



Growth and Yield Responses of Three Cassava Varieties (*Manihot esculenta* Crantz) Using Two Compound Fertilizers in Humid Tropics, Rivers State, Nigeria

T. S. Lawson ^{a*}, L. D. Gbaraneh ^b and I. B. Foby ^b

^a University Farm, University of Port Harcourt, P.M.B. 5323, Rivers State, Nigeria.

^b Department of Crop and Soil Science, Rivers State University, P.M.B. 5080, Port Harcourt, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An experiment on the growth and yield responses of cassava (*Manihot esculenta* Crantz) using two compound fertilizer types was conducted at the Teaching and Research Farm, Rivers State University Port Harcourt between March 2021 and February 2022. The treatments consisting of three cassava varieties (TME 419, TMS 95/0289, TMS 96/0523) and two compound fertilizer types (NPK 20-10-10, NPK 15-15-15) and a control without fertilizer application were combined in a split plot arrangement with cassava varieties to the main plot while fertilizer types took the subplots, in a Randomized Complete Block Design (RCBD) replicated three times. Parameters evaluated were plant height and leaf number at four weekly interval starting at ten weeks after planting, also tuber

*Corresponding author: E-mail: lawsonstobotamuno@gmail.com, lazarusonisowurun@gmail.com;

number and tuber weight. Results show that cassava variety TME 419 interacting with NPK 15-15-15 produced the highest plant height (288.3cm) while TMS96/0523 without fertilizer application produced the lowest plant height(199cm) at harvest. Cassava variety TMS 95/0289 interacting with NPK 15-15-15 produced the highest tuber number per plot (241.3) and per stand (10.1) respectively. Cassava variety TMS 96/0523 interacting with NPK 15-15-15 produced the highest leaf number per stand (103.3). Application of NPK fertilizer especially NPK 15-15-15 enhances tuber number, leaf number and plant height. Cassava variety TMS 95/0289 produced the highest tuber number and tuber weight. Thus it is recommended that TMS 95/0289 be recommended to farmers as it produced highest tuber number and tuber weight. Also, fertilizer NPK 15-15-15 is a preferred NPK fertilizer as it produced high yield in tuber number per stand and tuber weight.

Keywords: Cassava; varieties; growth; yield; responses; compound fertilizer.

1. INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a perennial crop of the family Euphorbiaceae domesticated in Nigeria. It is a root crop that is propagated vegetatively from stem cuttings for commercial purposes, but can also be propagated by seed. Due to its adaptability to marginal soils and erratic rainfall, high productivity per unit of land and labour, the possibility of supply throughout the year has been obtained [1,2]. Cassava plays an important role in terms of food security, income generation and employment for families in the humid tropics where hunger and starvation prevail [3]. It is the major staple starch of people in Nigeria [4]. Its main value is in its storage roots with dry matter containing more than 80% starch. Cassava is also processed to cassava chips, pellets and flour for consumption. Cassava processed to 'garri' and 'tapioca' are staple food for many persons in the Niger Delta and Nigeria at large.

The major limiting factor of cassava production in Nigeria is low soil fertility [5]. There have been misconceptions that cassava has a good yield in low fertile soil [6]. Reports from Asia suggest that cassava produces 5 to 10 t ha⁻¹ in a very acidic and infertile soil. In contrast, it produces 30 to 40 t ha⁻¹ in a fertile soil and can yield up to 60t ha⁻¹ under irrigation [7]. The cassava cropping season is variable because the cropping season and harvest date is dependent upon the type of cassava grown [8] and household consumption needs. However, in Nigeria, planting of cassava commence with the onset of the rainy season from March/April in Rivers State and other South-South regions. For many varieties, maximum cassava yield occurs after 10 to 12 months [9]. Nitrogen (N) Phosphorous (P) and Potassium (K) are nutrients required for cassava and are always deficient in the coarse- textured soils that

are mostly used in the cultivation of cassava in Nigeria.

In a bid to ensure food security a number of cassava varieties were released for cultivation by the International Institute of Tropical Agriculture (I.I.T.A).The varieties released includes TMS 95/0289, TMS 96/0523 and TME 419, which were bred to be disease resistant and to produce high yield. Overtime because of the increase in population and land limitation there is need to enhance production by the use of compound fertilizer to improve yield to meet up with the growing population of people in the country. It is against this backdrop that it has become pertinent to assess the effects of two compound fertilizers (NPK 20-10-10 and NPK 15-15-15) on the growth and development of three cassava varieties (TMS 95/0289, TMS 96/0523 and TME 419).

The soil in Rivers State are prone to erosion, leaching, soil nutrient depletion due to continuous cropping and non-application of soil conservation measures so causing low fertility resulting in low cassava yield. Therefore, this research seeks to provide information on the effect of two compound fertilizers on the growth and development of three cassava varieties.

2. MATERIALS AND METHODS

2.1 Study Area

The cassava evaluation site was in the Rivers State University Teaching and Research farm, Port Harcourt. It is in the humid forest zone with mean annual rainfall of about 2400mm distributed March to November; There is a seasonal break in rainfall around August which is commonly referred to as August break. Temperatures range from 27°C to 33°C and

humidity could be about 89% from July to September. The soil of the study area was formed from coastal plain sand geomorphic unit [10] and a sandy-loam textural class. The research was conducted between March, 2021 to February, 2022.

2.2 Source of Planting Materials

The cassava varieties studied were: TME 419, TMS 96/0523 and TMS 95/0289. These varieties are improved varieties released from I.I.T.A. and collected from International Institute of Tropical Agriculture (I.I.T.A) Onne Station in Rivers State.

List 1. Year of release of the different improved varieties; Source; I.I.T.A

Varieties	Year of Released
TME 419	2005
TMS 96/0523	2005
TMS 95/0289	2005

2.3 Growth Indicators/Parameters

The parameters evaluated are namely; plant height, number of leaves and tuber number. Data was taken at four weekly interval starting from the tenth week after planting. Data involving tubers were taken at harvest in February 2022.

2.4 Compound Fertilizers

The compound fertilizers used in the study were NPK 20-10-10 and NPK 15-15-15. Whereas NPK 20-10-10 is readily available NPK 15-15-15 is relatively scarce. Also NPK 20-10-10 is relatively cheaper than NPK 15-15-15. The fertilizer rates used were 300kg per hectare which resulted to 720 grams per 24m² per plot.

2.5 Land Preparation, Establishment and Planting, and Fertilizer Application

The area was manually cleared and plots of 24m² were made into beds with furrows of 1.5 meters in between plots to avoid treatment interaction, enable water drainage and ensure easy access within the study area. Cassava cuttings of 20 – 25cm length were planted per hole at a spacing of 1m by 1m on plots of 24m². Each replicate had nine (9) plots with a total of 27 plots covering an area of about 648/m². Thus the plant population was 10,000 stands per hectare. Two weeks after planting 75% crop

emergence was observed and supplies made thereafter.

Fertilizer was applied at the rate of 300kg/ha each in split doses of half at eight weeks after planting and half at twelve weeks after planting.

2.6 Weed Control

Weeding was done manually: first weeding was done at four weeks after planting, second weeding at nine weeks after planting and third weeding was done at thirteen weeks after planting.

2.7 Parameters Monitored

- i. **Measurement of Plant Height:** The plant height of the cassava varieties was taken from 8 tagged stands in each replicate plot by measuring the distance between the base of the plant and the top of the canopy using a meter rule.
- ii. **Determination of Leaf Number:** Leaf number was counted for five (5) cassava stands per plot.
- iii. **Determination of Tuber Number:** Tuber number was obtained by counting all tubers harvested from each plot.
- iv. **Determination of tuber weight:** Tuber weights were recorded by weighing the freshly harvested tubers from each plot using a Salter calibrated scale.

2.8 Experimental Design

The three cassava varieties using the two types of compound fertilizers were planted in split plot arrangement fitted into a Randomized Complete Block Design (RCBD). This included a control whereby all the varieties did not receive any fertilizer treatment. There were three (3) replicates or blocks with the cassava varieties planted at a spacing of 1meter by 1meter in plots of 24m² which resulted to nine (9) plots per replicate.

2.9 Data Analysis

Data were collected from the field at four weekly intervals and arranged in excel spread sheet. Analysis of data was done using Computer Minitab software and significant means were separated using Tukey's Pairwise comparison grouping method [11].

3. RESULTS

The interaction between two NPK compound fertilizers and three cassava varieties on plant height in Table 1 indicated that TME 419 grown with NPK 20-10-10 fertilizer (V_3F_1) had the highest mean height (74.0cm, 118.7cm, 258.7cm) in 10WAP, 14WAP and 34WAP followed by TME 419 grown with NPK 15-15-15 fertilizer (V_3F_2): (18WAP, 22WAP, 26WAP, 30WAP and 38WAP) while the lowest mean height in the study period (10WAP - 38WAP) was noted in TMS 96/0523 with no fertilizer application (V_1F_0). Although, there was indifference significantly ($P>0.05$) during the study period between TME 419 variety grown with NPK 15-15-15 (V_3F_2), TME 419 variety grown with no fertilizer application (V_3F_0) and TME 419 variety grown with NPK 20-10-10 fertilizer (V_3F_1) respectively but mean differences. TME 419 grown with NPK 15:15:15 (V_3F_2) recorded the highest mean plant height value followed by TME 419 grown with NPK 20-10-10 fertilizer (V_3F_1) at 18WAP – 30WAP; TME 419 grown with NPK 15-15-15 fertilizer (V_3F_2) plants were the highest at 38WAP. There was no significant difference between the treatments TMS 96/0523 grown with 20-10-10 (V_2F_1), TMS 95/0289 grown with NPK 20-10-10 (V_1F_1), TMS 96/0523 grown with no fertilizer (V_2F_0), TMS 95/0289 grown with no fertilizer (V_1F_0), TMS 95/0289 grown with NPK 15-15-15 (V_1F_2), TMS 96/0523 grown with NPK 15-15-15 (V_2F_2) at 10WAP, 14WAP, 18WAP, 30WAP and 34WAP respectively.

The difference between varieties showed that TME 419 had the highest mean plant height across the sampled weeks than TMS 96/0523 and TMS 95/0289 with a mean value of 73.3cm, 117.3cm, 161.7cm, 189.3cm, 238.7cm, 247.0cm, 255.7cm and 288.3cm respectively followed by TMS 95/0289 and the least is TMS 96/0523 (Fig. 1). The effect of fertilizers in Fig. 2 showed that plants cultivated with NPK 15-15-15 had the highest mean value except at 10WAP and 34 WAP where NPK 20-10-10 treated plants had high mean height; the lowest plant height during the study was observed in control (no fertilizer) plants.

Table 2 shows the interactive effect of fertilizers and cassava varieties on number of leaves per plant with TMS 96/0523 treated with NPK 15-15-15 (V_2F_2) having the highest leaf number followed by TMS 95/0289 without fertilizer

treatment (V_1F_0) and the lowest TMS 96/0523 without fertilizer treatment (V_1F_0) at 10WAP; TMS 96/0523 grown with NPK 15-15-15 fertilizer (V_2F_2) recorded high mean values (42.0, 88.7, 113.7, 136.0, 73.0 and 103.3) at 14WAP, 22WAP - 38WAP with the least in TME 419 treated with NPK 15-15-15 fertilizer (V_3F_2) (14WAP and 18WAP), TME 419 treated with NPK 20-10-10 fertilizer (V_3F_0) (22WAP – 38WAP) respectively. TMS 96/0523 grown with NPK 20-10-10 (V_2F_1) had highest leaf number at 18WAP followed by TMS 96/0523 treated with NPK 15-15-15 fertilizer (V_2F_2) whilst lowest number was observed in TME 419 treated with NPK 15-15-15 (V_3F_2). However, there was no significant difference ($P>0.05$) between the treatments value of V_2F_1 from 10WAP to 26WAP Also it was observed in Table 2 that the leaf numbers for the three respective cassava varieties reduced from the values in 30 weeks after planting to lower leaf numbers in 34 WAP and increased relatively slightly in week 38 after planting.

Varietal difference affected the number of leaves recorded (Fig. 3) with highest mean value in TMS 96/0523 at 18WAP - 38WAP respectively followed by TMS 95/0289 at 10 and 14WAP while the least number of leaves was observed in TME 419 in the study period. Fertilizer effect showed that plants cultivated with NPK 15-15-15 had the highest number of leaves except at 10 and 18WAP where the highest was in plants cultivated with NPK 20-10-10 fertilizer. The cassava varieties without fertilizer treatment in this study {control} had the lowest mean number of leaves as observed in Fig. 4.

Table 3 shows that the highest tuber number and tuber weight was observed in TMS 95/0289 grown with NPK15-15-15 compound fertilizer (V_1F_2) followed by TMS 95/0289 grown with NPK 20-10-10 compound fertilizer (V_1F_1) and the least was noted in TMS 96/0523 grown with no fertilizer (V_2F_0) in tuber number and TME 419 grown with no compound fertilizer (V_3F_0) in terms of tuber weight. However, TMS 95/0289 produced the highest mean value of 241.3 in tuber number and 102.6 in tuber weight which was followed by TMS 96/0523 (in tuber number) and lowest was in TME 419 variety respectively (Fig. 5) Also in fertilizer effect, it was observed that compound fertilizer NPK15-15-15 produced the highest mean in tuber number. Control had the least mean values in tuber number and tuber weight (Fig. 6).

Table 1. Interaction effect of two fertilizer types and three cassava varieties on cassava plant height {cm}

Treatments	10WAP	14WAP	18WAP	22WAP	26WAP	30WAP	34WAP	38WAP
V ₂ F ₁	42.0 ^b	78.3 ^b	105.3 ^{bcd}	138.0 ^c	170.0 ^{bc}	194.0 ^{bc}	206.0 ^{ab}	232.3^c
V ₁ F ₁	59.7 ^{ab}	106.0 ^{ab}	132.0 ^{abc}	162.7 ^b	199.7 ^{ab}	206.3 ^b	234.3 ^{ab}	250.3^b
V ₃ F ₁	74.0 ^a	118.7 ^a	156.0 ^a	183.0 ^a	218.3 ^{ab}	226.3 ^{ab}	258.7 ^a	283.3^{ab}
V ₃ F ₀	71.7 ^a	113.0 ^a	140.7 ^{ab}	171.0 ^a	218.0 ^{ab}	227.3 ^{ab}	243.7 ^{ab}	267.3^b
V ₂ F ₀	37.0 ^b	60.0 ^c	86.3 ^d	118.7 ^d	144.0 ^c	165.7 ^c	185.7 ^b	199.0^d
V ₁ F ₀	43.7 ^b	87.7 ^b	112.0 ^{bcd}	143.3 ^{bc}	176.0 ^{bc}	190.3 ^{bc}	216.0 ^{ab}	230.7^c
V ₁ F ₂	57.0 ^{ab}	103.3 ^{ab}	132.7 ^{abc}	161.0 ^b	195.7 ^{ab}	206.0 ^a	221.0 ^{ab}	255.7^a
V ₃ F ₂	73.3 ^a	117.3 ^a	161.7 ^a	189.3 ^a	238.7 ^a	247.0 ^a	255.7 ^a	288.3^{ab}
V ₂ F ₂	40.7 ^b	76.7 ^{bc}	104.7 ^{cd}	137.0 ^c	166.0 ^{bc}	183.3 ^{bc}	206.7 ^{ab}	213.3^{cd}

*Means that do not share same letter in columns are significantly different (Tukey method at 95% confidence level)

WAP – Weeks after planting, V₁ - TMS 95/0289, V₂ – TMS 96/0523, V₃ – TME 419, F₀– No Fertilizer, F₁ – 20-10-10, F₂– 15-15-15.

Table 2. Interaction effect of two fertilizer types and three cassava varieties on number of cassava leaves

Treatments	10WAP	14WAP	18WAP	22WAP	26WAP	30WAP	34WAP	38WAP
V ₂ F ₁	23.7 ^a	36.0 ^a	56.3 ^a	79.0 ^a	80.7 ^{ab}	97.0 ^b	61.7 ^a	63.7 ^b
V ₁ F ₁	28.3 ^a	41.7 ^a	44.7 ^a	57.7 ^a	69.0 ^{ab}	70.0 ^{bc}	46.0 ^b	67.7 ^b
V ₃ F ₁	27.3 ^a	34.3 ^a	38.3 ^a	46.3 ^a	53.3 ^b	46.3 ^c	24.7 ^b	34.3 ^c
V ₃ F ₀	24.7 ^a	37.0 ^a	45.0 ^a	50.7 ^a	46.0 ^b	45.7 ^c	26.0 ^b	31.7 ^c
V ₂ F ₀	20.0 ^a	33.7 ^a	45.3 ^a	60.3 ^a	75.7 ^{ab}	89.0 ^b	53.0 ^{ab}	88.7 ^{ab}
V ₁ F ₀	28.7 ^a	36.0 ^a	42.3 ^a	56.0 ^a	56.7 ^b	101.7 ^a	39.0 ^b	57.0 ^b
V ₁ F ₂	31.7 ^a	39.7 ^a	42.3 ^a	59.0 ^a	67.0 ^{ab}	65.3 ^c	40.3 ^b	60.7 ^b
V ₃ F ₂	25.7 ^a	32.3 ^a	38.0 ^a	53.3 ^a	57.3 ^b	57.7 ^c	26.0 ^b	38.0 ^c
V ₂ F ₂	21.3 ^a	42.0 ^a	53.3 ^a	88.7 ^a	113.7 ^a	136.0 ^a	73.0 ^a	103.3 ^a

*Means that do not share same letter in columns are significantly different (Tukey method at 95% confidence level)

WAP – Weeks after planting, V₁ - TMS 95/0289, V₂ – TMS 96/0523, V₃ – TME 419, F₀– No Fertilizer, F₁ – 20-10-10, F₂– 15-15-15.

Table 3. Interaction effect of two fertilizer types and three cassava varieties on Tuber component

Treatment	Tuber number	Tuber weight
V ₂ F ₁	144.0 ^{bc}	61.3 ^{bc}
V ₁ F ₁	214.0 ^{ab}	99.7 ^{ab}
V ₃ F ₁	116.7 ^c	43.7 ^c
V ₃ F ₀	90.7 ^c	28.7 ^c
V ₂ F ₀	88.0 ^c	38.0 ^c
V ₁ F ₀	170.7 ^b	87.3 ^{ab}
V ₁ F ₂	241.3 ^a	120.7 ^a
V ₃ F ₂	111.7 ^c	45.7 ^c
V ₂ F ₂	153.0 ^{bc}	65.0 ^{bc}

*Means that do not share same letter in columns are significantly different (Tukey method at 95% confidence level)

WAP – Weeks after planting, V₁ - TMS 95/0289, V₂ – TMS 96/0523, V₃ – TME 419, F₀– No Fertilizer, F₁ – 20-10-10, F₂– 15-15-15

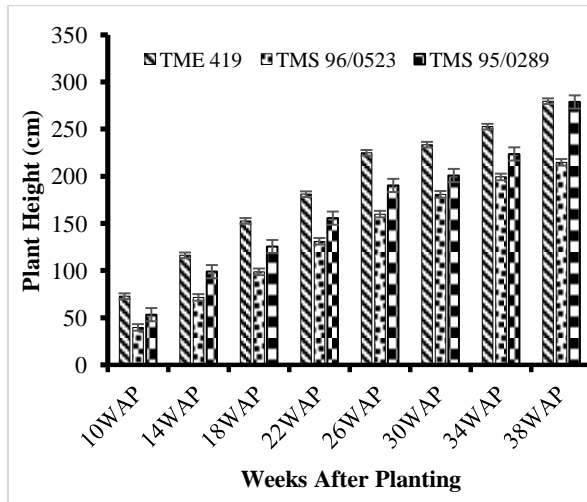


Fig. 1. Varietal difference on plant height

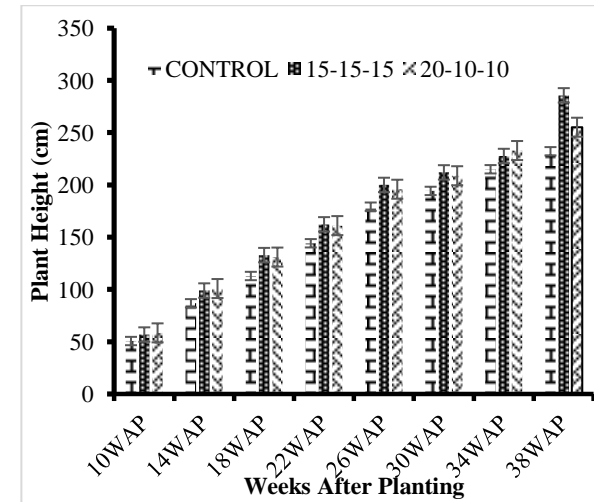


Fig. 2. Fertilizer effect on plant height

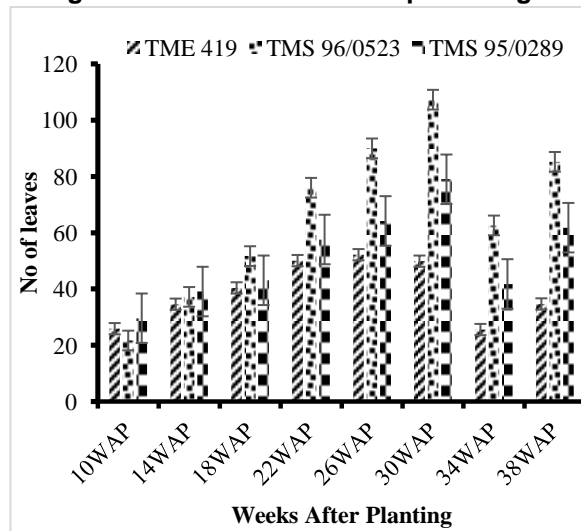


Fig. 3. Varietal difference on number of leaves

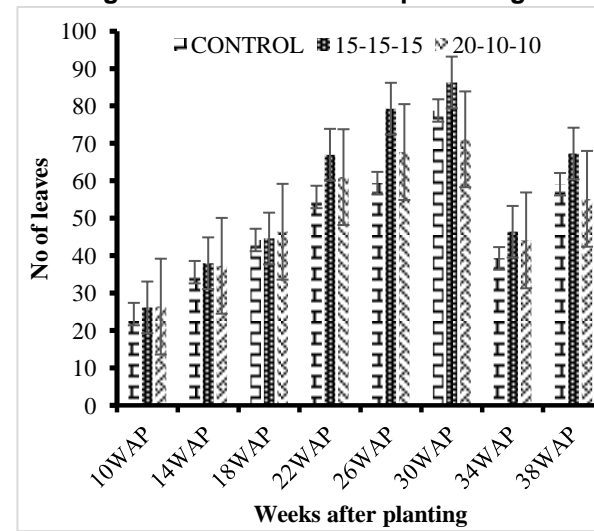


Fig. 4. Fertilizer effect on number of leaves

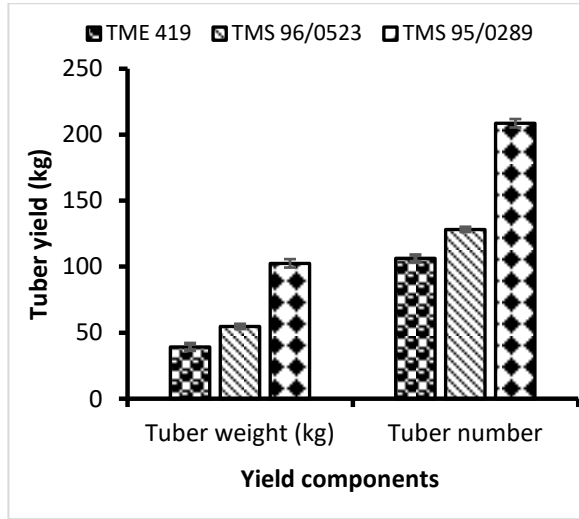


Fig. 5. Varietal difference on yield components

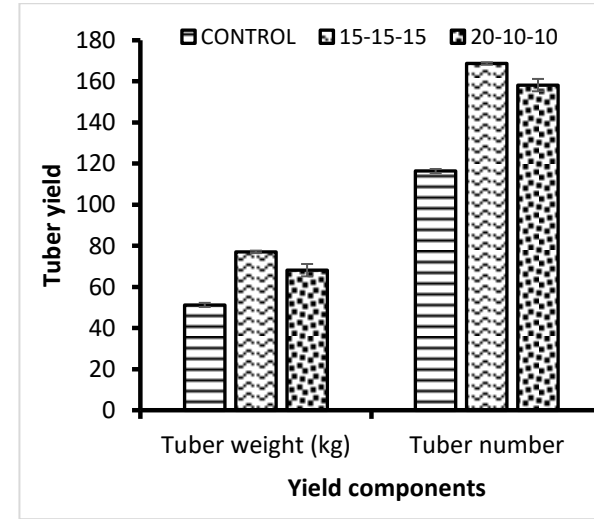


Fig. 6. Fertilizer effect on yield components

4. DISCUSSION

The plant height obtained across the weeks of planting in the interaction between NPK fertilizers and cassava varieties indicated that TME 419 variety applied with NPK 15-15-15 fertilizer gave the highest height and this corroborates with the findings of [12] that assessed 43 cassava varieties in two locations (Onne and Ogurugu) and reported that fertilization in cassava production significantly stimulates plant growth. TME 419 had the best plant height followed by TMS 95/0289 and this report corroborates the observation of [13], their studies in Uyo, Southern Nigeria found TME 419 to be the tallest variety when compared to TMS 98/0505. The low growth (plant height) rate of TMS 96/0523 contradicted the works of [12]. NPK 15-15-15 produced the highest height seconded by NPK 20-10-10 while the least height was indicated in the control plots. This finding supported the reports of [4] that reported growth parameters from fertilized plots to be significantly higher than those from unfertilized plots.

TMS 96/0523 variety applied with NPK 15-15-15 fertilizer produced the highest number of leaves in 38WAP followed by TMS 96/0523 variety applied with NPK 20-10-10 fertilizer while the least was indicated in the unfertilized plot of TME 419. This observation suggests that fertilizer improved the production of leaves in the studied cassava varieties [2]. However, this result controverted the findings of [12] in Onne and Ogurugu who found that NPK 15-15-15 applied to TME 419 resulted to high forage yield when surveying 43 cassava varieties. For varietal assessment in number of leaves, TME 419 was the lowest and this agreed with the result of [13] that observed low number of leaves in variety TME 419 during their research. The high number of leaves noted in the fertilizer effect of this research is in NPK 15-15-15 and this may be due to the positive response of the cassava varieties to potassium as it aids photosynthesis and cell multiplication which results to intensification of length and size of stems and leaves [14] and increase in photosynthetic capacity and leaf chlorophyll leads to higher yields [14]. The leaf number reduced considerably from week 30 to week 38 after planting {30-38 WAP} and this could be due to the deciduous growth pattern of cassava crop. Plant height and leaf area were stimulated by application of higher nitrogen [15].

TMS 96/0523 grown with no fertilizer (V_2F_0) produced the least tuber number and the highest

was TMS 95/0289 grown with 15-15-15 compound fertilizer (V_1F_2). Fertilizer application positively affected tuber number with the control having the least. This observation is in line with the findings of [4] who noted no difference between fertilizers applied but difference when compared to control plot. TMS 95/0289 was highest in tuber number but was not significantly different from other varieties. Tuber weight on the combined effect of two compound fertilizers on three cassava varieties revealed the highest tuber weight of 120.7kg (50.29t/ha) in TMS 95/0289 variety applied with NPK 15-15-15 fertilizer; this high fresh tuber weight of TMS 95/0289 variety applied with NPK 15-15-15 fertilizer maybe as a result of high potassium content which helps in increasing photosynthetic activity and transportation of photosynthates to tuberous roots [7]. Variety TMS 95/0289 produced 102.6kg (42.75tons/hectare) of tuber weight followed by TMS 96/0523 which produced 54.8kg (22.83t/ha) while the least was TME 419 (39.3kg and 16.38t/ha). Thus, the high tuber yield of TMS 95/0289 may be due to its high branching ability which exposes the leaves to sunlight for photosynthesis thereby leading to high tuber yield [16]. TMS 95/0289 tuber yield was above the ranges of 22.81-35.82t/ha (Onne station), Zaria (23.76t/ha) and Ubiaja (11.70-26.44t/ha); TMS 96/0523 tuber yield was within the range of 21.03-38.85t/ha in Onne station but above that of Ibadan and Zaria (10.75-19.33t/ha and 21.80t/ha); TME 419 variety yield was in the range of Ibadan (10.69-23.45t/ha) and Ubiaja (14.52-24.91t/ha) but was below the yield ranges of 19.94-27.26t/ha in Mokwa and 24.46-25.09t/ha in Onne [17].

5. CONCLUSION

The quest to know the effect of NPK compound fertilizers on the growth and yield of three cassava varieties in the humid tropics has been the purpose for this research whose result revealed that TME 419 variety applied with NPK 15-15-15 fertilizer gave the best plant height; TMS 96/0523 variety applied with NPK 15-15-15 fertilizer resulted to highest number of leaves; TMS 95/0289 variety applied with NPK 15-15-15 fertilizer produced the highest tuber number and tuber weight. Also, NPK 15-15-15 produced significantly higher number of leaves, tuber weight, tuber number and plant height. The fertilized plots resulted to significantly greater fresh tuber numbers and tuber weight than unfertilized plot (control). Thus, TMS 95/0289 and NPK 15-15-15 should be recommended to

subsistence farmers so as to increase cassava productivity since the variety and compound fertilizer produced highest tuber number and tuber weight.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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