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

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Abstract
The present investigation was carried out to assess the genetic variability parameters, correlation and path analysis in twenty four maize genotypes for eleven yield and its contributing traits during *kharif*, 2017 at Field Experimentation Centre, Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Uttar Pradesh in Randomized Block Design with three replications. The difference between Phenotypic Coefficient of Variation and Genotypic Coefficient of Variation was low for all the character indicating less influenced by the environment. The characters like 100 grain weight, grain rows/cob and cob length showed high heritability coupled with high genetic advance as percentage of mean indicating the preponderance of additive gene action. Hence, direct selection for these characters would be very effective for further improvement of grain yield.

Keywords: Variability parameters, Direct selection and Maize

Introduction
Maize (*Zea mays* L.) is a most important crop of the world after wheat and rice. The nutritional qualities of these industrialized and traditional foods greatly impact the status of many civilizations throughout the world (Saldivar *et al.*, 2016). Progress from selection has been reported to be directly related to the magnitude of genetic variance in the population (Tabanao and Bernardo, 2005). Among the various characteristics in hybrid maize, grain yield is the most important and complex quantitative character controlled by numerous genes. Genetic variability for agronomic characters is a key component of breeding programmes for broadening the gene pool of crops (Ahmad *et al.*, 2011). Knowledge on the nature and magnitude of genetic variation governing the inheritance of quantitative characters like yield and its components is essential for genetic improvement. A critical analysis of genetic variability present in the germplasm of a crop and its estimation is a pre-requisite for initiating any crop improvement programme as well as adopting appropriate selection techniques (Sravanti *et al.*, 2017) [14].

The important function of heritability in genetic studies of quantitative characters is predictive role to indicate the reliability of phenotypic value as a guide to breeding value (Falconer and Mackay, 1996). Characters with high heritability can easily be fixed with simple selection resulting in quick progress. However, it has been accentuated that heritability alone has no practical importance without genetic advance (Najeeb *et al.*, 2009). Genetic advance shows the degree of gain obtained in a character under a particular selection pressure. High genetic advance coupled with high heritability estimates offers the most suitable condition for selection. Hence, a quantitative approach for exploitation of the extensive genetic variability in maize cultivars is of paramount importance. Keeping in view the importance of aforesaid aspects, the present investigation was undertaken to identify the genetic variability, heritability and genetic advance for quantitative characters in maize.

Materials and Methods
The experimental materials comprising of 24 maize genotypes were evaluated in randomized block design with three replications at Field Experimentation Centre, Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad (U.P) during *kharif* 2017. Data were recorded on visual observations of plants on plot basis for traits like days to 50% tasseling, days to 50% silking and days to 50% maturity while data for plant height, cob length, cob girth, grain rows/cob, grains/ row, 100 seed weight, and grain yield/plant were taken from five randomly selected plants of each entry in each replication.

The difference between days to 50% silking and tasseling of each entry was reported as anthesis-silking interval (ASI) (days) for each entry. The mean values over replications were subject to analysis of variance as suggested by Panse and Sukhatme (1964). The variability presence in the genotypes was estimated by phenotypic and genotypic variances and coefficient of variations using the procedure suggested by Burton and De Vane (1952). Heritability in broad sense was computed using the formula given by Burton and Devane, 1953 The genetic advance (GA) was calculated by the formula suggested by Lush (1940).

Results and Discussion

Genotypic and phenotypic correlation

As per Table-1, it was observed that the grain yield per plant had highly significant and positive correlations at genotypic levels with 100 grain weight (0.88**), cob girth (0.57**), cob length (0.44**), anthesis silking interval (0.93**) and grains/ row (0.23*). Days to 50% silking (0.0281), plant height (0.1132), grain rows/ cob (0.2003) and days to maturity (0.1106) had non-significant but positive correlation with grain yield per plant at genotypic levels whereas days to 50% tasseling (-0.0614) had non-significant and negative correlation at genotypic level. As per Table-2, it was observed that the grain yield per plant had highly significant and positive correlations at phenotypic levels with 100 grain weight (0.83**), cob girth (0.49**) and cob length (0.38**).Days to 50% tasseling (0.00), days to 50% silking (0.04), anthesis silking interval (0.03), plant height (0.07), grain rows/ cob (0.16), grains/ row (0.19) and days to maturity (0.1007) had non-significant but positive correlation with grain yield per plant at phenotypic levels. Most of the character pairs had higher values of genotypic correlations their corresponding phenotypic correlations. Such high amount of genotypic correlations could result due to masking or modifying effect of environmental on the association of characters. This indicates that though there was high degree of association between two variables at genotypic level, its phenotypic expression was deflated by the influence of environment. These findings were in agreement with reports of Jayakumar *et al.* (2007) [8], which showed significant and positive correlation of grain yield with ear girth, grains/rows, ear length and grain weight while days to silking were negatively and significantly correlated with grain yield. Bhusal *et al.* (2017) [2] for ear girth, grains/rows, ear length and grain weight. Similar results were observed by Mohammedein *et al*. (2017) [9], Pandey *et al*. (2017) [10], Rahman *et al*. (2017) [11] and Bisen *et al*. (2018) [3].

Path coefficient analysis

As per table 3, the highest positive and direct effect was found for 100 grain weight (1.1451) followed by days to 50 per cent tasseling (0.8376), days to maturity (0.3549), grains/row (0.1557), cob girth (0.1176) and anthesis silking interval (0.0081) at genotypic level. The negative and direct effect was found for days to 50% silking(-1.3770), plant height(-0.0400), cob length(-0.2180) and grain rows/cob(-0.1851) at genotypic level. As per the table 4, the highest positive and direct effect was found for days to 50% tasseling (3.7677) followed by anthesis silking interval (0.7671), 100 grain weight (0.7507), cob girth (0.1244), days to maturity (0.1063), grain rows/cob(0.0814), cob length(0.0694), and grains/row(0.0068) at phenotypic level. The negative and direct effect was found for days to 50% silking(-3.8844) and plant height(-0.0472) at phenotypic level. Path coefficient analysis was used to make partition of the correlation coefficient of the different characters studied to know direct and indirect effects on yield. The information obtained helps in giving proper importance to the various characters during selection or other breeding program so that the improvement of desirable traits can be achieved effective. These findings were in agreement with reports of Saidaiah *et al.* (2008) [12] for 100 grain weight and Jakhar *et al.* (2017) [7] for days to maturity, days to 50% tasseling and days to 50% silking. It is concluded that the genotypes studied show grain yield per plant had highly significant and positive correlations both at genotypic and phenotypic levels with 100 grain weight and cob girth high direct effects of these characters appeared to be the main reason for their strong association with grain yield. Hence, direct selection for these characters would be very effective for further improvement of grain yield.

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Table 1: Genotypic correlation coefficient among yield and yield components in maize

Characters	Days to 50% tasseling	Days to 50% silking	Anthesis silking interval	Plant height	Cob length	Grain rows/ cob	Grains/ row	Cob girth	Days to maturity	100 grain weight	Grain yield per plant
Days to 50% tasseling	1.00	0.90**	0.89**	0.34**	-0.37**	-0.66**	-0.41**	0.22	0.76**	0.03	-0.06
Days to 50% silking		1.00	0.77**	0.34*	-0.32*	-0.64**	-0.37*	0.29*	0.76**	0.11	0.02
Anthesis silking interval			1.00	0.53**	0.74**	-0.95**	0.14	0.96**	0.89**	0.99**	0.93**
Plant height				1.00	0.10	-0.14	-0.17	0.30*	0.43**	0.14	0.11
Cob length					1.00	0.49**	0.78**	0.26*	0.04	0.39**	0.44**
Grain rows/ cob						1.00	0.30*	0.05	-0.15	0.14	0.20
Grains/ row							1.00	0.03	-0.43**	0.24*	0.23*
Cob girth								1.00	0.21	0.58**	0.57**
Days to maturity									1.00	0.17	0.11
100 grain weight										1.00	0.88**
Grain yield per plant											1.00

*,** Significant at 5% and 1% level of significance respectively

Table 2: Phenotypic correlation coefficients among yield and yield components in maize

Characters	Days to 50% tasseling	Days to 50% silking	Anthesis silking interval	Plant height	Cob length	Grain rows/ cob	Grains/ row	Cob girth	Days to maturity	100 grain weight	Grain yield per plant
Days to 50% tasseling	1.00	0.98**	0.10	0.06	-0.21	-0.50**	-0.32*	0.12	0.27*	-0.03	0.00
Days to 50% silking		1.00	0.29*	0.06	-0.21	-0.50**	-0.32*	0.17	0.28*	0.02	0.04
Anthesis silking interval			1.00	0.03	-0.02	-0.11	-0.04	0.33*	0.05	0.27*	0.03
Plant height				1.00	0.08	-0.04	-0.10	0.27*	0.30*	0.08	0.07
Cob length					1.00	0.47**	0.62**	0.26*	0.04	0.32*	0.38**
Grain rows/ cob						1.00	0.29*	0.05	-0.09	0.12	0.16
Grains/ row							1.00	0.11	-0.21	0.15	0.19
Cob girth								1.00	0.10	0.41**	0.49**
Days to maturity									1.00	0.04	0.10
100 grain weight										1.00	0.83**
Grain yield per plant											1.00

*,** Significant at 5% and 1% level of significance respectively

Table 3: Direct and indirect effects of component traits attributing to grain yield in maize genotypic level

Characters	Days to 50% tasseling	Days to 50% silking	Anthesis silking interval	Plant height	Cob length	Grain rows/ cob	Grains/ row	Cob girth	Days to maturity	100 grain weight	Grain yield per plant
Days to 50% tasseling	0.84	0.84	1.59	0.29	-0.32	-0.55	-0.34	0.19	0.64	0.03	-0.06
Days to 50% silking	-1.38	-1.38	-2.44	-0.47	0.45	0.88	0.52	-0.41	-1.05	-0.15	0.02
Anthesis silking interval	0.02	0.01	0.01	0.00	0.01	-0.01	0.00	0.02	0.01	0.02	0.93**
Plant height	-0.01	-0.01	-0.02	-0.04	-0.00	0.01	0.01	-0.01	-0.02	-0.01	0.11
Cob length	0.08	0.07	-0.16	-0.02	-0.22	-0.11	-0.17	-0.06	-0.01	-0.09	0.44**
Grain rows/ cob	0.12	0.12	0.18	0.03	-0.09	-0.19	-0.06	-0.01	0.03	-0.03	0.20
Grains/ row	-0.06	-0.06	0.02	-0.03	0.12	0.05	0.16	0.01	-0.07	0.04	0.23*
Cob girth	0.03	0.04	0.27	0.04	0.03	0.01	0.00	0.12	0.02	0.07	0.57**
Days to maturity	0.27	0.27	0.32	0.16	0.02	-0.06	-0.15	0.08	0.35	0.06	0.11
100 grain weight	0.04	0.13	2.37	0.17	0.46	0.17	0.28	0.67	0.20	1.15	0.88**

Table 4: Direct and indirect effects of component traits attributing to grain yield in maize phenotypic level

Characters	Days to 50% tasseling	Days to 50% silking	Anthesis silking interval	Plant height	Cob length	Grain rows/ cob	Grains/ row	Cob girth	Days to maturity	100 grain weight	Grain yield per plant
Days to 50% tasseling	3.77	3.70	0.41	0.23	-0.82	-1.90	-1.21	0.46	1.04	-0.11	0.00
Days to 50% silking	-3.81	-3.88	-1.14	-0.24	0.83	1.95	1.25	-0.67	-1.11	-0.10	0.04
Anthesis silking interval	0.08	0.23	0.77	0.03	-0.02	-0.09	-0.04	0.25	0.05	0.21	0.03
Plant height	-0.00	-0.00	-0.00	-0.05	-0.00	0.00	0.00	-0.01	-0.01	0.00	0.07
Cob length	-0.02	-0.01	-0.00	0.01	0.07	0.03	0.04	0.02	0.00	0.02	0.38**
Grain rows/ cob	-0.04	-0.04	-0.01	-0.00	0.04	0.08	0.02	0.00	-0.01	0.01	0.16
Grains/ row	-0.00	-0.00	-0.00	-0.00	0.00	0.00	0.01	0.00	-0.00	0.00	0.19
Cob girth	0.02	0.02	0.04	0.03	0.03	0.01	0.01	0.12	0.01	0.05	0.49**
Days to maturity	0.03	0.03	0.01	0.03	0.00	-0.01	-0.02	0.01	0.11	0.00	0.10
100 grain weight	-0.02	0.02	0.21	0.04	0.24	0.09	0.12	0.31	0.03	0.75	0.83**

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