Selection Criteria for Stem and Tuber Yields in Cassava (*Manihot esculenta* Crantz)

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ABSTRACT: Five cassava genotypes; NR 419, 98/0505, TMS 30572, 97/4763 and TMS 30211 were evaluated at two locations in Calabar, Cross River State and Obio Akpa in Akwa Ibom State, Nigeria. Variations were observed on some agronomic characteristics such as the number of nodes/stem, stem length, stem width, stem weight, number of stem/stand and root tuber yield except number of branches. Pooled data analysis of the variance components showed significant variation in both environmental and genotypic effect especially in number of nodes/stem and number of stems/stand. The estimate of genetic variability of the agronomic characteristics showed that the number of stems/stand and number of nodes/stem showed maximum genotypic and phenotypic variations in all the genotypes. These indicated that the two characters offered considerable scope for improvement and combination of high genotypic and phenotypic coefficient proffers effective selection criteria. Estimate of heritability and genetic advance for number of nodes/stem (71%), number of stems/stand (51%) and stem length (45%) were high compared with other characters. Linear correlation analysis showed that the number of nodes/stem correlated positively and significantly (r = 0.794 and 0.788) with stem length and number per stand. There was direct correlation between the number of stem per stand and root tuber yield. High heritability value coupled with high genetic advance and positive correlation indicated the effectiveness of direct selection through stems/stand and root tuber yield.

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1. INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is cultivated in over 90 countries and provides a livelihood for half a billion people in the developing world. It is Africa's second most important staple after maize in terms of per capita calories consumed and also a major source of calories for roughly two out of every five Africans. (Nweke et al 2002)

It is estimated that cassava provides about 40% of all calories consumed in Africa (IITA, 1990). The fresh foliage is used as the sole source of protein and fibre for supplementing a liquid diet of molasses-urea for fattening cattle and goats. Cassava starch has wide applications in industry. Cassava is used extensively in the manufacture of adhesive, dextrines and pastes and as filler in the manufacture of paints. It plays an important role in terms of food security, employment creation and income generation for farm families in parts of the humid tropics where hunger and starvation prevail. Ugwu and Ukpabi (2000) stated that farmers generally realize a higher income from cassava production than from the production of most other staple. In some countries, cassava is consumed daily, and sometimes more than once per day.

Global production of cassava is put at 152 million tonnes per year. Half of the 16 million hectares devoted to cassava cultivation in the world is in Africa with 30 percent in Asia and 20 percent in Latin America. Nigeria is the world's largest producer of cassava (FAO, 2002) and it production is currently put at about 34 million tonnes. The average yield of cassava on the field worldwide is about 9.6 tonnes/ha, which is less than yields of sweet potato and yams. The low yield of cassava could be attributed to cultivation of traditional varieties and management practices by farmers which give low levels of output (FAO, 1989).

Cassava production in Africa is characterized by poor production system and unstable yields; even though several improved varieties of cassava have been recommended and released to farmers. The yield of cassava per unit area may be improved through selection using existing genetic variability in the breeding materials and positive/negative effects of characters on the dependent character (yield). The purpose of this study therefore was to determine the selection criteria for improvement of stem and tuber yields in cassava.

2. MATERIALS AND METHODS

The research work was carried out in two locations; University of Calabar Teaching and Research Farm, Calabar, Cross River State and Teaching and Research Farm of the College of Agriculture, Obio Akpa, Akwa Ibom State in 2007/2008 cropping seasons. These locations are in tropical rain forest ecological zone. Calabar lies at latitude 4^0.96' N of the equator and longitude 8^0.3' E with bimodal annual rainfall ranging from 3500mm-5000mm and average monthly temperature of 25^0C to 27^0C. Obio Akpa lies between latitude 4^0.31' and 5^0.30' N and longitude 8^0. 36' and 8^0.0 E. It has a bimodal annual rainfall ranging from 2500mm to 3,000mm. The annual temperature range is 24^0C to 30^0C. (SLUS – AK, 1989).

The cassava planting materials were obtained from the National Root Crop Research Institute, (NRCRI), Umudike, Nigeria. These included TMS 30572, TM 30211, 98/0505, 97/4763 and NR 419. The experimental design was randomized complete block design. A three-row plot of 3m X 5m ($15m^2$) was maintained in three replications. A plant spacing of 1m X 1m at one cutting per stand was used. Cultural practices such as hoe weeding was carried out twice and fertilizer (NPK 15:15:15) was applied at the rate of 400kg/ha at 4 weeks after planting (WAP).

Data were collected on six plants sampled from each plot in all the replicates and assessed for the following agronomic characteristics; stem length, stem weight, number of nodes/stem, stems/stand, stem width, branching habit and root tuber yield. The data generated were subjected to analysis of variance (ANOVA) as described by Snedecor and Cochran (1980) and significant differences among treatment means were separated using DMRT at P=0.05. Genetic analysis for the genotypic and phenotypic coefficient of variability of the agronomics traits were carried out using the formula suggested by Singh and Chaudhary (1995) and broad sense heritability (h^2) according Hanson et al (1956).

$$\text{GCV (\%)} = \frac{\sqrt{\delta^2 g}}{X} \times 100$$

$$\text{PCV (\%)} = \frac{\sqrt{\delta^2 ph}}{X} \times 100$$

Where

$\delta^2 g$ = genetic variation

$\delta^2 ph$ = phenotypic variation

X = population mean

Broad sense heritability (h^2)

$$h^2 = \frac{\delta^2 g}{\delta^2 ph} = \frac{\delta^2 g}{\delta^2 e + \delta^2 g}$$

Genetic Advance (G.A) as % of the mean

$$G.A = \frac{\delta^2 g}{\delta^2 ph} \times \frac{100}{X}$$

Where X = general mean of a triat

Correlation coefficient: This was calculated using the formula below:

$$Rxy = \frac{CoV(x,y)}{\sqrt{v(x) \cdot v(y)}}$$

Rxy = the correlation coefficient between x and y

CoV (x,y)= is the co-variance between x and y

V(x) = is the variance of x

V(y) = is the variance of y

3. RESULTS

Field evaluation of five cassava genotypes at two locations; Calabar in Cross River State and Obio Akpa in Akwa Ibom State, Nigeria, showed some degree of variability in number of nodes/stem, stem length, stem width, stem weight, number of stems/stand, number of branches and root tuber yield. There were significant differences (P = 0.05) in all parameters considered at the two locations, except number of branches. The cassava genotype 97/4763 had both primary and secondary branches while 98/0505 and TMS 30211 had only primary branches (Tables 1 and 2).

Pooled analysis showed significant difference (P = 0.05) for the evaluated characters and component variance analysis showed significant variation in both environmental and genotypic effects especially in number of nodes/stem and numbers of stems/stand (Table 3). The genotypic component was higher in number of nodes/stem and number of stems/stand with corresponding negative environmental effect. Stem length and root tuber yield were highly influenced by the environmental component. The estimate of genetic variability of the agronomic characteristics showed that the number of stems/stand and number of nodes/stem showed maximum genotypic and phenotypic variations (Table 4). This indicated that the two characters offered considerable scope for improvement and the combination of high genotypic and phenotypic coefficient will proffer effective selection criteria. Estimate of heritability and genetic advance for number of nodes/stem (71%), number of stems/stand (51%), and stem length (45%) were higher compared with other characters.

Result of the linear correlation analysis carried out between the characters themselves and between the root tubers and stem yield are presented in Table 5. The number of nodes/stem correlated positively (r = 0.794 and 0.788) with stem length (r = 0.794 and number of stems/stand r= 0.988 while stem length correlated positively (r=0.538) with stem weight and number of stems/stand (r=0.816). There was direct correlation between the number of stems/stand and the root tuber yield. Stem weight negatively correlated (r = 0.004, 0.266, 0.0085) with the number of stems/stand, root tuber yield and number of nodes/stem respectively.

Partial correlation analysis for each character with the root tuber and number of stem/stand showed that the number of nodes/stem and stem weight positively and significantly correlated with number of stems/stand with r = 0.97 and 0.992, respectively (Table 6). The stem length (r = 0.908) and stem weight (.734) correlated positively and significantly with the tuber yield (Table7).

4. DISCUSSION

The agronomic characteristics with relatively high heritability values and also with corresponding Selection of these two traits as criteria for improvement of stem and tuber yield in cassava will be effective. On the other hand, characters with high heritability and very low genetic advance are less likely to facilitate an effective selection due to the resultant influence of non-additive gene action (Liang and Walter, 1968). This was observed on the cassava stem weight and tuber yield. The environmental effect appears to be prominent on the performance of these two characters.

From the overall results, the high heritability value coupled with high genetic advance in number of nodes/stem, number of stems/stand and stem length show that direct selection could be effective for stem and tuber yield. However, direct selection through the stem weight and tuber yield may not be possible because of the environmental effect. A close high genetic advance often express a huge measure of variation. (Iwo and Ekaette, 2010). These were observed on number of nodes/stem, and number of stems/stand. observation between the number of nodes/stem and the number of stems/stand also support the effectiveness of choosing these characteristics as selection criteria for stem yield. Direct and positive correlation between the number of stems/stand and tuber yield also gave an indication that the two characteristics could be used as selection criteria for cassava improvement.

In conclusion, selection criteria for improvement of both stem and root tuber yield requires the number of stems/stand and the number of nodes/stem as indexes for considerable improvement.

This is because the two selected agronomic traits showed maximum genotypic and phenotypic variation in addition to the observed direct positive correlation between the two traits.

TABLE 1. Mean value of some agronomic characteristics of cassava genotypes evaluated at Calabar at 12 months after planting

Genotype	No. of Nodes Stem (cm)	Stem Length (cm)	Stem Width (kg)	No of Wt. (kg)	No of Stem/ stand	No of Branches 1^0	2^0	Root Yield (kg/ha)
NR 419	63d	191c	8.9a	1799b	4.3ab	0	0	3980.0
98/0505	37e	83e	4.0b	1690c	1.4b	0	0	1802.6c
TMS30572	134c	136d	4.1b	1015d	4.6ab	0	0	1760.0c
97/4763	238a	301a	8.0ab	1970a	5.4a	2	3	1948.0b
TMS	165b	225b	8.8a	2014a	4.8a	3	0	1890.0b
Mean	127	187	7.0	1698	4.0	1	1	2276.0
SEM(±)	36.06	37.28	1.12	180.37	0.70	0.63	0.6	427.23
LSD (p=0.05)	23.57	23.98	4.15	52.72	3.28	NS	NS	80.851

Mean followed by the letter within the same column are not significantly different (p = 0.05) NS = Non significant.

TABLE 2. Mean value of some agronomic characteristics of cassava genotypes evaluated at Obio Akpa at 12 months after planting

Genotype	No. of Nodes Stem (cm)	Stem Length (cm)	Stem Width (kg)	No of Wt. (kg)	No of Stem/ stand	No of Branches 1^0	2^0	Root Yield (kg/ha)
NR 419	57d	201.5b	8.1a	1886b	4.0a	0	0	4010a
98/0505	42d	95.3d	4.6d	1793c	1.1b	2	0	1985b
TMS30572	138c	138.6c	4.5b	1026de	4.4a	0	0	1755c
97/4763	238a	305.2a	8.3a	2000a	5.5a	2	3	1950d
TMS 30211	157b	223.8b	8.9a	1980a	4.9a	3	0	1562d
Mean	126	193	7.0	1719	4.0	1	1	2251
SEM(±)	35.68	36.14	0.96	176.33	0.76	0.6	0.6	446.16
LSD (p=0.05)	23.45	23.60	3.83	52.13	3.42	NS	NS	82.91

Mean followed by the letter within the same column are not significantly different (p = 0.05) NS = Non significant

Table 3

Character	Range	Mean	GCV	PCV	h^2(%)	GA(%)
No of nodes	**62-221**	**394.2**	**9.94**	**30.4**	**71**	**21.60**
Stem Length (cm)	**121-309**	**679.4**	**-6.480**	**0.0032**	**45.4**	**11.02**
Stem Wht (g)	**1690-3385**	**6597.6**	**20.9**	**2.703**	**32.4**	**0.31**
No of Stems/ Plant	**1.50-6.01**	**12.5**	**69.08**	**189.6**	**51.6**	**9.12**
Tuber Yield (g)	**1501-5400**	**7502.6**	**0.0215**	**9.734**	**25.0**	**1.36**

Component of variance Key:

$\delta^2 g$ = genotypic value

$\delta^2 e$ = environmental variance

$\delta^2 ph$ = phenotypic variance

TABLE 4. Genetic variability for the investigated agronomic characters in cassava

Control variance			Nodes	Stem length	Stem wht	No of stalk
Root Tuber	Nodes	Correlation	1.000	.425	.133	-798
		Significance (2tailed)	.	.575	.867	.202
		df	0	2	2	Tuber 2
	Stem length	Correlation	.425	1.000	.929	.092
		Significance (2tailed)	0.575	.	.071	.908
		df	2	0	2	2
	Stem weight	Correlation	.133	.928	1.000	.2668
		Significance (2tailed)	.867	.071	.	734
		df	2	0	2	2
	No of Stems/ stand	Correlation	.798	.092	.266	1.000
		Significance (2tailed)	.202	.098	.734	.
		df	2	2	2	0

Key:

GCV = Genotypic Coefficient of Variability

PCV = Phenotypic Coefficient of Variability

h^2 = Heritability

GA = Genetic Advance

TABLE 5. Correlation matrix between characters studied and root yield

	No ofNode	Stem Length	Stem Wt	No of Stems/stand	Root Tuber yield
No of nodes	-	0.794	0.085	0.788	-0.502
Stem Length(cm)	-	-	0.538	0.816	0.040
Stem wt	-	-	-	0.004	0.266
No of Stems/pt	-	-	-	-	0.981
Tuber Yield (kg)					

TABLE 6. Partial correlation between root tuber yield and other attributes

Component	No. of Nodes Stem (cm)	Stem Length (cm)	No of Wt. (kg)	No of Stem/ stand	Root Yield (kg/ha)
$\delta^2 g$	6774	-7926	18501	8.3	-1960
$\delta^2 e$	-9153	2425	1685	-2.1	6009
$\delta^2 ph$	1593	-5502	3535	86.2	8482

Key: Significance at p = 0.05

TABLE 7. Partial correlation between number of Stems/stand and other attributes

Control variance			Nodes	Stem length	Stem wht	No of stalk
Root Tuber	Nodes	Correlation	1.000	.944	.263	903
		Significance (2tailed)	.	.56	.737	.097*
		df	0	2	2	2
	Stem length	Correlation	.994	1.000	.548	818
		Significance (2tailed)	0.56	.	.452	.182
		df	2	2	2	2
	Stem weight	Correlation	.263	.548	1.000	.008
		Significance (2tailed)	.737	.452	.	992
		df	2	2	2	0
	No of Stems/ stand	Correlation	.903	.818	.008	1.000
		Significance (2tailed)	.097	.182	.992*	.
		df	2	2	2	0

Key: Significance at p = 0.05

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