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Assessment of Genetic Variation and Heritability of Seedling Emergence Traits, and Association with Grain Yield Characteristics of some Tropical Maize Varieties representing different Breeding Eras

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ABSTRACTS

Ten tropical maize varieties were evaluated at two location during the cropping season of 2007 and 2008 to assess the genetic variation and heritability of seedling emergence traits, and association with grain yield characteristics. Genotypic relative to phenotype variation were higher for all traits. Variety DMRLSR-Y had highest 300 kernel weight (105.2g), but least grain yield and second to the least emergence percentage, indicates bigger kernel and highest kernel weight /cob but low plant stands. Genotypic and agronomic correlation analysis revealed positive associations ($p < 0.01$) between grain yield and emergence percentage (E%) and 300 kernel weight, however, anthesis-silking interval was negatively correlated with physiological maturity period and 300 kernel weight. Improvement of this variety for higher emergence percentage is therefore predicted for higher grain yield. Genotypic and phenotypic coefficient of variation (GCV & PCV) were high for emergence percentage (41% and 45%) and grain yield (25% and 32%) respectively, suggesting that these characters are under the influence of genetic control. High heritability in broad sense coupled with maximum genetic advance recorded by emergence percentage (E%) and 300 kernel weight implying that phenotypic selection could identify superior genotypes for these traits.

Keywords: Genetic, Emergence, seedling, heritability, Era

INTRODUCTION

One important component of seed quality is seed/seedling vigour, which is defined as the sum total of those properties of the seed that determine the level of activity and performance of the seed or seed lot during germination and seedling emergence [1] Vigour test represents significant technological advances in seed quality control. [2] and [3] have shown that seedling vigour can also be a selection criterion when breeding for improved seed yield in crops. Seed vigour is an important aspect of quality, which controls field stand, establishment ability and performance. The problems associated with establishing vigourously growing maize seedlings are often related to poor seed quality. High quality maize seeds have the capacity to produce vigourous seedlings across a wide range of environments. Low maize yields have been reported in Nigeria, and several factors, among which is poor quality seed with low seed vigour, have been identified. Information on seed and seedling vigour levels among the tropical maize inbred lines, extent of relationship among seed and seedling vigour characters and their heritability pattern are necessary for maize seed improvement in the tropic. Different traits such as emergence percentage (E%), emergence index (EI), emergence rate index has been used to quantify seedling vigour [4]. Moreover, [5] also reported significant correlations between maize grain yield and emergence traits. [6] observed that early planted maize had emergence percentage (E%) of only 60-70% of delayed plantings yet grained yield of early planted maize was more than doubled that of delayed plantings. The author therefore hypothesized that higher yield can be obtained if high rate of emergence and seedling vigour can be ensured under cultural and genetically favor conditions.

Knowledge of genetic variability of seedling traits is needed for improvement of crop. Information on the genetic components of variation, heritability and character association are needed for effective selection in plant breeding [7]. [8] observed that large sized fruits gave higher seed sizes but medium sized fruits gave higher emergence rate in a study carried out on seedling vigour of fluted pumpkin. He also suggested that an attempt to improve the seedling traits of any crop can only be achieved if there is sufficient genetic variability in such traits. According to [9], differences in emergence within a population and between populations may result from the condition under which the seed were produced, processed and stored; but it may also be due to genetic factors. The presence of genetic variation for seedling emergence would be of considerable importance in determining the best method to ensure improved plant stand. Selection of lines that are high yielding with superior seedling emergence are characterized by high and fast rate of emergence. [10] observed that genetic variability exists for emergence traits among tropical maize. However, knowledge of genetic component of seedling traits is needed for improvement of this crop. Information on the genetic components of variation, heritability, genetic advance and character association are needed for effective selection in plant breeding. The magnitude of genetic variability present in base population of any crop species is pivotal to crop improvement which must be exploited by plant breeders for yield improvement [11]. Genetic improvement of maize crop depends on the strength of genetic diversity within the crop species. Adequate variability provides options from which selections are made for improvement and possible hybridizations. Genotypic correlations had been used as an effective tool to determine the relationships among agronomic traits in genetic diverse population for enhanced progress in crop improvement.

Correlated responses are of interest to plant breeders because they provide information on the type of change that selection for one trait could cause in another trait. This information is useful in the construction of selection indices for the simultaneous improvement of two or more traits [9]. The authors in their study observed that selection for emergence traits led to positive gain in yield. Also suggested that selection for yield improvement would be expected to result in desirable gain in emergence traits. They therefore concluded that since desirable progress will be made in emergence traits by selection for yield improvement, selection for yield per se was suggested to continue or that the improvement of yield and emergence traits should be done simultaneously through index selection. More importantly, [12], also reported that information on character association in crops is important for effective and rapid selection in crop improvement. Heritability is another selection tool use by maize breeder because that provides him an idea of the extent of genetic control for the expression of a particular character [13]. Moreover, heritability serves as a guide to the reliability of phenotypic variability in the selection programme and hence determines its success [14].
Genetic advance on the other hand explains the degree of gain obtained in a character under a particular selection pressure. High genetic advance coupled with high heritability estimates offers the most suitable condition for selection. It also indicates the presence of additive genes in the trait and further suggests reliable crop improvement through selection

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of such traits. Estimates of heritability with genetic advance are more reliable and meaningful than individual consideration of the parameters .Continuous improvement of maize is imperative for the increased competition for the crop. This can be achieved through effective selection of suitable parent materials of significant genetic variability.

This study was therefore carried out, to assess genetic variation and heritability of seedling emergence traits, and association with grain yield characteristics of some tropical maize varieties.

MATERIALS AND METHODS

The materials used in this study comprised 10 open-pollinated varieties (OPVs) of maize which were developed for grain yield and adaptation to biotic and abiotic stress factors at the International Institute of Tropical Agriculture (IITA), Ibadan. They are late maturing white and yellow cultivars with maturity period ranging between 90 and 100 days. The characteristics of the 10 maize varieties are presented in Table 1. The materials were developed in two different breeding eras (before and after year 2000). Those varieties that were developed and released before year 2000 were classified as belonging to the first era (Era1), while those developed after year 2000 were considered as belonging to the second era (Era 2.). The materials were planted in a four-replicate Randomized Complete Block Design (RCBD) at two locations (IAR&T Sub Station,Orin –Ekiti and Iropora-Ekiti). Seedling emergence was recorded at 5, 7, 9 days after planting (DAP) and used to compute EI according to modified formula of [10].

i. Emergence index (EI) =∑(Plants emerged in a day)(Day after planting)Plants emerged by 19 days after planting

ii. Emergence percentage (E%): This was calculated as the percentage of seedling emerged 9 DAP relative to the number of seeds sown per plot.

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

iii. Emergence rate index (ERI) i.e. speed of emergence: was computed by expressing EI as a proportion of E% as follows:

ERI= EI/E% , days to 50% tasselling, days to 50% anthesis, days to 50% silking, 300 kernel weight, kernel row, seed weight/cob and grain yield was converted to tones/hectare (t/h^{-1}) at 15% moisture. Anthesis-silking interval (ASI) was also estimated as the difference between days to 50% silking and anthesis.

ESTIMATION OF VARIANCE COMPONENTS

The variability present in the population was estimated by measure mean, phenotypic and genotypic variance and coefficient of variance. To estimate the phenotypic and genotypic variance, genotypic and phenotypic coefficients of variation were estimated based on formula [15] as follow:

$\sigma^2 g = [(MSg) - (MSe)] / r$

$\sigma^2 P = [\sigma^2 g + (\sigma^2 e/r)]$,

where: $\sigma^2 g$ = Genotypic variance; $\sigma^2 p$ = Phenotypic variance;

$\sigma^2 e$ = environmental variance (error mean square from the analysis of variance); MSG = mean square of genotypes;

MSE = error mean square; r = number of replications.

ESTIMATION OF BROAD SENSE HERITABILITY AND GENETIC ADVANCE.

Broad sense heritability (h^2) estimate of each trait was computed according to the procedure outlined by Falconer as: Heritability $(h^2) = \frac{\delta^2 g}{\delta^2 p}$
. Where: $\delta^2 g$ = genotypic variance and
$\delta^2 p$ = phenotypic variance.

$\text{PCV}(\%) \frac{\sqrt{\delta^2 p}}{x} \times 100$ s number of replication.

The mean values were used for genetic analyses to determine phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV).

$$\text{GCV}(\%) = \frac{\sqrt{\delta^2 g}}{x} \times 100$$

where: $\delta^2 g$ = genotypic variance, $\delta^2 p$ = phenotypic variance and x = sample mean. GCV and PCV values are categorized as low when less than 10%, moderate at 10-20%, and high when greater than 20% [16].

Genetic advance (GA) The expected genetic advance for the different character under selection was estimated as suggested by [17]:

GA = K (σ_p) h^2, where: K = the selection differential (K = 2.06 at 5% selection intensity); σ_p = the phenotypic standard deviation of the character; h^2 = broad sense heritability

Table 1. Characteristics of the ten maize varieties representing two eras of maize breeding in Nigeria.

S/N	Genotype	Era	Year of released	Grain colour	Type	Maturity
1.	TZSR-W-1	1	1979	White	Flint	Late
2.	DMR-LSR-W	1	1980	White	Dent	Late
3.	DMR-LSR-Y	1	1980	Yellow	Dent	Late
4.	TZSR-Y-1	1	1979	Yellow	Flint	Late
5.	ACR 99 TZLCOMP4 DMRSR	1	1999	White	Dent/Flint	Late
6.	BR9922DMRSR	2	2008	White	Flint	Late
7.	BR9928DMRSR	2	2008	Yellow	Flint	Late
8.	BR9943 DMRSR	2	2008	White	Flint	Late
9.	AMA TZBR-W C2B	2	2008	White	Flint	Late
10.	TZBRELD 4 Co W	2	2000	White	Flint	Late

RESULT AND DISCUSSION

Variation due to environment were significant for days to physiological maturity and 300 kernel weight while other measured parameters did not significantly vary with environment (Table 2). Genotypic variation were significant for emergence percentage, emergence index, days to physiological maturity, 300 kernel weight and grain yield. The magnitude of genetic variability present in base population for a particular trait is a factor that could be exploited by plant breeders for improving such trait [11]. Genetic improvement of maize crop for any trait depends on the strength of genetic diversity within the crop species. Adequate variability provides options from which selections are made for improvement and possible hybridizations. Era 1 genotypes (older maize varieties) were significantly different for emergence percentage (E%) and days to physiological maturity. Mean value of Emergence percentage were higher among older maize varieties (Era 1) relative to newer varieties era 2 (Table 3). The older maize varieties also emerge more rapidly than old ones (Table 3). Variation were significantly higher for grain yield among modern maize varieties i.e Era 2 genotypes. Environment by Era 1 genotypes interaction effect were not significant for all the measured traits except days to physiological maturity, this indicates that selection base on the phenotype will therefore remain stable in various environments. Moreover, Environment by Era 2 genotypes interaction effect was only significant for emergence percentage (E%), this suggests the influence of environmental factors on the expression of emergence percentage (E%) among Era 2 i.e. modern maize varieties (Table 2). This indicates that selection for emergence index among these genotypes in not reliable as it changes with environment.

Mean for emergence percentage (%) was highest (80%) for variety TZSR-Y in Era 1 while the least emergence percentage (30.70%) was recorded by variety BR9922DMRSR in Era 2 (Table 3). Highest and least emergence index were obtained by varieties BR9928DMRSR and TZSR-Y respectively. However, both varieties TZSR-W and BR9922DMRSR recorded the same value of emergence rate index (ERI) i.e. speed of seed emergence relative to the remaining eight varieties. Least anthesis silking interval (ASI) was recorded by ACR99TZLCOM4DMRSR, BR9928DMRSR, TZBRELD4CO-W and TZSR-Y, these four genotypes are therefore good candidates for drought tolerance maize improvement programmes. Highest and significantly different 300 kernel weight (105.2 g) was obtained by variety DMRLSR-Y while the highest grain yield (3.71 t/ha) was recorded by variety BR9943DMRSR. The two maize genotypes (DMRLSR-Y and BR9943DMRSR.) can be included in maize grain yield improvement programmes. However, variety DMRLSR-Y that recorded the highest 300 kernel weight (105.2g) also recorded least grain yield and second to the least emergence percentage, indicates that this genotype has bigger kernel and highest kernel weight /cob but low plant stands. It shows the important of improving seedling emergence percentage (%) in quest to breed maize for higher grain yield. [18] suggested that the gains in maize grain yield may also have been accompanied by changes in seedling emergence, early growth characteristics and other morpho-physiological characteristics.

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Table 2: Mean squares from combined ANOVA for grain yield and agronomic traits in 10 maize varieties representing two maize breeding eras in Nigeria (Orin and Iropora, 2008 & 2009)

Sources	Df	Emergence percentage (E%)	Emergence Index (EI)	Emergence rate Index (ERI)	Anthesis Silking interval (days)	Days to maturity (Days)	300 kernel weight (g)	Kernel Weigt/ cob (g)	Yield (t/ha)
Rep	3	440.60	0.23	0.01	0.41	0.05	219.50	381.0	0.70
Environment(Env)	1	6182.9	2.78	0.08	6.61	108.**	32322**	35045.	2.92
Genotypes(G)	9	1904.60**	1.65**	0.03	0.53	136.**	1042.60**	495.10	3.61**
Entr (Era 1)	4	1612.80**	1.09	0.35	0.53	265.0**	66.70	517.60	1.82
Entry (Era 2)	4	1785.78	1.84	0.02	0.65	2.90	515.80	435.60	6.29**
Era 1 vs Era 2	1	3547.08	3.13	0.026	0.05	154.0	7053.4	643.1	0.05
Genotypes x Env(ge).	9	319.70	0.33	0.34	0.61	9.67	696.80	571.70	1.35
Env x Era 1	4	49.30	0.26	0.02	0.53	17.9**	458.60	100.90	1.60
Env x Era 2	4	633.30**	0.48	0.03	0.48	0.85	748.30	118.70	0.93
Env X (Era 1vs Era 2)	1	146.9	0.01	0.01	1.45	12.03	1443.2	4266.9	2.03
Pooled Error	65	195.80	0.33	0.03	6230	1.36	183.30	570.0	1.10

*,** Significant at < 0.05 and 0.01 levels of probability respectively.

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Table 3: Means for location and genotypes for grain yield and agronomic traits in 10 tropical maize varieties representing two maize breeding eras in Nigeria (Orin and Iropora, 2008&2009)

Source	Emergence percentage (E %)	Emergence Index (EI)	Emergence rate Index(ERI)	Anthesis Silking Interval (Days)	Days to Maturity (cm)	300 Kernel Weight (cm)	Yield (t/ha)
TZSR-W	44.50	6.31	0.25	2.00	89.00	92.60	2.62
DMRLSR-Y	44.10	6.93	0.19	2.00	90.00	105.20	2.32
DMRLSR-W	75.60	6.41	0.18	2.00	77.00	102.8	3.02
TZSR-Y	80.70	5.89	0.08	1.00	89.00	97.50	3.57
ACR99TZLCOM4DMRSR	62.20	6.40	0.11	1.00	91.00	82.20	2.68
BR9922DMRSR	30.70	6.58	0.24	2.00	91.00	94.80	3.60
BR9928DMRSR	44.60	7.28	0.17	1.00	91.00	79.20	3.18
BR9943DMRSR	66.80	7.23	0.11	2.00	90.00	77.20	3.92
AMATZBR-W	64.80	6.70	0.22	2.00	90.00	74.40	3.71
TZBRELD4CO-W	53.60	6.13	0.15	1.00	89.00	78.50	3.15
Mean	52.10	6.8	0.20	2.00	90.00	80.8	3.50
Lsd	14.01	0.58	0.19	0.79	1.17	13.55	1.01

Genotypic variation relative to variation due to phenotype were higher for all the measure traits (Table 2). The existence of variability is essential for resistance to biotic and abiotic factors as well as for wide adaptability of genotype [19]. In genotypic covariance(GCV) and phenotypic covariance(PCV) most of the economic characters (grain yield) are greatly influenced by several genes interacting and are complex in heritability with various environmental conditions, the study of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) useful both for comparing the relative amount of phenotypic and genotypic variations among the different traits and also very useful in estimating the scope for improvement by selection. A parameter to be selected for breeding is reliable for the breeding programme depending on the magnitude of especially the GCV. Genotypic and phenotypic coefficient of variation (GCV & PCV) were high for emergence percentage (41% and 45%) and grain yield (25% and 32%) respectively, suggesting that these characters are under the influence of genetic control [20]. A high proportion of GCV to the PCV is desirable in breeding works as it show that the environment does not have high influence on the genotype which is what breeders need to breed for. This suggests the greater effectiveness of selection and improvement to be expected for these characters in future breeding programme as the genetic variance is mostly due to the additive gene action [21]. [22] also reported high values of PCV and GCV observed in Anthesis-silk interval followed by grain yield, husk cover and plant aspect, which showed that the selection protocol can be effective for these traits, it also indicated the existence of substantial variability in the population, ensuring ample scope for their improvement through selection. However, genotypic coefficients of variation (GCV %) was low for emergence index (EI) while phenotypic coefficients of variation (PCV %) was moderate for the same trait. Both genotypic coefficients of variation (GCV %) and phenotypic coefficients of variation (PCV %) were moderate for anthesis-silking interval (ASI). High genotypic coefficients of variation (GCV %) was recorded for 300 kernel weight while moderate value of phenotypic coefficients of variation (PCV %) was recorded for the same trait. Broad sense heritability were high for emergence percentage (92%), Emergence index (85%), anthesis-silking interval (83%) and physiological maturity period (98%), indicating that these characters were predominantly controlled by genetic factors

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Table: 3 Mean, genetic (6^2_g), genotype x environment interaction (6^2_{ge}), phenotypic variance, and heritability estimates (h^2) for emergence and yield traits 10 maize varieties representing two maize breeding eras in Nigeria (Orin and Iropora, 2008 & 2009)

Parameter	E%	EI	ERI	ASI (days)	MAT (days)	300kw (g)	GY (t/ha)
Mean	52.10	6.8	0.20	2.00	90.00	80.8	3.50
6^2_g	455.93	0.38	0.005	0.126	33.90	241.62	0.79
6^2_{ge}	319.70	0.33	0.34	0.61	9.67	696.80	1.35
6^2_p	537.26	0.52	0.017	0.152	34.46	317.76	1.25
h^2	92.00	85.00	30.00	83.00	98.00	76.00	63.00
GA	40.48	1.09	0.01	0.66	11.88	27.92	1.45
GCV	41.00	9.00	35.0	18.0	7.00	19.00	25.00
PCV	45.00	11.00	65.0	20.0	7.00	22.00	32.00

E% =Emergence percentage, EI = Emergence index,
ERI = Emergence rate index, ASI = Anthesis silking interval,
MAT = Physiological maturity time, 300kw = 300kernel weight, GY = Grain yield.

Table 5: Correlation between emergence and grain yield parameters among 10 tropical maize varieties representing two breeding eras (Iropora and Orin-Ekiti, 2008 &2009)

Parameter	E%	EI	ERI	ASI	MAT	300KW	GY
E%		-0.329	-0.661*	-0.190	-0.478	-0.035	0.295
EI			0.145	0.305	0.246	-0.295	0.119
ERI				0.641*	0.042	0.173	-0.206
ASI					-0.267	0.308	0.052
MAT						-0.462	0.109
300KW							0.109
GY							

* Significantly different at 0.05 level of probability
E% =Emergence percentage, EI = Emergence index,
ERI = Emergence rate index, ASI = Anthesis silking interval,
MAT = Physiological maturity time, 300kw = 300kernel weight, GY = Grain yield.

The estimates of heritability help the plant breeder in selecting for elite genotypes from different genetic population. Therefore, high heritability helps in effectively selecting for a desired character. Heritability is hence classified as low (below 30%), medium (30-60%) and high (above 60%) [23]. High heritability indicates the scope of genetic improvement of these characters through selection. Similar results have been reported by([24, 25, 23, 26]. The genetic advance is a useful indicator of the progress that can be expected as result of exercising selection on the pertinent population [25]. Heritability coupled with genetic advance would give a more reliable index of selection value [17]. In the present study (Table 5) high genetic advance was recorded for Emergece percentage (E%) and 300 kernel weight. Low genetic advance were recorded for the remaining parameters under the same environment. High heritability in broad sense coupled with maximum genetic advance recorded by emergence percentage (E%) and 300 kernel weight implying that phenotypic selection could identify superior genotypes for these traits [11, 20. 27] reported higher magnitude of broad sense heritability coupled with higher genetic advance in grain yield ,plant height, days taken to silking, and further explained that days taken to tasseling provided the evidence that these plant parameters were under the control of additive genetic effects. This is implies that standard selection protocols would be effective in breeding strategy aimed at improving the traits [28].

Genotypic and agronomic correlation analysis revealed that grain yield had positive associations ($p < 0.01$) with emergence percentage (E%) and 300 kernel weight, however, anthesis-silking interval was negatively correlated with physiological maturity period and 300 kernel weight. Its an indication that early flowering is positively associated with 300 kernel weight and grain yield. This an indication that interval between pollen shed and silking could be adopted for maize grain yield improvement in moisture stressed areas. ASI is a useful indicator in screening genotypes for tolerance to stress because it is a measure of nicking (synchronization) of pollen shed with silking. [29], reported that most significant changes in the new Ontario, Canada hybrids was a tendency for a higher final leaf number, a longer duration from planting to tassel emergence and reduction in ASI.

CONCLUSION

Genotypic and agronomic correlation analysis revealed that grain yield had positive associations ($p < 0.01$) with emergence percentage (E%) and 300 kernel weight, however, anthesis-silking interval was negatively correlated with physiological maturity period and 300 kernel weight. Its an indication that early flowering is positively associated with 300 kernel weight and grain yield. Genotypic and phenotypic coefficient of variation (GCV & PCV) were high for emergence percentage (41% and 45%) and grain yield (25% and 32%) respectively, suggesting that these characters are under the influence of genetic control. High heritability in broad sense coupled with maximum genetic advance recorded by emergence percentage (E%) and 300 kernel weight implying that phenotypic selection could identify superior genotypes for these traits. Moreover, variety BR9943DMRSR that obtained the highest grain yield per hectare only recorded (66%) and (77g) of emergence percentage and 300 kernel weight respectively. For greater grain yield per hectare to be manifested by this variety, it needs to be improved for seedling emergence percentage and kernel size.

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