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Genetic Analysis of Tassel and Ear Characters in Maize (*Zea mays* L.) Using Triple Test Cross

Parvez A. Sofi
Division of Plant Breeding and Genetics, SKUAST-K, Shalimar, 191121, India

Abstract: The genetic architecture of tassel and ear traits was studied by triple test cross design. Fifteen diverse white maize inbred lines (Four local and 11 exotic) viz., WI-9, W-6, W-7, GLET-7, GLET-27, CML-77, CML-79, CML-111, CML-38, CML-173, CML-213, CML-214, CML-240, CML-244 and 463 were crossed with three testers W3, 5 and W3×5. The test crosses were generated in 2004 at winter maize nursery, Amberpet (Hyderabad). The parental lines, testers and crosses were evaluated at two diverse locations of Kashmir valley viz., Larnoo and Wadura in RBD with three replications at each location. Analysis of variance for detection of epistasis revealed significant epistasis as well as its components for all traits except tassel branch number and ear length for which additive interaction was non-significant. The epistasis as well its components interacted significantly with environment except for tassel length where interaction component was non-significant. The estimates of genetic components of variance revealed that both additive and dominance components were significant for all traits except ear diameter where dominance component was non-significant. The correlation between tassel and ear traits revealed strong correlation between tassel branch number and ear height (0.72%) followed by tassel branch number and ear length (0.548), tassel length and tassel weight (0.416). Negative correlation was recorded between tassel length and weight with ear length. Selecting for upright tassel branches may compensate for yield reduction without comprising on tassel size to ensure sufficient pollen availability, especially in hybrid seed production and stress environments.

Key words: Tassel and ear traits, triple test cross, genetic analysis, hybrid seed

INTRODUCTION

Tassel branch number, tassel length and tassel weight are important tassel characters while as ear height, ear length and ear diameter are important ear characters that affect maize plant yielding efficiency. The tassel traits affect grain yield either physiologically by competing for photosynthates or physically by shading effect (Gue and Wasson, 1996). It has been generally found that low yielding plants produce large tassels by directing more photosynthates. Therefore, plant breeders have generally selected for small tassel as it has been found to be negatively correlated with grain yield. However, in hybrid breeding programmes an ideal male parent is supposed to have large tassels that can produce large amount of pollen whereas, an ideal female should partition more towards big ears and hence should possess small tassels (Upadyayula *et al*., 2006).

The nature of gene action involved in inheritance of tassel traits can help breeders to devise better selection strategies, to seek improvement in these traits in desired direction. Most of the studies have revealed that additive gene action is predominant in the inheritance of tassel and ear traits whereas, few studies have come up with evidence for non-additive gene action such as dominance and epistasis (Schuetz and Mock, 1978; Gue and Wasson, 1996; Berke and Rocheford, 1999; Wolf and Hallauer, 1997; Hinze and Lamkey, 2003). Therefore the present investigation was undertaken to elucidate the nature of gene action for tassel and ear traits in maize using triple test cross mating design (Kearsey and Jinks, 1968).

MATERIALS AND METHODS

The material for present study was generated by crossing 15 white inbred lines (Four local and 11 exotic) of maize viz., WI-9, W-6, W-7, GLET-7, GLET-27, CML-77, CML-79, CML-111, CML-138, CML-173, CML-213, CML-214, CM-240, CML-244 and CML-463 with three testers W3, 5 and W3×5. The test crosses were generated in 2004 at winter maize nursery, Amberpet (Hyderabad). The parental lines, testers and crosses were evaluated at two diverse locations of Kashmir valley viz., Larnoo and Wadura in RBD with three replications at each locations. Data was recorded for three tassel traits viz., tassel branch number, tassel length and tassel weight and three ear characters viz., ear height, ear length and ear diameter from 10 competitive plants from each replication and analyzed as per the procedure of Ketata *et al.* (1976) which is based on the original model proposed by

Kearsey and Jinks (1968). Triple test cross procedure is an efficient genetic model and is applicable to segregating and non-segregating populations arising from F2, Backcross or homozygous lines. Besides, it is independent of gene frequency, linkage relationship and degree of inbreeding. In addition to the detection of epistasis, it provides unambiguous estimates of additive and dominance components in absence of epistasis. The basic model for Kearsey and Jinks (1968) model is;

$$L_{ijk} = M + G_{ij} + r_k + E_{ijk}$$

Where:

L_{ijk} = Phenotypic value of cross between tester L_i and line j in replication K.

M = Genotypic value of the cross between tester Li and line j.

rk = Effect of k^{th} replication and

E_{kjk} = Error associated with cross ij in replication K

The epistatic components i.e., total epistasis, [I] type [j +l] type were tested against their environmental interaction which in turn were tested, for significance, against their block×environment interactions. The degree of dominance was calculated as (H/D) ½ and the direction of dominance was determined by the correlation coefficient between corresponding sums (L_{1i}+L_{2i}) and differences (L_{1i}-L_{2i}).

RESULTS AND DISCUSSION

Analysis of variance for detection of epistasis (Table 1) revealed significant epistasis as well as its components i.e., [I] and [j+l] for all traits except tassel branch number and ear length for which additive interaction was non-significant. Comparatively the magnitude of non-fixable epistasis [j+l] was greater than the fixable component [I] for tasel branch number, tassel length and ear length whereas, reverse was the case with rest of the traits. The epistasis as well its components interacted significantly with environment except for tassel length where interaction component was non-significant. Comparatively [I] type epistasis interacted with environment more strongly as compared to [j+l] type, indicating that fixable component is more prone to environmental variations, besides reinforcing the need to conduct experiments involving genetic components across environments to get reliable estimates. Earlier studies have also reported epistasis to be an integral part of genetic variance for tassel and ear traits (Schuetz and Mock, 1978); Wolf and Hallauer, 1999; Azizi *et al.*, 2006).

The estimates of genetic components of variance (Table 2) revealed that both additive and dominance components were significant for all traits except ear diameter where dominance component was non-significant. Additive component was greater in magnitude than the corresponding estimates of dominance component except for tassel length. Both additive and dominance components interacted with the environment except for ear height and ear diameter. Besides for tassel branch number and ear length G2H and G2D estimates were, respectively non-significant. For most of the traits G2D estimates were greater than G2H, indicating greater vulnerability of additive genetic variance. The degree of dominance was in the range of partial dominance for all traits except tassel length for which it was over-dominance. The direction of dominance was non-significant for all traits indicating ambi-directional nature of dominance. Similar results have been reported in maize by Gue and Wassn (1996) Berke and Rocheford (1999).

The correlation between tassel and ear traits (Table 3) revealed strong correlation between tassel branch number and ear height (0.72%) followed by tassel branch number and ear length (0.548), tassel length and tassel weight (0.416). Negative correlation was recorded between tassel length and weight with ear length. A number of previous workers have reported similar findings (Berke and Rocheford, 1999; Mickelson *et al.*, 2002; Upadyayula *et al.*, 2006).

Maize breeders have found conflicting interests in selection of tassel traits. From the standpoint of yielding efficiency and shading effect, a smaller tassel is ideal but in case of certain situations such as hybrid breeding and stress environments larger tassels are selected for to ensure sufficient and extended pollen availability. This is especially important for stress environments where pollen production is drastically reduced.

Progress from selection would be expected as the bulk of genetic variance is additive for most of the traits, but the presence of significant epistasis implicates that such progress would not be evident in immediate generations and therefore, selection process would have to be delayed to later generations when sufficient homozygosity sets in.

Appropriate selection indices help in achieving desired change in phenotypic expression of a particular trait. In the present study, the tassel length and tassel weight were negatively, correlated with ear length which is an important yield attribute. Thus selecting for shorter and lighter tassels may result in higher yields. Tassel branch number was positively correlated with both ear length and ear diameter. This is possibly due to effect of tassel branch angle on light interception by minimising its shading effect (Mickerlson *et al.*, 2002). Thus selecting for upright tassel branches may compensate for yield

Table 1: Pooled analysis of variance for detection of epistasis for tassel and ear diameter in maize

Source of variation	d.f.	Tassel branch No.	Tassel length (cm)	Tassel weight (g)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)
Epistasis	15	19.84*	4.57*	0.61**	451.36**	55.68**	2.07*
(L_{1i}+L_{2i}-2 L_{3i})	1	14.34	3.09*	2.05**	403.45**	24.52	2.58*
[I] type epistasis	14	20.24**	4.68*	0.50**	448.67**	57.90**	2.03*
Epistasis×environment	15	7.64*	1.39	0.19*	127.42**	18.09**	0.93**
[1] type×environment	1	8.27**	1.57	0.73	103.18*	18.64**	1.12**
[j+l] type×environment	14	7.59*	1.37	0.15	129.13**	18.05**	0.92**
[1] type ×blocks×environment	2	2.72	1.37	0.17	13.96	3.19	0.06
Epistasis×blocks×environments	30	3.24	1.83	0.09	44.62	6.98	0.16

*,** Significant at 5 and 1% level, respectively

Table 2: Additive component (D), dominance component (H) additive×environment (G2D), dominance×environment (G2H), degree and direction of dominance in maiz

Components	Tassel branch No.	Tassel length (cm)	Tassel weight (g)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)
Additive component (D)	23.43±9.37*	4.38±1.69**	1.73±0.29**	1181.81±428.47**	13.03±4.95**	0.37±0.14*
Dominance component (H)	12.69±6.12	6.02±2.66*	0.89±0.27**	80.36±39.03*	5.40±2.41*	0.10±0.05
Additive×environment (G2D)	8.13±3.65	1.98±0.37**	0.61±0.04**	36.32±4.50	1.06 ±0.71	0.08±0.05
Dominance×environment (G2H)	3.78±2.83	2.23±0.77**	0.34±0.09**	24.40±6.36	2.58±0.98**	0.06±0.04
Degree of dominance (H/D) ½	0.73	1.17	0.71	0.17	0.64	0.52
Direction of dominance of	-0.39	0.83	1.43	19.05	1.38	0.01

*,** Significant at 5 and 1% level, respectively

Table 3: Genotypic correlation between tassel and ear characters in maize (pooled over environments)

Traits	Tassel branch No.	Tassel length (cm)	Tassel weight (g)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)
Tassel branch number	-	-0.021	0.375	0.724**	0.548**	0.213
Tassel length (cm)		-	0.416**	0.380*	-0.027	0.036
Tassel weight (g)			-	0.039	-0.073	0.011
Ear height (cm)				-	0.253	0.262*
Ear length (cm)					-	0.133
Ear diameter (cm)						-

*,** Significant at 5 and 1% level, respectively

reduction without comprising on tassel size to ensure sufficient pollen availability, especially in hybrid seed production and stress environments. Therefore, studies should be carried out to elucidate the effect of various tassel branch angles on yield and its components.

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