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ASSESSMENT OF GENETIC VARIABILITY IN S_2 MAIZE (*ZEA MAYS* L.) INBRED LINES UNDER STRESS CONDITION

B. Praveenkumar*, O. Sridevi[1] and P. M. Salimath

Department of Genetics and Plant Breeding, University of Agricultural Sciences, Dharwad-580 005 (Karnataka), India.
[1]Department of Genetics and Plant Breeding, Bijapur, India.

Abstract

In order to study the effect of drought stress on morphophysiologic characteristics, yield and yield components of 80 S_2 inbred lines of corn (*Zea maize* L.) along with twelve inbred lines, three composite populations and five checks an experiment was conducted in a lattice square design (10 x 10) with two replications under stress condition during summer season 2013-14, The results of analyze variance showed that under drought condition, there was a highly significant difference for 17 characters except relative water content at 60 days, relative water content at 90 days and number of kernel rows per cob. High heritability and high genetic advance as per cent mean was noticed for grain yield per plot, bulk cob weight, anthesis to silking interval and grain yield per plant revealed that variation in these characters is largely controlled by heritable factors. indicative of additive gene action. Thus, the heritability estimates will be reliable if accompanied by high genetic advance. Hence, these traits could be used as selection criteria for yield in maize under stress condition.

Key words : Maize, stress, genetic variability, yield and yield components.

Introduction

Maize (*Zea mays* L.; 2n = 20) is an important cereal crop with high yield potential. The total production at world level has surpassed both sorghum and pearl millet gaining a third place after wheat and rice. The demand for maize grain is increasing every year due to its diversified use in poultry, piggery and industry. In India, the maize occupies an area of 8.67 million hectares with the production of 22.25 million tonnes and the average productivity is 2566 kg/ha (Anonymous, 2013). The maize is cultivated in the state of Gujarat, Bihar, Andhra Pradesh, Karnataka, Madhya Pradesh, Rajasthan, Chattishgarh, Maharashtra, Tamil Nadu and Uttar Pradesh. The productivity of maize in India is increasing in recent years during *rabi* season particularly in the states of Bihar, Andhra Pradesh, Karnataka, Jharkhand and Madhya Pradesh. It is also widely believed that, in the very near future maize may become a staple food for human consumption if the demand for rice and wheat is not fulfilled through increased production.

Moisture stress is one of the major constraints in maize productivity. Moisture stress is very common in the areas where maize is predominantly grown under rainfed condition. Most of the world maize area is grown under rainfed conditions and maize is more susceptible to drought than all other cereals (Hall *et al.,* 1981). The unpredictability of drought, geographically and across seasons has emphasized the importance of drought tolerance as a maize breeding objective. The need to increase maize production in developing countries is hindered by a number of constraints including both abiotic and biotic stresses. Among the major abiotic stresses limiting tropical maize production are drought and low soil fertility. Most tropical maize is produced under rainfed conditions, in areas where drought is considered to be the most important abiotic constraint to production. Drought at any stage of crop development affects production, but maximum damage is inflicted when it occurs during flowering. Effects of drought stress include delayed silking and female sterility caused by abortion (Moss and Downey, 1971) resulting into a large reduction in grain yield. It was estimated that annual yield losses due to drought may approach 24 million tonns, equivalent to 17 per cent of a normal year's production in the developing world (Edmeades *et al.,* 1994).

Breeding for drought tolerance in maize is a complex task, because drought affects the different developmental stages of crop growth. Many breeders have focused on alleviating the effects of drought at flowering and during grain filling, because maize is most vulnerable to drought

***Author for correspondence :** E-mail: praveenbarurkar@gmail.com

at these stages. The characteristic of maize under drought stress is a delay in silking, resulting in an increase in the anthesis to silking interval (ASI), incomplete fertilization and decreasein kernel development (Hall *et al.*, 1981), by evaluating maize under moisture stress during flowering, it is possible to identify maize genotype capable of maintaining a shorter ASI and achieving the high grain yield. The success of genetic improvement in any character depends on the nature of variability present in the material or a gene pool for that character. Hence, assessment of existing variability for any character present in the material of a crop species is of utmost importance to a plant breeder for starting a judicious plant breeding programme. The genetic variability of lines and populations is important in hybrid development programs.

The present study was conducted to evaluate eighty maize inbred lines under drought stress for estimating their genetic variability.

Materials and Methods

The experiment was carried out at Botanical Garden, MARS Agriculture College, Dharwad (Karnataka), India. The weather data during total crop growth period indicated that mean minimum and maximum temperatures ranged from 14.5 to 36.9^{0}C, rainfall received during the period of crop growth was 382 mm 2013-14.

Eighty S_2 generation selfed seeds along with twelve inbred lines, three composite populations and five checks were raised in ear to progeny row by using lattice square design (10 × 10) during summer seasons 2013, with two replications under stress situation, in a plot size of one row of 4 m length with inter row and intra row spacing of 75 and 20 cm. Two seeds were dibbled per hill and later thinned to retain one seedling per hill. The eighty S_2 progenies under stress situation received recommended cultural practices but irrigation is given up to 30 days after sowing and no irrigation thereafter till harvest so that they experience moisture stress during flowering and grain filling period. Out of 20 plants maintained in a row, five competitive plants were chosen at random and tagged separately for observation, the mean of five observations were computed for all the characters. Observations recorded on morphological characteristics like days to 50 per cent tasseling, days to 50 per cent silking, plant height (cm), ear height (cm), maturity, Yield and yield related traits like cob length (cm), cob girth (cm), cobs per plant, number of kernel rows per cob, number of kernels per row, hundred grain weight (g), grain yield per plant (g), grain yield per plot (kg), shelling percentage and physiological parameters like as follows:

1. Anthesis-Silking Interval (ASI)

2. Relative water content

Relative water content expresses the water in the original sample as a percentage of the water in the fully hydrated tissue. It was estimated by following the method of Barrs and Weatherly (1962) at 60 and 90 DAS. Leaf discs of the third leaf from the top were collected (from five random plants) and weighed up to three decimals. This was taken as fresh weight of the tissue sample. The weighed leaf discs were floated in petridish containing distilled water and allowed to take up water for four hours. After four hours, leaf discs were blotted gently and weighed to get a turgid weight. After recording turgid weight, the leaf discs were dried in an oven at 80°C for 48 hours to get a dry weight. Then, RWC was calculated by using the following formula:

$$RWC = \frac{\text{Fresh weight (g)} - \text{Dry weight (g)}}{\text{Turgid weight (g)} - \text{Dry weight (g)}}$$

3. Chlorophyll content

The chlorophyll content of the third leaf from the top was measured at 60 and 90 DAS on five random plants using chlorophyll meter (SPAD-502, Konica Minolta make). The SPAD readings were recorded as the average value of chlorophyll at lower, upper and middle portion of the leaf of sample plant. SPAD reading is equivalent to chlorophyll content mg cm^{-2} (Herre *et al.*, 2001 and Teng *et al.,* 2004).

The data were analyzed in Windowstat software by using analysis of variance technique given by Panse and Sukhatme (1964). Phenotypic and genotypic components of variance were computed according to the formula given by Lush (1940) and Choudhary and Prasad (1968). Genotypic and phenotypic coefficients of variability were computed according to Burton and Devane (1953). Broad sense heritability was estimated as the ratio of genotypic variance to the phenotypic variance and was expressed in percentage (Hanson *et al.*, 1956). Genetic advance (GA) was computed according to the formula given by Johnson *et al.* (1955a).

Results and Discussion

Evaluation of 80 S_2 inbred lines was carried out during *rabi* season of 2013-14 under managed stress (drought) conditions to isolate inbred lines for drought tolerance. Variability is very important for improvement of any trait. The nature and magnitude of variation for different traits apart from mean performance decides the worth of the cross for exploitation after hybridization. Adopting the procedures described in the material and methods phenotypic and genotypic variances were computed for different traits. In order to know the nature and magnitude of variances for divergent traits, genetic parameters *viz.,* phenotypic and genotypic coefficients of variation, heritability in broad sense and genetic advance over mean were computed and presented in table 2. The analysis of variance indicated highly significant differences for 17 characters except relative water content at 60 days, relative water content at 90 days and number of kernel rows per cob (table 1). There is a considerable variation in the mean sum of square values for all the 17 traits. Genetic variability parameters of S2 progenies like mean, range and the components of genetic variability *viz.*, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), broad sense heritability and genetic advance as per cent mean (GAM) were worked out for the 20 quantitative characters. Results obtained in the present investigation for each character is presented in table 2.

Days to 50 per cent anthesis ranging from 53.0 to 78.0 with an average of 64.91 days (S_2) under stress condition. The variability parameters, like GCV (5.43%) and PCV (6.36%) exhibited low and S_2 progenies showed high heritability (73.0%) coupled with low genetic advance as per cent of mean (9.57%) under stress condition. Days to 50 per cent silking ranging from 54.0 to 85.0 with an average of 67.32 days (S_2) under stress condition. The genetic variability components, *viz.,* GCV (5.63%) and PCV (6.56%) exhibited low values and S_2 progenies showed high heritability (73.7%) coupled with low genetic advance as per cent of mean (9.97%) under stress condition. Days to anthesis to silk interval ranging from 1.0 to 7.0 with an average of 2.41 days (S_2) under stress condition. The genetic variability components, *viz.,* GCV (34.22%) and PCV (41.42%) exhibited high values and S_2 progenies showed high heritability (68.2%) coupled with low genetic advance as per cent of mean (58.24%) under stress.

At 60 days after sowing chlorophyll content ranging from 31.6 to 48.9% with an average of 41.9% (S_2) under stress condition. Genetic components of both GCV (7.34%) and PCV (7.55%) were low and S_2 progenies showed high heritability (94.7%) coupled with moderate and low genetic advance as per cent of mean (14.72%) under stress. At 90 days after sowing chlorophyll content ranging from 23.1 to 47.9 %with an average of 37.4%(S_2) under stress condition. The genetic variability components, *viz.,* GCV (7.03%) and PCV (8.72%) exhibited low and S_2 progenies showed high heritability (65.5%) coupled with low genetic advance as per cent of mean (11.68%) under stress. Relative water content at 60 days ranging from 0.3 to 0.94 %with an average of 0.69% (S_2) under stress condition. The genetic variability components, *viz.*, GCV (5.66%) and PCV (9.77%) exhibited low values and S_2 progenies showed low heritability (7.8%) coupled with moderate genetic advance as per cent of mean (15.7%) under stress. Relative water content at 90 days ranging from 0.24 to 0.86 %with an average of 0.58% (S_2) under stress condition. Genetic components of both GCV (2.48%) and PCV (9.75%) were low and S_2 progenies showed moderate heritability (50.0%) coupled with moderate genetic advance as per cent of mean (10.12%) under stress.

Plant height ranging from 112.3 to 278.0 cm with an average of 202.3cm (S_2) under stress condition. The genetic variability components, *viz.,* GCV (7.44%) and PCV (10.47%) exhibited low and moderate values and S_2 progenies showed high heritability (50.5%) coupled with moderate genetic advance as per cent of mean (10.89% under stress. Ear height ranging from 44.4 to 132.0 cm with an average of 91.1cm (S_2) under stress condition. Genetic components of both GCV (9.28%) and PCV (13.72%) were low and moderate values and S_2 progenies showed moderate heritability (45.8%) coupled with moderate genetic advance as per cent of mean (12.93%) under stress. Days to maturity ranging from 102.0 to 139.0 with an average of 122.0 days (S_2) under stress condition. The variability components of both GCV (3.46%) and PCV (4.92%) were low,S_2 progenies showed moderate heritability (49.6%) coupled with low genetic advance as per cent of mean (5.03%) under both stress.

Cob length ranging from 9.8 to 20.3cm with an average of 14.7cm (S_2) under stress condition. The genetic variability components, *viz.,* GCV (7.47%) and PCV (10.85%) exhibited low and moderate values and S_2 progenies showed moderate heritability (47.4%) coupled with moderate genetic advance as per cent of mean (10.6%) under stress. Cob girth ranging from 2.0 to 5.2 cm with an average of 4.16cm (S_2) under stress condition. Genetic components of both GCV (6.44%) and PCV (10.01%) were low and moderate and S_2 progenies showed high heritability (41.4%) coupled with low genetic advance as per cent of mean (8.53%) under stress.

Number of kernel rows per cob ranging from 10.2 to 18.9 with an average of 14.27 (S_2) under stress condition. The variability components of both GCV (2.25%) and PCV (6.67%) were low and S_2 progenies showed low heritability (11.4%) coupled with low genetic advance as per cent of mean (1.56%) under stress. Number of kernels per row ranging from 14.8 to 44.8 with an average of 31.1 (S_2) under stress condition. The genetic variability components, *viz*., GCV (9.25%) and PCV (13.16%) exhibited low and moderate values, Under stress S_2 progenies showed moderate heritability (49.4%) with

Table1: Analysis of variance for twenty characters in 80 S_2 progenies of maize inbred lines under stress situation

Characters	Source of variation					
	Replication MSS	**Treatments (Adjusted) MSS**	**Blocks within Reps (adj.)**	**Inter block error**	**CD at 5 %**	**CD at 1 %**
DF	1	99	18	81		
50% Tasseling(days)	42.32	34.085**	9.51	9.12	6.03	8.00
50% Silking (days)	35.28	39.096**	11.37	10.04	6.38	8.46
Anthesis silk interval (days)	0.32	1.994**	0.25	0.72	1.58	2.09
Chlorophyll @ 60 days	24.63	20.029**	0.79	1.13	2.05	2.71
Chlorophyll @ 90 days	1.21	21.356**	13.60	6.11	5.44	7.21
Relative water content @ 60 days	108.12	90.18	38.93	138.59	21.78	28.83
Relative water content @ 90 days	665.36	63.48	19.98	78.18	16.31	21.59
Plant height (cm)	2829.78	899.116**	478.09	438.01	41.99	55.67
Ear height (cm)	41.99	312.604**	158.70	172.00	25.84	34.20
Days to maturity (days)	359.12	72.207**	33.57	36.98	11.97	15.84
Cob length (cm)	128.02	5.147**	2.73	2.70	3.27	4.34
Cob girth (cm)	2.01	0.348**	0.16	0.21	0.90	1.19
Number of Kernel rows per cob	4.58	1.81	1.21	1.69	2.51	3.33
Number of Kernels per row	290.07	33.703**	18.32	16.77	8.22	10.89
Number of cobs	156.65	18.734**	1.75	3.19	3.40	4.49
Bulk Cob weight (g)	1596080.51	239136.647**	8962.29	21201.22	273.33	361.80
Grain yield per plot (kg)	1.06	0.173**	0.01	0.02	0.27	0.35
Grain yield per plant (g)	1276.24	265.146**	35.20	45.64	13.12	17.37
100-Seed weight (g)	131.38	21.236**	5.52	12.05	6.54	8.66
Shelling (%)	52.55	79.028**	14.31	27.80	9.99	13.22

moderate genetic advance as per cent of mean (13.4%). Number of cobs ranging from 4.0 to 26.0 with an average of 12.4 (S_2) under stress condition. Genetic components of both GCV (22.60%) and PCV (24.61%) were high and S_2 progenies showed high heritability (84.4%) coupled with high genetic advance as per cent of mean (42.77%) under stress.

Bulk cob weight ranging from 114 to 2237.0 with an average of 948.2g(S_2) under stress condition. The variability components of both GCV (34.99%) and PCV (36.46%) were high, S_2 progenies showed high heritability (92.1%) coupled with high genetic advance as per cent of mean (69.16%) under stress. Grain weight per plot ranging from 0.09 to 1.92kg with an average of 0.72kg (S_1) under stress condition. The genetic variability components, *viz*., GCV (38.52%) and PCV (40.68%) exhibited high values and S_1 progenies showed high heritability (92.10%) coupled with high genetic advance as per cent of mean(69.16%) under the stress condition. Grain weight per plant ranging from 19.5 to 79.9g with an average of 55.5g (S_2) under stress condition. The genetic variability components, *viz.,* GCV (18.93%) and PCV (20.72%) exhibited moderate and high values, S_2 progenies showed high heritability (83.5%) coupled with high genetic advance as per cent of mean (35.64%) under stress. Hundred seed weight ranging from 13.6 to 35.9g with an average of 22.8g (S_2) under stress condition. The variability components of both GCV (9.95%) and PCV (14.24%) were low and moderate.Under stress S_2 progenies exhibited moderate heritability(48.8%) and genetic advance as per cent of mean (14.32%). Shelling per centage ranging from 31.5 to 93.2% with an average of 74.9% (S_2) under stress condition. Genetic components of both GCV (6.91%) and PCV (8.38%) were low and S_2 progenies showed high heritability (67.9%) coupled with moderate genetic advance as per cent of mean (11.73% under stress.

To know the amount of variability for yield and yield contributing characters, 80 inbred lines were evaluated under stress condition. ANOVA revealed presence of highly significant differences for all morphological characteristics, physiological parameters and Yield and yield related traits studied in this investigation indicating high variability among the S_2progenies. This could be assessed through standardizing the genotypic and phenotypic variance and by obtaining coefficients of variability. Thus, components of variation, such as genotypic coefficient of variation (GCV) and phenotypic

Table2 : Estimation of genetic variability parameters in 80 S_2 progenies of maize inbred lines under stress situation

Characters	MEAN	Range		GCV (%)	PCV (%)	h^2 (Broad Sense)	GAM
		MIN	MAX				
50% Tasseling(days)	64.91	53.00	78.00	5.44	6.36	73.00	9.57
50% Silking (days)	67.32	54.00	85.00	5.64	6.57	73.70	9.97
Anthesis silk interval (days)	2.41	1.00	7.00	34.22	41.43	68.20	58.24
Chlorophyll @ 60 days	41.91	31.64	48.92	7.35	7.55	94.70	14.73
Chlorophyll @ 90 days	37.47	23.16	47.91	7.03	8.72	65.00	11.68
Relative water content @ 60 days	0.69	0.30	0.94	5.66	9.77	78.00	15.73
Relative water content @ 90 days	0.58	0.24	0.86	2.48	9.75	50.00	10.12
Plant height (cm)	202.33	112.30	278.00	7.45	10.48	50.50	10.90
Ear height (cm)	91.12	44.40	132.02	9.28	13.72	45.80	12.93
Days to maturity (days)	122.05	102.00	139.00	3.47	4.92	49.60	5.03
Cob length (cm)	14.77	9.80	20.31	7.48	10.86	47.40	10.61
Cob girth (cm)	4.16	2.00	5.20	6.44	10.02	41.40	8.54
Number of Kernel rows per cob	14.27	10.20	18.90	2.25	6.67	11.40	1.57
Number of Kernels per row	31.18	14.80	44.80	9.26	13.17	49.40	13.40
Number of cobs	12.44	4.00	26.00	22.61	24.61	84.40	42.78
Bulk Cob weight (g)	948.20	114.00	2237.00	34.99	36.47	92.10	69.16
Grain yield per plot (kg)	0.72	0.09	1.92	38.53	40.69	89.70	75.15
Grain yield per plant (g)	55.56	19.54	79.91	18.94	20.72	83.50	35.65
100-Seed weight (g)	22.88	13.68	35.97	9.95	14.24	48.80	14.33
Shelling (%)	74.93	31.50	93.27	6.91	8.39	67.90	11.74

coefficient of variation (PCV) were computed.

The estimates of heritability alone fail to indicate the response to selection (Johnson *et al*., 1955). Therefore, the heritability estimates appears to be more meaningful when accompanied by estimates of genetic advance. The genetic advance as per cent mean (GAM) was also estimated. The GCV and PCV were high for anthesis to silk interval (34.22% and 41.43%, respectively), grain yield per plot (38.53% and 40.69%, respectively), bulk cob weight (34.99% and 36.47%, respectively) and number of cobs (22.61% and 24.61%, respectively) Mani *et al.* (1996b), Choudhary and Choudhary (2002), Prakash *et al.* (2006) and Kuchanur (2010) noticed similar results. The high variability values among the inbred lines suggest that there is lot of scope for selection of high yielding superior inbred lines. Moderate values of genotypic coefficient of variation and phenotypic coefficient of variation were noticed for grain yield per plant. Similar results of moderate GCV and PCV were noticed by Mani *et al.* (1996b), Chaudhary *et al.* (2002), Kumar *et al* (2006), Prakash *et al.* (2006), Prashanth (2008) and Kuchanur (2010) and for 100-seed weight, ear height, number of kernels per row, cob length, plant height and cob girth the GCV was low and PCV was moderate.

For relative water content at 60 days, relative water content at 90 days, chlorophyll content at 90 days, shelling percentage, chlorophyll content at 60 days, number of kernel rows per cob, 50 per cent silking, 50 per cent anthesis and days to maturity the GCV and PCV was low. Mani *et al.* (1996b) and Prakash *et al.* (2006) reported similar results. High heritability values for chlorophyll content at 60 days, bulk cob weight, grain yield per plot, number of cobs, grain yield per plant, relative water content at 60 days, 50 per cent anthesis,50 per cent silking, anthesis to silking interval, shelling percentage and chlorophyll content at 90 days revealed that variation in these characters is largely controlled by heritable factors. Similar results for high heritability was reported by Sumathi *et al.* (2005), Alake *et al.*(2008) and Kuchanur (2010). Moderate heritability values for plant height, relative water content at 90 days, days to maturity, number of kernels per row, 100-seed weight, cob length ear height and cob girth showed that both genetics and environment played equal roles in the expression of these traits. And for number of kernel rows per cob low heritability it was influenced mostly by environment rather than genetic constitution. The results suggest that the yield components in maize are less influenced by environmental conditions. High heritability values for these traits indicate that the variation observed was mainly under genetic control and less influenced by environment. The characters showing high GCV and high heritability can be considered for selection.

High genetic advance as per cent mean was noticed for grain yield per plot, bulk cob weight, anthesis to silking interval, number of cobs and grain yield per plant indicative of additive gene action and low values are indicative of non-additive gene action (Singh and Marayanan, 1993). Thus, the heritability estimates will be reliable if accompanied by high genetic advance. reported similar results of high heritability coupled with high genetic advance by Mani *et al.* (1996b), Kumar *et al.* (2006), Prakash *et al.* (2006), Prashanth (2008) and Kuchanur (2010).

Conclusion

Under drought condition high genetic variation was observed for all the traits except relative water content at 60 days, relative water content at 90 days and number of kernel rows per cob. High heritability and high genetic advance as per cent mean was noticed for grain yield per plot, bulk cob weight, anthesis to silking interval and grain yield per plant revealed that variation in these characters is largely controlled by heritable factors indicative of additive gene action. Thus, these traits could be used as selection criteria for yield in maize.

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