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GENETICS AND PLANT BREEDING

Studies on Variability, Heritability, Genetic advance and Correlation in Maize (*Zea mays* L.)

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Abstract

The present investigation was undertaken to study association between different characters, the direct and indirect contribution of the component characters on the yield, genetic advance, heritability for various characters and to assess the extent of variability through genetic divergence in 40 genotypes (38 inbreds and 2 hybrids) of maize. The treatment differences were statistically significant for all the characters and also the magnitude of genotypic and phenotypic coefficient of variation indicated the presence of good amount of variability. Grain yield per plant showed the highest heritability (98.00%) followed by plant height, number of kernels per row and 100 grain weight. Grain yield per plant exhibited highest genetic advance which was followed by plant height and ear head height. The grain yield per plant showed highly significant positive correlation with ear circumference, number of kernels per row, ear length and plant height. Path analysis studies revealed that days to maturity, plant height, ear length, numbers of kernel row per cob and 100 grain weight exhibited high direct effects on grain yield indicating true and perfect relationship between them. This also suggests that direct selection for these traits will help in improvement of grain yield in maize.

Highlights

- The characters *viz.*, days to maturity, plant height, ear length, number of kernel row per cob and 100 grain weight exerted positive direct effect on grain yield per plant and correlation of these characters with seed yield was positively significant except for days to maturity. Thus, direct selection for these traits will be rewarding for yield improvement.

Keywords: Maize, heritability, genetic advance, path coefficient, yield components

Maize (*Zea mays* L.) popularly known as corn, is a well known cereal crop of global importance. It belongs to family Poaceae. *Zea mays* is the only species in genus Zea. It is diploid species with chromosome number 2n = 20. Tripsacum (Gamma grass) 2n = 18 and Teosinte (*Euchleana spp*) 2n = 36 are two close relatives. Central America (Mexico) is the origin of Maize. In fact the suitability of maize to diverse environments is unmatched by any other crop. It is grown from 580 N to 400 S, from below sea level to altitudes higher than 3000 m, and in areas with 250 mm to more than 5000 mm of rainfall per year. However the major maize production areas are located in temperate regions of the globe. The United States, China, Brazil and Mexico account for 70 per cent of global production. India has 5 per cent of corn acreage and contributes 2 per cent of world production.

Maize is the third most important food grain in India after wheat and rice. In India, about 28 per cent of maize produced is used for food purpose, about 11 per cent as livestock feed, 48 per cent as

Table 1: Analysis of variance for 12 characters in maize

Source of variance	Degree of freedom	Mean sum of squares											
		Days to 50% tasseling	Days to 50% silking	Days to maturity	Plant height (cm)	Ear head height (cm)	Ear length (cm)	Ear circum-ference (cm)	No. of kernel rows per cob	No. of kernels per row	100 grain weight (g)	Shelling (%)	Grain yield / plant (g)
Replication	2	9.164	8.580	21.067	211.630	26.823	7.856	7.373	9.003	6.696	9.365	20.536	20.006
Treatment	39	7.78**	7.54**	15.21**	358.28**	306.07**	7.49**	2.37**	5.81**	44.02**	33.92**	16.96**	570.98**
Error	78	1.773	2.241	3.963	10.296	2.164	1.523	1.138	1.653	1.277	1.328	4.039	2.949
F ratio		4.38	3.36	3.83	34.79	141.43	4.91	2.08	3.51	34.46	25.53	4.20	193.61
F tab (1%)		1.863	1.863	1.863	1.863	1.863	1.863	1.863	1.863	1.863	1.863	1.863	1.863
F tab (5%)		1.553	1.553	1.553	1.553	1.553	1.553	1.553	1.553	1.553	1.553	1.553	1.553

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

Table 2: Variability for 40 genotypes of Maize

Sl. No.	Characters	General mean	Range	GCV (%)	PCV (%)	Heritability (bs) %	Genetic advance	G.A as a per cent of mean
1	Days to 50% tasseling	49.25	46.31 – 52.77	2.87	3.94	53	2.12	4.31
2	Days to 50% silking	50.12	46.69 – 52.89	2.65	3.99	44	1.81	3.63
3	Days to maturity	85.14	81.93 – 91.35	2.27	3.26	48	2.78	3.26
4	Plant height (cm)	161.46	135.23 – 182.66	6.67	6.96	91	21.26	13.16
5	Earhead height (cm)	69.64	46.59 – 94.46	14.47	14.62	97	20.51	29.50
6	Ear length(cm)	14.86	11.80 – 18.16	9.48	12.60	56	2.18	14.70
7	Ear circumference (cm)	12.39	10.37 – 15.40	5.17	10.04	26	0.68	5.49
8	No. of kernel rows per cob	13.70	10.50 – 16.00	8.59	12.72	45	1.63	11.95
9	No. of kernels per row	30.41	21.20 – 37.90	12.41	12.95	91	7.44	24.49
10	100 grain weight (g)	21.14	16.30 – 32.48	15.58	16.51	89	6.40	30.31
11	Shelling %	83.22	77.45 – 89.86	2.49	3.47	51	3.07	3.69
12	Grain Yield per plant (g)	81.04	54.74 – 115.00	16.97	17.11	98	23.12	34.70

poultry feed, 12 per cent in wet milling industry (for example starch and oil production) and one per cent as seed. In the last one decade, it has registered the highest growth rate among all food grains including wheat and rice because of newly emerging food habits as well as enhanced industrial requirements. Seed yield, an extremely complex trait, is an example of integration of component factors. Both genotypic and phenotypic correlations among and between pairs of agronomic traits provide scope for indirect selection in a crop breeding program (Pavan *et al.,* 2011). Therefore, an analysis of the association between yield and other morphological components through correlation coefficient studies would be vital to understand the intricacy of the trait. Therefore, for designing effective breeding programme, adequate knowledge about the degree and direction of association between yield and its components traits, is of great significance to the breeders when they have to exercise selection for simultaneous improvement of more than one character. However path coefficient analysis helps in partitioning the correlation coefficient into direct and indirect effects, thereby providing relative importance of each of casual factors.

Materials and Methods

The present investigation, was undertaken with 40 genotypes (38 inbreds and 2 hybrids) of maize which were collected from All India coordinated Research Project on Maize, Kasba bawda, Kolhapur, India. During kharif 2012, the experiment was conducted at the Post Graduate Research Farm, College of Agriculture, Kolhapur. The objectives were to study association between different characters, to know direct and indirect effects of different characters on

Table 3: Genotypic (above diagonal) and phenotypic (below diagonal) correlation of 12 characters in 40 genotypes of maize

Characters	Days to 50% tasselling	Days to 50% silking	Days to maturity	Plant height (cm)	Earhead height (cm)	Ear length (cm)	Ear circumference (cm)	No. of kernel rows per cob	No. of kernel per row	100 grain weight (g)	Shelling %	Grain yield/ Plant
Days to 50% tasseling	**1.00**	0.901**	0.748**	0.638**	0.564**	-0.049	0.110	0.417**	0.047	0.007	0.264	0.232
Days to 50% silking	0.505**	1.00	0.838**	0.547**	0.493**	-0.110	0.265	0.367*	0.007	0.131	0.484**	0.167
Days to maturity	0.448**	0.428**	**1.00**	0.341*	0.414**	-0.136	0.148	0.325*	0.072	-0.021	0.420**	0.184
Plant height	0.400*	0.312	0.184	1.00	0.749**	0.217	0.434**	0.204	0.358*	0.165	0.144	0.428**
Earhead height	0.387*	0.330*	0.285	0.711**	1.00	-0.020	0.200	0.186	0.091	0.159	0.380*	0.305
Ear length	-0.023	-0.106	-0.025	0.124	-0.007	1.00	0.604**	0.164	0.937**	0.245	-0.029	0.525**
Ear circumference	0.109	0.100	0.146	0.164	0.115	0.265	1.00	0.290	0.595**	0.723**	-0.172	0.850**
No. of kernel rows per cob	0.260	0.273	0.212	0.106	0.131	0.137	0.227	1.00	0.207	-0.179	0.172	0.281
No. of kernels per row	0.056	0.007	0.103	0.324*	0.085	0.719**	0.307	0.166	**1.00**	0.203	0.029	0.613**
100 grain weight	0.027	0.092	0.032	0.142	0.149	0.189	0.416**	-0.054	0.207	1.00	0.034	0.397*
Shelling %	0.212	0.237	0.255	0.050	0.205	-0.079	0.082	0.203	0.014	0.028	1.00	0.040
Grain yield/Plant	0.162	0.117	0.136	0.406**	0.302	0.403**	0.437**	0.211	0.589**	0.380*	0.029	**1.00**

**, ** significant at 5% and 1% respectively.*

Table 4: Direct (Diagonal) and indirect path effects using genotypic correlation of different characters towards grain yield

Characters	Days to 50% tasselling	Days to 50% silking	Days to maturity	Plant height (cm)	Ear head height (cm)	Ear length (cm)	Ear circumference (cm)	No. of kernel rows per cob	No. of kernels per row	100 grain weight (g)	Shelling (%)	Correlation with Grain yield/plant (g)
Days to 50% tasseling	-2.3458	-0.0911	1.6153	1.4786	-0.3664	-0.1461	-0.1985	0.4850	-0.1173	0.0108	-0.0918	0.2326
Days to 50% silking	-2.1155	-0.1011	1.8085	1.2663	-0.3203	-0.3301	-0.4770	-0.4268	-0.0187	0.1968	-0.1682	0.1670
Days to maturity	-1.7567	-0.0847	2.1570	0.7911	-0.2690	-0.4080	-0.2675	-0.3788	-0.1797	-0.0313	-0.1458	0.1842
Plant height (cm)	-1.4985	-0.0553	0.7372	2.3146	-0.4868	0.6471	-0.7809	0.2381	-0.8838	0.2470	-0.0502	0.4285**
Ear head height (cm)	-1.3236	-0.0498	0.8935	1.7349	-0.6494	-0.0611	-0.3613	0.2167	-0.2247	0.2380	-0.1073	0.3059
Ear length (cm)	0.1150	-0.0112	-0.2953	0.5027	0.0133	2.9797	-1.0872	0.1913	-2.3135	0.3663	0.0424	0.5257**
Ear circumference (cm)	-0.2590	-0.0268	0.3208	1.0052	-0.1305	1.8016	-1.7981	0.3377	-1.4696	1.0809	-0.0119	0.8503**
No. of kernel rows per cob	-0.9784	-0.0371	0.7027	0.4739	-0.1210	0.4901	-0.5222	1.1628	-0.5117	-0.2681	-0.1090	0.2819
No. of kernels per row	-0.1115	-0.0008	0.1571	0.8290	-0.0591	2.7937	-1.0709	0.2411	-2.4676	0.3034	-0.0011	0.6133**
100 grain weight (g)	0.0108	-0.0133	-0.0452	0.3828	0.1035	0.7307	-1.3013	-0.2088	-0.5012	1.4936	-0.0196	0.3973*
Shelling %	-0.6205	0.0490	0.9066	0.3351	-0.2010	-0.3642	-0.0616	0.3653	-0.0079	0.0843	-0.3469	0.0403

grain yield. The experimental material was sown in a randomized block design with three replications and each entry was represented by a single row of 4 m length spaced at 75 cm between the rows and 20 cm between the plants within the rows. Two border rows were planted at both sides of blocks to reduce the border effects.

Five random plants from each treatment in each replication were selected and tagged at the age of 35 days for recording observations viz., days to 50 per cent tasselling, days to 50 per cent silking, days to maturity, plant height (cm), ear head height (cm), ear length (cm), ear circumference (cm), number of kernel rows per cob, number of kernels per row, 100 grain weight (g), shelling percentage and grain yield per plant (g). The ratio of total grain weight per cob to the total weight of ear head in percentage was worked out as shelling percentage. The mean values of five randomly selected observational plants for twelve different traits were used for statistical analysis.

The analysis of variance was done as suggested by Panse and Sukhatme (1985). GCV and PCV estimated as per the formula suggested by Burton (1952). Heritability percentage in broad sense was estimated for various characters as suggested by Hanson et al. (1956). Genetic advance was calculated by the formula given by Johnsen et al. (1955). To understand the association among the characters, genotypic and phenotypic correlations coefficient were worked out by adopting method described by Singh and Chaudhary (1977). Path coefficient analysis was done according to the procedure suggested by Dewey and Lu 1959.

Results and Discussion

The analysis of variance revealed highly significant differences for all the 12 characters (Table 1). The variation observed for grain yield ranged from 54.74g to 115.00g with a mean of 81.04 g. While, comparing the genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV), it was observed that the PCV estimates were magnitudinally higher than GCV for all the characters indicating the influence of environment on these traits. These results confirmed the findings of Bhoite and Sonone (2007). The GCV and PCV estimates were high for grain yield per plant and 100 grain weight. These results confirmed the findings of Kabdal *et al.* (2003a). Maximum difference between PCV and GCV estimates was observed for ear circumference followed by number of kernel rows per cob and ear length suggesting considerable influence of environment on these traits. However, the differences between PCV and GCV estimates were minimum for earhead height followed by grain yield per plant suggesting less influence of environment on the expression of these characters. These results were in accordance with the finding of Satyanarayana *et al.* (2005). High heritability values (Table 2) were recorded for grain yield per plant (98.00%), ear head height (97.00%), number of kernels per row and plant height (91.00%) and 100 grain weight (89.00%). These findings were in consonance with the reports made earlier in maize by Sumalini and Manjulatha (2012).

The traits grain yield per plant (98.00%), ear head height (97.00%), plant height (91.00%), number of kernels per row (91.00%) and 100 grain weight (89.00%) showed high heritability estimates accompanied with good genetic advance which indicates that additive gene action and direct selection for such traits is rewarding in maize Improvement. These results were in accordance with Reddy and Agrawal (1992) for plant height and Robin and Subramanian (1993) for grain yield. Other traits viz. ear circumference (26.00%) recorded comparatively low heritability estimates coupled with low genetic advance among the character studied. This indicated that the inheritance of these characters under the large influence of environmental factors. These results were in accordance with Hallauer (1971) for ear circumference. This complex quantitative character is under the control of polygenes.

Polygenes are highly sensitive to the environment. Hence, the selection of superior genotype based on yield alone may not be effective. For the rational approach towards the improvement of yield, selection has to be operated through associated characters. In the present investigation the characters ear circumference, number of kernels per row, ear length, 100 grain weight and plant height showed significant positive correlation with grain yield both at phenotypic and genotypic levels indicating dependence of these characters on each other. Hence, selection criteria should be considered for these traits for the improvement of grain yield per plant in maize. Similar findings were reported by Panchanandan *et al.* (1978) for 100 grain weight, Sharma and Kumar (1987) for number of kernels per row. The other traits, viz. days to 50 per cent tasseling, days to 50 per cent silking, earhead height, days to maturity, number of kernel rows per cob and shelling percentage recorded non significant positive correlation with yield, both at genotypic and phenotypic levels. Similar findings were reported by Shakoor *et al.* (2007).

In the present study, the path coefficient analysis was performed at genotypic level (Table 4.5 and Fig. 3). The characters viz., days to maturity, plant height, ear length, number of kernel row per cob and 100 grain weight exerted positive direct effect on grain yield per plant (Table 4) and correlation of these characters with seed yield was positively significant except for days to maturity (Table 3). Thus, direct selection for these traits will be rewarding for yield improvement. These findings were in agreement with reports of Venugopal *et al.* (2003) for plant height, ear length, and number of kernel row per cob. Kumar *et al.* (2006) and Shakoor *et al.* (2007) for 100 grain weight.

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