academicJournals

Vol. 13(5), pp. 651-656, 29 January, 2014
DOI: 10.5897/AJB2013.13200
ISSN 1684-5315 ©2014 Academic Journals
http://www.academicjournals.org/AJB

African Journal of Biotechnology

Full Length Research Paper

Assessment of growth and yield of some high-and low-cyanide cassava genotypes in acid ultisols of south eastern Nigeria

Okpara[1], D. A., Mbah[2], E. U. and Chukwu[1], E. I.

[1]Department of Agronomy, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.
[2]Department of Crop Production Technology, Federal College of Agriculture, P. M. B. 7008, Ishiagu, Ebonyi State, Nigeria.

Accepted 20 January, 2014

Thirty-eight high and low cyanide cassava genotypes were evaluated for growth and yield. The experiment was fitted in a randomized complete block design with three replications. Analysis of variance (ANOVA) revealed significant difference ($P \leq 0.05$) in growth and yield parameters, indicating strong genetic variations among the genotypes. Significant ($P \leq 0.05$) highest average storage root weight of 1.5 and 1.8 kg were obtained from TMS 94/0035 (high cyanide cassava genotype) and TMS 98/0505 (low cyanide cassava genotype), respectively. Correlation analyses indicated significant ($P \leq 0.05$) and positive associations between number of storage roots per plant, average storage root weight and root yield in the two types of cassava genotypes tested, indicating that the parameters are good indices that can be improved upon during breeding and selection to enhance root yield. Four high cyanide cassava genotypes (TMS 99/2123, TMS 96/1642, TMS 98/0068 and TMS 94/3200) were outstanding in fresh root yield performance. To improve fresh root yield in cassava, the inter-relationships among the various agronomic character of the cassava genotypes demands appropriate attention. The study gives more information on the improvement of fresh storage root yield of cassava.

Key words: High cyanide cassava genotypes, low cyanide cassava genotypes, correlations, growth, yield.

INTRODUCTION

In the humid and sub-humid topics, cassava, which is one of the most important food crops play a dominant role in the rural economy and food security of the people living there. The root crop is characterized by the presence of cyanoglycosides (linamarin and lotoaustralin), which make both the roots and leaves potentially toxic to man and animals (Padmaja, 1995). Two distinct cassava genotypes exists namely, the bitter (high cyanide) and sweet (low cyanide) genotypes and their performance in terms of growth, photosynthetic efficiency and yield vary greatly. Santana et al. (2002) in their physiological studies on cassava reported that the content and quantity of cyanoglycosides in cassava roots depend on the genotypes and the growth conditions the plants are exposed to such as drought and soil composition. Eke-Okoro (2000) assessed the photosynthetic efficiency and productivity of low and high cyanide cassava genotypes and reported that high cyanide cassava genotypes had better photosynthetic efficiency and higher storage root yield than low cyanide cassava genotypes. Also, cassava genotypes with profuse branching characters have the tendency to produce higher fresh root yield than the less branching types (Eke-Okoro et al., 2001).

The breeding and release of cassava varieties by the

*Corresponding author. E-mail: emmaukmbah@gmail.com.

Table 1. High- and low-cyanide cassava genotypes used in the study.

Cassava genotype	Level of cyanide in storage root
TMS 91/02324	High
TMS 92/0067	High
TMS 94/0026	High
TMS 94/0561	High
TMS 94/0039	High
TMS 95/0379	High
TMS 95/0166	High
TMS 96/0523	High
TMS 96/1632	High
TMS 96/1569	High
TMS 96/1642	High
TMS 96/1317	High
TMS 96/0603	High
TMS 97/4763	High
TMS 97/0211	High
TMS 97/3200	High
TMS 97/4779	High
TMS 98/0581	High
TMS 98/2226	High
TMS 98/0068	High
TMS 98/2101	High
TMS 98/0002	High
TMS 99/3073	High
TMS 99/2123	High
TMS 30572	High
TMS 82/0058	Low
TMS 92/0326	Low
TMS 92/0057	Low
TMS 92^{B}/0068	Low
TMS 97/4769	Low
TMS 97/0325	Low
TMS 97/6012	Low
TMS 98/0510	Low
TMS ^{m}98/0028	Low
TMS 98/0040	Low
TMS 98/0505	Low
TMS 4(2)1425	Low
TME 419	Low

National Root Crops Research Institute, Umudike and International Institute of Tropical Agriculture, Ibadan, Nigeria has necessitated the evaluation of the new cultivars for the purpose of advising farmers on their yield potentials. A number of researchers have stressed that tuber bulking and yield in cassava are determined by the characteristics of the genotype, assimilation supply of the plant and environmental factors (Cock, 1986; Akoroda, 2005; and IITA, 1990). Furthermore, Githunguri et al. (2004) reported that cassava cultivated under humid conditions with high rainfalls have higher tuberous root bulking ability and lower cyanogenic potential than those cultivated in drier conditions. In recent years, studies have been directed at improving fresh storage root yield of cassava, one of which involves the analysis of inter-relationship among important agronomic characters in high- and low-cyanide cassava genotypes and some of them include the works of Asante and Dixon (2002), Akinwale et al. (2011) and Mulualem and Ayenew (2012).

The purpose of the study therefore was to assess the effect of genotypic difference of high and low cyanide cassava on root yield and other related characters, assess the performance of the genotypes as basis for ascertaining their acceptability and recommendation to farmers in the humid agro-ecozone of south-eastern Nigeria. Also, to clarify the inter-relationship between storage root yield and other agronomic characters of the genotypes as to elicit information that can be useful in boosting root yield of cassava during breeding and selection.

MATERIALS AND METHODS

Thirty-eight high- and low-cyanide cassava genotypes were obtained from the germplasm unit of National Root Crops Research Institute, Umudike, Nigeria and used for the study (Table 1). The experiment was carried out at Michael Okpara University of Agriculture, Umudike, Research Farm (latitude 05° 29' N, longitude 07° 33' E, altitude 122 m) in the low-land humid tropics of south eastern Nigeria in 2004 and 2005 cropping seasons. The treatments were laid out in a randomized complete block design (RCBD) with three replications. The total annual rainfall was 1,911.4 mm (2004) and 2,064.8 mm (2005). The soil, which is a sandy loam classified as ultisol (Paleulstalt), had, at 0 – 20 cm depth a pH of 4.86 (1:2.5; Soil:Water), 1.62% organic matter; 0.56% total N; 26.0 mg/kg available P, which was high; 0.164 cmol/kg exchangeable K; and 0.34, 2.40 and 0.80 cmol/kg of Na, Ca and Mg, respectively.

The soil samples from the experimental plots were bulked, thoroughly mixed and then one composite sample obtained from which, a sub-sample was collected, air-dried and subjected to analyses in the laboratory. Soil pH was measured potentiametrically in a glass electrode in deionized water (pH water) at soil:water solution ratio of 1:2.5. Percentage organic matter was analysed using wet oxidation method by Walkley and Black (1934), while total nitrogen (N) was obtained by Microkjeldahl method of wet oxidation (Bremner, 1996). Available phosphorus was determined by calorimetric method (Olson and Sommers, 1982). Exchangeable potassium (K) and sodium (Na) were determined by Flamephoto-metory (Udo and Ogunwale, 1978), while calcium (Ca) and magnesium (Mg) were determined by ethylenediaminetetraacetate (EDTA) titration method (Olson and Sommers, 1982).

Twenty-five (25) cm long planting setts obtained from 12-month old matured cassava stems were planted at a spacing of 1 m apart on the crest of ridges spaced 1 m apart, which gave a plant population of 10,000 plants/ha. Each genotype occupied two rows of ridges measuring 20 m in length. A mixture of grammaxon (2 L/ha) and primextra (3 litres/ha) was applied to the field immediately after planting and two manual weeding regimes were carried out at 4 and 8 months after planting (MAP) to control weeds. N:P:K:Mg 12:12:17:2 fertilizer was applied at 1 MAP at the rate of 400 kg/ha.

Growth data were taken on plant height, number of stems per plant, number of internodes per plant and number of leaves per plant at 6 MAP. Yield data collected were on number of storage

Table 2. Growth and yield characters of twenty five high-cyanide cassava genotypes in 2004 and 2005 cropping seasons.

Cassava genotypes	Plant height (m)	Number of stems/ plant	Number of inter-nodes/ plant	Number of leaves/ plant	Number of storage roots/ plant	Average storage root weight (kg)	Fresh storage root yield (t/ha)
TMS 91/02324	2.1	2.3	280.0	71.7	4.2	0.5	45.8
TMS 92/0067	1.4	1.7	265.0	71.0	4.5	0.6	28.5
TMS 94/0026	1.7	1.3	290.3	85.7	45	0.5	23.7
TMS 94/0561	1.6	1.0	366.3	231.0	3.5	0.8	27.3
TMS 94/0039	1.6	1.6	195.0	56.0	3.6	1.5	49.0
TMS 95/0379	1.3	2.0	298.3	101.0	3.8	0.6	24.0
TMS 95/0166	1.2	2.3	316.3	93.7	4.0	1.0	38.0
TMS 96/0523	1.8	1.7	295.7	124.0	5.5	0.9	42.5
TMS 96/1632	1.8	1.1	270.0	137.7	5.0	0.9	42.7
TMS 96/1569	1.8	1.3	444.0	294.7	4.8	1.0	47.7
TMS 96/1642	2.1	1.0	373.7	168.7	6.5	0.8	54.4
TMS 96/1317	2.1	2.6	298.3	69.0	3.5	0.7	25.7
TMS 96/0603	2.0	2.3	347.7	153.7	4.5	0.5	25.1
TMS 97/4763	1.7	1.3	319.7	279.7	4.2	0.9	26.6
TMS 97/0211	1.5	1.0	405.0	232.3	3.7	1.1	39.3
TMS 97/3200	2.1	2.0	438.7	288.7	4.3	1.2	50.6
TMS 97/4779	2.3	2.0	349.3	176.7	6.0	0.7	40.6
TMS 98/0581	2.3	2.0	221.7	52.0	4.2	0.8	34.1
TMS 98/2226	1.7	1.0	286.3	134.7	3.5	0.9	29.1
TMS 98/0068	2.0	2.0	359.0	251.7	6.4	0.8	52.0
TMS 98/2101	1.5	2.0	360.0	205.7	4.2	0.9	37.4
TMS 98/0002	1.3	2.0	361.0	166.0	4.0	0.8	32.7
TMS 99/3073	1.3	2.0	202.0	152.0	4.5	0.7	31.3
TMS 99/2123	2.3	1.3	402.0	212.0	5.5	1.1	63.4
TMS30572	1.4	1.7	347.3	283.7	4.2	0.6	25.6
$LSD_{0.05}$	0.3	0.7	87.0	95.3	1.9	0.4	17.9

roots per plant, average storage root weight (kg) and fresh storage root yield (t/ha) at 12 MAP. Analysis of variance (ANOVA) was performed on growth and yield related traits following the procedure outlined for randomized complete block design (Steel et al., 1997). Data were also subjected to simple and partial correlation and regression analyses using SPSS statistical package for windows version 17.0 (2010). Mean separation was done using least significant difference (LSD) at 5% probability level according to Obi and Obi (2002).

RESULTS AND DISCUSSION

The ANOVA revealed that there was significant difference ($P \leq 0.05$) among the cassava genotypes in all the plant characters assessed such as plant height, number of stems per plant, number of internodes per plant, number of leaves per plant, number of storage roots per plant, average storage root weight and fresh storage root yield (t/ha) (Table 2), indicating the presence of genetic differences. Plant height, number of stems per plant, number of internodes per plant and number of leaves per plant ranged between 1.20 and 2.30, 1.0 and 2.6, 195.0 and 444.0 as well as 52.0 and 288.7, respectively.

TMS 99/2123, TMS 98/0581, and TMS 97/4779 cassava genotypes were significantly ($P \leq 0.05$) taller compared with the other genotypes except TMS 91/02324, TMS 96/1642, TMS 97/3200, TMS 96/1317, TMS 98/0068 and TMS 96/0603 while TMS 98/0581 significantly ($P > 0.05$) had the lowest number of leaves per plant (52.0) relative to the other cassava genotypes. TMS 96/1569 had significantly highest number of internodes per plant (444.0) followed by TMS 97/3200 (438.7), which also had significantly highest number of leaves per plant, while TMS 96/1317 gave the highest number of stems per plant (2.6) relative to the other high cyanide cassava varieties. The results obtained corroborated studies by Okonkwo (2002) on evaluation of cassava genotypes for yield and biotic stress in which he reported significant differences in plant height and other growth parameters between cassava genotypes.

In high cyanide cassava genotypes, number of storages roots per plant, average storage root weight (kg) and fresh storage root yield (t/ha) ranged from 3.5 – 6.5, 0.5–1.5 kg and 23.7 – 63.4 t/ha, respectively. TMS 96/1642 gave the highest ($P \leq 0.05$) number of storage roots per

Table 3. Growth and yield characters of thirteen low-cyanide cassava genotypes in 2004 and 2005 cropping seasons.

Cassava genotype	Plant height (m)	Number of stems/plant	Number of inter-nodes/plant	Number of leaves/plant	Number of storage roots/plant	Average storage root weight (kg)	Fresh storage root yield (t/ha)
TMS 82/0058	2.2	2.0	300.3	111.0	3.0	0.7	22.3
TMS 92/0326	2.2	2.3	392.0	213.7	4.3	1.1	44.0
TMS 92/0057	1.6	1.0	448.0	267.7	4.5	1.2	56.0
TMS 92^B/0068	2.3	2.0	238.3	102.6	5.2	1.7	37.1
TMS 97/4769	1.7	1.3	304.3	231.0	3.8	0.7	25.0
TMS 97/0325	1.1	1.0	188.0	84.3	4.0	1.2	36.7
TMS 97/6012	3.0	1.3	240.7	45.7	3.3	1.0	32.1
TMS 98/0510	1.7	1.7	234.3	87.0	2.8	0.9	26.0
TMS ^{m}98/0028	1.6	1.3	493.0	377.0	5.0	1.1	54.0
TMS 98/0040	2.3	1.7	281.0	148.0	4.0	1.0	46.7
TMS 98/0505	2.1	2.0	548.0	301.3	3.5	1.8	60.7
TMS 4(2)1425	1.4	2.3	427.0	168.3	3.7	1.1	29.3
TME 419	2.7	2.0	217.3	48.0	4.0	1.3	43.7
$LSD_{0.05}$	0.4	0.7	61.6	64.8	ns	0.5	ns

plant (6.5) but had very low average storage root weight (0.8 kg) compared to the other genotypes assessed, while TMS 98/2226, TMS 94/0561 and TMS 96/1317 with the lowest (3.5) number of storage roots per plant also had very low average storage root weight. Data on fresh storage root yield indicated significant difference ($P \leq 0.05$) in the yield of TMS 99/2123 (63.4 t/ha) relative to the other cassava genotypes except TMS 96/1642 (54.4 t/ha), TMS 98/0068 (52.0 t/ha) and TMS 97/3200 (50.6 t/ha). The yield results obtained were higher compared with yields obtained from similar works by Eke-Okoro (2000) on evaluation of photosynthetic efficiency and productivity of sweet and bitter cassava varieties in the humid tropics as well as Okonkwo (2002) on some cassava genotypes in the cool highlands of Jos Plateau, Nigeria.

Table 3 shows that there was significant difference ($P \leq 0.05$) among the low cyanide cassava genotypes for plant height, number of stems per plant, number of inter-nodes per plant, number of leaves per plant and average storage root weight. TMS 99/6012 significantly ($P \leq 0.05$) exhibited the highest value for plant height (3.0 m) but had lowest number of leaves per plant (45.7) compared to the other genotypes. The differences in number of stems per plant and number of internodes per plant were significant ($P \leq 0.05$). TMS 98/0505 produced the highest number of internodes per plant (548.0), which was higher by 65.7% relative to TMS 97/0325, which had the lowest number of internodes per plant (188.0), while TMS 4(2)1425 and TMS 92/0326 exhibited the highest values of 2.3 stems per plant. TMS ^{TM}98/0028 had the highest number of leaves per plant while TMS 98/0505, TMS 92/0057 TMS 97/4769, and TMS 92/0326 were intermediate. The other genotypes exhibited the lowest values. These findings were in consonance with studies by Naskar et al. (1989) in which they surmised that differences in growth parameters could be basically due to high genetic variability among cassava genotypes, though environmental factors may also be considered. The number of storage roots per plant and fresh storage yield among low cyanide genotypes did not differ statistically ($P>0.05$). However, average storage root weight was significantly ($P \leq 0.05$) highest in TMS 98/0505 (1.8 kg), followed by TMS 92^B/0068 (1.7 kg), while lowest values were obtained in TMS 97/4769 and TMS 82/0058 (0.7 kg).

The correlation between fresh storage root yield and the plant characters studied showed significant ($P \leq 0.05$) and positive relationship between number of storage roots per plant and fresh storage root yield with correlation coefficients (r) of (0.59) as well as between average storage root weight and storage root yield with (r = 0.58) in high cyanide cassava genotypes, an indication that these yield parameters are good indices that can be improved upon to boost cassava storage crop yield during breeding and selection (Table 4). The other parameters (plant height, number of stems per plant, number of internodes per plant and number of leaves per plant) did not show any correlated response with storage root yield of cassava. In low cyanide cassava genotypes, number of leaves per plant, number of internodes per plant and number of tubers per plant were significantly ($P \leq 0.05$) correlated with fresh storage root yield while average storage root weight had highly significant ($P \leq 0.01$) correlation with fresh storage root yield of cassava with (r = 0.74) (Table 5). These parameters demand close attention in breeding for improved storage root yield. Similar studies by Amadi et al. (2008) on potato genotypes showed that tuber number and average tuber weight are major individual contributors to crop yield.

Table 6 shows that analysing the plant characters using the method of partial correlation coefficients further highlighted the importance of average storage root weight and number of storage roots per plant with correlation

Table 4. Simple correlation matrix for the relationship between high-cyanide cassava genotype characters.

Plant character	Plant height (cm)	Number of stems/plant	Number of inter-nodes/plant	Number of leaves/plant	Number of storage roots/plant	Average storage root weight (kg)
Number of stems/plant	0.06 ns					
Number of inter-nodes/plant	0.19 ns	-0.20				
Number of leaves/plant	0.22ns	-0.33	0.77**			
Number of storage roots/plant	0.49 ns	0.18ns	0.25 ns	0.22 ns		
Average storage root weight (kg)	0.01 ns	-0.30	0.15 ns	0.22 ns	-0.09	
Fresh storage root yield(t/ha)	0.48 ns	-0.16	0.34 ns	0.22 ns	0.59*	0.58*

*, Significant at 5 % level of probability; **, significant at 1 % level of probability; ns, non-significant.

Table 5. Simple correlation matrix for the relationship between low-cyanide cassava genotype characters.

Plant character	Plant height (cm)	Number of stems/ plant	Number of inter-nodes/ plant	Number of leaves/ plant	Number of storage roots/ plant	Average storage root weight (kg)
Number of stems/plant	0.32ns					
Number of inter-nodes/plant	-0.25	-0.14				
Number of leaves/plant	-0.40	-0.13	-0.21			
Number of storage roots/plant	-0.12	-0.13	0.21 ns	0.40 ns		
Average storage root weight (kg)	-0.04	0.05 ns	0.53*	0.34 ns	0.01 ns	
Fresh storage root yield (t/ha)	0.02 ns	-0.12	0.62*	0.61*	0.52*	0.74**

*, Significant at 5 % level of probability; **, significant at 1 % level of probability; ns, non-significant.

Table 6. Partial correlation coefficients between fresh storage root yield of cassava and six agronomic characters of high- and low-cyanide cassava genotypes.

Plant attributes	Yield (t/ha)	Partial Correlation coefficients (r)	
		HC	LC
Plant height (cm)	Fresh storage root	0.28ns	0.61*
Number of stems/plant	Fresh storage root	0.13ns	-0.33ns
Number of internodes/plant	Fresh storage root	0.33 ns	-0.04ns
Number of leaves/plant	Fresh storage root	0.29ns	-0.32 ns
Number of storage roots/plant	Fresh storage root	0.73**	0.76 **
Average storage root weight (Kg/plant)	Fresh storage root	0.81**	0.87**

*, Significant at 5 % level of probability; **, significant at 1 % level of probability; ns, non-significant; HC, high cyanide cassava genotypes; LC, low cyanide cassava genotypes.

coefficients (partial r) of 0.81 and 0.73, respectively, for high cyanide cassava genotypes, as well as 0.87 and 0.76, respectively for low-cyanide cassava genotypes as vital characters that contributed greatly to storage root yield of cassava. Similar studies by Ntawuruhunga et al. (2001) on twenty broad-based cassava genotypes in the forest savanna, northern and southern guinea savanna as well as Sudan savanna agro-ecozones of Nigeria indicated increased storage root yield of cassava, which was mainly due to increase in number of storage roots per plant as well as individual storage root weight of the tested genotypes. This implies that for breeding and selection, premium should be placed on increasing the number of storage roots per plant and weight of average storage root in other to obtain higher root yield in both high- and low-cyanide cassava genotypes.

Conclusion

The results showed that among the thirty-eight high and low cyanide cassava genotype tested, four high cyanide cassava genotypes (TMS 99/2123, TMS 96/1642, TMS ^{m}98/0068 and TMS 97/3200) were outstanding in fresh storage root yield performance, hence can be considered for recommendation to farmers in the humid agro-eco-zone of southeastern Nigeria. Furthermore, the correlation studies specifically reviewed the inter-relationships among the various agronomic character of the cassava genotypes, which indicated that cassava selection programmes based on number of storage roots per plant and average weight of storage root, demands appropriate attention, especially when the challenge is aimed at improving fresh storage root yield in cassava.

REFERENCES

Akinwale MG, Akinyele BO, Odiyi AC, Dixion AGO (2011). Genotype X environment interaction and yield performance of 43 improved cassaa (*Manihot esculenta* Crantz) genotypes at three agro-climatic zones in Nigeria. Br. Biotechnol. J. 1 (3): 68 – 84.

Akoroda MO (2005). Root Crops. Institute of Agricultural Research, Ngaounudere, Cameroon. p. 537.

Amadi CO, Ene-Obong EE, Okonkwo JC, Lenka DM (2008). Preliminary studies on yield and some yield attributes of potato grown under high and low ambient temperatures. Niger. Agric. J. 39 (1): 65 -75.

Asante K, Dixon AGO (2002). Heritability studies of some cassava genotypes. West Afr. J. Appl. Ecol. 3: 49 – 53.

Bremner JM (1996). Nitrogen-Total. In: Spark, DL (ed). Methods of soil analysis. Part 3, chemical method. 2nd ed. SSSA Book Series. No. 5. SSSA Madison, W. I. pp. 1085 – 1121.

Cock JH (1986). Cassava: Its calories can overcome malnutrition. International Center for Tropical Agriculture (CIAT), Cali Colombia, Topic. 147: 30-33.

Eke-Okoro ON (2000). Evaluation of photosynthetic efficiency and productivity of sweet and bitter cassava cultivars. J. Sustain. Agric. Environ. 3 (1): 165 – 170.

Eke-Okoro ON, Okereke OU, Okeke JE (2001). Effect of stem sizes on some growth indices and yield of three cassava cultivars. J. Agric. Sci. Camb. 37: 419 – 426.

Githunguri CM, Kanayake IJ, Waithaka K (2004). Effect of the growth environment and bulking rate on cyanogenic potential of cassava tuberous roots. Agric. Res. Inst. Nairobi (Kenya). Proc. 8th KARI Biennial Sci. Conf. held 11th – 15th November. pp. 151 - 157.

IITA (International Institute of Tropical Agriculture) (1990). Cassava in Topical Africa, IITA. Cassava Reference Manual, Chayce Publication Services, UK. p. 196.

Mulualem T, Ayenew B (2012). Cassava (Mannihot esculenta Crantz) varieties and Harvesting Stages Influenced Yield and Yield Related Components. J. Nat. Sci. Res. 2(10): 122 - 128.

Naskar SK, Singh DP, Srinivasan G (1989). Performance of cassava varieties in the laterite soils of Bhubaneswar and their yield stability. J. Root Crops 15: 29 - 31.

Ntawuruhunga P, Rubaihayo PR, Whye JBA, Dizon AGO, Osiru DSO (2001). Inter-relationship, among traits and path analysis for yield components of cassava. A search for storage root yield indicators. Afr. Crop Sci. J. 9 (4): 599 - 606.

Obi IU, Obi E (2002). Statistical Methods of Detecting Difference Between Treatment Means and Research Methodology. Issues in Laboratory and Field Experiments, (ed. 2nd) p. 117.

Okonkwo JC (2002). Evaluation of cassava genotypes for yield and response to biotic stress in Jos Plateau. J. Sustain. Agric. Environ. 4 (1): 29 – 35.

Olson SR, Sommers LE (1982). Phosphorus. In: Page AL (ed). Method of Soil Analysis. Part 2, Argon. Monogr. No. 9. Madison, W. I., pp. 403 – 431.

Padmaja G (1995). Cyanide detoxification in cassava for food and feed uses. Crit. Rev. Food Sci. Nutr. 35: 299 – 339.

Santana MA, Vasquez V, Matehu J, Aldao RR (2002). Linamarase expression in cassava cultivars with roots of low- and high- cyanide content. Plant Physiol. 129 (4): 1686 – 1694.

SPSS Statistical Package for Windows (2010). SPSS for windows. Release 17.0 Standard Version.

Steel RDG, Torrie JH, Dickey DA (1997). Principles and Procedures of Statistics: A Biometrical Approach. 3rd ed.McGraw-Hill. p. 666.

Udo EJ, Ogunwale JA (1978). Laboratory manual for analysis of soil and water samples. Department of Agronomy, University of Ibadan, pp. 87 – 99.

Walkley A, Black AI (1934). In: Examination of the Degtaga-reff. Methods of determining soil organic matter and a proposed modification of the chronic acid titration method. Soil Sci. 37: 29 – 38.