

Yield Potential of Sub-Tropical Maize Hybrids of Different Maturity Groups across Nigeria Guinea Savanna

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Abstract

Yield potential can be defined as the yield of a crop cultivar when grown in environments to which it is adapted, with nutrients and water non-limiting with pests and diseases effectively controlled. This study assessed the yield potential of sub-tropical hybrids of different maturity classes in Nigeria's savannas and also identify superior hybrids that could be further evaluated. 45 early, 42 intermediate and 40 late maize maturing hybrids along with two (2) checks were evaluated at three planting sites (Ilorin, Zaria and Kano) in 2016. The experiments were laid out in Randomized Complete Block Design with three (3) replicates on each site. Data collected were subjected to analysis of variance and means were separated using least significant difference. Hybrid CZH142153 (2978.95 kg ha⁻¹) was the highest yielder for the early maturing hybrids, CZH15028 (3027.77 kg ha⁻¹) for intermediate and CZH142123 (2702.77 kg ha⁻¹) ranked top for late hybrids. Kano was the best for grain yield among the early (2731.22 kg ha⁻¹) and late (2836.53 kg ha⁻¹) hybrids while Zaria was best for the intermediate hybrids (2010.88 kg ha⁻¹). This study should be repeated at the locations used and other locations for two or more seasons to confirm their yield potential.

Keywords: Early varieties; guinea savannah; late/intermediate; maturing groups; yield potential; *Zea mays*.

Introduction

Maize (*Zea mays* L.) is among the world's three most important cereals along with wheat (*Triticum aestivum*) and rice (*Oryza sativa*) (McCann, 2005). The larger proportion of maize in Africa is produced by resource-limited, small-scale farmers and is characterized by low yields due to cash shortage to utilize the necessary inputs for maize production (Dawit *et al.*, 2008). Due to increased demand, maize production has also spread into marginal areas which will likely engender risk to biotic and abiotic threats leading to greater loss in maize productivity. One way to address problem of low maize yields in West and Central Africa sub-region is to boost productivity through the use of maize genotypes that are tolerant to various stress factors including diseases and pests infestation in cultivation in the different agro-ecologies (Dagne *et al.*, 2004).

Maize (*Zea mays* L.) has a high grain yield potential, which is determined by the genetics of the cultivated hybrid and is influenced by the environmental factors that are affecting the plant growth (Ion *et al.*, 2014). The yielding capacity of plants is determined by the yield components, which are the components that are participating to the yield formation (Ion *et al.*, 2013). Yield potential is the ability of a genotype to exhibit its inherent capacity for superiority in yield when grown in different environments to which it is adapted, with nutrients and water non-limiting, and pests and diseases effectively controlled

(Evans, 1993). It is a term mainly used in measured comparisons of cultivars as well as for estimating plausible future limits to crop yields. It is designed to provide information and better understanding of maize yield potential and the interactive effects of crop management practices and climate on maize yields.

The differential response of a genotype across environments is defined as the genotype (G) × environment (E) interaction (GEI). Genotype interaction with environmental factors (location, year of planting, soil type, level of technology used, etc.) is an important consideration for plant breeders (Scapim *et al.*, 2002). In breeding programmes, genotype stability for yield and agronomic performance is an important breeding objective. Previous research suggests that selection of superior genotypes for grain yield and agronomic traits in maize hybrid performance trials is impacted by Genotype by Environment Interaction (GEI) (Butron *et al.*, 2004). The genotype by environment interaction is an important aspect in both plant breeding programmes and the introduction of new maize hybrids. Deitos *et al.*, (2006), indicated that genotype x environment interaction is important for plant breeding because it affects the genetic gain and, recommendation and selection of cultivars with wide adaptability.

In Nigeria, GEI effect on maize grain yield is usually significant due to considerable variation in soil heterogeneity and weather conditions at the growing sites. 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 however, maize is grown twice due to bimodal rainfall pattern (a short early growing season followed by fairly long late season) (Bello *et al.*, 2012). The soil in the SGS (Southern Guinea Savannah) is also fragile with low organic matter, poor buffering and water holding capacity, resulting in low nitrogen availability (Fakorede *et al.*, 2003). However, the peculiarities of the agro-ecologies which include biotic (*Striga hermonthica*, stem borer, army worm *etc*) and abiotic (low soil Nitrogen, drought) stress factors necessitates wide testing of maize varieties (open pollinated varieties and hybrids) to identify superior genotypes with respect to yield and adaptation. Consequently, improvement of maize genotypes for cultivation in the different ecologies within Nigeria's guinea savannas requires a rigorous and consistent effort to identify maize genotypes that combine high yield potential with adaptation to prevailing stress factors. Furthermore, the effect of global warming on climate change, often manifesting in form of unpredictable weather condition, poses a serious threat to maize production activities (Olakojo, 2016).

Early and extra-early maize varieties readily fit in to the maize production activities of the resource-limited farmers in West-Africa sub-region because of their short duration. Furthermore, recent breeding efforts by maize scientist in international and national centres which resulted in the availability of maize

genotypes (hybrids and OPVs), with genes for tolerance to specific stress factors in the different ecologies is a strategy for adapting maize to the gradually shortened 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). Hybrid varieties compared to open pollinated varieties (OPV) are more preferred in the sub-region because of their high yield and stability.

The objectives of the study are to (i) assess the yield potential of sub-tropical hybrids of different maturity classes in the Nigeria's savannas, and (ii) identify superior hybrids that could be further evaluated for commercial cultivation in farmers' fields.

Materials and Method

The study Area

The experiment was conducted in the main cropping season of 2016 at three (3) locations in the Nigeria Guinea Savanna namely: University of Ilorin teaching and research farm (8° 30' N; 4° 33'E), Samaru in Zaria (11°11'N; 07°38'E), Bunkure in Kano (11° 42'N; 8° 33'E). The test locations and there agro-ecologies are presented in Table 1.

Table 1: Description of test locations that were used for the study

Location	Latitude	Longitude	Mean annual temperature (°C)	Mean Seasonal Rainfall (mm)	Relative humidity (%)	Agro ecological zone
University Of Ilorin Teaching and Research Farm	8° 30' N	4° 33'E	29	1186	85	Southern Guinea Savannah
Institute of Agricultural Research Samaru Zaria	11°11'N	07°38'E	24	1082	36	Northern Guinea Savannah
Bunkure	11° 42'N	8° 33'E	28	828	72	Sudan Guinea Savannah

Method of data collection

One hundred and twenty-seven maize genotypes comprising of forty five (45) early, 42 intermediate and 40 late maize maturing sub-tropical drought tolerant hybrids were evaluated along with two (2) checks in this study. The maize hybrids used for this

study were developed by maize scientists at Maize and Wheat Improvement Center (CIMMYT), Zimbabwe. Land preparation was mechanically done with two regimes of ploughing and one harrowing operation. The experiments were laid out as a randomized complete block design (RCBD), in alpha lattice

arrangement with three (3) replications at each of the location. . A 2-row plot with plant spacing of 0.75m between the rows and 0.5m within the rows was used in each of the locations.

Immediately after planting, 5 g/l Metolachlor and 170 g/l Atrazine was applied as a pre- emergence herbicide and supplementary hoe weeding was also carried out regularly to control the growth of weeds. Fertilizer NPK 15:15:15 was applied three weeks after planting (3WAP) using ring method. The second dose was applied seven weeks after planting (7WAP) as top dressing using urea. Army worm was controlled by Spirotetramate 75 g/l + Flubendiamide 100 g/l.

Data collected include plant stand which was taken by recording the total number of plants per plot obtained soon after thinning. Days to 50% anthesis (number of days after planting when 50% of the plants shed pollen), days to 50% silking (number of days after planting when 50% of the plants extrude silks) and anthesis-silking interval (ASI) (the difference between silking date and anthesis date). Plant heights was measured as the distance (cm) from the base of the plant to the height of the first tassel branch, while ear height (cm) was measured as the distance from the base of the plant to the node bearing the upper ear. Root lodging was recorded as the numbers of plants that have lodged at the root. 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 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. Field weight which is the weight of cobs per plot was measured in kilograms and recorded. The moisture content of the harvested grain was measured using a moisture tester. Grain yield in kilograms per plot was calculated using the formula:

$$\text{Yield} = \frac{\text{Field wt (100 - Moisture)} \times \text{CF}}{1000}$$

Where CF = Correction Factor (11.41)

Data collected with respect to each maturity group were subjected to Analysis of Variance (AOV), first on location basis before a combined ANOVA using SAS Software version 9.0. Pertinent means were thereafter separated with least significant difference (LSD) according to (Steel and Torrie, 1982).

Results and Discussion

Grain yield and related traits in the maize hybrids of different maturity groups.

Yield is the final result of many plant characters, which are interacting with other numerous external factors during the life span of plants.

Therefore, evaluation of yield potential of hybrid maize varieties may be considered as a reliable measure for genotypic performance. It is always expected that the intermediate and late maturing hybrids will have higher yield than the early maturing hybrids but in this study the early varieties had the highest yield (2244.28 kg ha⁻¹) (Table 2), followed by late (2124.98 kg ha⁻¹) (Table 3) then intermediate (1809.48 kg ha⁻¹) (Table 4) across the three (3) locations. This result corroborate with the result of Takim *et al.*, (2017) who reported highest yield in early maturing hybrids and open pollinated varieties (OPV). The grain yield was low because of army worm outbreak in the cropping year.

Also, there was drought prior to anthesis which is also estimated to cause yield loss in the range of 21 to 50% by Olaoye *et al.*, (2009). For the early maturing class (Table 2), grain yield was highest in Kano (2731.32 kg ha⁻¹) followed by Zaria (2262.77 kg ha⁻¹) and lowest at Ilorin (1738.74kg ha⁻¹). Grain yield was highest in Zaria (2010.88 kg ha⁻¹) followed by Kano (1879.31 kg ha⁻¹) and lastly Ilorin (1538 kg ha⁻¹) for the intermediate group (Table 3). Kano (2836.53 kg ha⁻¹) had the highest yield for the late maturing hybrids followed by Zaria (2098.85 kg ha⁻¹) and least in Ilorin (1439.56 kg ha⁻¹) (Table 3). Kano (3723.58 kg ha⁻¹) had the highest mean yield of all the locations and Ilorin (1572.56 kg ha⁻¹) had the lowest overall mean yield.

The intermediate and late maturing hybrids are taller with plant height of 158.39 cm and 156.59 cm respectively while the early varieties are the shortest (149.83 cm). Late (69.47 cm) and intermediate (68.52 cm) maturing hybrids had the highest ear placement while the early (61.52 cm) class were the shortest. As expected, the early maturity group flowered early with days to 50 % flowering of 59.03 with intermediate and late maturing flowering later at 60.71 and 61.25 days respectively. The number of ears per plant, ear aspect and anthesis-silking interval was nearly the same for all the maturity groups. Result of ear aspect which is vital in determining varietal acceptability under farmer's condition showed that the intermediate maturing hybrids had the most phenotypic appeal (2.52), this indicates that the genotypes in the group were not greatly affected with prevalent diseases during the cropping season.

Table 2: Means, standard error (S.E.) ranges and coefficient of variation (%CV) for grain yield and related traits in early maturing maize hybrids in Nigeria's savannas (2016).

Parameter	Ilorin			Zaria			Kano			Overall Mean±S.E.
	Mean ±S.E.	Range	%CV	Mean±S.E.	Range	%CV	Mean±S.E.	Range	%CV	
Grain yield (kg ha⁻¹)	1738.74±53.43	291.30-3211.80	35.70	2262.77±79.39	201.17-5230.37	40.77	2731.32±116.34	10.04-5522.44	49.49	2244.28±54.00
Plant Height (cm)	115.83±1.47	75.3-169.5	14.76	162.70±1.58	119.0-200.0	11.29	170.94±1.48	130.0-201.0	10.08	149.83±1.49
Ear Height (cm)	45.50±0.93	24.00-96.30	23.69	57.74±1.12	25.00-87.00	22.51	81.32±1.19	36.00-100.00	17.06	61.52±1.08
Root Lodging (no)	12.61±0.92	0-43	42.79	3.59±0.27	0-16	86.29	7.29±0.46	1-22	73.23	7.83±0.55
Days to 50% Anthesis (no)	59.47±0.16	56-65	3.18	59.85±0.25	50-68	4.87	51.58±0.16	48-56	3.62	56.97±0.22
Days to 50% Silking (no)	62.20±0.19	57-67	3.48	61.42±0.26	51-69	4.86	53.47±0.28	48-61	6.18	59.03±0.24
Anthesis- Silking Interval (no)	2.74±0.11	0-4	47.38	1.96±0.11	0-6	66.28	1.89±0.17	0-7	60.42	2.20±0.08
Ear Aspect (1-5)	2.84±0.08	1-5	34.06	2.51±0.04	1-4	18.00	2.80±0.05	2-5	20.83	2.72±0.04
Ears Per Plant (no)	0.63±0.03	0.07-3.00	60.21	0.86±0.04	0.28-5.00	52.45	0.75±0.03	0.32-2.75	39.96	0.75±0.02

Table 3: Means, standard error (S.E.) ranges and coefficient of variation (%CV) for grain yield and related traits in intermediate maturing maize hybrids in Nigeria's savannas (2016).

Parameter	Ilorin			Zaria			Kano			Overall Mean±S.E.
	Mean ±S.E.	Range	%CV	Mean±S.E.	Range	%CV	Mean±S.E.	Range	%CV	
Grain yield (kg ha⁻¹)	1538.24±42.33	329.00-2728.00	30.89	2010.88±61.22	100.58-4023.36	34.18	1879.31±90.30	1.00-4217.14	53.93	1809.48±40.23
Plant Height (cm)	131.04±1.87	81-188	15.98	167.14±2.16	75-230	14.47	176.98±1.61	102-215	10.20	158.39±1.49
Ear Height (cm)	49.39±0.97	24.00-84.00	22.09	66.89±1.56	15.00-160.00	26.13	89.26±1.07	39.00-109.00	13.48	68.52±1.20
Root Lodging (no)	26.21±1.21	2-48	51.75	3.54±0.15	1-11	36.40	14.06±0.61	2-25	48.35	14.60±0.99
Days to 50% Anthesis (no)	61.10±0.16	59-66	2.90	62.08±0.24	54-68	4.27	53.55±0.24	47-63	5.05	58.91±0.23
Days to 50% Silking (no)	64.08±0.21	59-70	3.75	63.92±0.25	54-69	4.44	54.12±0.30	48-71	6.23	60.71±0.28
Anthesis-Silking Interval (no)	2.98±0.11	0-4	40.21	1.86±0.10	0-6	59.27	1.47±0.12	0-9	44.33	2.10±0.07
Ear Aspect (1-5)	2.83±0.10	1-5	39.05	2.21±0.07	1-4	36.79	2.52±0.06	1-4	26.49	2.52±0.05
Ears Per Plant (no)	0.68±0.05	0.03-4.00	43.23	0.85±0.06	0.08-7.67	39.52	0.72±0.03	0.05-2.01	41.18	0.75±0.03

Table 4: Means, standard error (S.E.) ranges and coefficient of variation (%CV) for grain yield and related traits in late maturing maize hybrids in Nigeria's savannas (2016).

Parameter	Ilorin			Zaria			Kano			Overall Mean±S.E.
	Mean ±S.E.	Range	%CV	Mean±S.E.	Range	%CV	Mean±S.E.	Range	%CV	
Grain yield (kg ha⁻¹)	1439.56±39.56	96.76-3031.07	30.10	2098.85±68.61	301.75-3922.78	35.81	2836.53±91.40	502.04-5020.40	35.30	2124.98±50.23
Plant Height (cm)	114.59±1.83	70.00-165.50	17.50	172.13±1.56	108.00-205.00	9.92	183.04±1.40	145.00-210.00	8.40	156.59±1.84
Ear Height (cm)	44.95±1.08	22.00-75.00	26.40	76.48±1.44	30.00-125.00	20.60	86.97±1.31	56.00-113.00	18.53	69.47±1.28
Root Lodging(1-5)	23.43±1.24	1-46	57.87	3.79±0.26	1-13	36.87	12.46±0.62	1-24	54.35	13.23±0.71
Days to 50% Anthesis (no)	61.97±0.21	59-67	3.73	61.56±0.22	54-67	3.94	60.20±0.06	59-63	1.05	61.25±0.11
Days to 50% Silking (no)	65.60±0.23	60-71	3.85	63.62±0.20	57-68	3.37	61.65±0.06	60-64	1.15	63.62±0.13
Anthesis-Silking Interval (no)	3.63±0.09	0-5	27.62	2.05±0.12	1-6	61.26	1.45±0.06	0-2	42.74	2.38±0.07
Ear Aspect (1-5)	2.72±0.09	1-5	37.33	2.52±0.05	2-4	20.76	2.62±0.05	2-5	22.36	2.62±0.04
Ears Per Plant (no)	0.61±0.04	0.04-2.14	64.45	0.82±0.05	0.08-6.50	70.17	0.72±0.03	0.28-3.56	48.30	0.72±0.02

Mean squares from the combined (ANOVA) for grain yield and related characters in 45 early maturing hybrids evaluated across three locations in the Nigeria savannas (2016)

The results of the mean squares from the combined analysis of variance (AOV) for grain yield and other related traits in 45 early maturing maize hybrids evaluated across three (3) locations in Nigeria's savannas in 2016 are presented in Table 5. Location (L) effect was significant ($p < 0.01$) for all the traits studied which implies that the test environments influence the expression of the traits in the hybrids. Except for days to silking, the genotypes (G) also differed significantly ($p < 0.01$) for all the traits measured indicating that the performance of the early maturing hybrids differed significantly from one location to the other. This differences in performance may be due to differences in their inherent genetic potential for the traits. Obi (1991) and Akande and Lamidi (2006) had earlier hypothesized that the reason why genotypes perform differently in a particular location may be due to the fact that various agronomic characteristics are controlled by diverse genetic factors. Days to 50 % anthesis was significant ($p < 0.01$ or $p < 0.05$) for genotype, location and there interaction. Genotype x Location (G x L) interaction effect was significant ($p < 0.05$) for grain yield, ear height and days to 50 % anthesis. The significant G x L effect for grain yield among these hybrids is similar to the report of Kunwar *et al.*, (2016) who evaluated five (5) early maturing maize varieties in four environments and reported significant effect of genotype ($p < 0.05$), environments and genotype by environment interaction for grain yield.

Mean squares from the combined (ANOVA) for grain yield and other agronomic characters for 42 intermediate maturing hybrids evaluated at three locations in Nigeria savannas (2016)

The results of the mean squares from the combined AOV for grain yield and related traits in 42 intermediate maturing maize hybrids evaluated across the three (3) locations in the Nigeria savannas during the 2016 cropping season are presented in Table 6. Differences in the factors of environment in each location (L) was significant ($p < 0.05$ or $p < 0.01$) for all the characters while the hybrids (G) also differed significantly ($p < 0.01$) for all the traits measured or estimated. Number of ears per plant was also significant ($p < 0.05$ or $p < 0.01$) for all the sources of variation. Genotype by Location (G x L) interaction for plant height and days to flowering were highly significant ($p < 0.01$) and ears per plant was significant ($p < 0.05$). However, G x L interaction was not significant for grain yield. This suggest that the intermediate hybrids maintained their relative ranking for grain yield in each of the test location. In other words, there is the possibility of identifying adapted individuals among the hybrids within this maturity group. Wadejo and Hussien (2015) reported that there

was no significant difference among the four (4) maize genotypes they evaluated across three (3) locations. Their findings were corroborated by (Olakojo and Iken (2001) when they also observed no significant difference among the maize genotypes evaluated for grain yield.

Mean square from the combined (ANOVA) for grain yield and other related characters for 40 late maturing hybrids evaluated at three locations in Nigeria's savannas (2016).

The results of the mean squares from the combined analyses of variance for grain yield and other related traits for 40 late maturing maize hybrids evaluated across three (3) locations in the 2016 cropping season are presented in Table 7. Location (L) effect was significant ($p < 0.01$) for all the characters studied except ear aspect while the hybrids (G) differed significantly ($p < 0.01$) except anthesis-silking-interval. Genotype (G) by location (G x L) effects differed significantly ($p < 0.05$ or $p < 0.01$) for all the traits except anthesis-silking-interval, root lodging, ear height and ears per plant. The significant G x L effect for grain yield among these hybrids indicates that differential performance for grain yield in each environment. Root lodging was significant ($p < 0.05$ or $p < 0.01$) for all the sources of variation. This is similar to the findings of Sallah *et al.*, (2004), who evaluated nine early, eight intermediate and nine late maturing maize cultivars at seven locations in four seasons and observed significant difference ($p < 0.05$ or $p < 0.01$) among the different maturity groups.

Top Five (5) hybrids with yield in parenthesis (t/ ha⁻¹) for the different maturity groups of the maize hybrids at the three locations in Nigeria savannas (2016).

The top five (5) best yielders for the different maturity class is presented in Table 8. For early maturing group, the result showed that five hybrids (CZH142153, CZH142056, CZH15187, CZH15004 and CZH15010) with grain yields range between 2978.95 kg ha⁻¹ and 2751.10 kg ha⁻¹ were the best in this maturity group. Hybrid CZH142056 (4518.36 kg ha⁻¹) had the highest yield in kano and the highest yield of any hybrid in this maturity group. Hybrids CZH15028 (3027.77 kg ha⁻¹), CZH15219 (2556.10 kg ha⁻¹) and CZH15030 (2318.78 kg ha⁻¹) were the top three (3) yielding hybrids across the three locations for the intermediate maturing hybrids. The range of the grain yield for the top five late maturing class was between 2580.23 kg ha⁻¹ to 2702.77 kg ha⁻¹. The results further showed that genotypes CZH142123 (2702.77 kg ha⁻¹), CZH15157 (2675.76 kg ha⁻¹), CZH15146 (2639.40 kg ha⁻¹), CZH142213 (2580.23 kg ha⁻¹) and CZH15077 (2580.23 kg ha⁻¹) were the best five hybrids for grain yield.

Table 5: Mean squares from the combined (ANOVA) for grain yield and related characters in 45 early maturing hybrids evaluated across three locations in the Nigeria savannas (2016)

Source of Variation	df	Grain Yield	Plant Height	Ear Height	Days to 50% Anthesis	Days to 50% Silking	Anthesis Silking Interval	Ear Aspect	Root Lodging	Ears Per Plant
Location (L)	2	33285770.89**	119294.10**	44747.95**	2944.17**	3148.19**	29.91**	4.32**	2781.39**	1.79**
Rep/Loc (R/L)	6	12100998.53	1485.82	741.55	34.08	59.65	10.79	0.17	516.10**	0.12
Genotype(G)	44	1462982.09**	430.09**	188.15	8.28**	9.76	3.54**	0.93**	116.04**	0.23*
G x L	88	949463.96*	319.77	177.47*	5.25*	7.06	2.01	0.38	35.16	0.09
Pooled Error	264	719514.3	258.20	135.00	4.00	7.11	2.14	0.46	34.79	0.15

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

Table 6: Mean squares from the combined (ANOVA) for grain yield and other agronomic characters for 42 intermediate maturing hybrids evaluated at three locations in Nigeria savannas (2016)

Source of Variation	df	Grain Yield	Plant Height	Ear Height	Days to 50% Anthesis	Days to 50% Silking	Anthesis Silking Interval	Ear Aspect	Root Lodging	Ears Per Plant
Location(L)	2	7497705.28**	73731.54**	50360.16**	2745.24**	4101.39**	78.10**	11.92**	16212.07**	1.06**
Rep/Loc(R/L)	6	384278.68	2583.95	256.29	64.62	52.33	4.90	2.91**	288.19**	1.13**
Genotype(G)	41	1569028.32**	1005.63**	419.49**	11.84**	20.32**	2.47**	1.70**	148.91**	0.39**
G x L	82	235607.33	461.51**	246.15**	7.22**	12.84**	1.57	0.46	55.11	0.29*
Pooled Error	245	527338.3	300.91	131.11	2.93	3.87	1.15	0.45	66.58	0.21

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

Table 7: Mean square from the combined (ANOVA) for grain yield and other related characters for 40 late maturing hybrids evaluated at three locations in Nigeria's savannas (2016).

Source of Variation	df	Grain Yield	Plant Height	Ear Height	Days to 50% Anthesis	Days to 50% Silking	Anthesis Silking Interval	Ear Aspect	Root Lodging	Ears Per Plant
Location (L)	2	58606860.2**	162293.21**	57407.74**	103.30**	468.08**	152.68**	1.20	11626.75**	1.27**
Rep/Loc(R/L)	6	274482.4	1305.34	2886.03	20.20	16.01	1.53	0.12	168.46*	0.07
Genotype(G)	39	1073159.3**	442.37**	245.03**	9.11**	8.43**	1.20	0.98**	188.94**	0.38**
G x L	78	780581.4**	363.86*	157.05	4.42**	4.42**	1.95	0.34	75.15	0.13
Pooled Error	234	446463.8	246.84	135.84	2.40	2.55	0.96	0.55	59.15	0.19

*, **, significant at $\rho \leq 0.05$ and $\rho \leq 0.01$ respectively

Table 8: Top Five (5) hybrids with yield in parenthesis (kg ha⁻¹) for the different maturity groups of the maize hybrids at the three locations in Nigeria savannas (2016).

Early			
Ilorin	Zaria	Kano	Overall Mean
CZH15187 (2616.08)	CZH1261 (3889.25)	CZH142056(4518.36)	CZH142153(2978.95)
CZH15010 (2458.82)	CZH15220 (3453.38)	CZH15004 (4417.95)	CZH142056(2946.94)
CZH15004 (2444.17)	CZH15003 (3118.10)	CZH15009 (3848.97)	CZH15187 (2893.12)
CZH142143(2434.06)	CZH142145(3051.05)	CZH142023(3681.63)	CZH15004 (2767.94)
CZH142056(2344.30)	CZH15187 (3051.05)	CZH15012 (3681.63)	CZH15010 (2751.10)
Intermediate			
CZH15028 (2384.00)	CZH15028 (3118.10)	CZH15028 (3581.22)	CZH15028 (3027.77)
CZH15219 (2242.33)	CZH15030 (2782.82)	CZH15219 (3179.59)	CZH15219 (2556.10)
CZH15215 (1993.00)	CZH15041 (2782.82)	CZH15215 (2811.42)	CZH15030 (2318.78)
CZH15026 (1955.21)	CZH132043(2581.66)	CZH15044 (2644.08)	CZH15041 (2310.23)
CZH15225 (1948.01)	CZH142087(2514.60)	CZH15025 (2577.14)	CZH15044 (2304.36)
Late			
CZH15068 (3184.08)	CZH15077 (3118.10)	CZH15078 (4183.67)	CZH142123(2702.77)
CZH15153 (2749.06)	CZH15164 (2950.46)	CZH15157 (4016.32)	CZH15157 (2675.76)
CZH142213(2717.72)	CZH15146 (2916.94)	CZH15067 (4016.32)	CZH15146 (2639.40)
CZH15164 (2678.55)	CZH15068 (2883.41)	CZH128 (3848.97)	CZH142213(2580.23)
CZH15065 (2667.84)	CZH142123(2816.35)	CZH142123(3514.28)	CZH15077 (2580.23)

Conclusion

Since grain yield is the final result of many intermediate plant characters, which interact with other numerous external factors during the life span of plants, multi-location evaluation of yield potential is a reliable measure for genotypic performance as well as the stability of performance from one environment to the other. Results of the performance of the individual hybrids with respect to yield and other agronomic traits evaluated differed significantly across the tested environments. The high yielding hybrids could serve as potential sources of unique combinations of favourable alleles for developing high yielding genotypes. This study should be repeated at the locations used and probably at other major maize growing ecological zones of Nigeria for two or more years to confirm yield stability and the pattern of response of the maize hybrids of different maturity class across locations and years. To save resources, the low yielding hybrids should not be selected for further testing.

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