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Response of Top Cross Hybrid Maize to Variation in Different Environments

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Abstract

Top cross can be defined as the hybridization or a cross performed between an open pollinated variety (OPV) and either a single cross hybrid or an inbred line. This study assessed the performance of 21 yellow hybrid maize evaluated at Kishi and Ibadan during the 2020 and 2021 farming seasons. A Randomized Complete Block Design (RCBD) with three replications was used to set up the experiment on each site. The ANOVA result showed significant differences among the genotypes for all the traits except for plant and ear aspect. Hybrid TZEI 8 X DMR-LSR-Y (4.57 t ha^{-1}) had the highest yield. TZEI 8 X DMR-LSR-Y was the earliest to remove tassel (51 days) and hybrid TZEI 12 X ART98-SW1-Y was the earliest to exhibit silk (55 days). TZEI 12 X DMR-ESR-Y was noted for its significantly tall plants and ear placement. Positive non-significant correlation was observed between grain yield and plant height and also for grain yield and ear height. Ibadan 2020 had the best performance for grain yield (5.25 t ha^{-1}) followed by Kishi 2020 and Ibadan 2021 had the lowest yield per location. TZEI 12 and TZEI 8 were observed to be the best female parents while DMR-ESR-Y, PROVIT-A and BR9928-DMR-SR-Y are similarly observed as the best male parent in the hybrid combinations. This study can be repeated at the locations used and at other locations to confirm the yield and pattern of response of the maize hybrids across locations and years.

Keywords: Agronomic response; ANOVA; correlation; hybrid maize; top cross

Introduction

Maize is an important crop in Nigeria that gives staple food to sustain the teeming increasing population, apart from being a major component of diets for the population, it is also a crucial raw material for some industries, especially livestock production in Nigeria (Olaniyan and Lucas, 2004). It guarantees employment and income for families and businesses in sub-Saharan Africa (FAO, 2015).

Agronomic practices adopted on the field during the growth of the crops maybe influenced by the environmental condition peculiar to a particular location (Ogunniyan et al., 2018). Consequently, improvement of maize genotypes for cultivation in different environment requires a rigorous and consistent effort to identify maize genotypes that combine desirable traits and yield potential with adaptation to prevailing stress factors. Furthermore, the effect of climate change, often manifesting in form of unpredictable weather condition, poses a serious threat to maize production activities (Olakojo, 2016).

Top cross can be defined as the hybridization or a cross performed between an open pollinated variety (OPV) and either a single cross hybrid or an inbred line. Recent breeding efforts by maize scientist in national and international centres which resulted in the availability of maize genotypes (hybrids and OPVs), with genes for tolerance to specific stress factors in different ecologies is a strategy for adapting maize to the gradually reducing rainy season and avoid the drought stress that usually occurs in the late-season grain-filling phase. These cultivars have favorable genes for stability across different environmental conditions and high yield potential, with yield increases between 20 and 50 percent compared to other maize varieties (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. Despite the efforts in intensifying maize production, average grain yield of maize estimated at 1.7 t ha^{-1} on farmers' fields has been low (FAO, 2016), which is markedly lower than its potential yield of about 7 t ha^{-1} (Guilpart et al. 2017). Furthermore, maize production in the southern part of Nigeria has not kept up with the demand for its many uses, primarily because of population growth, droughts, diseases, and new end-user requirements such as animal and poultry feed, breweries processors, among others and high demand for hybrid seeds from agri-business farmers. In order to meet the increasing needs of Nigeria farmers and to increase maize yield per unit area of land, efforts are continuously undertaken to expand the areas where maize can be cultivated. To address this, Nigerian research institutes have developed and released different variety of open pollinated and hybrid maize varieties with different maturity period. Some of the improved maize varieties in Nigeria include SUWAN 1-SR, BR9943DMRSR-W, ART/98/SW6-OB, BR9928DMRSR-Y, DMR-LSR-W, DMR-LSR-Y, DMR-LSR-W, DMR-ESR-Y, 8644-3, 8644-27, 8644-32 etc These improved and adopted varieties can be gotten from seed companies, research institutes and other agro-allied shops (Oloyede-Kamiyo et al., 2019; Baiyegunhi et al., 2022). Despite this progress, access to better maize seeds remains a challenge for smallholder farmers, and maize production in Nigerian farms remains low.

The usage of conventional low-yielding open-pollinated varieties which are mostly available to farmers has been identified as one contributing factor to low productivity. The adoption of hybrid seeds is becoming more and more popular, particularly the early maturing types with high grain production potential that can withstand dry spells during the season and give optimum early harvest thereby improving food security. Therefore, the objective of this research was to evaluate the performance of yield and other yield related traits of top cross hybrid maize as influenced by different environments.

Materials and Method

Advanced breeding lines of twenty one (21) yellow hybrid maize from Institute of Agricultural Research and Training (IAR&T) was evaluated at Kishi (southern Guinea savanna) (Latitude 8°98'N, Longitude 3°94'E and 380m above sea level) and Ibadan (Derived savanna agro-ecology) (7° 38'N, 3°84'E 182 182m above sea level) during the 2020 and 2021 cropping season, but the data for 2021 cropping season in kishi was un-usable.

The hybrids were generated using top-cross method of breeding. A Randomized Complete Block Design (RCBD) with three replications was used to set up the experiment. A single row plot with plant spacing of 0.75m by 0.5m between and within rows was used for this experiment. NPK fertilizer (15:15:15) was applied to supply 90 kgN ha^{-1}, 60 $kgPha^{-1}$, and 60 kgK ha^{-1}, at two weeks after planting (WAP) with an additional dose of 30 kgN ha^{-1} from urea was top dressed at 6 Weeks After Planting (WAP).

Traits on which data were collected include: Days to 50% anthesis and silking (number of days after planting when 50% of the plants in a plot have shed pollen and extrude silks) and anthesis-silking interval (ASI) (the difference between the days to 50% silking and anthesis). Plant height 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 upper ear bearing the node.

Plant aspect (PASP) was visual assessment of the plant quality, it was scored on plot basis before harvest and after flowering when plants were still on. It was scored on the scale 1 to 5 where 1 = excellent; 5 = very poor. Ear aspect was also rated on a scale of 1 to 5 where 1 is uniform, clean, large and well-filled ears and 5 is variable, small with partially filled cobs. Field weight which is the weight of cobs per plot was measured in kilograms and recorded. Grain yield was calculated using the formula:

$$\varepsilon * \frac{\mathbf{100-n}}{\mathbf{85}} * \frac{\mathbf{10000}}{\boldsymbol{\varphi}} * \frac{\mathbf{0.80}}{\mathbf{1000}}$$

ε =Field weight (kg), n = grain moisture content at harvest, adjusted moisture content = 15%, φ= plot area (m^2) (plot length * breadth).

The collected data collected were subjected to Analysis of Variance (ANOVA), Pertinent means were separated using Least Significant Diference (LSD), relationship between the traits in the environments were determined using Pearson's correlation analysis. All the analysis was carried out using SAS software version 9.0.

Results and Discussion

The Analysis of Variance (ANOVA) result in table 1 revealed significant genotypic difference (P<0.05) among the yellow hybrid maize for number of days to anthesis and silking, anthesis-silking interval (ASI), plant height, ear height and grain yield. The significant difference among the genotypes indicates the presence of variability for grain yield and other agronomic traits. The genotype by location interaction effect shows significant variation (P<0.01) for number of days to anthesis and silking, and anthesis-silking interval. However, no significant variation was observed for grain yield, plant height, ear height, plant aspect and ear aspect in the genotype by location interaction. This indicates that these traits were stable across the three locations where the study was carried out. On the other hand, Emmanuel et al., (2017) reported that significant difference was observed in the interaction between the maize genotypes and location for grain yield, they also attributed the differences to soil conditions and rainfall patterns at the different sites used. Also, mean squares for location was significant for all the traits except anthesis-silking interval. The significant effect of location may be due to the variation in the amount of rainfall amount and its seasonal distribution, temperature and also soil type. Therefore locations was important in influencing the expression of these traits. This is also in agreement with the research of Hailegebrial et al., (2016).

Source of variation	***df***	***Days to anthesis***	***Days to Silking***	***Anthe-sis-Silking Interval***	***Plant Height (cm)***	***Ear Height (cm)***	***Plant Aspect (1-5)***	***Ear Aspect (1-5)***	***Grain Yield ($t\ ha^{-1}$)***
Location (L)	2	168.42**	181.28**	4.10	2303.89**	2080.54**	16.49**	15.76**	145.84**
Genotype (G)	20	10.15**	14.95**	3.57*	868.33*	294.60*	0.50	1.04	2.03*
G x L	40	6.93**	11.85**	4.56**	562.08	171.78	0.65	0.50	1.69
Rep/Loc (R/L)	4	10.04*	4.32	1.35	1323.50*	136.28	1.59*	1.18	2.24
Error	120	3.73	5.67	2.14	475.41	181.61	0.59	0.67	0.27

*,**,: Significant at < 0.05, < 0.01 level of probability respectively; ($t\ ha^{-1}$) = tonnes per hectare; cm: centimeter.

Table 1: Mean squares from the combined analysis of variance for grain yield and some agronomic characters of the twenty one (21) yellow hybrids evaluated at ibadan and kishi in 2020 and 2021.

The result in table 2 showed the mean performance, standard error and ranges for grain yield and other traits across the three environments. Ibadan 2020 had the best performance for grain yield (5.25 $t\ ha^{-1}$) with a coefficient of variation (CV) of 28.84% which indicates moderate precision. Kishi 2020 had the next best grain yield (4 $t\ ha^{-1}$), which also had a moderate precision (24.41%). The lowest grain yield (2.04 $t\ ha^{-1}$) was observed in Ibadan 2021 with high CV (50.4%). The differences in the grain yields observed in Ibadan 2020 and Ibadan 2021 could be attributed to differences in environmental conditions which vary from year to year. The prevalent climate change which causes variation in the average weather condition of a place at a time often results to variation in yield performance from one year to another (Oloyede-Kamiyo et al., 2019). Ibadan 2020 also had the best values for number of days to anthesis (51 days) and silking (55 days) both with good precisions. The longest time to anthesis (54 days) and silking (58 days) were observed in the other two locations. Taller plants were observed in Ibadan 2021 (172.93cm) while the shorter ones were observed in Ibadan 2020 (160cm). Ear height had it highest value at Kishi (91.95cm) while the least value was observed at Ibadan 2020 (80.5cm).

Parameter	***Ibadan 2020***			***Kishis 2020***			***Ibadan 2021***			***Overall Mean±S.E.***
	Mean ±S.E.	***Range***	***CV (%)***	***Mean±S.E.***	***Range***	***CV (%)***	***Mean±S.E.***	***Range***	***CV (%)***	
Days to anthesis (days)	51.00±0.32	46-55	5.02	54.27±0.21	52-59	3.00	52.60±0.32	47-61	4.87	52.62±0.19
Days to Silking (days)	54.81±0.30	49-59	4.30	58.16±0.19	54-62	2.64	56.02±0.50	50-64	7.13	56.33±0.23
Anthesis-Silking Interval	3.81±0.13	2-5	27.03	3.89±0.13	2-5	26.58	3.41±0.31	0-10	73.05	3.70±0.12
Plant Height (cm)	160.84±3.38	76.67-216.67	16.65	167.34±2.63	115-213	12.49	172.93±2.89	99-213	13.27	167.04±1.75
Ear Height (cm)	80.50±1.75	41-111.67	17.28	91.95±1.78	60-133	15.32	87.06±1.85	48.1-114.8	16.91	86.50±1.09
Plant Aspect (1-5)	2.21±0.05	2-3	18.49	1.38±0.11	1-4	60.21	2.32±0.13	1-4	44.40	1.97±0.07
Ear Aspect (1-5)	2.75±0.10	1-5	29.23	3.27±0.08	1.5-4.5	19.77	2.27±0.13	1-4	45.60	2.76±0.07
Grain Yield (t ha^{-1})	5.25±0.19	1.24-9.60	28.84	4.00±0.12	0.91-6.22	24.41	2.04±0.14	0.54-4.76	50.40	3.85±0.13

(t ha^{-1}) = tonnes per hectare; cm: centimeter; CV= coefficient of variation; S.E= standard error.

Table 2: means, standard error, ranges (maximum and minimum) and coefficient of variation for grain yield and related traits in the maize hybrids evaluated at the two agroecologies in 2020 and 2021.

The highest grain yield was observed for hybrid TZEI 8 X DMR-LSR-Y (4.57 t ha^{-1}) which differed significantly from TZEI 10 X LNTP-Y (2.19 t ha^{-1}) which recorded the lowest score (Table 3). Hybrid TZEI 8 X DMR-LSR-Y was the earliest to attain 50% anthesis (51 days) and hybrid TZEI 12 X ART98-SW1-Y was the earliest to exhibit silk (55 days) while hybrid TZEI 12 X DMR-ESR-Y had the highest anthesis (56 days) and silking (59 days) value. Anthesis-silking intervals ranged from 3-5 days for all the hybrids. TZEI 12 X ART 98-SW1-Y had the shortest interval while TZEI 8 X BR9928-DMR-SR-Y had the longest. TZEI 12 X DMR-ESR-Y was noted for its significantly tall plants (181.67 cm) with a corresponding tall ear height (94.1 cm) value while the shortest plant and ear height was noted for TZEI 10 X LNTP-Y (145.88cm and 95.86cm) respectively.

Name	*Days to Anthesis (days)*	*Days to Silking (days)*	*Anthesis-Silking Interval*	*Plant Height (cm)*	*Ear Height (cm)*	*Plant Aspect (1-5)*	*Ear Aspect (1-5)*	*Grain Yield ($t\ ha^{-1}$)*
TZEI 8 X SUWAN 1	52.44	56.00	3.56	160.88	77.99	2.00	3.17	3.66
TZEI 8 X PROVIT-A	52.44	55.78	3.33	151.07	85.31	1.67	2.33	4.34
TZEI 8 X LNTP-Y	51.78	55.22	3.45	169.74	86.42	2.22	2.78	4.19
TZEI 8 X DMR-LSR-Y	50.78	54.78	4.00	174.14	88.94	1.56	2.11	4.57
TZEI 8 X DMR-ESR-Y	52.11	55.33	3.22	171.15	83.8a	1.89	3.00	3.87
TZEI 8 X BR9928D-MR-SR-Y	51.44	56.78	5.33	171.89	84.39	2.00	2.72	4.54
TZEI 8 X ART98-SW1-Y	53.67	57.67	4.00	165.48	93.43	2.00	3.11	3.82
TZEI 12 X SUWAN 1	52.89	57.44	4.56	180.44	94.15	1.45	2.83	4.05
TZEI 12 X PROVIT-A	52.56	55.56	3.00	151.48	87.89	1.67	2.50	3.98
TZEI 12 X LNTP-Y	54.67	58.78	4.11	173.07	92.90	1.89	2.50	3.73
TZEI 12 X DMR-LSR-Y	52.67	56.11	3.45	171.07	95.25	1.89	2.67	4.12
TZEI 12 X DMR-ESR-Y	55.56	59.22	3.67	181.67	94.10	1.78	2.28	4.42
TZEI 12 X BR9928D-MR-SR-Y	52.33	55.22	2.89	158.44	77.68	2.44	3.00	3.91
TZEI 12 X ART98-SW1-Y	51.44	54.00	2.56	168.35	83.52	1.67	2.50	3.97
TZEI 10 X SUWAN 1	52.89	57.33	4.44	178.63	84.26	2.11	2.83	3.85
TZEI 10 X PROVIT-A	52.44	55.77	3.33	156.18	81.82	2.33	3.11	3.38
TZEI 10 X LNTP-Y	52.00	56.00	4.00	145.88	75.86	2.33	3.39	2.19
TZEI 10 X DMR-LSR-Y	52.77	56.67	3.89	175.07	91.99	1.89	2.83	3.58
TZEI 10 X DMR-ESR-Y	52.77	56.89	4.11	165.67	82.10	2.00	2.89	3.61
TZEI 10 X BR9928D-MR-SR-Y	52.11	55.33	3.22	168.22	88.27	1.89	2.33	3.90
TZEI 10 X ART98-SW1-Y	53.33	57.00	3.67	169.22	86.50	2.00	3.11	3.29
Mean	52.62	56.33	3.7	167.04	86.5	1.97	2.76	3.85
LSD (0.05)	2.39	2.82	1.53	21.72	13.63	0.86	0.86	1.82
CV (%)	3.67	4.23	39.53	13.05	15.58	39.18	29.63	28.79

$t\ ha^{-1}$: tonnes per hectare; cm: centimeter; LSD: least signiicant difference; CV= coefficient of variation.

Table 3: Mean values for grain yield and other agronomic characters in 21 yellow hybrids evaluated across the different environments.

The best performing hybrid in Ibadan 2020 was hybrid TZEI 12 X DMR-ESR-Y (7.38 $t\ ha^{-1}$) as shown on table 4 while in Kishi 2020, TZEI 8 X DMR-LSR-Y (4.95 $t\ ha^{-1}$) produced highest. TZEI 10 X LNTP-Y produced the least grain yield (2.28 and 2.79 $t\ ha^{-1}$) in Ibadan 2020 and Kishi 2020 respectively. However, in 2020 all the hybrid produced better than the national average of 2.25 $t\ ha^{-1}$ reported by FAOSTAT 2020. Ibadan 2021 had a comparative yield lower than what was obtained in the previous year for both Ibadan 2020 and Kishi 2020. TZEI 8 X ART98-SW1-Y (3.27 $t\ ha^{-1}$) produced the highest yield while hybrid TZEI 10 X SUWAN 1 (1.37 $t\ ha^{-1}$) recorded least yield for Ibadan 2021. Oloyede-Kamiyo et al., 2019 also reported variations in yield gaps in different agro-ecologies of Nigeria. The overall mean performance of the hybrids across the three environment in Table 4 revealed hybrid TZEI 12 X DMR-ESR-Y (4.42 t ha^{-1}) as the overall best hybrid which is closely followed by hybrids TZEI 8 X DMR-LSR-Y (4.36 t ha^{-1}) and TZEI 8 X BR9928 DMR-SR-Y (4.31 t ha^{-1}). Hybrids TZEI 8 X LNTP-Y, TZEI 8 X DMR-LSR-Y and TZEI 8 X Provit-A alongside the three leading hybrids has overall mean yield greater than 4 t ha^{-1}. TZEI 10 X LNTP-Y (2.19 t ha^{-1}) is noted as the least performing hybrid.

S. No	***Name***	***Ibadan 2020***	***Kishi 2020***	***Ibadan 2021***	***Overall Mean***
1	TZEI 12 × DMR-ESR-Y	7.38	4.22	1.67	4.42
2	TZEI 8 × DMR-LSR-Y	5.48	4.95	2.65	4.36
3	TZEI 8 × BR9928DMR-SR-Y	7.18	3.29	2.45	4.31
4	TZEI 8 × LNTP-Y	5.92	3.52	3.13	4.19
5	TZEI 12 X DMR-LSR-Y	5.46	4.89	2.02	4.12
6	TZEI 8 X PROVIT-A	6.18	4.37	1.55	4.03
7	TZEI 12 X PROVIT-A	5.01	4.18	2.74	3.98
8	TZEI 12 X ART98-SW1-Y	5.05	4.35	2.50	3.97
9	TZEI 12 X BR9928DMR-SR-Y	6.68	3.55	1.49	3.91
10	TZEI 10 X BR9928DMR-SR-Y	5.22	4.41	2.07	3.90
11	TZEI 8 X ART98-SW1-Y	5.30	4.66	1.49	3.82
12	TZEI 8 X DMR-ESR-Y	5.06	3.07	3.27	3.80
13	TZEI 12 X SUWAN 1	5.53	4.33	1.43	3.76
14	ZEI 12 X LNTP-Y	5.31	4.27	1.63	3.74
15	TZEI 10 X DMR-LSR-Y	4.99	4.02	1.73	3.58
16	TZEI 10 X SUWAN 1	4.82	4.54	1.37	3.58
17	TZEI 8 X SUWAN 1	4.37	4.07	1.99	3.48
18	TZEI 10 X DMR-ESR-Y	4.36	3.72	2.33	3.47
19	TZEI 10 X ART98-SW1-Y	4.25	3.71	1.92	3.29
20	TZEI 10 X PROVIT-A	4.51	3.10	2.11	3.24
21	TZEI 10 X LNTP-Y	2.28	2.79	1.51	2.19
	MEAN	5.25	4.00	2.05	3.77

Table 4: Average yield performance of the 21 hybrids at each location.

Significant negative correlations was observed for grain yield and number of days to anthesis (-0.24) and silking (-0.19), and plant aspect (-0.19) (Table 5). Positive highly significant correlation was also observed for ear aspect with number of days to anthesis (0.22), number of days to 50% silking (0.26) and plant aspect (0.28). Similarly, highly significant positive correlation were also observed between ear height and plant height (0.60), number of days to anthesis and silking (0.85), and number of days to silking and ASI (0.54). Ear height had significant negative correlation with plant aspect (-0.21) and ear aspect (-0.23). When making selection, it is crucial to note that when positive correlation is observed between two traits, making selection for one trait would ensure the selection of the other trait (Emmanuel et al., 2017). Positive non-significant correlation was observed between grain yield and plant height (0.04), grain yield and ear height (0.03). This means increase in these agronomic traits could invariably increase yield. However, when Bello et al., (2010) investigated the relationship between maize grain yield and other agronomic characters in order to identify characters whose selection could be used to improve grain yield, they found positive significant phenotypic correlations of grain yield with plant and ear height.

Traits	*Days to anthesis*	*Days to Silking*	*Anthesis-Silking Interval*	*Plant Height*	*Ear Height*	*Plant Aspect*	*Ear Aspect*	*Grain Yield*
Days to anthesis		0.85**	0.00	0.06	0.08	-0.07	0.22**	-0.25**
Days to Silking	0.85**		0.54**	0.09	0.11	-0.04	0.26**	-0.19*
Anthesis-Silking Interval	0.00	0.54**		0.06	0.07	0.04	0.14	0.04
Plant Height	0.06	0.09	0.06		0.60**	-0.08	0.14*	0.04
Ear Height	0.08	0.11	0.07	0.60**		-0.21**	-0.23**	0.03
Plant Aspect	-0.07	-0.04	0.04	-0.08	-0.21**		0.28**	-0.19*
Ear Aspect	0.22**	0.26**	0.14*	-0.30**	-0.23**	0.28**		-0.03
Grain Yield	-0.24**	-0.19**	0.04	0.04	0.03	-0.19**	-0.03	

*,**,: Significant at < 0.05, < 0.01 level of probability respectively.

Table 5: Pearson correlation coefficient for different characters of 21 yellow hybrids evaluated at the two agro-ecologies in 2020 and 2021.

Conclusion

Since grain yield is the ultimate goal of any plant breeding activities, it also interact with other numerous external factors during the life span of plants. Results of the performance of the individual hybrids with respect to yield and other agronomic traits evaluated differed significantly across the tested environments. TZEI 12 and TZEI 8 were observed to be the best female parents while DMR-ESR-Y, PROVIT-A and BR9928-DMR-SR-Y are similarly observed as the best male parent in the hybrid combinations. The hybrids can be used as either male or female parents in breeding programmes because of the good combining abilities. The high yielding hybrids have the ability to provide favourable alleles for the development of varieties that are high yielding. This study can be repeated at the locations used and probably at other major maize growing ecological zones for two or more years to confirm their yield and the pattern of response of the maize hybrids across locations and years.

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References

1. Baiyegunhi LJS, Akinbosoye and Bello LO. "Welfare impact of improved maize varieties adoption and crop diversification practices among smallholder maize armers in Ogun State, Nigeria". Heliyon 8.5 (2022): e09338.
2. Bello OB., et al. "Correlation and path coefficient analysis of yield and agronomic characters among open pollinated maize varieties and their F1 hybrids in a diallel cross". African Journal of Biotechnology 9.18 (2010): 2633-2639.
3. Emmanuel G Vah., et al. "Evaluation of Maize Top Cross Hybrids for Grain Yield and Associated Traits in Three Agro-Ecological Zones in Ghana". International Journal of Environment, Agriculture and Biotechnology 2.4 (2017): 2077-2087.
4. FAO. FAOSTST. Food and Agriculture Organization of United Nations, Rome Italy (2015).
5. FAO. FAOSTAT. Rome, Italy. Gautam A.S., Mittal R.K., Bhandari J.C (1999). Correlations and path coefficient analysis in maize (Zea mays L.). Annals of Agri-Bio Research, 4 (2016):169-71.
6. Food and Agriculture Organization of the United Nations (FAO) (2020). Rome, Italy: FAOSTAT 2020.
7. Guilpart N., et al. "Rooting for food security in Sub-Saharan Africa". Environmental Research Letters 12 (2017): 114036.
8. Hailegebrial K., et al. "Evaluating Hybrid Maize Genotypes for Grain Yield and Yield Related Traits in north western Tigray, Ethi-

opia". International Journal of Research in Agriculture and Forestry 3.12 (2016): 17-21.
9. Ogunniyan DJ., et al. "Agronomic performance of hybrids of white low-nitrogen maize (Zea mays L.) inbred lines under managed nitrogen environments". Tropical Agriculture (Trinidad) 95.1 (2018): 18-30.
10. Olakojo OO. "Genotypic and agronomic performance of drought tolerant yellow quality protein hybrid maize (Zea mays L.) in savanna agro ecologies of south western Nigeria". Nigerian Journal of Genetics 31 (2016): 54-64.
11. Olaniyan AB and Lucas EO. "Maize hybrids cultivation in Nigeria - A review". Journal of Food, Agriculture & Environment 2.3&4 (2004): 177-181.
12. Olaoye G., et al. "Evaluation of local maize (Zea mays L.) varieties from Burkina Faso as source of tolerance to drought". Journal of Applied Bioscience 17 (2009): 887-898.
13. Oloyede-Kamiyo QO., et al. "Yield analysis of maize varieties in varied agroecologies of southwestern Nigeria". Ife Journal of Agriculture 31.3 (2019).

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