Ife Journal of Agriculture, 2018, Volume 30, Number 3

COMPARATIVE ANALYSIS OF PHYSIOLOGICAL SEED QUALITY AND FIELD PERFORMANCE OF SINGLE-, THREE-WAY AND DOUBLE-CROSS HYBRIDS OF TROPICAL MAIZE GERMPLASM

***Oluwaranti A, Badmus O. T., Awoniyi S. O., Akintola A. M., Bankole O.O. and Awosanmi F. E.**

Department of Crop Production and Protection, Faculty of Agriculture, Obafemi Awolowo University, le-Ife, Nigeria.
boluwaranti@yahoo.com
+234-806-783-0144

ABSTRACT

Limited information is available on the comparative field performance of the conventional maize hybrid types as influenced by the seed qualities. Therefore, the objectives of this study were to evaluate the different types of conventional maize hybrids for seed quality and agronomic traits and determine the relationship between the seed quality and agronomic traits of the maize hybrids Fifteen maize hybrids consisting of five varieties each of single, three-way and double cross hybrids were evaluated for seed quality and agronomic traits at the Seed Science Laboratory and Teaching and Research Farm of Obafemi Awolowo University, respectively. Single cross hybrid was observed to have the highest germination percentage and lowest germination rate index, while the double cross has the lowest number of abnormal seedlings and conductivity values. The double cross maize hybrid had higher ear height compared to the single and three-way hybrids of maize. The single cross maize hybrid had higher ear length compared to three-way and double hybrids of maize. In conclusion increased germination percentage and reduced germination rate index resulted to increased ear height in the early cropping season while in the late season reduced shoot dry weight and root fresh weight resulted into increased ear number.

Keywords:* *Conventional Hybrids, Field Performance, Seed quality, Tropical Maize, Viability, Vigour

INTRODUCTION

Maize (*Zea mays* L.) is the third most important cereal crop species, after wheat and rice, grown throughout a wide range of climates. Maize is not only an important source of nutrient to man, but also a basic element of animal feed and raw material for manufacturing of many industrial products (CIMMYT, 2000). The versatility of maize has brought about a continuous increase in its market demand, which cultivation of open pollinated varieties (OPVs) alone could not be met due to low yielding potential of OPVs. Hence, the need for higher yielding maize hybrid cultivation. The advent of science and technology has led to the wide development of improved quality maize; one of which is through maize hybrid seed production.

Maize plant, being cross pollinating crop species with the distinctive development and placement of its reproductive parts (i.e., the tassel which contains the pollen and the silk which contains the stigma) ensures ease in crossing and development of inbred lines through enforced self-pollination for the production of hybrid seeds (Pegah *et al.*, 2008). The increase in vigour of a hybrid over its two parents, known as hybrid vigour is generally observed in hybrids.

Hybrid seed provides farmers with varieties containing improved genetics, such as high yield potential and unique trait combinations to counter diseases and adverse growing conditions. Hybrids are generally higher yielding than open pollinated varieties. If grown under suitable conditions, hybrids are uniform in colour, maturity, and other plant characteristics, which enables farmer to carry out certain operations such as harvesting at the same time (Rajesh *et al*., 2012). Maize hybrids are developed by cross–pollinating two genetically different inbred parent lines with desired characters. Generally, hybridization helps to improve the characteristics of the resulting plant such as better yield, greater uniformity, disease resistance. An important factor is the heterosis of the hybrids from cross of the parental lines. Cross-pollinating any particular pair of inbred strains may or may not result in superior offspring. The parent used are therefore carefully chosen so as to achieve the uniformity that comes from the uniformity of the parents, and the superior performance that comes from heterosis (Paul, 2016). There are different types of hybrids which are either conventional or non-conventional maize hybrids. The conventional maize hybrids are the single cross, double cross and three-way cross while the non-conventional hybrid types are double top cross, modified single cross, double modified single cross and modified three-way cross (Mohammad 2017) The single cross maize hybrid is the most productive, uniform and expensive because both parents are inbreds while double cross hybrid is the least expensive since both parents are single crosses (MacRobert *et al*., 2014). The most common types of hybrids in maize are single-cross, three-way and double-cross which are the conventional hybrid types (MacRobert *et al*., 2014). Single cross maize hybrids are developed by crossing two unrelated inbred parents; three-way cross hybrids are produced by crossing an inbred line as the male parent to a single cross as the female parent while the double cross hybrids are developed from the cross of two single crosses which entails two stages of crossing (Rajesh *et al*., 2012).

Seed is a matured ovule which consists of the seed coat, endosperm and the embryo. The effectiveness of seed as the end product of plant growth, biological entity and basic agricultural input, and the instrument for technology transfer (Ajayi, 2007) are all influenced by the potential seed quality and also by its interaction with the environment. The use of high-quality seeds is one of the essential prerequisites to achieving greater productivity in the field (Munamava *et al*., 2004). Delouche (2004) also observed that seed performance is dependent on high level of seed quality. Therefore, knowledge of inherent hybrid seed quality is important for selection in breeding programs; However, limited information is available on the comparative field performance of the conventional maize hybrid types as well as the influence of hybrid types on seed quality. Hence, the objectives of this study were to evaluate the different types of maize hybrids for seed quality and agronomic traits and determine the relationship between the seed quality and agronomic traits of the maize hybrid types.

MATERIALS AND METHODS

There were two experiments for this study. These experiments were carried out in the Seed Science Laboratory of the Department of Crop Production and Protection and Teaching and Research Farm, Faculty of Agriculture Obafemi Awolowo University Ile Ife. Fifteen maize hybrids consisting of five varieties each of the three conventional types; single, three-way and double cross hybrids obtained from the maize breeding program of International Institute of Tropical Agriculture (IITA), Ibadan were used for this study.

Laboratory Experiment

The laboratory experiment was laid out in a randomized complete block design, (RCBD) with three replicates. Viability tests were conducted using germination test and vigour tests were conducted using seedling vigour and conductivity tests.

Germination test: Fifty seeds from each variety were sown in plastic bowls containing wet sterilized river-bed sand all in three replicates and kept on a shelf. Germination counts were taken on the 4^{th}, 5^{th}, 6^{th} and 7^{th} day after planting.

Seedling vigour test: At 7^{th} day after planting, the number of abnormal seedlings were recorded and 10 normal seedlings were removed from each bowls, and the following parameters were taken; Shoot length (mm), Primary root length (mm), Root number (mm), Shoot wet weight (g), Root wet weight (g), Shoot dry weight (g), Root dry weight (g).

Electrical conductivity test: Fifty seeds of each variety were weighed and soaked in beakers containing 100ml distilled water and covered with Aluminum foil paper each in three replicates. The solutions were left for 24 hours. Using the conductivity meter; Metttler Toledo Mc 126 manufactured from GmbH Schwerzenbach, Switzerland, the conductivity was measured (with the seeds submerged), and the final weight of the seeds were taken.

The values obtained from the emergence counts taken at 4, 5, 6, and 7 days after planting were used to obtain the Germination Percentage (G%), Germination Index (GI),and the Germination Rate Index(GRI) as described as follows (Fakorede and Agbana, 1983):

$$G\% = \frac{\text{(Number of seedlings emerged 7 DAP)}}{\text{Total number of seeds planted}} \times 100$$

$$GI = \frac{\sum (Nx)(DAP)}{\text{Seedlings emerged 7 DAP}}$$

Nx = number of seedlings that emerge on day x

$$GRI = \frac{\text{Germination index}}{\text{Germination percent / 100}}$$

Field Experiments

The fifteen maize hybrids were planted during the early and late cropping seasons of 2015 and 2017, respectively at the Teaching and Research Farm, OAU. The field experiments were laid out using 2-row plot in a randomized complete block design with 3 replications. Three seeds were planted per hole at a spacing of 50 cm within row and 75 cm between rows. The plants were thinned to two at three-leaf stage, giving a population of 53,333 plants/ha. Seeds were treated with Apron plus prior to planting against downy mildew disease. Pre-emergence herbicide was applied to the plot 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. A compound fertilizer, NPK 15:15:15 was applied at a rate of 60 kg N, 30 kg P_20_5 and 30 kg K_20/ha in two splits; first at three weeks after planting and finally at five weeks after planting.

The following data were collected on each plot, in each replicate and in all planting dates.

(i) Emergence percentage (E%): The total number of seedlings in a plot that emerged 5, 7, and 9 days after planting (DAP) were collected. The total number of seedlings in a plot on the 9th DAP was expressed as a percentage of seeds planted to obtain E%; that is:

$$E\,\% = \frac{\text{Seedling emerged 9 DAP}}{\text{Number of seeds planted}} \times 100$$

(ii) Flowering dates: Dates when 50% of the plants in a plot attained tasseling (TS), anthesis (AS) and incipient silk extrusion (SK) were recorded and expressed as DAP.

(iii) Plant and ear heights: The distance from the soil surface to the nodes bearing the flag leaf and the top ear were obtained for 5 random plants in a plot and their means were expressed as plant height (PHT) and ear height (EHT), respectively.

(iv) Yield components: Number (ENO) and weight (EWT) of ears harvested per plot were recorded. Ear length (EL), ear diameter (ED) and kernel row number (KRN) were estimated from 5 random ears in each plot (Oluwaranti *et al* 2008).

DATA ANALYSIS

Data collected were subjected to Analysis of Variance (ANOVA) using System Analysis Software (SAS) (SAS Institute 2003) and significant means were separated using LSD at 5% level of probability. The Spearman's correlation analysis was performed to assess the relationship that exists between the seed quality traits in the laboratory and agronomic traits in the field.

RESULTS

Means squares due to the type of hybrid type effects were significant at the 0.05 or 0.01 level of probability for germination percent, germination rate index, shoot length, abnormal seedlings, root number, shoot fresh weight, shoot dry weight, root fresh weight and conductivity of the seeds (Table 1). This showed that there were differences among the different types of hybrid as well as the varieties within the hybrid types for these traits.

The coefficients of determination (R^2) obtained from the model for most of the traits ranges from 47% to 98% except for Number of roots which is rather low. This is an indication of the reliability of the model. The coefficients of variability (CVs) were generally low for most of the traits ranging from 2.26 – 24.22 and rather high for number of abnormal seedlings which was observed to be 53.12 (Table 1).

Table 1: Mean squares from the analysis of variance for germination and seedling traits of the 15 maize hybrids evaluated at the Seed Science Laboratory Obafemi Awolowo University, Ile-Ife.

Traits	Rep. (df = 2)	HType (df = 2)	V(HType) (df = 12)	Error (df = 28)	Total (df = 44)	R^2	CV
G%	13.16	2933.96**	1649.20**	54.44	27124.98	0.95	9.57
GI	0.005	0.02	0.02**	0.008	0.55	0.57	2.26
GRI	2.49	48.67**	32.68**	2.03	551.32	0.89	21.85
SHLT	1.06	6.62**	12.13**	1.85	212.83	0.76	17.97
ABNS	2.42	5.76*	6.42**	1.78	143.24	0.65	53.12
RTN	0.15	0.66**	0.64**	0.15	13.57	0.15	13.57
PRLT	2.46	8.51	16.22	8.71	460.38	0.47	17.96
SFW	4.91	1.04	4.61**	1.93	121.12	0.55	24.22
SDW	0.02	0.03**	0.02**	0.003	0.38	0.79	13.92
RFW	0.18	6.41**	7.98**	1.64	154.93	0.70	15.09
RDW	0.09	1.09	0.92	0.16	17.94	0.75	19.64
COND	0.003	0.34**	0.64**	0.007	8.53	0.98	10.07

*, **: significant at 5% and 1% levels of probability.

Where,
G%: Germination Percentage**, GI:** Germination Index**, GRI:** Germination Rate Index, **SHLT**: shoot length, **ABNS**: abnormal seedlings, **RTN**: root number, **PRLT**: pry root length, **SDW**: shoot dry weight, **SFW**: shoot fresh weight, **RDW**: root dry weight, **RFW**: root fresh weight, **COND**.: conductivity **Rep.**: Replication, **HType:** Hybrid type**, V(HType):** Varieties within hybrid types, **df**: Degree of freedom, **R^2**: Coefficient of determination, **CV**: Coefficient of variation.

Single cross hybrids produced seedlings with the highest germination percentage, shoot length, and the lowest germination rate index, root numbers, shoot fresh weight and root dry weight (Table 2). Highest germination rate index, abnormal seedlings, shoot fresh weight, root dry weight and conductivity were obtained from the seedlings of three-way cross of maize hybrids. However, double cross hybrid produced seedlings with highest root number and lowest number of abnormal seedlings, shoot dry weight and conductivity (Table 2).

Table 2: Means of the three types of hybrids evaluated for germination and seedling traits at the Seed Science Laboratory of the Faculty of Agriculture, OAU Ile-Ife in 2017

HYBRIDS	G%	GRI	SHLT(cm)	ABNS	RTN	SDW(g)	SFW(g)	RDW(g)	COND(μS/cm/g
SINGLE	90.8	4.49	8.30	2.80	4.95	0.41	1.95	1.74	0.83
TH-WAY	64.3	7.94	7.44	2.93	5.14	0.41	5.80	2.23	0.97
DOUBLE	69.9	7.12	6.99	1.80	5.37	0.34	5.44	2.18	0.67
LSD $_{0.05}$	5.36	1.07	1.02	0.99	0.29	0.04	1.04	0.30	0.06

G%: germination percentage, **GRI**: germination rate index, **SHLT**: shoot length, **ABNS**: abnormal seedlings, **RTN**: root number, **SDW**: shoot dry weight, **SFW**: shoot fresh weight, **RDW**: root dry weight, **COND**: conductivity.

Among the single cross maize hybrids, variety hybrid 5 (TZEI60 x TZEI86) gave the highest germination percentage while hybrids 1 (TZEEI29 x TZEE21), 2 (TZEI11 x TZEI136) and 3 (TZEEI29 x TZEEI14) produced the lowest (Table 3). There were no significance differences in germination index and germination rate index among the hybrids within the single cross maize hybrids evaluated in this study (Table 3). Hybrids within the three-way hybrid-type showed that hybrid 8 ((TZEI157 x TZEI17) x TZEI16) and 9 ((TZEI59 x TZEI108) x TZEI63) had the highest germination percentage while hybrid 10 ((TZEEI21 x TZEEI14) x TZEE19) had the lowest germination percentage. Hybrid 7 ((TZEEI63 x TZEEI87) x TZEEI59) had the highest germination index (GI) while 6 (TZEEI29 x TZEEI49) x TZEE37 and 8 ((TZEI157 x TZEI17) x TZEI16) produced the lowest GI. The highest germination rate index (GRI) was obtained from hybrid 10 ((TZEEI21 x TZEEI14) x TZEE19) while hybrids 6 (TZEEI29 x TZEEI49) x TZEE37, 8 (TZEI157 x TZEI17) x TZEI16 and 9 ((TZEI59 x TZEI108) x TZEI63) had the lowest GRI (Table 3). Hybrid 14 (TZEI108 x TZEI63) x (TZEI59 x TZEI87) among the hybrids of the double cross maize had the highest germination percentage (G%) while hybrid 15 (TZEEI21 x TZEEI14) x (TZEEI129 x TZEEI49) had the least G%. There were no significant differences in the germination index among the hybrids within the double cross maize hybrids. Hybrid 15 (TZEEI21 x TZEEI14) x (TZEEI129 x TZEEI49) within the double maize hybrids gave the highest germination rate index (GRI) while hybrid 14 (TZEI108 x TZEI63) x (TZEI59 x TZEI87) had the least GRI (Table 3).

Table 3: Genotypic differences for Germination traits among the 15 maize hybrids evaluated at the Seed Science Laboratory of the Faculty of Agriculture OAU Ile-Ife in 2017

S/N	Hybrid	Hybrid Type	G%	GI	GRI
1	TZEEI29 x TZEE21	S	78.67	4.08	5.19
2	TZEI11 x TZEI136	S	85.33	4.01	4.72
3	TZEEI29 x TZEEI14	S	92.67	4.00	4.35
4	TZEI60 x TZEI15	S	97.3	4.06	4.18
5	TZEI60 x TZEI86	S	100	4.04	4.04
6	(TZEEI29 x TZEEI49) x TZEE37	THW	72.00	4.04	5.72
7	(TZEEI63 x TZEEI87) x TZEEI59	THW	42.67	4.35	10.40
8	(TZEI157 x TZEI17) x TZEI16	THW	89.33	4.04	4.55
9	(TZEI59 x TZEI108) x TZEI63	THW	88.00	4.07	4.65
10	(TZEEI21 x TZEEI14) x TZEE19	THW	29.33	4.08	14.39
11	(TZEEI29 x TZEEI37) x (TZEEI4 x TZEEI14)	D	43.33	4.15	9.27
12	(TZEI135 x TZEI57) x (TZEI17 x TZEI63)	D	86.00	4.04	4.70
13	(TZEEI95 x TZEEI63) x (TZEEI79 x TZEEI58)	D	85.33	4.06	4.81
14	(TZEI108 x TZEI63) x (TZEI59 x TZEI87)	D	100	4.03	4.03
15	(TZEEI21 x TZEEI14) x (TZEEI129 x TZEEI49)	D	34.67	4.06	12.36
	LSD $_{0.05}$		12.00	0.15	2.38

S- single cross, **THW**-Three way cross, **D**-double cross.
G%: germination percentage, **GI**: Germination index, **GRI:** germination rate index

Genotypes within the single cross maize hybrids indicated that TZEI11 x TZEI136, TZEEI29 x TZEE21 and TZEI60 x TZEI15 produced seedlings with the highest shoot length while TZEI60 x TZEI86 had seedlings with the lowest shoot length (Table 4). The highest number of abnormal seedlings (ABNS) were produced from TZEI11 x TZEI136 among the single cross maize hybrids while hybrid 3 TZEEI29 x TZEEI14 had the least number of ABNS. The highest root number (RTN) was obtained from hybrid 5 while hybrid 4 produced the least RTN among the single cross maize hybrids (Table 4). Hybrid 4 produced seedlings with the largest shoot fresh and dry weights (SFW, SDW) while hybrid 5 TZEI60 x TZEI86 had the least SFW and SDW. On the contrary, hybrid 5 TZEI60 x TZEI86 produced seedlings with the largest root fresh weight (RFW) while hybrid 1 had the least RFW among the single cross maize hybrids. The highest conductivity (COND) of the single cross maize hybrids was recorded for TZEEI29 x TZEEI14 and TZEI11 x TZEI136 while TZEI60 x TZEI86 gave the least COND among the single cross maize hybrids (Table 4). Hybrids within the three-way cross maize hybrids indicated that hybrid 9 (TZEI59 x TZEI108) x TZEI63 gave seedlings with the highest shoot length (SHTLT) while seedlings of hybrid 8 (TZEI157 x TZEI17) x TZEI16 had the least SHTLT. The largest number of ABNS was obtained in hybrid 8 (TZEI157 x TZEI17) x TZEI16 while hybrid 6 (TZEEI29 x TZEEI49) x TZEE37 had the least number of ABSN (Table 4). Hybrid 9 (TZEI59 x TZEI108) x TZEI63 produced the highest RTN while hybrid 8 (TZEI157 x TZEI17) x

TZEI16 had the least among the three-way cross maize hybrids. There were no significant differences in the shoot fresh weights and root fresh weights among the varieties within the three-way cross of maize hybrids evaluated in this study (Table 4). Hybrid 10 (TZEEI21 x TZEEI14) x TZEE19 within the three-way cross maize hybrids gave the largest shoot dry weight (SDW) while hybrid 6 (TZEEI29 x TZEEI49) x TZEE37 gave the least SDW (Table 4). Among the double cross maize hybrids evaluated in this study, (TZEI135 x TZEI57) x (TZEI17 x TZEI63) had the highest SHTLT while hybrid 14 (TZEI108 x TZEI63) x (TZEI59 x TZEI87) gave the least SHTLT (Table 4). Hybrid 10 (TZEEI21 x TZEEI14) x TZEE19 and 11(TZEEI21 x TZEEI14) x TZEE19 produced the highest number of ABSN while (TZEI108 x TZEI63) x (TZEI59 x TZEI87) produced no ABSN. The largest RTN was obtained in hybrid 12 (TZEI135 x TZEI57) x (TZEI17 x TZEI63) while hybrid 15 (TZEEI21 x TZEEI14) x (TZEEI129 x TZEEI49) produced the least RTN. The highest SHTFWT was obtained in hybrid 13 (TZEEI95 x TZEEI63) x (TZEEI79 x TZEEI58) while hybrid 14 (TZEI108 x TZEI63) x (TZEI59 x TZEI87) produced the least. Hybrid (TZEEI21 x TZEEI14) x (TZEEI129 x TZEEI49) gave seedlings with the highest SDW while (TZEI135 x TZEI57) x (TZEI17 x TZEI63), (TZEEI95 x TZEEI63) x (TZEEI79 x TZEEI58) and (TZEI108 x TZEI63) x (TZEI59 x TZEI87) produced seedlings with least SDW. Whereas, hybrid 12 (TZEI135 x TZEI57) x (TZEI17 x TZEI63) produced seedlings with highest RFWT while hybrid 11 (TZEEI29 x TZEEI37) x (TZEEI4 x TZEEI14) gave the least SDW. However, hybrid 11(TZEEI29 x TZEEI37) x (TZEEI4 x TZEEI14) had the highest COND while hybrid 14 (TZEI108 x TZEI63) x (TZEI59 x TZEI87) gave the least COND (Table 4). In the Analysis of Variance (ANOVA) combined for the two seasons, significant or highly significant mean squares were obtained for seasonal effect on emergence percent, days to tasseling, anthesis and silking, Anthesis Silking Interval (ASI), Plant and ear heights, ear number and weight, grain moisture content, ear diameter and length, kernel row number, shelling percentage and grain yield (Table 5). Hybrid type and varieties within hybrid type effects were also observed for Emergence percentage, ear diameter, ear height, ear number and weight, shelling percentage and grain yield at 0.05 and 0.01 levels of probability (Table 5).

Season x Hybrid type interaction mean squares was significant only for ear height, ear length and shelling percent (Table 5). Replication effect was significant (P=0.05) for only ear number (Table 5). CV ranged from 3.84 for flowering traits to 37.60 for grain yield while the R^2 was about 33% for days to tasseling and 74% for Plant height (Table 5)

Among the single cross maize hybrids, hybrid 1 TZEEI29 x TZEE21 had the highest E% while hybrid 4 TZEI60 x TZEI15 gave the least E% (Table 6). The ear height (EHT) of hybrid 4, TZEI60 x TZEI15 was the highest while variety 2 TZEI11 x TZEI136 gave the least EHT. Largest ear number was obtained from hybrid 1 TZEEI29 x TZEE21 while hybrid 5 TZEI60 x TZEI86 produced the least number of ears among the single cross maize hybrids evaluated in this study.

Table 4: Hybrid differences for seedling traits among 15 maize hybrids evaluated at the Seed Science Laboratory of the Faculty of Agriculture OAU Ile-Ife in 2017

S/N	Hybrid	Hybrid Type	SHTLT (cm)	ABNS	RTN	SFW (g)	SDW (g)	RFWT (g)	COND (μS/cm/g)
1	TZEEI29 x TZEE21	S	10.08	1.00	4.53	5.86	0.29	5.43	0.57
2	TZEI11 x TZEI136	S	10.29	4.00	5.50	6.60	0.42	9.94	1.33
3	TZEEI29 x TZEEI14	S	7.84	2.00	4.60	6.59	0.46	7.03	1.34
4	TZEI60 x TZEI15	S	8.89	3.67	4.47	7.10	0.52	5.65	0.59
5	TZEI60 x TZEI86	S	4.40	3.33	5.63	3.61	0.36	10.70	0.35
6	(TZEEI29 x TZEEI49) x TZEE37	THW	7.82	1.00	5.27	6.45	0.33	8.24	0.42
7	(TZEEI63 x TZEEI87) x TZEEI59	THW	7.04	3.00	5.5	5.09	0.34	7.75	1.32
8	(TZEI157 x TZEI17) x TZEI16	THW	5.62	6.00	4.54	5.24	0.50	9.61	1.33
9	(TZEI59 x TZEI108) x TZEI63	THW	9.78	2.67	5.57	5.73	0.40	9.79	1.32
10	(TZEEI21 x TZEEI14) x TZEE19	THW	6.94	2.00	4.87	6.48	0.52	9.53	0.45
11	(TZEEI29 x TZEEI37) x (TZEEI4 x TZEEI14)	D	8.31	2.67	5.57	5.19	0.33	7.00	1.37
12	(TZEI135 x TZEI57) x (TZEI17 x TZEI63)	D	9.73	2.67	5.77	7.02	0.30	9.98	0.54
13	(TZEEI95 x TZEEI63) x (TZEEI79 x TZEEI58)	D	5.42	1.33	5.13	6.77	0.31	8.71	0.50
14	(TZEI108 x TZEI63) x (TZEI59 x TZEI87)	D	4.89	0.00	5.43	3.33	0.31	9.10	0.25
15	(TZEEI21 x TZEEI14) x (TZEEI129 x TZEEI49)	D	6.62	2.33	4.93	4.88	0.42	8.92	0.67
	LSD $_{0.05}$		2.28	2.23	0.65	2.32	0.09	2.14	0.14

SHLT: shoot length, **ABNS**: abnormal seedlings, **RTN**: root number, **SFW**: shoot fresh weight, **SDW**: shoot dry weight, **RFW**: root fresh weight, **COND**.: conductivity

There are no significant differences for ear weight and grain yield among the hybrids within the single cross hybrids (Table 6). The largest ear weight and yield were obtained in hybrid 8 (TZEI157 x TZEI17) x TZEI16 among the three-way maize hybrids while hybrid 9 (TZEI59 x TZEI108) x TZEI63 had the least ear weight and yield (Table 4). Highest E% was obtained in hybrid 14 (TZEI108 x TZEI63) x (TZEI59 x TZEI87) while hybrid 15 (TZEEI21 x TZEEI14) x (TZEEI129 x TZEEI49) produced the least E% among the double cross maize hybrids (Table 4). Hybrid 12 (TZEI135 x TZEI57) x (TZEI17 x TZEI63) produced plants with the highest ear height (EHT) while hybrid 11 (TZEEI29 x TZEEI37) x (TZEEI4 x TZEEI14) gave the lowest EHT. There are no significant differences among the hybrids within the double cross maize hybrids for ear number. Hybrid 12 (TZEI135 x TZEI57) x (TZEI17 x TZEI63) produced the largest ear weight (EWT) while hybrid 13 (TZEEI95 x TZEEI63) x (TZEEI79 x TZEEI58) gave the smallest EWT. The highest yield was obtained from hybrid 12 (TZEI135 x TZEI57) x (TZEI17 x TZEI63) while hybrid 13 (TZEEI95 x TZEEI63) x (TZEEI79 x TZEEI58) gave the least yield among the double cross maize hybrids evaluated in this study (Table 6).

Table 5: Mean squares from the Analysis of Variance for emergence, flowering, vegetative yield and yield components traits of the 15 maize hybrids evaluated at OAU Teaching and Research Farm Ile Ife during the late cropping season of 2017

Traits	Season (df=1)	Rep(Season) (df=4)	HType (df=2)	Var(HType) (df=12)	Season x Type (df=2)	Season x Var(Type) (df = 12)	Error (df=56)	Total (df=89)	R^2	CV
E%	8699.52**	121.47	721.25**	532.27**	10.51	84.05	161.72	305.76	0.66	15.24
TS	12.10	2.36	4.98	5.82	6.53	8.94	8.18	7.64	0.33	5.38
ANTH	115.60**	8.43	7.43	4.53	9.23	7.86	4.47	6.53	0.57	3.84
SK	332.54**	13.18	4.84	1.49	8.04	8.74	7.30	10.59	0.57	4.70
ASI	56.01**	2.44	2.34	3.62	1.48	2.10	3.44	3.76	0.42	83.94
EHT	4101.98**	97.22	52.02	204.52**	260.95*	72.88	66.56	136.77	0.69	15.06
PHT	19149.38**	156.73	112.71	221.47	180.87	161.92	155.77	378.51	0.74	10.14
ENO	883.60**	123.83*	5.43	85.93*	28.43	56.21	43.18	62.59	0.57	24.83
EWT	27.61**	0.25	0.14	0.71*	0.31	0.44	0.33	0.67	0.72	36.74
MC	761.99**	18.88	32.56	41.91	8.37	27.01	24.71	35.17	0.56	30.96
ED	2.52**	0.07	0.30*	0.28**	0.07	0.03	0.08	0.13	0.63	7.94
EL	13.00*	1.11	0.45	3.63	7.68*	3.22	2.06	2.60	0.50	12.68
KRN	6.08**	0.26	1.04	0.88	0.96	0.90	0.53	0.71	0.52	5.90
SH%	954.87**	129.90	37.89	401.90**	992.33**	72.56	150.94	198.67	0.52	15.84
YLD	145.71**	1.08	0.44	3.31*	1.02	1.78	1.41	3.29	0.73	37.60

*, ** Significant at 0.05 and 0.01 levels of probability, respectively, Where,
E%= Emergence percentage, **TS**= Days to 50% tasseling, **ANTH**= Days to 50% anthesis, **SK**= Days to 50% silking, **ASI**= Anthesis silking interval, **PHT**= Plant height, **EHT**= Ear height, **ENO**= Ear number, **EWT**= Ear weight, **MC**= Moisture content, **EL**=Ear length, **ED**=Ear diameter, **KRN**= Kernel row number, **SH%**= Shelling percentage, **YLD**= Yield,

Table 6: Hybrid mean differences for emergence, ear height, ear number and weight and yield of fifteen maize hybrids evaluated during the early and late cropping season of 2015 and 2017 respectively at the Teaching and Research Farm, OAU, Ile-Ife.

S/N	Hybrid	Hybrid Type	E%	EHT (cm)	ENO	EWT (Kg)	YLD (tons/ha)
1	TZEEI29 x TZEE21	S	87.88	50.67	33.33	1.49	3.29
2	TZEI11 x TZEI136	S	75.76	49.03	24.17	1.30	2.67
3	TZEEI29 x TZEEI14	S	83.33	54.43	32.17	1.87	4.04
4	TZEI60 x TZEI15	S	66.16	59.20	21.83	1.50	3.11
5	TZEI60 x TZEI86	S	82.83	53.83	19.00	1.58	3.14
6	(TZEEI29 x TZEEI49) x TZEE37	THW	86.62	49.47	27.50	1.28	2.75
7	(TZEEI63 x TZEEI87) x TZEEI59	THW	90.66	56.43	30.67	1.56	3.29
8	(TZEI157 x TZEI17) x TZEI16	THW	95.96	57.13	28.00	1.92	4.16
9	(TZEI59 x TZEI108) x TZEI63	THW	84.34	50.00	22.83	1.19	2.50
10	(TZEEI21 x TZEEI14) x TZEE19	THW	87.37	53.80	25.67	1.54	3.35
11	(TZEEI29 x TZEEI37) x (TZEEI4 x TZEEI14)	D	82.33	50.97	26.83	1.42	3.00
12	(TZEI135 x TZEI57) x (TZEI17 x TZEI63)	D	78.54	65.27	30.17	2.00	4.37
13	(TZEEI95 x TZEEI63) x (TZEEI79 x TZEEI58)	D	89.65	54.57	23.67	1.08	2.26
14	(TZEI108 x TZEI63) x (TZEI59 x TZEI87)	D	92.93	54.87	25.83	1.27	2.66
15	(TZEEI21 x TZEEI14) x (TZEEI129 x TZEEI49)	D	74.75	52.73	25.33	1.30	2.84
	LSD $_{0.05}$		15.69	9.85	7.80	0.67	1.42

There are no significant differences in ear height (EHT) among the single, three-way and double cross hybrids during the early cropping season of this study (Table 7). However, in the late cropping season, double cross maize hybrids produced the highest EHT. Highest ear length was obtained from the three-way hybrids in the early cropping season while in the late season, there are no significant differences for ear length among the three types of hybrids evaluated in this study (Table 7).

Table 7: Hybrid types means of maize hybrids evaluated for ear height and length during the early and late cropping season of 2015 and 2017 respectively at the Teaching and research farm, OAU, Ile-Ife

	Ear Height (cm)		Ear Length (cm)	
Types of Hybrid	**Early Season**	**Late Season**	**Early Season**	**Late Season**
Single	62.92	43.95	11.06	11.46
Three-way	60.51	46.23	12.19	10.73
Double	59.31	52.05	11.85	10.61
$LSD_{0.05}$	7.69	4.36	0.99	1.20

Spearman's correlations among the seed quality and agronomic traits of maize hybrids evaluated during the early and late cropping seasons of 2015 and 2017 are presented in Tables 8 and 9 respectively. Ear height was observed to be positively and negatively correlated with germination percentage and germination rate index respectively across the 15 hybrids evaluated in the early season of this study (Table 8) while in the late season of this study, across the 15 hybrids. ear height had negative correlations with shoot dry weight and root fresh weight (Table 9).

Table 8: Spearman's correlation among the seed quality traits and the ear height, ear number, ear weight and yield of the 15 maize hybrids evaluated at the Seed Science Laboratory of the Faculty of Agriculture and the Teaching and Research Farm, OAU, Ile-Ife during the early cropping season of 2015.

	G%	GI	GRI	SHTLT (cm)	NROOTS	SHTFWT (g)	SHTDWT (g)	RTFWT (g)	COND (μS/cm/g)
EHT	0.53*	-0.18	-0.53*	0.01	0.02	0.13	0.18	0.39	-0.25
ENO	-0.30	-0.12	0.29	0.04	-0.41	0.23	0.03	-0.20	0.23
EWT	0.17	-0.19	-0.17	0.07	-0.16	0.18	0.34	0.15	0.11
YLD	0.13	-0.15	-0.13	0.02	-0.17	0.15	0.35	0.15	0.09

Table 9: Spearman's correlation among the seed quality traits and the ear height, ear number, ear weight and yield of the 15 maize hybrids evaluated at the Seed Science Laboratory of the Faculty of Agriculture and the Teaching and Research Farm, OAU, Ile-Ife during the late cropping season of 2017.

	G%	GI	GRI	SHTLT (cm)	NROOTS	SHTFWT (g)	SHTDWT (g)	RTFWT (g)	COND (μS/cm/g)
EHT	-0.13	-0.28	0.08	0.19	-0.40	0.41	0.18	-0.31	0.43
ENO	-0.68**	0.11	0.66**	0.41	-0.09	0.14	-0.38	-0.47	0.10
EWT	-0.24	-0.06	0.25	0.08	0.01	-0.01	-0.17	-0.20	0.07
YLD	-0.32	-0.05	0.31	0.13	-0.08	-0.01	-0.22	-0.30	0.09

DISCUSSION

Double cross hybrid had a better vigour potential from the vigour traits observed, hence, possess a better ability to develop and survive even under stress conditions. Although, single cross hybrids had the highest germination potential, this eventually decreased as the vigor decreases as supported by the findings of Delouche (2017). Hence single cross has a lower tendency to survive after germination under stress conditions as the germinated seeds will be weak and low yielding (Olisa *et al.*, 2010). These differences observed in the seed quality traits of the hybrid type established the fact that there are variations due to genetic composition in the hybrids.

The varieties within the hybrid types showing a highly significant difference in their germination percentage, total number of days to complete germination and the speed of germination. These significant differences in germination parameters appears to be highly dependent on genotype as also observed by Soyelu *et al*., (2001) and less responsive to other factors because it is usually carried out under ideal conditions. This has been a consistent observation in all previous studies aimed at partitioning variations in maize seed germination and seedling vigor (Ajayi and Fakorede, 2000). Differences in seedling growth rate and vigour index among genotypes have been reported to be dependent on reserve food material and its efficient utilization during germination by maize genotypes (Styer *et al.*, 1983). The no significant variation of the maize hybrids for most of the field traits evaluated implies that all the hybrids tested are not different for the emergence and flowering traits. It is expected because the hybrids are of the early and extra-early maturity groups. The significant difference of the maize hybrids for only ear height and length implies that only these two traits contributed most to the variation observed within the 15 hybrids of maize evaluated in this study. The significant difference in hybrids within types of maize hybrids for mergence percentage, ear height, ear number and weight, ear diameter, shelling percentage and grain yield implies that these traits contributed most to variation among varieties within the types of maize hybrids in this study.

Positive correlation observed between ear height and germination percentage during the early season of this study implies that increased germination increases ear height while negative correlation between the ear height and germination rate index implies that the lower the rate of germination the higher the ear height of the 15 maize hybrids evaluated during the early season of this study. High ear height had been reported to have a positive influence on grain yield (Oluwaranti *et al.*, (2008). This positive relationship between the ear height and grain yield was also observed in the findings of (Andrade *et al*. (1999); Xiao *et al.* (2005) and Gemenet *et al.* (2010) which reported that ear height, and plant height directly influence the grain yield.

CONCLUSION

In conclusion, single cross hybrid had the best viability traits while the three-way cross hybrids had the least. However, the double cross hybrids are more vigorous than the single and three way cross hybrids. The double cross maize hybrids performed better than the other conventional maize hybrids on the field having the highest ear height compared to the single and three-way maize hybrids in this study. A significant positive relationship was observed between the germination percentage of the maize hybrids and the ear height during the early cropping season of this study.

REFERENCES

Andrade F. H., C. Vega, S. Uhart, A. Cirilo, M. Cantarero, and O. Valentinuz (1999). Kernel number determination in maize. *Crop Science* 39:453-459. http://dx.doi.org/10.2135/cropsci1999. 0011183X00390 00200026x

Ajayi, S. A., and M. A. B. Fakorede. (2000) Physiological maturity effects on seed quality, seedling vigor, and mature plant characteristics of maize in a tropical environment. *Seed Sci & Tech 28:310–19.*

Ajayi S.A. (2007) Current trends in seed science: implication for sub-Saharan Africa. *African Crop Science Conference Proceedings* 8:79-85

Delouche, J.C. (2017) Seed quality is not always the problem. Seed News: The international seed magazine.[Online] Available*:* *http://www.seednews.inf.br*. [Retrieved: November 2017]

Fakorede M.A.B and S.B. Agbana (1983) Heterotic effects and association of seedling vigour with mature characteristics and grain yield in some tropical maize cultivars. *Maydica* 28:327338.

Gemenet D. C., F. N. Wachira, R. S. Pathak and S. W. Munyiri (2010) Identification of molecular markers linked to drought tolerance using bulked segregant analysis in Kenyan maize (Zea mays L.) landraces. *Journal of Animal and Plant Sciences* 9(1), 1122- 1134

MacRobert J.F., P.S. Setimela, J. Gethi, and M. Worku. (2014) Maize Hybrid Seed Production Manual. Mexico, D.F.: CIMMYT. *https//repository cimmyt.org/* 26 pages

Mohammad S. A. N. (2017) Hybrid Seed Production Technology of Maize. [Online] Available *https//www.slideshare.net safarnoon/hybrid production technology of maize* [Retrieved: December 2017]

Moterle L.M., A.L. Braccini, C.A. Scapim, R.J.B. Pinto, L.S.A. Gonçalves, A.T. do Amaral Júnior and T.R.C. Silva (2011) Combining ability of tropical maize lines for seed quality and agronomic traits. *Genet Mol Res.* 10(3):2268-2278. doi:10.4238/vol10-3gmr1129.

Munamava M. R., A. S. Goggi and L. Pollak (2004) Seed quality of maize inbred lines with different composition and genetic backgrounds. *Crop Sci.* 44: 542-548.

Olisa B. S. , S. A. Ajayi and S. R. Akande (2010) Physiological Quality of Seeds of Promising African Yam Bean (*Sphenostylis stenocarpa*) and Pigeon pea (Cajanus cajan L. Mill sp.) Landraces. Res. *J. Seed Sci.* 3(2): 93-101.

Oluwaranti A., M. A. B. Fakorede and B. Badu-Apraku (2008) Grain yield of maize of different maturity groups under marginal rainfall conditions.

Journal of Agricultural Sciences 53(3):183 - 191

Paul K. C. (2016) A revolution Down on the Farm. The transformation of American Agriculture since 1929. [Online] Available:*https//www.Kentuckypress.com 240 pgs [Retrieved: August 2016]*

Pegah M. D., S. Farzad and J. Mohsen (2008) Influence of priming techniques on seed germination behavior of maize inbred lines (*Zea mays* L). *Journal of Agricultural and Biological Science* 3(3):22-25

Rajesh S., L. Ram and R.P. Srivastava (2012) A Journey of Hybrids in Maize: An Overview. *India Research Journal of Extension Education* 1(1):340-344

SAS Institute (2003). SAS/STAT User'guide. Version 9.1 SAS Institute, Inc. Cary NC USA

Soyelu, L. O., S. A. Ajayi, O. B. Aluko, and M. A. B. Fakorede (2001) Varietal differences for development of maize (*Zea mays* L.) seedlings on compacted soils *J Agron & Crop Sci* 186:157–66

Styer, R.C. and D. J. Cantliffe (1983) Changes in seed structure and composition during development and their effects on leakage in two endosperm mutants of sweet corn. *Journal of the American Society for Horticultural Science*,108:721-728

Xiao Y. N., X. H. Li, M. L. George, M. S. Li, S. H. Zhang, and Y. L Zheng (2005) Quantitative Trait Locus Analysis of Drought Tolerance and Yield in Maize in China. *Plant Molecular Biology* 23: 155-165. http://dx.doi.org/10.1007/BF02772706