Global Scientific JOURNALS

GSJ: Volume 9, Issue 8, August 2021, Online: ISSN 2320-9186
www.globalscientificjournal.com

USE OF INTEGRATED SELECTION INDEX AND RANK SUM FOR SELECTING DROUGHT TOLERANT MAIZE HYBRIDS BASE ON SOME PHYSIOLOGICAL AND YIELD PARAMETERS.

S.Z . Shaba*, A.S. Gana[2], O.A. Falusi[3] and N.M. Ishaq4.

Department of Crop Production Technology, College of Agriculture, Mokwa[1]Department of Crop production, Federal University of Technology, Minna[2], Department of Biological Sciences, Federal University of Technology, Minna[3], National Cereals Research Institute Badeggi, Bida[4]

Abstract

Drought stress is one of the environmental factors which significantly reduce maize productivity. Therefore, to identify the best drought tolerant maize hybrid under drought conditions, thirty F1 crosses were studied in a randomized complete block design with three replications under water stress and non-stress conditions in two locations during 2019 dry season. Traits studied include, Relative water content, Relative water loss, Proline content, stomata count, chlorophyll a, chlorophyll b and total chlorophyll. Analysis of variance showed significant interactions amongst the hybrids for all traits studied under stress and non-stress conditions, indicating high variation among hybrids. The integrated selected index identified (W.DT STR Syn/TZL COMP1-W) F2 x DT SYN 13-W F1 (29 X 18), DT SYN2-W x DT SYN2-W F1 (11 X 20) and DT SYN2-W F1 x DT Syn-1 F2 (20 X 15) as best hybrids, however rank sum identified the hybrids(W.DT STR Syn/TZL COMP1-W) F2 x DT Syn-1 F2 (29 X 15), DT Syn-1 F2 x DT SYN 13-W F1 (15 X 18) and (W.DT STR Syn/TZL COMP1-W) F2 x DT SYN 13-W F1 (29 X 18)as the most drought tolerant hybrids. They are therefore recommended for production in drought prone areas of Niger State, Nigeria.

Keywords:

F1 crosses, Rank sun, Maize hybrids, Selection index, Drought tolerant, Adunu and Jebba.

*Corresponding author. E-mail: solomonshaba88@gmail.com

1 INTRODUCTION

Maize (*Zea mays* L.) is an annual plant that assumes the height of 100 to 250 cm depending on the variety. It has high potential for production and productivity in the savanna ecology and it is favoured by high solar radiation and low night temperatures occurrence in sub-Saharan Africa is of great importance (Undie *et al*., 2012). Owing to the great economic contribution of maize as food for humans and livestock's and raw materials for industries, it production has received a boost and support in Nigeria. In view of the importance of maize in Nigeria, researchers are utilizing available genetic resources to reconstruct the ideotype of the plant in order to meet the increasing requirements of the population through improvement in grain quality, yield and other desirable characters (Bello *et.al.*,2010)

One of the serious problems of agriculture that reduces crop productivity greatly is drought, and maize is highly sensitive to drought. Severe drought causes stomata closure and reduction in gas exchange and can shut down basic metabolism all together leading to plant death (Jaleel*et al*., 2007).Mitra, (2001) reported that drought tolerance is a function of various morphological (early leaf emergence, flowering and maturity, reduced leaf area, leaf rolling, stability in yield, stomata density, root characteristics and cell membrane stability), physiological {low transpiration rate, high water-use efficiency, stomata conductance, osmotic adjustment, relative water content (RWC), relative water loss (RWL), chlorophyll a, chlorophyll b and total chlorophyll} and biochemical (accumulation of proline, polyamine, glycin betain, etc,) characters. Interactions between genotypes and the environment conditions suggest the difficulty in drought stress tolerance development. Therefore, various drought indices were used for identification of drought tolerant genotypes (Celaleddin *et, al.*,2016). Moradi *et. al*., 2012 stated that the use of several indices to identify maize genotype tolerant to drought stress is of more advantage.
Therefore identification and analysis of plant traits with sound and positive association with drought tolerance and high productivity under drought is necessary (Rauf and Sadaqat, 2008). In this regard this study was conducted to identify drought tolerant maize hybrid under water stress condition by integrating some physiological criteria associated with drought tolerance with yield.

2 MATERIALS AND METHOD

2.1 Experimental design and Plant materials

Thirty F1 crosses were studied in a randomized complete block design with three replications under water stress and non stress conditions in two locations during 2019 dry season (Adunu field $7^{o}9^{1}$E, latitude $9^{o}35^{1}$ N and 476 m above sea level and Jebba field $4^{o}51^{1}$E, latitude $9^{o}7^{1}$ N and 53 m above sea level) (table 1).

2.2 Physiological traits measured

Relative water content (RWC): Relative water content was determined according to Tuner (1986), where fresh leaves taken from each of the genotype in replication after tasseling was weighed immediately to record the fresh weight (FW).They were then placed in distilled water for 4 hours and weighed again to record their turgid weight (TW). Samples were later subjected to oven dry at the temperature of 70^{o}C for 24 hours to record the dry weight (DW). The following equation was used to estimate the RWC. RWC = [(FW-DW)/(TW-DW)] × 100

Relative water loss (RWL): Five young fully expanded leaves were sampled from each replication after tasseling. Fresh weight of the samples were taken (FW), and samples were allowed to wilt for 4 hours at temperature of 35^{o}C then reweighed (4hW) and oven dry at 72^{o}C for 24h to obtain dry weight (DW). Relative water loss was calculated using the formula (Gavuzzi*et al*., 1997): RWL (%) = [(FW – 4hW)/(FW – DW)] × 100

Proline concentration (PC): The PC was determined according to the method of Bates *et al*. (1973). Plant leaves collected and ground after tasseling and 0.5g of the grounded materials mixed with 10 ml of 3% sulfosalicylic acid. The homogenate were filtered and 1 ml of glacial acetic acid and 1 ml of acid ninhydrin reagent were added to 1 ml of filtrate. Then the mixture was shaken by hand and incubated in boiling water-bath for 1hour, after which it was transferred to ice bath and warmed to room temperature. 2 ml toluene was added to the mixture and upper toluene layer was measured at 520nm using UV Spectrophotometer

Chloropylla, b and total chlorophyll (Chl a, Chl b, Chl T**):** Chloropylla and b were determined by the method described by Horil*et al*., (2007), after tasseling. 3 ml of 99.5% methanol was added to the leaf tissue (50mg) and incubated in dark for 2hours. The sample was homogenized and centrifuged at 10000 rmp for 10min. Absorbance of the samples at 665nm were determined by the UV spectrophotometer. Absolute methanol (99.5%) was used as a blank. Chl a, Chl b and Chl T content was calculated using the following equations:

Chlorophyll a (µg/mL) = 16.5 × A665 - 8.3 × A650

Chlorophyll b (µg/mL) = 33.8 × A650 – 12.5 × A665

Total Chlorophyll (µg/mL) = 25.8 × A650 + 4.0 × A665

Yield per plant was taken as the weight of the total grains per plant after threshing at 13% moisture content, yield potential (Yp) and yield stress (Ys) were also measured.

2.3 Statistical analysis

Collected data were subjected to statistical analysis of variance (ANOVA) and principal component analysis using SAS 9.4 (2015). Standard deviation of ranks (SDR) and rank sum (RS) were measured according to (Farshadfar and Elyasi, 2012) using the following relationship:

Rank sum (RS) = Rank mean ($\bar{R}$) + Standard deviation of rank (SDR).
Standard deviation of ranks (SDR) was calculated using Microsoft excel.

3.4 Integrated selection index (ISI)

The ISI (Integrated selection Index) was calculated based on factor analysis of physiological traits under water deficit using the following formulae:

(i) Sij = (Xi j - μj)/σj

(ii) MPij = (Sijd + Sijw)/2

(iii) ISI_i = b1MPi1 + b2MPi2 + ………+bjMPij

Where,

Sij = standardized physiological value of trait j (j = 1 to 9, ie. RWC, RWL, Stomata count, Chl a, Chl b, Chl T, PC, Ys and Yp) in genotype i under normal (w) and stress (d) conditions,

Xij = physiological value of genotype i on trait j, μj = mean value of trait j in all genotype, σj = the standard deviation of trait j, MPij = the mean productivity of trait j on genotype i, Sijd = standardized physiological value of trait j under water stress condition Sijw= standardized physiological value of trait j under non stress condition

bj the weight value of trait j, bj is populated from the average contribution to factor 1 and ISI = integrated selection index, Ys = Yield under stress condition, Yp = Yield under non stress condition. Formula (i) standardizes the value of different traits to the same unit of measure; Formula (ii) evaluates the appearance of genotype for each trait; and formula (iii) integrates the appearance of genotypes for all traits. When defining weighted values for each trait, the contribution of factor 1 to 9 major traits related to drought resistance at irrigated and rainfed conditions were considered in the factor analysis as bj and trait had negative functions in the final result (Farshadfar and Elyasi, 2012).

Table 1. Codes and name of hybrid

S/NO	CODE	NAMES OF CROSSES		
1.	29 X 6	(W.DT STR Syn/TZL COMP1-W) F2	×	TZL COMP1-W C6/DT-SYN-1-W
2.	29 X 11	(W.DT STR Syn/TZL COMP1-W)F2	×	DT SYN2-W
3.	29 X 15	(W.DT STR Syn/TZL COMP1-W) F2	×	DT Syn-1 F2
4.	29 X 18	(W.DT STR Syn/TZL COMP1-W) F2	×	DT SYN 13-W F1
5.	29 X 20	(W.DT STR Syn/TZL COMP1-W) F2	×	DT SYN2-W F1
6.	20 X 6	DT SYN2-W F1	×	TZL COMP1-W C6/DT-SYN-1-W
7.	20 X 11	DT SYN2-W F1	×	DT SYN2-W
8.	20 X 15	DT SYN2-W F1	×	DT Syn-1 F2
9.	20 X 18	DT SYN2-W F1	×	DT SYN 13-W F1
10.	20 X 29	DT SYN2-W F1	×	(W.DT STR Syn/TZL COMP1-W) F2
11.	18 X 6	DT SYN 13-W F1	×	TZL COMP1-W C6/DT-SYN-1-W
12.	18 X 11	DT SYN 13-W F1	×	DT SYN2-W
13.	18 X 15	DT SYN 13-W F1	×	DT Syn-1 F2
14.	18 X 29	DT SYN 13-W F1	×	(W.DT STR Syn/TZL COMP1-W) F2
15.	18 X 20	DT SYN 13-W F1	×	DT SYN2-W F1
16.	15 X 6	DT Syn-1 F2	×	TZL COMP1-W C6/DT-SYN-1-W
17.	15X 11	DT Syn-1 F2	×	DT SYN2-W
18.	15 X 29	DT Syn-1 F2	×	(W.DT STR Syn/TZL COMP1-W) F2
19.	15 X 20	DT Syn-1 F2	×	DT SYN2-W F1
20.	15 X 18	DT Syn-1 F2	×	DT SYN 13-W F1
21.	6 X 29	TZL COMP1-W C6/DT-SYN-1-W	×	(W.DT STR Syn/TZL COMP1-W) F2
22.	6 X 20	TZL COMP1-W C6/DT-SYN-1-W	×	DT SYN2-W F1
23.	6 X 18	TZL COMP1-W C6/DT-SYN-1-W	×	DT SYN 13-W F1
24.	6 X 15	TZL COMP1-W C6/DT-SYN-1-W	×	DT Syn-1 F2
25.	6 X 11	TZL COMP1-W C6/DT-SYN-1-W	×	DT SYN2-W
26.	11 X 29	DT SYN2-W	×	(W.DT STR Syn/TZL COMP1-W) F2
27.	11 X 20	DT SYN2-W	×	DT SYN2-W F1
28.	11 X 18	DT SYN2-W	×	DT SYN 13-W F1
29.	11 X 15	DT SYN2-W	×	DT Syn-1 F2
30.	11 X 6	DT SYN2-W	×	TZL COMP1-W C6/DT-SYN-1-W

3. RESULTS

3.1 Result of combined Mean square estimate of physiological traits from analysis of variance

The result of analysis of variance for physiological traits evaluated under stress and non stress conditions across the two locations presented on table 3 showed significant difference across all traits studied. The relative water content of the maize hybrids differs significantly. Higher relative water content (RWC) was observed in the cross 15x29 while cross 15x11 had low RWC among other crosses under water stress condition. The cross 18x29 loss higher amount of water under water stress condition compare to other crosses, while 15x11 loss only about 47.39%. Higher amount proline was fund in the crosses 11x20 and 15x20 had higher significant amount of proline (1.31.) and the cross 6x15 had the least amount of proline (0.21mol) under stress condition. The cross 20x15 had more number of stomata (21.63) in the leaves under stress. Significant higher mean were recorded for the cross 29x18 for chlorophyll a, 6x11 for chlorophyll b and total chlorophyll. Grain yield per plant was significantly higher in the crosses 29x20, 6x11 and 11x6while 18x29, 18x20 and 11x15 had least grain yield per plant in stressed condition. But in non stress condition high significant grain yield per plant was found in the crosses 29x20, 6x18 and15x6.

3.2 Integrated selection index

The integrated selection index for drought tolerance was proposed to identify drought tolerant genotype. In this study, nine traits including, Relative water content, Relative water loss, Proline concentration, Stomata count, chlorophyll a, chlorophyll b, Total chlorophyll, Yield stress, and yield potential were identified traits attributed to drought tolerance used for evaluation. With respect to this study, hybrids 29x18, 11x20and 20x15 had high integrated selection index value while 6x15, 11x29 and 20x11 recorded low value.

3.3 Ranking Method

The result on table 3 showed the ranking of the crosses according to the performance of physiologic and agronomic traits identified as drought indicators. The crosses 15x29, 29x20 and 18x20 were ranked 1, 2 and 3, while 29x11, 6x18 and 15x11 were ranked 28, 29 and 30 respectively for relative water content. In terms of relative water loss, the crosses 15x 11, 11x18 and 6x18 were ranked 1, 2 and 3 and 11x15, 15x20 and 18x29 were ranked 28, 29 and 30 respectively. The rank 1, 2 and 3 for proline concentration were noted for crosses15x20, 11x20 and 15x11 while the crosses 18x20, 11x18 and 15x6 ranked 28, 29 and 30 respectively. The crosses 20x15, 11x20 and 6x15 were ranked 1, 2, and 3 respectively for stomata counts. 11x18, 29x18 and 15x18 were ranked 1, 2 and 3 for chlorophyll a while 6x11, 15x18 and 11x6 were raked 1, 2 and 3 for chlorophyll b and total chlorophyll respectively. Table 4 showed that the crosses 29x20, 15x6 were ranked 1 and 3 for both yield stress and yield potential respectively, while the crosses 6x11 and 6x18 were ranked 2 for yield stress and yield potential respectively.

Table:2 Analysis of variance for Physiological traits of maize hybrids evaluated under stress conditions at two locations in 2018 growing season.

		Mean squares							
		Grain yield		RWC%		RWL%		Prolineconc	
S.O.V.	df	stressed	unstressed	stressed	unstressed	stressed	unstressed	stressed	unstressed
Replication	2	0.954	0.536	8.063	4.941	0.063	8.533*	0.350	0.026*
Crosses	29	109.054**	309.139**	259.974**	234.480**	215.962**	440.250**	0.395*	0.103**
Error	58	0.491	1.072	6.047	4.237	2.180	2.375	0.141	0.004
C.V.%		6.19	4.03	4.46	3.07	2.08	2.90	53.36	18.14

		Mean squares							
		Stomata count		CHLa (633)		CHL b(644)		T.CHL	
S.O.V.	df	stressed	unstressed	stressed	unstressed	stressed	unstressed	stressed	unstressed
Replication	2	2.593	0.391	0.000015	0.075	2.041*	0.041	0.713	1.261*
Crosses	29	26.565**	41.129**	2.251**	1.166**	36.581**	5.680**	51.793**	11.216**
Error	58	1.262	0.617	0.051	0.066	0.414	0.313	0.339	0.153
C.V.%		7.11	4.53	17.26	13.39	8.84	10.21	6.79	5.29

*and **: Significant at 1% and 5% level of probability respectively, S.O.V: Source of variation. df: Degree of freedom, RWC: Relative water content, RWL: Relative water loss, CHLa: Chlorophyll a, CHL b: Chlorophyll b and T,CHL: Total chlorophyll

Table 3. Mean and Ranks (R) of physiological trait identified as drought tolerant indicators under water stress condition

Entry	Crosses	RWC %	R	RWL %	R	PC	R	SC	R	CHL a	R	CHL b	R	T. CHL	R
1	29x6	70.54	4	63.93	9	0.97	7	18.66	26	2.24	5	7.59	12	9.81	9
2	29x11	46.15	28	69.75	14	0.53	17	13	8	1.21	15	5.37	21	6.55	20
3	29x15	62.44	11	69.97	15	0.5	18	13.4	9	1.48	12	8.27	10	9.72	10
4	29x18	58.41	14	61.21	6	1.04	4	16.37	17	2.97	2	11.04	4	13.98	4
5	29x20	73.88	2	67.3	11	0.71	12	12.34	4	0.57	22	4.15	26	4.71	24
6	20x6	58.04	16	68.87	13	0.76	10	13.85	11	0.04	29	3.73	28	3.71	27
7	20x11	48.41	27	55.94	4	0.86	9	14.88	13	0.06	28	3.97	27	3.93	26
8	20x15	54.18	22	61.74	7	0.91	8	21.63	30	0.54	23	6.55	17	7.07	19
9	20x18	66.28	8	67.89	12	1.02	5	15.8	15	0.92	19	5.42	20	6.32	21
10	18x6	53.13	24	63.38	8	0.35	22	13.92	12	2.36	4	10.82	5	13.16	6
11	18x11	66.06	9	77.27	24	0.23	28	17.65	23	2.24	5	6.04	19	8.26	16
12	18x15	57.03	19	79.1	26	0.48	19	12.71	5	2.15	6	9.81	7	11.95	7
13	15x6	53.33	23	65.13	10	0.3	24	10.54	1	0.98	17	6.3	18	7.27	18
14	15x11	39.99	30	47.39	1	1.08	3	19.38	27	1.04	16	9.32	8	10.35	8
15	11x6	62.15	12	58.75	5	0.59	15	16.96	18	1.95	7	13.16	3	15.09	3
16	6x29	60.6	13	71.75	17	0.28	26	12.98	7	0.96	18	8.42	9	9.37	12
17	6x20	51.67	26	70.11	16	0.75	11	18.58	25	1.58	11	5	23	6.55	20
18	6x18	43.7	29	53.17	3	0.69	13	17.85	24	1.84	8	7.37	14	9.2	13
19	6x15	51.7	25	76.99	23	0.21	29	20.45	28	1.22	14	4.78	24	5.98	22
20	6x11	57.99	17	76.31	22	0.29	25	17.52	22	1.8	9	17.5	1	19.52	1
21	11x29	66.3	7	78.35	25	0.31	23	16	16	0.39	26	5.31	22	5.68	23
22	11x20	56.85	20	79.11	27	1.26	2	20.62	29	0.41	24	2.59	30	2.98	29
23	11x18	68.01	6	49.93	2	0.64	14	11.11	2	0.84	20	7.46	13	8.28	15
24	11x15	56.54	21	80.25	28	1.01	6	13.5	10	2.98	1	10.76	6	13.78	5
25	15x29	74.73	1	72.31	18	0.35	22	17.32	19	0.4	25	2.63	29	3.01	28
26	15x20	63.42	10	80.44	29	1.31	1	15.29	14	1.61	10	7.87	11	9.46	11
27	15x18	70.34	5	74.71	20	0.46	20	17.42	20	2.84	3	14.16	2	16.98	2
28	18x29	57.82	18	84.5	30	0.37	21	17.46	21	0.16	27	4.31	25	4.45	25
29	18x20	71.61	3	74.38	19	0.58	16	12.24	3	1.26	13	7.15	16	8.39	14
30	20x29	58.39	15	76.28	21	0.24	27	12.78	6	0.62	21	7.21	15	7.82	17

RWC: Relative water content, RWL: Relative water loss, PC: proline content, SC: Stomata count, CHL a : Chlorophyll a, CHL b: Chlorophyll b, T. CHL. Total chlorophyll

Table 4 Ranks (R), ranks mean (RM), standard deviation of ranks (SDR), rank sum (RS) and integrated selection index(ISI) of genotypes investigated.

S/NO	Genotypes	Ys kg/ha	R	Yp kg/ha	R	ISI	R	RM	STD	RS
1	29x6	554.31	7	1643.90	22	-0.22	15	11.60	7.34	18.94
2	29x11	476.88	13	2165.00	8	-3.69	25	16.90	6.67	23.57
3	29x15	581.78	5	2078.80	12	-3.47	24	12.60	5.30	17.90
4	29x18	174.07	27	1767.70	17	12.04	1	9.60	8.63	18.23
5	29x20	1234.43	1	2980.80	1	0.43	10	11.30	9.70	21.00
6	20x6	577.19	6	1753.60	18	-2.67	22	18.00	8.19	26.19
7	20x11	263.61	22	1226.60	29	-10.59	30	21.50	9.35	30.85
8	20x15	209.48	26	1726.60	20	6.1	3	17.50	8.81	26.31
9	20x18	548.02	8	1416.50	25	-0.63	16	14.90	6.54	21.44
10	18x6	244.09	23	1778.20	16	-0.99	18	13.80	7.81	21.61
11	18x11	484.13	10	2297.80	5	-1.92	21	16.00	8.29	24.29
12	18x15	620.76	4	2097.00	11	-0.08	14	11.80	7.44	19.24
13	15x6	369.52	3	2346.40	3	-3.19	23	14.00	9.01	23.01
14	15x11	288.68	21	1364.00	26	5.33	5	14.50	10.87	25.37
15	11x6	875.41	2	1590.20	24	-0.81	17	10.60	7.68	18.28
16	6x29	296.46	20	2181.40	7	3.59	7	13.60	6.50	20.10
17	6x20	458.74	14	2034.80	14	0.33	11	17.10	5.93	23.03
18	6x18	98.50	30	2414.30	2	0.32	12	14.80	9.90	24.70
19	6x15	396.72	15	1241.00	28	-5.57	28	23.60	5.36	28.96
20	6x11	216.41	24	2130.20	9	5.86	4	13.40	9.67	23.07
21	11x29	215.93	25	1344.30	27	-8.57	29	22.30	6.41	28.71
22	11x20	316.62	18	687.85	30	6.11	2	21.10	10.89	31.99
23	11x18	311.77	19	2052.80	13	-1.76	20	12.40	6.88	19.28
24	11x15	161.00	28	1734.40	19	-1.61	19	14.30	9.91	24.21
25	15x29	477.89	12	1631.50	23	1.7	8	18.50	9.03	27.53
26	15x20	478.90	11	1950.10	15	1.03	9	12.10	7.02	19.12
27	15x18	661.51	16	2212.80	6	4.59	6	10.00	7.96	17.96
28	18x29	316.89	17	2343.40	4	0.04	13	20.10	7.59	27.69
29	18x20	120.10	29	1703.70	21	-4.04	26	16.00	8.52	24.52
30	20x29	547.91	9	2110.80	10	-4.39	27	16.80	7.25	24.05

Ys kg/ha Yields under stress condition in kilogram per hecter, Yp kg/ha Yield under non stress condition in kilogram per hecter, ISI: Intergrated selection index, MP: Mean productivity, STI: Stress tolerant index, R: Rank, RM: Rank Mean, SDR: Standard Deviation of Ranks and RS: Rank sum

4 DISCUSSION

The response of plant to water stress vary greatly, according to Decov*et al*., 2000, relative water content in leaves of maize decreases significantly when leaves are subjected to drought, this reduces the leaf growth rate and ultimately its cell wall plasticity. These in general affect leave area development. Crosses that showed higher relative water content suggest that they have ability to tap more water from the soil or have high water use efficiency. These results can be related to earlier findings of Farshadfar *et. al,*. 2013, in which it was observed that decreased relative water content in bread wheat under water stressed condition was associated with decreased plant vigor. Relative water content had been identified as physiological maker for drought tolerant in many plants such as bread wheat (Rarshadfar 2012), Maize (Mohammad et. al., 2011). Poline acts as an osmolytes for osmotic adjustment and enhances leaf growth rate. Qayyum*et al*. (2011) observed that in response to environmental stresses including drought, proline is one of the major organic osmolytes that accumulate in a variety of plant species. However in the present study, level of proline was significantly enhanced in hybrids under stressed condition. This finding agrees with the earlier report of Mohsenzadeh *et. al.*, 2006 who reported that amount of proline may increase up to 30 times when drought condition is increased by 18 days. Also Ezatollah *et. al,*.2013, had similar report in bread wheat under drought condition. Therefore, crosses with high proline content might have increased ability to synthesize osmotic regulators against the resultant effect of drought. The significant reduction observed in the yield under stressed condition in this study indicates existence of variability amongst the crosses. Studies on maize, revealed that drought stress greatly reduce grain yield, this could be attributed to the level of defoliation due to water stress during early reproductive growth (Jaleel*et al*. 2009). Early grain filling is most sensitive to water stress as compared with pre flowering and late grain-filling stages which is considered the most determinant in maize yield. Esmail Nabizadeh *et al.*, 2012, reported that number of grain per cob reduction may be due to embryo abortion or delay in silk appearing because of the carbohydrates shortage in drought stress condition. Li *et al*., 2012 concluded that plants under normal irrigation condition produced more number of grains per cob, because during the granulation phase (the most sensitive stage of drought stress) plant has received water. Selecting best drought tolerant hybrid is difficult when selection is based on a single criteria, this is because the hybrids respond differently to each different criterion. For example relative water content identified 15x29 as the best hybrid while integrated selection index identifies 29x18 as the best. Therefore selection based on a combination of indices may provide a more useful criterion for improving drought tolerance in maize (Mohammadreza, *et., al* 2010). Determining most drought tolerant genotypes can be achieved by using mean ranking, standard deviation of ranks and rank sum of all the criteria's used in calculating the indices. In consideration to all indices, crosses with the lowest rank sum identified under stress condition are considered the most drought tolerant crosses. This procedure is been implored as the overall judgment of the entire criterion used for selection. Mohammadi *et al., (*2011) and Farshadfar*et. al.,* (2013b) reported the use of this method for screening quantitative indicators of drought tolerance in maize, wheat and bread wheat respectively.

Conclusion

With global climate change, droughts become more frequent and severe, therefore hybrids with high level of drought tolerance are advised for maximum production. In this study, hybrids (W.DT STR Syn/TZL COMP1-W) F2 × DT Syn-1 F2 (29x15), (W.DT STR Syn/TZL COMP1-W) F2 × DT SYN 13-W F1 (29x18) and DT Syn-1 F2 × DT SYN 13-W F1 (15x18) were recommended for planting in the drought prone region of Niger state, Nigeria.

References

Bello O. B., Ige S. A., Azeez M. A., Afolabi M. S., Abdulmaliq S. Y. and Mahamood J. (2012) Heritability and Genetic Advance for Grain Yield and its Component Characters in Maize (*Zea Mays* L.)*International Journal of Plant Research*, 2(5): 138-145

Bello OB, Abdulmaliq SY, Afolabi MS, and Ige SA (2010). Correlation and Path coefficient analysis of yield and agronomic characters among open pollinated maize varieties and their F1 hybrids in a diallel cross. Afri. J. Biotech., 9(18): 2633-2639.

Betran, F.J., J.M. Ribaut, D.L. Beck and D. Gonzalez de Leon, 2003. Genetic analysis of inbred and hybridgrain yield under stress and non stressenvironments. Crop Sci., 43: 807-817.

Campos, H., M. Cooper, J.E. Habben, G.O. Edmeadesand J.R. Schussler, 2004.Improving droughttolerance in maize a view from industry. Field CropsRes., 90: 19-34.

CelaleddinBarutcular, Ayman EL Sabagh, Omer Konuskan, Hirofumi SaneokaandKhairMohammad Yoldash (2016). Evaluation of maize hybrids to terminal drought stress tolerance by defining drought indices.
Journal of Experimental Biology and Agricultural Sciences, 2016; 4(6)

Jaleel, C.A., P. Manivannan, B. Sankar, A. Kishorekumar, R. Gopi, R. Somasundaram and R. Panneerselvam (2007). Induction of drought stress tolerance by ketoconazole in *Catharanthusroseus*is mediated by enhanced antioxidant potentials and secondary metabolite accumulation. Colloids and Surfaces B: Biointerfaces 60, 201-206.

Mitra J (2001) Genetics and genetic improvement of drought resistance in crop plants Current Sci. 80: 758-763.

Mohammaderaza Shiri, R. Choukan and R.T. Aliyev (2010). Drought tolerance evaluation of hybrid maize using Biplot method. Trends in applied science research 5 (2): 129-137.

Moradi H, Akbari GA, KvahariKhorasani S, Ramshini HA (2012) Evaluation of drought tolerance in corn (Zea mays L.) new hybrids with using stress tolerance indices. European Journal Sustainable Development 1: 543-560.

Nigussie, M. &Zelleke, H. (2011).Heterosis and combining ability in a diallel among eight elite maize populations.*African J. Crop Sci. 9:471-479.*

Ojo, G.O.S., Adedzwa, D.K. & Bello, L.L. (2007). Combining ability estimates and heterosis for grain yield and yield components in maize (*Zea mays* L.). *J. Sustainable develop. Agric. Environ. 3: 49-57.*

Undie UL, Uwah DF and Attoe EE (2012). Growth and development of late season maize/soybean intercropping in response to nitrogen and crop arrangement in the forest agro-ecology of south southern Nigeria. Int. J. Agric.Res., 7(1): 1-16.

Rauf S and Sadaqat HA (2008) Identification of physiological traits and genotypes combined tohigh achene yield in sunflower (*Helianthus annuus*L.) under contrasting water regimes. *Aust J CropSci*1:23-30

Reynolds, M.P., G. Rebetzke, A. Pellegrineschi and R.M. Trethowan, 2005.Genetic, Physiological andBreeding Approaches to Wheat Improvement under Drought.In Drought Tolerance in Cereals.Ed. Jean-Marcel Ribaut. New York: Haworth's Food Products Press.

Yasir T. A., Chen, X., Tian, L., Condon, A. G., Yin-Gang, H. U. (2013). Screening of Chinese bread wheat genotypes under two water regimes by various drought tolerance indices. *Australia. Journal.of Crop Sci.*, 7(13):2005-2013.