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Research Article

STUDIES ON GENETIC VARIABILITY, HERITABILITY, CORRELATION AND PATH ANALYSIS IN MAIZE (*ZEA MAYS* L.) OVER LOCATIONS

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ABSTRACT: The present investigation was carried out to study the heritability, correlation and path coefficient analysis in 45 hybrids and ten parents. In pooled analysis of variability parameters revealed that the phenotypic coefficients of variation (PCV) were higher than genotypic coefficient of variation for all the characters studied indicating the role of experimental variance to the total variance. The magnitude of PCV and GCV was high for grain yield per plant followed by ear height, number of kernels per row, 100-seed weight, ear length, plant height, ear girth and number of kernel rows per ear. High heritability coupled with high genetic advance as percentage of mean was observed for ear height, grain yield per plant, plant height, number of kernels per row and ear length. In general, magnitudes of genotypic correlations were found to be higher than phenotypic correlations. The results indicated that grain yield was positively and significantly associated with 100-seed weight, ear girth, ear length, number of kernels per row, plant height, number of kernel row per ear and ear height. Days to 50 percent tasseling had largest direct effect on grain yield per plant followed by 100-seed weight, ear length, days to maturity, ear height, number of kernels per row, ear height, number of kernel rows per and plant height.

Key words: Genetic variability, heritability, correlation, path analysis, maize

INTRODUCTION

Maize is the third most important cereal food crop of the world after wheat and rice. In India, maize ranks third next to rice and wheat (Centre for Monitoring Indian Economy, 2011). Among the cereals maize is rich in starch, oil and sucrose. Globally 67 percent of maize is used for livestock feed, 25% human consumption, industrial purposes and balance is used as seed and demand for grain is increasing world wide. Plant breeders are interested in developing cultivars with improved yield and other desirable agronomic and phenological characters. In order to achieve this goal, the breeders had the option of selecting desirable genotype in early generations or delaying intense selection until advanced generations.

The selection criteria may be yield or one or more of the yield component characters. However, breeding for high yield crops require information on nature and magnitude of variation in the available material, relationship of yield with other agronomic characters and the degree of environmental influence on the expression of these component characters. Since grain yield in maize is quantitative in nature and polygenically controlled, effective yield improvement and simultaneous improvement of yield components are imperative. To enhance the yield productivity, genetic parameters and correlation studies between yield and yield components are per requisite to plan a meaningful breeding programme to develop high yielding inbreds and hybrids.

MATERIALS AND METHODS

Ten diverse inbred lines of maize were crossed in Diallel mating design (excluding reciprocals) during *kharif*, 2011 at College Farm, College of Agriculture, Rajendranagar, Hyderabad, Andhra Pradsh, India. The resultant 45 hybrids along with ten parents were evaluated during *rabi*, 2011-12 at three locations *viz.*, Rajendranagar, Karimnagar and Kampasagar.

Pooled Analysis of variance was carried out according to the standard statistical method to establish the level of significance among the genotypes. Correlation coefficients were determined as described by Singh and Chaudhary (1979). The correlation coefficients were partitioned into direct and indirect effects using the path coefficient analysis according to Dewey and Lu (1959).

RESULTS AND DISCUSSION

The pooled analysis of variance revealed highly significant differences among the genotypes for all the characters studied days to 50 per cent tasseling, days to 50 per cent silking, days to maturity, plant height, ear height, ear girth, ear length, number of kernel rows per ear, number of kernels per row, 100- seed weight and grain yield per plant indicating the existence of considerable genetic variation in the experimental material. The Genotypic Coefficient of Variation (GCV) was less than its corresponding estimates of Phenotypic Coefficient of Variation (PCV) for all the traits which indicated significant role of environment in the expression of these traits. The magnitude of PCV and GCV was high for grain yield per plant followed by ear height, number of kernels per row, 100-seed weight, ear length, plant height, ear girth and number of kernel rows per ear.

Most of the traits had high heritability estimates indicating the preponderance of additive gene action. High heritability estimates were recorded in ear height followed by plant height, days to 50 percent tasseling, days to maturity, days to 50 percent silking, grain yield per plant, ear length, number of kernels per row and ear girth. However, the selection for improvement of such characters may not be useful, because broad sense heritability is based on total genetic variance which includes additive, dominant and epistatic variances. Thus, heritability values coupled with high genetic advance would be more reliable and useful on correlating selection criteria.

The character grain yield per plant recorded high magnitude of genetic advance as percentage of mean followed by ear height, number of kernels per row, plant height and ear length.

In the present investigation high heritability coupled with high genetic advance as percentage of mean observed for ear height, grain yield per plant, plant height, number of kernels per row and ear length (Table 1). Thus these traits are predominantly under the control of additive gene action and hence, these characters can be improved by selection. Similar results were reported by Khehra *et al.*, (1985), Kumar and Singh (1986), Reddy and Agarwal (1992), Saha and Mukherjee (1993), Gyanendra Singh *et al.*, (1995), Satyanarayana and Sai Kumar (1996), Kabdal *et al.*(2003), Aboyi *et al.*, (2004), Mohammad Akbar *et al.*,(2006) Sofi and Rather (2007), Ali *et al.*, (2010) and Ram Reddy *et al.*, (2012).

Grain yield is a complex character and is dependent on several contributing characters. Hence, character association was studied to assess the relationship among yield and its components for enhancing the usefulness of selection.

Genotypic correlations reveal the existence of real associations, whereas phenotypic correlations may occur by chance. Significant phenotypic correlations without significant genotypic associations are of no value. If the genotypic correlation is significant and phenotypic is not, it means that the existing real association is masked by environmental effect. In general, genotypic correlations were of higher magnitude than the corresponding phenotypic values and hence only the genotypic correlations are discussed.

The grain yield per plant was positively correlated with 100-seed weight, ear girth, ear length, number of kernels per row, plant height, number of kernel rows per ear and ear height. These observations are in conformity with the findings of 100-seed weight (Kumar *et al.*, 2006 and Pavan *et al.*, 2011), ear girth (Raghu *et al.*, 2011), ear length (Choudhary and Chaudhary, 2002), number of kernels per row (Sadek *et al.*, 2006), plant height (Jayakumar *et al.*, 2007), number of kernel rows per ear (Ravi *et al.*, 2012) and ear height (Sofi and Rather, 2007). The characters days to 50 percent tasseling, days to 50 percent silking and days to maturity were negatively correlated with grain yield per plant and are similar to the results reported by Umakanth and Sunil (2000) and Pavan *et al.*, (2011).

Inter correlation among yield components (Table 2) revealed that days to 50 percent tasseling was significantly and positively correlated with days to 50 percent silking, days to maturity and ear height. Similarly for days to 50 per cent silking, the days to maturity and ear height exhibited significant positive correlation. Whereas days to maturity was negatively correlated with plant height, ear height, ear girth, ear length, number of kernel rows per ear, number of kernels per row, 100-seed weight and grain yield per plant, while the plant and ear height were positively correlated with ear girth, ear length, number of kernel rows per ear, number of kernels per row, 100-seed weight, and grain yield plant. Ear girth and ear length was positively correlated with number of kernel rows per ear, number of kernels per row, 100-seed weight and grain yield per plant. Whereas the number of kernels per row and 100-seed weight positively correlated with grain yield per plant.

Path coefficient analysis was also done used to obtain further information on interrelationships among traits and their effects on grain yield (Table 3). The path coefficient analysis at genotypic level revealed that the days to 50 percent tasseling exhibited the largest direct effect on grain yield per plant followed by 100-seed weight, ear length, days to maturity, number of kernels per row, ear height, number of kernel rows per ear and plant height. These observations are in conformity with the findings of others related to days to 50 percent tasseling (Venugopal *et al.*, 2003) 100-seed weight (Kumar *et al.*, 2006), ear length (Pavan *et al.*, 2011), number of kernels per row (Raghu *et al.*, 2011), ear height (Raghu *et al.*, 2011), number of kernel rows per ear (Devi *et al.*, 2001), and plant height (Kumar *et al.*, 2006).

The high direct effects of these traits appeared to be the main reason for their strong association with grain yield. Hence, direct selection for these traits would be effective. Days to 50 percent silking exhibited negative direct effect on grain yield and indicated that selection for high yield can be done by indirect selection through yield components.

The results thus emphasized the need for selection based on plant with greater days to 50 percent tasseling, 100-seed weight, ear length, days to maturity, ear height, number of kernels per row, ear height, number of kernel rows per ear and plant height, since these traits were found to be the important direct contributors for grain yield.

Table 1: Genetic parameters for yield and yield components in maize

Character	Days to 50% tasseling	Days to 50% Silking	Days to Maturity	Plant Height (cm)	Ear height (cm)	Ear girth (cm)
PCV (%)	6.12	5.86	5.02	15.81	22.84	12.93
GCV (%)	5.61	5.32	4.61	15.08	22.08	10.53
h^2_{bs} (%)	84.00	82.00	84.00	91.00	93.00	66.00
Genetic Advancement 5%	7.60	7.39	9.41	58.43	36.63	2.28
Gen.Adv as % of Mean 5%	10.58	9.94	8.73	29.63	43.95	17.67
Mean	71.83	74.38	107.85	197.20	83.34	12.93

Character	Ear length (cm)	Number of kernel rows per ear	Number of kernels per row	100-Seed weight	Grain yield per plant
PCV (%)	17.97	10.79	22.80	20.20	37.57
GCV (%)	15.18	6.04	18.69	14.04	31.69
h^2_{bs} (%)	71.00	31.00	67.00	48.00	71.00
Genetic Advancement 5%	3.97	0.99	9.32	4.82	52.34
Gen.Adv as % of Mean 5%	26.41	6.95	31.55	20.09	55.05
Mean	15.05	14.25	29.55	24.01	95.08

PCV= Phenotypic coefficient of variation,
GCV= Genotypic coefficient of variation,
h^2_{bs}=broad sense heritability,
GA = Genetic advancement at 5%
GAM= genetic advance as percent of mean at 5 percent level.

Table 2: Phenotypic (P) and Genotypic (G) Pooled correlations for 11 characters in maize

Source		Days to 50% tasseling	Days to 50% silking	Days to maturity	Plant height (cm)	Ear height (cm)	Ear girth (cm)	Ear length (cm)	Number of kernel rows per ear	Number of kernels per row	100-seed weight (g)	Grain yield per plant (g)
Days to 50% tasseling	P	1.0000	0.8460**	0.6096**	0.0362	0.1543**	-0.0743	-0.2347**	-0.2034**	-0.2590**	-0.1137**	-0.1622**
	G	1.0000	0.9873**	0.7275**	0.0366	0.1770**	-0.0907	-0.3000**	-0.4225**	-0.3164**	-0.1743**	-0.2003**
Days to 50% silking	P		1.0000	0.6519**	0.007	0.1060*	-0.1441**	-0.2620**	-0.2295**	-0.2693**	-0.1298**	-0.2058**
	G		1.0000	0.7698**	0.0062	0.1275**	-0.1689**	-0.3223**	-0.4871**	-0.3550**	-0.1835**	-0.2605**
Days to maturity	P			1.0000	-0.2310**	-0.1426**	-0.2778**	-0.4213**	-0.2412**	-0.3899**	-0.1793**	-0.3023**
	G			1.0000	-0.2493**	-0.1588**	-0.3646**	-0.5191**	-0.4377**	-0.5284**	-0.2949**	-0.3958**
Plant height (cm)	P				1.0000	0.6787**	0.4377**	0.3943**	0.0681	0.4292**	0.3101**	0.4872**
	G				1.0000	0.7427**	0.5858**	0.5067**	0.1505**	0.5313**	0.4559**	0.5966**
Ear height (cm)	P					1.0000	0.4118**	0.2206**	0.1041	0.2375**	0.1031*	0.2898**
	G					1.0000	0.5167**	0.2700**	0.1619**	0.3009**	0.1541**	0.3612**
Ear girth (cm)	P						1.0000	0.5146**	0.2428**	0.4175**	0.4510**	0.5852**
	G						1.0000	0.6088**	0.4252**	0.5604**	0.6442**	0.7054**
Ear length (cm)	P							1.0000	0.1544**	0.7317**	0.3532**	0.6099**
	G							1.0000	0.2750**	0.8454**	0.5011**	0.6877**
Number of kernel rows per ear	P								1.0000	0.0752	0.0209	0.0618
	G								1.0000	0.2778**	0.2192**	0.4147**
Number of kernels per row	P									1.0000	0.3060**	0.6416**
	G									1.0000	0.4189**	0.6771**
100 seed weight (g)	P										1.0000	0.6329**
	G										1.0000	0.7778
Grain yield per plant (g)	P											1.0000
	G											1.0000

* Significant at 5 percent level; ** significant at 1 percent level

Table 3. Phenotypic (P) and Genotypic (G) path coefficients for various characters in maize

Source		Days to 50% tasseling	Days to 50% silking	Days to maturity	Plant height (cm)	Ear height (cm)	Ear girth (cm)	Ear length (cm)	Number of kernel rows per ear	Number of kernels per row	100-seed weight (g)	Grain yield per plant (g)
Days to 50% tasseling	P	**0.0340**	-0.0664	0.0217	0.0040	0.0021	-0.0134	-0.0251	0.0086	-0.0845	-0.0431	-0.1622**
	G	**2.1119**	-2.2332	0.1796	0.0032	0.0250	0.0256	-0.0819	-0.0504	-0.0613	-0.1186	-0.2003**
Days to 50% silking	P	0.0287	**-0.0785**	0.0232	0.0008	0.0014	-0.0261	-0.0280	0.0097	-0.0879	-0.0492	-0.2058**
	G	2.0851	**-2.2620**	0.1900	0.0005	0.0180	0.0477	-0.0880	-0.0582	-0.0687	-0.1249	-0.2605**
Days to maturity	P	0.0207	-0.0512	**0.0356**	-0.0253	-0.0019	-0.0502	-0.0450	0.0102	-0.1272	-0.0680	-0.3023**
	G	1.5365	-1.7412	**0.2468**	-0.0215	-0.0224	0.1030	-0.1418	-0.0523	-0.1023	-0.2006	-0.3958**
Plant height (cm)	P	0.0012	-0.0005	-0.0082	**0.1095**	0.0091	0.0792	0.0422	-0.0029	0.1401	0.1176	0.4872**
	G	0.0774	-0.0140	-0.0615	**0.0860**	0.1047	-0.1654	0.1384	0.0180	0.1029	0.3102	0.5966**
Ear height (cm)	P	0.0052	-0.0083	-0.0051	0.0743	**0.0134**	0.0745	0.0236	-0.0044	0.0775	0.0391	0.2898**
	G	0.3737	-0.2885	-0.0392	0.0639	**0.1410**	-0.1459	0.0738	0.0193	0.0583	0.1048	0.3612**
Ear girth (cm)	P	-0.0025	0.0113	-0.0099	0.0479	0.0055	**0.1808**	0.0550	-0.0103	0.1362	0.1711	0.5852**
	G	-0.1915	0.3821	-0.0900	0.0504	0.0729	**-0.2824**	0.1663	0.0508	0.1085	0.4383	0.7054**
Ear length (cm)	P	-0.0080	0.0206	-0.0150	0.0432	0.0030	0.0931	**0.1069**	-0.0066	0.2388	0.1340	0.6099**
	G	-0.6336	0.7290	-0.1281	0.0436	0.0381	-0.1719	**0.2731**	0.0328	0.1637	0.3409	0.6877**
Number of kernel rows per ear	P	-0.0069	0.0180	-0.0086	0.0075	0.0014	0.0439	0.0165	**-0.0425**	0.0245	0.0079	0.0618
	G	-0.8923	1.1019	-0.1080	0.0129	0.0228	-0.1201	0.0751	**0.1194**	0.0538	0.1491	0.4147**
Number of kernels per row	P	-0.0088	0.0211	-0.0139	0.0470	0.0032	0.0755	0.0782	-0.0032	**0.3263**	0.1161	0.6416**
	G	-0.6681	0.8030	-0.1304	0.0457	0.0424	-0.1583	0.2309	0.0332	**0.1936**	0.2850	0.6771**
100 seed weight (g)	P	-0.0039	0.0102	-0.0064	0.0340	0.0014	0.0816	0.0378	-0.0009	0.0999	**0.3793**	0.6329**
	G	-0.3681	0.4152	-0.0728	0.0392	0.0217	-0.1819	0.1369	0.0262	0.0811	**0.6804**	0.7778**

Bold values are direct effects; Phenotypic residual effect =0.5701; Genotypic residual effect = 0.3615

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