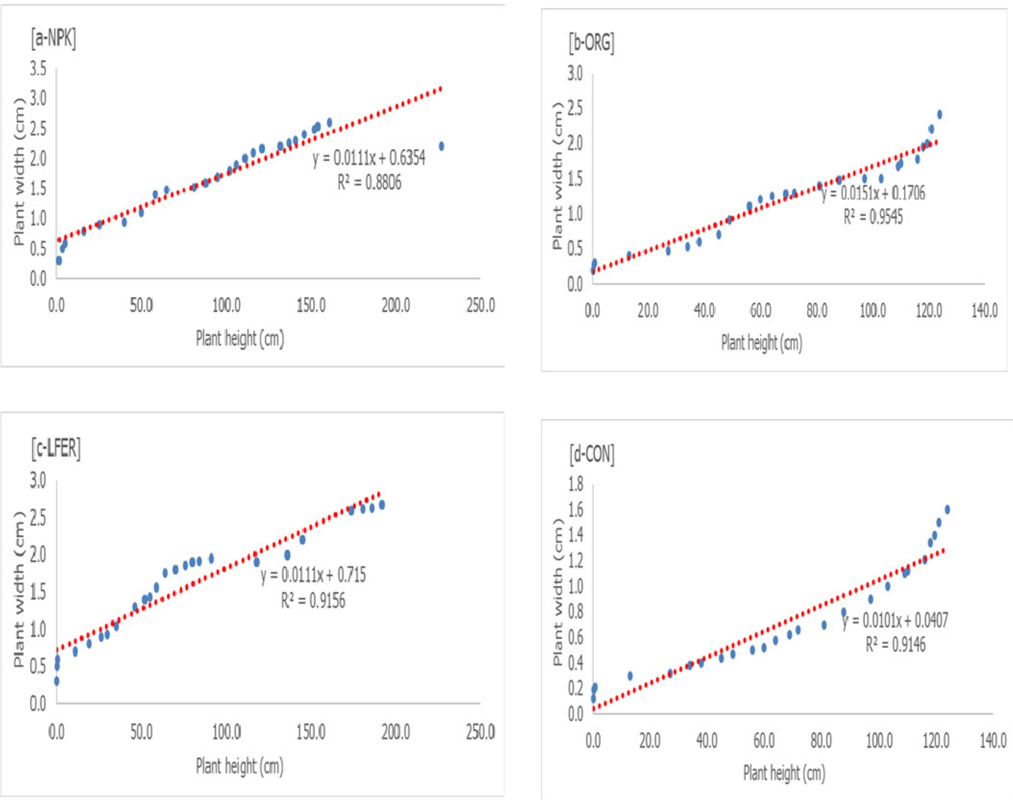

Figure 2. Plant width and plant height under NPK (a-NPK), organic fertilizer (b-org), fertigation (c-lfer), and control (d-CON)

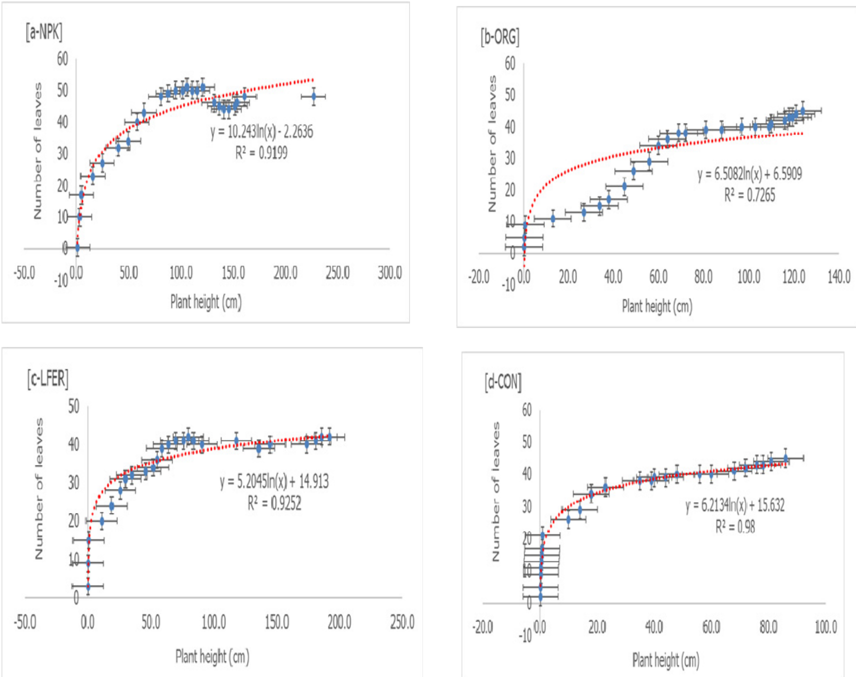

Figure 3. Leave number and plant height under NPK (a-NPK), organic fertilizer (b-org), fertigation (c-lfer), and control (d-CON).

Fig. 3 shows the relationship between the leaf emergency and plant height for each of the fertilized and uncontrolled treatments. The R^2 value under NPK treatment is 0.919, whereas, in fertigation, organic fertilizer, and unfertilized treatment, the R2 is 0.7265, 0.9252, and 0.980. The accumulation of potassium, nitrogen and phosphorous accumulation resulted in the early plant leaf emergency and an increase in cassava stem height and diameter. However, the observation under fertigation with the least R2 (0.7265) could probably be due to pest infection

4. Conclusion

The study investigates the effects of various fertilizer applications on the phenological development of cassava TMS 30573 variety compared to unfertilized treatment in Edo State. The overall results show that fertilization improves cassava growth and development. The investigation revealed that under fertigation and N.P.K fertilizer, plant height, plant width, and the number of leaves suddenly increased from the early stage of cultivation, whereas a steady rise in physiological under organic fertilization was observed. Therefore, cassava growth under organic fertilizer tends to grow better due to its lower leaf death rate and increase in cassava root storage compared to fertigation, NPK, and unfertilized soil. Conversely, the use of NPK fertilizer and fertigation will lead to an early harvest and improved yield per hectare, but organic fertilizer can produce higher under longer periods. Hence the choice of fertilizer application somehow depends on the purpose of cultivation. For instance, if the cassava is to meet early market force, it is recommended to apply either fertigation or NPK fertilizer and for other purposes organic fertilizer is highly recommended.

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