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Assessment of quantitative genetic variability and character association in maize (*Zea mays* L.)

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Abstract
The study was conducted for the analysis of variance, heritability, genetic advance, the coefficient of variation, correlation coefficient and path analysis. The present investigation consists of 10 genotypes of Maize, including 1 check. Highly significant variation was obtained for all character studies. The values of PCV were higher than that of GCV for all the characters. High heritability observed in anthesis-silking interval, grain yield per plant, plant height, cob height, days to maturity and grain row per cob, days, while other characters showed moderate heritability. The high genetic advance is observed in grain yield per plant. All characters showed a low genetic advance as the percentage of the mean, indicating the role of non-additive gene action. The present study revealed that grain yield per plant was positive significantly correlated with 100 grains weight and cobs per plant. The path analysis results showed the positive direct effect on grain yield was exhibited by days to 50% tasseling, day to 50 percent silking, plant height, cob height, days to maturity, cob length, cob girth and 100 seed weight. Therefore, indirect selection can be exercised upon these traits for yield improvement in Maize.

Keywords: maize, GCV, PCV, heritability, variability and genetic advance, correlation and path analysis

Introduction
Maize (*Zea mays* L.) is the most important and widely distributed cereal in the world after rice and wheat and also a staple food crop for human consumption. In country like India, rapid growth in population outstrips our grain in cereal production. Increased production of Maize and its alternate utilization in food channel can reduce the pressure on wheat, rice and its imports. Maize grain has a variety of uses such as for human consumption, livestock feed and ethanol production. As a result of these uses, increasing population and economic development, Maize grain demand is continually increasing. World population is expected to continue to grow as the estimated population of 7.2 billion in 2014 (PRB, 2014) is expected to grow to 9 billion by 2050. Achievements in hybrid development should be adequately backed up by germplasm enhancement, synthesizing of gene pools and heterotic populations representing variability for diverse requirement the knowledge of nature and magnitude of genotypic and phenotypic variability present in the crop species plays a vital role in formulating a successful breeding programme to evolve superior cultivars (Abdurakhmonov and Abdukarimov, 2008) [1]. Variability refers to the presence of difference among the individuals of plant population. 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. (Bello *et al.*, 2012) [4]. Correlation coefficient analysis reveals the magnitude and direction of yield components, while path analysis identifies components which directly or indirectly influences yield. Both character and path analysis helps in formulating an effective breeding strategy to further develop productive inbreds in Maize.

Material and Methods
The present investigation was carried out at Field Experimental Centre of Department of Genetics and Plant Breeding, SHUATS, Allahabad (U.P.) during *Kharif* 2016. This comprised of 10 Maize genotypes including one checks which were obtained from Uttar Pradesh Council of Agricultural Research (UPCAR), Lucknow and raised in Randomized Block Design with three replications. The recommended packages of practices were followed to ensure a good crop stand in hybrid evaluation plot. Observations were recorded on ten randomly selected plants from each replication for thirteen quantitative traits *viz.*, days to 50% tasseling, days to 50% silking, anthesis-silking interval, plant height (cm), cob height (cm), number of cobs/plant, days to maturity, cob length (cm), cob girth (cm), grain rows/cob, grains/row, grain yield/plant (g.) and 100 grain weight (g.). Days to 50 per cent tasseling and silking and days

to maturity were recorded per plot through judgmental sampling. Genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability estimates in broad sense (h^2_{BS}), genetic advance (GA) as percent of means were measured as described by Burton and Devane (1953). The genetic association among the traits was estimated according to the formulae described by Al-Jibouri (1968) [3]. The path coefficient analysis was done according to Dewey and Lu (1959) [9] for assessing the direct and indirect effects of each trait on grain yield.

Results and Discussion

Analysis of variance

The analysis of variance for different characters is presented in (table.1) The treatment i.e., mean sum of squares due to hybrid showed significant differences to all the quantitative characters except for days to 50% tasseling under study at 1% level and 5% level of significant. This indicates that there was an ample scope for selection of promising lines for yield and its components. Similar results in Maize have also been reported by Hepziba *et al.* (2013) [11] for grain yield per plant grains per row, plant height and cob length. Nayaka *et al.* (2015) for grain yield per plant cob height and plant height. Kumar *et al.* (2014) and Nataraj *et al.* (2014) also reported significant mean sum of squares for various quality traits in Maize.

Genetic variability, heritability and genetic advance

In the present investigation the highest estimates of coefficients of variation were registered for grain yield per plant followed by anthesis silking interval. These findings are in agreement with the findings of Saikia *et al*. (2000) [19], Kumar and Satyanarana (2001) [14], Singh *et al*. (2003) [21] and Abirami *et al.* (2005) [2]. Moderate estimates of coefficients of variation were recorded for ear length by Singh *et al.* (2003) [21]. In the present investigation, the heritability estimates were found to be high (more than 60 percent) for grain yield per plant anthesis silking interval, grain yield per plant, plant height, cob height, days to maturity and grains per row Nayaka *et al*. (2015) [17], Choudhary and Chaudary (2002) [8], Singh *et al.* (2003) [21].

In present investigation high heritability coupled with high genetic advance for the characters like, grain yield per plant (84.30% and 32.41 %) and plant height (69.90 % and 24.83%) was observed. High heritability accompanied with high to moderate GCV and genetic advance in case of yield per plant indicates that most likely the heritability is due to additive gene effects and selection may be effective in early generations for these traits. High heritability with moderate genetic gene was observed in cob height, similar results was observed by Choudhary and Chaudary (2002) [8], Bharathiveeramani *et al.* (2012) [5] Whereas cobs per plant, days to 50% silking, grain rows per cob, 100 seed weight, cob length, cob girth and days to 50% tasseling exibuted moderate heritability along with low genetic advance indicating non-additive gene action and provides limited scope for improvement of traits through selection, similar results were also reported by Krishnam (2001) [12] and Kumar and Satyanarayanan (2001) [14].

Correlation Coefficient Analysis

The genotypic and phenotypic correlation for all the trials reveled that genotypic correlation was at the higher magnitude than the phenotypic correlation in most of the cases indicating a higher degree of association among the characters. Therefore, selection based on the phenotypic traits would be effective in achieving genetic gain. Grain yield per plant showed highly significant positive association with 100 seed weight (0.99**), cobs per plant (0.92**), plant height (0.84**), cob girth (0.71**) 50% tasseling (0.67**), cob height (0.64**) cob length(0.59**) and 50% silking (0.41*).it also showed positive but non-significant association with days to maturity(0.33).While negative and significant anthesis silking interval (-0.57**) and negative but non-significant association was recorded for grains rows per cob (-0.16) and grains per row (-0.06).Grain yield per plant showed significant positive association with plant height (0.64**), 100 seed weight (0.58**) cob per plant (0.53**) and days to 50% tasseling (0.45**). While positive but non-significant with cob height (0.36), days to maturity (0.34), 50% silking (0.32), cob length (0.30) and cob girth (0.24). While negative significant was recorded for anthesis silking interval (-0.50**) and negative but non-significant observed in and number of grain rows per cob and grains per row (-0.09).

The present study revealed that Grain yield per plant showed highly significant positive association with 100 seed weight and cobs per plant. This also further indicates a very strong inherent association between these yield components with grain yield. It was also observed that, among the yield components 100 seed weight exhibited highly significant positive association with most of the trait, similar results were given by Kumar and Satyanarayana (2001) [14], Choudhary and Chaudary (2002) [8] and Kumar *et al.*(2014) [13].

Path Analysis

The path coefficient analysis at genotypic level revealed that the 100-seed weight exhibited the largest direct effect on grain yield per plant followed by, days to 50 percent tasseling ear girth, ear height. These observations are in conformity with the findings of others related to days to Vaezi *et al.* (2000) [22], Venugopal *et al*., (2003) [23], 100-seed weight followed by ear height showed direct effect on grain yield Mohan *et al.* (2002) [15]. And path coefficient analysis at phenotypic leve; indicated that, the traits having direct effects on grain yield are understood to be strongly associated with it. Phenotypic level showed that positive direct effect on grain yield was exhibited by day to 50 percent silking, cob girth, plant height, 100 seed weight, days to maturity and cob length, while negative direct effect on anthesis silking interval, cob height, grains per row, days to 50% tasseling, cobs per plant and grain rows per cob on grain yield per plant was exhibited at phenotypic level. These observations are inconformity with the finding of others related to plant height 100 seed weight, days to 50 percent tasseling, plant height Venugopal *et al.* (2003) [23], 100 seed weight showed by Mohan *et al.* (2002) [15] and 50% tasseling resulted by Chiniadurai and Nagarajan (2011) [7] and Reddy *et al.* (2016) [18]. Therefore, any variation in these traits will highly influence grain yield per plant. On the whole, the result of path analysis showed that cob girth and seed index had a very strong relationship with grain yield per plant. The observation showed the extent of the reliability of these traits as a good selection index for grain yield. So direct selection for these traits can help to improve Maize grain yield per unit area.

Table 4.1: Analysis of variance for thirteen quantitative characters in Maize

S. No.	Parameters	Mean Squares		Error (df=18)
		Replications (df =2)	Treatments (df =9)	
1	Days to 50% tasseling	0.93	7.48	3.11
2	Days to 50% silking	2.10	16.05**	3.91
3	Anthesis silking interval	0.00	1.41**	0.07
4	Plant height	275.55	726.2**	94.58
5	Cob height	10.51	166.93**	23.58
6	Cobs per plant	0.00	0.01**	0.00
7	Days to maturity	5.70	31.48**	5.21
8	Cob length	2.49	6.27*	1.90
9	Cob girth	0.44	3.24*	1.23
10	Grain rows per cob	0.89	2.20**	0.60
11	Grains per row	3.97	12.79**	2.17
12	100 seed weight	3.33	3.33*	9.33
13	Grains yield/ plant	87.15	935.90**	54.69

** Significant at 1% level and *Significant at 5% level

Table 2: Estimation of components of variance and genetic parameter for grain yield and other components

Parameters Characters	σ2g	σ2p	Coefficient of variance		Heritability (h2) (BS) %	Genetic advance 5 %	Genetic advance as % of mean 5%
			GCV	PCV			
50% Tasseling	1.45	4.57	2.49	4.41	31.8	1.40	2.89
50%Silking	4.04	7.96	3.97	5.57	50.8	2.95	5.84
ASI	0.44	0.51	29.92	32.21	86.3	1.27	57.26
Plant height	210.54	305.12	6.94	8.36	69.0	24.83	11.88
Cob height	47.69	71.54	8.86	10.85	66.7	11.61	14.90
Cobs/plant	0.00	0.00	5.52	7.54	53.7	0.08	8.33
Days to Maturity	8.75	13.97	3.48	4.40	62.7	4.82	5.68
Cob length	1.45	3.36	7.21	10.95	43.4	1.63	9.78
Cob girth	0.67	1.90	5.81	9.81	35.1	0.99	7.09
Grain rows/cob	0.53	1.13	5.00	7.31	46.9	1.03	7.06
Grains/row	3.53	5.71	5.66	7.20	61.9	3.04	9.189
100 Seed weight	7.33	16.66	8.64	13.02	44.0	3.70	11.81
Grain yield/plant	293.78	348.43	31.62	34.38	84.3	32.41	59.71

σ^2g = Genotypic variance, σ^2p = Phenotypic variance, h^2 = Heritability (broad sense), GCV = Genotypic coefficient of variation, PCV = Phenotypic coefficient of variation

Table 3: Genotypic and phenotypic correlation coefficients of grain yield and yield component traits in Maize.

Characters		Days to 50% tasseling	Days to 50% silking	ASI	Plant height	Cob height	Cobs per plant	Days to maturity	Cob length	Cob girth	Grain rows per cob	Grains per row	100 seeds weight	Grains yield/ plant
Days to 50% tasseling	g	1.00	0.99**	0.18	0.89**	0.84**	0.48**	0.66**	0.81**	1.32	0.89**	0.65**	0.67**	0.67**
	p	1.00	0.87**	0.09	0.44*	0.37*	0.20	0.48**	0.25	0.31	0.47**	0.26	0.26	0.45
Days to 50% silking	g		1.00	0.43*	0.53**	0.37*	0.49**	0.55**	0.55**	0.94**	0.85**	0.67**	0.62**	0.41*
	p		1.00	0.35	0.35	0.29	0.21	0.33	0.17	0.26	0.55**	0.26	0.14	0.32
ASI	g			1.00	-0.60**	-0.61**	0.43*	0.06	-0.14	0.00	0.71**	0.32	-0.19	-0.57**
	p			1.00	-0.51**	-0.44*	0.26	0.04	-0.12	0.06	0.49**	0.21	-0.16	-0.50
Plant height	g				1.00	0.93**	0.26	0.46*	0.44*	0.53**	0.17	-0.03	0.64**	0.84**
	p				1.00	0.75**	-0.04	0.35	0.20	0.19	0.02	0,05	0.45**	0.64
Cob height	g					1.00	0.26	0.56**	0.04	0.51**	0.20	-0.11	0.26	0.64**
	p					1.00	0.04	0.24	0.11	0.26	0.06	-0.01	0.18	0.36
Cobs per plant	g						1.00	-0.10	0.11	0.33	0.87**	0.41*	-0.26	0.92**
	p						1.00	-0.11	0.04	0.15	0.50**	0.16	-0.25	0.53**
Days to maturity	g							1.00	0.09	0.01	0.30	-0.04	0.52**	0.33
	p							1.00	0.09	0.02	0.08	0.06	0.52**	0.34
Cob length	g								1.00	0.69**	0.48**	0.78**	0.24	0.59**
	p								1.00	0.46*	0.19	0.60**	0.22	0.30
Cob girth	g									1.00	0.67**	0.38*	0.14	0.71**
	p									1.00	0.34	0.47**	0.22	0.24
Grain rows per cob	g										1.00	0.62**	-0.02	-0.16
	p										1.00	0.29	-0.16	-0.09
Grains per row	g											1.00	-0.41*	-0.06
	p											1.00	-0.08	-0.09
100 seeds weight	g												1.00	0.99**
	p												1.00	0.58**
Grains yield/ plant	g													1.00
	p													1.00

G = Genotypic correlation coefficient. P = Phenotypic correlation coefficient. *Significant at 5% level, **Significant at 1% level.

Table 4: Path coefficient (genotypic) analysis showing Direct (bold) and indirect effects of component traits in Maize.

Character	Days to 50% Tasseling	Days to 50% Silking	Anthesis Silking Interval	Plant Height	Cob Height	Cobs per Plant	Days to Maturity	Cob Length	Cob Girth	Grain Rows per Cob	Grains per Row	100 Seed Weight
Days to 50% Tasseling	-0.0796	-0.0793	-0.0144	-0.0711	-0.0673	-0.0385	-0.0528	-0.0646	-0.1054	-0.0714	-0.0519	-0.0537
Days to 50% Silking	0.6639	0.6663	0.2916	0.3558	0.2492	0.3330	0.3679	0.3679	0.6320	0.5702	0.4499	0.4190
Anthesis Silking Interval	-0.1149	-0.2771	-0.6331	0.3845	0.3864	-0.2766	-0.0405	0.0934	-0.0038	-0.4509	-0.2082	0.1247
Plant Height	0.3156	0.1887	-0.2146	0.3533	0.3320	0.0936	0.1654	0.1563	0.1881	0.0609	-0.0131	0.2291
Cob Height	-0.3271	-0.1446	0.2360	-0.3633	-0.3866	-0.1025	-0.2194	-0.0190	-0.1993	-0.0793	0.0456	-0.1022
Cobs/ Plant	-0.1830	-0.1890	-0.1652	-0.1002	-0.1002	-0.3781	0.0398	-0.0440	-0.1263	-0.3303	-0.1577	0.0996
Days to Maturity	-0.0263	-0.0219	-0.0025	-0.0186	-0.0225	0.0042	-0.0397	-0.0039	-0.0008	-0.0121	0.0018	-0.0209
Cob Length	0.0659	0.0448	-0.0120	0.0359	0.0040	0.0095	0.0079	0.0812	0.0565	0.0391	0.0637	0.0202
Cob Girth	0.4292	0.3074	0.0020	0.1725	0.1671	0.1082	0.0063	0.2257	0.3241	0.2180	0.1248	0.0469
Grain Rows/ Cob	0.0896	0.0854	0.0711	0.0172	0.0205	0.0872	0.0305	0.0481	0.0672	0.0999	0.0622	-0.0022
Grains/ Row	-0.2218	-0.2297	-0.1119	0.0126	0.0401	-0.1419	0.0155	-0.2670	-0.1310	-0.2118	-0.3402	0.1411
100 Seed Test Weight	0.0644	0.0600	-0.0188	0.0619	0.0252	-0.0251	0.0503	0.0237	0.0138	-0.0021	-0.0396	0.0954
r_g Grains Yield/ Plant	0.6757	0.4111	-0.5719	0.8406	0.6478	-0.3270	0.3313	0.5980	0.7151	-0.1698	-0.0627	0.9971
Partial R^2	-0.0538	0.2738	0.3621	0.2970	-0.2505	0.1236	-0.0131	0.0486	0.2318	-0.0170	0.0213	0.0951

R Square = 1.0262, Residual Effect = SQRT (1-1.0262)

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