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## EFFECT OF PLANTING PATTERN ON GROWTH AND YIELD OF TWO CASSAVA (*MANIHOT ESCULENTA* CRANTZ) VARIETIES

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### ABSTRACT

A study was carried out at the Teaching and Research farm of Federal University of Agriculture Umudike in Eastern Nigeria to assess the effects of planting pattern on growth and yield of two cassava varieties (*Manihot esculenta* Crantz) in 2018 cropping season. The experiment was laid out in a randomized complete block design (RCBD) with 3 replications, in a factorial arrangement. Treatments consisted of three planting patterns (East-west orientation, North-south orientation and mound), and two cassava cultivars (UMUCASS 37 and TME 419). Morphological parameters were taken at different growth stages and yield parameters taken at harvest while soil temperatures were monitored throughout the duration of the crops. The analysis of variance indicated that the treatments (planting pattern and cultivar) showed no significant ( $p>0.05$ ) effect on the soil temperatures. Cassava cultivar TME 419 significantly improved plant height at 1% level of probability in the north south (NS) orientation while the cassava cultivar UMUCASS 37 significantly increased canopy cover at 5% level of probability in the north-south (NS) row orientation. UMUCASS 37 randomly planted on mounds significantly increased ( $p<0.05$ ) total plant biomass while crops in the north-south (N-S) row orientation significantly increased ( $p<0.05$ ) the harvest index of TME 419. Cassava fresh root yield did not show any significant difference due to treatments. There was no remarkable change in soil temperature that can be attributed to the treatments. It therefore appears that cassava could be planted without adopting any distinct planting pattern as neither cassava yield nor soil temperature were influenced by planting arrangement on the ground.

Keywords: Cassava, Planting pattern, Spacing, growth.

### INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is native to tropical America (Olsen and Schaal, 2001). It is one of the most important crop of unfavourable environments in developing countries, where poverty is common and severe (Rabinowicz, 2010). Because of its high productivity, even in extreme conditions, cassava constitutes a source of food and income for poor farmers in Africa, Asia and Latin America. It is efficient in carbohydrate production, adapted to a wide range of environments, and tolerant to drought and acidic soils (Cock, 1982; Kawano, 2003). Cassava has relatively high productivity under conditions of erratic rainfall and low fertility soils, 250 million Africans depend on cassava as food, with more than 90 percent of the 117 million tons produced in Sub-Saharan Africa (SSA) in 2007 cassava was being used for fresh consumption and processed food (Philips et al; 2006).

The major constraints to cassava production include poor cultural practices, insect pest and plant disease which can cause yield losses that may be as high as 50%, as well as its inability to enhance or maintain

soil fertility thereby posing a threat to food security throughout developing countries in Africa. The bulk of cassava grown in Nigeria is produced by peasant smallholders under traditional agricultural practices. High demand for organically grown foods has made farmers to seek new methods to increase crop yields and reduce production cost without the use of chemicals.

Among the new production techniques crop row orientation is a management practice that can be applied anywhere without increasing production cost. It influences natural bio-regulation of plant morphogenesis and interception of photo synthetically active, incident solar radiation (Maddonni et al., 1999). This natural bio-regulation of plant development occurs because row orientation can cause subtle changes in far-red light ratio that influences the plant phytochrome system. Changes in row direction have been shown to change spectral light quality and influence growth and development of wheat (Angiras and Sharma, 1996). More so, it accounts for the total amount of sunlight captured by a field throughout the growing season. The incidence of row orientation however, varies according to canopy shape in height, latitude and time of year

(Smart, 1973; Baldini and Intrieri, 1987). The effects induced by row orientation are in fact more pronounced for vertical narrow canopies; they become negligible for more horizontal or flat canopies. A north-south (NS) orientation determines symmetrical light distribution over both sides of the field at relatively low latitudes; it also allows higher seasonal light interception than east-west (EW) orientated rows (Smart, 1973). At such latitudes the east-west (EW) orientation is inherently limiting since the diurnal sun's path tends to be parallel to the canopy losing much light directly to the ground especially during the midday hours. Rays of the sun reaching the soil may affect its quality through raised temperature (Catherine et al, 2010).

More so, sunshine is the most important growth factor with respect to temporal factors such as relative humidity (Simwambana *et al.*, 1995). Work at CIAT, showed that shading 5 months old cassava plant to 50% of full sunlight had little effect on leaf appearance rate and leaf area index (Cock and Rosas, 1975). Similarly, Fukai *et al.* (1984) recorded reduction in leaf area index, root number and harvest index under low solar input. The two major factors affecting crop yield and productivity are weather condition and soil nutrient Wright (1993), thus to improve the production of any crop it is rational to understand the average weather conditions of such area. Temperature is a major weather factor which affects the growth of plant (Salvi *et al.*; 1984). Keatings and Evenson (1979) reported that low soil temperature delay emergence while low air temperature (5°C) decreases growth rates of cassava. Large seasonal differences in temperature cause variation in growth and subsequent yield of cassava (Keatings and Evenson, 1979; Fukia *et al.* 1984). Many authors suggest that the orientation of the rows is a fundamental factor that affects the interception of radiation, leaf microclimate and its vapour pressure deficit, and therefore, the amount of water consumed by the plant, as well as its photosynthetic capacity and these effects are more obvious in vertical and continuous canopies than in open and discontinuous system (Champagnol 1984, Galet, 2000; Zufferey and Murisier, 2003).

There were reports that planting density influences all crop traits (Eke-Okoro et al 1999). Due to the importance of planting density, several studies have been conducted with cassava, at planting density that ranged from 6,666 plants ha<sup>-1</sup> (Rojas et al., 2007) to 27,777 plants ha<sup>-1</sup> (Guerra et al., 2003). Larger populations (of up to 50,000 plant ha<sup>-1</sup>) have been tested to determine their effect on the above ground part of the plant (Lima et al., 2002). Studies have demonstrated that the planting density effect on root yield varies with cultivar (Guerra et al., 2003; Rojas et al., 2007). In other words, an increased planting density may increase, reduce, or maintain cassava root yield, depending on the

cultivar that is evaluated. This study was undertaken with the following objectives:

1. To evaluate the effect of planting pattern on growth and yield of cassava genotypes
2. To determine the effect of planting pattern on soil temperature

## MATERIAL AND METHODS

### EXPERIMENTAL SITE

A field experiment was conducted in the 2018 cropping season at the Eastern farm of the National Root Crops Research Institute Umudike, Research Farm (latitude 05°29'N; longitude 07°33'E; Altitude 122m). Umudike is in the humid tropics and has a total rainfall of about 2177 mm per annum, annual average temperature of 26°C. The predominant vegetative type is rain forest (NEST, 1991), while the soils has been classified as sandy loam ultisol (Agboola, 1979). The rainfall pattern is bimodal. A long wet season from April to July is interrupted by a short "August break" followed by another short rainy season from September to October/early November. Dry season stretches from early November to March.

### PLANTING MATERIALS

The planting materials used for this study were two improved cassava cultivar having low and high cyanide content ((TME 419 and UMUCASS 37). The materials were obtained from the germplasm of the National Root Crop Research Institute, Umudike, Abia State. The materials were selected for their possession of good yield and tuber formation which are of agronomic importance.

### EXPERIMENTAL DESIGN

The experiment was laid out as a randomized complete block design (RCBD) with the treatments replicated three times. Each replication had its treatments randomly assigned to them. The crop rows on ridges were aligned in two row-orientations, east-west and north-south, while those on mound were randomly spaced as in farmers' practices.

### AGRONOMIC PRACTICES

#### Land preparation

The land was cleared mechanically by the use of a tractor slasher. The trash was left to decay for a period of 3 weeks and then it was ploughed, harrowed and ridged. The area of land to be planted was marked out.

#### Planting and field maintenance

Cassava plants were planted 16 July 2018 using stems cut into 25cm planting sets. The ridges were oriented either in east-west/ or north-south direction at spacing of 1m x 1m and 1m x 0.8m. Mounds maintained no orientation and stem cuttings placed 2 per mound. Supplying was done at one month after planting. The field was sprayed with a combination of "touchdown (containing glyphosate) and primextra (containing

metolachlor atrazine and other related compounds)” a day after planting to control weeds. Subsequent hand weeding was done as required. The N.P.K. 20-10-10 fertilizer was applied (600kg/ha for root production at a recommended population of 10,000 plants/ha) at 6weeks after planting based on the soil analytical result. The plants were well maintained following appropriate agronomic practices.

#### DATA COLLECTION

Morphological and yield parameters taken were on the following:

- Plant establishment:** survival count was taken at 6weeks by counting the survived ones.
- Plant height:** This was taken as height from the ground to the top of the canopy using a meter rule (cm).
- Canopy cover:** Four net plant stands were measured with a measuring tape and the average taken (cm).
- Fresh root yield (t/ha):** Roots of cassava harvested were weighed using a weighing balance.
- Biomass:** The stems, branches and leaves were measured using a weighing balance.
- Root number:** It was obtained by counting the harvested root number.
- Harvest index (HI):** This was obtained through calculation (Root weight/Root weight +Biomass).

#### STATISTICAL ANALYSIS

Data collected were subjected to analysis of variance (ANOVA) using the Generalized Linear Model procedure of SAS (SAS, 2000). While LSD was applied in the separation of means done. LSD values are not shown when the differences between the measurements are not significant at  $P=0.05$  according to the F-test.

#### RESULTS

##### Meteorological data of the experimental site

Meteorological data obtained during experimentation is presented in Table 1. The monthly rainfall (mm) distribution showed that the total annual rainfall at Umudike during the experimental period was 2045.4mm. The average monthly rainfall for the experimental period was recorded as 170.45mm. During the experimental period there was no rain in the month of December 2018. The rainfall pattern showed that there was a bi-modal rainfall distribution. In 2018 the highest rainfall was recorded in September, whereas in 2019, the monthly rainfall was high and maintained a slightly erratic stretch from May and July with no distinct break as observed in the southeast of Nigeria. The mean monthly maximum and minimum temperature during the experimental period were 31.45°C and 22.76°C. Relative humidity observed in the experimental site had an increase for the months of August-November in 2019 and also in June 2019 as a result of the presence of rainfall in those months. The total sunshine during the duration of the experiment was 45.5 hours.

#### GROWTH AND DEVELOPMENT OF CASSAVA

##### Effect of soil temperature on cassava growth and development

The influence of cassava under the soil temperature variations that occurred at the experimental site indicated that its growth is favourable under annual mean temperatures  $\geq 35^{\circ}\text{C}$ . Higher temperatures are usually associated with a greater crop growth rate and high photosynthetic rate. Soil temperatures observed at the site ranged from 35°C to 40°C. However the results obtained from the analysis of variance indicated that the treatments (planting patterns and cultivar) showed no ( $p<0.05$ ) difference on the soil temperatures observed at both morning and evenings (Table 2). North south (NS) oriented crops produced the highest mean temperature than those planted on east west (EW) while those of mound had the least mean temperature. Cultivar showed no significant effect on mean temperature.

##### Cassava growth parameters as affected by variety and planting pattern.

Results obtained from experiment showed that morphological parameters including plant establishment, height of cassava planted, and canopy cover of cassava were not influenced ( $p<0.05$ ) by row orientation (RO), row spacing (RS), and variety (Table 3). However the height of cassava variety, TME 419 was significantly improved at 1% level of probability in the north south (NS) orientation at spacing of 1mx1m while the cassava cultivar UMUCASS 37 showed significant increase in canopy cover in the north south (NS) orientation. There were no significant interactions detected between planting pattern and spacing, spacing and variety and among planting pattern, spacing and variety. However interaction existed between planting pattern and variety on canopy cover.

##### Yield and Yield Components of Cassava as Influenced by Planting Pattern and Cultivar(V)

Planting pattern, spacing and cultivar had no effect on fresh root yield and root weight. Planting pattern was significant on biomass production with cassava planted on mound producing the highest biomass while those in north south (NS) row orientation producing the least. However NS oriented crops produced the highest significant harvest index (HI) while cassava grown on mound yielded the least HI. (Table 4)

The cassava variety TME 419 produced biomass which is significantly higher than UMUCASS 37 ( $p<0.05$ ). Variety also significantly influence root number with TME 419 producing more roots than UMUCASS 37. No interactions was detected between planting pattern and spacing (RO\*S), spacing and variety (S\*V) and among row orientation, spacing and

variety (RO\*S\*V). However interaction existed between row orientation and variety (RO\*V) on biomass and root number. (Table 4)

## DISCUSSION

The results obtained from analysis of variance indicated that planting pattern and cultivar showed no ( $p>0.05$ ) difference on the soil temperatures observed at both morning and evening (Table 4.2). This could be attributed to the temperature of the area ranging between the required temperatures for maximum root production ( $25^{\circ}\text{C}$  to  $35^{\circ}\text{C}$ ). Akmal et al, (2010) reported that temperature plays a major role in plant vegetative growth and development. This is in line with temperature condition and sunshine hours, which among other factors accelerated the initial sprouting ability, breaking of bud dormancy, plant vigour and plant establishment (Eke-okoro et al., 1999; Njoku and Muoneke, 2008). Cassava crops planted at north south orientation (NS) had higher mean temperature  $38.33^{\circ}\text{C}$  than those planted in east west orientation (EW)  $38.17^{\circ}\text{C}$ . This is in line with Borger et al, (2010) which pointed out that north south orientation gives crops higher levels of light absorption for most of the months in the year.

Cassava cultivar TME 419 with row spacing of  $1\text{m} \times 1\text{m}$  had significant effect ( $p>0.05$ ) on plant height in the north south orientation (Table 4.3). Ruberti et al., (2012) pointed that increase in height of plant could probably be because of availability of solar radiation and intensity on cassava grown in NS direction. Spacing and/or orientation, highly affect plant height (Tsubo et al., 2001). Regarding orientation, the plants oriented NS were absorbed with solar light efficiently than the plants

in the EW orientation bringing differences in canopy cover. However, the interactive effect of treatment RO\*V showed a significant difference in the canopy cover of cassava in the north south (NS) orientation with UMUCASS 37 developing a denser canopy than TME 419.

The results of analysis of variance showed that the effect of planting pattern on biomass production was significant at 1% probability level, with no significant effects on those planted on NS and EW orientation (Table 4.4). Cassava planted on NS orientation had the least biomass production followed by EW oriented plants. However, planting pattern was significant at 5% probability level for harvest index (HI). This result is in line with Graybill et al., (1991) who reported that planting pattern differs significantly with regards to harvest index. Cassava planted on NS orientation had the highest root number followed by those on mound, with EW oriented plants having the least root number. There was no significant effect observed between fresh root yield and root weight. Cultivar had a significant effect at 5% probability level on biomass and number of roots; this could be as a result of agronomic factors and temperature effects which are in line with Eke-Okoro et al., (2001) who pointed out that cassava cultivar NR8083 gave the highest number of roots. The interaction effect between RO\*V was significant for biomass production and number of root whereas no significant interaction existed between RO\*S and S\*V and among RO\*S\*V. Temperature effects is of critical importance when assessing growth and productivity of cassava in recent times.

**Table 1: Meteorological data of the experimental site**

Month	Total Rainfall (mm)	Mean Monthly Sunshine (hr)	Mean Maximum Temperature (°C)	Mean Minimum Temperature (°C)	Relative Humidity (%)
August 2018	161.8	2.3	29.0	23.2	66.83
September 2018	349.0	3.3	30.1	22.3	76.65
October 2018	244.6	4.7	30.1	21.4	77.58
November 2018	58.5	4.5	31.4	23.5	73.70
December 2018	0.0	3.9	33.0	21.0	59.77
January 2019	75.4	3.8	32.3	22.3	34.29
February 2019	36.5	3.0	33.0	24.0	38.10
March 2019	40.8	4.1	33.1	24.4	38.06
April 2019	92.8	4.8	33.0	24.0	26.48
May 2019	466.1	5.3	32.5	21.9	41.52
June 2019	239.4	3.9	30.9	22.7	84.3
July 2019	280.5	1.9	29.0	22.6	86.5

**Table 2: Effect of planting pattern and variety on soil temperature**

Treatment	TM (°C)	TE (°C)	MT (°C)
<b>Planting pattern</b>			
EW orientation	35.92	38.31	38.17
NS orientation	35.86	38.40	38.33
Mound (Random)	38.89	38.56	37.81
LSD <sub>0.05</sub>	NS	NS	NS
<b>Row spacing (RS)</b>			
1m x 1m	35.81	38.21	38.23
1m x 0.8m	35.93	38.37	38.23
LSD <sub>0.05</sub>	NS	NS	NS
<b>Cultivar (V)</b>			
UMUCASS 37	35.85	38.35	38.27
TME 419	35.90	38.23	38.20

LSD<sub>0.05</sub> NS NS NS

TM = morning temperature, TE = evening temperature, MT = mean temperature,  
EW = east west, NS = north south, LSD = least significant difference.

**Table 3: Growth phenology of cassava as influenced by planting pattern, spacing and variety (V)**

Treatment/ Interaction	Plant establishment	Plant height (m)	Canopy cover (cm)
<b>Planting pattern</b>			
<sup>a</sup> EW orientation	16.33	1.25	105.30
<sup>b</sup> NS orientation	14.25	1.27	104.50
Mound (Random)	16.17	1.28	102.70
<sup>c</sup> LSD <sub>0.05</sub>	NS	NS	NS
<b>Spacing (S)</b>			
1m x 1m	15.17	1.33	103.70
1m x 0.8m	16.00	1.21	104.60
LSD <sub>0.05</sub>	NS	NS	NS
<b>Variety (V)</b>			
UMUCASS 37	15.56	1.14	106.50
TME 419	15.61	1.40	101.80
LSD <sub>0.05</sub>	NS	**	NS
RO*RS	NS	NS	NS
RO*V	NS	NS	*
RS*V	NS	NS	NS
RO*RS*V	NS	NS	NS

<sup>a</sup>East-west orientation; <sup>b</sup>North-south orientation; <sup>c</sup>Least significant difference; NS=not significant; \*= (p<0.05); \*\*=(p<0.001)

**Table 4: Yield parameters of cassava as influenced by planting pattern and variety**

Treatment/ Interaction	Biomass (Kg/plt)	<sup>a</sup> FRY (tonha <sup>-1</sup> )	<sup>b</sup> RtWt (Kg/plt)	<sup>c</sup> HI	<sup>d</sup> RtNo
<b>Planting pattern</b>					
<sup>e</sup> EW	1.80	9.29	3.72	0.66	8.17
<sup>f</sup> NS	1.33	6.88	2.75	0.69	9.92
Mound	2.52	7.50	3.00	0.52	9.33
<sup>g</sup> LSD <sub>0.05</sub>	**	NS	NS	*	NS
<b>Spacing (S)</b>					
1m x 1m	1.88	7.74	3.09	0.62	9.89
1m x 0.8m	1.89	8.04	3.22	0.63	8.39
LSD <sub>0.05</sub>	NS	NS	NS	NS	NS

Variety(V)					
UMUCASS 37	1.59	7.32	2.93	0.65	8.28
TME 419	2.18	8.46	3.38	0.60	10.01
LSD <sub>0.05</sub>	*	NS	NS	NS	*
RO*RS	NS	NS	NS	NS	NS
RO*V	*	NS	NS	NS	*
RS*V	NS	NS	NS	NS	NS
RO*S*V	NS	NS	NS	NS	NS

<sup>a</sup>Fresh root yield(ton ha<sup>-1</sup>);<sup>b</sup>Root weight(kg); <sup>c</sup>Harvest index(0-1);<sup>d</sup>Number of roots per plant; <sup>e</sup>East-west orientation; <sup>f</sup>North-south orientation; \*Least significant difference;

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