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GENETIC ANALYSIS OF TROPICAL MAIZE (*ZEA MAYS* L.) INBRED LINES UNDER HEAT STRESS

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ABSTRACT

The present investigation was carried out with the objective of estimating the genetic variability, heritability and genetic advance of key traits in tropical maize inbred lines .Analysis of variance revealed significant differences among the inbred lines for all the characters studied except for cob length,The PCV values were greater than GCV values for all the characters indicating considerable influence of environment on the expression of traits. High magnitude of GCV and PCV values were reported for an the sissilking interval (32.27 and 47.68), pollen shed duration (70.3 and 106.38), 100 grain weight (20.97 and 27.49), shelling per cent (28.18 and 35.30), grains per cob (95.56 and 104.4) and grains yield per plant (113.99 and 135.84). Broad sense heritability ranged from 34 per cent for cob length to 89 per cent for number of days to male flowering. High heritability along with high genetic advance as per cent of mean was observed for ear height (73% and 22.71), cob girth (67% and 21.16), shelling per cent (64% and 46.28), grains per cob (84% and 180.19) and grain yield per plant (70% and 197.04), favoring simple selection for the traits in early generations for developing heat tolerant maize.

INTRODUCTION

Maize is known as queen of cereals because of its highest genetic yield potential among the cereals. Although maize was first domesticated in Mexico,the presence of immense genetic diversity has led to cultivation in diverse climatic conditions ranging from 58° N to 40°S in areas with 250 mm to more than 5000 mm of rainfall per year.In India maize is cultivated year round with an area of 9.50 m ha producing 23.29 milliontonof grain yield(India maize summit, 2014). The average maize productivity (2.45 t ha^{-1}) of Indian soils was much lesser than most of the maize growing countries of the world.

Despite lesser productivity, maize production in India was severely hampered by increased temperatures. It was predicted that the global mean temperature would rise by 0.3°C per decade reaching to approximately 1°C and 3°C above the present value by years 2025 and 2100, respectively(IPCC, 2007). Moreover, a slight increase in temperature by 2°C reduce maize yield by 13 per cent while a 20 per cent increase in intra seasonal variation reduces maize yield by only 4.5 per cent (Rowhani *et al*., 2011; Lobell *et al*., 2011; Deryng *et al*., 2014).There were no extensive breeding efforts for heat stress tolerance in tropical and subtropical maize (Cairns *et al*., 2012). Under this concern, to self sustain the maize production in India for growing demand, there is an immense need for development of hybrids tolerant for heat stress. The success of any breeding program mainly depends upon extent of genetic variability present in the germ plasm and heritability of the traits (Mather and Jinks, 1983). Moreover, the variability present in the population is directly proportional to the selection for desirable types (Vavilov, 1951). The heritability of a character denotes the extent to which the trait is transferred next generation.The fixation of characters in improving the genotype by selection mainly depends on its heritability. The study of heritability and genetic advance of yield contributing traits helps in selection of best genotype to mitigate the any stress than heritability alone (Johnson *et al*., 1955). Genetic variability studies in tropical maize under heat stress were previously reported by Khodarahmpour, 2012; Khodarahm pour and Choukan, 2011; Hussain *et al*., 2006. The reports on heritability and gene action of the traits in tropical maize under heat stress conditions was very scanty. This study aims at providing preliminary knowledge about the gene action and inheritance of different traits under heat stress for developing the heat resiliuent maize.

MATERIALS AND METHODS

The present investigation was carried out during summer 2014 at International Maize and Wheat Improvement Center (CIMMYT) Hyderabad, ICRISAT, located at 17°53′ N latitude and 78°27′ E longitude with an altitude of 545 m above mean sea level. The experimental material consists of 75 tropical maize inbred lines, which serve as source for developing heat tolerant hybrids. The in breds were laid out in á-lattice design, randomized and sown in two replications, accommodating 150 plots. Each plot had two rows with net plot size of 3m length.The inter row spacing of 75 cm X 20 cm was maintained. The recommended dose of fertilizers (150:75:37.5 NP_2O5 K_2O kg ha^{-1}) was given to the crop. Data on climatic parameters such as relative humidity, minimum and maximum temperature recorded at experimental site during crop growth period are presented Fig. 1.

The observations recorded during crop period for important secondary traits *viz*., days to 50% anthesis, days to 50% silking, pollen shed duration, anthesis silk interval, plant height, ear height, cob length, cob girth, 100 grain weight, shelling per cent, grains per cob and grain yield per plant. The Analysis of variance of the data was analyzed using SAS. The genetic parameters of the traits like PCV, GCV, GA and GAM were analyzed in excel using following formulae.

Phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV)

The PCV and GCV of all the traits was calculated as suggested by Burton and Devane (1953) using following formulae

Phenotypic coefficient of variation (PCV) $= \frac{\sigma p}{\bar{X}} \text{ X } 100$

Genotypic coefficient of variation(PCV) $= \frac{\sigma g}{\bar{X}} \text{ X } 100$

Where,

s_p = Phenotypic standard deviation

s_g = Genotypic standard deviation

$\bar{X}$ = Grand mean

GCV and PCV values were categorized as low, moderate and high values as indicated by Sivasubramanian and Menon (1979) as below.

1-10%	:	Low
11-20%	:	Moderate
20% and above	:	High

Heritability (h^2)

Heritability in broad sense for all the characters was computed as suggested by Lush (1949).

$$h^2 = \frac{\sigma^2 g}{\sigma^2 p} \text{ x } 100$$

Expected genetic advance as a percent of mean $= \frac{GA}{\bar{X}} \text{ X } 100$

Where,

h^2 = Broad sense heritability

$\acute{o}^2g$ = Genotypic variance

$\acute{o}^2p$ = Phenotypic variance

Heritability was classified in to low (0-30 %), moderate (31-60 %) and high (>61 %) as suggested by Johnson*et al*. (1955).

Genetic advance (GA)

Genetic advance for each character was predicted by the formula given by Johnson *et al*. (1955).

$GA = h^2 \times \acute{o}_p \times K$

Where,

K = Constant selection differential at 5% level intensity (= 2.06)

$\acute{o}_p$ = Phenotypic standard deviation

h^2 = Heritability in broad sense

Genetic advance as percent of mean (GAM)

The formula of Genetic advance as percent of mean was as follow:

Where,

GA = genetic advance

$\bar{X}$ = Grand mean

The genetic advance as per cent of mean was categorized into three classes and which was suggested by Johnson *et al*. (1955).

Low	:	0-10 per cent
Moderate	:	10-20 per cent
High	:	more than 20 per cent

RESULTS AND DISCUSSION

The presence of genetic variability in the breeding material is foremost important for any crop improvement programme and its exploitation will result in solution for different biotic and abiotic stresses. In the present study, the analysis of variance among 75 inbred lines in respect of all the characters (days to 50% anthesis, days to 50% silking, pollen shed

Table 1: Analysis of variance for morphological and yield attributing traits in inbreds under heat stress condition

Character	Mean Sum of Square Source of variation Replication	Genotype	Block(Rep)	Error
Days to 50% anthesis	2.15	32.37**	2.06	1.83
Days to 50% silking	20.40	30.85**	4.07	2.62
Anthesissilking interval	12.19	4.67**	1.55	1.74
pollen shed duration	6.17	5.81**	2.61	2.29
Plant-height (cm)	93.18	150.32**	60.81	25.36
Ear height (cm)	36.59	126.32**	41.24	19.89
Cob length (cm)	1.26	2.65	2.30	1.35
Cob girth (cm)	0.42	2.65**	1.10	0.53
Shelling per cent	469.00	639.56*	177.29	142.09
100 Grain weight (g)	23.41	31.69**	6.76	9.80
Grains per cob	769.77	7455.48**	1226.05	658.07
Grain yield per plant (g)	1525.61	24777.83**	5099.94	4301.80

*, ** indicate level of significance at 5 and 1 per cent, respectively.

Table 2: Genetic component of variation for morphologicaland yield attributing traits in inbred lines under heat stress conditions.

Character	GCV (%)	PCV (%)	h^2_{BS} (%)	GAM @ 5%
Days to 50% anthesis	6.74	7.13	89	13.11
Days to 50% silking	6.30	6.86	84	11.92
Anthesis to silking interval	32.27	47.68	46	44.98
Pollen shed duration	70.13	106.38	43	95.24
Plant height (cm)	7.96	9.43	71	13.82
Ear height (cm)	12.92	15.15	73	22.71
Cob length (cm)	9.44	16.16	34	11.37
Cob girth (cm)	12.56	15.36	67	21.16
Shelling per cent	28.16	35.30	64	46.28
100 Grain weight (g)	20.97	27.49	53	29.89
Grains per cob	95.56	104.41	84	180.19
Grain yield per plant (g)	113.99	135.84	70	197.04

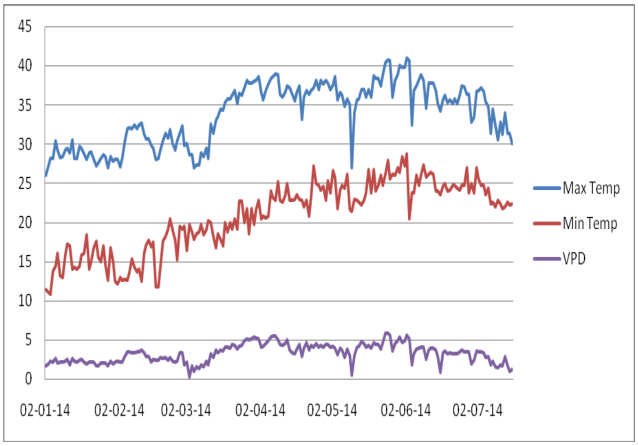

Figure 1: Weather data during crop growth stage

duration, anthesis silk interval, plant height, ear height, cob girth, 100 grain weight, shelling per cent, grains per cob and grain yield per plant) except cob length under heat stress showed significant difference, indicating that sufficient genotypic variability was present for traits under study. The population used for current study includes inbred lines from diverse source which may be the reason for significant difference in respect of traits among the inbred lines. Similar results were reported by Angadi *et al*. (2014) for different trait under heat stress. The results of ANOVA for different traits are presented in Table 1.

The genetic components of variation for traits studied under heat stress in present investigation showed low to high phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV). As expected, the PCV values were greater than the GCV values for all the characters under abiotic stress (Santosh *et al*., 2013), indicating considerable influence of environment on the expression of these characters under field conditions. The highest PCV was observed for grain yield per plant (135.84) followed by pollen shed duration (106.38), grains per cob (104.41) and ASI (47.68) and lowest PCV was observed for Days to 50% silking (6.86). The GCV values were high for grain yield per plant (113.99) followed by grains per cob (95.56) and lowest for Days to 50% silking (6.30).The GCV values for all the traits fallowed similar trend as PCV.Under heat stress ,Khodarahmpour(2012) and Khodarahmpour and Choukan. (2011) reported high PCV for grains per cob ,grain yield per plant and ASI, which were in accordance with our results.

The knowledge of heritability enables the plant breeder to decide the course of selection procedure to be followed under a given situation. Highest heritability was observed for days to 50 % anthesis (89 %) and lowest for cob length (34 %). It was known that heritability alone does not provide indication of the amount of genetic improvement that would result from selection of individual genotypes. High heritability estimates along with the high genetic advance reveals the presence of lesser environmental influence and prevalence of additive gene action in expression of traits, is usually more helpful in predicting gain under selection (Johanson *et al*., 1955)

In the present study, High heritability along with high genetic advance as per cent of mean was observed for ear height, cob girth, shelling per cent, grains per cob and grain yield per plant, indicating additive gene action controlling these traits with lesser influence of environment, favoring simple selection in early generations for crop improvement. Similar, results were reported by Angadi *et al*. (2014) for these traits. The traits like ear girth, plant height, ear height and 100 grain weight showed high heritability accompanied with high to moderate GCV and genetic advance as per cent mean was reported from our study. This indicates the heritability for these traits is due to additive gene effect (Azam *et al*., 2014). A very high genetic advance as per cent of mean along with high heritability was observed for grains per cob (180.7 %) and grain yield per plant (197 %)in the present study were in consistent with earlier results reported by Azam *et al*.(2014) under drought stress .The traitcob length showed moderate heritability with moderate GAM, indicating both additive and non-additive gene action governing the trait. Selection for this trait should be done carefully to get gain from selection (Hasan *et al*., 2015).

The findings indicate that there exists adequate genotypic variation among the inbred line with high PCV and GCV for anthesissilking interval, pollen shed duration, 100 grain weight, shelling per cent, grains per cob and grains yield per plant indicating wide range of genetic variability in the germplasm,providing ample scope for selection of desirable lines. High heritability along with high genetic advance as per cent of mean observed for shelling per cent, grains per cob and grain yield per plant with high PCV and GCV indicating additive gene action controlling the traits, favoring simple selection in early generations for crop improvement.

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