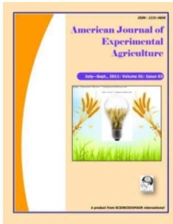

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Performance of Improved Sweet Potato (*Ipomea batatas* L.) Varieties in Makurdi, Southern Guinea Savanna of Nigeria

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Authors' contributions

This work was undertaken in collaboration between all authors. Author SOA designed the study, wrote the protocol and participated in data collection at final harvest. OME planted and managed the experiments, participated in data collection from growth to harvest, performed the statistical analysis, and wrote the first draft of the manuscript. JAI participated in planting, managed the analyses of the study and the literature searches. All authors read and approved the final manuscript and contributed to pay the journal page charges.

Research Article

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ABSTRACT

Aim: To investigate the performance of some improved sweet potato varieties obtained from the National Root Crops Research Institute (NRCRI), Umudike, Nigeria, for root yield and other yield components.
Study Design: Field experiment.
Place and Duration of Study: Teaching and Research Farm of the Federal University of Agriculture, Makurdi in Benue State, located in the Southern Guinea Savanna of Nigeria from June-November of 2010 and 2011.
Materials and Methods: The treatments comprised of eleven sweet potato varieties [CIP 440141, K134, NASPOT4, NASPOT2, SPK004, TIS87/0087(check), CIP440037, 1900411, NARSP/05/007C, CIP440293 (orange skin and flesh) and NARSP/05/022 (orange flesh)] set out in randomized complete block design with three replications. Ten farmers were used for the preference test of the varieties.
Results: Some vegetative growth parameters evaluated in the study (number of branches/plant, internodes length, number of leaves per plant and vine length) increased at different rates between 4 - 16 weeks after planting. Root diameter and length, number of

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saleable roots and weight varied with the varieties of sweet potato in Makurdi. NARSP/05/022 gave the highest number of leaves, number of roots (121817/ha) and weight (54151 kg/ha) at harvest, although it also had the highest incidence of sweet potato weevil infestation. This variety was the only one that had significantly higher saleable root weight than the check (TIS 87/0087). Saleable root weight correlated positively and significantly with number of saleable roots and root diameter.

Conclusion: Farmers will likely consider NARSP/05/022 for adoption despite the high weevil infestation. For reasons other than root yield (taste and colour), farmers may adopt CIP440293.

Keywords: Sweet potato; growth; saleable root; Makurdi.

1. INTRODUCTION

Sweet potato (*Ipomea batatas* L.) is adaptable to a broad range of agro-ecological conditions and fits into low-input agriculture. It is highly productive even under adverse farming conditions (Prakash, 1994).Sweet potato is cultivated in more than 100 countries as a valuable source of human food, animal feed and industrial raw material. The production, marketing and utilization of sweet potato have expanded in the last decade to almost all ecological zones of Nigeria (FAO, 2008). Nigeria is the single largest producer of sweet potato in Africa with 3.46 million metric tonnes and second only to China globally. In Benue State, Nigeria, approximately 212,840 ha was subjected to sweet potato production with a mean yield of 9800 kg/ha in 2008 (BNARDA, 2008). Sweet potato varieties exist in many colours of skin and flesh, ranging from white to deep purple, although white and yellow-orange flesh are the most common (Adam, 2005). Sweet potatoes are usually consumed without special processing. The fresh root is boiled, roasted, baked, or fried as chips, which may be sold as snacks or salted and eaten as sweet potato crisps in most parts of Nigeria. Sweet potatoes are fed to livestock or processed industrially into alcohol, starch, noodles, candy, desserts and flour. The sweet potato bears alternate heart-shaped or palmately-lobed leaves, which are not spared from being used as food. The young leaves are stir-fried as a leafy vegetable with chilli and minced dried shrimps (Wong, 2007; Tewe et al., 2003). Orange flesh sweet potatoes are rich in β – carotene (precursor of vitamin A). The strategy of increasing orange flesh sweet potato consumption helps to alleviate vitamin A deficiency (Anderson et al., 2007). The sweet potato varieties commonly grown by farmers in Southern Guinea Savanna zone of Nigeria is characterized with low yields (3000 - 9000 kg/ha) (BNARDA, 2007). Similarly, farmers in Makurdi location grow traditional white-coloured varieties of sweet potato which give equally low yields (3000 - 4000 kg/ha) (BNARDA, 2007). The work reported here was undertaken to investigate the performance of some sweet potato varieties obtained from the National Root Crops Research Institute (NRCRI), Umudike, Nigeria, with the sole aim of selecting the most adaptable variety (-ies) in this ecology, thereby ameliorating food shortages in the region.

2. MATERIALS AND METHODS

2.1 Study Area

A field experiment was conducted during the wet seasons (June-November) of 2010 and 2011 at the Teaching and Research Farm of the Federal University of Agriculture, Makurdi [latitude 07º45'-07º50'N, longtitude 08º45'-08º50'E, elevation 98 meters above sea level, masl] in Benue State, located in the Southern Guinea Savanna of Nigeria (Kowal and Knabe, 1972). The objective of the study was to evaluate the growth, yield and yield components of eleven sweet potato varieties obtained from the NRCRI, Nigeria. The experimental site received a total rainfall of 1115.3mm and 1211.4mm in 2010 and 2011, respectively.

2.2 Soil Sampling and Analysis

Ten core samples of soil were collected from different parts of the experimental field from a depth of 0-30 cm and bulked into a composite sample and used for the determination of the physical and chemical properties of the soil (Table 1) before planting. The soil of the experimental site was classified as Dystric Ustropept (USDA).

Table 1. Physical and chemical properties of the surface soil (0-30cm) at the experimental site in Makurdi in 2010 and 2011

Particulars	Values		Methods
	2010	2011	
Sand (%)	68.20	68.00	Hydrometer Method (Bouyoucos,1962)
Silt (%)	16.20	17.12	
Clay (%)	15.60	17.12	
Textural class	Sandy loam	Sandy loam	
pH (H_2O)	6.25	6.75	Glass Electrode pH Meter (Jackson, 1973).
Organic Carbon (g kg^{-1})	0.79	0.83	Improved Chromic Acid Digestion and Spectrophotometric Method (Heanes, 1984).
Organic matter(g kg^{-1})	1.37	1.42	Multiplying the organic carbon figure by 1.724
Total N (g kg^{-1})	0.19	0.20	Phenols Color Formation Method (Chaykin,1969)
Available P (cmol kg^{-1}) soil	8.33	8.31	Bray 1 Method (Bray and Kurtz,1945)
Ca^{2+} (cmol kg^{-1} soil	2.80	2.76	Method described by Jou (1983)
Mg^{2+} (cmol kg^{-1} soil)	1.25	1.32	Method described by Tel and Rao (1982).
K^{+} (cmol kg^{-1} soil)	0.41	0.36	Method described by Jou (1982).
Na^{+} (cmol kg^{-1} soil)	0.17	0.16	Flame photometer Method
CEC (cmol kg^{-1} soil	5.21	4.76	Summation Method

2.3 Treatments and Experimental Design

The treatments comprised sweet potato varieties [CIP440141, K134, NASPOT4, NASPOT2, SPK004, TIS 87/0087(check), CIP440037, 19004-11, NARSP/05/007C, CIP440293 (orange skin and flesh) and NARSP/05/022 (orange flesh)] set out in randomized complete block design with three replications.

2.4 Agronomic Practices

Land preparation was done manually with the aid of hoes and cutlasses. Ridges were constructed and spaced 1m apart. Gross plot consisted of four ridges, 3m long and the net plot was made up of the inner two ridges. Planting was done on 24^{th} of August in 2010 and 11^{th} of June, 2011. Sweet potato cuttings measuring 20 cm with at least four nodes were planted at the crest of the ridge at a spacing of 1m x 0.30m (33,000 plants/ha).Fertilizer was applied at land preparation by broadcasting at the rate of 300 kg NPK:15:15:15 per ha before splitting of the ridges as recommended by BNARDA (2003). Two manual weeding were done at 3 and 6 weeks after planting (w.a.p.) using traditional hoes. Earthening up was done from 8 w.a.p. until harvest, as the need arose.

2.5 Data Collection and Analysis

From 4 w.a.p. to 16 w.a.p., data on growth parameters (number of branches, nodes, internode and vine length per plant) were measured. The number of leaves/plant was also measured from 4 w.a.p.at monthly intervals until harvest. At harvest, data on the plant stand count, number of branches per plant, vine girth and length, root diameter and length, number and weight of fresh saleable root and fresh fodder weight were recorded. All data at harvest were collected from the net plot. Saleable roots were fresh roots ≥ 150g. Also at harvest, sweet potato weevil (*Cylas spp*.) infestation was scored on a scale of 0-5 as described by NRCRI (2008) as follows:

- 0- no infestation
- 1- very little portion of the roots infected
- 2- little portion of the roots infected
- 3- nearly half of the roots infected
- 4- more than half of the roots infected
- 5- entire roots infected

Ten farmers from a village called Pila, located near the experimental plot were invited to participate in the harvesting, cooking and “palatability” test in 2011.Farmers were told to make a choice of the most preferred, more preferred and the preferred variety (-ies) in terms of root yield, colour, taste and consistency (fluffiness).The interview was oral and conducted by the researchers.

Year x treatment interactions were not significant, so data for both years were pooled together and analyzed. The data generated were analyzed using the SAS, 2000, Statistical).Mean separation was by Duncan’s Multiple Range Test at 5% level of probability. Also, correlation of the saleable root weight with some of the other yield components was done.

3. RESULTS

3.1 Vegetative Growth (4 -16 w.a.p.)

All vegetative growth parameters evaluated in this study (number of branches/plant, internode length, number of leaves per plant and vine length) increased in size between 4 and16 w.a.p. (Figs. 1 - 4), but at different rates, as indicated by the steepness of the slope of the different trend lines. All these characters showed an upward trend of growth, even at the termination of the observation.

The number of branches per plant and internode length of sweet potato increased slowly from WK 4 (4 w.a.p.) to a maximum in WK 16 (Figs. 1 & 2). SPK 004 had the highest number of branches per plant (4.83) at 16 w.a.p., when the observation was terminated (Fig. 1). CIP440141 consistently had the longest internode from 4 - 16 w.a.p. Its internode length increased from 7.68 cm in WK4 to 10.65 cm in WK16. Vine length of all sweet potato varieties used in the study increased steadily from WK 4-WK16, although the rate of such increases depended on the variety. For example, while CIP TIS 87/0087 only increased from 245.5 cm in WK10 to 251.3 cm in WK16, NARSP/05/022 increased from 73.55 to 193.8 cm within the same period. Varieties K134, CIP440141 and 19004-11 produced the longest vines, right from WK8 through WK16 (Fig. 3). Fig. 4 shows that the number of leaves per plant of sweet potato varieties in WK16 was hardly below 250, except CIP440293, which had 227 leaves. Leaf production had began to decline in some varieties (e.g.,NASPOT2 and NASPOT4) by 12^{th} week after planting, but it continued to increase in the others (e.g., NARSP/05/022 and TIS 87/0087) until the 16^{th} week after planting. NASPOT4 produced significantly higher number of leaves than the other varieties at harvest (WK16), although this was comparable to leaves produced by TIS 87/0087, CIP440037 and NARSP/05/007C.

3.2 Plant Stand Count, Vine Length, Vine Girth, Branches/Plant and Fodder Weight of Sweet Potato at Harvest

There were no significant differences in the plant stand count of the sweet potato varieties in Makudi, but significant differences were observed between the varieties in the vine length, vine girth, branches/plant and the fodder weight obtained (Table 2). While CIP 440141 had the highest significant vine length per plant (456.12cm), NARSP/05/022 produced the lowest vine length (197.18cm) when compared to the other sweet potato varieties. Primary branches of sweet potato per plant varied from 3.83-4.83. SPK004 gave significantly higher number of branches per plant (4.83) than the other varieties of sweet potato in Makurdi, but NASPOT 2 and NASPOT 4 gave the least number of branches/plant (3.83). Varieties CIP 440037 and NARSP/05/022 produced higher vine girth (6.42cm) than the others. TIS 87/0087 gave the lowest vine girth (3.42cm). While NARSP/05/007C, TIS 87/0087 and NARSP/05/022 gave the highest significant fodder weight, the other varieties of sweet potato in Makurdi had similar values (Table 2).

3.3 Root Diameter and Length, Number and Weight of Saleable Roots

Root diameter and length, number of saleable roots and weight varied with the varieties of sweet potato in Makurdi (Table 3). Root diameter varied from 0.00 - 8.23cm. NARSP/05/022 gave the highest significant root diameter (8.23cm). CIP 440037, which had no root, along with NASPOT 2 had the lowest root diameter. NARSP/05/022 and CIP 440293 produced significantly higher root length and number of saleable root than all other varieties of potato in Makurdi, but NARSP/05/022 singularly had the highest significant saleable root weight (54,151kg/ha). Other varieties such as TIS 87/0087 and NARSP/05/007C had good root yield (15610.00 and 13933.30kg/ha, respectively) (Table 3). All the sweet potato varieties used in this study were attacked by the sweet potato weevil, except K134,NASPOT 2 and CIP 440037 (which produced no root)(Table3). NARSP/05/022 had the highest incidence of the weevil. Intensive and deep cracks were also observed on nearly all the roots of NARSP/05/022 that weighed above 150g.

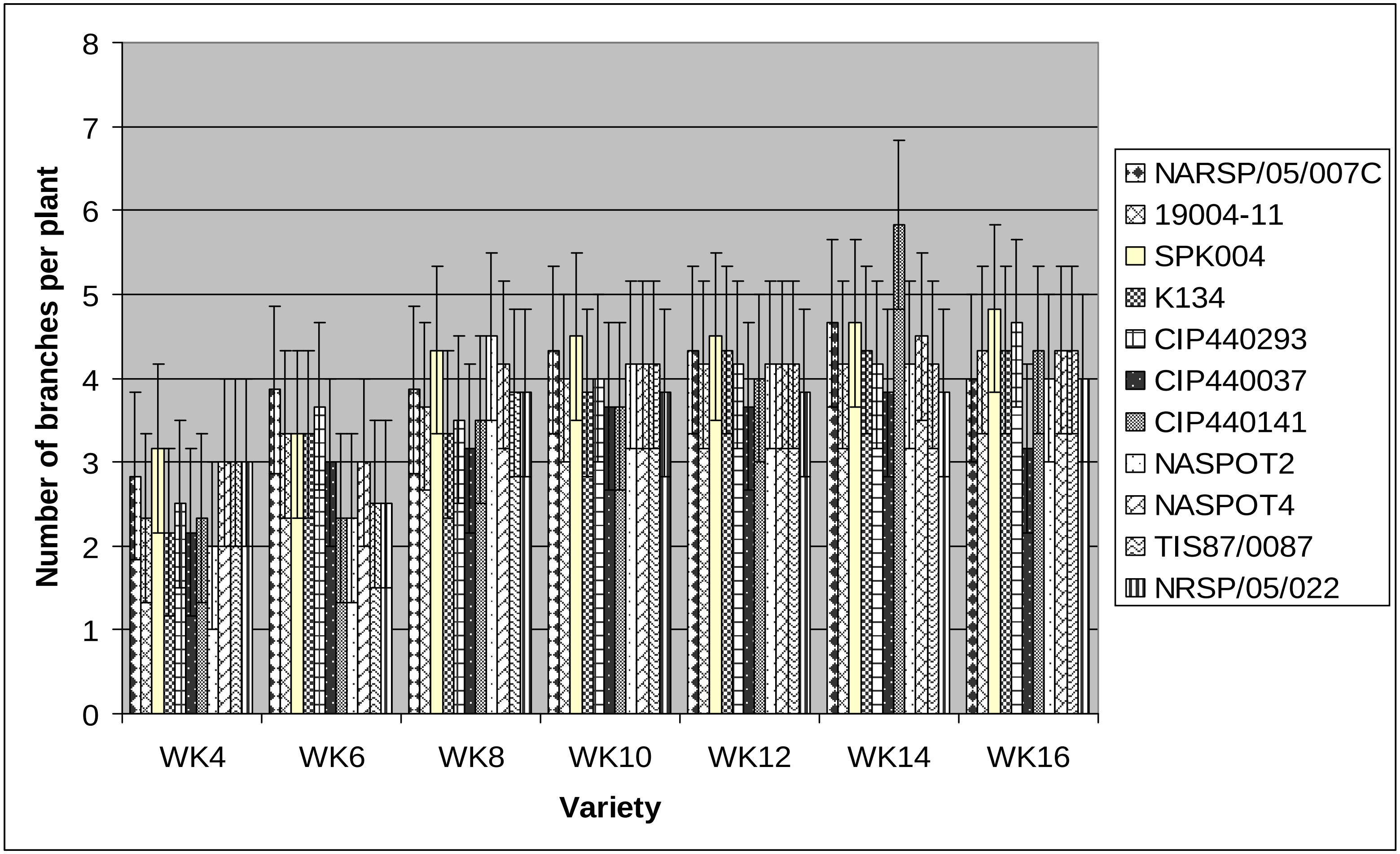

Fig. 1. Number of branches per plant of sweet potato varieties (Weeks 4-16) in Makurdi, Nigeria

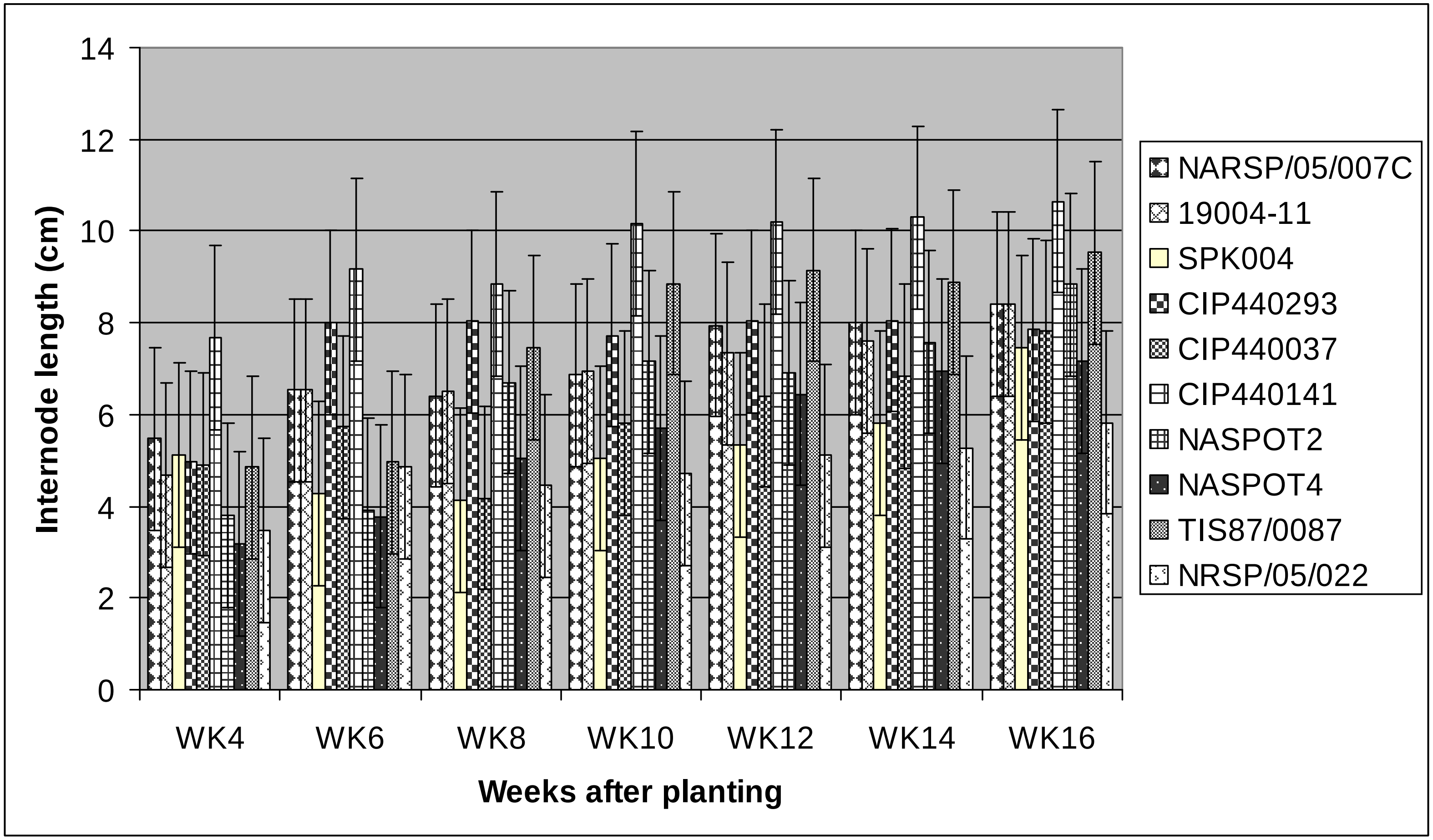

Fig. 2. Internode length of sweet potato varieties in Makurdi, Nigeria (Weeks 4-16)

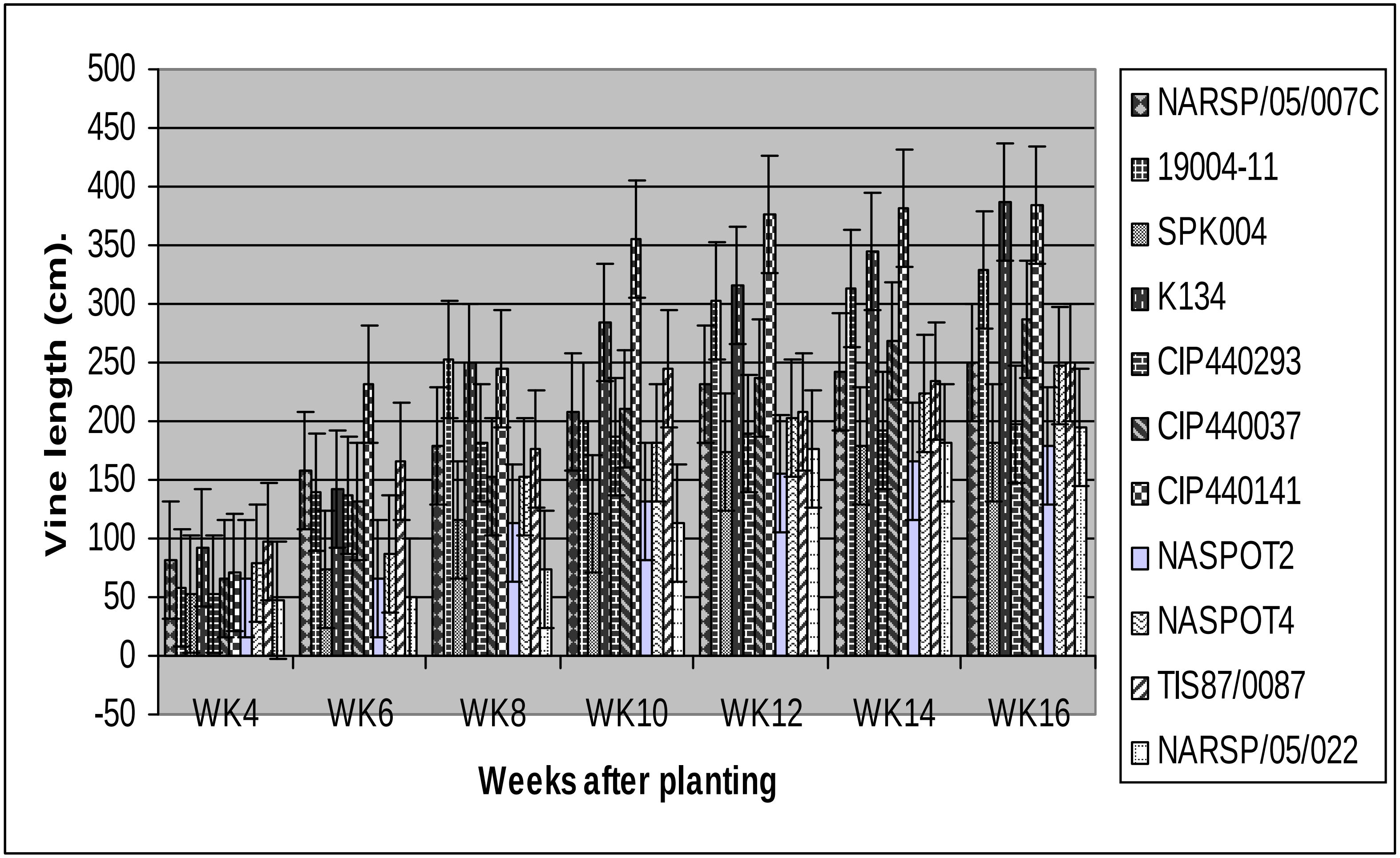

Fig. 3. Vine length (cm) of sweet potato varieties in Makurdi, Nigeria (Weeks 4 - 16)

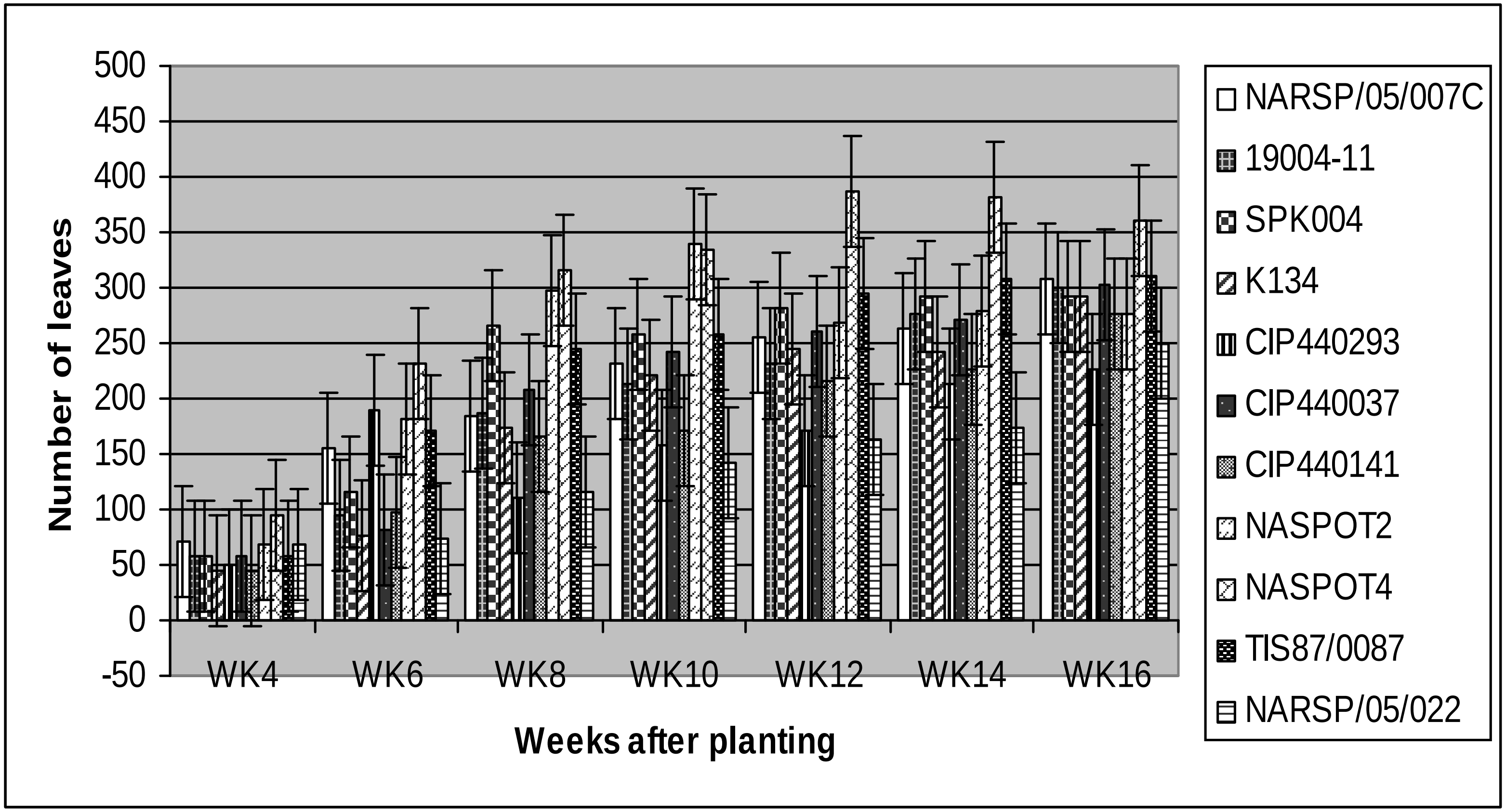

Fig. 4. Number of leaves per plant of sweet potato varieties in Makurdi, Nigeria (Weeks 4-harvest)

Table 2. Plant stand count/ha, vine length, branch/plant, vine girth and fresh fodder weight of sweet potato varieties at harvest in Makurdi

Variety	Plant stand count	Vine length (cm)	Branches/ plant	Vine girth (cm)	Fodder weight (kg/ha)
NARSP/05/007C	30444a	282.63bac	4.00ba	5.17ba	48083a
19004-11	29445a	326.35bac	4.33ba	4.33bc	33817ba
SPK004	31100a	216.23bc	4.83a	5.25ba	3430ba
K134	35443a	390.38ba	4.33ba	5.83ba	31638ba
CIP440293	29167a	302.87bac	4.67ba	5.25ba	13250b
CIP440037	29000a	286.52bac	4.33ba	6.42a	30100ba
CIP440141	30555a	456.12a	4.00ba	5.67ba	28805ba
NASPOT2	32712a	287.28bac	3.83b	5.08ba	55397a
NASPOT4	32100a	290.08bac	3.83b	5.50ba	41055ba
TIS 87/0087	28850a	294.68bac	4.33ba	3.42c	45300a
NARSP/05/022	33244a	197.18c	4.00ba	6.42a	51570a

Data followed by the same letter are not statistically different, according to Duncan's Multiple Range Test at 5% level of probability.

Table 3. Root diameter, root length, number of saleable roots/ha and weight of sweet potato varieties in Makurdi

Variety	Root diameter (cm)	Root length (cm)	Number of saleable roots	Saleable root weight (kg/ha)	*Cylas spp*. infection score
NARSP/05/007C	5.81dac	19.42ba	58349bc	13933.03ba	3
19004-11	3.85d	20.53a	33600dc	3034.70b	1
SPK004	5.59bdc	13.72bac	32333dc	1966.70b	1
K134	4.26dc	13.37bac	39876dc	1818.00b	0
CIP440293	6.54bac	21.42a	108417a	4675.00b	2
CIP440037	0.00e	0.00d	0d	0.00b	0
CIP440141	4.38dc	14.96ba	13037dc	467.60b	1
NASPOT2	0.80e	5.83dc	4642d	233.00b	0
NASPOT4	7.07ba	11.92bdc	23333dc	7442.50b	3
TIS 87/0087	6.90ba	19.18ba	90667ba	15610.30ba	2
NARSP/05/022	8.23a	21.67a	121817a	54151.00a	4

Data followed by the same letter are not statistically different, according to Duncan's Multiple Range Test at 5% level of probability.

3.4 Correlation Analysis

Saleable root weight correlated positively and significantly with number of saleable roots and root diameter (Table 4).The correlations of saleable root weight with the fresh fodder weight, root length, and vine girth were positive but not significant. Vine length and number of branches per plant were negatively correlated with saleable root weight in this study. Number of saleable roots were positively and highly correlated with root diameter and root length, but negatively correlated with fresh fodder weight, vine length and girth. The number of saleable roots had positive correlation with the number of branches per plant (Table 4).

Table 4. Correlation (Pearson coefficient) of saleable root weight (Salwt) of sweet potato with number of saleable root (No. sal root), fresh fodder weight (fodder weight), root diameter (Root dia), root length (Root len), vine length (Vinelen), vine girth (Vine girth) and number of branches per plant (Branch)

	Salwt	No. sal root	Fodder	Root dia	Root len	Vinelen	Vine girth	Branch
Salwt	1	r = .727*	r = .475	r = .626*	r = .489	r = -.539	r = .208	r = -.253
No.sal root	-	1	r = -.005	r = .772**	r = .780**	r = -.387	r = -.147	r = 0.221
Fodder	-	-	1	r = .022	r = -.062	r = -.405	r = -.124	r = -.658*
Root dia	-	-	-	1	r = .786	r = -.288	r = -.144	r = .083
Root len	-	-	-	-	1	r = -.063	r = -.382	r = .164
Vine len	-	-	-	-	-	1	r = -.053	r = -.163
Vine girth	-	-	-	-	-	-	1	r = -.168
Branch	-	-	-	-	-	-	-	1

**: Correlation is significant at the 0.05 level (2-tailed)*
***: Correlation is significant at 0.01 level (2-tailed).*

3.5 Farmers' Preferences

All the ten farmers involved in the test preferred CIP440293 to all the other varieties tested, including the high-yielding ones like NARSP/05/022, TIS 87/0087 and NARSP/05/007C. The ten farmers also indicated that they would prefer NARSP/05/022 to the local check (TIS 87/0087), despite its susceptibility to high weevil infestation.

4. DISCUSSION

The rainfall reported within the period of experimentation was considered adequate for crop growth and development. The increase in plant growth parameters measured (number of branches/plant, internode length, number of leaves per plant and vine length) over time as observed in this study were expected. Somda and Kays (1990) reported that during growth of sweet potato plant, substantial morphological changes occur and these influence the accumulation or distribution of the total dry matter among the major plant organs. As observed in this work, Tewe et al. (2003) stated that the duration and size of this increase will vary with the variety and environmental conditions. For example, the continual production of leaves in some of the varieties (NARSP/05/022 and TIS 87/0087) and the decline just before root maturation (NASPOT2 and NASPOT4) agreed with observation of Somda and Kays (1990). This implies that harvesting the leaves as vegetable will have to be monitored closely in order to do so at the most appropriate time depending on the locality and cuisines being contemplated. The variation in fresh fodder weight, number of branches, root diameter, root length, number of saleable roots and weight of sweet potato varieties at harvest in Makurdi was also to be expected, as genetic composition of these materials were probably different. Choudhary et al. (2000), Tewe et al. (2003) and Muktar et al. (2010) had observed wide variation among sweet potato varieties in most of the parameters (number of branches per plant, vine length, fresh fodder weight, saleable root yield) studied and attributed such differences to genetic composition. Saleable root yield (number and weight) is the most important parameter to the sweet potato farmers in Makurdi, as it is in most parts of the world. The results obtained in this work indicated that CIP440037 and NASPOT2 produced zero or very little root yield and would most likely not be considered for adoption by farmers in Makurdi. NARSP/05/022 gave the highest number and weight of saleable roots, although it also had the highest incidence of sweet potato weevil infestation. This variety was the only one that had significantly higher saleable root weight than the local check (TIS 87/0087), implying that the farmers may likely consider it for adoption despite the high weevil infestation, as early harvesting may reduce this problem. Although CIP440293 gave far less saleable root yield than NARSP/05/022, NARSP/05/007C and TIS 87/0087, farmers preferred it to these varieties (NARSP/05/022, NARSP/05/007C and TIS 87/0087) and several others (data not shown) because of its carrot-like colour and its fluffiness and taste when cooked. Although NASPOT2 produced very little root, its fresh fodder yield was quite considerable and could be grown for grazing animals. The significant positive correlation of saleable root weight with saleable root number and diameter as well as the positive correlation of saleable root with fresh fodder weight, root length and vine girth were similar to the results obtained by Anshebo et al. (2004) when 86 genotypes of sweet potato were subjected to genetic variability and correlation studies in Madras, India. Their studies showed that characters such as weight of a single root, girth of root, length of root and number of branches showed strong positive correlations with root yield. Their report also showed that length of vine exhibited a negative correlation with root weight as observed in this study. The implication of the result of correlation analysis of the eleven sweet potato tested in Makurdi is that selection of varieties for adoption could be based on the number of roots, root diameter, fresh fodder weight, root length and vine girth.

5. CONCLUSION

Eleven sweet potato varieties were tested in Makurdi for growth and yield. The sweet potato varieties varied in the number of branches/plant, internode length, number of leaves per plant, vine girth and length, root diameter, length, number and weight produced. NARSP/05/022 had the highest significant number and weight of saleable roots, although it recorded the highest incidence of potato weevil attack. There was a positive and significant correlation of saleable root weight with root number and diameter.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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