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Evaluation of late maturing maize varieties for late season planting in a rainforest location of Nigeria

A. Oluwaranti[1*], M.A.B. Fakorede[1], A. Menkir[2], A. Akinyooye[1], A.O. Bello[1]

[1]*Department of Crop Production and Protection, Obafemi Awolowo University, Nigeria*

[2]*International Institute of Tropical Agriculture, Ibadan, Nigeria*

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Abstract

Observations at Ile-Ife (7°28'N 4°33'E and 244m above sea level) in the rainforest ecology of South-Western Nigeria suggest that the global climatic change has resulted in the shortening of the growing season for maize (*Zea mays* L.)... Several newly developed late maturing varieties are available but had not been evaluated under the late season conditions of the rainforest ecology as typified by the Teaching and Research Farm of Obafemi Awolowo University, Ile-Ife. This study was conducted to evaluate 36 recently developed varieties of maize under the late season conditions of the rainforest ecology. The varieties were planted September 3, 2006; August 8, 2007 and September 13, 2007. For purposes of comparison, a fourth trial was planted on May 20, 2008 under early season conditions. Each trial was laid out in a 6 × 6 lattice design with three replications. Mean yield was 1.6 tons/ha for the two September plantings (Late seasons), 1.8 tons/ha for August planting (Late season) and 3.4 tons/ha for May planting (Early season). Mean squares for environment, varitety and Variety × environment interaction were statistically significant for ear number, ear weight and yield per plot. The highest yielding variety across all environments was LNP-WXLNTPF1 (2.91 tons/ha).The best varieties for August planting are TZLCOMP.IC4 (3.31 tons/ha), LNP-WXLNTPF1 (2.89 tons/ha) and the widely grown variety TZB-SR (2.46 tons/ha).. It was concluded that planting of the late maturing varieties of maize should not be delayed beyond the last week in August for optimum yield.

* **Corresponding Author:** A. Oluwaranti ✉ boluwaranti@yahoo.com

Introduction

Maize (*Zea mays* L.) is one of the major cereal crops cultivated in Nigeria and is adapted to various ecological zones of the country ranging from the rainforest in the South to the savanna zones of the Northern parts of the country. In the rainforest ecology of South-Western Nigeria, the wet (rainy) season is punctuated by 2-3 weeks of dry spell in July/August, thus resulting in a bimodal rainfall distribution; that is, the early rainy season (March/April to July) and late rainy season (late August to October). In southern Nigeria, early season maize is planted between mid-March and mid-May and in the late season, planting is done mainly in August. Bruns (2009) observed that time of maturity of crops, which is the time necessary for crops to successfully complete reproduction, is species and environment dependent. Yield of late season maize can be increased if planted at the optimum planting date. Robert *et al.* (2002) reported that delayed planting shortens the effective growing season for corn which can lead to moisture stress at flowering. Kucharik (2008) also reported that early planting of maize allows late maturing varieties to perform optimally. According to Lee and Tollenaar (2007), grain yield is the product of accumulated dry matter and effeciency allocation of the dry matter to the grain. They further observed that dry matter accumulation is highly influenced by the environment. In the rainforest zone of South-Western, Nigeria, early season maize is higher yielding than that of the late season. However, grain quality of late season maize is better than that of the early season and the grain can be better stored and preserved. There is less attack of insect pests and disease organisms during the late season. Therefore, the late season is more suited for both seed and grain production than the early season. Farmer lay much emphasis on early season maize production in south-western Nigeria not only because the yield is higher but also because rainfall, is more abundant and the season is longer. But late season maize goes beyond complementing early season maize. It helps to produce grains for consumption purposes when the succeeding year's early season planting is yet to be ready for consumption as green maize.

A major limiting factor to increased maize production in the later part of the late rainy season in the forest zone is drought. Edmeades *et al.* (1995) estimated annual yield losses of maize due to drought in sub-Sahara Africa at 15%, although localized losses may be much higher in the marginal areas where the annual rainfall is below 500mm or where the soils are sandy or shallow. Although Badu-Apraku and Fakorede (2001) reported that the probability of drought stress is lower at silking, its consequences on grain yield can be severe if it occurs at this stage. Drought probability is high during much of the late season and frequently, terminal drought occurs at or before flowering and or grain filling stages. Fakorede and Akinyemiju (2003) reported that the global climatic change is already impacting maize production practices at Ile-Ife (7^{o}28'N 4^{o}33'E, 244 m) in the rainforest ecology of south-western Nigeria. Several studies were conducted to identify maize populations and varieties that may be recommended for better performance in the late season of the rainforest ecology. In all trials, early and extra-early varieties were not as high yielding as the late maturing varieties. It became necessary, therefore, to identify intermediate or late maturing varieties that are specifically adapted to the conditions of the second season in this ecology. The objective of this study was to evaluate 36 recently developed maize varieties in the late season under the current global climatic change and identify the high yielding ones that may be released to the farmers.

Materials and Methods

Experimental design

Field experiments were conducted during the late season at the Obafemi Awolowo University Teaching and Research Farm (7^{o}28'N, 4^{o}33'E, altitude 224m above sea level). The trials were planted on September 3, 2006, August 8, 2007 and September 13 2007. For the purpose of comparison, a fourth trial was planted in the early season, on May 20, 2008. The treatments comprised of 36 late maturing varieties (Table 1) obtained from the Maize Breeding Programme of the International Institute of Tropical

Agriculture (IITA), Ibadan. The varieties were laid out as 6 x 6 tripple lattice design with three replicates. There were two rows per plot, spaced 0.75m apart with a spacing of 0.5m within row. Three seeds were planted per hill and the plants were thinned to two at the three-leaf stage, giving a population of 53,333 plants/ha. Seeds were treated with Apron plus prior to planting. Ploughing and harrowing were done before laying out of the experimental field. Fertilizer NPK was applied at a total rate of 180 kg N, 90 kg P_2O_5 and 90 kg K_2O/ha in two splits; first at three weeks after planting and finally at five weeks after planting. Weeds were controlled with primextra, which contained atrazine (2-chloro-4-(ethyl amino)-6-isopropylamino-s-triazine) and alachlor (N-(1-methyl-2-methoxy-ethyl)-2-ethyl-8-methylchloroac-etanilide) as active ingredients. The herbicide was applied one day after planting at the rate of 5 litres/ha. Weeds were also controlled by hand weeding as necessary after the crop had established. Data were collected on flowering traits (days to 50% tasseling, pollen shed and silking), plant and ear heights, yield and yield components from each plot within each replication.

Statistical analyses

All data collected were subjected to the Analysis of Variance (ANOVA). Means were separated using the Least Significant Difference (LSD). The data were statistically analyzed according to PROC GLM in SAS (SAS Institute, 2003).

Results

Mean squares due to variety and environments were significant at 0.01 and 0.05 levels of probability for all the traits measured except kernel moisture content which showed no varietal significance (Table 2).

Table 1. Names and days to 50% silking of 36 late maturing varieties of maize evaluated at the Teaching and Research Farm, Obafemi Awolowo University, Ile-Ife, Nigeria.

S/N	Names	Days to 50% Silking
1	TZLCOMP.1C4	64
2	TZLCOMP.1C1	64
3	TZLCOMP.1C5	63
4	TZLCOMP.3C3	65
5	LNPC3-YF1	65
6	TZLCOMP.1C2	65
7	IK.91TZLCOMP.3-Y	64
8	TZLCOMP3F2QPM	62
9	LNP-WXLNTPF1	64
10	OBATANPA	60
11	AFLATOXSYNVAR1F2	64
12	TZB-SE3C4-W	63
13	LNPC2F2	64
14	EV.8766SRBC6QPM	65
15	LNPYC5FS	61
16	TZB-SR	60
17	Z.DIPL.BC3-W	62
18	TZSR-W-1C4	67
19	IWDCoSTR	62
20	DTSR-WC1	68
21	Oba Super II	66
22	AK95TZLCOMP4DMR	63
23	ACR91SUWAN1SRC1	63
24	TZLCOMP1.SYN-Y	65
25	TZLCOMP1.C6	63
26	ACR.97TZLCOMPL-W	65
27	SIN93TZUTSR-W	63
28	IYFDCo	65
29	SIN9449-SR	65
30	Oba Super I	66
31	TZLCOMP.1SYN-W	64
32	ACR9449-SR	62
33	IK88TZSR-Y-1	65
34	ACR.96DMR-LSRW	65
35	TZLCOMP4C3	66
36	ACR.9128-NN	64

Variety × environment interactions were significant for ear number and weigth per plot (P<0.05, P<0.01) and yield (P<0.01) (Table 2). The coefficient of determination (R^2) values were higher for kernel moisture content, ear weight and grain yield when compared to the other traits measured, (Table 2). Coefficient of variability (CV) were low for ear height, plant height and kernel moisture content, but rather high for ear number, ear weight and yield (Table 2).

Table 2. Mean squares from the analysis of variane for plant and ear heigths, number and weight of ears, kernel moisture content and grain yield of 36 late maturing varieties of maize evaluted at the Teaching and Research Farm of Obafemi Awolowo University in 2006, 2007 and 2008.

Traits	Rep (d.f.=2)	Var (V) (d.f.=35)	Env (E) (d.f.=3)	V x E (d.f.=105)	Error	Total	R^2 (%)	CV
EHT	0.007	0.042**	1.845**	0.021	0.016	0.063	56	17.97
PHT	0.070	0.068**	2.280**	0.039	0.036	0.093	56	12.48
ENO	78.80	149.17**	763.45**	63.54*	46.16	97.05	52	36.16
EWT	0.160	0.481*	25.471**	0.499**	0.300	0.997	63	53.49
MC	1.610	1.803	2185.34**	2.126	1.85	47.64	93	8.30
YLD	1.509	70.737*	254.510**	226.422**	1.266	3.78	61	53.18

*, ** Significant at 0.05 and 0.01 levels of probability, respectively Where, EHT and PHT = Ear and Plant height (cm), ENO = Ear number, EWT = Ear weight (kg), MC = Kernel moisture content (%), YLD = Grain Yield (t/ha), Rep = Replication, Var = Varieties, Env = Environment of planting, R^2 = Coefficient of determination, CV = Coefficient of variability.

Table 3. Mean± standard error, range and coefficient of variation (CV) for grain yield of 36 late maturing maize varieties evaluated in four environments at the Teaching and Research Farm of Obafemi Awolowo University, Ile-Ife, Nigeria, 2006, 2007 and 2008.

Environments	Mean±S.E (tons/ha)	Range (tons/ha)	CV (%)
1	1.45±0.13	0.13 – 3.21	55.28
2	1.82±0.07	1.30 – 3.31	23.62
3	1.71±0.10	0.72 - 3.07	34.87
4	3.44±0.21	0.52 - 6.53	37.47

Environment 1: September 3, 2006 Environment 2: August 8, 2007.
Environment 3: September 13, 2007 Environment 4: May 20, 2008.

The response of the yield to the different dates of planting in the late and early seasons of this study indicated that the varieties generally perfomed better in May (Env 4); an early season when compared to the August and September plantings (Env 1, 2 and 3) which are late seasons palntings (Table 3). Within the late seasons plantings, performance of the August planting (Env. 2) was better than the September plantings (Env 1 and 3) (Table 3). The highest yielding variety in the August planting (Env 2) was TZLCOMP.1C4 (3.31 tons/ha), followed by LNP-WXLNTPF1 (2.89 tons/ha)(Table 4). Other high yielding varieties were TZB-SR (2.46 tons/ha),TZLCOMP3C3 (2.45tons/ha) while AFLATOSYNVAR1F2 (3.21 tons/ha) and OBATANPA (3.00 tons/ha) were the highest yielding varieties in the September plantings. Other relatively high-yielding varieties in the September planting were LNP-WXLNTPF1 (3.07 tons/ha), Oba super I (2.94 tons/ha), TZLCOMP4C3 (2.68 tons/ha), TZLCOMP.1C2 (2.62 tons/ha), TZLCOMP.3F2 QPM (2.56tons/ha) and ACR.97TZLCOMPL-W (2.34 tons/ha) (Table 4). In general, the highest yielding varieties for the combined late season plantings were

LNP-WXLNTPF1 (2.57 tons/ha), AFLATOSYNVAR1F2 (2.27 tons/ha), TZLCOMP.1C4 (2.08 tons/ha) and OBATANPA (2.07 tons/ha) (Table 4). The highest yielding varieties in the early season planting were Z.DIPL.BC3-W (6.53 tons/ha), IK.91TZLCOMP.3-Y (5.76 tons/ha), LNPYC5FS (5.70 tons/ha), AK95TZLCOMP4DMR (5.28 tons/ha) and LNPC3-YF1 (4.85 tons/ha).

Discussion

Several useful information relevant to improved maize production practices emanated from this study. First late season planting should not be delayed beyond last week in August as corroborated by Cirilo and Andrade (1994). They found that late sowings affected grain yield by decreasing kernel weight and kernel number per unit land area. They concluded that delaying the sowing date strongly decreased dry matter partitioning to the grain. As shown in Table 1, the varieties reached 50% silk extrusion in 60 or more days. Thus, maize planted as from 1 September would not silk until end of October thus predisposing the maize crop to terminal drought which normally starts late october/early November in this location as reported by Oluwaranti *et al.* 2008. It was clearly indicated in the study that the later part of the late season and early part of the early season are characterized by drought. They further reported that optimum yield for the maturity classes evaluated would be obtained when maize is planted about the middle of August for the late season and about the middle of April when the soil would have received enough rainfall for the plant's growth in the early season.

Table 4. Mean grain yield (tons/ha) of the best 10 varieties in each environments evaluated at the Teaching and Research Farm, Obafemi Awolowo University, Ile-Ife, 2006, 2007 and 2008.

S/N	Env 1		Env 2		Env 3		Overall Mean (Env 1, 2 & 3)		Env 4	
	Var	Yld	Var	Yld	Var	Yld	Var	Yld	Var	Yld
1	11	3.21	1	3.31	9	3.07	9	2.51	17	6.53
2	10	3.00	9	2.89	30	2.94	11	2.27	7	5.76
3	13	2.88	16	2.46	35	2.68	25	2.18	15	5.70
4	25	2.61	4	2.45	6	2.62	1	2.08	22	5.28
5	19	2.58	26	2.16	8	2.56	10	2.07	45	4.85
6	22	2.30	21	2.16	25	2.34	30	2.03	1	4.84
7	16	2.26	6	2.03	14	2.29	16	1.96	13	4.67
8	14	1.96	29	2.02	36	2.11	14	1.94	26	4.31
9	20	1.84	28	2.01	31	1.97	4	1.88	25	4.25
10	29	1.84	5	1.96	10	1.93	13	1.84	9	4.10
$LSD_{0.05}$		0.72		0.75		0.70		0.75		1.32

Note: *The varieties number are as specified in Table 1.

This probably explains why the september plantings were lower yielding than the August planting for most of the varieties as corroborated by Azadbahkt *et al.* 2012, Casini (2012) and Tsimba *et al.* 2013 which reported that delay planting would result in reduced yield. Second, the early and late seasons are clearly distinct and thus require different varieties as supported by Oluwaranti *et al.* 2008. It was reported in the study that performance of maize varieties during the early season was better than that of the late season Indeed, the best yielding varieties in the late season, wether planted in August or September, were quite different from those of the early season. The best variety across all late season environment (LNP-W x LNTPF1) took the last position among the 10 top yielding varieties in the early season (Table 4). Thus breeder need to develop varieties specifically adapted to the late season condition. This implies that drought tolerance be introgressed into the presently cultivated varieties. It should be noted however that the top 5 in the late seasons plantings are TZLCOMPI, Low Nitrogen and *Striga* Resistant Varieties. TZLCOMP1 are varieties that have been selected from diverse conditions, the Low-Nitrogen varieties have also been bred for efficient use of nitrogen and the S*triga resistant* Varieties have been bred for striga stress. These varieties in addition to the various stresses they have been bred for, were able to incoperate drought tolerance into their genetic make-up. It was also observed from this study that the top yielders in the early seasons are varieties that have been developed from the rainforest ecology. Among these are IK91TZLCOMP.3-Y, AK95TZLCOMP4DMR, LNPC3YF1 and LNPYC5FS.

Conclusion

In conclusion, from the result of this study, planting of the late maturing varieties of maize should not be delayed beyond the last week in August for optimum yield of the crop. The highest yielding varieties from this study are TZLCOMP1, LNP-WXLNTPF1, OBATANPA, AFLATOSYNVAR1F2 and Oba Super I. Development of varieties should be season specific for optimum yield. The top yielders of these late maturing varieties can be recommended as sources of drought tolerant varieties because of their ability to withstand stress.

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