

Genetic variability and inter-relationship among grain yield and its components in Maize (*Zea mays* L.)

Abstract

The aim of the present study was to estimate genetic variability, correlation and path coefficient analysis for fifteen yield attributing traits in twenty maize cultivars. High GCV and PCV were observed for grain yield per plant, number of grains per row, number of grain rows per cob, harvest index, cob weight, ear height and biological yield per plant. Maximum heritability conjoined with higher genetic advance for the traits grain yield per plant, plant height, ear height, harvest index, biological yield and cob weight. Grain yield per plant was significantly strong association with harvest index, number of grains per row, cob weight, cob girth, cob length, ear height at both levels. The trait days to 50% tasselling had high direct positive effect with grain yield per plant at genotypic level. The trait biological yield per plant had high direct positive effect with grain yield per plant at phenotypic level.

Not given the cultivar superior/promising in grain and growth characters

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

Introduction

Maize is a vital crop for billions of people, providing food, fodder, and industrial raw materials. Maize has a nutritional profile of 72 percent carbohydrates, 8-11 percent protein, and 4 percent fat, as well as iron 4.8mg/100g, Zn 4.6mg/100g, vitamin C, vitamin E, and vitamin K. USDA National Nutrient Database Currently, over 170 nations produce roughly 1162.3 million MT of maize from an area of 201.9 million ha with an average productivity of 5.75 t/ha; in India, it is grown in an area of 9.89 million ha and produces around 31.65 million tones with an average productivity of 31.99 q/ha, (IIMR, 2021-22).

The demand for maize grain is always increasing. The global population is anticipated to reach 9 billion by 2050. Achievements in hybrid development should be sufficiently supported by germplasm enhancement, gene pool synthesis, and heterotic populations that represent variability for varied requirements. The understanding of the type and magnitude of genotypic and phenotypic variation found in crop species is critical in developing a successful breeding programme to evolve improved cultivars (Abdurakhmonov and Abdukarimov *et al.*, 2008). The presence of differences among individuals in a plant

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community is referred to as variability. The degree of gain acquired in a character under a specific selection pressure is referred to as genetic progress. High genetic advancement combined with high heritability estimates provides the best conditions for selection (Bello *et al.*, 2012). Correlation coefficient analysis exposes the amount and direction of yield components, whereas path analysis finds components that influence yield directly or indirectly. As a result, the current study was conducted to determine the yield contributing features on seed yield per plant in kharif that would be useful for increasing productivity under the respective environmental conditions.

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Materials and Methods

During Kharif-2021, the current experiment was carried out at the Field Experimentation Centre of the Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology, and Sciences, Prayagraj, U.P. The experiment was set up in a randomised block design with three replications. Data for 15 quantitative characters were collected from five randomly selected plants for each genotype in all replications: days to 50% tasseling, days to 50% silking, anthesis to silking interval (ASI), days to 75 percent maturity, plant height, ear height, cob length, cob girth, cob weight, number of grain rows per cob, number of grains for each row, 100 seed weight, biological yield per plant, harvest index and yield per plant.

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The statistical analysis was carried out in accordance with Panse and Sukhatme's instructions (1967). Burton's formula was used to calculate the genotypic (GCV) and phenotypic (PCV) coefficients of variation (1952). Heritability in broad sense, genetic advance and genetic advance as a percent of mean were calculated using the approach described by Lush (1940) and Johnson *et al.* (1955). Correlation analysis was performed using the formula published by Al Jibouri *et al.* (1958) and path coefficient analysis was performed using the approach proposed by Dewey and Lu (1959).

Results and Discussion

The variations among the genotypes identified by results of Analysis of Variance (Table.1) indicating ample scope for selection of promising lines for yield and its components.

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Higher GCV and PCV were found for grain yield per plant, number of grains per row, number of grain rows per cob, harvest index, cob weight, ear height and biological yield per plant (Table 2 & Figure 1). Similar outputs were given by Rai *et al.* (2021) for grain yield per

plant, harvest index and Beulah *et al.* (2018) for number of grains per row, number of grain rows per cob and Magar *et al.* (2021) for cob weight, ear height, biological yield per plant.

Maximum heritability conjoined with high genetic advance for the traits grain yield per plant, plant height, ear height, cob weight, biological yield and harvest index. These findings were same as Bekele *et al.* (2014) for these traits. This results suggested that additive gene action predominated and selection may be helpful for improving these features. The traits grain yield per plant, number of grains per row, number of grains per cob had higher heritability coupled with high genetic advance as percent of mean. This results were same as to Bartaula *et al.* (2019) findings. This suggests that the genotypic variation in the genetic material analysed is most likely attributable to additive genetic variance, which can be efficiently utilized in crop improvement programmes through correct selection methods.

The results of correlation analysis showed significant and non-significant association between yield and other component traits (Table 3). Grain yield per plant was significantly strong association with anthesis to silking interval, plant height, number of grain rows per cob, harvest index, number of grains per row, cob weight, cob girth, cob length and ear height at both levels. These findings were similar with results of Kapoor *et al.* (2015) for number of grains per row, cob weight, cob girth and Jawaharlal *et al.* (2011) for harvest index, cob length and ear height. Days to maturity significantly positive closely associated with days to 50% silking. This is similar to results of Kumar *et al.* (2011). Number of grains per row significantly positive strongly associated with harvest index. This is similar to results of Suhaisini *et al.* (2016). Cob length significantly positive strongly associated with cob weight. This is similar to results of Hemavathy *et al.* (2019). These results were indicated the grain yield per plant was increased when their component traits performing well.

Path analysis furnished to contribution of component traits for grain yield per plant (Table 4) The trait days to 50% tasseling had high direct positive effect with grain yield per plant at genotypic level. The traits cob weight, harvest index moderately positive direct effect with grain yield per plant at genotypic level. This finding were similar with Ferdoush *et al.* (2017) for highly positive direct effect and Sadaiah *et al.* (2013) for moderately positive direct effect. The trait biological yield per plant highly positive directly effect with grain yield per plant at phenotypic level. The traits days to 50% tasseling, ear height, harvest index moderately positive direct effect with grain yield per plant at phenotypic level. This finding were similar with Wali *et al.* (2012) for highly positive direct effect and Chinthiya *et al.* (2019) for moderately positive direct effect. As a result, the features should be regarded as

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essential selection criteria in all maize improvement programmes and direct selection for the traits is advised for yield improvement.

The results revealed that there was considerable variability among the genotypes for all the characters. High GCV and PCV were recorded for grain yield per plant and maximum heritability coupled with high genetic advance was revealed for 100 grain weight. The characters anthesis to silking interval, plant height, ear height, cob length, cob girth, cob weight, number of grain rows per cob, number of grains per row, biological yield and harvest index exhibited significant and positive correlation with grain yield per plant both at genotypic and phenotypic levels. Anthesis to silking, days to 50% tasselling, ear height, number of grain rows per cob, 100 seed weight, biological yield, harvest index had high direct positive effect on seed yield at both levels. Thus, these characters can be used as selection criteria for improvement in maize genotypes.

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Table1: Analysis of variance for quantitative traits of Maize

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Traits	Mean Sum of Squares		
	Genotypes (d=19)	Replication (df=2)	Error (df=38)
Days to 50% tasselling	93.77*	1.85	2.48
Days to 50% silking	92.23*	1.87	2.15
Anthesis to silking interval	0.43*	0.32	0.46
Days to 75% maturity	85.29*	22.87	4.59
Plant height	1105.21*	147.66	54.46
Ear height	730.95*	432.67	45.19
Cob length	12.99*	4.63	2.07
Cob girth	818.12*	96.43	131.85
Cob weight	53.44*	3.65	1.04
Number of grain rows per cob	53.44*	3.65	1.04
Number of grains per row	53.71*	5.91	3.99
100 grain weight	46.62*	0.93	0.27
Biological yield per plant	1706.93*	383.69	218.44
Harvest index	465.24*	27.27	48.41
Grain yield per plant	1089.94*	18.95	92.83

*Indicates Level of significance at 5%.

Table 2: Genetic parameters for quantitative traits of Maize

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Traits	Genotypic Coefficient of Variance	phenotypic Coefficient of Variance	h ² (Broad Sense %)	Genetic Advancement	Genetic Advance as % of Mean
Days to 50% tasseling	9.966	10.101	97.4	11.212	20.257
Days to 50% silking	9.602	9.716	97.7	11.156	19.549
Anthesis to silking interval	5.456	22.072	6.1	0.048	2.778
Days to 75% maturity	5.768	5.93	94.6	10.394	11.559
Plant height	12.922	13.253	95.1	37.591	25.956
Ear height	29.278	30.227	93.8	30.167	58.418
Cob length	16.214	17.684	84.1	3.604	30.624
Cob girth	9.339	12.23	58.3	1.609	14.691
Cob weight	32.943	35.969	83.9	28.536	62.154
Number of grain rows per cob	37.862	38.237	98.1	8.525	77.233
Number of grains per row	41.997	43.65	92.6	8.069	83.239
100 grain weight	16.022	16.069	99.4	8.074	32.911
Biological yield per plant	28.852	30.897	87.2	42.849	55.502
Harvest index	36.172	38.215	89.6	22.984	70.532
Grain yield per plant	65.907	68.907	91.5	35.921	98.858

Table 3: Correlation coefficient for yield and yield contributing traits of Maize

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Traits		DT	DS	ASI	DM	PH	EH	CL	CG	CW	NGRPC	NGPR	SI	BYPP	HI	GYPP
DT	r _g	1	1.000**	-0.214 ^{NS}	0.940**	-0.267*	-0.244 ^{NS}	-0.153 ^{NS}	-0.368**	-0.223 ^{NS}	-0.174 ^{NS}	-0.125 ^{NS}	-0.261*	-0.179 ^{NS}	-0.214 ^{NS}	-0.229 ^{NS}
	r _p	1	0.993**	-0.197 ^{NS}	0.881**	-0.260*	-0.231 ^{NS}	-0.139 ^{NS}	-0.211 ^{NS}	-0.192 ^{NS}	-0.165 ^{NS}	-0.121 ^{NS}	-0.242 ^{NS}	-0.168 ^{NS}	-0.197 ^{NS}	-0.203 ^{NS}
DS	r _g		1	-0.248 ^{NS}	0.942**	-0.283*	-0.268*	-0.176 ^{NS}	-0.398**	-0.258*	-0.202 ^{NS}	-0.138 ^{NS}	-0.262*	-0.213 ^{NS}	-0.248 ^{NS}	-0.262*
	r _p		1	-0.213 ^{NS}	0.886**	-0.273*	-0.244 ^{NS}	-0.141 ^{NS}	-0.222 ^{NS}	-0.208 ^{NS}	-0.181 ^{NS}	-0.118 ^{NS}	-0.244 ^{NS}	-0.191 ^{NS}	-0.213 ^{NS}	-0.226 ^{NS}
ASI	r _g			1	-0.280*	0.558**	0.585**	0.875**	0.768**	0.903**	0.983**	0.381**	0.103 ^{NS}	0.866**	1.000**	0.954**
	r _p			1	-0.255*	0.500**	0.523**	0.692**	0.571**	0.797**	0.866**	0.387**	0.089 ^{NS}	0.737**	1.000**	0.921**
DM	r _g				1	-0.239 ^{NS}	-0.255*	-0.257*	-0.501**	-0.306*	-0.250 ^{NS}	-0.316*	-0.229 ^{NS}	-0.268*	-0.280*	-0.319*
	r _p				1	-0.212 ^{NS}	-0.204 ^{NS}	-0.173 ^{NS}	-0.257*	-0.218 ^{NS}	-0.223 ^{NS}	-0.249 ^{NS}	-0.201 ^{NS}	-0.208 ^{NS}	-0.255*	-0.271*
PH	r _g					1	0.983**	0.678**	1.000**	0.748**	0.693**	0.515**	0.175 ^{NS}	0.789**	0.558**	0.721**
	r _p					1	0.965**	0.583**	0.578**	0.658**	0.646**	0.513**	0.162 ^{NS}	0.695**	0.500**	0.661**
EH	r _g						1	0.649**	1.000**	0.725**	0.727**	0.545**	0.129 ^{NS}	0.778**	0.585**	0.736**
	r _p						1	0.605**	0.593**	0.660**	0.677**	0.554**	0.119 ^{NS}	0.693**	0.523**	0.677**
CL	r _g							1	0.960**	0.856**	0.894**	0.518**	0.072 ^{NS}	0.794**	0.875**	0.867**
	r _p							1	0.586**	0.821**	0.750**	0.552**	0.047 ^{NS}	0.808**	0.692**	0.790**
CG	r _g								1	0.906**	0.929**	0.774**	0.439**	1.000**	0.768**	0.945**
	r _p								1	0.663**	0.570**	0.492**	0.242 ^{NS}	0.676**	0.571**	0.666**
CW	r _g									1	0.885**	0.520**	0.203 ^{NS}	0.989**	0.903**	0.987**
	r _p									1	0.745**	0.573**	0.148 ^{NS}	0.965**	0.797**	0.925**
NGRPC	r _g										1	0.453**	-0.058 ^{NS}	0.833**	0.983**	0.938**
	r _p										1	0.446**	-0.061 ^{NS}	0.723**	0.866**	0.854**
NGPR	r _g											1	0.159 ^{NS}	0.518**	0.381**	0.489**
	r _p											1	0.135 ^{NS}	0.560**	0.387**	0.519**
HSW	r _g												1	0.259*	0.103 ^{NS}	0.173 ^{NS}
	r _p												1	0.196 ^{NS}	0.089 ^{NS}	0.144 ^{NS}
BYPP	r _g													1	0.866**	0.975**
	r _p													1	0.196 ^{NS}	0.089 ^{NS}
HI	r _g														1	0.954**
	r _p														1	0.921**
GYPP	r _g															1
	r _p															1

DT= days to 50% tasselling, DM= days to 50% silking, ASI= anthesis to silking interval, PH= plant height, EH= ear height, CL=Cob length, CG=Cob girth, CW= Cob weight, NGRPC= number of grain rows per cob, NGPR= number of grains per row, HSW=100seed weight, BYPP= biological yield per plant, HI= harvest index, GYPP= grain yield per plant. *, ** indicates significant level at 5% and 1%, NS= Non significant.

Table 4: Path coefficient for yield and yield contributing traits of Maize

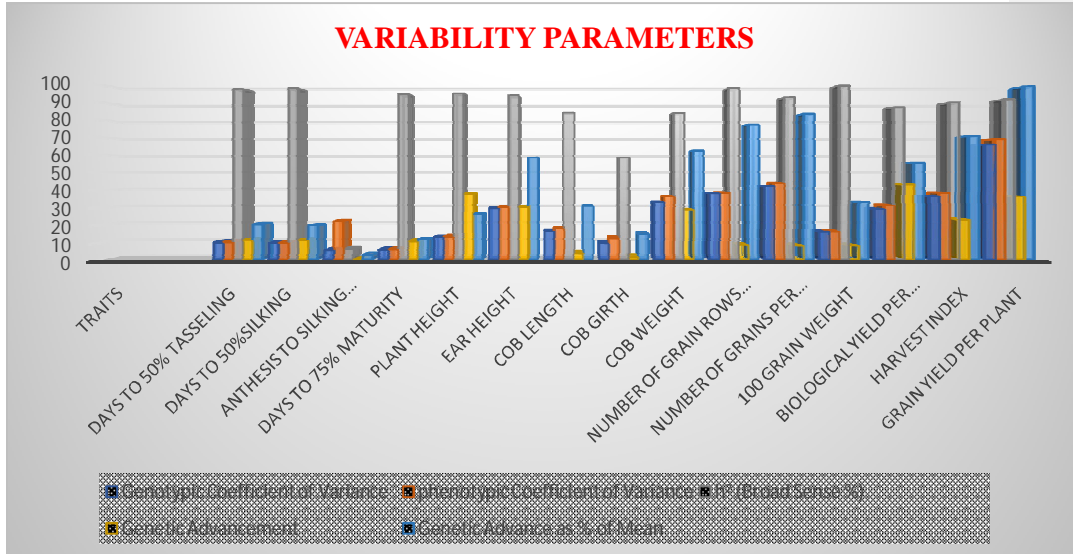
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Traits		DT	DS	ASI	DM	PH	EH	CL	CG	CW	NGRPC	NGPR	HSW	BYPP	HI	GYPP
DT	r _g	0.787	0.787	0.299	0.740	-0.210	-0.192	-0.121	-0.290	-0.176	-0.137	-0.098	-0.206	-0.141	-0.169	-0.229 ^{NS}
	r _p	0.222	0.221	-0.034	0.204	-0.059	-0.053	-0.033	-0.063	-0.047	-0.038	-0.027	-0.057	-0.039	-0.046	-0.203 ^{NS}
DS	r _g	-0.540	-0.540	-0.216	-0.508	0.153	0.145	0.095	0.215	0.139	0.109	0.075	0.141	0.115	0.134	-0.262 [*]
	r _p	-0.157	-0.157	0.014	-0.145	0.044	0.041	0.025	0.048	0.037	0.031	0.021	0.040	0.032	0.037	-0.226 ^{NS}
ASI	r _g	-0.003	0.000	0.052	0.001	-0.005	-0.009	-0.009	-0.009	-0.014	-0.012	0.000	0.005	-0.016	0.004	0.954 ^{**}
	r _p	-0.007	-0.004	0.048	-0.003	-0.009	-0.013	-0.009	-0.013	-0.018	-0.016	-0.004	0.001	-0.020	-0.018	0.921 ^{**}
DM	r _g	-0.255	-0.255	-0.072	-0.271	0.065	0.069	0.070	0.136	0.083	0.068	0.086	0.062	0.073	0.076	-0.319 [*]
	r _p	-0.104	-0.104	0.007	-0.113	0.026	0.027	0.025	0.042	0.030	0.027	0.033	0.025	0.028	0.030	-0.271 [*]
PH	r _g	-0.009	-0.010	0.029	-0.008	0.034	0.033	0.023	0.035	0.025	0.024	0.018	0.006	0.027	0.019	0.721 ^{**}
	r _p	0.053	0.056	0.038	0.046	-0.200	-0.195	-0.127	-0.157	-0.142	-0.135	-0.103	-0.034	-0.150	-0.107	0.661 ^{**}
EH	r _g	-0.009	-0.009	0.048	-0.009	0.035	0.035	0.023	0.038	0.025	0.026	0.019	0.005	0.027	0.021	0.736 ^{**}
	r _p	-0.063	-0.068	-0.072	-0.062	0.255	0.262	0.165	0.214	0.182	0.185	0.143	0.033	0.195	0.147	0.677 ^{**}
CL	r _g	0.012	0.014	-0.101	0.021	-0.055	-0.052	-0.081	-0.077	-0.069	-0.072	-0.042	-0.006	-0.064	-0.071	0.867 ^{**}
	r _p	-0.005	-0.005	-0.006	-0.007	0.020	0.020	0.032	0.024	0.026	0.026	0.017	0.002	0.025	0.025	0.790 ^{**}
CG	r _g	-0.004	-0.005	0.018	-0.006	0.012	0.012	0.011	0.011	0.010	0.011	0.009	0.005	0.012	0.009	0.945 ^{**}
	r _p	0.039	0.041	0.036	0.051	-0.108	-0.112	-0.103	-0.137	-0.105	-0.100	-0.084	-0.046	-0.112	-0.089	0.666 ^{**}
CW	r _g	-0.107	-0.123	0.915	-0.146	0.357	0.346	0.408	0.432	0.477	0.422	0.248	0.097	0.472	0.431	0.987 ^{**}
	r _p	0.050	0.056	0.087	0.064	-0.167	-0.164	-0.198	-0.181	-0.236	-0.195	-0.127	-0.043	-0.230	-0.202	0.925 ^{**}
NGRPC	r _g	-0.037	-0.043	0.331	-0.053	0.146	0.153	0.188	0.196	0.186	0.211	0.095	-0.012	0.175	0.207	0.938 ^{**}
	r _p	-0.014	-0.016	-0.027	-0.020	0.055	0.058	0.068	0.059	0.067	0.081	0.037	-0.005	0.064	0.076	0.854 ^{**}
NGPR	r _g	0.009	0.010	-0.052	0.022	-0.036	-0.038	-0.036	-0.054	-0.036	-0.032	-0.070	-0.011	-0.036	-0.027	0.489 ^{**}
	r _p	0.001	0.001	0.000	0.001	-0.002	-0.003	-0.002	-0.003	-0.003	-0.002	-0.005	-0.001	-0.002	-0.002	0.519 ^{**}
HSW	r _g	-0.010	-0.010	-0.003	-0.009	0.007	0.005	0.003	0.017	0.008	-0.002	0.006	0.039	0.010	0.004	0.173 ^{NS}
	r _p	-0.003	-0.003	0.000	-0.003	0.002	0.002	0.001	0.004	0.002	-0.001	0.002	0.013	0.003	0.001	0.144 ^{NS}
BYPP	r _g	-0.021	-0.025	0.225	-0.032	0.094	0.092	0.094	0.119	0.117	0.099	0.062	0.031	0.119	0.103	0.975 ^{**}
	r _p	-0.142	-0.167	-0.337	-0.199	0.613	0.607	0.653	0.669	0.798	0.644	0.436	0.191	0.816	0.663	0.924 ^{**}
HI	r _g	-0.047	-0.054	0.415	-0.061	0.121	0.127	0.190	0.167	0.196	0.214	0.083	0.022	0.188	0.217	0.954 ^{**}
	r _p	-0.088	-0.100	-0.157	-0.115	0.228	0.238	0.339	0.277	0.364	0.398	0.163	0.041	0.345	0.425	0.921 ^{**}

DT= days to 50% tasselling, **DM**= days to 50% silking, **ASI**= anthesis to silking interval, **PH**= plant height, **EH**= ear height, **CL**=Cob length, **CG**=Cob girth, **CW**= Cob weight, **NGRPC**= number of grain rows per cob, **NGPR**= number of grains per row, **HSW**= 100seed weight, **BYPP**= biological yield per plant, **HI**= harvest index, **GYPP**= grain yield per plant. *, ** indicates significant level at 5% and 1%, NS= Non significant.

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Figure 1. Genetic parameters for quantitative traits of Maize



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