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Genetic Studies on Morphophysiological Traits With Elite Inbreds of Maize

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ABSTRACT

A 6 x 6 diallel analysis, generation mean analysis, path analysis and correlation analysis were carried out in maize with elite inbred lines in Delhi and Dharwad during 2010 and 2011. The results revealed that for most of the characters, magnitude of additive variance was more than that of dominance variance in both the locations. This was also reflected in degree of dominance being far below 1.0. However, for grain yield, dominance component was more important. Further, for most of the characters, additive variance was higher in *rabi* season compared to *kharif*. As such these finding are also reflected in higher heritabilities of these traits in rabi. The characters that had higher heritabilities (narrow sense) were 50% silking and ASI. The highest negative midparent (MPH) and better parent heterosis (BPH) were observed for ASI. This was more negative in rabi (> - 29.0 %). Highest positive heterosis was observed for grain yield in all three seasons.

Key words : Genetics, Heritability, Heterosis, Maize, Morpho-physiological traits.

Maize (*Zea mays* L) is one of the most important cereals of the world. Maize provides nutrients for humans and animals and serves as a basic raw material for the production of starch, oil and protein, alcoholic beverages, food sweeteners and, more recently, fuel. Maize is high yielding, easy to process, readily digested, and costs less than other cereals. It is also a versatile crop, allowing it to grow across a range of agroecological zones. Every part of the maize plant has economic value: the grain, leaves, stalk, tassel, and cob can all be used to produce a large variety of food and nonfood products. Development of early maturing maize types is an important breeding objective along with the primary goal of higher productivity. The characters like days to 50 per cent anthesis, days to 50 per cent silking are the indicators of earliness. The narrow Anthesis silking interval (ASI) is useful in moisture stress situations.ASI is a correlated secondary trait of yield under moisture stress and is being used as a criterion of selection for drought tolerance (Chapman and Edmeades, 1999). For any successful breeding programme, information on variability, heritability, genetic advance *etc.,* is a pre-requisite. Hence, it is essential to know the genetic architecture of traits concerned and mode of their inheritance. The present investigation, therefore, was taken up to obtain information on gene action, correlation and heterosis of some morpho-physiological traits in maize.

MATERIAL AND METHODS

The present study included six genetically diverse inbreds (coded as Ib_1 to Ib_6), as base material. The inbreds selected were mated in a diallel mating system excluding reciprocals to obtain 15 experimental single cross hybrids. The field experiment involving parents F_1s and check was laid out in Randomized Complete Block Design (RCBD) with three replications. The experiment was conducted at two locations *viz.,* Delhi and Dharwad. In Delhi, the experiment was conducted in two consecutive seasons, *viz*., *kharif* 2010 and *rabi* 2010. In Dharwad, the experiment was carried out in *kharif* 2011. Each plot of parents, F_1s and checks consisted of two rows each of five-metre length. The spacing followed was 75 x 20 cm and each row consisted of 20 plants. Five plants were randomly selected for recording observations like, days to 50 per cent tasseling, days to 50 per cent silking, anthesis-silking interval, plant height (cm), ear height (cm) and grain yield on parents, F_1s and Checks.

Statistical analysis

The statistical analyses were carried out following the standard procedures. The genotypic coefficients of variation (GCV %) and the expected genetic advance were calculated by the formula suggested by Burton and De Vane (1953) and Johnson *et al*. (1955), respectively. Information on combining ability was obtained by method-II, model-1 of Griffings (1956), which was used to derive information on different genetic parameters/

The computation of heterosis (%) values was done as per Turner (1953) and Hayes *et al.* (1955). Phenotypic and genotypic correlations were computed by using the formulae given by Weber and Moorthy (1952). The path coefficient analysis of various traits was done following Dewey and Lu (1959).

RESULTS AND DISCUSSION

1. Gene action

The magnitude of variances due to *GCA* and *SCA* for morphophysiological traits in all three experiments indicated that *GCA* variances were higher in magnitude for all the characters implying predominance of additive gene action (Table 1). In addition, both *GCA* and *SCA* variances were significant for most of the characters under all growing conditions and thus, showed the importance of both additive and non-additive components in the inheritance of these characters.

Khamis (1983) and Mahajan *et al.* (1991) also reported that GCA variance was more than *SCA* variance for days to 50% silking and plant height. However, Nawar and El-Hasary (1984) reported significant *sca* effects for plant height, ear height and days to 75% silking. Subba Rao (1992) and Mathur and Bhatnagar (1995) reported that both *GCA* and *SCA* variances were significant for days to 75% silking, days to 75% pollen shed, plant height and ear height. Among the parents, Ib_3 and Ib_5 were better combiners for grain yield. While crosses Ib_5 x Ib_6 and Ib_2 x Ib_3 were good specific combiners (data not shown). Subba Rao (1992) reported the predominance of additive component for grain yield; while in the present study both additive and non additive components were significant. For almost all characters, *GCA* variances were significant and consistent in all situations implying stable expression of additive components.

2. Genetic Parameters

Genetic variances:

Estimates of additive variances were more than the dominance variance in all the characters except grain yield indicating the predominance of additive gene action in the control of these characters (Table 1). The grain yield on the other hand had higher dominance variance under all three conditions indicating the importance of non additive component in the inheritance. This was also reflected in degree of dominance. The degree of dominance was less than 1.0 for almost all the characters and more than 1.0 for grain yield.

Heritability:

The narrow sense heritability estimates were high (more than 58%) for almost all morpho-physiological traits (Table 1). However, the low estimate of heritability (<45%) was recorded for grain yield. Thus, selection would be effective in improving the morpho-physiological characters. However, for improving grain yield family selection has to be followed due to its low heritability.

Genetic advance and Genotypic coefficient of variation:

In case of genetic advance, highest estimate (>19%) was recorded for plant height followed by grain yield in all three experiments. The genotypic co-efficient of variation (GCV %) was highest for anthesis silking interval followed by grain yield indicating the substantial variability for these traits in the material studied. Since GCV (%) expressed as percentage over mean of each trait, the GCV (%) values can be compared across characters. Thus, magnitude of variability was high for these traits and improvement by selection is possible.

Thus, in the present investigation, for most of the characters, magnitude of additive variance was more than that of dominance variance under all three experiments (Table 1). This was also reflected in degree of dominance being far below 1.0, except for grain yield for which degree of dominance was >1.0. As such these findings are also reflected in higher heritability of these traits. This indicates that phenotype as a good index of its genotype for these traits. In a breeding programme, where selection is practiced for several traits simultaneously, it would be advantageous to select at high levels of heritability for all attributes (Johnson and Frey, 1967). These findings were in conformity with the findings of Chapman and Baretto (1996) and Locatelli *et al.* (2002).

Table 1. Summary of genetic studies on morpho-physiological traits in maize under two locations during 2010-11

Parameters	Days to 50% tasseling				Days to 50% silking				Anthesis-silking interval			
	Delhi-K	Delhi-R	DWD	PO	Delhi-K	Delhi-R	DWD	PO	Delhi-K	Delhi-R	DWD	PO
Predominant gene action	A	A*	D*	A*	A	A*	D*	A*	A	A*	A*	A*
***GCA* Variance**	3.02**	2.96**	3.02**	4.49**	4.03**	6.32**	3.73**	9.43**	0.55**	4.56**	0.46**	6.37**
***SCA* Variance**	1.24	1.84**	4.07**	4.18**	1.03	2.49**	4.06**	4.13**	0.26	0.49**	0.40**	0.67**
Additive Variance	6.04	5.92	6.04	8.98	8.06	12.64	7.46	18.86	1.10	9.12	0.92	12.74
Dominance Variance	1.24	1.84	4.07	4.18	1.03	2.49	4.06	4.13	0.26	0.49	0.40	0.67
Degree of Dominance	0.45	0.56	0.82	0.68	0.36	0.44	0.74	0.47	0.49	0.23	0.66	0.23
Heritability	75.9	70.9	58.6	65.6	83.5	80.8	63.6	81.9	72.8	92.8	63.9	93.7
Genetic Advance	2.72	2.65	2.48	1.99	2.94	3.53	2.75	2.45	1.21	2.67	0.90	1.90
GCV (%)	2.06	2.56	3.42	1.53	2.12	3.24	3.42	1.58	13.61	16.2	15.1	16.3
Path Analysis												
Direct effect on yield	-1.17	-0.81	-1.47	-5.52	1.81	1.08	1.36	5.65	-0.07	0.69	-0.36	-3.41
Correlation with yield	-0.57**	-0.32	-0.46*	-0.55**	-0.49**	-0.81**	-0.45*	-0.88**	0.08	-0.87**	-0.44*	-0.54**
Heterosis (Highest)												
Mid parent heterosis	-7.2	-7.2	-5.3	-6.6	-4.4	-7.4	-4.2	-5.3	-15.8	-44.0	-25.0	-28.3
Better parent heterosis	-6.6	-7.2	-5.0	-6.3	-3.8	-6.3	-3.0	-4.3	-20.1	-29.4	-25.0	-24.8
Standard heterosis	-5.6	-6.2	-5.2	-5.7	-4.2	-6.2	-3.4	-4.6	-18.1	-25.5	-23.0	-22.2

Delhi-K - Delhi kharif, 2010
Delhi -R -Rabi 2010
DWD- Dharwad kharif 2011

A*-Dominance also significant
A- Additive gene action
D*- Additivity also significant

D- Dominance gene action
PO - Pooled analysis

Table 1 contd...

Parameters	Plant height (cm)				Ear height (cm)				Grain yield per plant			
	Delhi-K	Delhi-R	DWD	PO	Delhi-K	Delhi-R	DWD	PO	Delhi-K	Delhi-R	DWD	PO
Predominant gene action	A*	A*	A*	A*	A*	A	A*	A*	D*	D*	D*	D*
***GCA* Variance**	296.2**	157.7**	266.0**	717.4**	78.32**	79.02**	136.5**	254.8**	115.6**	105.3**	133.5**	169.5**
***SCA* Variance**	86.03**	95.21**	264.5**	499.9**	52.18**	23.9	60.43**	90.2**	253.2**	342.6**	303.4**	498.2**
Additive Variance	592	315.4	532.1	1435	156.6	158.1	273	510	231.2	180.6	267.0	631.2
Dominance Variance	86.0	95.2	264	500	52.18	23.9	60.4	90	253.3	342.6	303.5	959.7
Degree of Dominance	0.38	0.55	0.71	0.59	0.58	0.39	0.47	0.42	1.05	1.38	1.066	1.233
Heritability	84.5	73.3	65.2	93.7	71.9	80.0	80.3	83.3	44.13	32.24	42.24	38.82
Genetic Advance	23.6	19.7	23.4	19.4	12.98	13.67	15.92	13.4	18.41	11.66	17.60	14.73
GCV (%)	4.99	4.61	7.66	16.3	7.64	5.75	9.38	5.83	12.79	15.77	13.74	14.20
Path Analysis												
Direct effect on yield	0.71	-0.39	-0.14	0.23	-1.36	0.25	0.04	-0.15	-	-	-	-
Correlation with yield	0.48**	0.68**	0.67**	0.64**	-0.22	-0.11	0.20	0.10	-	-	-	-
Heterosis (Highest)												
Mid parent heterosis	12.9	14.3	22.0	16.4	12.4	11.6	18.9	14.3	47.77	40.12	51.41	46.4
Better parent heterosis	11.5	10.6	19.3	13.8	7.9	7.7	16.8	10.8	43.66	40.08	43.61	42.4
Standard heterosis	13.5	12.5	22.6	16.2	8.5	9.1	18.2	11.9	32.50	30.70	35.40	32.9

Delhi-K - Delhi kharif, 2010
Delhi -R -Rabi 2010
DWD- Dharwad kharif 2011

A*-Dominance also significant
A- Additive gene action
D*- Additivity also significant

D- Dominance gene action
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4. Path Analysis and correlation

The path coefficient analysis (Table 1) revealed that characters like days to 50% silking, number of rows per cob, hundred seed weight, plant height and number of grains per row had high positive direct effect on yield, while days to 50% tasseling and ear-height had negative indirect effects on yield. However, days to 50% silking showed negative correlation with yield because of high negative indirect effect *via* days to 50% tasseling and some other traits. High positive indirect effects on yield was shown by days to 50% tasseling and hundred seed weight *via* days to 50% tasseling and hundred seed weight *via* number of grains per row. Similar results were earlier reported by Kumar (1996).

Grain yield was found to be positively correlated with plant height. Hemalatha Devi (1989) and Kumar (1996) found strong positive correlation between yield and plant height. However, yield was negatively correlated with days to 50% tasseling, days to 50% silking and ASI.

These results indicated that selection for high yield can be done by indirect selection through correlated characters and characters having high positive direct effects on yield. This is particularly so in breeding for drought tolerance. These characters are termed secondary traits and evaluation of adaptive value of secondary trait begins by establishing its relationship to productivity under drought in a field environment (Marshall, 1987). Fischer *et al.* (1983) suggested a combination of direct and indirect selection using selection index of desirable secondary traits and grain yield under stressed and normal conditions.

5. Heterosis

Table 1 gives only highest heterosis for various traits in desirable direction. The highest negative midparent (MPH) and better parent heterosis (BPH) were observed for ASI. This means that there is a possibility of developing hybrids with shorter ASI and indicated that the inbreds with shorter ASI could be extracted. For characters like plant height and ear height high positive heterosis is desirable as these are positively correlated with yield both under optimum and stress conditions. Highest positive heterosis was observed for grain yield followed by plant height under all three growing conditions. Similar observations were reported by Subba Rao (1992) and Kumar (1996). Among the hybrids, Ib_5 x Ib_6, Ib_3 x Ib_6 and Ib_2 x Ib_3 were with high better parent and standard heterosis.

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