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GENETIC VARIABILITY IN S_1 MAIZE (*ZEA MAYS* L.) INBRED LINES UNDER STRESS CONDITION

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Abstract

Two hundred S_1 generation selfed seeds of maize (*Zea mays* L.) alongwith their parents (nine) and few checks (sixteen) were raised in ear-to-row progenies during post rainy season 2012 with two replications were evaluated under stress condition by using lattice square design (15x15). The analysis of variance indicated highly significant differences for eighteen characters except relative water content at 60 days and relative water content at 90 days. Close resemblance between genotypic correlation coefficient (GCV) and phenotypic correlation coefficient (PCV) was observed for all traits indicating that selection for these characters would be effective. Heritability estimates in general were high for ten characters studied *viz.,* 50 per cent anthesis, 50 per cent silking, bulk cob weight, grain yield per plot, number of cobs, plant height, ear height, anthesis to silking interval, number of kernels per row and cob length. Highest heritability couple with high genetic advance as per cent of mean was observed for bulk cob weight, grain yield per plot, number of cobs, anthesis to silking interval and number of kernels per row. Thus, these traits could be used as selection criteria for yield in maize.

Key words : Maize, genotypic correlation coefficient, phenotypic correlation coefficient, heritability estimate, genetic advance.

Introduction

Maize is one of the third most important crop of world. Globally, maize is known as 'Queen of Cereals' because of its highest genetic yield potential among cereals. Maize is native to South America and has adapted significantly to temperate with much higher productivity. Being a C_4 plant, it is physiologically more efficient and has higher grain yield and wider adaptation over a range of environmental conditions. Due to the growing demand for dairy and meat products in developing countries and the decline in rice production in China and India, maize has been projected to become the most important crop by 2030 (Salvi *et al.,* 2007).

Maize has a wider range of uses than any other cereals as animal feed, human food and for hundreds of industrial purposes. 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

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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).

The choice of selection strategy is critical to breeding for stress tolerance, selection for drought avoidance or escape through earlier maturity can play a deciding role in whether a crop will yield anything, particularly in areas that have a very short growing season. However, given adequate rainfall, yield is positively correlated with late maturity in determinate annual crop like maize (Edmeades *et al.,* 1989). 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 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. Knowledge about genetic diversity of a crop allows more efficient and effective use of genetic resources in crop improvement programmes (Duan *et al.,* 2006). 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 two hundred 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 14.8 to 29.5^{0}C during 2012-13, rainfall received during the period of crop growth was 201.1 mm (2012-13).

Two hundred S_1 generation selfed seeds along with their parents (nine) and few checks (sixteen) were evaluated in lattice square design (15×15) during post rainy seasons with two replications under managed stress situation. Each selfed seed was grown in ear to progeny row, in a plot size of one row of 4 m length with inter row and intra row spacing of 75 and 20cm. Two seeds were dibbled per hill and later thinned to retain one seedling per hill. The genotypes under stress situation received recommended cultural practices but irrigation is given up to 20 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, the observations were recorded on five competitive plants in each progeny row were chosen at random and tagged. 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 fallows

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:

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

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; Teng *et al.,* 2004).

The data were analyzed in WINDOSTAT 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

The effect of stress on growth and yield manifest in varying degrees amongst the genotypes within the species. Maize is more susceptible to moisture stress at flowering (2 weeks before and after). Some genotypes of maize yield better than the others under moisture stress by reducing their anthesis to silking interval. Moisture stress affects almost all morpho-physiological and biochemical processes.

Evaluation of 200 S_1 inbredlines was carried out under managed stress (drought) conditions to isolate inbred lines for drought tolerance during *rabi* season of 2012-13. 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 18 characters except relative water content at 60 days and relative water content at 90 days (table 1). There is a considerable variation in the mean values for all the traits as indicated by highly significant mean squares for 18characters. Genetic variability parameters of S1 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 54.0 to 79.0 with an average of 65.8 days (S_1 progenies) under stress condition. The variability parameters, like GCV (6.58%) and PCV (6.09%) exhibited low and S_1 progenies showed high heritability (85.5%) coupled with moderate genetic advance as per cent of mean (11.59%) under stress condition. Days to 50 per cent silking ranging from 56.0 to 82.0 with an average of 68.2 days (S_1) under stress condition. The genetic variability components, *viz.*, GCV (6.25%) and PCV (6.78%) exhibited low values and S_1 progenies showed high heritability (84.9%) coupled with moderate genetic advance as per cent of mean (11.86%) under stress condition. Days to anthesis to silk interval ranging from 1.0 to 6.0 with an average of 2.4 days (S_1) under stress condition. The genetic variability components, *viz*., GCV (30.53%) and PCV (37.73%) exhibited high values and S_1 progenies showed high heritability (65.6%) coupled with high genetic advance as per cent of mean (50.93%) under stress condition.

At 60 days after sowing chlorophyll content ranging from 29.8 to 56.8% with an average of 39.9% (S_1) under stress condition. Genetic components of both GCV (5.19%) and PCV (8.07%) were low and S_1 progenies showed moderate heritability (41.3%) coupled with low genetic advance as per cent of mean (6.87%) under stress. At 90 days after sowing chlorophyll content ranging from 23.0 to 53.5% with an average of 38.5% (S_1) under stress condition. The genetic variability components, *viz.,* GCV (8.06%) and PCV (11.65%) exhibited low and moderate values, S_1 progenies showed moderate heritability (47.8%) coupled with moderate genetic advance as per cent of mean (11.48%) under stress.

Relative water content at 60 days ranging from 0.49 to 0.99% with an average of 0.70% (S_1) under stress condition. The genetic variability components, *viz.,* GCV (2.83%) and PCV (9.62%) exhibited low values and S_1 progenies showed low heritability (8.7%) coupled with low genetic advance as per cent of mean (1.71%) under stress. Relative water content at 90 days ranging from 0.33 to 0.77% with an average of 0.57 % (S_1) under stress condition. Genetic components of both GCV (1.94%) and PCV (8.04%) were low, S_1 progenies showed moderate heritability (47.0%) coupled with low genetic advance as per cent of mean (7.54%) under stress.

Plant height ranging from 103.0 to 263.6cm with an average of 189.7 cm (S_1) under stress condition. The genetic variability components, *viz.,* GCV (9.99%) and PCV (12.12%) exhibited low and moderate values and S_1 progenies showed high heritability (68.0%) coupled with moderate genetic advance as per cent of mean (16.98%) under stress. Ear height ranging from 42.2 to 130.0cm with an average of 85.9 cm (S_1) under stress condition. Genetic components of both GCV (13.06%) and PCV (16.05%) were moderate and S_1 progenies showed high heritability (66.2%) coupled with high genetic advance as per cent of mean (22.88%) under stress. Days to maturity ranging from 104.0 to 136.0 with an average of 120.8 days (S_1) under stress condition. The variability components of both GCV (3.67%) and PCV (4.76%) were low, and S_1 progenies showed moderate heritability (59.4%) coupled with low genetic advance as per cent of mean (5.83%) under stress.

Cob length ranging from 7.0 to 20.7cm with an average of 13.2 cm (S_1) under stress condition. The genetic variability components, *viz.,* GCV (11.87%) and PCV (14.98%) exhibited moderate values, S_1 progenies showed high heritability (62.8%) coupled with moderate genetic advance as per cent of mean (19.37%) under stress. Cob girth ranging from 1.18 to 5.0cm with an average of 3.8 cm (S_1) under stress condition. Genetic components of both GCV (8.16%) and PCV (11.95%) were low and moderate and S_1 progenies showed moderate heritability (46.6%) coupled with moderate genetic advance as per cent of mean (11.48%) under stress. Number of kernel rows per cob ranging from 6.0 to 19.6with an average of 13.5 (S_1) under stress condition. The variability components of both GCV (7.50%) and PCV (9.99%) were low and S_1 progenies showed moderate heritability (56.5%) coupled with moderate genetic advance as per cent of mean (11.62%) under stress. Number of kernels per row ranging from 9.0 to 49.8with an average of 25.8 (S_1) under stress condition. The genetic variability components, *viz.,* GCV (15.99%) and PCV (19.85%) exhibited moderate values, S_1 progenies showed high heritability (64.9%) coupled with high genetic advance as per cent of mean (26.53%) under stress. Number of cobs ranging from 2.0 to 39.0with an average of 13.0 (S_1) under stress condition. Genetic components of both GCV (30.91%) and PCV (36.20%) were high and S_1 progenies showed high heritability (72.9%) coupled with high genetic advance as per cent of mean (54.36%) under stress.

Bulk cob weight ranging from 59.0 to 2741g with an average of 916.7 (S_1) under stress condition. The variability components of both GCV (48.36%) and PCV (53.47%) were high, S_1 progenies showed high heritability (81.8%) coupled with high genetic advance as per cent of mean (90.09%) under stress. Grain weight per plot ranging from 0.03 to 2.12kg with an average of 0.68kg (S_1) under stress condition. The genetic variability components, *viz.,* GCV (45.14%) and PCV (51.19%) exhibited high values and S_1 progenies showed high heritability (77.70%) coupled with high genetic advance as per cent of mean (81.99%) under the stress condition. Grain weight per plant ranging from 4.0 to 151.3g with an average of 51.8 (S_1) under stress condition. The genetic variability components, *viz.,* GCV (25.02%) and PCV (34.72%) exhibited high values, S_1 progenies showed moderate heritability (51.8%) coupled with high genetic advance as per cent of mean (37.08%) under the stress condition. Hundred seed weight ranging from 11.9 to 34.5g with an average of 20.4 (S_1) under stress condition. The variability components of both GCV (10.93%) and PCV (15.40%) were moderate and S_1 progenies showed moderate heritability (50.4%) coupled with moderate genetic advance as per cent of mean under stress (15.98). Shelling per centage ranging from 30.1 to 98.5 % with an average of 74.4 % (S_1) under stress condition. Genetic components of both GCV (4.5%) and PCV (9.77%) were low, S_1 progenies showed low heritability (21.8%) coupled with low advance as per cent of mean (4.39 %) under stress.

To know the amount of variability for yield and yield contributing characters, 200 inbred lines were evaluated under stress condition. ANOVA revealed presence of highly significant differences for all Morphological characteristics, Physiological parameters and yield related traits studied in this investigation indicating high variability among the S_1 progenies. This was also evidenced by wide range values for all the traits under study. Therefore, there is lot of scope for selection for majority of the traits in the progenies. Absolute variability of different characters does not reveal which of the particular characters are showing the highest variability. 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 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. A wide range of variation for bulk cob weight, grain yield per plot, number of cobs, anthesis to silk interval

Table 1 : Analysis of variance for twenty characters in 200 S_1 progenies of maize inbred lines under stress situation.

Characters	Source of variance					
	Replication MSS	Treatments (Adjusted) MSS	Blocks within Reps (adj.)	Interblock error	CD at 5%	CD at 1%
DF	1	224	28	196		
50% Tasseling(days)	9.68	0.886**	0.44	0.44	1.31	1.73
50% Silking (days)	0.11	33.137**	3.10	2.72	3.28	4.33
Anthesis silk interval (days)	7.74	35.029**	4.22	3.20	3.60	4.75
Chlorophyll @ 60 days	920.41	14.331*	6.61	11.84	6.59	8.69
Chlorophyll @ 90 days	5.60	15.81	7.69	14.13	7.19	9.48
Relative water content @ 60 days	0.15	0.008**	0.002	0.002	0.087	0.115
Relative water content @ 90 days	0.39	0.01	0.012	0.005	0.147	0.193
Plant height (cm)	9116.10	1141.625**	152.72	138.34	23.35	30.79
Ear height (cm)	10925.18	410.813**	157.48	161.37	25.03	33.00
Days to maturity (days)	355.56	44.484**	30.28	20.95	9.27	12.23
Cob length (cm)	58.45	9.687**	0.38	0.27	1.04	1.37
Cob girth (cm)	0.37	0.223**	0.03	0.04	0.40	0.53
Number of Kernel rows per cob	2.28	2.282**	0.63	1.43	2.27	3.00
Number of Kernels per row	308.15	60.963**	2.34	2.04	2.84	3.75
Number of cobs	18.40	14.508**	1.34	0.70	1.74	2.30
Bulk cob weight (g)	618123.74	386755.861**	3651.17	5176.93	139.15	183.45
Grain yield per plot (kg)	201358.58	298885.73**	4969.80	5165.85	141.30	186.28
Grain yield per plant (g)	0.20	0.299**	0.01	0.01	0.14	0.19
100-Seed weight (g)	338.82	27.395**	2.83	1.57	2.59	3.42
Shelling (%)	543.82	144.419**	19.42	34.69	11.28	14.88

and grain yield per plant was noticed in the present investigation. A narrow difference between GCV and PCV indicate that they are less influenced by environment.

The character also showed high GCV and PCV values with high heritability and GAM, indicating that it is controlled by additive gene action and less influenced by environment. The other characters differed in the extent of their variation as measured by the coefficients of variation. The magnitude of genotypic coefficient of variation was low as compared to that of phenotypic coefficients of variation in all the traits studied. The GCV and PCV were high for bulk cob weight (48.36% and 53.47% , respectively), grain yield per plot (45.14% and 51.19% , respectively), anthesis to silk interval (30.53% and 37.73%, respectively), number of cobs (30.91% and 36.20%, respectively) and grain yield per plant (25.02% and 34.72%, respectively) Mani *et al.* (1999b), Choudhary and Choudhary (2002), Rafique *et al*. (2004), Prakash *et al*. (2006) Prashanth (2008), Alake *et al.* (2008), Kuchanur (2010) and Salman (2011) observed similar results. The high variability values for bulk cob weight, grain yield per plot, anthesis to silk interval, number of cobs and grain yield per plant 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 number of kernels per row, ear height, 100-seed weight, cob length and plant height. Similar results of moderate GCV and PCV were observed by Mani *et al.* (1996b), Chaudhary *et al.* (2002), Kumar *et al.* (2006), Prakash *et al.* (2006), Prashanth (2008), Alake *et al.* (2008), Kuchanur (2010) and Salman (2011). And, for cob girth and chlorophyll content at 90 days the GCV was low and PCV was moderate. For number of kernel rows per cob, shelling percentage, relative water content at 60 days, chlorophyll content at 60 days, relative water content at 90 days, 50 per cent silking, 50 per cent anthesis and days to maturity the GCV and PCV was low. Similar results were reported by Mani *et al.* (1996b), Prakash *et al.* (2006), Kumar *et al.* (2006), Prashanth (2008), Alake *et al.* (2008) and Kuchanur (2010).

High heritability values for 50 per cent anthesis,50 per cent silking, bulk cob weight, grain yield per plot,

Table 2 : Estimation of genetic variability parameters in 200 S_1 progenies of maize inbred lines under stress situation.

Characters	Mean	Range		GCV%	PCV%	h² (Broad Sense)	GAM 5%
		Min.	Max.				
50% tasseling (days)	68.43	59.00	80.00	5.70	5.95	0.92	11.23
50% Silking (days)	70.62	61.00	84.00	5.64	5.93	0.91	11.05
Anthesis silk interval (days)	2.19	1.00	4.00	21.48	30.38	0.50	31.28
Chlorophyll @ 60 days	42.63	28.60	49.80	2.94	6.28	0.22	2.84
Chlorophyll @ 90 days	36.54	26.70	45.80	3.05	7.69	0.16	2.49
Relative water content @ 60 days	0.73	0.42	0.94	7.87	8.97	0.77	14.23
Relative water content @ 90 days	0.47	0.30	0.76	4.92	12.16	0.16	4.11
Plant height (cm)	196.05	119.60	269.80	11.41	12.19	0.88	22.02
Ear height (cm)	104.31	33.60	129.90	10.71	13.74	0.61	17.19
Days to maturity (days)	120.87	104.00	134.00	2.77	3.90	0.50	4.04
Cob length (cm)	17.66	10.75	24.15	12.28	12.46	0.97	24.94
Cob girth (cm)	4.40	3.25	5.30	6.85	7.58	0.82	12.75
Number of Kernel rows per cob	14.74	12.00	18.00	4.68	7.25	0.42	6.23
Number of Kernels per row	34.11	18.50	48.59	15.91	16.19	0.97	32.20
Number of cobs	7.94	1.00	16.00	33.00	33.92	0.95	66.11
Bulk cob weight (g)	885.63	52.00	2748.00	49.33	49.65	0.99	-
Grain yield per plot (kg)	0.70	0.04	2.37	54.56	55.03	0.98	-
Grain yield per plant (g)	84.02	24.50	188.58	25.88	27.43	0.89	50.30
100-Seed weight (g)	22.96	13.24	35.67	15.60	16.12	0.94	31.11
Shelling (%)	77.33	41.02	98.15	9.66	10.99	0.77	17.50

Note : Non-estimable due to high parental variances.

number of cobs, plant height, ear height, anthesis to silking interval, number of kernels per row, and cob length revealed that variation in these characters is largely controlled by heritable factors. Similar results for high heritability was reported by Sumathi *et al.* (2005) Prashanth (2008), Alake *et al.* (2008), Kuchanur (2010) and Salman (2011). Moderate heritability values for days to maturity, number of kernel rows per cob, grain yield per plant, 100-seed weight, chlorophyll content at 90 days, relative water content at 90 days, cob girth and chlorophyll content at 60 days showed that both genetics and environment played equal roles in the expression of these traits. And, for shelling percentage and relative water content at 60 days 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. Similar results for moderate and low heritability was reported by Prashanth (2008), Alake *et al.* (2008), Kuchanur (2010) and Salman (2011).

High genetic advance as per cent mean was noticed for bulk cob weight, grain yield per plot, number of cobs, Anthesis to silking interval, grain yield per plant, number of kernels per row and ear height 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), Kumar *et al.* (2006), Prashanth (2008), Alake *et al.* (2008), Kuchanur (2010) and Salman (2011).

Conclusion

The study suggested that inbred lines were highest heritability couple with high genetic advance as per cent of mean was observed for bulk cob weight, grain yield per plot, number of cobs, anthesis to silking interval and number of kernels per row. Thus, these traits could be used as selection criteria for yield in maize because it indicates the importance of additive gene action and having broader genetic makeup and high yielding traits under drought conditions might be exploited in breeding programs for the development of drought tolerant maize hybrids/ varieties.

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