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GROWTH AND YIELD OF SWEET POTATO (*Ipomoea batatas* (L.)Lam.) AS INFLUENCED BY TYPE OF PLANTING MATERIAL

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ABSTRACT

An experiment was carried out in 2004 at the Vom Garden of the Plateau Agricultural Development Programme (PADP), Kuru, in Plateau State, Nigeria. The aim was to study the influence of the type of planting material on growth and yield of sweet potato. Five clones of sweet potato (CIP 4400168, TIS.2532.OP.1.13, TIS.2544 Rusanya1.5, TIS.86/0356 and TIS.87/0087) and three regions of vine-cutting (terminal, middle and basal) constituted the treatment combinations. The results showed that leaf area index (LAI), leaf area duration (LAD) and crop growth rate (CGR) were highest when terminal vine-cutting was used as planting material. Net assimilation rate (NAR) was highest when the basal vine-cutting was used. The highest LAI, LAD, CGR and NAR were observed in the clone, TIS.2544 Rusanya1.5. This clone also produced the highest total tuber yield. Tuber yield was highest when the terminal vine-cutting was planted. The interaction effects of planting material and clone on LAI, LAD, CGR and NAR were significant. Coefficients of correlation were positive in all the attributes studied. The results indicate that total tuber yield in sweet potato could be improved by using terminal vine-cutting as planting material.

KEYWORDS: Growth, yield, sweet potato, planting material, *ipomoea batatas*

INTRODUCTION

The production of sweet potato is influenced by many factors such as clone, pests and diseases, cultural practice and propagation methods. Wilson (1988) reported that high yield could be obtained by using good planting material. To select good planting material, the grower must consider the length, age and health of the planting material. Onwueme (1978) observed that sweet potato would grow adequately if propagated by means of tuber or vine-cutting. The use of sets derived from the tubers for direct planting is not generally recommended because it usually results in very low yields. Yayock *et al.*(1988) reported the use of vine-cuttings as the best planting material for the propagation of sweet potato.

The types of planting material used vary from region to region and from country to country. In Trinidad, terminal cuttings are planted (Kennard, 1944) whereas in Peru, basal cuttings recorded the highest yields (Farge and Chiappe, 1968). In Tamil Nadu, basal and middle portions have been recommended as the best planting material (Sundararaj *et al.*, 1970) even though they are often reported to carry weevils (Wilson, 1988).

In Nigeria, while some farmers use whole vines, others use cuttings of different sizes depending on availability during the cropping season. The objective of this study is to examine the influence of the type of planting material on the growth and yield of sweet potato in the Jos-Plateau environment of Nigeria.

MATERIALS AND METHODS

The experiment was conducted in 2004 at the Vom Garden of the Plateau Agricultural Development Programme (PADP), Kuru, in Jos-South Local Government Area of Plateau State(09° 44'N; 08° 47'E; 1,239.4m above mean sea level).

The experiment was a 5x3 factorial, consisting of five clones of sweet potato (CIP 4400168, TIS.2532.OP.1.13, TIS.2544 Rusanya1.5, TIS.86/0356 and TIS.87/0087) and three regions of vine-cutting (terminal, middle, and the basal). A randomized complete block design (RCBD) was used with four replications.

The net plot size, measuring 3 X 3 m^2, consisted of two 1.5 m rows each measuring 3m long. A path of 0.5 m was left between blocks. Planting was done on July 24, 2004. Vine-cuttings of about 20 cm long were planted at inter-and intra-row spacings of 1.5 m and 0.3 m, respectively, giving a population of 22,222 plants per hectare.

Hoe-weeding was carried out at 25 and 75 days after planting (DAP). At 62 DAP, the plots were earthed up to keep the tubers from exposure. Fertilizer (NPK 15:15:15) was applied at 27 DAP at the rate of 50 kg ha^{-1} each of elemental N, P and K, corresponding to 300g per plot.

FIELD OBSERVATION

Growth Analysis Study

Growth analysis study was carried out at 40, 80 and 120 DAP at which times leaf area index (LAI), leaf area duration (LAD), crop growth rate (CGR) and net assimilation rate (NAR) were obtained.

At each sampling stage, two (2) plants were harvested from each plot and separated into leaves, stem and tuber. Each part was weighed fresh and a sub-sample of 30 g was placed into separate envelopes and dried in a moisture-extraction oven at 100°C for 48 hours. The weights of the dry samples were then recorded. The proportion of the weight of each plant part of the total dry weight was calculated.

Leaf Area Index (LAI). Leaf area index was measured using the leaf - disc method (Watson, 1947) as modified by Bremner and Taha (1966) and reported by Ifenkwe (1975). The method involved the removal of leaves from the plant, determination of the total dry weight and of area/weight relationship of a sub-sample taken from a mass of leaves with a punch of known diameter. The cross-sectional area of the punch used in this study was 0.28 cm^2. Fifty (50) discs were taken from each sample and placed in envelopes for drying. The rest of the leaves along with the remains of the punched leaves were put into well labelled envelopes and dried in the moisture-extraction oven at 100° C for 48 hours. Leaf area index was then calculated as:

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$$LAI = \frac{Area\ of\ one\ disc\ x\ no\ of\ discs\ x\ total\ leaf\ dry\ wt.}{Dry\ weight\ of\ discs} \Big/ Land\ area\ occupied\ by\ sampled\ plant$$

Leaf Area Duration (LAD)

This was calculated by summing up the individual LAI values over the growing period (Watson, 1947).

Crop Growth Rate (CGR)

Crop growth rate, defined as the increase in dry weight of plant parts per unit time, was calculated in g m^{-2} $week^{-1}$ using Watson's (1952) formula as reported by Mukhopadhyay *et al.* (1990).

$$CGR = \frac{W_2 - W_1}{t_2 - t_1}$$

where W_1 and W_2 are plant dry weights at times t_1 and t_2, respectively.

Net Assimilation Rate (NAR)

Net assimilation rate, defined as the increase in dry weight per unit leaf area, per unit time was calculated in g m^{-2} $week^{-1}$ following Watson (1947) as cited by Mannan *et al.* (1992).

$$NAR = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{Log_e L_2 - Log_e L_1}{L_2 - L_1}$$

where W_1 and W_2 and L_1 and L_2 are total plant dry-weights and total leaf area at times t_1 and t_2, respectively.

Total Tuber Yield

The tubers were harvested at 150 DAP. All the tubers harvested from each net plot were weighed and the weight were extrapolated to the equivalent in tonnes per hectare before statistical analysis.

Data Analysis

Data collected were subjected to analysis of variance (ANOVA) and means were compared using the least significant difference (LSD) at 5% level of probability. Total tuber yield was correlated with LAI, LAD, CGR and NAR, using Spiegel's (1972) formula.

RESULTS

Leaf Area Index (LAI)

Leaf area index increased with crop age up to 80 DAP and declined thereafter (Table 1). Planting of terminal vine-cuttings resulted in the highest LAI, which differed significantly from that of the middle or basal vine-cuttings. At 80 DAP, the highest LAI was observed in the clone, TIS.2544 Rusanya1.5. This was significantly different ($P<0.05$) from the other clones.

A significant planting material and clone interaction on LAI was observed at all sampling dates (Table 1). At 40 DAP, the highest leaf area indices in the clones, TIS.2544 Rusanya 1.5 and TIS.87/0087 were observed when terminal vine-cuttings were planted whereas in the clones, TIS.2532.OP.1.13 and TIS.86/0356, the planting of middle vine-cuttings resulted in the highest leaf area indices. In the clone, CIP 4400168, the highest LAI was recorded when basal vine-cuttings were planted (Table 1).

At 80 DAP the highest leaf area indices in the clones, CIP 4400168, TIS.2544 Rusanya 1.5 and TIS.87/0087 were observed when terminal vine-cutting was used as planting material. But in the clones, TIS.2532.OP.1.13 and TIS.86/0356, the maximum leaf area indices were recorded when middle vine-cutting was planted (Table 1).

At 120 DAP, the highest leaf area indices were recorded for clones, TIS.86/0356 and TIS.87/0087 when terminal vine-cutting was planted. In the clones, CIP 4400168 and TIS.2532.OP.1.13, however, the highest leaf area indices were observed when middle vine-cuttings were planted. The planting of basal vine-cuttings in the clone TIS.2544 Rusanya 1.5 resulted in the highest LAI (Table 1).

Table1: Effects of Planting Material and Clone on Leaf Area Index (LAI) at (a) 40 (b) 80 and (c) 120 DAP in Sweet Potato.

(a)

	Planting Material			
Clone	Terminal	Middle	Basal	Mean
CIP 4400168	1.3	1.4	1.8	0.8
TIS.2532.OP.1.13	0.9	1.1	0.4	0.4
TIS.2544 Rusanya 1.5	2.8	1.2	1.3	0.9
TIS.86/0356	1.5	1.8	1.2	0.8
TIS.87/0087	1.1	0.9	0.7	0.5
Mean	0.8	0.6	0.5	

$LSD_{(0.05)}$ Planting = 0.2
Clone = 0.2
Planting material and clone = 0.4

b)

	Planting Material			
Clone	Terminal	Middle	Basal	Mean
CIP 4400168	29.1	12.9	8.7	8.5
TIS.2532.OP.1.13	3.3	7.0	6.1	2.7
TIS.2544 Rusanya 1.5	34.5	8.3	17.1	10.0
TIS.86/0356	12.9	21.1	6.2	6.7
TIS.87/0087	5.5	3.9	2.5	2.0
Mean	8.0	5.3	4.1	

$LSD_{(0.05)}$ Planting material = 2.7
Clone = 1.5
Planting Material and clone = 1.7

c)

Clone	Planting Material Terminal	Middle	Basal	Mean
CIP 4400168	5.2	12.0	3.8	3.5
TIS.2532.OP.1.13	1.4	5.2	3.4	1.7
TIS.2544 Rusanya 1.5	7.0	3.6	8.4	3.2
TIS.86/0356	6.0	4.7	2.3	2.2
TIS.87/0087	1.6	0.6	1.1	
Mean	2.1	2.6	1.9	

$LSD_{(0.05)}$ Planting material = 0.6
Clone = 0.8
Planting material clone = 1.4

Leaf Area Duration (LAD)

The planting of terminal vine-cuttings resulted in the highest LAD of 11.4 weeks, which was significantly different from those of the middle (8.6 weeks) and basal (6.5 weeks) vine-cuttings (Table 2). The clone, TIS.2544 Rusanya1.5 had the highest LAD (14.0 weeks), which differed significantly ($P<0.05$) from all but the clone, CIP 4400168 (Table 2).

The interaction of planting material and clone on LAD was observed to be significant. The use of terminal vine-cutting as planting material resulted in the highest leaf area duration in the clones, CIP 4400168, TIS.2544 Rusanya 1.5 and TIS.87/0087. In the clone, TIS.2532.OP.1.13, however, the highest leaf area duration was recorded when middle vine-cuttings were planted (Table 2).

Table 2: Effects of Planting Material and Clone on Leaf Area Duration (LAD) (weeks) in Sweet Potato.

Clone	Planting Material Terminal	Middle	Basal	Mean
CIP 4400168	35.6	26.3	14.3	12.7
TIS.2532.OP.1.13	5.6	13.3	9.9	4.8
TIS.2544 Rusanya 1.5	44.3	13.1	26.8	14.0
TIS.86/0356	20.4	27.6	9.7	9.6
TIS.87/0087	8.2	5.4	4.3	3.0
Mean	11.4	8.6	6.5	

$LSD_{(0.05)}$ Planting material and clone = 1.5
Clone = 2.0
Planting material and clone = 3.4

Crop Growth Rate (CGR)

Crop growth rate increased with crop age up to 80 DAP and thereafter decreased irrespective of the type of planting material or clone used (Table 3). The highest CGR was obtained by planting terminal vine-cuttings, which was significantly different from that of middle or basal vine-cuttings at 80 DAP. But at 120 DAP, the highest CGR was obtained by planting middle vine-cuttings. The clone, CIP 4400168 had the highest CGR at the early stages of growth whereas at the later stages the highest CGR was observed in the clone, TIS.2544 Rusanya 1.5 (Table 3).

Table 3: Main Effects of Planting Material and Clone on Crop Growth Rate (g m^{-2} $week^{-1}$) at Different Stages of Growth in Sweet Potato.

	Days After Planting		
Planting Material	**40**	**80**	**120**
Terminal	0.4	4.8	2.0
Middle	0.4	3.0	3.4
Basal	0.3	2.6	2.7
$LSD_{(0.05)}$	0.1	0.5	1.1
Clone			
CIP 4400168	0.5	4.1	2.7
TIS.2532.OP.1.13	0.2	2.2	2.7
TIS.2544 Rusanya 1.5	0.4	5.2	4.9
TIS.86/0356	0.4	4.0	1.7
TIS.87/0087	0.3	1.8	1.5
$LSD_{(0.05)}$	0.1	0.7	1.4

The interaction of planting material and clone on CGR was significant at 80 and 120 DAP. The highest CGRs in the clones, CIP 4400168, TIS.2544 Rusanya 1.5 and TIS.87/0087 were observed when terminal vine-cutting was planted. At 80 DAP; the highest CGR of 5.0g m^{-2} $week^{-1}$ was observed when basal vine-cutting was used as planting material in the clone, TIS.2532.OP.1.13. In the clone, TIS.86/0356, however, the planting of middle vine-cutting resulted in the highest CGR of 130.0g m^{-2} $week^{-1}$ (Table 4). At 120 DAP; the highest CGRs in the clones, CIP 4400168 and TIS.2532.OP.1.13 were observed when middle vine-cuttings were planted. The clones, TIS.2544 Rusanya 1.5 and TIS.87/0087 recorded the highest CGRs when basal vine-cuttings were planted. The highest CGR in the clone, TIS.86/0356 was observed when the terminal vine-cutting was used as planting material (Table 4).

Table 4: Effects of Planting Material and Clone on Crop Growth Rate (g m^{-2} $week^{-1}$) at (a) 80 and (b) 120 DAP in Sweet Potato.

a)

Clone	Planting Material: Terminal	Middle	Basal	Mean
CIP 4400168	13.0	7.0	4.5	4.1
TIS.2532.OP.1.13	4.0	4.0	5.0	2.3
TIS.2544 Rusanya 1.5	20.0	3.0	8.0	5.2
TIS.86/0356	6.0	13.0	5.0	4.0
TIS.87/0087	5.0	3.0	3.0	1.8
Mean	4.8	3.0	2.6	

$LSD_{(0.05)}$ Planting material = 0.5
Clone = 0.7
Planting material and clone = 1.1

b)

Clone	Planting Material: Terminal	Middle	Basal	Mean
CIP 4400168	3.8	11.2	1.0	2.7
TIS.2532.OP.1.13	6.6	8.2	1.6	2.7
TIS.2544 Rusanya 1.5	2.3	10.7	16.1	4.9
TIS.86/0356	4.6	3.5	1.8	1.7
TIS.87/0087	2.4	0.3	6.0	1.5
Mean	2.0	3.4	2.7	

$LSD_{(0.05)}$ Planting material = 1.1
Clone = 1.4
Planting material and clone = 2.4

Net Assimilation Rate (NAR)

Net assimilation rate decreased with crop age irrespective of the type of planting material or clone (Table 5). At the end of the growing season, the highest NAR was obtained by planting basal vine-cuttings, although the difference was not significant (P>0.05). Across the clones, CIP 4400168 recorded the highest NAR of 148.3 g m^{-2} $week^{-1}$ at 40 DAP, but at the later stages of growth the highest NAR was observed in the clone, TIS.2532.OP.1.13 (Table 5).

Table 5: Main Effects of Planting Material and Clone on Net Assimilation Rate (g m^{-2} $week^{-1}$)(X 10^{-5}) at Different Stages of Growth in Sweet Potato.

	Days After Planting: 40	80	120
Planting Material			
Terminal	130.0	55.1	30.3
Middle	134.0	41.7	29.1
Basal	134.0	51.9	38.1
$LSD_{(0.05)}$	19.4	14.6	13.9
Clone			
CIP 4400168	148.3	44.3	13.1
TIS.2532.OP.1.13	116.3	63.0	51.5
TIS.2544 Rusanya 1.5	122.3	42.3	37.1
TIS.86/0356	138.3	43.7	11.5
TIS.87/0087	139.3	54.5	49.4
$LSD_{(0.05)}$	25.0	18.9	17.9

The significant planting material and clone interaction was observed at 120 DAP. The highest NARs in the clones, TIS. 2532.OP.1.13 (193.0 gm^{-2} $week^{-1}$) and TIS.86/0356 (34.0 g m^{-2} $week^{-1}$) were observed when terminal vine-cuttings were planted, whereas in the clones, CIP 4400168 and TIS.2544 Rusanya 1.5, the planting of middle vine-cuttings resulted in the highest NAR. The clone, TIS.87/0087 recorded the highest NAR of 240.0 gm^{-2} $week^{-1}$ when basal vine-cuttings were planted (Table 6).

Table 6: Effects of Planting Material and Clone on Net Assimilation Rate (g m^{-2} $week^{-1}$) (x10^{-5}) at 120 DAP in Sweet Potato

Clone	Planting Material: Terminal	Middle	Basal	Mean
CIP 4400168	18.4	49.0	11.1	13.1
TIS.2532.OP.1.13	193.0	86.0	30.0	51.5
TIS.2544 Rusanya 1.5	9.7	126.0	87.0	37.1
TIS.86/0356	34.0	22.0	12.8	11.5
TIS.87/0087	48.0	8.4	240.0	49.4
Mean	30.3	29.1	38.1	

$LSD_{(0.05)}$ Planting material = 13.9

Clone = 1.4
Planting material and clone = 31 0

Total Tuber Yield

The highest total tuber yield of 6.6 t ha^{-1} was obtained by planting terminal vine-cuttings while the lowest (4.1 t ha^{-1}) was obtained by planting basal vine-cuttings and the difference (P<0.05) was significant (Table 7). The clone, TIS.2544 Rusanya1.5 recorded the highest tuber yield, which differed significantly (P<0.01) from the clones (Table 7).

Table 7: Main Effects of Planting Material and Clone on Total tuber Yield in Sweet Potato.

Planting Material	Total Tuber Yield (t ha^{-1})
Terminal	6.6
Middle	6.3
Basal	4.1
$LSD_{(0.05)}$	1.3
Clone	
CIP 4400168	6.4
TIS.2532.OP.1.13	3.3
TIS.2544 Rusanya 1.5	8.9
TIS.86/0356	5.1
TIS.87/0087	4.6
$LSD_{(0.05)}$	1.6

Coefficients of Correlation

Total tuber yield was positively correlated with LAI ($\hat{Y}$= -1.9160 + 1.3878X), LAD ($\hat{Y}$= -1.4779 + 1.8142X), CGR ($\hat{Y}$= -0.1053 + 0.6253X) and NAR ($\hat{Y}$= 132.5043 + 0.0755X). The relationship was significant for all the attributes except NAR (Table 8).

Table 8: Coefficients of Correlation of Total Tuber Yield with some Morphological traits

Parameter	Coefficient of Correlation (r)
Leaf Area Index	0.6776**
Leaf Area Duration	0.7030**
Crop Growth Rate	0.5967*
Net Assimilation Rate	0.0087^{ns}

* = Significant at P< 0.05
** = Significant at P< 0.01
ns = Not significant

DISCUSSION

The decline in LAI with crop age might be due to senescence and death of individual leaves during the period that followed the initiation of tuberous roots (Watson, 1952). Variations in total leaf area and hence LAI, depend on changes in the number of leaves and on their size, both of which change as the crop ages. The significant interaction of planting material and clone on LAI showed that the clones responded differently to the type of planting material. In the clone, TIS.2544 Rusanya 1.5, for example, the maximum LAI was recorded when terminal vine-cutting was planted, whereas, in the clone, TIS.86/0356, the highest LAI was recorded when basal vine-cutting was used as planting material. In the sweet potato, yield is dependent on dry matter production from the lead source. The larger the photosynthetic area, the higher the dry matter produced and made available for tuberous root growth. This might explain the very high positive relationship between LAI and total tuber yield in this study.

Leaf area duration was observed to be higher (11.4 weeks) when terminal vine-cutting was used than when basal cutting (6.5 weeks) was used. It has been noted (Watson, 1852) that if NAR remained constant, dry matter production of different crops would be proportional to LAD. Forbes and Watson (1992) noted that in crops such as sugar beet, which maintain LAI at around optimum levels for longer periods of time than cereals, yield is related not simply to LAI at any one time but to the product of LAI and the time for which it is maintained. It is no wonder, then, that the clone, TIS.2544 Rusanya 1.5 which recorded the highest LAD also produced the highest tuber yield.

Interaction of planting material and clone on CGR was also observed at 80 and 120 DAP. Agatha (1982) reported a linear increase in CGR and LAI up to 60 DAP in sweet potato. The decline in LAI after 80 DAP due to senescence and death of individual leaves might be responsible for the corresponding decrease in CGR. Forbes and Watson (1992) noted that yield in most crop plants is related to a high CGR, which in turn could be due to a high LAI or NAR or both. The clone, TIS.2544 Rusanya 1.5, which recorded maximum CGR at 80 and 120 DAP also produced the highest tuberous root yield, when compared to the other clones.

Net assimilation rate decreased with crop age across types of planting material and clones. At the end of the growing season, the highest NAR was observed by planting basal vine-cuttings and by using the clone, TIS.2532.OP.1.13. tsuno and Fujise (1963) observed that mutual shading resulting from prostrate arrangement of leaves in the sweet potato causes poor light penetration so that NAR decreases with an increase in total leaf area. In this study, planting of terminal and middle vine-cuttings resulted in higher LAI and hence lower NAR.

The planting of terminal vine-cutting resulted in the highest total tuber yield of 6.6 t ha^{-1} and this was followed by the middle and basal cuttings. The clone, TIS.2544 Rusanya1.5 produced the highest tuber yield of 8.9 t ha^{-1}. This result conformed with Mukhopadhyay *et al.* (1990) and Shanmugavelu *et al.* (1972) who reported highest tuberous root yields when terminal vine-cutting was used as planting material.

CONCLUSION

The results of this study showed that the growth response of the sweet potato to type of planting material varies with clone. Generally, however, there is a tendency for total tuber yield to be increased by using terminal vine-cutting as planting material.

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