Journal of Biotechnology and Bioengineering
Volume 1, Issue 1, 2017, PP 1-9

Variability for Drought Resistance on the Growth and Yield of Five Selected Cultivars of Cassava (Manihot Esculenta) in Ekiti State, Nigeria

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ABSTRACT

Field experiments were conducted using five selected cassava cultivars *in 2014 and 2015 years at the Teaching and Research Farm, Federal University Oye, Ekiti State, Nigeria to determine variability for drought resistance among five cassava cultivars through estimating heritability of yield and yield components, genetic advance, correlation coefficients of yield contributing traits. The experiments were conducted as a Randomized Complete Block Design (RCBD) with three replications. Twelve competitive plants were selected from the middle row of plots for data collection. Data collected include plant height (cm), stem girth (cm), number of leaves, number of branches/plant, average number of tuber/plant, average tuber length, total tuber weight/plant and yield/ha. Slight to high differences were observed between the Phenotypic Coefficient of Variation (PCV) and Genotypic Coefficient of Variation (GCV). Phenotypic variances for the characters under study were higher than genotypic variances in the years, indicating high influence of the environment which allows for the selection of character combinations and pools for genetic gain. This study revealed that indigenous cassava (Manihot esculenta) cultivars used in this experiment showed better growth responses in dry weather conditions, an indication that the cultivars posses some strains in their genetic constitution that may be useful in developing improved drought resistant varieties of cassava.*

Keywords: *Cassava, Cultivars, Drought, Resistance, Variability.*

INTRODUCTION

The cassava (*Manihot esculenta Crantz*) is cultivated mainly in the tropic and sub-tropic regions of the world, over a wide range of environmental and soil conditions. It is very tolerant of drought and heat stress and produces well on marginal soils. It is an important dietary staple in many countries within the tropical regions of the world (Kenneth, 2011), where it provides food for more than 800 million people (FAO, 2017). Cassava production is vital to the economy of Nigeria as the country is the world's largest producer of the commodity which is a staple food in most African countries. The crop is produced in 24 of the country's 36 states. In 1999, Nigeria produced 33 million tonnes, while a decade later; it produced approximately 45 million tonnes, which is almost 19% of production in the world. The average yield per hectare is 10.6 tonnes. It has well-established multiplication and processing techniques for food products and cattle feed. There are more than 40 cassava varieties in use. Cassava is remarked high among the top 10 most significant food crops produced in developing countries and a major source of carbohydrate for human consumption throughout the tropics but particularly in Africa (Ayo-John and Olaniyi, 2012). Locally adapted cassava landraces constitute an important part of the traditional diet of more than 600 million people in sub-Saharan Africa, Asia, and Latin America (FAOSTAT, 2017). African genetic resources for cassava improvement has been limited compared to the resources from Latin America and Asia (FAO document repository, 2017). One of the factors impeding the development of African landraces has been their shy flowering habit. Other major constraints include lack of information on agronomic traits (Elizabeth

Yaaparkes, 2011), and details on the extent of available genetic diversity for most traits of economic importance in the African germplasm. Field research under representative environments and in relevant cropping systems using a broad genetic base must be conducted not only to verify findings in laboratories and controlled environments but also to generate essential information and insights concerning the real potential of crops under natural conditions as well as their responses to a specific limiting environmental factor (America *et al., 2017*).

Hence, there is need to explore more African landraces for other end-user preferred traits, particularly agronomic parameters towards genotypic and phenotypic variability. Climate change pose long and unpredictable drought to crops, farmer bend to this unpredictable weather by changing planting patterns and periods within the year (Apronius *et al*., 2013).

The impact of climate variation on crop growth and yield has recently gained prominence, given the significant trend towards global warming and impending climate change causing increasing temperature and unpredictable dry spell (IPCC, 2013). This study compares the differences between cassava cultivars and attempts to assess the way these relate to their tolerance for drought, on the premise that weather variability and uneven distribution of rainfall strongly influences crop growth.

In this study also, we examined the variability among cassava cultivars for drought resistance that is best fit for the long, unusual and unpredictable drought that occurs in recent years. This research on cassava for drought resistance will boost production and reduce crop loss, even with long season drought for effective and future adaptation strategies. The objectives of the research work are;

- To identify cultivars that show divergent responses to drought and in greater detail, characters that influence growth and yield performance in drought.
- To explore variability among the selected cultivars towards detecting cultivars that can be planted year round and enhance food security.
- To determine the character association among yield and its components in the cassava cultivars.

MATERIALS AND METHOD

Sources of Cassava Stem Cuttings

Selected five cultivars of cassava identified for the purpose of this experiment were Idileru, Oko-yawo, Bamgbose, Abalaye and TMS 30572 (Improved variety as control). Local cultivars of cassava cutting were gotten from farmers in neighboring villages and identified; the improved variety was gotten from International Institute of Tropical Agriculture (IITA), Ibadan station, Nigeria. In the region where the experiment was carried out, farmers practice traditional farming where stem cuttings are re-planted after harvest or are obtained from relatives' and neighbor's fields or from abandoned fields. Focus discussions were held with farmers to determine the use, where it was gotten from and the preferred traits of their accessions and among the cultivars, those said to be drought tolerant were selected.

Experimental Design

Cassava planting stakes of 20-30 cm in length were planted on September 2014 and repeated in 2015 on a tractorized prepared piece of land, laid out in a randomized complete block design at University Teaching and Research Farm, Federal University Oye, (Ikole campus) Ekiti State, Nigeria.

Cassava stem cuttings 25 cm long were planted out. Each plot was 6m × 6m while each block size was 40.5m. Spacing between block was 2 m and 1.5 m within plots.

The experiment was replicated three times. A planting distance of 1 m x 1 m was maintained making 36 stands per plot. Pre and post-emergence herbicide was used (*Amine force*) before planting and hand weeding of the farm was done when necessary thereafter. No fertilizer was applied throughout the experiment.

Data Collection

Data were collected on twelve (12) competitive plants among the population/plot and data were collected on the following parameters evaluated at periodic intervals (4, 6, 8, 10, 12,14, 16, 18 and 20weeks after planting), at four weeks after planting (4WAP), plant height to the first apical branch (ground level to the base of the first crown-forming branch), number of branches per plant i.e. angle of first apical branch (between the vertical line of the main stem and the first branch), Number of leaves per stand and stem girth. Yield parameters were as well collected on cassava tuber as; Average tuber length (ATL) (cm), average tuber girth (ATG) (cm), average number of tubers/plant (ANT/P), total tuber weight/plant (TTW/P) (g), peel thickness (PT) (mm) and Yield/ha (tons).

Data Analysis

The data were subjected to analysis of variance (ANOVA) using MINITAB (version 17) and significant means were compared by Tukey test at 5% and 1% level of probability. Phenotypic and genotypic coefficients of correlation were determined using PB tools.

Test of significance of correlation was done by comparing the computed values against table 'r' values (Ben Lambert, 2013; Fisher and Yates 1963).

Components of Variance

Estimates of variance components (Genotypic and phenotypic variances) were generated from ANOVA table based on the expected mean sum of squares.

Coefficient of Variations (CV)

Genotypic and phenotypic coefficients of variation were computed according to Boney *et al.*, 2014 as follows;

Genotypic coefficients of variation (GCV) = $\frac{\sqrt{\sigma^2 g}}{\mu} \times 100$

Phenotypic coefficient of variation (PCV) $= \frac{\sqrt{\sigma^2 P}}{\mu} \times 100$

Heritability

Broad-sense heritability (H) was calculated as the ratio of the genotypic variance to the phenotypic variance using the formula according to Boney *et al.*, 2014 as follows:

$$\text{Heritability (H)} = \frac{\sigma^2 g}{\sigma^2 g + \sigma^2 e} \times 100$$

Heritability values were categorized as low, moderate and high as indicated by Elrod and Stranfield (2002) as follows;

High heritability estimate (≥50%),

Moderate heritability estimate (21 – 50%) and

Low heritability estimate (0 -20%).

Genetic Advance (GA) and Expected Genetic Gain (EGG)

Genetic advance was calculated at 5% selection differential (K=2.06) and Expected Genetic gain using the formula given by Singh (1990).

$$GA = \frac{\sigma^2 g}{\sqrt{\sigma^2 p}} \times K$$

Where:

K = 2.06 (Selection differential at 5%)

$\sqrt{\sigma^2 p}$ = square root of phenotypic variance

Expected Genetic Gain was determined from genetic advance (GA) expressed as a percentage of the population mean (μ).

Expected Genetic Gain (G_s) = $\frac{GA}{\mu}$ x100

Climatic Conditions

At this site, mean annual rainfall is about 1100 mm, with eight raining months (from March to October). The remaining four months of the year is extremely dry (January, February, November and December) when monthly rainfall distribution oscillated between zero and 40mm. Data on the vagaries of weather were taken and averaged within the period of this experiment. Soil samples of 10 g each were dried at 105^{0}C for 3hours in an air-drying oven to estimate the percentage moisture content in the soil. Percentage soil moisture content (%MC) was determined to be 3.52 for the one hundred and twenty days (120 days) observed for drought tolerance during the experiment without rainfall compared to 9.69 percentage soil moisture content observed towards the end of raining season in the years. The dry season occurred in November, 2015 to March, 2016. Rainfall seized lately in the month of November in both years, and commenced early in the month of March, the following year. The crop plants were allowed to develop a stable vegetative structure before the drought commenced with the aid of eight (8) weeks of light shower after planting (September to November). After, the crop stands experienced the seasonal drought with low relative humidity and high sunshine intensity, atmospheric temperature was 38^{0}c during the day and 30^{0}c overnight without rainfall for one hundred and twenty days (120 days).

RESULTS AND DISCUSSION

Analysis of Variance

The analysis of variance revealed significant differences among the cultivars studied as shown for plant height (PH), stem girth (SG) and number of leaves (NL), (Table 1, 2, 3). This indicates the existence of a high degree of variability in the germplasm which could be exploited in breeding programmes. Variety interactions were significant for PH, NL and SG indicating that differences among mean values of cultivars vary. Based on results, average plant height of the cultivars ranged from 10-150cm for 4-20 weeks of study, stem girth also ranged from 2-8cm for the 4-20 weeks of study among the cultivars. Number of leaves ranged from 8-103 in 4-20weeks among the cultivars. SG and PH were highest for '*Oko-yawo*' at 20 weeks with 8.43cm and 150cm respectively. Number of branches emerged within the sampled plants were averaged and ranged between one (1) to two (2) (Table 4). No branching was recorded among the varieties of cassava chosen for this experiment in 2-6weeks, which means that branching started 8weeks after planting and no significant differences were recorded for branching among the cultivars studied.

Table1. *Mean performance of five cassava cultivars evaluated for plant height in two years (2014&2015)*

Cultivars	Weeks of observation on plant height(PH)(cm) (character)							
	PH4	PH6	PH8	PH10	PH12	PH14	PH16	PH18	PH20
Idileru	12.83ab	50.77a	73.67a	98.80a	118.63a	128.50a	139.23a	144.70a	149.30a
Oko-yawo	14.13a	52.93a	75.67a	99.87a	119.50a	129.46a	139.87a	145.70a	150.77a
TMS 30572	12.00ab	44.97a	68.20b	91.60b	104.56b	113.73b	125.13b	136.20b	142.93ab
Abalaye	10.77b	48.03a	71.07ab	97.30ab	115.23ab	124.30ab	134.60ab	141.16a	145.10a
Bamgbose	11.97ab	48.03a	73.00ab	98.80a	118.13a	126.83a	138.90a	144.70a	149.30a
Ms	1.18	6.08	6.78	9.19	31.66	34.16	31.31	10.68	7.82
MsE	1.10	9.29	3.66	5.11	18.97	19.05	20.68	13.99	9.37

**Mean in a column with the same letter(s) are not significantly different bTukey (P=.05)*

Table 2. *Mean performance of five cassava cultivars evaluated for stem girth(cm) in two years (2014&2015)*

Cultivars	Weeks of observation on stem girth(SG) (cm)(character)								
	SG4	SG6	SG8	SG10	SG12	SG14	SG16	SG18	SG20
Idileru	2.83a	5.41a	7.41a	7.42a	7.72a	7.72a	7.92a	7.92a	8.28a
Oko-yawo	2.45a	5.52a	7.45a	7.49a	7.72a	7.72a	7.96a	7.96a	8.43a
TMS 30572	2.31a	5.30a	7.31a	7.31a	7.62a	7.62a	7.81a	7.81a	7.83b
Abalaye	2.42a	5.34a	7.28a	7.28a	7.59a	7.59a	7.88a	7.88a	8.10ab
Bamgbose	2.38a	5.41a	7.41a	7.42a	7.72a	7.72a	7.92a	7.92a	8.28a
Ms	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
MsE	0.00	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.02

**Mean in a column with the same letter(s) are not significantly different by Tukey (P=.05)*

Table 3. *Mean performance of five cassava cultivars evaluated for number of leaves in two years (2014&2015)*

Cultivars	Weeks of observation for number of leaves(NL) (character)								
	NL4	NL6	NL8	NL10	NL12	NL14	NL16	NL18	NL20
Idileru	9.07a	14.17a	34.23a	43.37a	51.09a	59.90a	68.67ab	85.67a	98.87a
Oko-yawo	9.67a	15.07a	36.57a	45.00a	53.47a	61.40a	69.93a	86.40a	103.10a
TMS 30572	9.00a	12.70a	31.13a	39.27a	48.93a	54.03a	61.20c	72.27a	83.87ab
Abalaye	9.03a	13.07a	32.40a	39.57a	49.33a	54.93a	62.46bc	72.77a	86.27a
Bamgbose	8.87a	13.83a	33.57a	42.03a	50.90a	57.57a	67.00abc	76.00a	89.86a
Ms	0.04	0.63	1.76	4.06	2.64	7.06	12.48	35.15	45.74
MsE	0.17	0.72	7.26	5.92	2.64	10.02	6.78	38.29	67.65

**Mean in a column with the same letter(s) are not significantly different by Tukey (P=.05)*

Observed growth rate ranges in plant height from 4weeks to 10weeks and stem girth from 4-8weeks were relatively high compare to the ranges noticed from 12-20weeks, which means that at early stage of growth, the plants made use of available nutrient through relative moisture content conserved in the soil at that time (8weeks) for proper vegetative growth in the study.

Review of collected data on the growth of selected plants for different characters observed in this study showed that these cultivars are involved in physiological processes that influence growth, even in such adverse weather conditions. Number of leaves (NL) was highest for '*Oko-yawo*' cultivar from 4-20 weeks with 103 leaves. Reduced growth rate were observed in leaf number and emergence on the sampled plants (Table 3) (NL18 & NL20) when leaf shedding characteristic was observed mainly on the lower part of the plants vegetative structure, the leaves initially turns yellowish and later with brownish die tips before shedding, leaving the nodes fresh. This can be said to be a mechanism used by the plants in surviving adverse weather conditions. This also reduces physiological reactions on the plants, since less number of leaves was cared for. However, there was tolerance to prolonged drought, as indicated by leaf retention and duration during most of the cropping cycle.

Number of branches (NB) from 14–20 weeks had no significant differences (Table 4), an indication for plant growth and development in maintaining the emerged branches towards realizing a complete cycle for mitotic division in plants.

Table 4.*Mean performance of five cassava cultivars evaluated for number of branches in two years (2014&2015)*

Cultivars	**Weeks of observation for number of branches(NB) (character)**						
	NB8	NB10	NB12	NB14	NB16	NB18	NB20
Idileru	1.13a	1.13a	1.40a	1.53a	1.53a	1.53a	1.53a
Oko-yawo	1.16a	1.17a	1.47a	1.47a	1.47a	1.47a	1.47a
TMS 30572	1.16a	1.17a	1.37a	1.50a	1.70a	1.70a	1.70a
Abalaye	1.13a	1.13a	1.40a	1.40a	1.60a	1.60a	1.60a
Bamgbose	1.13a	1.13a	1.40a	1.53a	1.53a	1.53a	1.53a
Ms	0.00	-0.02	-0.01	-0.02	-0.03	-0.03	-0.03
MsE	0.06	0.06	0.05	0.07	0.11	0.11	0.11

**Mean in a column with the same letter(s) are not significantly different by Tukey (P=.05)*

Yield performance for analysis of variance (Table 5) showed that average number of tuber per plant (ANT/P) were not significantly different, tuber produced in the two years ranges between three to four (3-4 tubers/plant) while significant differences were observed on average tuber length (ATL) which ranges between 30-35cm. Average tuber girth (ATG) ranges from 30-34cm while yield/plant (TTW/P) of the selected cassava varieties ranges from 5000g – 5398g. Yield per hectare (Y/ha) ranges from 50 – 53 tons/ha. Highest total tuber weight/plant of 5.39kg was recorded for '*Abalaye*' cultivar and highest yield/ha of 53.90 t/ha. This cultivar '*Abalaye*' might be a more efficient cassava cultivar in accumulating carbohydrates in storage roots. The roots were well formed, smooth and without surface defects. The uniformly sized tubers of this cultivar might make it attractive to farmers and consumers alike.

Table 5.*Mean yield performance of five cassava cultivars evaluated in two years (2014&2015)*

Cultivars	**Yield performance**					
	ANT/P	ATL(CM)	ATG(CM)	TTW/P(g)	PT(mm)	Y/ha(ton)
Idileru	4.00a	30.13b	33.23a	5000.00a	3.00a	50.00a
Oko-yawo	4.00a	32.07ab	34.57a	5300.00a	3.00a	53.00a
TMS 30572	4.00a	35.67a	33.13a	5350.00a	3.00a	53.50a
Abalaye	3.00a	35.44a	30.40ab	5398.00ab	3.00a	53.90a
Bamgbose	4.00a	30.03b	33.52a	5004.00a	3.00a	50.00a
Ms	0.07	0.70	1.87	3.07	2.32	0.23
MsE	0.13	0.47	3.76	4.07	2.54	1.02

**Mean in a column with the same letter(s) are not significantly different by Tukey (p=0.05)*

ANT/P= AVERAGE NUMBER OF TUBERS/PLANT

ATL=AVERAGE TUBER LENGTH (CM)

ATG=AVERAGE TUBER GIRTH (cm)

TTW/P=TOTAL TUBER WEIGHT/PLANT (g)

PT=PEEL THICKNESS (mm)

Y/ha = Yield/Hectare (Tons)

This finding reiterated the result of Ntawuruhunga and Dixon (2010) that differences in cassava tuber yield are determined by several factors, such as number of tubers, tuber length and tuber weight. This finding also concluded that storage root number, storage root size and storage root diameter were the main yield components contributing to yield enhancement in cassava. According to FAOSTAT estimates, the average yield in 2009 for cassava growing regions of the world was 12.6 t/ha, which is well below the results obtained by this study, under experimental conditions. These results demonstrate that under improved agronomic practices, increases in tuber yields can be obtained from cassava.

No significant difference was observed in peel thickness (PT) of the selected cassava cultivars used. This means that the differences observed on the growth parameters were not capable of causing significant yield differences among the cultivars or might be caused by rate of cultivars response to favorable weather conditions before harvesting.

Genetic Variation

Genotypic and phenotypic variances ($Ó^2$g and $Ó^2$p), genotypic and phenotypic coefficient of variation (GCV and PCV), broad-sense heritability (H) and genetic advance (GA) as percentage of mean was calculated for traits. There were differences between PCV and GCV for all traits (Table 6). Higher phenotypic coefficients of variance (PCV) values were found for all measured traits, indicating that the expression of these traits is highly influenced by the environment.

Table6. *Genetic variability parameters for different quantitative traits in five cassava cultivars across the years (2014&2015)*

S/N	Characters	Variance		GCV%	PCV%	H (bs)%	GA	Gs
		Vg	Vp					
1	Plant height (cm)	7.82	17.19	1.89	2.81	45.49	3.89	2.63
2	Number of Branches	0.00	0.08	0.00	18.13	0.00	0.00	0.00
3	Stem girth (cm)	0.04	0.06	2.44	2.99	66.00	0.34	4.15
4	Number of leaves	45.74	113.39	6.84	10.77	40.33	8.85	8.95

**Vg = genotypic variance, Vp = phenotypic variance, GCV = Genotypic Coefficient of Variability, PCV = Phenotypic*

Coefficient of Variability, H (bs) = Broad sense heritability, GA = Genetic Advance, Gs = Genetic gain.

Drought tolerance will contribute to better yield stability since water supply is the largest variable affecting yields (Ober and Luterbacher, 2002; Pidgeon *et al.*, 2001). Cultivars that show consistent and contrasting drought responses are useful tools to determine the morpho-physiological traits that confer drought tolerance.

One of the plant processes most sensitive to drought is leaf increase (Md *et al.*, 2015). Thus, it seemed relevant to examine variation for sensitivity of leaf increasing rates to drought (Table 3), but differences were statistically noticed due to the variation in growth rates between individual leaves within a cultivar. Relatively high growth rate observed in the cultivars and most especially the indigenous cultivars would be a desirable character for selection towards dry conditions.

Broad-sense heritability estimates ranged from 0.00 to 66% with the highest values obtained for stem girth, and the lowest value for number of branches/plant. Heritability combined with genetic advance is more useful than heritability alone for estimating the selection effects. Zero values (0.00) observed on number of branches (NB) for genotypic variation (Vg), Genotypic coefficient of variation (GCV), Heritability (H), Genetic advance (GA) and Genetic gain (Gs) are indications that this trait is not heritable and is determined by the environment, such trait may be less considered as a veritable tool in improving the test crop. Heritability and genetic advance were highest for stem girth (66%, 0.34) and plant height (45.49, 3.89), followed by number of leaves (40.33, 8.85), meaning that these traits are useful for estimating the selection effects towards cassava improvement, even in adverse weather conditions. This also suggests that the association between these traits is keys to achieving drought resistant cassava cultivars. Similar findings were reported by Karim *et al.*, (2012). For all studied traits, PCV values were higher than GCV values (Table 6), indicating the influence of environment on the expression of these traits. Similar results have been reported by Karim *et al.*, (2012). This suggests that crop improvement, in terms of these traits, may be possible by simple selection, given that high heritability coupled with high genotypic variation reveals the presence of additive gene effects (Hafiz *et al.*, 2013).

For genotypic and phenotypic correlations, Plant height (PH) was positively and significantly correlated with stem girth (SG), PH was also positive and significant with number of leaves (NL), and this indicated that increase in plant height (PH) results in an increase in stem girth (SG) and number of leaves (NL) respectively. Also, correlation coefficients showed the interaction/association between the characters observed in this experiment (Table 7,8 &9), while high performance of the characters observed are determined by the environment, since Vp (phenotypic variance) values were higher than Vg (genotypic variance) values (Table 6).

Table7. *Genotypic correlation coefficients of four traits observed in five cultivars of cassava*

Traits	Plant height(cm)	stem girth(cm)	Number of leaves	Number of Branches
Plant height(cm)	1			
stem girth(cm)	0.99**	1		
Number of leaves	0.94**	0.97**	1	
Number of Branches	-1.00	-1.00	-1.00	1

**significant @ P=.05, **significant @ P=.01*

Table8. *Phenotypic correlation coefficients of four traits observed in five cultivars of cassava*

Traits	Plant height(cm)	stem girth(cm)	Number of leaves	Number of Branches
Plant height(cm)	1			
stem girth(cm)	0.97**	1		
Number of leaves	0.87**	0.86**	1	
Number of Branches	-0.53	-0.55	-0.46	1

**significant @ P=.05, **significant @ P=.01*

Table9. *Correlation coefficients of growth and yield traits observed in five cultivars of cassava in two years (2015&2016)*

Traits	Rep	PH10	PH20(cm)	SG10cm	SG20	NL10	NL20	NB10	NB20	ANT/P	ATG	TTW/P	Y/ha(t)
	1												
PH(cm)@10	-0.24	1											
PH(cm)@20	-0.40	0.91**	1										
SG(cm)@10	-0.49	0.65	0.87*	1									
SG(cm)@20	-0.25	0.89*	0.90*	0.83*	1								
NL10	-0.35	0.73	0.86*	0.82*	0.77	1							
NL20	-0.12	0.68	0.74	0.63	0.69	0.86*	1						
NB10	-0.61	0.15	0.25	0.31	0.23	0.08	-0.15	1					
NB20	-0.67	-0.05	0.04	0.15	0.01	-0.04	-0.32	0.95**	1				
ANT/P	0.00	0.19	0.14	-0.03	0.21	0.00	0.10	0.42	0.27	1			
ATG(cm)	0.18	-0.10	0.08	0.09	0.01	0.22	0.27	-0.05	-0.12	-0.11	1		
TTW/P(g)	0.01	-0.33	-0.38	-0.26	-0.33	-0.26	-0.20	0.00	0.04	0.25	-0.34	1	
Y/Ha(tons)	-0.04	-0.39	-0.39	-0.20	-0.36	-0.27	-0.22	0.06	0.11	0.24	-0.34	0.98**	1

**significant @ P≤0.05, **significant @ P≤0.01*

CONCLUSION AND RECOMMENDATION

Drought adversely affects cassava's vegetative growth and productivity. The study revealed genetic variability among cassava genotypes in response to drought. The study also revealed that indigenous cultivars have unique characters (stronger stem girth, higher plant height and higher number of leaves) that are better compared on the growth for drought tolerance to the improved variety (TMS 30572) used as control in this experiment, this better performance in adverse weather conditions may be the basis for the farmer preferred traits or may suggest that the indigenous cultivars have genes for adaptation to this particular area, allowing the farmers to plant cassava all year round. The information generated from this study is important for breeders for selecting parents with traits associated with drought tolerance. These alleles could be associated with inclusion of such unique indigenous cultivars in cassava breeding programmes, which would increase chances of producing farmer preferred or better drought performing cultivars. It is recommended that studies to understand genetic inheritance of drought tolerance among different cassava genotypes be undertaken to understand the heritability of this important trait.

Lastly, the variation observed among the cultivars in this study is an indication that cassava cultivars in Nigeria may be very useful for identification of unique and improved characters towards crop improvement.

REFERENCES

[1] America Berenice Morales-Diaz, Hortensia Ortega-Ortiz, Antonio Juarez-Maldonado, Gregorio Cadenas-Pliego, Susana Gonzalez-Morales and Adalberto Benavides-Mendoza. 2017. Application of nanoelements in plant nutrition and its impact in ecosystem. Nanosci. Nanotechnol. 8(2017) 013001 (13pp)

[2] Apronius Mbilinyi, Georgina Ole Saibul and Vivia Kazi. 2013. Impact of climate change to small scale farmers: voice of farmers in villages in Tanzania; ESRF Discussion paper No. 47, Economic and social research foundation. ISBN: 978-9987-610-80-8

[3] Ayo-John EI and Olaniyi O.O. 2012. Reactions of cassava (Manihot esculenta Crantz) cultivars to African cassava mosaic Disease, publication of Nassarawa State University, Keffi. PAT December, 2012; 8(2): 117-126 ISSN: 0794-5213

[4] Ben Lambert. 2013. Hypothesis testing. The significance of correlation coefficients. Available online @

https://www.youtube.com/watch?v=THjS0CbGDJY

[5] Boney Wera, Abner Yalu, Akkinapally Ramakrishna, Myla Deros. 2014. Genotypic variability estimates of agronomic traits for selection in Sweet Potato (Ipomea batatas) polycross population Papua, New Guinea; Journal of Plant breeding and Genetics. ISSN 2305-297X (online)

[6] Elrod, S. L. and W. D. Stansfield.2002. Schaum's Outline of Theory and Problems of Genetics,4th ed. (pp. 43–45). New York: McGraw-Hill.

[7] Elizabeth YaaParkes. 2011. Assessment of genetic diversity, combining ability and farmer preference of cassava germplasm in Ghana, PhD thesis at the Department of Plant sciences, University of the Free State, South Africa.

[8] FAOSTAT. 2017. Food and Agricultural Commodities Production; Available online: http://faostat.fao.org(accessed 25 March 2017)FAO (Food and Agriculture Organization of the United Nations) Yearbook. 2017. Website: www.fao.org.

[9] FAO document repository .2017. Genetic resources of cassava; Potential of breeding for improving storage potential, chapter 3. Post-harvest deterioration of cassava. Accessed 26 April, 2017 Fisher R and Yates F. 1963. Statistical tables for biological, agricultural and medical research. 6th Edition.

[10] Edinburgh and Boyd. 146pp Hafiz Mahboob, Muhammad Ahsan, Qurban Ali and Imran Javed. 2013. Path coefficient analysis for various quantitative traits of Mungbean (Vigna radiate L.) at different radiation levels. International Research Journal of Microbiology, ISSN: 2141-5463. Vol. 3(11) Pp 352-362.

[11] IPCC. 2013. Intergovernmental Panel on Climate Change (IPCC).climate change 2013, physical science basis. Fifth assessment report, C/O World Meteorological Organization 7bis Avenue de la Paix C.P. 2300 CH- 1211 Geneva 2, SwitzerlandKarim, M.R. Zhang, Y.Q. Zhao, R.R. Chen, X.P. Zhang, F.S. Zou, C.Q .2012. Alleviation of drought stress in winter wheat by late foliar application of zinc, boron, and manganese. J. Plant Nutr. Soil Sci., 175 (2012), pp. 142–151Kenneth Richardson. 2011. Evaluation of three cassava varieties for tuber quality and yield. Department of Agriculture, Nassau, Bahamas. Gladstone road agricultural centre, crop research report No. 4Md, Rezaul Karim and Mohammed Ataur Rahman. 2015. Drought risk management for increased cereal production in Asian least developed countries. Elsevier, Vol. 7. Pp 24-35Minitab Statistical Software Features – Minitab.2011." Software for Statistics, Process Improvement, Six Sigma, Quality - Minitab.N.p., n.d. Web. 11 Apr. 2011. http://www.minitab.com/en-US/products/minitab/features/ Ntawuruhunga, P. and Dixon, A. 2010. Quantitative variation and interrelationship between factors influencing cassava yield. Journal of Applied Biosciences 26: 1594-1602.

[12] Ober ES and Luterbacher MC. 2002. Genotypic variation for drought tolerance in Beta vulgaris. Ann.

[13] Bot. Vol. 89 (7), 917-924PidgeonJD, Werker AR, Jaggard KW, Richter GM, Lister DH, Jones PD.2001. Climatic impact on the productivity of sugar beet (Beta vulgaris L.) in Europe 1961 – 1995. Agricultural and Forest Meteorology 109: 27–37

[14] Plant Breeding Tools (PBTools). 2013. International Rice Research Institute (IRRI) 2013 - 2020 Version: 1.3Singh, B.D. 1990. Plant breeding; Principles and methods. A text on plant breeding. Kalyanipublishers; 7th Edition. ISSN-10:8127220744. Online search at www.amazon.com/plant-breeding-principles-B-singh/dp/8127220744