ASSESSMENT OF GENETIC VARIABILITY OF MAIZE INBRED LINES AND THEIR HYBRIDS UNDER NORMAL AND DROUGHT CONDITIONS

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ABSTRACT

Fifty-six maize genotypes were evaluated at Kadawa Irrigation Research Sub-station (11°39'N, $08^0$027`E) of the Institute for Agricultural Research, Ahmadu Bello University, Zaria during 2012/13 dry season to estimate genetic variability of grain yield and its component characters. Analysis of variance revealed significant differences for most of the characters under study which indicates the presence of sufficient amount of variability offering ample scope for improving the population for these characters. The ranges of mean values revealed sufficient variation for all the traits under study. The magnitude of phenotypic variances and phenotypic coefficients of variation were slightly higher than the corresponding genotypic variances and genotypic coefficients of variation for all the characters under study. Grain yields under both conditions, leaf senescence under intermediate stress and severe stress, ear height under severe stress and number of ears per plant under intermediate stress had higher amount of exploitable genetic variability among the attributes. These traits may be used as an effective selection criterion to improve yield potential of maize genotypes under non-stress and water stress conditions.

Keywords: Drought, Inbred lines, Genetic Gain, Grain Yield and Maize

INTRODUCTION

Maize (*Zea mays* L.) is a multipurpose crop which provides food for humans, feed for poultry, fodder for livestock, edible oil for human use, to mention but a few. It is one of the most widely cultivated cereal crops due to it adaptation to a wide range of environment. It is also a major staple food crop in Nigeria and receiving much attention in industrial development. Despite its importance and higher yield potential than either sorghum or pearl millet, maize productivity is limited by several constraints particularly in the West African sub-Sahara region, among which is drought (Izge, and Dugje, 2011). Drought is one of the most important environmental stresses affecting agricultural productivity worldwide and can result in a considerable yield loss (Ludlow and Muchow, 1990). The risk of drought stress is severe particularly in the Sudan savanna zone due to unreliable and uneven distribution of rainfall (Eckebil, 1991). In maize, grain yield reduction caused by drought ranges from 10 to 76% depending on the severity and stage of occurrence (Bolanos *et al*., 1993). The use of genetics to improve drought tolerance and provide yield stability is an important part of the solution to stabilizing global maize production.

Genetic improvement in traits of economic importance along with maintaining sufficient amount of variability is always the desired objective in maize breeding programs (Hallauer and Scobs, 1973). To improve genetic diversity of local germplasm, it is important to know the extent of already existing genetic variability in the material. Genetic variability, which is a heritable difference among cultivars, is required in an appreciable level within a population to facilitate and sustain an effective long term plant breeding programme. The analysis of genetic diversity provides maize breeder and researchers with useful information for germplasm preservation and the identification of germplasm that may be exploited by the production of improved varieties, hybrids and synthetics. The study was conducted to determine the genetic variability among maize inbred lines and their hybrids under normal and drought conditions. The results from this investigation would serve as a guide to plant breeders to initiate an improvement programme.

MATERIALS AND METHODS

The research was conducted at Kadawa Irrigation Research Sub-station (11°39'N, $08^0$027`E) of the Institute for Agricultural Research, Ahmadu Bello University, Zaria during 2012/13 dry season. Fifty six maize genotypes were used for this study comprising six drought tolerant male inbred lines; seven drought susceptible female inbred lines, forty two single cross hybrids and a commercial check. The single cross hybrids were generated in the year 2012 rainy season using North Carolina mating design II. The genotypes were grown in a simple lattice replicated two times under three environmental conditions resulting in non-stress, intermediate stress and severe drought stress conditions. Apart from the targeted stress, the management of the trials was the same in all the three conditions. The non-stress condition continued to receive irrigation water once every week until the end of physiological maturity. In the intermediate stress condition, water stress was imposed by withdrawing irrigation water as from 6 weeks after planting until the end of the growing season, to enable drought stress at grain filling stage. The crop was allowed to mature only on stored soil water. In the severe stress condition, water stress was imposed by withdrawing irrigation water as from 5 weeks after planting to enable drought stress at flowering stage. The crop was allowed to mature only on stored soil water. Each entry was planted in a 3 m row plot spaced 0.75 m apart with 0.25 m spacing between plants within each row. Two seeds were planted in a hill and thinned to one plant after emergence to obtain a population density of approximately 53,333 plants per hectare. Data were taken on the following traits: days to 50% tasseling, days to 50% silking, anthesis-silking interval (ASI), plant height (cm), ear height (cm), leaf senescence, number of ears per plant and grain yield (kg/ha). Analysis of variance was carried out following the standard procedures using the generalized linear model (SAS Institute, 2004). The genotypic and phenotypic variances, genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were computed according to Singh and Chaudhary (1985). Genetic advance (GA) was estimated according to Falconer and Mackay, (1996).

RESULTS AND DISCUSSION

From the analysis of variance (Table 1), it is evident that highly significant ($P<0.01$) differences among the genotypes were observed for days to 50% tasseling non-stress and intermediate stress, plant height under non-stress and ear height under intermediate stress. Significant (<0.05) differences were observed for days to 50% silking and grain yield under non-stress and intermediate stress, ASI and height under non-stress and severe stress, plant height under intermediate stress and severe stress, leaf senescence under severe stress and number of ears per plant under intermediate stress. The significant differences observed for almost all the characters under different conditions indicate the presence of sufficient amount of variability in the genotypes under study. Such wide variation indicated the scope for improving the population for these characters.

Table 1 Analysis of variance for maize traits under non-stress, intermediate stress and severe stress conditions at Kadawa

		Days to 50% tasseling			**Days to50% silking**			**Anthesis-silking interval**			**Plant height**		
Source	**df**	**NS**	**IS**	**SS**	**NS**	**IS**	**SS**	**NS**	**IS**	**SS**	**NS**	**IS**	**SS**
Block(Rep)	14	11.92	16.49*	18.26	11.50	16.43*	18.33	0.71	0.76	1.45*	319.90*	719.68	477.17*
Rep	1	137.29**	45.01**	32.14**	130.72**	55.72**	31.08**	0.14	0.08	0.08	1460.61**	56.64	4007.79**
Genotype	55	50.89**	30.47**	24.16	51.55*	28.65*	28.15	0.96*	0.83	0.97*	429.95**	819.73*	777.27*
Error	41	7.56	7.57	8.65	7.86	8.01	9.15	0.40	0.30	0.30	199.04	186.93	113.47

		Ear height			Leaf senescence		Number of ears per plant			Grain yield		
Traits	df	NS	IS	SS	IS	SS	NS	IS	SS	NS	IS	SS
Block(Rep)	14	379.44	84.45*	74.64	0.54	2.81*	0.02	0.02	0.11*	3086024.50*	4417817.00*	156845.41
Rep	1	253.98**	540.41**	662.27**	8.04**	8.58**	0.01	0.92**	0.01	5630083.50**	11146848.53**	112879.51
Genotype	55	304.79*	153.91**	284.18*	0.74	3.19*	0.02	0.11*	0.04	4587458.00*	1163565.50*	686740.66
Error	41	95.10	39.48	64.56	0.28	0.20	0.01	0.01	0.01	1203363.80	381045.50	258501.14

*and **-significant at 0.05 and 0.01 probability level, respectively; NS=non-stress; IS=intermediate stress; SS=severe stress; df=degree of freedom; Rep=replication

The extent of variability in respect of the simple measures of variability like mean and range under non-stress, intermediate stress and severe stress conditions are presented in Table 2. The ranges of mean values revealed sufficient variation for all the traits under study. Under non-stress, maximum range of variability was observed for grain yield (666.67-5625.56 kg/ha) followed by plant height (91.84-172.84 cm) and ear height (46.67-95.00 cm). Under intermediate stress, maximum range of variability was observed for grain yield (444.44-3333.33kg/ha) followed by plant height (92.50-173.33 cm) and ear height (39.83-88.50 cm). Under severe stress, maximum range of variability was also observed for grain yield (444.44-2222.22 kg/ha) followed by plant height (67.69-141.33 cm) and ear height (33.83-69.34 cm).

Table 2 Descriptive statistics of maize traits under non-stress, intermediate stress and severe stress conditions at Kadawa

				Range					
	Mean			Minimum			Maximum		
Traits	**NS**	**IS**	**SS**	**NS**	**IS**	**SS**	**NS**	**IS**	**SS**
DYTS	62.00	60.00	66.00	57.00	54.00	58.00	71.00	72.00	75.00
DYSK	65.00	63.00	69.00	60.00	57.00	61.00	75.00	74.00	78.00
ASI	3.00	3.00	3.00	2.00	2.00	2.00	5.00	5.00	5.00
PLHT	142.04	132.02	114.75	91.84	92.50	67.69	172.84	173.33	141.33
EHT	73.55	65.63	49.17	46.67	39.83	33.83	95.00	88.50	69.34
SEN	-	1.39	3.11	-	1.00	1.00	-	3.00	7.00
EPP	1.08	1.04	0.70	1.00	1.00	0.35	1.77	1.45	1.75
GY	3037.88	1410.72	819.44	666.67	444.44	444.44	5625.56	3333.33	2222.22

NS=non-stress; IS=intermediate stress; SS=severe stress; DYTS=days to 50% tasseling; DYSK=days to 50% silking; PLHT=plant height; ASI= anthesis-silking interval; EHT= ear height; SEN=leaf senescence; EPP=number of ears per plant; GY=grain yield

Estimates of genotypic and phenotypic variances, GCVs and PCVs and genetic advance of traits of maize under non-stress, intermediate stress and severe stress conditions are presented in Table 3. Under non-stress, the genotypic variance ranged from 0.01 for number of ears per plant (indicating the least genotypic variation for the trait) to 1692047.10 for grain yield, (the highest genotypic variation), while the phenotypic variance ranged from 0.02 to 2293729.00 for the same traits, respectively. Under intermediate stress, the genotypic variance ranged from 0.05 for number of ears per plant to 391260.00 for grain yield, while the phenotypic variance ranged from 0.06 to 581782.75 for the same traits, respectively. Under severe stress, the genotypic variance ranged from 0.02 for number of ears per plant to 214119.76 for grain yield while the phenotypic variance ranged from 0.03 to 343370.33 for the same traits, respectively. High proportion of genetic variation implies that genetic variation plays an important role in the inheritance of yield attributes in maize. In general, phenotypic variances were higher than the corresponding genotypic variances for all the characters under study. Therefore expressions for most of the characters were genetic, which indicates that advances can be achieved in breeding programs. This finding is in agreement with the findings of Bello *et al*. (2007).

Genetic variability is essential in order to realize response to selection pressure. It has also been pointed out that the magnitude of genetic variability present in base population of any crop species is important in crop improvement and must be exploited by plant breeders for yield improvement. Under non-stress, the estimates of GCV (Table 3) were of high magnitude (>20%) for grain yield (43.74%), of moderate magnitude (10-20%) for ASI (17.64%) and ear height (13.92%), and of low magnitude (<10%) for days to 50% silking (7.51%), days to 50% tasseling (7.19%), plant height (7.56%) and number of ears per plant (6.55%). Under intermediate stress, the estimates of GCV (Table 3) were of high magnitude (>20%) for leaf senescence (47.96%), number of ears per plant (20.90%) and grain yield (45.49%), of moderate magnitude (10-20%) for ASI (17.16%) and plant height (13.47%) and ear height (11.53%) and of low magnitude (<10.00%) for days to 50% tasseling (5.61%) and days to 50% silking (5.10%). Under severe stress, the estimates of GCV (Table 3) were of high magnitude (>20%) for grain yield (57.73%), leaf senescence (40.76%) and ear height (21.31%), of moderate magnitude (10-20%) for ASI (19.29%), plant height (15.88%), number of ears per plant (17.50%), and of low magnitude (<10.00%) for days to 50% silking (4.47%) and days to 50% tasseling (4.22%).

Table 3 Estimates of variability and genetic advance of maize traits under non-stress, intermediate stress and severe stress conditions at Kadawa

	σ_g^2			σ_{ph}^2			GCV (%)			PCV (%)			GA (%)		
	NS	IS	SS	NS	IS	SS	NS	IS	SS	NS	IS	SS	NS	IS	SS
DYTS	21.67	11.45	7.76	25.45	15.24	12.09	7.51	5.61	4.22	8.14	6.51	5.27	12.30	8.68	6.00
DYSK	21.85	10.32	9.50	25.78	14.33	14.08	7.19	5.10	4.47	7.81	6.01	5.44	11.75	7.68	6.52
ASI	0.28	0.27	0.34	0.48	0.42	0.49	17.64	17.16	19.29	23.09	21.47	23.21	23.91	24.49	28.61
PLHT	115.46	316.40	331.90	214.98	409.87	388.64	7.56	13.47	15.88	10.32	15.33	17.18	9.84	21.01	26.04
EHT	104.85	57.22	109.81	152.40	76.96	142.09	13.92	11.53	21.31	16.78	13.37	24.24	20.50	17.64	33.25
SEN	-	0.23	1.50	-	0.37	1.60	-	47.96	40.76	-	60.83	42.10		48.28	67.67
EPP	0.01	0.05	0.02	0.02	0.06	0.03	6.55	20.90	17.50	9.26	21.92	20.20	11.62	31.35	39.93
GY	1692047.10	391260.00	214119.76	2293729.00	581782.75	343370.33	43.74	45.49	57.73	50.92	55.47	73.10	65.28	64.54	79.15

NS=non-stress; IS=intermediate stress; SS=severe stress; DYTS=days to 50% tasseling; DYSK=days to 50% silking; PLHT=plant height; ASI= anthesis-silking interval; EHT= ear height; SEN=leaf senescence; EPP=number of ears per plant; GY=grain yield; σ_g^2 =genotypic variance; σ_{ph}^2 =phenotypic variance; GCV=genotypic coefficient of variation; PCV=phenotypic coefficient of variation; GA=genetic advance

Since GCV compares the relative amount of variability among attributes, it could, therefore, be deduced that ear height under severe stress, leaf senescence under intermediate and severe stress, number of ears per plant under intermediate stress and grain yield under both conditions had higher amount of exploitable genetic variability among the attributes. It also signifies that there is greater potential for favourable advance in selection in these attributes when compared to others.

Under non-stress, the estimates of PCV (Table 3) were of high magnitude (>20%) for ASI (23.09%) and grain yield (50.92%), of moderate magnitude (10-20%) for ear height (16.78%) and plant height (10.32%), and of low magnitude (<10%) for days to 50% silking (7.81%), days to 50% tasseling (8.14%) and number of ears per plant (9.26%). Under intermediate stress, the estimates of PCV (Table 3) were of high magnitude (>20%) for leaf senescence (60.83%), ASI (21.47%), number of ears per plant (21.92%) and grain yield (55.47%), of moderate magnitude (10-20%) for plant height (15.33%) and ear height (13.37%) and of low magnitude (<10.00%) for days to 50% tasseling (6.51%) and days to 50% silking (6.01%). Under severe stress, the estimates of PCV (Table 3) were of high magnitude (>20%) for grain yield (73.10%), number of ears per plant (20.20%), leaf senescence (42.10%), ear height (24.24%) and ASI (23.21%), of moderate magnitude (10-20%) plant height (17.18%) and of low magnitude (<10.00%) for days to 50% silking (5.44%) and days to 50% tasseling (5.27%). High degree of genetic variability for most of the characters in the present investigation offers a greater scope for effective selection. In general, the magnitudes of PCVs were higher than the corresponding GCVs for all the characters under study indicating that these attributes had to some extent interacted with the environment. However, the differences between PCV and GCV were narrow indicating low environmental influence in the expression of these characters, thus suggesting greater possibilities of improvement through selection.

The genetic advances (GA) at 10% selection intensity for the traits studied are also presented in Table 3. Under non-stress, the estimates of GA were of high magnitude (>20%) for ASI (23.91%), ear height (20.50%) and grain yield (65.28%), of moderate magnitude (10-20%) for days to 50% tasseling (12.30%), days to 50% silking (11.75%) and number of ears per plant (11.62%) and of low magnitude (<10.00%) for plant height (9.84%). Under intermediate stress, the estimates of GA were of high magnitude (>20%) for ASI (24.49%), plant height (21.01%), leaf senescence (48.28%), number of ears per plant(31.35%) and grain yield (64.54%), of moderate magnitude (10-20%) for ear height (17.64%) and of low magnitude (<10.00%) for days to 50% tasseling (8.68%) and days to 50% silking (7.68%). Under severe stress, the estimates of GA were of high magnitude (>20%) for ASI (28.61%), plant height (26.04%), ear height (33.25%), leaf senescence (67.67%), number of ears per plant (39.93%) and grain yield (79.15%), and of low magnitude (<10.00%) for days to 50% tasseling (6.00%) and days to 50% silking (6.52%). The high genetic gain recorded for ASI and grain yields under the three conditions, plant height, leaf senescence and number of ears per plant under intermediate stress and severe stress and ear height under non-stress and severe stress may indicate that there is a better scope for their selection for genetic improvement of this crop. The low genetic gain recorded for days to 50% tasseling under and days to 50% silking under intermediate stress and severe stress, and plant height under non-stress signifies that there is no significant variability in these traits and hence may not be so useful in breeding program involving this crop.

CONCLUSION

The analysis of variance revealed considerable amount of variation for most of the characters studied which indicates the presence of appreciable variability in them which is a prerequisite for any crop improvement programme. The overall mean performance of the genotypes signifies that there is substantial variability within the germplasm which could be used in drought tolerant maize breeding programs to develop suitable hybrids and varieties. Maize grain yields under both conditions, leaf senescence under intermediate stress and severe stress, ear height under severe stress and number of ears per plant under intermediate stress can be improved by selection as these characters exhibited high PCV, GCV and genetic gain. Hence, these characters need to be given more emphasis in selection as these are expected to be controlled by additive genes. The breeder should adopt suitable breeding methodology to utilize both additive and non additive gene effects simultaneously, since varietal and hybrid development will go a long way in the breeding programmes especially in case of maize.

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