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PROGRESS FROM SELECTION OF SOME MAIZE CULTIVARS' RESPONSE TO DROUGHT IN THE DERIVED SAVANNA OF NIGERIA

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ABSTRACT

Field experiments were conducted to investigate the variations in sixteen maize genotypes in relation to drought tolerance. The experimental set up was subjected to drought stress after five weeks of planting for three weeks before data on morphological and yield characters of maize genotypes were obtained for three cropping years. Plant height and grain yield of Bodija yellow maize were the highest overall. There was a significant difference among genotypes for drought stress resistance and Bodija yellow maize showed the most tolerance, while TZBR Comp 1 – C1 S2 510 genotype was the least. First principal component axis (Prin 1) had the highest contribution to the variation of the morphological, yield and drought tolerance traits. Prin 1 was highly related to the morphological and yield characters more than to the drought resistance. Plant height was negatively and strongly correlated (p<0.01) with stem height, number of leaves, stem girth, leaf length, leaf width and week after planting, but negatively correlated with the drought resistance. Therefore, Bodija yellow maize should be considered as parent material in breeding for the development of drought tolerant traits in maize.

Keywords: breeding, drought tolerance, maize, variability

INTRODUCTION

The high productivity of maize is one of the contributing factors of its appeal to farmers. It occupies less land area than either wheat or rice, but has a greater average yield per unit area (Lyon, 2000). Maize is a C_4 plant, which makes it more likely to be efficient in its use of water and carbon dioxide than C_3 plants (Esau,1977). Maize is primarily a warm weather crop successfully grown in areas of wide range of climatic conditions with an annual rainfall of 60 cm, and well distributed throughout its growing stage, and is the most suitable crop to diverse environment compared to other cereals. It is grown from 58^0N to 40^0S, from below sea level to altitudes higher than 3000 m, and in areas with 250 mm to more than 5000 mm of rainfall per year, with a growing cycle ranging from 3 to 13 months (Shaw, 1988; Dowswell *et. al.* 1996; CIMMYT, 2000). It needs more than 50% of its total water requirements in about 30 to 35 days after tasseling, but inadequate soil moisture at grain filling stage results in poor yield and shriveled grains (Edmeades, 2008; Tripathi *et al.,* 2011). Archaeological records and phylogenetic analysis revealed that domestication began at least 6000 years ago (Piperno and Flannery 2001; Matsuoka *et al*., 2002).

Maize is much important in human nutrition and also, a basic and vital element of animal feed as well as raw material for the manufacturing of various products. Some of these products include; corn starch, corn oil, fermented products, and have also been used recently as source of bio fuel (Morris, 1998; Olakojo*,* 2004; Olawuyi *et al.,* 2010; Olawuyi *et al.,* 2013).

Successful production of maize also depends on proper adoption of the production inputs that will sustain agricultural production and environment simultaneously. Some of these inputs include; soil tillage, fertilizer application, resistance genotypes to drought, insect, pest and disease control.

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(Morris, 1998; Olakojo, 2004; Olawuyi *et al.,* 2010; Olawuyi *et al.,* 2013). Successful production of maize also depends on proper adoption of the production inputs that will sustain agricultural production and environment simultaneously. Some of these inputs include; soil tillage, fertilizer application, resistance genotypes to drought, insect, pest and disease control. Drought however, like many other environmental stresses had adverse effects on some morphological characters including plant height, stem girth, number of leaves, and is one of the major constraints limiting the maize production. Low water availability is one of the major causes of yield loss of crops in majority of the planting regions around the world (Edmeades, 2004; Olawuyi *et al.,* 2011; Olowe *et al*., 2013; Olawuyi *et al.,* 2014; Bello *et al*., 2014). In spite of this, there is need to develop quality and high yield genotypes with drought tolerant trait in temperate and tropical environments, especially in Sub-Saharan Africa where drought is a threat to maize production. Thus, genetic improvement of drought and heat tolerant crops will play an important role in meeting the need of an increasing population. This study, therefore, investigated the variability of maize genotypes with respect to morphological, yield and drought tolerant traits.

MATERIALS AND METHODS

The experiment was carried out at the nursery farm (Longitude 7.17^{o}N and Latitude 3.90^{o}E) of the Department of Botany, University of Ibadan, Nigeria. A total of 16 maize genotypes comprising 13 maize genotypes were collected from International Institute of Tropical Agriculture (IITA), while the other 3 were obtained from Bodija and Agbowo markets in Oyo State in Nigeria. The experiment was factorially laid out in complete randomized block design with three replications. The maize genotypes were planted on January 15, 2012 January 20, 2013 and January 11, 2014 in sterilised black polythene bags in an open field. The polythene bags were spaced at a distance of 30cm, while the replicates along a genotype were separated at the distance of 40 cm. Three seeds each of maize genotype were planted into each polythene bag. The crop was grown under normal condition for the first seven weeks and then subjected to drought for two weeks.

Parameters recorded included; number of days from sowing to emergence; plant height, stem height, number of leaves, stem girth, leaf length and leaf width, and weretaken for the first five weeks with the aid of a meter rule and manual counting. The yield parameters; shoot biomass, root biomass and leaf biomass were taken at the end of the experiment from the harvested plants. The shoot biomass, root biomass and leaf biomass were obtained by weighing the plant shoot, root and leaves respectively on a weighing scale. The maize genotypes were subjected to drought without watering or irrigation at the fifth week after planting. Data on morphological characterswere collected from the eighth week after planting. Drought was scored for by the wilting scale, according to the standard procedure modified by Olawuyi *et al*. (2011). The drought tolerance rating ranged from Scale 1-5, with 1-Excellent, 2-Very good, 3-Moderate/Fairly good, 4-Poor and 5-Very poor.

Statistical analysis

The data collected were then subjected to analysis of variance (ANOVA) using SPSS version 16.0, while the means were separated using the Duncan Multiple Range Tests at $p<0.05$. The relationships between the morphological and yield parameters in relation to drought tolerance were established using correlation coefficient.

RESULTS AND DISCUSSION

RESULTS

The sources and collection of maize genotypes from different locations in Nigeria are shown in Table 1. The result of variations of genotypes and growth stages on morphological characters of maize is shown in Table 2. The genotypes were varied for plant height, stem height, number of leaves, stem girth, leaf length and leaf width. Also, the week after planting had highly significant effect on plant height, stem height, number of leaves, stem girth, leaf length and leaf width at $p<0.01$, while the means across all characters at replicate level are not significant (Table 2).

Table 1. Sources and collection of maize genotypes

Label	Maize Genotype	Source
G1	(IBIZA – EN13) TZBR Comp 2 – Y c1 s1	IITA
G2	TZBR Comp 2 – Y c1 s1	IITA
G3	TZBR Comp 2 – Y c1 s1 280	IITA
G4	TZBR Comp 1 – Y c1 s1 519	IITA
G5	AMA TZBR Y Ci Fi	IITA
G6	TZBR Comp 2 – Y c1 f2 (IBHC –EH2)	IITA
G7	TZBR Comp 1 c1 s2 (IB12C CS4) 414	IITA
G8	TZBR Comp 1 – Y c1 f1 (IBI2A EN13)	IITA
G9	TZBR Comp 1 – c1 s2 510	IITA
G10	TZBR Comp 2 – Y c0 207	IITA
G11	TZBR Comp 1 – Y c0 458	IITA
G12	TZBR Comp 2 – Y c1 194	IITA
G13	TZBR Comp 2 – Y c1 s1 244	IITA
G14	Pop corn	Agbowo market
G15	Yellow maize	Bodija market
G16	White maize	Agbowo market

Table 2. Mean square of genotypes and growth stages on morphological characters of maize from 2012-2014 dry seasons

Source of variation	Degree of freedom	Plant height	Stem height	Number of leaves	Stem girth	Leaf length	Leaf width
Genotype	15	716.99	32.94	10.89	1.50	604.89	4.15
Weeks after planting	4	6835.68**	652.17**	35.47**	9.99**	11599.51**	118.30**
Replicate	2	263.60^{ns}	8.75^{ns}	10.28^{ns}	1.39^{ns}	307.82^{ns}	1.60^{ns}
Error	218	60.61	6.48	1.03	0.14	100.32	0.39
Total	240						
Corrected Total	239						

Remarks: * P < 0.05 significant, ** P < 0.01 is highly significant, ns = non significant

There were significant differences (p<0.05) in the response of maize genotypes to growth characters (Table 3). There were variations across all genotypes with respect to plant height, stem height, number of leaves, stem girth, leaf length and leaf width. The height of plant in TZBR Comp 2 – Y c1 s1 244 was significantly different from other genotypes. The stem height of TZBR Comp 2 – Y c1 194 had the highest value of 8.39cm, while the number of leaves for Agbowo white maize was significantly different from other genotypes. The stem girth of Agbowo white maize was significantly different from other genotypes, with TZBR Comp 2 – Y c1 f2 (IBHC –EH2) having the lowest stem girth of 0.53cm. Though, the leaf length of TZBR Comp 2 – Y c1 s1 was the least (22.71cm), but TZBR Comp 1 – Y c1 s1 519, TZBR Comp 1 c1 s2 (IB12C CS4) 414, TZBR Comp 1 – Y c1 f1 (IBI2A EN13), TZBR Comp 1 – c1 s2 510, TZBR Comp 2 – Y c0 207, TZBR Comp 1 – Y c0 458, TZBR Comp 1 – Y c0 458, TZBR Comp 2 – Y c1 s1 244, Bodija yellow maize and Agbowo white maize were not significantly different from one another. The leaf width of TZBR Comp 1 – Y c1 f1 (IBI2A EN13) was significantly different from other genotypes (Table 3).

The result of the effect of growth stages on morphological characters of maize genotypes shown in Table 4 reveals that in week five after planting (WAP), the plant height, stem height, number of leaves, stem girth, leaf length and leaf width were the highest and significantly different from those in other weeks, while the number of leaves from 3, 4 and 5 WAP were significantly different from those of the first and the second week after planting (Table 4). The result of correlation coefficient of growth characters of maize genotypes in table 5 shows that the plant height was positive and strongly correlated (p<0.01) with stem height, number of leaves, stem girth, leaf length, leaf width and week after planting (WAP) with (r=0.81, 0.81, 0.89, 0.93, 0.85, 0.72) respectively. There was no significant correlation with the replicates (r=-0.00) and a weak correlation existed between plant height and genotype. The stem height was highly significant and positively associated with number of leaves, stem girth, leaf length, leaf width and week after planting (WAP) at p<0.01; r=0.51, 0.85, 0.83, 0.77, 0.72 respectively. The number of leaves was highly significant and positively correlated with stem girth, leaf length and leaf width at p<0.01; r=0.79, 0.78, 0.78 respectively, while there were no relationship with genotype (r=0.29) and week after planting (r=0.41). The stem girth was highly significant and positively associated with leaf length, leaf width and week after planting (WAP) at p<0.01; r=0.87, 0.91, 0.63 respectively. The leaf length was highly significant and positively correlated with, leaf width and week after planting (WAP) at p<0.01; r=0.87, 0.76 respectively. There was a highly significant and positive association between leaf width and week after planting at p<0.01; r=0.57.

Table 3. Genotypic effect on growth characters of maize from 2012-2014 dry seasons

Genotype	Plant height (cm)	Stem height (cm)	Number of leaves	Stem girth (cm)	Leaf length (cm)	Leaf width (cm)
G1	25.05^{cd}	6.86^{abcd}	4.00^{abc}	1.45^{bc}	29.43^{abc}	1.82^{ef}
G2	19.64^{de}	6.36^{abcd}	3.27^{cd}	1.30^{cd}	22.71^{c}	1.63^{f}
G3	16.40^{e}	5.03^{d}	3.00^{d}	1.08^{d}	23.86^{bc}	1.65^{f}
G4	26.69^{bc}	6.98^{abcd}	4.33^{ab}	1.65^{ab}	32.47^{a}	2.39^{bc}
G5	28.35^{abc}	6.31^{abcd}	4.07^{ab}	1.62^{ab}	31.27^{ab}	2.39^{bc}
G6	8.85^{f}	2.23^{e}	1.47^{e}	0.53^{e}	12.43^{d}	0.72^{g}
G7	32.32^{ab}	6.36^{abcd}	4.47^{ab}	1.52^{abc}	33.21^{a}	1.84^{def}
G8	30.34^{abc}	6.15^{bcd}	4.67^{ab}	1.67^{ab}	34.36^{a}	2.95^{a}
G9	27.71^{abc}	5.03^{d}	4.40^{ab}	1.57^{abc}	33.19^{a}	2.34^{bcd}
G10	27.12^{abc}	6.67^{abcd}	3.87^{bc}	1.42^{bc}	32.87^{a}	2.05^{cdef}
G11	32.19^{ab}	6.34^{abcd}	4.40^{ab}	1.58^{abc}	34.08^{a}	2.26^{bcde}
G12	32.45^{ab}	8.39^{a}	4.47^{ab}	1.72^{ab}	36.17^{a}	2.66^{ab}
G13	33.61^{a}	8.05^{ab}	4.53^{ab}	1.74^{ab}	36.52^{a}	2.57^{abc}
G14	29.53^{abc}	5.60^{cd}	4.67^{ab}	1.65^{ab}	30.89^{ab}	2.05^{cdef}
G15	33.06^{ab}	8.06^{ab}	4.53^{ab}	1.71^{ab}	35.89^{a}	2.42^{bc}
G16	32.75^{ab}	7.42^{abc}	4.80^{a}	1.77^{a}	35.53^{a}	2.37^{bc}

Remarks: Means with the same letter in the same column are not significantly different at P>0.05 using Duncan's Multiple Range Test (DMRT)

Table 4. Effect of growth stages on morphological characters of maize genotypes from 2012-2014 dry seasons

Weeks after planting	Plant Height (cm)	Stem Height (cm)	Number of Leaves	Stem Girth (cm)	Leaf Length (cm)	Leaf Width (cm)
1	10.32^{e}	3.21^{d}	2.60^{c}	1.06^{d}	8.61^{e}	1.41^{e}
2	21.25^{d}	3.20^{d}	3.96^{b}	1.13^{d}	22.70^{d}	1.68^{d}
3	29.77^{c}	5.07^{c}	4.71^{a}	1.38^{c}	34.21^{c}	2.09^{c}
4	33.46^{b}	8.81^{b}	4.50^{a}	1.79^{b}	41.55^{b}	2.55^{b}
5	41.47^{a}	11.53^{a}	4.52^{a}	2.14^{a}	47.58^{a}	2.92^{a}

Remarks: Means with the same letter in the same column are not significantly different at P> 0.05 using Duncan's Multiple Range Test (DMRT)

Table 5. Pearson correlation coefficient of growth characters of maize genotypes from 2012-2014 dry seasons

	Plant height (cm)	Stem height (cm)	Number of leaves	Stem girth (cm)	Leaf length (cm)	Leaf width (cm)
Stem height (cm)	0.81**					
Number of leaves	0.81**	0.51**				
Stem girth (cm)	0.89**	0.85**	0.79**			
Leaf length (cm)	0.93**	0.83**	0.78**	0.87**		
Leaf width (cm)	0.85**	0.77**	0.78**	0.91**	0.87**	
Genotypes	0.29**	0.13*	0.29**	0.25**	0.19**	0.24**
Week after planting	0.72**	0.72**	0.41**	0.63**	0.76**	0.57**
Replicate	-0.00^{ns}	-0.03^{ns}	-0.08^{ns}	-0.05^{ns}	-0.00^{ns}	-0.04^{ns}

Remarks: * P < 0.05 significant, ** P < 0.01 highly significant, ns = non significant

Table 6. Mean square effect of genotypes and replicates on growth characters and drought resistance of maize from 2012-2014 dry seasons

Source	Plant height	Stem Height	Number of Leaves	Stem Girth	Leaf Area	Drought Resistance
Genotype	1017.76^{ns}	162.63^{ns}	13.10^{ns}	1.52^{ns}	8728.79^{ns}	1.39^{ns}
Replicate	2609.11^{ns}	446.35^{ns}	27.44^{ns}	1.96^{ns}	30752.64^{ns}	1.31^{ns}
Total	20484.64	3331.95	251.35	26.58	192437.14	23.44
Error	31103.74	5253.32	318.46	36.23	269049.49	21.38
Corrected Total	51588.38	8585.27	569.82	62.81	461486.62	44.82

Remarks: * P<0.05 significant, ** P < 0.01 highly significant, ns= non significant

Table 7. Performance of maize genotypes in relation to growth and drought resistance from 2012-2014 dry seasons

Genotype	Plant height (cm)	Stem height (cm)	Number of Leaves	Stem girth (cm)	Leaf area (cm^2)	Drought resistance
G1	28.07^{ab}	14.40^{a}	2.67^{ab}	1.27^{ab}	98.24^{a}	3.67^{abc}
G2	15.70^{ab}	8.20^{a}	2.00^{ab}	0.60^{ab}	47.35^{a}	3.67^{abc}
G3	24.23^{ab}	9.23^{a}	1.67^{ab}	1.70^{ab}	59.95^{a}	4.33^{ab}
G4	40.03^{ab}	9.90^{a}	5.00^{ab}	1.47^{ab}	148.79^{a}	3.67^{abc}
G5	42.33^{ab}	15.70^{a}	4.67^{ab}	1.76^{ab}	165.40^{a}	3.00^{bc}
G6	20.97^{ab}	8.17^{a}	1.67^{ab}	0.70^{ab}	69.52^{a}	4.33^{ab}
G7	48.27^{ab}	19.53^{a}	4.67^{ab}	1.03^{ab}	103.73^{a}	4.00^{abc}
G8	20.10^{ab}	7.90^{a}	2.00^{ab}	0.70^{ab}	0.00^{a}	4.67^{ab}
G9	0.00^{b}	0.00^{a}	0.00^{b}	0.00^{b}	0.00^{a}	5.00^{a}
G10	17.97^{ab}	8.93^{a}	1.33^{ab}	0.53^{ab}	39.96^{a}	4.67^{ab}
G11	23.03^{ab}	7.43^{a}	3.00^{ab}	0.70^{ab}	41.53^{a}	4.67^{ab}
G12	44.17^{ab}	19.87^{a}	4.67^{ab}	1.50^{ab}	49.83^{a}	4.33^{ab}
G13	59.23^{ab}	25.83^{a}	6.67^{a}	2.60^{a}	124.35^{a}	3.67^{abc}
G14	45.50^{ab}	16.03^{a}	4.67^{ab}	1.47^{ab}	108.27^{a}	3.67^{abc}
G15	68.93^{a}	23.87^{a}	7.67^{a}	2.37^{a}	99.91^{a}	2.67^{c}
G16	52.10^{ab}	23.80^{a}	4.67^{ab}	1.83^{ab}	176.66	3.00^{bc}

Remarks: Means with the same letter in the same column are not significantly different at P>0.05 using Duncan's Multiple Range Test (DMRT)

There was no significant association between the replicate and stem height, number of leaves, stem girth, leaf length, leaf width and week after planting (WAP) with r= -0.03, -0.08, -0.05, -0.00, -0.04 respectively (Table 5). The mean square of the growth traits and drought resistance recorded for the maize genotypes and replicates produced no significant effect (p>0.05) (Table 6).

There was significant effect of growth characters and drought tolerance on maize genotypes (Table 7). There are variations across all the genotypes with respect to plant height, stem height, number of leaves, stem girth, leaf area and drought resistance. The plant height of Bodija yellow maize was significantly different and higher (68.93cm) than other genotypes. The stem height was significant across all genotypes. TZBR Comp 2 – Y c1 s1 244 and Bodija yellow maize were significantly different from other genotypes in the number of leaves and stem girth. Agbowo white maize had higher leaf area than TZBR Comp 1 – Y c1 f1 (IBI2A EN13) and TZBR Comp 1 – c1 s2 510 h. The drought resistance of TZBR Comp 1 – c1 s2 510 was significantly different from other genotypes (Table 7).

The result of the mean square effect of genotypes on yield related characters of maize shows that the root biomass produced significant effect for all the genotypes, while the shoot biomass and leaf biomass were not significantly different (Table 8). There were variations across all genotypes with respect to shoot biomass, root biomass and leaf biomass. The shoot biomass and root biomass of Bodija yellow maize were significantly different ($p<0.05$) from other genotype.

Table 8. Mean square effect of genotypes and replicates on yield of maize from 2012-2014 dry seasons

Source	Shoot Biomass	Root Biomass	Leaf Biomass
Genotype	248.26^{ns}	14.57*	35.54^{ns}
Replicate	237.84^{ns}	3.32^{ns}	32.35^{ns}
Total	4199.51	225.18	597.79
Error	5094.55	201.48	837.73
Corrected Total	9294.06	426.65	1435.52

The leaf biomass had significant effect on the genotypes with the highest value of 10.09cm recorded for Bodija yellow maize, while TZBR Comp 1 – c1 s2 510 had the least (Table 9). The result of correlation coefficient of growth characters, yield and drought resistance of maize genotypes is shown in Table 10. The plant height is positive and strongly correlated ($p<0.01$) with stem height, number of leaves, stem girth, leaf area, shoot biomass, root biomass and leaf biomass with (r=0.96, 0.94, 0.94, 0.71, 0.88, 0.87 and 0.87) respectively. There were no positive associations between the plant height and drought resistance. The stem height is positive and strongly correlated associated with number of leaves, stem girth, leaf area, shoot biomass, root biomass and leaf biomass with (r=0.88, 0.91, 0.74, 0.83, 0.85 and 0.82) respectively. The number of leaves is positive and strongly correlated with stem girth (r=0.94), leaf area (r=0.77), shoot biomass (r=0.89), root biomass (r=0.82) and leaf biomass (r=0.87).

The stem girth is positive and strongly associated with leaf area, shoot biomass, root biomass and leaf biomass with (r=0.80, 0.91, 0.86 and 0.89) respectively. Again, there was positive association between leaf area and shoot biomass, root biomass and leaf biomass at $p<0.01$; r=0.84, 0.64and 0.84 respectively. The shoot biomass was also positive and strongly related to the root biomass (r=0.89) and leaf biomass (r=0.99), while positive and strong correlation existed between root biomass and leaf biomass (r=0.86). The relationship between leaf biomass and drought resistance was significant ($p< 0.05$), but negative and strongly correlated (r=-0.85).

Table 9. Genotypic effect on yield related characters of maize from 2012-2014 dry seasons

Genotype	Shoot Biomass (g)	Root Biomass (g)	Leaf Biomass (g)
G1	10.40^{ab}	1.40^{c}	3.92^{a}
G2	4.23^{ab}	0.58^{c}	1.81^{a}
G3	7.53^{ab}	0.80^{c}	2.58^{a}
G4	22.70^{ab}	2.06^{bc}	2.58^{a}
G5	23.84^{ab}	4.21^{abc}	10.23^{a}
G6	8.33^{ab}	2.06^{b}	3.29^{a}
G7	14.23^{ab}	3.55^{abc}	5.63^{a}
G8	6.35^{ab}	0.97^{c}	2.59^{a}
G9	0.00^{b}	0.00^{c}	0.00^{a}
G10	4.40^{ab}	0.92^{c}	1.75^{a}
G11	7.25^{ab}	1.60^{c}	2.84^{a}
G12	14.53^{ab}	2.68^{abc}	5.62^{a}
G13	24.90^{ab}	6.82^{ab}	9.30^{a}
G14	20.31^{ab}	3.48^{abc}	6.85^{a}
G15	29.21^{a}	7.38^{a}	10.09^{a}
G16	24.23^{ab}	4.94^{abc}	9.00^{a}

Remarks: Means with the same letter in the same column are not significantly different at P> 0.05 using Duncan's Multiple Range Test (DMRT)

Table 10. Correlation of growth characters, yield and drought tolerance in different maize genotypes from 2012-2014 dry seasons

Correlation	Plant height (cm)	Stem height (cm)	Number of leaves	Stem girth (cm)	Leaf area (cm^2)	Shoot biomass	Root biomass	Leaf biomass	Drought besistance	Replicate
Plant height(cm)										
Stem height(cm)	0.96**									
Number of leaves	0.94**	0.88**								
Stem girth(cm)	0.94**	0.91**	0.94**							
Leaf Area(cm^2)	0.71**	0.74**	0.77**	0.80**						
Shoot Biomass	0.88**	0.83**	0.89**	0.91**	0.84**					
Root Biomass	0.87**	0.85**	0.82**	0.86**	0.64*	0.89**				
Leaf Biomass	0.87**	0.82**	0.87**	0.89**	0.84**	0.99**	0.86**			
Drought Resistance	-0.80**	-0.73**	-0.80**	-0.81**	-0.79**	-0.86**	-0.76**	-0.85**		
Genotype	0.28ns	0.28ns	0.29ns	0.27ns	0.07ns	0.29ns	0.44*	0.22ns	-0.12ns	0.00ns

Remarks: * $P < 0.05$,** $P < 0.01$ is highly significant, ns = non significant

Table 11. Contribution of principal component axis (pca) to the variation of the morphological, yield and drought resistance traits in maize genotypes from 2012-2014 dry seasons

Traits	Prin 1	Prin 2	Prin 3	Prin 4	Prin 5	Prin 6	Prin 7	Prin 8	Prin 9
Plant height (cm)	0.34	0.34	0.10	-0.18	-0.03	-0.27	0.18	0.79	-0.05
Stem height (cm)	0.33	0.46	0.28	-0.02	-0.47	-0.35	-0.08	-0.50	0.05
Number of leaves	0.34	0.15	0.18	-0.17	0.66	0.14	0.50	-0.32	-0.01
Stem girth (cm)	0.34	0.17	0.20	-0.02	0.22	0.46	-0.74	0.07	-0.04
Leaf Area (cm^2)	0.31	-0.54	0.57	0.19	-0.33	0.26	0.24	0.09	-0.01
Shoot Biomass	0.35	-0.23	-0.2	0.29	0.18	-0.29	-0.12	0.02	0.76
Root Biomass	0.33	0.25	-0.56	0.29	-0.31	0.51	0.27	-0.01	-0.03
Leaf Biomass	0.34	-0.25	-0.21	0.38	0.18	-0.4	-0.13	-0.07	-0.65
Drought Resistance	-0.32	0.38	0.33	0.77	0.18	0.02	0.07	0.10	0.03
Proportion (%)	86.0	4.71	3.06	2.07	1.66	0.79	0.55	0.29	0.07
Eigen value	7.81	0.42	0.28	0.19	0.15	0.07	0.05	0.03	0.06

There was no significance between the genotype and plant height, stem height, number of leaves, stem girth, leaf area, shoot biomass, leaf biomass, drought resistance and replicate in their relationship (Table 10). The drought resistance was highly significant ($p<0.01$) and negatively correlated to plant height, stem height, number of leaves, stem girth, leaf area, shoot biomass, root biomass and leaf biomass.

The contribution of Principal Component Axis (PCA) to the variation of the morphological, yield and drought resistance traits in maize genotypes is presented in Table 11. The variations were shown across the nine PCA as; 7.81 (86.0%), 0.42 (4.71%), 0.28 (3.06%), 0.19 (2.07%), 0.15 (1.66%), 0.07 (0.79%), 0.05 (0.55%), 0.03 (0.29%), 0.06 (0.07%). The first PCA was highly related to the morphological and yield characters than to the drought resistance. The second PCA was more related to the plant height, stem height, number of leaves, stem girth, root biomass and drought resistance compared to the third PCA which was related to the morphological characters and drought resistance and fourth PCA; leaf area, shoot biomass, root biomass, leaf biomass and drought resistance. The fifth PCA was more related to the number of leaves, stem girth, shoot biomass, leaf biomass and drought resistance. There was more relation to the number of leaves, stem girth, leaf area, root biomass and drought resistance in the sixth PCA compared to the seventh PCA which was more related to the plant height, number of leaves, leaf area, root biomass and drought resistance. The eight PCA was more related to plant height, stem girth, leaf area, shoot biomass and drought resistance compared to the ninth PCA which was more related to stem height, shoot biomass and drought resistance (Table 11).

DISCUSSION

The global demand for maize, with an increasing demand coming from developing countries has been estimated to increase from 526 million tons to 784 million tons from 1993 to 2020 (Rosegrant, *et al.,* 1999). The yield of plant is largely dependent on the amount of water used up or the water use efficiency of the plant. Plant yield is mostly prone to damage due to limited water. Low amount of water in the soil moisture reserve tends to have direct effect on some morphological characters such as plant height, stem girth, number of leaves. Drought is also a very important abiotic stress which constrains and destabilizes maize grain production. Drought constitutes limiting factors to the increased production of maize as to sustain the rising global demands (Kramer, 1980; Craig *et al.,* 2000; Golbashy *et al.,* 2010).

Stunted growth, loss of turgor, vein clearing and wilting were observed in the maize genotypes subjected to drought stress, this was coherent with the report of Hsiao (1973) emphasizing that normal functions of the plant are interfered by reduced turgor and plant water potential in water deficit conditions. The effects of drought stress in plants as shown by the data recorded from the genotypes, three weeks after being subjected to drought stress showed that drought affected the yield of plants. Different genotypes responded differently to the effect of drought, in which Bodija yellow maize performed better than other genotypes, while TZBR Comp 1 – c1 s2 510 performed the least. This shows that genetic variability is the key to yield as reported by Welsh (1981) who considered genetic variability as key to crop improvement.

Some of the drought-tolerance related traits include plant height, number of leaves, and stem girth. The morphological characters of the plant performed well in the absence of drought stress, but suffered throughout the drought period (Olawuyi *et al.,* 2014). There were variations in the performance of the morphological characters of each genotype in relation to drought stress, which in turn affected the yield product. Drought tolerant genotypes distinguished themselves from non tolerant ones by their higher photosynthetic rates (Skingh and Tsunoda, 1978). This is shown in the relationship exhibited in the morphological characters of the plant such as the number of leaves, plant height with the genotypes. The number of leaves produced had direct correlation with other morphological characters, and similar results had been reported by Haq *et al*. (2005). The reason could be due to the photosynthetic ability of the leaves which in turn enhances plant growth (Skingh and Tsunoda, 1978).

The positive and strong correlation between the morphological characters indicates that the genotypic make-up of maize affects the morphological characters, which invariably influences yield products and drought resistance/tolerance. The highest proportion and eigen vector accounted for the variation of maize characters in PRIN 1 which should be considered for breeding purpose. It also confirms the delineation of genotypes from varied environment. With the increasing effect of climate change and irregularities in the time and volume of rainfall and with the expensive cost and difficulties associated with irrigation, there has been an ever- increasing need of raising maize genotypes with the ability to tolerate drought resistance. The first PCA was highly related to the morphological and yield characters than to the drought resistance. There were also variations in shoot, root and leaf biomass in the maize genotypes. Bodija recorded the highest yield performance.

CONCLUSIONS

Plant height and grain yield of Bodija yellow maize were the highest overall. There was a significant difference among genotypes for drought stress resistance and Bodija yellow maize showed the most tolerance, while TZBR Comp 1 – C1 S2 510 genotype was the least. First principal component axis (Prin 1) had the highest contribution to the variation of the morphological, yield and drought tolerance traits. Prin 1 was highly related to the morphological and yield characters more than to the drought resistance. Plant height was negatively and strongly correlated ($p<0.01$) with stem height, number of leaves, stem girth, leaf length, leaf width and week after planting, but negatively correlated with the drought resistance. Therefore, Bodija yellow maize should be considered as parent material in breeding for the development of drought tolerant traits in maize.

REFERENCES

Bello, O.B., Olawuyi, O.J., Abdulmaliq, S.Y., Ige, S.A., Mahamood, J., Azeez, M.A., Afolabi, M.S. 2014. Yield performance and adaptation of early and intermediate drought-tolerant maize genotypes in Guinea Savanna of Nigeria. Sarhad J. Agric. 30(1): 53-66.

CIMMYT, 2000. CGIAR Research, Areas of Research: Maize (*Zea mays* L.). <http://www.cgiar.org/areas/maize.htm>. 30 July, 2013. 04:48:38.

Craig, A. A , Richard L. W , Billy R. W , William H. W and Frank M. D , 2000. Conventional resistance of experimental maize lines to corn Earworm (Lepidoptera: Noctuidae), Fall Armyworm (Lepidoptera: Noctuidae), Southwestern Corn Borer Lepidoptera: Crambidae) and Sugarcane Borer (Lepidoptera: Crambidae). J. Econ. Entomol. 93(3): 982-988.

Dowswell, C.R., Paliwal, R.L. and Cantrell, R.P. 1996. Maize in the third world. In: Tripathi, K.K., Warrier, R., Govila, O.P., Ahuja, V. (2011). Biology of *Zea mays* L. (Maize). Department of Biotechnology, Ministry of Science and Technology and Ministry of Environment and Forests, Government of India. P. 01 – 02.

Edmeades, G.O. (2008). Drought tolerance in maize: An Emerging Reality. The International Service for the Acquisition of Agri-biotech Applications (ISAAA). Metro Manila, Philippines.

Edmeades, G.O., Banziger, M., Schussler, J.R., Campos, H., 2004. Improving abiotic stress tolerance in maize: a random or planned process? In: Campos, H., Cooper, M., Habben, J.E., Edmeades, G.O., Schussler, J.R. (2004). Improving drought tolerance in maize: a view from industry. Field Crops Research. 90: 19–34.

Esau, K. 1977. The stem: Primary state of growth. Chapter 16. In: OGTR (2008). The biology of *Zea mays* L. Australia government office of the gene technology regulator. pp 20 – 22.

Golbashy, M., M. Ebrahimi, S.K. Khorasani and R. Choukan, 2010. Evaluation of drought tolerance of some corn (*Zea mays* L.) hybrids in Iran. African J.Agric. Res. 5: 2714-2719.

Haq, N.M., Saad, I.M., Mozamil, H., Sajjad, R.C., Habib, I.J., 2005. Genetic correlation among various quantitative characters in maize (*Zea mays* L.) Hybrids. Journal of Agriculture and Social Sciences 3(1): 262 – 265.

Hsiao, T.C., 1973. Plant responses to water stress. Annual Review of Plant Physiology 24: 519-570.

Kramer, P.J. 1980. Drought, stress, and the origin of adaptations. In adaptation of plants to water and high temperature stress. Eds. N.C. Turner and P.J. Kramer. John Wiley and Sons, New York, Pp. 7-20.

Lyon,F., 2000. Science direct - world development: II. Trust, networks and norms: The creation of social capital in agricultural economies in Ghana. Journal of Stored Product Research 28(4): 663 -681.

Matsuoka, Y., Yves V., Major M.G., Jesus S.G., Edward B. and J. Doeble, 2002. A single domestication for maize shown by multilocus microsatellite genotyping. Proceedings of The National Academy of Sciences of The United States of America 99(9): 6080-6084.

Morris, M. L. 1998. Overview of the world maize economy. In: Tripathi, K.K., Warrier, R., Govila, O.P., Ahuja, V. 2011. Biology of *Zea mays* (Maize). Department of Biotechnology, Ministry of Science and Technology and Ministry of Environment and Forests, Government of India. p. 01 – 02.

Olakojo S.A. 2004. Evaluations of maize inbreed lines for tolerance to Striga lutea in Southern Guinea Savannah Ecology. Food, Agriculture and Environment, 2(2): 256-259.

Olawuyi, O.J., Odebode, A.C., Alfar – Abdullahi, Olakojo, S.A., Adesoye, A.I. 2010. Performance of maize genotype and Arbuscular mycorrhizal fungi in samara district of south west region of Doha – Qatar.Nigeria Journal of Mycology, 3: 86 – 100.

Olawuyi, O.J., F.E. Babatunde and C.G. Njoku, 2011. Yield, drought resistance, fruiting and flowering ofokra (*Abelmoschus esculentus*) as affected by inorganic fertilizer (NPK). Proc. 2nd Tech. workshopof the Nigerian Organic Agric. Network (NOAN) 12-16. Sept. 2011. p. 13-18.

Olawuyi, O.J., Odebode, A.C., Olakojo, S.A. 2013. Genotypes×concentration×mycorrhiza interaction on early maturing maize under *Striga lutea* in Nigeria. In: Tielkes E, editor. Book of Abstracts. Tropentag 2013. International Research of Food security, National Resource Management and Rural Development; Sep 17–19; Stuttgart: University of Hohenheim.

Olawuyi, O.J., Odebode, A.C., Babalola, B.J., Afolayan, E.T. and Onu, C.P. 2014. Potentials of Arbuscular mycorrhiza fungus in tolerating drought in maize (*Zea mays* L.). American Journal of Plant Sciences 5: 779-786.

Olowe, O.M., Odebode, A.C., Olawuyi O.J., Akanmu, A.O. 2013. Correlation, principal component analysis and tolerance of maize genotypes to drought and diseases in relation to growth traits. American-Eurasian Journal of Agriculture and Environmental Science 13 (11): 1554-1561.

Piperno, D.R., Flannery, K.V. 2001. The earliest archaeological maize (*Zea mays* L.) from highland Mexico: New accelerator mass spectrometry dates and their implications. In: OGTR (2008). The biology of *Zea mays* L. Australia Government Office of the Gene Technology Regulator. Pp. 5-20.

Rosegrant, M.W., N. Leach and R.V. Gerpacio, 1999. Alternative future for world cereal and meat consumption. Summer meeting of the Nutrition Society. Guildford, UK. 29 June-2 July 1998. Proc. Nutr. Soc., 58: 1-16.

Shaw, R. H. 1988. Climate requirement. In: Tripathi, K. K., Warrier, R., Govila, O.P., Ahuja, V. (2011). Biology of *Zea mays* (Maize). Department of Biotechnology, Ministry of Science and Technology and Ministry of Environment and Forests, Government of India. p. 01 – 02.

Skingh, M.K. and Tsunoda, S., 1978. Photosynthetic and transpirational response of cultivated and wild species of Triticumto soil moisture and air humidity. Photosynthetica 12: 412 – 418.

Tripathi, K. K., Warrier, R., Govila, O.P., Ahuja, V. 2011. Biology of *Zea mays* (Maize). Department of Biotechnology, Ministry of Science and Technology and Ministry of Environment and Forests, Government of India.

Welsh, J., 1981. Fundamental of plant breeding and genetics. John Wiley and sons, New York.