Genetic variability and interrelationship in maize (*Zea mays* L.) genotypes for grain yield and yield component characters

Abstract

An experiment was conducted including 20 genotypes of maize during Kharif season of 2020-21. All characters under study showed highly significant variation. High values of genotypic and phenotypic coefficients of variation were observed for the characters like anthesis and silking interval, grain yield per plant, biological yield, number of grains per row, number of grain rows per cob, harvest index and ear height. Biological yield per plant, plant height, grain yield per plant, ear height and harvest index showed high heritability coupled with high genetic advance suggesting their importance for direct selection. Number of cobs per plant, ear length, number of grains per row, 100 grain weight, harvest index, biological yield exhibited significant positive association with grain yield per plant. Highest direct positive effect on yield per plant was observed for harvest index followed biological yield, number of cobs per plant, anthesis and silking interval. Thus priority should be given to these characters during selection for maize yield improvement.

Key words: Maize, variability, heritability, genetic advance, correlation, path analysis

Introduction

"Maize (*Zea mays* L.) is the third foremost important cereal crop in India succeeding rice andwheat. It accord to the tribe Maydeae, of the grass family, Poaceae. Globally maize covers an area of 193.7 million hectares with a production of 1147.7 million tonnes and productivity of 5.75 t/ha" [1] and "in India maize occupies an area of 9.27 million hectares with a production of 27.14 million tonnes and productivity of 2965 kg ha^{-1}" [2]. "In Uttar Pradesh, it covers an area of 7.33 lakh hectares with a production of 15.26 lakh tonnes and productivity of 2081 kg ha^{-1}. The suitability of maize to manifold environment is peerless by any other crop as it has an extensive range of adaptability. The existing prominence on the development of single cross hybrids is to be expected to ensure enhanced growth rates in productivity of this versatile crop in the years to come. The existence of genetic variability is the imperative for a successful hybrid development program

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in maize and constitution of the breeding population. Computation of genetic variability in the prevailing populations resume prime prominence in this context. Study of variability, heritability, genetic advance, and character association in the germplasm will assist to comprehend the genuine potential of the genotype". [27]

"Proficiency of selection in every breeding programme typically depends upon the apprehension of association of the characters; and upon the useful variability present in the population and the magnitude to which the desirable characters are heritable. Appropriate formulation of selection indices for genetic improvement of yield, the cause and effect relationship of the trait is immensely crucial. Considering these aspects, the present study was outlined and accomplished with the objectives of analyzing the genetic variability, heritability, genetic advance and study of character association besides partitioning of their association into direct and indirect effects". [27]

Materials and method

The present experiment was carried out at the Crop Research Farm of Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India. The experimental materials consisted of 20 genotypes of maize (*Zea mays* L.) obtained from the International Crop Research Institute of Semi-Arid Tropics, Hyderabad, Telangana. The experiment was laid out in randomized block design with three replications. Each entry was sown with a single row of 3 m length with row to row spacing of 60 cm and plant to plant spacing of 20 cm. Originally two seeds per hill were planted and further one plant was thinned to optimize single plant per hill. Two boarder rows were even planted to minimize the boarder effect. The recommended cultural practices were accomplished to augment a good crop. The pre and post harvest parameters were recorded on five plants selected at random from each genotype in each replication for 14 polygenic characters *viz.* days to fifty percent tasseling, days to fifty percent silking, anthesis and silking interval, plant height (cm), ear height (cm), ear length (cm), ear diameter (cm), number of cobs per plant, number of grain rows per cob, number of grains per row, 100 grain weight (g), harvest index (%), biological yield (g), grain yield per plant (g).

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Mean of the data from the sampled plants of each genotype in respect of different parameter was utilized for various statistical analysis *viz.*, variability analysis, correlation analysis, path analysis. Data was analyzed using statistical analysis software Windostat® V.9.3.

Results and Discussion

Statistical analysis of data collected exhibit highly significant variation for all the characters studied (Table 1). The results of the diverse variability parameters *viz.*, phenotypic and genotypic coefficients of variation, heritability in broad sense and genetic advance as per-cent of mean is represented in Table 2. The relatively high values of phenotypic coefficientof variation than their corresponding genotypic coefficient of variation stipulate the involvement of environmental factors in the inheritance of these quantitative traits. Anthesis and silking interval, grain yield per plant, biological yield, number of grains per row, number of grain rows per cob, harvest index and ear height exhibited comparatively higher values of genotypic coefficientof variation, therefore, direct selection for these traits would be effectualand responsive. Similar findings for grain yield per plant, number of grains per row, ear height [3- 6], plant height [7] revealed presence of considerable variability for all characters studied. High heritability estimates for all the traits which indicate that the variation observed for these characters are mainly genotypic. Similar results high heritability estimates for grain yield per plant and plant height [8], ear height [9], days to 50 % silking [10, 11], ear length [12], ear girth [13], number of grains per row [14] and 100 grain weight [15]. "Among the traits under study, some traits viz., biological yield per plant, plant height, grain yield per plant, ear height, harvest index had shown higher estimates of genetic advance representing the additive gene action in the inheritance of these traits, thereby selection for these traits will be highly responsive. Similar results have been reported in maize for grain yield per plant and ear height" [16].

High significant positive correlation with yield per plant was recorded by number of cobs per plant followed by ear length, number of grains per row, 100 grain weight, harvest index, biological yield, suggesting that indirect selection for high yield through direct selection for these characters will be highly effective (Table 3). Similar type of results for number of grains per row [17-19], number of cobs per plant [20], ear length [21, 22], 100 grain weight [23, 24], harvest index [25]. Flowering traits like days to 50% tasseling and days to 50% silking showed significant negative correlation with grain yield.

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Table 1: Analysis of variance for different characters of Maize

Source	df	DFPT	DFPS	ASI	PH	EH	EL	ED	NC/P	NGR/C	NG/R	100GW	HI	BY	GY/P
Replication	2	14.06	6.86	0.01	179.73	21.66	0.42	0.56	0.006	0.06	1.21	5.63	76.18	42.23	11.41
Treatment	19	65.55**	98.57**	2.90**	1163.87**	562.24**	14.51**	9.80**	0.18**	32.94**	69.76**	118.61**	417.91**	1785.94**	572.84**
Error	38	10.82	16.35	0.03	111.94	31.08	1.42	0.81	0.005	1.08	2.32	4.83	33.71	45.53	13.54

**P=0.01

DFPT: Days to 50% tasseling ; DFPS: Days to 50% silking; ASI: Anthesis and silking interval; PH: Plant height ; EH: Ear height; EL: Ear length; ED: Ear diameter; NC/P: Number of cobs per plant; NGR/P: Number of grains row per cob; NG/R: Number of grains per row; 100GW: 100 grain weight; HI: Harvest index; BY: Biological yield; GY/P: Grain yield per plant

Table 2: Estimates of variability parameters for yield and yield traits in maize

Sl. No.	Characters	Mean ± SEM	Range		GCV	PCV	h^2 (bs) (%)	Genetic Advance	Genetic Advance % Mean
			Max.	Min.					
1	Days to 50% tasseling	58.47 ± 1.9	66.00	51.33	7.30	9.22	62.77	6.97	11.92
2	Days to 50% silking	60.78 ± 2.34	71.67	54.33	8.61	10.88	62.62	8.53	14.04
3	Anthesis and silking interval	2.58 ± 0.11	4.20	1.02	37.99	38.65	96.60	1.98	76.92
4	Plant height	148.46 ± 6.11	184.84	121.03	12.61	14.48	75.80	33.58	22.62
5	Ear height	64.48 ± 3.22	88.97	47.40	20.63	22.37	85.06	25.28	39.20
6	Ear length	12.23 ± 0.69	15.76	8.79	17.08	19.67	75.44	3.73	30.57
7	Ear diameter	11.93 ± 0.52	14.55	9.00	14.51	16.36	78.65	3.16	26.51
8	Number of cobs per plant	1.49 ± 0.04	1.97	1.09	16.67	17.29	93.03	0.49	33.13
9	Number of grains row per cob	12.6 ± 0.6	18.58	8.14	25.86	27.15	90.74	6.39	50.76
10	Number of grains per row	16.89 ± 0.88	22.85	8.21	28.07	29.48	90.63	9.29	55.05
11	100 grain weight	31.06 ± 1.27	41.32	19.6	19.82	21.05	88.70	11.94	38.46
12	Harvest index	48.48 ± 3.35	64.17	24.50	23.34	26.23	79.16	20.74	42.78
13	Biological yield	82.67 ± 3.9	143.74	49.84	29.13	30.25	92.72	47.77	57.79
14	Grain yield per plant	39.8 ± 2.12	63.03	16.77	34.30	35.52	93.22	27.15	68.22

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Table 3: Correlation coefficient between yield and its related traits in 20 maize genotypes at genotypic and phenotypic level.

Characters		DFPS	ASI	PH	EH	EL	ED	NC/P	NGR/C	NG/R	100GW	HI	BY	GY/P
DFPT	r_g	0.824**	-0.116	0.218	0.365*	0.0738	0.487**	-0.484**	0.440**	0.1618	-0.401*	-0.1769	-0.375*	-0.446**
	r_p	0.581**	-0.1284	0.1574	0.294*	0.0238	0.374*	-0.350*	0.304*	0.1249	-0.273*	-0.1247	-0.308*	-0.350*
DFPS	r_g	1.000	-0.014	0.0009	0.303*	0.0797	0.337*	-0.338*	0.488**	0.364*	-0.2192	-0.0251	-0.379*	-0.337*
	r_p	1.000	0.0101	0.0153	0.1051	0.0402	0.1682	-0.255*	0.356*	0.2481	-0.2246	-0.0160	-0.2478	-0.2430
ASI	r_g		1.0000	-0.246	-0.342*	-0.1892	-0.392*	-0.0669	-0.2500	0.1203	-0.0360	0.317*	-0.315*	-0.0313
	r_p		1.0000	-0.2101	-0.314*	-0.1758	-0.355*	-0.0670	-0.2301	0.1277	-0.0400	0.289*	-0.294*	-0.0190
PH	r_g			1.000	0.853**	0.359*	0.365*	-0.1155	-0.1214	-0.2067	-0.0729	0.1678	-0.314*	-0.1167
	r_p			1.0000	0.674**	0.2291	0.350*	-0.1137	-0.0822	-0.1590	-0.0809	0.0978	-0.255*	-0.1033
EH	r_g				1.000	0.1980	0.292*	-0.2365	0.0667	0.0207	-0.2172	0.0752	-0.373*	-0.2378
	r_p				1.0000	0.1161	0.2321	-0.1978	0.0874	0.0088	-0.1740	0.0757	-0.348*	-0.2120
EL	r_g					1.0000	0.602**	0.438**	-0.0079	0.543**	0.518**	0.1054	0.478**	0.402*
	r_p					1.0000	0.447**	0.369*	-0.0091	0.434**	0.435**	0.0761	0.382*	0.320*
ED	r_g						1.0000	-0.0432	0.264*	0.338*	0.0846	-0.1267	0.288*	0.0931
	r_p						1.0000	-0.0070	0.2296	0.292*	0.0910	-0.0764	0.2153	0.0873
NC/P	r_g							1.0000	-0.1657	0.418**	0.987**	0.619**	0.705**	0.958**
	r_p							1.0000	-0.1489	0.383*	0.919**	0.548**	0.641**	0.897**
NGR/C	r_g								1.0000	-0.0723	-0.2378	-0.385*	0.0067	-0.2148
	r_p								1.0000	-0.0721	-0.2206	-0.318*	-0.0030	-0.1940
NG/R	r_g									1.0000	0.549**	0.405*	0.359*	0.494**
	r_p									1.0000	0.487**	0.336*	0.332*	0.456**
100GW	r_g										1.0000	0.707**	0.699**	0.995**
	r_p										1.0000	0.580**	0.635**	0.896**
HI	r_g											1.0000	-0.0032	0.636**
	r_p											1.0000	-0.0865	0.630**
BY	r_g												1.0000	0.762**
	r_p												1.0000	0.701**

*P=0.05; **P=0.01

DFPT: Days to 50% tasseling; DFPS: Days to 50% silking; ASI: Anthesis and silking interval; PH: Plant height; EH: Ear height; EL: Ear length; ED: Ear diameter; NC/P: Number of cobs per plant; NGR/P: Number of grains row per cob; NG/R: Number of grains per row; 100GW: 100 grain weight; HI: Harvest index; BY: Biological yield; GY/P: Grain yield per plant

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Table 4: Direct and indirect effects between yield and its related traits in 20 maize genotypes at genotypic and phenotypic level

Traits		DFPT	DFPS	ASI	PH	EH	EL	ED	NC/P	NGR/C	NG/R	100GW	HI	BY	Correlation coefficient with GY/P
DFPT	G	**-0.0054**	-0.0060	0.0006	-0.0012	-0.0020	-0.0004	-0.0026	0.0026	-0.0024	-0.0009	0.0021	0.0009	0.0020	-0.446**
	P	**0.0016**	0.0009	-0.0002	0.0002	0.0005	0.0000	0.0006	-0.0005	0.0005	0.0002	-0.0004	-0.0002	-0.0005	-0.350*
DFPS	G	-0.0093	**-0.0084**	0.0001	0.0000	-0.0025	-0.0007	-0.0028	0.0028	-0.0041	-0.0031	0.0018	0.0002	0.0032	-0.337*
	P	-0.0321	**-0.0553**	-0.0006	-0.0008	-0.0058	-0.0022	-0.0093	0.0141	-0.0197	-0.0137	0.0124	0.0009	0.0137	-0.2430
ASI	G	-0.0129	-0.0016	**0.1107**	-0.0273	-0.0378	-0.0209	-0.0434	-0.0074	-0.0277	0.0133	-0.0040	0.0350	-0.0348	-0.0313
	P	-0.0015	0.0001	**0.0116**	-0.0024	-0.0037	-0.0020	-0.0041	-0.0008	-0.0027	0.0015	-0.0005	0.0034	-0.0034	-0.0190
PH	G	-0.1007	-0.0004	0.1135	**-0.4608**	-0.3931	-0.1655	-0.1683	0.0532	0.0559	0.0952	0.0336	-0.0773	0.1448	-0.1167
	P	0.0124	0.0012	-0.0166	**0.0788**	0.0531	0.0181	0.0276	-0.0090	-0.0065	-0.0125	-0.0064	0.0077	-0.0201	-0.1033
EH	G	0.1315	0.1094	-0.1231	0.3075	**0.3605**	0.0714	0.1051	-0.0853	0.0240	0.0074	-0.0783	0.0271	-0.1346	-0.2378
	P	-0.0103	-0.0037	0.0110	-0.0237	**-0.0351**	-0.0041	-0.0082	0.0069	-0.0031	-0.0003	0.0061	-0.0027	0.0122	-0.2120
EL	G	0.0088	0.0095	-0.0226	0.0428	0.0236	**0.1192**	0.0717	0.0522	-0.0009	0.0647	0.0617	0.0126	0.0570	0.402*
	P	-0.0010	-0.0017	0.0072	-0.0094	-0.0048	**-0.0411**	-0.0183	-0.0151	0.0004	-0.0178	-0.0179	-0.0031	-0.0157	0.320*
ED	G	0.1050	0.0728	-0.0846	0.0789	0.0629	0.1299	**0.2159**	-0.0093	0.0569	0.0730	0.0183	-0.0274	0.0621	0.0931
	P	-0.0088	-0.0039	0.0083	-0.0082	-0.0054	-0.0105	**-0.0234**	0.0002	-0.0054	-0.0069	-0.0021	0.0018	-0.0050	0.0873
NC/P	G	-0.2927	-0.2046	-0.0404	-0.0699	-0.1431	0.2649	-0.0261	**0.6049**	-0.1003	0.2528	0.5971	0.3744	0.4265	0.958**
	P	-0.0391	-0.0284	-0.0075	-0.0127	-0.0221	0.0411	-0.0008	**0.1116**	-0.0166	0.0428	0.1026	0.0612	0.0716	0.897**
NGR/C	G	-0.0364	-0.0404	0.0207	0.0100	-0.0055	0.0007	-0.0218	0.0137	**-0.0827**	0.0060	0.0197	0.0318	-0.0006	-0.2148
	P	0.0193	0.0227	-0.0147	-0.0052	0.0056	-0.0006	0.0146	-0.0095	**0.0637**	-0.0046	-0.0141	-0.0203	-0.0002	-0.1940
NG/R	G	-0.0458	-0.1029	-0.0341	0.0585	-0.0058	-0.1537	-0.0957	-0.1183	0.0205	**-0.2830**	-0.1555	-0.1146	-0.1015	0.494**
	P	0.0031	0.0062	0.0032	-0.0040	0.0002	0.0109	0.0074	0.0096	-0.0018	**0.0252**	0.0123	0.0085	0.0084	0.456**
100GW	G	0.1635	0.0894	0.0147	0.0297	0.0886	-0.2111	-0.0345	-0.4025	0.0970	-0.2241	**-0.4078**	-0.2885	-0.2851	0.995**
	P	0.0070	0.0057	0.0010	0.0021	0.0045	-0.0111	-0.0023	-0.0235	0.0056	-0.0125	**-0.0256**	-0.0149	-0.0163	0.896**
HI	G	-0.1174	-0.0167	0.2100	0.1113	0.0499	0.0699	-0.0840	0.4105	-0.2552	0.2685	0.4693	**0.6633**	-0.0022	0.636**
	P	-0.0809	-0.0104	0.1875	0.0635	0.0492	0.0494	-0.0496	0.3560	-0.2063	0.2182	0.3767	**0.6493**	-0.0562	0.630**
BY	G	-0.2342	-0.2368	-0.1968	-0.1964	-0.2334	0.2987	0.1798	0.4407	0.0042	0.2242	0.4370	-0.0020	**0.6251**	0.762**
	P	-0.2196	-0.1764	-0.2095	-0.1815	-0.2481	0.2723	0.1533	0.4567	-0.0021	0.2367	0.4524	-0.0616	**0.7120**	0.701**
GY/P	G	-0.446**	-0.337*	-0.0313	-0.1167	-0.2378	0.402*	0.0931	0.958**	-0.2148	0.494**	0.995**	0.636**	0.762**	1.0000
	P	-0.350*	-0.2430	-0.0190	-0.1033	-0.2120	0.320*	0.0873	0.897**	-0.1940	0.456**	0.896**	0.630**	0.701**	1.0000

Genotypic Residual Effect = 0.112; Phenotypic Residual Effect = 0.138; Direct effects are on main diagonal

*P=0.05; **P=0.01

DFPT: Days to 50% tasseling ; DFPS: Days to 50% silking; ASI: Anthesis and silking interval; PH: Plant height ; EH: Ear height; EL: Ear length; ED: Ear diameter; NC/P: Number of cobs per plant; NGR/P: Number of grains row per cob; NG/R: Number of grains per row; 100GW: 100 grain weight; HI: Harvest index; BY: Biological yield; GY/P: Grain yield per plant; G:Genotypic path; P:Phenotypic path

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The study revealed that "the major portion of the highly significant positive correlation between grain yield per plant and harvest index is due to its direct effect only, also it expressed high direct positive effect on grain yield per plant among all the traits studied (Table 4). Biological yield, number of cobs per plant, ear height, ear diameter, ear length, anthesis and silking interval also has high direct positive effect on yield per plant. Similar results have been reported for ear height, ear length, ear diameter in respect to grain yield" [26]. Plant height had highest direct negative effect on grain yield per plant. The results of path coefficient analysis suggest that the selection for higher harvest index, biological yield, number of cobs per plant, ear height, ear diameter, ear length, anthesis and silking interval will be highly effective in improving the grain yield per plant in maize.

Conclusion

In maize breeding, occurrence of variability in germplasm is essential for selection and for the success of the breeding programme. A geno-typically distinct genotypes are a priority for the selection of better inbreds to be subsume in single cross hybrid development in maize. The present investigation stipulated the presence of genetic variability for most of the characters in genotypes under study. Character association and path-coefficient analysis unveiled the significance of component characters like harvest index, biological yield, number of cobs per plant in advancement of yield as they were found significantly and positively associated with yield. Thus, from the present investigation it has been presumed that due importance should be given on thesetraits during the selection in maize for improvement of grain yield.

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