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Genetic Variability in Physiological Seed Quality of Maize Genotypes of Different Maturity Groups

J. O. Olasoji[1*] and D. J. Ogunniyan[1]

[1]*Institute of Agricultural Research and Training, Obafemi Awolowo University, P.M.B. 5029, Moor Plantation, Ibadan, Oyo State, Nigeria.*

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

A study was conducted to investigate genetic variability in physiological seed quality using viability and vigour tests which were conducted at the seed testing laboratory of Institute of Agricultural Research and Training (IAR&T), Moor Plantation, Ibadan. The investigational materials consisted of twelve genotypes of maize of different maturity-early, intermediate and late collected from the International Institute of Tropical Agriculture (IITA), Ibadan and IAR&T, Moor Plantation, Ibadan, respectively. The experimental design used was completely randomize design (CRD) and data was collected for some viability and vigour traits and the data collected were subjected to analysis of variance. Significant differences were found among all the maize genotypes for the characters under observation. Hundred seed weight ranged from 24.6-29.3 g, 18.5-26.6 g, 22.9-29.1 g, standard germination ranged from 54.0-100.0%, 16.0-92.0%, 50.0-100% and accelerate ageing germination also ranged from 6.0-96.0%, 7.0-84.0%, 0-90.0% in the early, intermediate and late-maturing genotypes, respectively. Conductivity ranged from 5.34-17.10 µS/cm/g, 13.7-91.7 µS/cm/g and7.06-33.6 µS/cm/g with mean values of 11.14, 39.23 and 14.05 µS/cm/g in the early, intermediate and late-maturing genotypes, respectively. Variability was smaller in the late-maturing genotypes for Root Number (RN) and Shoot Length (SLT) but higher for both early and late-maturing genotypes. It was concluded from this study that seeds of early-maturing genotypes had

**Corresponding author: E-mail: joolasoji@iart.gov.ng;*

significantly higher physical and physiological quality parameters. All the early materials used for the study tend to be homogenous for all the traits measured and selection should be practiced for hundred seed weight to increase yield potential in maize varieties.

Keywords: Genetic variability; viability; vigour; homogenous; ageing.

1. INTRODUCTION

Maize is among the most significant dietary crop worldwide. Millions of people in the developing world derive their protein and calorie requirement from it [1]. In addition to providing raw product to animal feed, it also contribute a substantial quantity of raw product to several industries, hence gains an important position in global economy and trade [2].

Seed is a critical and the most important external input in the production of field crops because it is the only living input with quantifiable response to levels of other inputs [3]. Quality of seeds is an important consideration in crop production because it influences field emergence, seedling establishment and subsequent performance of the resultant adult plant [4]. Seeds are a plants way of moving through time and space, and securing the next generation of individuals in annual species [5]. The planting of seed in the soil also represent the starting point for the vast majority of world agriculture. Rapid and uniform crop establishment is a key determinant of crop yield [6], making understanding the variability within seeds a vital component of the global seed industry and ensuring crop security. The seeds quality is the sum of genetic, physical, physiologic and sanitary attributes that affect the seed capacity to perform vital functions, being related to germination, vigour and longevity [7]. It encompasses physical, biological, pathological, and genetic attributes that contributes to plant performance and the final yield of a crop in the farmer's field [8].

Physiological quality of seed is based on the genotype, and may be accompanied from the first stages of selection, obtained with tests of viability and vigour during the genetic improvement process [9]. Despite the obvious effect of the environment on the seeds quality, the maximum quality potential, such as seedling germination, emergence and vigour, is genetically controlled [10] and may be handled exploring the genetic variance of a species or lineages in the crossbreeding process [11]. Mertz et al. [12] state that the physiological quality characteristics of soy seeds are genetically inherited from its parental, thus, different varieties of one species may present variation of vigour, germination and field emergence.

The seeds quality may be verified in advance, based on the genetic difference between the parental, which may be foreseen based on agronomic, morphologic, nutritional quality, physiologic and molecular characteristics. The dissimilarity among such characteristics is measured by multivariate analysis techniques, which enables to express the genetic diversity degree between the parental analyzed [13].

Genetic variability in maize genotypes plays a vital role in grain yield variation [14]. Significant variation found in the germplasm of maize for ear height, ear length, plant height, 100-grain weight and ear girth [15]. Maize production could be increase through development of improved genotypes capable of producing enhanced yield under different agro climatic conditions. The contribution of genetic attributes to the seeds quality requires further studies. The objective of the present study was therefore, designed to compare the genetic variability in physiological seed potential of different maize genotypes.

2. MATERIALS AND METHODS

2.1 Seed Quality Assessment

The quality of seeds of 12 selected quality protein maize (QPM) genotypes (4 early, 4 intermediate and 4 late-maturing genotypes) stored for two years was assessed in the seed testing laboratory of the Institute of Agricultural Research and Training, Moor Plantation, Ibadan in year 2014 to 2015. The seeds were subjected to three quality tests namely standard germination, electrical conductivity and accelerated ageing using completely randomize design (CRD).

2.2 Standard Germination

Standard germination test was carried out in three replications of 50 seeds per replicate. Plastic germination bowls were filled with moistened sand and seeds were evenly spaced on the sand, with the germinal side facing down, and thereafter thinly covered with moistened sand and lightly pressed for a good seed-substratum contact. The bowls were covered with nylon sheets to conserve moisture and kept at ambient room temperature. Germination counts were made daily from the 4^{th} to 7^{th} day after planting. On the 7^{th} day, seedling analysis was carried out and the numbers of normal and abnormal seedlings were recorded. Germination was interpreted as the percentage of seeds producing normal seedlings [16]. After seedling analysis, ten (10) normal seedlings were selected for the determination of seedling vigour traits.

2.3 Electrical Conductivity

Fifty clean and intact seeds in three replicates were counted, weighed, and placed in a glass flask containing 100 ml of distilled water. The flasks were covered with aluminum foil to prevent contamination and the flasks were gently shaken intermittently. Conductivity measurements were taken after 24 hrs at 25°C reference temperature using Mettler Toledo MC126 conductivity meter. All measurements were expressed as $\mu Scm^{-1}g^{-1}$ and the results were interpreted, as suggested by Hampton and TeKrony [17].

Conductivity/gram of seed (µS/cm/g) = (conductivity (µ) of each flask-conductivity of water)/ Initial weight of seed sample

2.4 Accelerated Ageing

Ageing of seeds were done by weighing fifty seeds from each sub-sample in three replicates. Thereafter, the seeds were placed on a wire mesh suspended over water inside accelerated ageing boxes and then placed in an ageing chamber for 72 h at a temperature of 43°C. The seeds were re-weighed after ageing to determine the amount of moisture gained during the ageing process. After the ageing period, the seeds were subjected to standard germination test as described above and the germination count on the 5^{th} and 7^{th} day after planting. The results were expressed in percentage as done for standard germination. Accelerated ageing index (AAI) was calculated from the accelerated ageing germination data.

Data collected were subjected to analysis of variance (ANOVA) separately for each maturity group and combined across maturity groups for the two years using general linear model procedures in statistical analysis system, SAS software version 9.2. [18] to compute mean squares for each character. Mean separation was done using Duncan Multiple Range Test (DMRT). Descriptive statistics was also carried outtocomputemean,standarddeviationandrange.

3. RESULTS AND DISCUSSION

The variability in seed quality traits did not follow a definite trend across the maturity groups (Table 1). The variability as measured by the standard deviation (SD) was smaller in the early- maturing genotypes compared to intermediate and late-maturing genotypes. Hundred seed weight (HSW) ranged from 24.6-29.3 g, 18.5-26.6 g, 22.9-29.1 g, standard germination ranged from 54.0-100.0%, 16.0-92.0%, 50.0-100% and accelerated ageing germination also ranged from 6.0-96.0%, 7.0-84.0%, 0-90.0% in the early, intermediate and late-maturing genotypes, respectively. Seed weight as an index of seed quality was high in the early genotype and this contributed greatly to the quality of early-maturing genotypes. Considering the value of 68.55% which was an average for 4 genotypes that make up the early-maturating group is close to 70%, the basic standard for high quality seed lots as proposed by Woltz [19]. Conductivity ranged from 5.34-17.10 µS/cm/g, 13.7-91.7 µS/cm/g and7.06-33.6 µS/cm/g with mean values of 11.14, 39.23 and 14.05 µS/cm/g in the early, intermediate and late-maturing genotypes, respectively. Variability was smaller in the late-maturing genotypes for root number (RN) and shoot length (SLT) but higher for both early and intermediate-maturing genotypes. This genetic variability corroborates the findings of [20]. The authors reported genetic variability in seedling traits of some selected African yam beans *Sphenostylis stenocarpa* Hochst. Ex A. Rich Harm) seeds. Lower viability recorded in intermediate-maturing genotypes is in agreement with the findings of Mahesha et al. [21] who reported that varieties differed significantly on germination percentage. The poor viability in intermediate materials could be as a result of damages done to the seed lots during processing because the materials were from two different sources. Differences in vigour were reflected among maturity groups with respect to seed longevity. The result corroborate the findings that high vigour seed lots show poor storage potential and may show a rapid decline in germination [22] Mean values and variability in physiological quality of seeds of four early-maturing genotypes is presented in Table 2. TZE-YPOPDT had the highest mean values for both

Table1. Indices of variability in physiological seed quality and seedling vigor of maize seed of different maturity groups

Traits	Early maturing			Intermediate maturing			Late maturing		
	Mean	**Range**	**SD**	**Mean**	**Range**	**SD**	**Mean**	**Range**	**SD**
Seed Vigour									
HSW(g)	26.95a	24.6-29.3	1.31	23.20c	18.5-26.6	1.92	25.80b	22'9-29.1	1.82
SG (%)	85.92a	54.0-100	12.52	54.19b	16.0-92.0	21.34	83.00a	50.0-100.	14.16
SGI(DAS)	3.34a	2.03-4.39	0.65	3.57b	2.21-5.00	0.68	3.52b	2.84-4.32	0.46
AAG (%)	68.56a	6.0-96.0	25.93	37.85c	7.00-84.0	17.21	49.58b	0-92.00	28.31
AAGI(DAS)	4.33b	4.0-5.33	0.42	4.85a	4.00-6.44	0.78	4.35b	0-6.17	0.95
COND	11.14c	5.34-17.1	3.16	39.23a	13.7-91.7	22.40	14.05b	7.06-33.6	5.29
Seedling Vigour									
RN	4.58a	2.40-6.67	1.04	3.52c	1.00-5.33	1.09	3.96b	2.00-5.00	0.85
RL(cm)	15.41a	9.60-22.5	2.72	12.67b	1.30-17.80	4.59	15.24a	7.70-20.80	2.99
SL(cm)	9.87a	7.3-16.5	1.57	8.39c	7.30-16.50	1.25	8.89b	7.17-10.70	0.89
RDW(g)	0.04a	0.01-0.07	0.01	0.03b	0.01-0.08	0.01	0.04a	0.03-0.06	0.01
SDW(g)	0.06a	0.03-0.08	0.02	0.05c	0.03-0.07	0.01	0.05b	0.04-0.07	0.01
SDL(cm)	25.28a	19.1-34.3	2.74	21.05b	18.46-26.6	1.92	24.13a	17.3-31.5	3.21
SVI	2.19a	1.07-3.43	0.46	1.16c	0.12-2.43	0.60	2.05a	0.95-3.09	0.54

Means with the same letter in each row are not significantly different at $P<0.05$ using Duncan's Multiple Range Test.
HSW=Hundred Seed Weight; SG=Standard Germination: SGI= Standard Germination Index; AAG=Accelerated ageing germination percentage; AAGI= Accelerated ageing germination index; DAS= Days after sowing; COND=Conductivity (μS/cm/g); RN= Root Number; RTL=Root Length; SLT=Shoot Length; RDW= Root Dry Weight; SDW= Shoot Dry Weight;SDL=Seedling Length; SVI=Seedling Vigour Index; SD= Standard Deviation (±)

Table 2. Mean values and variability in physiological quality of seeds of four early maturing maize genotypes

Traits	EVDT-W99			DMR-ESR-W			TZE-YPOPDT			POOL-18SR		
	Mean	**Range**	**SD**	**Mean**	**Range**	**SD**	**Mean**	**Range**	**SD**	**Mean**	**Range**	**SD**
Seed Vigour												
HSW(g)	25.94b	24.6-26.9	0.71	25.69b	24.8-26.4	0.59	27.89a	27.1-28.4	0.44	28.28a	27.26-29.31	0.70
SG (%)	88.67a	56.0-98.0	15.03	80.44b	70.0-96.0	8.35	95.89a	86.0-100.	4.31	78.89b	54.0-100.0	12.73
SGI(DAS)	3.24b	2.03-4.10	0.68	3.41a	2.58-4.39	0.67	3.44a	3.00-4.17	0.51	3.26b	2.29-4.33	0.80
AAG (%)	81.89a	54.0-92.0	13.14	47.22c	7.0-88.0	32.38	83.11a	60.0-96.0	11.88	62.00b	6.0-86.0	24.04
AAGI(DAS)	4.20a	4.0-4.9	0.31	4.52b	4.0-5.3	0.56	4.28b	4.00-4.88	0.39	4.31b	4.00-4.89	0.37
COND	7.77b	5.34-11.90	2.28	12.19a	7.75-17.10	2.99	12.97a	9.68-16.20	2.40	11.61a	8.43-15.90	2.39
Seedling Vigour												
RN	4.84a	3.40-5.80	0.72	4.53ab	2.40-5.60	1.00	4.16a	2.60-5.40	0.91	4.81a	2.80-6.67	1.43
RLT (cm)	14.10a	9.60-17.63	2.82	15.66a	11.2-19.2	2.49	16.66a	11.6-22.5	2.70	15.23a	10.1-18.5	2.70
SLT (cm)	10.40a	8.9-12.2	1.13	8.85b	7.3-10.1	0.87	9.70ab	8.8-11.8	0.94	10.51a	8.0-16.5	2.43
RDW (g)	0.04a	0.02-0.05	0.01	0.03a	0.01-0.05	0.01	0.05a	0.02-0.06	0.01	0.05a	0.03-0.07	0.01
SDW(g)	0.07a	0.05-0.09	0.01	0.05b	0.03-0.08	0.02	0.06	0.04-0.07	0.01	0.06a	0.04-0.09	0.02
SDL(cm)	24.49b	19.1-26.9	2.70	24.5b	19.8-28.5	2.95	26.36a	22.4-34.3	3.32	25.74a	23.0-28.9	1.68
SVI	2.20b	1.07-2.64	0.53	1-98b	1.50-2.74	0.36	2.53a	2.10-3.43	0.40	2.03b	1.44-2.89	0.40

Means with the same letter in each row are not significantly different at P<0.05 using Duncan's Multiple Range Test.
HSW=Hundred Seed Weight; SG=Standard Germination: SGI= Standard Germination Index; AAG=Accelerated ageing germination percentage; AAGI= Accelerated ageing germination index; DAS= Days after sowing; COND=Conductivity (µS/cm/g); RN= Root Number; RTL=Root Length; SLT=Shoot Length; RDW= Root Dry Weight; SDW= Shoot Dry Weight; SDL=Seedling Length; SVI=Seedling Vigour Index; SD= Standard Deviation (±)

Table 3. Mean values and variability in physiological quality of seeds of four intermediate maturing maize genotypes

Traits	ART/98/SW5-OB			POP66-SR/ACR 91			ILE-1-OB			ART/98/SW6-OB		
	Mean	Range	SD	Mean	Range	SD	Mean	Range	SD	Mean	Range	SD
Seed vigour												
HSW(g)	22.87b	21.49-24.7	1.03	23.79a	20.2-25.74	1.56	22.69b	21.32-24.3	0.93	23.46a	18.46-26.6	3.33
SG (%)	64.74b	38.0-73.3	11.37	44.67c	30.0-78.0	14.97	41.11c	16.0-64.0	19.05	66.22a	22.0-92.0	29.33
SGI(DAS)	3.24c	2.95-4.51	0.63	3.82a	2.21-5.00	1.01	3.67ab	2.66-4.78	0.65	3.56b	3.22-4.04	0.36
AAG (%)	37.85ab	18.33-58.0	15.02	36.11b	21.0-54.0	11.29	39.11a	16.0-60.0	15.98	38.33ab	7.0-84.0	26.12
AAGI(DAS)	4.85b	4.12-6.00	0.77	4.89b	4.00-6.19	0.93	4.91b	4.00-5.71	0.59	4.74a	4.02-6.44	0.91
COND	39.22b	20.36-58.7	13.73	29.41b	13.7-60.1	14.32	62.42a	23.4-91.7	26.08	25.85b	13.9-50.0	14.38
Seedling vigour												
RN	3.40bc	2.07-4.87	1.06	3.57b	2.00-4.80	0.97	3.16c	1.0-5.0	1.29	3.94a	2.60-5.33	1.04
RLT(cm)	12.52a	8.13-16.33	3.31	11.66a	1.70-17.0	5.08	11.72a	1.3-17.8	6.42	14.78a	12.7-17.8	1.93
SLT (cm)	7.55c	7.23-9.73	0.88	9.22a	5.80-11.4	1.78	7.87c	5.60-9.50	1.24	8.91b	8.40-9.60	0.38
RDW(g)	0.04a	0.02-0.05	0.01	0.03a	0.01-0.04	0.01	0.04a	0.01-0.08	0.02	0.04a	0.02-0.07	0.02
SDW(g)	0.04b	0.04-0.06	0.01	0.05a	0.03-0.07	0.02	0.04b	0.03-0.06	0.01	0.05a	0.04-0.07	0.01
SDL (cm)	20.07b	15.43-25.6	4.04	20.88b	7.50-27.6	6.61	19.59c	6.90-26.8	7.54	23.69ab	21.4-27.0	1.99
SVI	1.50a	0.95-1.86	0.31	0.99b	0.26-2.15	0.57	0.92b	0.12-1.61	0.59	1.57a	0.53-2.43	0.73

Means with the same letters in each row are not significantly different at P<0.05 using Duncan's Multiple Range Test.
SW=Hundred Seed Weight; SG=Standard Germination: SGI= Standard Germination Index; AAG=Accelerated ageing germination percentage; AAGI= Accelerated ageing germination index; DAS= Days after sowing; COND=Conductivity reading (µS/cm/g); RN= Root Number; RTL=Root Length; SLT=Shoot Length; RDW= Root Dry Weight; SDW= Shoot Dry Weight; SDL=Seedling Length; SVI=Seedling Vigour Index; SD= Standard Deviation (±)

Table 4. Mean values and variability in physiological quality of seeds of four late maturing maize varieties

Traits	SYNLDFO/OBANTAPA			SYNLDFO/OBAT			SYNLDFO/OBAT/TZL			OBANTAPA/TZLCOMP		
	Mean	Range	SD	Mean	Range	SD	Mean	Range	SD	Mean	Range	SD
Seed vigour												
HSW	24.20c	23.11-25.1	0.65	26.63b	25.80-28.11	0.79	28.07a	26.87-29.1	0.82	24.28c	22.94-25.6	0.88
SG (DAS)	88.22a	78.0-98.0	7.38	68.0b	50.0-94.0	16.49	90.44a	76.0-100.0	8.17	85.33a	64.0-100.0	11.49
SGI (%)	3.42b	3.0-4.1	0.48	3.68a	3.07-4.32	0.46	3.51b	3.00-4.15	0.46	3.46b	2.84-4.12	0.50
AAG (DAS)	64.44a	32.0-92.0	24.26	48.33b	6.0-80.0	30.56	40.44b	0-76.0	30.77	45.11b	18.0-86.0	25.91
AAGI (%)	4.37a	4.0-5.56	0.57	4.75a	4.0-6.17	0.88	3.96a	0-5.09	1.54	4.30a	4.0-4.95	0.37
COND	14.42ab	7.99-23.1	5.37	16.92a	9.4-33.6	7.43	10.82b	7.06-15.1	3.10	14.02ab	11.13-17.8	2.74
Seedling vigour												
RN	3.79b	2.0-5.0	1.09	4.20a	3.0-5.0	0.72	4.16a	2.80-4.80	0.63	3.69b	2.40-5.00	0.90
RLT(cm)	15.21a	12.2-19.0	2.49	14.42a	9.7-18.7	2.93	16.07a	7.7-20.8	4.02	15.26a	12.40-19.2	2.61
SLT(cm)	9.62a	8.6-10.1	0.51	8.87b	7.23-9.5	0.68	8.91b	7.63-10.70	1.01	8.37b	7.17-9.40	0.89
RDW(g)	0.04a	0.03-0.05	0.01	0.04a	0.03-0.05	0.01	0.04a	0.03-0.06	0.01	0.04a	0.03-0.05	0.01
SDW(g)	0.05ab	0.04-0.06	0.01	0.05ab	0.04-0.07	0.01	0.06a	0.04-0.07	0.01	0.04b	0.04-0.06	0.01
SDL(cm)	24.83a	21.63-29.1	2.83	23.08a	18.2-28.2	3.26	24.97a	17.3-31.5	4.21	23.63a	20.17-27.0	2.39
SVI	2.21a	1.79-2.85	0.42	1.61b	0.95-2.65	0.59	2.28a	1.42-3.08	0.55	2.03a	1.29-2.65	0.40

Means with the same letters in each row are not significantly different at P<0.05 using Duncan's Multiple Range Test. HSW=Hundred Seed Weight; SG=Standard Germination: SGI= Standard Germination Index; AAG=Accelerated ageing germination percentage; AAGI= Accelerated ageing germination index; DAS= Days after sowing; COND=Conductivity (µS/cm/g); RN= Root Number; RTL=Root Length; SLT=Shoot Length; RDW= Root Dry Weight; SDW= Shoot Dry Weight;SDL=Seedling Length; SVI=Seedling Vigour Index; SD= Standard Deviation (±)

Standard Germination (SG) and Accelerated Ageing Germination (AAG) compared to other genotypes. Speed of germination as measured by standard germination index (SGI) and Accelerated Ageing Germination Index (AAGI) was highest for EVDT-W99 with mean values of 3.24 and 4.20 days after sowing. The observed improvement in germination potentials for all the genotypes could be attributed to several factors among which are initial vigour of the seed lots and food storage conditions as reported by Wang and Hampton [23]. Conductivity reading was also the least for EVDT-W99 with mean value of 7.77 µS/cm/g. Average conductivity readings of all the genotypes were less than 13 µS/cm/g. The high average germination percentage after accelerated ageing (though lower than 70) and low electrical conductivity suggest that early-maturing group should be consider as having seed lots with high vigour. Table 2 also showed that mean values of RN was higher in EVDT-W99 compared to other 3 genotypes. TZE-YPOPDT recorded highest mean values in three out of the seedling traits measured. The result showed little variation in both RDW and SDW among all the genotypes as indicated by the small values of SD. POOL-18SR had the highest mean value in shoot length. Mean values and variability for physiological quality of seeds of four intermediate-maturing maize genotypes are presented in Table 3. ART/98/SW6-OB had the highest mean values in HSW and SG with values of 23.46 g and 68.22%, respectively. Large variation in standard germination and AAG was reported in ART/98/SW6-OB due to large SD with values of 29.33 and 26.12. This could be as a result of damages done to the seed lots during processing. This corroborates the findings of Jahufer and Borovoi [24] who reported that in maize after processing there were different rates of mechanical damage to seed coat in 89% of the seeds. This damage affected seed germination and seedling growth. This is attributable to the fact that 3 of the genotypes in intermediate group were sourced from the Institute (IAR&T) under different production environment and post-harvest handling from other genotypes. Speed of germination as measured by SGI and AAGI was also the fastest in ART/98/SW6-OB with mean values of 3.56 and 4.74 days after sowing. The mean value of conductivity was the least in ART/98/SW6-OB as compared to other genotypes. ILE-01-OB recorded the highest mean value of 39.11% germination after aging of the seed. Other genotypes showed wider variability in physiological traits measured as a result of their high SD. Reduced seed germination following seed ageing treatment might have resulted from the increased solute leakage following imbibitions which is usually accompanied with inevitable exist of some necessary materials for germination and normal seedling growth. This result is in agreement with those of Verma et al. [25]. They worked with different crops and reported that electrical conductivity and germination rate tests are suitable for evaluation of seed vigour in both laboratory and field experiments. ART/98/SW6-OB recorded highest mean values in 4 of the seedling traits measured after physiological seed quality tests (Table 3). Highest mean value of SLT was recorded by POP 66-SR/ACR 91. The root dry weight (RDW) and shoot dry weight (SDW) showed little variation among the four genotypes. Performance of all the genotypes in the intermediate group was relatively low as compare to the genotypes under early. Mean values and variability for physiological quality of seeds of four late maturing maize genotypes are presented in Table 4. The highest mean values of HSW and SG was recorded for SYNLDFO with small variability. All the four genotypes used had similar speed of germination as recorded by their SD of about 0.5. SYNLDFO/OBANTAPA had the highest AAG with mean value of 64.04%. All the genotypes had wider variability in AAG with large SD as a result of extreme mean values. SYNLDFO/OBAT/TZL germinates faster than the other genotypes but with large variation in mean values due to the extreme values recorded in the range. Conductivity reading was also the lowest in SYNLDFO/OBAT/TZL with average mean value of 10.82 µS/cm/g. Table 4 also showed that SYNLDFO/OBAT/TZL recorded highest mean values in four of the seven seedling traits measured. The variability among the mean values of these traits was small due to small values of SD. SYNLDFO/OBANTAPA had the highest mean value of 9.62 cm in SLT with small variation in the range of means as compared to other genotypes. RDW and SDW had similar mean values with the exception of SYNLDFO/OBAT/TZL that had 0.06 g in SDW. Greater variability in SDL due to large SD was recorded in SYNDFO/OBAT/TZL. From the above results there were variations among all the genotypes under late maturing materials as compared to early maturing genotypes. This corroborates the findings of Hussain et al. [15]. Correlation coefficients (r) between physiological seed quality tests and seedling traits of 12 maize varieties was presented in Table 5. Relationship between SG and all the seedling traits measured

Table 5. Pearson's correlation coefficients (N=36) between physiological seed quality tests and seedling traits of maize seed of different maturity groups

	RN	RL	SL	RDW	SDW	SDL	SVI
SG (%)	0.31**	0.61***	0.31*	0.25*	0.26*	0.63***	0.96***
AAG	0.50**	0.47**	0.48**	0.48**	0.36*	0.54**	0.51**
COND	-0.49**	-0.56**	-0.53**	-0.33*	-0.31	-0.63**	-0.67***

, **and * significant at P<0.05, 0. 01 and 0.001 respectively*
SG= Standard Germination; AAG= Accelerated ageing germination percent; COND= Conductivity(µS/cm/g); RN=Root Number; RL= Root Length(cm); SL= Shoot Length(cm); SDL= Seedling Length(cm); RDW=Root Dry Weight(g); SDW= Shoot Dry Weight(g); SVI= Seedling Vigour Index;

was significantly ($p < 0.05$-0.001) and positively correlated and strong with RL (0.61 ***), SDL (0.63***) and very strong with SVI (0.96***). From the result of this study, the positive and very strong relationship between SGI and SVI indicates increase in vegetative growth due to vigorous seedling architecture. AAG had a significant positive and strong relationship with RN (0.50**), SDL (0.54**) and SVI (0.51**) but weak with RL(0.47**), SL(0.48**), RDW(0.48**) and SDW (0.36**), respectively. The positive correlation between AAG and all the seedling traits is expected. Seed lot with high AAG values will produce vigorous seedlings. Conductivity also had significant negative correlation with all the seedling traits measured with the exception of SDW. The association was strong with RL (0-56**) SL (0.53**), SDL (-0.63**) and SVI (-0.67***) while it was weak with RN (-0.45**) and RDW(-0.33*).

The negative correlation between conductivity and the seedling traits is expected because high conductivity indicates low vigour which in turn will germinate poorly.

4. CONCLUSIONS

Keeping in view the above discussion it is concluded that: Highly significant genetic variability among the test maize genotypes was observed for the characters studied as measured by different laboratory quality assessments. Seeds of early, intermediate and late genotypes exhibited inherent variability in physical and physiological seed quality. All the early materials used for the study tend to be homogenous for all the traits measured and selection should be practiced for hundred seed weight to increase yield potential in maize varieties.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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