Yield and disease reactions of quality protein maize varieties in the Southern Guinea Savanna Agro-Ecology of Nigeria

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YIELD PERFORMANCE AND ADAPTATION OF EARLY AND INTERMEDIATE DROUGHT-TOLERANT MAIZE GENOTYPES IN GUINEA SAVANNA OF NIGERIA

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ABSTRACT

Drought-tolerant maize genotypes belonging to two different maturity (10 early and 10 intermediate) groups were evaluated for yield and other related characters in the Southern Guinea Savanna of Nigeria for two years (2009 and 2010). The differences among genotypes between and within maturity groups differed significantly (P<0.01) for grain yield, plant height, days to anthesis and silk. The effects of year x maturity group and year x maturity within group interactions were highly significant (P<0.01) only for grain yield. The rainfall patterns were favourable in both cropping years with comparable values of growth parameters. Intermediate maturing genotypes (TZL COMP1-W C6 F2, SUWAN-1-SR-SYN, TZB-SR, OBA SUPER I, EV 8435-SR) out-yielded early maturing ones with yield advantage of 34.29% and taller by 17.04% compared to early ones. However, early genotypes were early to anthesis with 6.57% advantage over intermediate genotypes. Four early genotypes (DMR-ESR Y CIF2, AC 90 POOL 16 DT, STR, TZE-W DT STR C4 and ACR 95TZE COMP4 C3) were superior for grain yield withn a range of 4.39 to 4.68 t ha^{-1}. These genotypes could be selected either as parental breeding cultivars to overcome the problem of moisture stress during the later part of the cropping season or introgressed with favourable cultivars for high yield adaptable to drought-prone areas in the SGS agro-ecology.

Key words: **Maize yield, early genotypes, intermediate genotypes**

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INTRODUCTION

Maize (*Zea mays* L.) is an important staple food crop and provides bulk of raw materials for livestock, pharmaceutical and many agro-allied industries in the world (Olawuyi et al., 2010; Randjelovic et al., 2011; Bello et al., 2013). The savanna agro-ecology of Nigeria has a great potential for food production because of its high solar radiation that favours maize production. In the southern guinea savannah (SGS), maize is grown twice due to bimodal rainfall pattern (a short early growing season followed by fairly long late season). Early maize varieties are usually planted at the onset of rainy season before it's fully established (March/April), and but matured earlier than the traditional crops (sorghum *[Sorghum bicolor* (L.) Moench] and millet [*Pennisetum glaucum* (L.) R. Br.]). This bridges the hunger gap in July when all food reserves have been consumed after the long dry period in the zone. On the other hand, the late season crop is planted during the second cycle of rains (July/August). The early season is usually characterized by abrupt cessation of rains during crop cycle, while the late season is normally affected by terminal drought.

The occurrence of extreme environmental events resulted to different degrees of drought stresses on crops thereby, affecting growth duration, plant size, dry matter accumulations, assimilation reserves and partitioning to grains. Due to insufficient water resources for agronomic uses which becomes more limiting, the development of drought-tolerant (DT) lines becomes increasingly necessary. Drought occurring during or shortly before flowering in crops, had been reported for estimated yield loss in the range of 21 to 50% (Olaoye et al., 2009). The soil in the SGS is also fragile with low organic matter, poor buffering and water holding capacity, resulting in low nitrogen availability (Fakorede et al., 2001; 2003). Since the timing of mid-season drought is unpredictable, early maturing cultivars that can tolerate the effects of reduced moisture supply during flowering could reduce farmers' risk in drought-affected ecologies (Olaoye et al., 2009; Hussain et al., 2011). Early maturing DT maize varieties are needed for intercropping by providing less competition for moisture, light, and nutrients than late maturing ones. They also offer flexibility in planting dates, which encourages: (i) mixed cropping in a season to avoid risk of losing a single crop to drought (ii) late plantings during delayed onset of rainfall, and (iii) avoidance of known terminal drought periods during the cropping season (CIMMYT, 2000). The occurrence of drought in most parts of West and Central Africa has currently made the production and utilization potential of DT maize varieties attract the attention of the national and international researchers to develop, test and transfer high yielding and adapted maize cultivars to farmers (Badu-Apraku et al., 2003; Olaoye and Omueti 2006). The release of improved drought-tolerant maize varieties by research institutes has created assurance for increased maize productivity in the savanna agro-ecologies. These could not only be achieved by promoting rate of adoption of improved maize cultivars by the farmers, but also provide farmers opportunities to overcome the challenges to maize production thus, ensuring food security in West and Central Africa. From 1987 to date, the regional early and intermediate varietal trials have been organized by West and Central Africa Maize Collaborative Research Network (WECAMAN) and the Maize and Wheat Improvement Center (CIMMYT), and Mexico as a vehicle for systematic testing and dissemination of elite maize across West African sub-region. They were on germplasm exchange among maize scientists in the sub-Sahara of West Africa with the aim of offering the opportunity to identify varieties suitable to their peculiar growing condition. Evaluation of extra early (80-85 days), early (90-95 days) and intermediate (100-105 days) maturing groups have formed part of their varietal trials in the marginal environments of the region under the auspices of International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria (Badu-Apraku et al., 2003; Sallah et al., 2004; Olaoye and Omueti, 2006; Oluwaranti et al., 2008). Availability of the early and extra-early varieties is a strategy for breeding adaptable and tolerant maize to withstand the effect of short rainy season, and prevent drought stress that occurs during the grain-filling stage in the late season. These cultivars are endowed with favourable genes for high yield (ranging from 20-50% yield increase than other maize varieties) potential and stability across a broad range of water availability (Kucharik, 2008; Olaoye et al., 2009). Based on these, assessment of early maturing DT varieties that fully explored the potential growing season and fit into the erratic rainfall pattern in the ecology is precondition to increasing maize yields. The present study was therefore conducted to evaluate the performance of early and late/intermediate DT maize maturity groups, with a view to identifying genotypes that are high yielding and adapted to marginal and drought-prone ecologies for farmers' use.

MATERIALS AND METHODS

Collection of Planting Materials

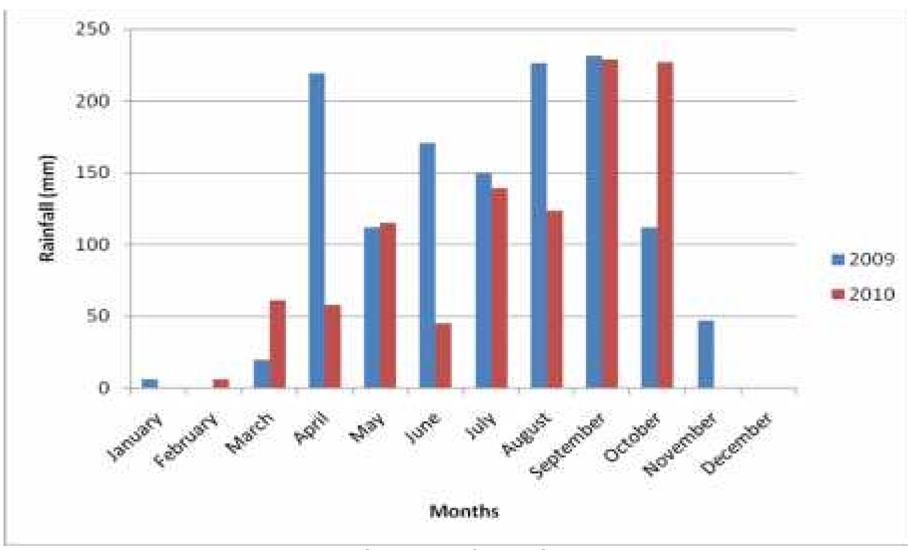
The genetic materials used for this study were set of drought-tolerant maize genotypes belonging to two different maturity (10 early and 10 intermediate) groups. These genotypes were developed by West and Central Africa Maize Collaborative Research Network (WECAMAN) which was originally part of the international trials coordinated by the IITA Ibadan, Nigeria. The popular local genotype, AFO and Composite-Y were used as checks for both early and intermediate maturity groups respectively. The genotypes were evaluated for two years (2009 and 2010) during late growing seasons at the Lower Niger River Basin Development Authority station, Oke-Oyi, Ilorin, Nigeria (8^0 30'N, 8^0 36'E). Planting was carried out on 21st July, 2009 and 27th July, 2010 respectively.

Soil Analyses and Rainfall Data

The physico-chemical characteristics of the soil at the experimental site were determined by collecting soil samples randomly at the depths of 0-15cm and 15-30cm respectively with an auger, and analyzed in the laboratory before planting in both cropping seasons (Table 1). The collected samples were air-dried and passed through 2mm sieve to remove large particles, debris and stones. The sieved samples were analyzed for pH in 1:1 soil to water ratio using the Coleman's pH meter. Organic carbon was determined by Walkley and Black procedure (Nelson and Sommers, 1992). Total nitrogen was determined by the micro Kjeldahl method (Bremner, 1965), while available phosphorus was extracted by Bray's P_1 method (Bray and Kurtz, 1945) and read from the Aatomic Aabsorption Sspectrometer. Exchangeable Ca, Mg, K, Na and effective cation exchangeable capacity (ECEC) were analyzed using Atomic Absorption Spectrophotometery (IITA, 1989), while soil textural analysis was done by hydrometer method. Rainfall distribution data for 2009 and 2010 were also recorded (Fig. 1).

Table 1. ***Physico-chemical characteristics of the soil in the experimental site prior to growing of maize at Ilorin, Nigeria in 2009 and 2010***

Soil properties	0-15cm depth		15-30cm depth	
	2009	**2010**	**2009**	**2010**
Physical characteristics				
Sand %	72.0	72.1	72.2	72.3
Clay %	6.0	6.3	6.3	6.4
Silt %	19.0	19.2	19.2	19.4
Texture	Sandy loam	Sandy loam	Sandy loam	Sandy loam
Chemical characteristics				
Soil PH (water)	6.1	6.2	6.3	6.3
Exchangeable Ca^{2+} (cmol kg $^{-1}$)	1.5	1.5	1.6	1.5
Exchangeable Mg^{2+} (cmol kg $^{-1}$)	1.3	1.4	1.4	1.3
Exchangeable Na^{+} (cmol kg $^{-1}$)	0.18	0.18	0.18	0.18
Exchangeable K^{+} (cmol kg $^{-1}$)	0.29	0.30	0.29	0.30
Total acidity H^{+} (cmol kg $^{-1}$)	1.1	1.1	1.1	1.1
Cation exchange capacity (cmol l kg $^{-1}$)	11.9	11.9	12.01	12.02
Organic Carbon %	8.7	8.8	8.6	8.6
Total Nitrogen %	0.5	0.5	0.5	0.5
Available phosphorus (mg kg^{-1})	6.3	6.2	6.2	6.2



Source: Lower Niger River Basin Development Authority, Ilorin, Nigeria
Fig. 1. Monthly rainfall distribution pattern at Ilorin in 2009 and 2010

Experimental Layout and Cultural Practices

Maize seeds (20 genotypes) were planted on 29th July, 2009 and 28 th July, 2010 in a randomized complete block design with four replications. The materials were planted in 4-row plots, 5 m long, with 0.75 m spacing between rows and 0.5 m spacing between plants. Within a row, three to four seeds were planted in a hill and later thinned to two plants after emergence to attain a population density of 53,333 plants ha^{-1}. A compound fertilizer NPK 15:15:15 was applied at the rate of 60 kg N, 60 kg P and 60 kg K ha^{-1} at three weeks after planting (WAP). An additional 60 kg N ha^{-1} was applied as top dressing at seven WAP using urea (46 % N). Weed control was done chemically by the use of 5 litres per hectare pre-emergence herbicides (a.i. 3 kg/l Metolachlor and 170 g/l Atrazine). Hand weeding was also supplemented at four WAP prior to topdressing.

Data Collection

Data were collected from the two middle rows in each plot. The parameters measured included: Days to anthesis and silking recorded as the number of days from planting to when 50% of the plants in each plot shed pollen and silks had emerged respectively. Anthesis-silking interval was computed as the difference between dates of silking and pollen shed. Plant and ear heights were measured as the distance (cm) from the base of the plant to the height of the first tassel branch and the node bearing upper ear respectively. Plant aspect was rated visually on a scale of 1 to 5 where 1 = excellent overall phenotypic appeal and 5 = poor overall phenotypic appeal of plants. Ear aspect was also rated on a scale of 1 to 5 where 1 = clean, uniform, large and well-filled ears and 5 = variable, small and partially filled cobs. The total number of plants and ears were counted in each plot at the time of harvest. The number of ears per plant was then calculated as the proportion of the total number of ears harvested divided by the total number of plants in a plot. All ears harvested from each plot were shelled to determine percentage moisture at harvest. Grain yield was adjusted to 12.5% moisture and used to compute grain yield in tonnes per hectare (t ha^{-1}).

Data Analyses

Data collected in respect of each maturity group were first computed with analysis of variance (ANOVA) separately before a combined ANOVA across maturity groups and the two years growing seasons using PROC GLM model of SAS (SAS Institute, 2007) was computed to determine mean squares for each character. The degree of variation was determined using % coefficient of variation $P< 0.05$. Differences in character means were also measured using Least Significant Difference (LSD).

RESULTS AND DISCUSSION

Distribution of Rainfall and Soil Analysis

In the cropping seasons of 2009 and 2010, there were false start of rain from February to March and a break in July, 2010. This was followed by adequate and evenly distribution throughout the flowering/grain filling periods of July to October. In each of the growing year, there was a significant rainfall drop (August break) in August, 2010 and October 2009. (Figure 1). However, the physico-chemical analysis of 0-15 and 15-30cm soil depth showed that the soil at the experimental area was comparable in both depths in both years (Table 1). The particle size analysis of the soil type was sandy loam with a high proportion of sand (72.2%) but less clay (6.3%), silt (19.2%). On the chemical characteristics, the soil was slightly acidic (pH of 6.2) with adequate cation exchange capacity (11.90 cmol kg^{-1}). Although the total nitrogen (0.5%), organic carbon (8.7%), calcium (1.5 cmol kg^{-1}) and magnesium (1.3 cmol kg^{-1}) values were low, there was a high concentration of available phosphorus (6.2 mg kg^{-1}).

Mean Squares from Combined Analysis of Variance

The differences among genotypes between and within maturity groups differed significantly ($P<0.01$) for grain yield, plant height, days to anthesis and silk (Table 2). The effect of year x maturity group and year x maturity within group interactions were highly significant ($P<0.01$) only for grain yield. The sources of variation however were non-significant for all the characters in both years. The rainfall patterns were favourable in both cropping years (Figure 1) with comparable values of growth parameters.

Genotypic Performance for Yield and other Agronomic Characters

Ranges in the means for grain yield, ears per plant, anthesis-silking interval (ASI), plant and ear aspect scores were lower in the intermediate maturity genotypes than early varieties (Table 3). While ranges in the means for ear height, days to anthesis and silk were high, reverse was the case for the values of plant height with comparable results. Although, early genotypes were early to anthesis with 6.57% advantage over intermediate cultivars, Intermediate genotypes had grain yield advantage of 34.29% and taller by 17.04% compared to early genotypes regardless of the growing year. Among early genotypes group, DMR-ESR Y CIF2 was superior with highest grain yield followed by AC 90 POOL 16 DT STR, TZE-W DT STR C4 and ACR 95TZE COMP4 C3 in that order. However, most of the late/intermediate maturing genotypes out-yielded early maturing ones. In intermediate maturing group, TZL COMP1-W C6 F2, SUWAN-1-SR-SYN, TZB-SR, OBA SUPER I, EV 8435-SR yielded higher with yield advantage of 29.06% compared with the best (DMR-ESR Y CIF2) in the early group. It was also observed that the two local genotypes as checks (SUWAN-1-SR and AFO) were the poorest for grain yield. On the other hand, similar and moderate ASI, ears per plant as well as plant and ear aspects scores were recorded between and within maturity groups.

Table 2. ***Mean squares from combined ANOVA for grain yield and other related characters in early and intermediate maize maturity groups***

Sources of variation	Df	Days to anthesis	Days to silking	ASI (days)	Plant height (cm)	Ear height (cm)	Plant aspect	Ear aspect	Ears per plant	Grain yield (t ha^{-1})
Year (y)	1	4.45	3.29	6.34	8.18	13.07	34.21	12.45	23.19	1.23
Rep (Year)	6	20.43	11.37	0.45	34.56	9.38	0.38	7.36	31.75	15.92
Maturity group (G)	1	987.25**	1243.36**	12.56	897.45**	34.42	13.78	10.04	15.11	1342.74**
Variety/group (V/G)	19	1265.34**	952.14**	13.24	875.24**	23.45	24.01	15.19	13.44	945.23**
Y x G	9	1.96	24.16	32,18	54.33	13.76	23.61	1.93	24,61	1528.22**
Y x V/G	9	10.75	24.89	3.65	17.34	54.29	28.63	41.39	31.72	987.12**
Error	181	13.26	5.36	10.38	1.83	32.49	28.26	36.81	21.59	1.58

*,**, significant at $P< 0.05$ and $P< 0.01$ respectively

Table 3. ***Mean grain yields and other related characters for early and intermediate maize maturity groups at Ilorin, Nigeria in 2009 and 2010***

Early maturing group	**Days to anthesis**	**Days to silking**	**ASI**	**Plant height (cm)**	**Ear height (cm)**	**Plant aspect**	**Ear aspect**	**Ears per plant**	**Grain yield (t ha^{-1})**
EV DT-Y 2000 STR C0	59.4	62.5	3.1	132.4	58.5	2.34	2.13	0.97	3.23
EV DT-W 97 STR C1	55.2	56.5	2.8	127.5	57.7	2.03	2.92	0.94	3.17
EV DT-Y 2000 STR QPM C0	59.5	62.4	2.9	128.2	60.4	2.70	2.74	0.84	2.34
DMR-ESR Y CIF2	56.7	58.8	2.6	138.8	61.7	2.86	2.02	0.73	4.68
BG 97 TZE COMP 3 x 4	60.1	62.9	2.8	127.6	51.9	2.12	2.73	0.83	2.62
TZE-W DT STR C4	60.6	62.3	2.7	137.4	62.5	2.93	2.88	0.85	4.44
TZE-W DT STR QPM C0	61.5	63.7	2.7	129.9	56.8	2.75	2.06	0.92	3.60
AC 90 POOL 16 DT STR	58.2	60.5	2.8	140.0	62.4	2.56	2.87	0.86	4.60
ACR 95TZE COMP4 C3	58.8	60.7	2.9	130.4	58.7	2.78	2.14	0.91	4.39
TZE COMP 3 DT C3	54.3	57.0	2.7	124.7	56.3	2.04	2.94	0.96	3.57
AFO (LOCAL CHECK)	54.5	56.6	2.7	118.1	51.5	2.59	2.77	0.99	2.17
Mean	58.1	60.4	2.8	130.5	58.0	2.5	2.6	0.9	3.50
Range	7.2	7.2	1.8	21.9	11	0.9	0.92	0.26	2.51
SE	3.54	23.12	4.75	11.52	14.39	1.09	3.81	12.93	13.52
LSD (0.05)	2.13**	1.23*	ns	4.17**	ns	ns	ns	ns	1.21**
CV (%)	4.14	9.27	13.17	28.33	13.71	12.64	2.34	14.19	12.24
Intermediate maturing group									
DT-SR-W C0 F2	65.5	67.6	2.0	168.6	69.6	2.35	2.12	0.99	4.88
DT-SYN-1-W	67.6	69.4	2.8	175.7	72.7	2.13	2.93	0.85	4.22
TZL COMP1-W C6 F2	67.3	69.5	3.1	178.3	70.4	2.70	2.75	0.90	5.94
IWD C2 SYN F2	69.6	72.2	2.6	153.7	60.2	2.84	2.57	0.94	2.96
SUWAN-1-SR-SYN	58.8	60.7	2.9	179.4	80.7	2.73	2.15	0.97	6.41
White DT STR SYN	69.2	71.5	2.8	167.9	70.5	2.89	2.13	0.91	3.22
TZUTSY-WSGY-SYN	69.1	71.3	2.7	170.6	70.8	2.16	2.99	0.86	3.87
TZB-SR	63.4	64.7	2.8	176.3	72.3	2.74	2.74	0.83	5.95
OBA SUPER I	63.3	65.2	2.9	175.5	81.5	2.34	2.42	0.89	5.84
EV 8435-SR	69.6	71.9	2.8	180.5	70.3	2.03	2.86	0.84	5.24
SUWAN-1-SR(LOCALCHECK)	69.9	71.8	2.9	158.7	59.5	2.70	2.73	0.80	2.80
Mean	66.7	68.7	2.8	171.4	70.8	2.5	2.6	0.9	4.70
Range	11.1	11.5	1.3	21.8	22.0	0.86	0.87	0.19	2.44
SE	1.13	1.26	0.70	14.30	9.01	0.61	0.31	0.08	1.28
LSD (0.05)	1.45**	2.87**	ns	3.24**	ns	ns	ns	ns	1.37**
CV (%)	1.05	13.5	0.36	2.83	5.87	13.41	3.09	11.75	13.56
+ Differential	12.9	12.1	-15	23.9	17.5	0	0	0	39.6

*, **; Significant F-Test at $p<0.05$ and $p<0.001$ levels, respectively; + Difference between early and late/intermediate maize maturity groups expressed as % of former. ASI = Anthesis-silking interval

Among early maturity group, ranking based on grain yield and days to silk showed that DMR-ESR Y CIF2 was the topmost ranked followed by AC 90 POOL 16 DT STR (Table 4). Consequently, ACR 95TZE COMP4 C3 and Syn E2 that had top entry for grain yield, ranked a distant 10th because of lateness in anthesis. Check genotype (AFO) that was the poorest for grain yield had rank entry of 6th based on its earliness to anthesis. However, among intermediate maturity groups, SUWAN-1-SR-SYN ranked top followed by TZB-SR., TZL COMP1-W C6 F2 and then OBA SUPER I, while Check genotype, SUWAN-1-SR which was the poorest for grain yield also ranked a distant 10th based on its lateness to anthesis (Table 5). It is important to note that the local genotype , SUWAN-1-SR with the lowest grain yielding had yield advantage of 129% after being improved to form SUWAN-1-SR-SYN.

Correlation among traits in early and intermediate maize genotypes

Grain yield showed positive and significant ($P < 0.05$) association with day to anthesis, plant and ear heights, but positive and non-significant for days to silking, ASI, ears per plant, plant and ear aspects (Table 5). Days to anthesis was positive and significantly associated with days to silking, but positive and non-significantly correlated with ASI and plant height as well as negative and non-significant associated with ear height as well as plant and ear aspects. Plant height however was negative and significantly correlated with plant aspect, but positive and significantly associated with ear aspect, as well as positive and non-significantly correlated to ears per plant.

Table 4. Ranking of entries within each maturity group based on days to silk and grain yield

Ear maturity group				Intermediate maturity group			
	Grain yield	Days to silking	Total ranking		Grain yield	Days to silking	Total ranking
EV DT-Y 2000 STR C0	7	9	16	DT-SR-W C0 F2	6	4	10
EV DT-W 97 STR C1	8	1	9	DT-SYN-1-W	7	5	12
EV DT-Y 2000 STR QPM C0	10	8	18	TZL COMP1-W C6 F2	3	6	9
DMR-ESR Y CIF2	1	4	5	IWD C2 SYN F2	10	11	21
BG 97 TZE COMP 3 x 4	9	10	19	SUWAN-1-SR-SYN	1	1	2
TZE-W DT STR C4	3	7	10	White DT STR SYN	9	8	17
TZE-W DT STR QPM C0	5	11	16	TZUTSY-WSGY-SYN	8	7	15
AC 90 POOL 16 DT STR	2	5	7	TZB-SR	2	2	4
ACR 95TZE COMP4 C3	4	6	10	OBA SUPER I	4	3	7
TZE COMP 3 DT C3	6	3	8	EV 8435-SR	5	10	15
AFO (LOCAL CHECK)	11	2	13	SUWAN-1-SR (LOCAL CHECK)	11	9	20

Table 5: Correlations between traits in early and intermediate maize maturity groups at Ilorin, Nigeria in 2009 and 2010

Early and intermediate maturity groups	Days to anthesis	Days to silking	ASI (days)	Plant height (cm)	Ear height(cm)	Plant aspect	Ear aspect	Ears per plant	Grain yield (t ha^{-1})
Days to anthesis		0.97**	0.18	0.36	-0.14	-0.42	-0.14	-0.45	0.57*
Days to silk			0.07	0.16	0.34	-0.67	-0.34	-0.09	0.34
ASI (days)				-0.43	-0.59	-0.16	-0.34	-0.69*	0.45
Plant height					-0.11	-0.79**	0.75**	0.45	0.67*
Ear height						-0.56	.-0.23	0.14	0.61*
Plant aspect							0.79**	-0.12	0.05
Ear aspect								-0.37	0.12
Ears per plant									0.25
Grain yield (t/ha)									

Precipitation pattern of rainfall has great impact in the expression of plants' potentials during period of flowering/grain filling of the crop growth cycle, especially maize. It also plays significant role in stimulating plants to speed up the process of maturation. Rainfall distribution and amount was probably the single most important environmental factor that affected overall crop performance in this study. The rainfall patterns were favorable in both cropping years which resulted to comparable values of the agronomic parameters (Fig.1). For example, soil moisture that was not limiting at anthesis during the two growing years created favourable environments for seed set and translocation of assimilates to grain filling. Though, soil analysis of the experimental site was sandy loam and slightly acidic favourable for maize growth, the soil nutrients especially nitrogen and organic matter were low. This may be due to continuous cropping of the land over four years without fallowing. With the appreciable application of fertilizer, appropriate weeding and favourable rainfall probably gave individual genotype ample opportunity to express their yield potentials. On the other hand, the differences in performance of the genotypes both between and within each maturity groups for grain yield, plant height, days to anthesis and silking confirmed the diversity of the genotypes and their differences for these characters. Year x maturity and year x maturity within group interactions that were significant only for grain yield underscored the differences in genetic makeup of the genotypes which have pre-requisite advantages in breeding for improved grain yield. Furthermore, this wide variability observed for these yield parameters showed that they were quantitatively inherited and offered way for further improvement through selection (Bello and Olaoye, 2009). These results were expected as the genotypes were of different maturity classes (early and intermediate maturity), different genetic backgrounds and bred for different traits such as drought tolerance, downy mildew resistance and streak resistance (Oluwaranti et al., 2008).

Plant height is not only important for breeding of new genotypes of maize, for green and dry matter production, but also for grain yield. The present result revealed highly significant variability in both early and intermediate genotypes for plant height (Table 2). Plant height has been observed to be controlled by the expression of many genes and the interactions between these genes (Yamakawa et al., 2006; Tahir et al., 2008). Many researchers have shown highly significant variability in plant height in various maize genotypes (Salami et al., 2007; Naushad et al., 2007; Nazir et al., 2010; Iqbal, et al., 2010a; Iqbal et al., 2010b). High correlation of grain yield with plant height was earlier reported by other researchers (Nazir et al., 2010; Bello et al., 2013; Olowe et al., 2013). Nazir et al., (2010) also reported that plant height was positively correlated with days to flowering morphologically, as internodes' formation stops at floral initiation, and that early flowering maize genotypes are usually shorter in height.

Ear height has also been described to be one of the most important selection criteria in most breeding programmes especially the root and stock lodging (Esechie et al., 2004; Olawuyi et al., 2013). High ear position could be susceptible to root and stock lodging, therefore the plant breeders usually prefer selecting for lower ear position in maize (Esechie et al., 2004; Salami et al., 2007). Early genotypes were shorter compared to intermediate with high ear heights in this study. Some early genotypes (DMR-ESR Y CIF2, AC 90 POOL 16 DT STR, TZE-W DT STR C4 and ACR 95TZE COMP4 C3) that had short ear height were high yielding. Previous researchers reported reduced ear height and increased grain yield in maize (Olakojo and Olaoye, 2005; Salami et al., 2007; Nazir et al., 2010; Bello, et al., 2011). Lower plant and ear height augments plant lodging resistance in maize with increase grain yield (Esechie et al., 2004). While high vertical root-pulling resistance (lodging resistance) took up more N and utilized it more efficiently, better agronomic performance and higher yield resulted (Kamara et al., 2003; Liu and Wiatrak, 2011). Therefore, these early genotypes could also be N-efficient or tolerant to N deficiency. Consequently, low ear heights could be suited to the conditions of small-holder farmers because the farmers hire small children and women for harvest. Harvesting using children becomes less cumbersome, and losses due to "gleaning" are reduced. Accessibility of short and early maturing genotypes to small-holder farmers has a good advantage, because higher yields could result from small cultivated area with increase in plant density (Nik et al., 2011; Bello and Mahamood, 2013). Furthermore, shorter plants attached with less and short leaves require high plant density, and could compete for light and soil nutrients for high yield favourably than the taller ones. For large-scale commercial farmers utilizing combined harvester, the operation is also less tedious. With the lodging resistance, large-scale farmer does not need to recruit extra hands to pick ears from lodged plants. (Ahmad et al., 2011). also reported that availability of earlier maize genotypes with shorter plant height, lower leaf number, upright leaves, smaller tassels and better synchrony between male and female flowering time, has enhanced the ability of maize to face high plant populations without showing excessive barrenness.

Consistent number of days (3 days) was recorded for anthesis-silking interval (ASI) among early and intermediate maturity groups in both years. This indicated an interval of 3 days between pollen shed and silk intrusion in the genotypes. Bello and Olaoye (2009) described ASI as a measure of nicking (synchronization) of pollen shed with silking. ASI has been reported to be a valuable diagnostic trait for cultivar performance under stress than days to silking per se, since it is largely independent of maturity differences among cultivars (Ibikunle et al., 2009; Abdalla et al., 2010). The number of ears per plant decreased significantly as ASI increased, and this trait was a major factor that contributed to differences between the top and lowest yielding genotypes under drought stress ((Bello and Olaoye, 2009). Genotypes with reduced ASI will allow for better fertilization and good cob fill (Ibikunle et al., 2009; Ahmad 2011) Therefore, selection for reduced ASI in tropical maize genotypes has been shown to be correlated with improved yields under drought stress (Ibikunle et al., 2009; Abdalla et al., 2010; Ahmad 2011). Plant and ear aspects are also vital in determining varietal acceptability under farmer's condition. Our result showed that among early and intermediate maturity groups, plant and ear aspects were fair in overall phenotypic appeal (2.6), but not significantly different in both years (Table 3). This indicated that these genotypes were not greatly affected with prevalent diseases during the two cropping seasons.

Comparison between the early and intermediate maturities showed that most of the intermediate genotypes out yielded early ones. Intermediate genotypes were late to maturity, higher in plant and ear heights and yield, compared to early group. It is generally recognized that longer maturity variety produced greater yield to enable for a long duration in metabolic transformation into grain and stover yields (Agele, 2006; Golbashy et al., 2010; Song et al., 2010; Hussain et al., 2011; Wang et al., 2011). Early maturing genotypes on the other hand, required fewer corn heat units to reach flowering, while late maturing genotypes exhibited extended vegetative period. Therefore, early flowering maize plants are smaller and have fewer leaves with low grain yield compared with late genotypes (Shi et al., 2008; Akbar et al. 2009; Kamara et al., 2009; Wang et al., 2010; Khan et al., 2011). However, grain yield and earliness to silk are two important characters that can be used in ranking genotypes for their suitability as genotypes especially in a drought–prone ecology such as savannas (Table 4). Earliness to anthesis and/ or silking allows short growth duration and maturity; and these could constitute important attributes of drought escape which often make earlier maturing maize genotypes adapt better to late season moisture stress than late maturing ones (Olakojo and Olaoye, 2005; Naushad et al., 2007; Salami et al., 2007; Akbar et al., 2008; Shi et al., 2008; Nazir et al., 2010; Majid et al., 2010). This therefore showed a direct relationship between grain yield and maturity irrespective of the group. Reports from WECAMAN regional trials also indicated that this situation is not peculiar to this study (Anon, 2001). Therefore, four early genotypes (DMR-ESR Y CIF2, AC 90 POOL 16 DT STR, TZE-W DT STR C4 and ACR 95TZE COMP4 C3) that combined low plant and ear heights and earliness to anthesis with grain yield were likely related to their earliness in reaching maturity which permitted the genotypes to better utilize the available soil moisture during anthesis (Olaoye et al., 2009). They probably contain certain attributes of drought escape and could adapt better to late season moisture stress than late maturing counterparts especially in the erratic rainfall pattern of the SGS agro-ecology (Shi et al., 2008; Olaoye and Bello, 2011; Wang et al., 2011). Nonetheless, AFO that was earliest to anthesis (54.5 days) among all the genotypes could be hybridized with higher yielding genotypes for yield improvement in the sub-region.

CONCLUSION AND RECOMMENDATION

Four intermediate maturing genotypes (TZL COMP1-W C6 F2, SUWAN-1-SR-SYN, TZB-SR, OBA SUPER I, EV 8435-SR) out-yielded early ones with yield advantage of 34.29% and taller by 17.04% compared to early maturing group. Early genotypes were however early to anthesis with 6.57% advantage over the intermediates. Four early genotypes (DMR-ESR Y CIF2, AC 90 POOL 16 DT, STR, TZE-W DT STR C4 and ACR 95TZE COMP4 C3) were also superior for grain yield withn a range of 4.39 to 4.68 t ha^{-1}. The superior genotypes (early and intermediate) that combined grain yield with earliness to silking and appreciable ASI and ear aspect among others could be used to escape the prolonged moisture stress during the later part of the cropping season. They could be tested on the farmers' field for adaptation and adoption by the farmers. They could also serve as potential sources of unique combinations of favourable alleles for developing high yielding genotypes adapted to drought affected areas in West and Central Africa.

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