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Variability Studies for Yield and Associated traits in Maize genotypes (*Zea mays* L.) of different maturity groups

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Abstract
Maize (Zea mays L.) is the world's third most important cereal crop that has remarkable productive potential. It is the second most important cereal crop in terms of production. The selection for high yield with desirable traits depends on the genetic variability in the existing germplasm. Successful breeding programs need adequate genetic variation for selection and improvement based on necessity. Field experiments were conducted at Kadawa, Kano State (11^{o}39'N latitude, 08^{o}02'E longitude with an altitude of 496m above sea level) situated in the Sudan Savannah zone in January 2011 dry season in two different sowing dates serving as two environments to assess the variability of the genotypes for economically important agronomic traits and to assess their interaction with the environment in respect to such traits. The study comprised of eight varieties belonging to four different maturity groups. Eighty-one genotypes generated, comprising the crosses, reciprocals, selfs, parents and nine checks were laid out in Randomised Completely Block Design (RCBD) with three replications. The results of the study indicated significant differences among the genotypes in environment one for all traits measured except ear height, ear diameter and cob diameter, indicating genetic variability in the parents used, whereas in environment two most of the studied traits were significant except (days to 50% tasselling and silking, number of leaves, plant height, days to maturity, ear length and ear diameter). A significant genotype x environment interaction was observed, indicating that suitable hybrids could be produced for specific environments. There is a need to select different parental varieties for hybrid production for specific environments. Specific hybrids should be produced for specific planting dates under irrigation and also Inter variety hybrid development program is recommended as an effective breeding approach to exploit the heterotic potential of the varieties.
***Keyword**: Breeding, Diversity, Lines, Morphological traits, Selection, Variance, Varieties*

INTRODUCTION

Maize is grown from 58^{0}N latitude without interruption through the temperate, subtropical and tropical regions of the world to 40^{0}S latitude (Hallauer and Miranda 1981), with growing cycle ranging from 3 to 13 months. It is the third most important crop in the world. Maize has become a major food item in Nigeria and it is consumed in many forms. It is consumed as green maize when the ear is boiled or roasted. When dry, the grain may be processed into different forms of products such as pap (*ogi*) and starch, it is also an industrial crop in Nigeria (Oluwaranti *et al*., 2008). It is an important food crop in Sub-Saharan Africa, providing 50% of the calories in diets in Southern Africa, 30% in Eastern Africa and 15% in West and Central Africa (Vivek *et al*., 2009). Maize represents a staple food for a significant proportion of the world's population and supplements the diets of millions of many. (Allard and Bradshaw, 1964) classified environments into predictable and unpredictable environments. The predictable variable also includes what are called controllable variables (Perkins and Jinks, 1971) which include: level of fertilizer application, sowing date, and sowing density, amount of irrigation which can be artificially created. Variability refers to the presence of difference among the individuals of plant population, the knowledge of variability present in the crop species plays an important role in formulating a successful breeding program to evolve superior cultivars (Abdurakhmonov and Abdukarimov, 2008). Genetic variability among individuals in the population offers effective selection (Rather *et al.*, 2003). Diversity among maize lines can be examined based on morphological traits (Xia *et al.,* 2005). Grain weight and grain yield; kernel weight and days to maturity, ear height, days to silking and cob length (Kadir, 2010); days to 50% anthesis, days to 50% silk emergence, days to maturity, grain yield, plant height and ear height (Muchie and Fentie, 2016) are variables that can contribute to genetic diversity assessment. As stated by Hallauer and Miranda (1981) that, genetic improvement in traits of economic importance along with maintaining sufficient amount of variability is always the desired objective in maize breeding program, generally variability is a key to crop improvement. Grzesiak (2001) observed considerable genotypic variability among various maize genotypes for different traits. Ihsan et al. (2005) reported significant genetic differences in the morphological parameter for maize genotypes. Environments were classified by Allard and Bradshow (1964) as predictable (includes the regular and more or less permanent features of the environment and it also includes what are called controllable variables as suggested by Perkins and Jinks (1971) which includes level of fertilizer application, sowing date, and sowing density) and unpredictable environments (includes weather fluctuations such as differences between seasons in terms of amount and distribution of rainfall and the prevailing temperature during crop growth).

Availability of early and extra-early varieties is a strategy for adopting maize to the gradually shortening rainy season so that maize could escape the drought stress that occurs during the grain-filling stage in the late season. The early and extra-early varieties were specifically developed for cultivation in the northern fringes of the Northern Guinea Savanna (NGS) and the Sudan Savanna (SS) (Fajemisin, 1989; Onyibe *et al.,* 1999 and Badu-Apraku, Fakorede *et al*., 2001). The use of extra-early maize results in the production of two or more crops in relays, especially where irrigation facilities are available. The extra-early maize is also very useful to “catch-up” with the season in situations where rainfall started late or rainfall distribution is so adverse as to require replanting. The use of extra-early varieties is an effective way of escaping havoc caused by drought (Ado *et al.*, 2007). Despite the importance of maize, for maize production to remain sustainable, research is necessary especially those related to yield is useful for the plant breeder to select breeding materials through secondary traits to initiate the efficient breeding program. Sujiprihati et al. (2003) suggested different agronomic parameters like estimated means, and variances as important to select the superior genotypes and to determine the efficiency of breeding. Genetic improvement in traits of economic importance along with maintaining a sufficient amount of variability is always the desired objective in maize breeding programs (Hallauer and Sears, 1973). Hence, the objectives of this research were to assess the variability of the economically important agronomic traits and to assess their interaction with the environment in respect to such traits.

MATERIALS AND METHODS

The research was conducted at Kadawa Irrigation Research Sub-station (11°39'N, 080027`E) of the Institute for Agricultural Research, Ahmadu Bello University, Zaria during 2011 dry season. The parent materials comprised of eight varieties consisting of Sammaz 19, Sammaz 17 and Sammaz 36 obtained from IAR-Zaria, Sammaz 27, Sammaz 37, Sammaz 35, Sammaz 29 and Sammaz 28 from International Institute of Tropical Agriculture. They were crossed in a complete diallel pattern to generate crosses, reciprocals and self’s at Samaru-Zaria in April 2010. Eighty-one varieties comprising the crosses, reciprocals, self's, parents and nine checks were evaluated at Kadawa in two sowing dates at three months interval in January 2011. The sowing dates were considered as separate environments. The 81 entries were evaluated in a Randomized Completely Block Design (RCBD) with three replications in each environment. One row of 5m long spaced at 0.75m apart was used as a plot. Three seeds were planted at intra row spacing of 50cm and later thinned to two plants per hill. Three hoe weedings were carried out, first one at two weeks after planting, second at four weeks after planting and earthing up at six weeks after planting. There was split fertilizer application of compound fertilizer (NPK 20:10:10) as basal dressing and urea (46 % N) as a top dressing, giving a total plant nutrient of 120 kg N, 60 kg P_2O_5 and 60 kg K_2O per hectare. Data were collected for: Days to 50% pollen shed (Daf), days to 50% silking (Das), plant height (PH) (cm), days to maturity (DM), kernels per row (KPR) and grain yield per hectare (Gy) (kg). A brief description of the varieties is presented in Table 1.

Table 1. Origin and descriptions of the varieties under study

S/N	Variety	Maturity period	Days to mid-silk	Source, description
1	Sammaz 19 (S.14 DKD DT)	Late (100-120 days)	62 days	IAR, White Flint
2	Sammaz 37 (Pop 66 SR/Acr91 Suwan-1-SR)	Late (100-120 days)	62 days	IITA, Yellow flint
3	Sammaz 17 (Acr Sakatifu)	Medium (91-95 days)	58 days	IAR, White Dent
4	Sammaz 36 (Cm 2007 pool QPM-Y)	Medium (91-95 days)	56 days	IAR, Yellow flint
5	Sammaz 27 (EV 99 DT-W-STR)	Early (86-90 days)	52 days	IITA,White flint,*Striga* resistant
6	Sammaz 35 (2000 EV DT-Y STRC4)	Early (86-90 days)	52 days	IITA, Yellow Flint, *Striga* resistant
7	Sammaz 29(2000 syn EE-W-STR)	Extra-Early(80-85 days)	50 days	IITA, White Flint
8	Sammaz 28 (99 TZEE-Y-STR)	Extra-Early(80-85 days)	50 days	IITA, Yellow flint

Data analysis

Analyses of variance (ANOVA) for the individual environment as well as for combined environments were computed using the Statistical Application for the Sciences Software (SAS 2002).

RESULTS

Analysis of variance

The analyses of variance for environment one, two and combined across environments are presented in Tables 2, 3 and 4, respectively. The result of the analysis of variance for fifteen traits measured at environment one indicated that mean squares due to genotypes (parents, crosses, reciprocals, selfs and checks) were highly significant ($p\leq 0.01$) for eleven traits (Table 2), and significant ($p\leq 0.05$) for number of leaves per plant, plant height and kernel row number. Ear height, ear diameter, and cob diameter were not significant. The results of environment two indicated highly significant ($p\leq0.01$) differences for seven traits (Table 3), while cob diameter was significant at $p\leq0.05$. The result of the combined analysis across environments (Table 4) indicated highly significant ($p \leq 0.01$) differences among the genotypes for eight traits. Days to 50% tasselling, days to 50% silk and a number of leaves per plant were significant ($p \leq 0.05$). There is no significant difference among the genotypes for days to maturity, ear length, kernel row number, ear diameter, and cob diameter. The mean squares for genotype x environment interaction were highly significant for seven traits. Days to maturity and ear length were significant at $p \leq 0.05$, whereas the genotype x environment interaction for days to 50% silking, number of leaves per plant, plant height, ear height, ear diameter, and cob diameter were not significant.

Table 2. Mean square for fifteen agronomic characters for environment one

SV	Df	Daf	Das	NL	PH	EH	DM	Ep	EL
Replication	2								
Genotype	80	31.39**	36.99**	2.69*	615.74*	267.40	44.22**	61.28**	9.29**
Error	159	12.80	17.73	1.75	414.46	197.69	18.00	25.05	3.95
Total	241								

Table 2. continued

SV	Df	KRN	KPR	ED	CD	Cw	Tp	Gy
Replication	2							
Genotype	80	3.52*	72.24**	6.02	0.05	1.05**	298.47**	4386929.1**
Error	159	2.48	41.34	8.54	0.07	0.54	135.22	2187249.3
Total	241							

**,* significantly different at 1% and 5% levels of probability, respectively.

KEY: SV: Source of variation, Df; Degrees of freedom, Daf: Days to flower, Das: Days to silk, NL: Number of leaves, PH: Plant height, EH: Ear height, DM: Days to maturity, Ep: Ears per plot, EL: Ear length, KRN: Kernel row number, KPR: Kernels per row, ED: Ear diameter, CD: Cob diameter, CW: Cob weight, Tp: Threshing percentage, Gy: Grain yield/ha

Table 3. Mean squares for fifteen agronomic characters for environment two

SV	Df	Daf	Das	NL	PH	EH	DM	Ep	EL
Replication	2								
Genotype	80	26.28	28.89	5.00	914.64	274.54**	29.74	58.74**	71.57
Error	160	28.67	32.89	4.16	696.97	177.96	42.80	34.53	56.98
Total	242								

Table 3. continued

SV	Df	KRN	KPR	ED	CD	Cw	Tp	Gy
Replication	2							
Genotype	80	6.90**	84.42**	8.69	0.06*	0.32**	345.43**	1586512.6**
Error	160	4.35	46.97	7.93	0.04	0.20	135.86	904096.7
Total	242							

**,* significantly different at 1% and 5% levels of probability, respectively.

KEY: SV: Source of variation, Df; Degrees of freedom, Daf: Days to flower, Das: Days to silk, NL: Number of leaves, PH: Plant height, EH: Ear height, DM: Days to maturity, Ep: Ears per plot, EL: Ear length, KRN: Kernel row number, KPR: Kernels per row, ED: Ear diameter, CD: Cob diameter, CW: Cob weight, Tp: Threshing percentage, Gy: Grain yield/ha

Table 4. Mean squares for fifteen agronomic characters combined across environments

SV	df	Daf	Das	NL	PH	EH	DM	Ep	EL
Env	1								
Rep (Env)	4								
Genotype	80	27.78*	33.59*	4.18*	901.72**	299.80**	31.55	55.65**	39.42
Genotype x Env	80	30.98**	33.31	3.51	631.23	242.16	42.53*	65.24**	41.47*
Error	319	20.76	25.34	2.96	556.16	187.80	30.44	29.80	30.55
Total	484								

Table 4. continued

SV	df	KRN	KPR	ED	CD	Cw	Tp	Gy
Env	1							
Rep (Env)	4							
Genotype	80	3.85	82.67**	6.84	0.05	0.70**	314.81**	3027724.4**
Genotype x Env	80	6.57**	73.96**	7.87	0.06	0.67**	329.21**	2944919.6**
Error	319	3.42	44.16	8.23	0.06	0.37	135.54	1543662
Total	484							

**,* significantly different at 1% and 5% levels of probability,. respectively

KEY: SV: Source of variation, Df; Degrees of freedom, Daf: Days to flower, Das: Days to silk, NL: Number of leaves, PH: Plant height, EH: Ear height, DM: Days to maturity, Ep: Ears per plot, EL: Ear length, KRN: Kernels row number, KPR: Kernels per row, ED: Ear diameter, CD: Cob diameter, CW: Cob weight, Tp: Threshing percentage, Gy: Grain yield/ha

DISCUSSION

In this study there were significant differences ($p<0.05$) among the genotypes in environment one and two for all traits measured except (ear height, ear diameter and cob diameter) and (Days to flower, Days to silk, Number of leaves, Plant height, Days to maturity, Ear length, and Ear diameter) respectively indicating presence of genetic variability among the genotypes. This agreed with the findings of (Kitila *et al.,* 2011) in coffee; (Nwangburuka *et al.,* 2012) in field pea and (Bhandari, Srivastava *et al.*, 2017) in okra and tomato; (Hepziba *et al.,* 2013; Ferdoush, Haque *et al.,* 2017 and Beulah *et al.,* 2018) in maize. Additionally, (Biswas *et al.,* 2018) in *Corchorus olitorius* genotypes. Who reported highly significant differences among those crops studied. Indicating considerable variability for such study traits which leads to wide genetic diversity and would be very meaningful for an effective selection for maize improvements. The non-significant differences of the genotypes for ear height, ear diameter and cob diameter in environment one indicate that they may be conditioned by the same genes and are genetically related for these characters. It might be possible that the genotypes are related through some remote ancestors. The significant genotype x environment interaction for nine traits indicated that the traits were influenced by differences in environments. For that reason, suitable hybrids could be developed for specific environments. In other words, specific hybrids can be developed for early planting in the dry season at Kadawa while some other hybrids will be suitable for planting late in the season represented as environment two in this study.

CONCLUSION

The results of the study indicated significant differences among the genotypes in both environments and combined across environments. The findings revealed that there is ample opportunity for better utilization of the studied maize genotypes for selecting desired traits in maize breeding programs. A significant genotype x environment interaction indicates that suitable hybrids could be produced for specific environments.

RECOMMENDATIONS

There is a need to select different parental varieties for hybrid production for specific environments, and for specific planting dates under irrigation and also Inter variety hybrid development program is recommended as an effective breeding approach to exploit the heterotic potential of the varieties.

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