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TABLE OF CONTENTS

Article	page
Crop Breeding and Genetics	
Breeding for Micro-Nutrient Dense Cassava in Nigeria C. N. Egesi, P. Itona, E. Okogbenin, B. Maziya-Dixon, S. Njoku, F. Ogbe, A. Dixon and M. Fregene	1-4
Pollen Grain Viability and Fruit Set Studies in the Genus <i>Solanum</i> L., (<i>Solanaceae</i>) A. L. Raji	5-9
Management of low pollination success in natural rubber tree (<i>Hevea brasiliensis</i> Muell. Arg.) K. O. Omokhafa	10-19
Simple General Classification of maize (<i>Zea mays</i> L.) based on Tassel inflorescence architecture T.O. Ajiboye	20-22
Prepondence of Dioecism in Maize (<i>Zea mays</i> L.) and its Practical advantage to Breeders T.O. Ajiboye, B. Anjorin, A.A. Olosunde and R.O. Akinwale	23-25
Conservation: Somatic embryogenesis and plant regeneration in cut non – embryonic portions of <i>Telfairia occidentalis</i> seeds O.A. Adetula, V.A. Chikaleke, M.T. Olatunji, P.E. Akin-Idowu and D.O. Ibitoye	26-28
Multivariate Analyses of Genetic Diversity among Local and Foreign Sugarcane Germplasm Accessions in Nigeria G. Olaoye and M.N. Ishaq	29-34
Genetic diversity of lipid and fatty acid profile in nine accessions of sesame (<i>Sesamum</i> and <i>Ceratotheca</i>) seed M. A. Azeez and J. A. Morakinyo	35-45
Multivariate analysis of variation of some diseases with growth and yield of cassava (<i>Manihot esculenta</i> Crantz) O. J. Ariyo and O. Adenuga	46-55
SDS-PAGE characterization of some elite cowpea (<i>vigna unguiculata</i> L.walp) varieties A.S.Oladejo, I.O. Obisesan and O.G. Omitogun	56-62
Combining Abilities of Quality Protein Maize Inbred Lines Evaluated at Samaru-Northern Guinea Savanna Zone of Nigeria. M. Yusuf and S.G. Ado	63-72
Studies on heterosis expression of yield and some yield determining traits in Potato grown under supra-optimal temperature C. O. Amadi, E. E. EneObong, and P. I. Okocha	73-76
Morphological and physiological descriptors as indispensable determinants of yield in cowpea (<i>Vigna unguiculata</i> L. Walp) A.S. Oladejo and I.O. Obisesan	77-83
Performance of Single Cross Quality Protein Maize Hybrids Evaluated at Samaru – Northern Guinea Savanna Zone of Nigeria M. Yusuf, S.G. Ado ,M.F. Ishiyaku and J.D. Olarewaju	84-90
Genotypic, Phenotypic and Environmental Associations between Fifteen Traits in Quality Protein Maize (<i>Zea mays</i> L.) Genotypes M. Yusuf and S. G. Ado	91-97
Correlation Coefficients among agronomically relevant traits in West African Okra (<i>Abelmoschus caillei</i>) (A. Chev.) Stevels) S. E. Aladele and O. J. Ariyo	98-104
Phenotypic characterization of edible vegetable <i>Solanum</i> species (<i>Solanaceae</i>) in South-Western Nigeria M.O. Sifau, L.A. Ogunkanmi, B.O. Obohand O.T. Ogundipe	105-110
Interrelationships and path analysis for germination rate and potential of rice (<i>Oryza sativa</i>) genotypes O. T. Adeniji	111-117
Character association and path analysis of yield and its components in sesame (Genera <i>Sesamum</i> and <i>Ceratotheca</i>) seed M. A. Azeez and J. A. Morakinyo	118-124
Analysis of growth indices in six maize cultivars representing Two Era of Maize Breeding in Nigeria F.A. Adebo, G. Olaoye and O.B. Bello	125-133

Efficiency of germination and vigour tests in predicting field performance of different genotypes of maize (<i>Zea mays</i> L.) A.A. Olosunde, M.A.B. Fakorede and S.A. Ajayi	134-138
Variation pattern for seedling characters among Bambara groundnut (<i>Vigna subterranean</i> [L.] Verde. Accessions O.T. Adeniji	139-143
Some physical and sensory evaluation of evaporated soymilk using Gel-T stabilizer F.T. Kolawole, M.A. Balogun and S.O.Ojelabi	144-147
Incidence and severity of sugarcane mosaic disease in selected varieties of sugarcane from the Unilorin Sugar research Institute Germplasm O.S. Balogun, S.O. Adebayo and T.H. Aliyu	148-154
Confined field trial as risk management measure in transgenic field trial E.C. Nwachukwu, E.N.A. Mbanaso, C.N. Egesi and K.I. Nwosu	155-158
Animal Breeding and Genetics	
Genetic distance obtained from Hemoglobin genetic types of the Nigerian West African Dwarf and Yankasa sheep A.D. Oladepo, A.E. Salako and M.A. Ayoola	159-161
Effect of Major Genes on Proximate Composition and Lipids Profile of Eggs from Four Chicken Strains C. E. Isidahomen, B. M. Ilori ¹ , M. O. Ozoje ¹ , C.S.O.Otiokhian and F.U.Igene	162-165
Effect of genotype on body weight and egg production traits of the Dominant Black Strain and the Fulani Ecotype Chicken F.E.Sola- Ojo and K.L. Ayorinde	166-168
Factor analysis scores in a multiple linear regression model for the prediction of liveweight in immature west african dwarf goat D. M. Ogah, M. M. Ari, S. I .Daikwo and M. O. Momoh	169-173
Potential for Colour-Crossed Inherence in the Fulani -Ecotype Chicken T. R.Fayeye, O. F. Ikubaje and M. A. Shehu	174-177
Egg production pattern of Japanese quail selected divergently for 35- day body weight V. Ojo and K. L. Ayorinde	178-181
Association between day-old body weight and juvenile growth of chicken I. I. Ipinoyomi, K. L. Ayorinde, O.O. Ismaila and A.E. Ayigun	182-185
Transit time and nutrient retention of mono-culture fungal fermented mango (Mangifera indica) kernel cake in cockerels R.M.O. Kayode, A. Sani and D. F.Apata	186-191
Fish Breeding and Genetics	
Embryogenesis of hybrid african catfish M.Y. Diyaware, A.B. Haruna, K.A. Abubakar and S.O. Olufeagba	192-196
Embryological studies of african mudfish (<i>Clarias anguillaris</i>) L.U. Onyia, B.M.B. Ladu and S.O. Olufeagba	197-201
Induction of Tetraploidy in Red Tilapia S.O. Olufeagba, R.Aminu, R. Kondadhasul and M. Kshitish	202-206
Human Genetics	
Genetics of Phenylthiocarbamide perception among 250 Families in Northern Nigeria O. A. Iyiola, A. A. Bakare, and T.B. Ayodele	207-211

Basic Genetics Assessment of the Mutagenic and Genotoxic Potential of Pharmaceutical Effluent <i>A.A. Bakare, O.A. Alabi, D. Ademeso, and H.B. Jenni</i>	212-222
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Analysis of growth indices in six maize cultivars representing Two Era of Maize Breeding in Nigeria.

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ABSTRACT: Growth parameters such as seedling germination attributes, crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR) and leaf area ratio (LAR) were investigated in six maize cultivars representing two eras of maize breeding in Nigeria during the 2005 late and 2006 early cropping seasons. Differences between maize breeding eras were significant for seedling emergence (E %) and emergence index (EI) while genotypes within a particular breeding era (G/E) differed significantly for E% and emergence rate index (ERI). Seasonal (S) variation in seedling parameters was also significant for E % and ERI with a 15% higher seedling emergence in 2006 early season. CGR in the genotypes in breeding era 1 was higher by seven percent (7%) during vegetative growth phase but lower by 14% at flowering phase compared to genotypes in breeding era 2. NAR on the other hand was consistently higher in varieties developed in 1970's by 15.2 and 13.8% compared to varieties developed in 1990's. Regardless of the breeding era, varieties with higher values for LAR at flowering (except var. TZPB-SR) were higher yielding than those with lower LAR. Overall, varieties developed in era 2 were superior to those developed in era 1 for E% and also had six percent (6%) higher values for LAR at vegetative growth phase than those developed in era 1 but decreased by two percent (2%) at flowering phase. E% in the genotypes ranged from 48.56 in ACR 9943 DMRSR to 79.33 in ACR99TZL COMP4 DMRSR, while EI and ERI ranged from 0.86 and 0.010 in TZB-SR to 0.96 and 0.014 in ACR 97 TZL COMP1-W. Grain yield was significantly higher in 2006 early cropping season by 0.3t/ha⁻¹ translating to 14.78% than in late season and it ranged from 1.64t/ha⁻¹ in TZPB-SR (era 1) to 2.94t/ha⁻¹ in ACR99TZLCOMP4DMRSR (era 2). Var. ACR99TZL COMP4DMRSR with the lowest values for CGR, RGR and NAR at vegetative phase had the highest grain yield (2.94t/ha⁻¹) indicating that genotypic superiority for grain yield is not particularly related to differences in any of these traits but rather dependent on the inherent genetic potential of the varieties themselves.

Key words: *Zea mays* L., growth indices, maize breeding era, grain yield
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Introduction

Maize improvement for grain yield potential, stability of yield including plant and grain characteristics have gone through several stages in Nigeria since 1950. The breeding efforts which began with the introgression of genes for pest and disease resistance (Fajemisin, 1985; Fakorede *et al.*, 1993; 2001) to the development of maize genotypes (open pollinated varieties and hybrids) with high grain yield potential (Kim *et al.*, 1993) as well as adaptation to different ecologies and stress factors (Kim, 1997), have resulted in the development and release of productive maize varieties for different agro-ecologies in Nigeria. Initial gains in grain yield by 1962 was estimated at between 1.5 and 2.5 t/ha⁻¹ or (43.71%) giving approximately 1.4 to 2.4% gains per annum (Fakorede *et al.* 1993). Introduction of high yielding open pollinated varieties (OPVs) and hybrids into the Nigeria's savanna between 1985 and 1990 resulted in further yield increase ranging from

4.25t/ha⁻¹ to 5.15t/ha⁻¹, representing an average of 22% yield advantage especially for the hybrids (Kim *et al.*, 1993). Maize grain yield since then has witnessed a phenomena increase as high as 14.7t/ha⁻¹ in high yielding environments of the West and Central Africa (WCA) representing 20 to 40% yield advantage (Kim, 1997). In a recent study which compared the performance of maize OPVs developed for WCA between 1970 and 1999 across the West African savannas, Kamara *et al.*, (2004) reported genetic gain in grain yield of 0.41% per year⁻¹.

Underlying the reported gains in grain yield, is the improvement in characters such as tolerance to plant population density stress, nitrogen (N) stress, cold temperature stress, water stress and weed competition (Castleberry *et al.*, 1984; Duvick, 1997; Tollenaar *et al.*, 1994b, 1997, 2000; Tollenaar and Wu, 1999; Ying *et al.*, 2000; Edmeades *et al.*, 2006; Campos *et al.*, 2006). Lee and Tollenaar, (2007) also noted that changes in light interception due to increased leaf

area index (LAI) and in light utilization due to more erect upper leaves, maintenance of green leaf area and leaf photosynthesis during grain filling period, resulted in significant increase in dry matter accumulation (DMA) of up to 113% in ERA-hybrid grain yield in the USA. Other attributes that have contributed to gains in grain yield of newer generation of maize cultivars include, kernel number (Tollenaar *et al.*, 1992) and greater partitioning of dry matter to the kernels during the sensitive period of kernel establishment (Echarte *et al.*, 2004; Echarte and Tollenaar, 2006).

However as plant breeding efforts result in emergence of newer varieties with increased productivity and better adaptation to diverse ecosystems as well as increased resistance/tolerance to biotic and abiotic stress factors and changing farming practices, so also is the possibility of changes in growth parameters which may be morphological, physiological or a combination of both. In other words, the gains in grain yield attributable to maize breeding in Nigeria (Kamara *et al.*, 2004), may also have been accompanied with changes which may include seedling and early growth characteristics.

Growth is a vital function of plants and is an indication of a gradual increase in number and size of cells. Growth parameters such as germination, leaf area index, relative growth rate and net assimilation rate are very important in assessing crop growth and may be an indication of potential productivity especially since cultivars having balanced vegetative growth under stress leads to better economic returns (Khan *et al.*, 2005). The authors further noted that genetic diversity for growth between and within crop species gives economic stability and enables to choose the crops and their cultivars that are adapted for a region or for the specific field conditions. This study was therefore designed to assess performance of six varieties representing two eras of maize breeding in Nigeria and to investigate possible changes which may have occurred in seed emergence and crop growth characteristics between the two eras of maize breeding in Nigeria.

Materials and Methods

Description of Genetic Materials

The materials used which comprised six late maturing maize cultivars were obtained from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. Three of the varieties (TZPB-SR, TZB-SR and ACR9943-DMRSR) were developed in the 1970's while the other three (ACR96 DMR

LSRW, ACR 97 TZL COMP1-W and ACR99TZL COMP4DMRSR) were developed in 1990's. The six varieties are all late maturing, white grained type with endosperm attributes ranging from Dent, Flint or Dent/flint.

Experimentation

The genetic materials were evaluated during the 2005 late and 2006 early-cropping seasons at the Teaching and Research (T & R) farm, University of Ilorin in the Southern guinea Savanna Zone (SGSZ) of Nigeria. Ilorin is in the Southern Guinea Savanna ecology (Lat 8° 29'N & Long 4° 24'E, 370mm above the sea level) of Nigeria. Rainfall distribution in the location is bimodal with annual rainfall of 1100-1400mm. However, the distribution is highly unpredictable, usually with false start around April which may stop abruptly few weeks after and ending not later than mid-October of every year. The trials were established on August 6, 2005 and May 23, 2006 respectively. The trials were laid out each season in a randomized complete block design (RCBD) with four replications and at a planting distance of 0.75m between the rows and 0.5m within the rows. Each plot was six rows and the outer rows were used for destructive sampling, while observations were taken from the four middle rows.

Seeds were treated with apron plus before planting for protection against seed borne diseases and soil borne pests. Three seeds were planted/hill but later thinned to two/hill two weeks after planting (WAP). Agronomic practices included pre-emergence application of herbicide (stomp and atrazine) to control weeds at the rate of 100ml to 20liters of water, supplemented by hoe weeding as necessary. Compound fertilizer (NPK 20:10:10) was applied as split-dosage at the rate of 80kgN/ha, 60K₂O/ha and 60P₂O₅ 3WAP and at anthesis (7WAP), using the side placement method.

Data Collection and Analyses

Data were collected from the four central rows on seedling emergence and growth characteristics as well as grain yield and yield components. Seedling emergence was collected on 5, 7 and nine (9) days after planting (DAP) respectively. Leaf area measurements were also taken at 2, 4, 6 and 8 weeks after planting (WAP). At each of these periods, fresh plants parts (root, stem and leaf) obtained from ten plants/plot were weighed in the laboratory and later dried to a constant weight in the oven at 80°C. Values obtained from the periodic measurements were then used to compute physiological parameters of relative growth rate (RGR), net assimilation rate (NAR) and

leaf area ratio (LAR) using the following formulae proposed by Gardner *et al.* (1985).

Relative Growth Rate (RGR) was computed in $\text{gkg}^{-1}\text{d}^{-1}$ from the oven dried weight of samples between 4, 6 and 8 WAP as

$$\text{RGR} = [\ln W_2 - \ln W_1 / T_2 - T_1].$$

Net Assimilation Rate (NAR) was computed in gm^2d^{-1} from the dry weight and leaf area at specified intervals as

$$\text{NAR} = [(W_2 - W_1) (\ln A_2 - \ln A_1) / (A_2 - A_1) (\ln W_2 - \ln W_1)]$$

Leaf Area Ratio (LAR) was also computed in m^2/kg -this was computed as

$$\text{LAR} = [(A_2 - A_1)(\ln W_2 - \ln W_1) / (W_2 - W_1)(\ln A_2 - \ln A_1)].$$

Where A_1 = Initial leaf area

A_2 = Final leaf area

W_1 = Initial dry weight

W_2 = Final dry weight

$\ln$ = Natural logarithm

$T_2 - T_1$ = Time interval between two harvests

Other data collected included days to anthesis (pollen shed) and silking, plant and ear heights (cm) and tassel branch number. 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 the upper ear, respectively. Ear aspect was rated visually on a scale of 1 to 5 where 1 = clean, uniform, large and well-filled ears and 5 = rotten, variable, small and partially filled ears. All ears harvested from each plot were weighed to determine grain yield per plot (assuming 80% shelling percentage) and was later converted to tones per ha (t/ha^{-1}) after adjusting to 12% moisture content. 300 grain-samples were collected from each plot at harvest for the determination of harvest moisture. The samples were first weighed to obtain initial weight followed by drying to a constant weight in the oven at 80°C in the laboratory and the difference between the two weights recorded as moisture at harvest. Additional data were also collected on yield components viz: cob length (cm) cob diameter (cm), kernel row number, kernel depth (cm) and 300 kernel weight (gm). Data on seedling emergence were used to compute emergence percentage (E %), emergence index (EI) and emergence rate index (ERI) respectively.

E % was computed as $100[\text{Number of seedlings emerged 9DAP}] / \text{Total number of seeds planted}$ while EI was computed as described by Fakorede and Ojo (1981)

$$\text{EI} = \sum (N_x) (\text{DAP}) / \text{Seedlings emerged 9DAP}.$$

$$\text{ERI} = \text{EI} / \text{E\%}.$$

N_x is the number of seedlings emerged on day x

Data collected and estimated were subject to analyses of variance (ANOVA) first on individual season basis before combined ANOVA over seasons using the SAS GLM Proc (SAS Inst. Inc., 1997) based on a randomized complete block design and a model in which genotypes in each trial were considered fixed effects and seasons as random. Pertinent means were thereafter separated by means of Duncan Multiple Range Test (Steel and Torrie, 1980).

Results and Discussion

Seedling emergence characteristics

Seasonal (S) variation was significant for emergence percentage (E %) and emergence rate index (ERI) but not for emergence index (EI) which is a measure of speed of emergence (Table 1). Differences between breeding eras (E) were also significant for E% and EI but not for ERI. Genotypes within a particular breeding era (G/E) differed significantly for E% and ERI but not for EI. The interactive effect of season by era (S x E) was significant only for E% but S x G/E interaction was not significant for any of the seedling emergence traits. Seedling emergence was higher in 2006 by 15%, consequently lower ERI value compared to 2005 late season, which was due to adequate moisture during crop establishment in 2006 early season as opposed to cessation of rains shortly after planting during the 2005 late cropping season. Our findings agree with earlier observation of Khan *et al.*, (2005) who noted that favourable environmental conditions and adequate availability of essential elements increases the growth of crops. High temperatures at the beginning of the crop cycle have also been shown to have a positive influence on seedling establishment (Valero *et al.*, 2005).

Overall, varieties developed in 1990's showed superiority for seedling emergence compared to those developed in 1970's but they did not differ in speed of emergence (Table 2). E% ranged from 48.56 in ACR 9943 DMRSR to 79.33 in ACR99TZL COMP4 DMRSR, while EI and ERI ranged from 0.86 and

0.010 in TZB-SR to 0.96 and 0.014 in ACR 97 TZL COMP1-W. One variety in each era of breeding (ACR 9943DMRSR and ACR96 DMR LSRW) had significantly lower E% than others within their respective groups, consequently higher ERI values.

Varieties developed in 1990's also had better speed of emergence (EI) than those developed in 1970's. Var. ACR99TZL COMP4 DMRSR with the highest E% also had the highest EI suggesting superiority of this variety for seedling emergence characteristics.

Table 1: Season and Era means for seedling emergence characteristics in six maize varieties representing two era of maize breeding in Nigeria (Ilorin, 2005 & 2006).

Season	Emergence percentage (E %)	Emergence index (EI)	Emergence rate index (ERI)
2005 Late	58.71b	0.90	0.015b
2006 Early	74.36a	0.93	0.013a
SE±	0.70	ns	0.003
Era			
1970's	63.30b	0.90b	0.013
1990's	69.77a	0.94a	0.015
SE±	0.71	0.069	Ns
F-Test			
Season (S)	2938.44**	0.013	$5.2 \times 10^{-5*}$
Era (E)	503.37**	0.017*	2.0×10^{-5}
Genotype/Era (G/E)	1572.10**	0.008	$2.0 \times 10^{-4***}$
S x E	482.73**	2.9×10^{-3}	1.9×10^{-5}
S x G/E	233.76	0.006	2.0×10^{-5}
%CV	18.37	7.05	22.45

*, **; significant F-test at 0.05 and 0.01 levels of probability respectively;

Table 2: Seedling emergence characteristics in six maize varieties representing two era of maize breeding in Nigeria (Ilorin, 2005 & 2006).

Genotype	Emergence percentage (E %)	Emergence index (EI)	Emergence rate index (ERI)
Era1(1970's)			
TZPB-SR	71.96b	0.90	0.011
TZB-SR	69.38bc	0.86	0.010
ACR 9943DMRSR	48.56d	0.94	0.020
Era 2 (1990's)			
ACR96 DMR LSRW	52.35c	0.92	0.020
ACR97TZLCOMP1-W	77.64ab	0.96	0.014
ACR99TZLCOMP 4 DMRSR	79.33a	0.93	0.011
Mean	66.54	0.92	0.014
SE±	1.22	ns	2.0 x 10 ⁻²

Means in a column followed by the same alphabets are not significantly different.

Physiological attributes

Seasonal effects which may be related to environmental factors (particularly rainfall amount and distribution) had significant effects on almost all the physiological attributes except for net assimilation rate (NAR) during growth phase that coincided with flowering (Table 3). Regardless of the cropping season, the lowest crop growth rate (CGR) values were recorded during the early vegetative growth stages and increased to the maximum during the flowering stage. This was in line with the reports of other workers (Awal and Khan, 2000; Valero *et al.*, 2005). Differences between the two breeding eras were significant only for CGR during flowering and leaf area ratio (LAR) during the vegetative phase. Differences between genotypes within a breeding era were significant for relative growth rate (RGR) during flowering phase and NAR at the vegetative growth phase. S x E interactive effects were significant also for RGR and NAR during the flowering phase while S x G/E interaction was not significant for any of the physiological attributes. CGR was better in 2005 late season than in 2006 early season while the reverse was the case for other physiological parameters (RGR, NAR and LAR) respectively. Samarraic, (1990) as well as Zalba and Peinemann (1998) noted that CGR do vary with incident solar irradiance. In this study, higher values recorded for CGR which is the accumulation of dry

matter per day in 2005 late season compared to 2006 early season was probably due to better insolation and lower incidence of biotic stress factors. Conversely, RGR which is the rate of dry matter production per gram of total dry weight per day especially during the active flowering stage was better in 2006 early cropping season than in 2005 late cropping season. This was probably due to availability of moisture in the early season as opposed to disruption in rains at different periods during the 2005 late cropping season.

NAR is a measure of the rate of dry matter accumulation per unit leaf area. This attribute was also significant higher during the vegetative phase with values obtained in the late season higher than that for early cropping season (Table 3). Low NAR might be due to restricted availability of essential nutrients, decreased photosynthetic efficiency (Datta, 1994) or lower rate of biomass production (Khan *et al.*, 2005). Although Valero *et al.*, (2005) reported higher values for NAR during early vegetative growth but a decline during the latter stages, a situation which the authors attributed to a general decline in photosynthetic efficiency with leaf age and also perhaps to lack of nutrients in later stages, our results revealed that NAR values were higher during vegetative phase than at flowering phase. The difference between the two studies might be due to the fact that the authors extended their sampling till harvest time while we stopped sampling at flowering.

Table 3: Season and Era means for grain yield and physiological characteristics in six maize varieties representing two era of maize breeding in Nigeria (Ilorin, 2005 & 2006).

	Crop growth rate ($\text{gm}^{-2}\text{d}^{-1}$)		Relative growth rate ($\text{gkg}^{-1}\text{day}^{-1}$)		Net assimilation rate ($\text{g cm}^{-2}\text{day}^{-1}$)		Leaf area
	42DAP	56DAP	42DAP	56DAP	42DAP	56DAP	42DAP
Season							
2005 Late	12.73a	37.40a	0.11b	0.01b	0.036a	0.08	3.16b
2006 Early	7.3b	31.79b	0.13a	0.11a	0.027b	0.07	5.01a
SE $\pm$	0.36	0.57	Ns	3.2×10^{-2}	2.1×10^{-2}	ns	0.18
Era							
1970's	10.37	32.25	0.12	0.01	0.033	0.080	3.96
1990's	9.66	36.94	0.12	0.01	0.028	0.069	4.21
SE $\pm$	Ns	0.57	Ns	ns	ns	ns	0.18
F-Test							
Season (S)	352.35**	376.99*	4.6×10^{-3} *	5.2×10^{-3} **	8.3×10^{-4} **	1.3×10^{-3}	41.29*
Era (E)	304.35	264.70*	2.1×10^{-6}	0.005	3.0×10^{-4}	1.5×10^{-3}	0.73*
Genotype/Era (G/E)	11.38	319.70	1.9×10^{-3}	3.0×10^{-3} **	1.0×10^{-4} **	3.3×10^{-4}	0.05
S x E	3.87	489.47	1.0×10^{-4}	2.7×10^{-4} **	0.0	1.7×10^{-4} 4**	1.25
S x G/E	1.08	72.21	1.0×10^{-4}	1.1×10^{-3}	1.1×10^{-5}	3.5×10^{-4}	0.19
%CV	30.46	22.27	26.47	34.44	33.23	32.75	19.57

*, **; significant F-test at 0.05 and 0.01 levels of probability respectively; DAP =Days after planting.

Table 4: Grain yield and physiological characteristics in six maize varieties representing two era of maize breeding in Nigeria (Ilorin, 2005 & 2006).

Genotype	Crop growth rate (gm ² d ⁻¹)		Relative rate growth (gkg ⁻¹ day ⁻¹)		Net assimilation rate (g cm ² day ⁻¹)		Leaf area ratio (m ² m ⁻²)		Grain yield (t/ha- 1)
	42DAP	56DAP	42DAP	56DAP	42DAP	56DAP	42DAP	56DAP	
Era1 (1970's)									
TZPB-SR	10.28ab	28.29c	0.118a	0.109	0.034	0.079	3.956	1.606a	1.64b
TZB-SR	9.22b	27.05d	0.106a	0.093	0.030	0.074	3.928	1.848a	2.02a
ACR 9943DMRSR	11.63a	41.40a	0.124a	0.098	0.036	0.088	4.004	1.333b	1.67b
Era 2 (1990's)									
ACR96 DMR LSRW	9.71b	41.12a	0.125a	0.103	0.031	0.075	4.269	1.631a	1.89b
ACR97TZLCOMP1-W	10.81ab	36.78ab	0.129a	0.098	0.030	0.064	4.093	1.469b	2.13a
ACR99TZLCOMP 4									
DMRSR	8.45c	32.94ab	0.093b	0.098	0.024	0.068	4.264	1.618a	2.94a
Mean	10.02	34.54	0.116	0.10	0.031	0.075	4.01	1.58	2.05
SE±	0.63	0.98	6.3 x 10 ⁻²	ns	ns	ns	ns	0.22	0.21

Means in a column followed by the same alphabets are not significantly different.

Values for LAR were higher in 2006 early season regardless of the sampling period (Table 3). Increase in LAR, and consequently the increase in rate of dry matter accumulation, is proportional to rate of dry matter accumulation per unit leaf area (NAR). However, values recorded for vegetative growth phase were significantly higher than values obtained for flowering phase. Soldati *et al.*, (1984) reported that an increase in dry matter accumulation leads to an increase in leaf area because proportion of dry matter allocated to leaves remain fairly constant while an increase in leaf area leads to an increase in rate of dry matter accumulation because light interception is directly related to leaf area during this phase of development. Our results however showed an inverse relationship between LAR and either CGR or RGR during the different cropping seasons or genotypes between the two eras of maize breeding.

The genotypes differed significantly for CGR, RGR and LAR respectively but not for NAR (Table 4). CGR and NAR in the genotypes increased with sampling time while RGR and LAR decreased with sampling time. Differences between eras for physiological attributes were not consistent. For example, CGR in the genotypes was higher by seven Percent during vegetative growth phase in breeding

era 1 relative to era 2 but lower by 14% at flowering. NAR on the other hand was consistently higher by 15.2 and 13.8% in varieties developed in 1970's when compared with those developed in 1990's. Varieties developed in 1990's however had six percent (6%) higher values for LAR at vegetative growth phase than those developed in era 1 but decreased by two percent (2%) at flowering phase. Comparison between varieties for CGR revealed that genotypes with the lowest and highest values (TZB-SR and ACR9943DMRSR) were from breeding era 1. Var. ACR9943DMRSR also had the highest value for RGR at the vegetative phase although the value was only significantly higher than that of var. ACR99TZLCOMP4DMRSR. Although the varieties were similar for LAR at the vegetative growth phase, Vars. ACR 9943DMRSR (era 1) and ACR97TZLCOMP1-W (era 2) had the least values for this parameter.

Grain yield

The effect of cropping season as well as differences between genotypes within a particular breeding era (G/E) was significant for grain yield but differences between eras of maize breeding was non

significant (Table 3.) Grain yield was significantly higher in the early cropping season than in late season by 0.3t/ha^{-1} translating to 14.78%. Although differences in grain yield between eras of breeding was not significant, varieties developed in 1990's generally yielded higher than those developed in 1970's with a yield advantage of 0.55t/ha^{-1} which translated to 23.4% gain/era.

Regardless of the era of breeding, varieties with higher values for LAR at flowering except (var. TZPB-SR) were higher yielding than those with lower values (Table 4). Grain yield ranged from 1.64t/ha^{-1} in TZPB-SR (era 1) to 2.94t/ha^{-1} in ACR99TZLCOMP4DMRSR (era 2). An increase in NAR during the growing season is indicative of response of the photosynthetic apparatus to an increased demand for assimilates to afford rapid growth of the grain fraction (Valero *et al.*, 2005). In our study, we observed that superiority of the varieties for any of the physiological attributes did not translate to concomitant high grain yield. For example, Var. ACR 9943DMRSR with the highest values for CGR at both vegetative and flowering growth phases was also one of the varieties with the highest value for RGR at vegetative phase had one of the lowest grain yield. Conversely var. ACR99TZL COMP4DMRSR with the highest grain yield had the lowest values for CGR, RGR and NAR at vegetative phase. In other words, genotypic superiority for grain yield is not particularly related to differences in any of these traits but rather dependent on the inherent genetic potential of the varieties themselves.

References

- Awal, M. A. and M.A.H. Khan. 2000. Mulch Induced Eco-physiological growth and Yield of maize. *Pakistan Journal of Biological Sciences* 3 (1): 61-64.
- Campos, H., M. Cooper, G.O. Edmeades, C. Löffler, J.R. Schussler, and M. Ibañez. 2006. Changes in drought tolerance in maize associated with fifty years of breeding for yield in the U.S. corn belt. *Maydica* 51:369-381.
- Castleberry, R.M., C.W. Crum, and C.F. Krull. 1984. Genetic yield improvement of US maize cultivars under varying fertility and climatic environments. *Crop Sci.* 24:33-36.
- Datta, S.C., 1994. *Plant Physiology*. Wiley Eastern Ltd. New Age Intl. Ltd. New Delhi, India.
- Duvick, D.N. 1997. What is yield? p. 332-335 In G.O. Edmeades *et al.* (ed.) *Developing drought and low N-tolerant maize*. Proceedings of a Symposium, CIMMYT, El Batán, Mexico. 25-29 March 1996. CIMMYT, México, D.F.
- Echarte, L., and M. Tollenaar. 2006. Kernel set in maize hybrids and their inbred lines exposed to stress. *Crop Sci.* 46:870-878.
- Echarte, L., F.H. Andrade, C.R.C. Vega, and M. Tollenaar. 2004. Kernel number determination in Argentinean maize hybrids released between 1965 and 1993. *Crop Sci.* 44:1654-1661.
- Edmeades, G.O., M. Bänziger, H. Campos, and J. Schussler. 2006. Improving tolerance to abiotic stresses in staple crops: A random or planned process. p. 293-309 In K.R. Lamkey and M. Lee (ed.) *Plant breeding: The Amel R. Hallauer international symposium*. Blackwell Publ., Oxford, UK.
- Fakorede, M.A.B. and D.K. Ojo. 1981. Variability for seedling vigour in maize. *Exptal. Agric.* 17: 195-201.
- Fakorede, M.A.B., J.M. Fajemisin, J.L. Ladipo, S.O. Ajala and S.K. Kim. 1993. Maize improvement in Nigeria. Past, present and future. P.15-40 in Fakorede, M.A.B., C.O. Alofe and S.K. Kim (eds.). *Maize improvement, production and utilization in Nigeria*. Maize Association of Nigeria Publication.
- Fakorede, M.A.B., J.M. Fajemisin, J.L. Ladipo, S.O. Ajala and S.K. Kim. 2001. Development and regional deployment of streak virus maize germplasm: an overview. 503-516 in Jacqueline d'A Hughes and Babajide O Odu (eds). *Plant Virology in Sub-Saharan Africa*. Proc. of a conference organized by the International Institute of Tropical Agriculture, Ibadan 4th-8th June, 2001.
- Fajemisin, J.M. 1985. Maize diseases in Africa and their role in varietal improvement process. Paper presented at the Maize Regional Workshop for Eastern and Southern Africa held at Lusaka, Zambia. March 10-17, 1985.
- Gardner, F.P., R.B. Pearce and R.L. Mitchell, 1985. *Physiology of Crop Plants*. pp. 187-208. Iowa State University Press.
- Kamara, A. Y., A. Menkir, M.A.B. Fakorede, S.O. Ajala, B. Badu-Apraku And I. Kureh. 2004. Agronomic performance of maize cultivars representing three decades of breeding in the Guinea Savannas of West and central Africa. *The Journal of Agricultural Science*. 142:5:567-575.
- Khan, M. A., M. Abid, N. Hussain and T. Imran. 2005. Growth and analysis of wheat (*Triticum aestivum* L.) cultivars under saline conditions. *International Journal of Agriculture and Biology* 2005 Vol. 7, No. 3, 508-510.
- Kim, 1997. Achievements, challenges and future direction of hybrid maize research and production in West and Central Africa. P42-82. in B. Badu-Apraku, M.O. Akoroda, M. Ouedrigo and F.M. Quin (eds.). *Contributing to food self sufficiency in maize research and development in West and Xentral Africa*. Proc. of a regional maize workshop, 29 may-2 June 1995, IITA Cotonou, Benin Republic.
- Kim, S.K., J.M. Fajemisin, M.A.B. Fakorede and J.E. Iken. 1993. Maize improvement in Nigeria-Hybrid performance in the savanna zone. P. 41-46. Fakorede, M.A.B., C.O. Alofe and S.K. Kim (eds.). *Maize improvement, production and utilization in Nigeria*. Maize Association of Nigeria Publication.
- Lee, E. A. and M. Tollenaar. 2007. Physiological Basis of Successful Breeding Strategies for Maize Grain Yield. *Crop Sci* 47:202-215.

- SAS Institute. 1997. SAS/STAT software: Changes and enhancement through release 6.12. SAS Inst., Cary, NC.
- Samarraie, S.M. H.E.Osman, H.R.Mian, O.E.Simsaa, and M.S. Alami. 1990. Shade Effects on growth and biomass production of corn and sunflower in Western Saudi Arabia. King Saud Univ., Vol. 2, Agric. Sci. (1), pp 51-59.
- Soldati, A., A. Stehli and P. Stamp. 1984. Temperature adaptation of tropical highland maize (*Zea mays* L.) during early growth and in controlled conditions. Crop Sci. 24:28-32.
- Steel, R.G.D. and Torrie, J.H. 1980. Principles and Procedures of Statistics. A Biometrical Approach. 2nd Edition. Mc Graw Hill Book Inc, New York. 1980, 580pp.
- Tollenaar, M., and J. Wu. 1999. Yield improvement in maize is attributable to greater stress tolerance. Crop Sci. 39:1597-1604.
- Tollenaar, M., and E.A. Lee. 2002. Yield potential yield, yield stability and stress tolerance in maize. Field Crops Res. 75:161-170.
- Tollenaar, M., A. Aguilera, and S.P. Nissanka. 1997. Grain yield is reduced more by weed interference in an old than in a new maize hybrid. Agron. J. 89:239-246.
- Tollenaar, M., A. Ahmadzadeh, and E.A. Lee. 2004. Physiological basis of heterosis for grain yield improvement in maize. Crop Sci. 44:2086-2094.
- Tollenaar, M., L.M. Dwyer, and D.W. Stewart. 1992. Ear and kernel formation in maize hybrids representing three decades of grain yield improvement in Ontario. Crop Sci. 32:432-438.
- Tollenaar, M., D.E. McCullough, and L.M. Dwyer. 1994a. Physiological basis of the genetic improvement of corn. p. 183-236. In G.A. Slafer (ed.) Genetic improvement of field crops. Marcel Dekker, Inc., New York.
- Valero, A. de Juan, M. Maturano, A. A. Ramírez, J. M. Tarjuelo Martín-Benito and J. F. Ortega Álvarez. 2005. Growth and nitrogen use efficiency of irrigated maize in a semiarid region as affected by nitrogen fertilization. Spanish Journal of Agricultural Research (2005) 3(1), 134-144
- Ying, J., E.A. Lee, and M. Tollenaar. 2000. Response of maize leaf photosynthesis to low temperature during the grain-filling period. Field Crops Res. 68:87-96.
- Zalba, P. and N. Peinemann, 1998. Salinity-fertility interactions on early growth of maize (*Zea mays* L.) and nutrient uptake. *Edafologia*, 5: 29-39