

Heritability, Correlation and Path Coefficient Analysis for Determining Interrelationships among Grain Yield and Related Characters in Maize (*Zea mays* L.)

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ABSTRACT

Knowledge of interrelationships between grain yield and its contributing components will improve the efficiency of breeding programs through the use of appropriate selection indices. The objective of this study was to evaluate of interrelationships among grain yield and related Characters in 45 F_1 corn hybrids. The hybrids were evaluated in randomized complete block design with three replications. The genetic parameters studied among the traits included the mean performance, genotypic variances, phenotypic variances, genotype by environment variances, broad sense heritability, phenotypic and genotypic correlation coefficients and path analysis. Significant differences were recorded for all traits studied thereby revealing the diversity of the maize genotypes. Grain yield per plant, shelling%, and 100seed weight (g) showed high heritability had high genotypic variances suggesting the involvement of additive gene action. Days to 50% tasseling, days to 50% silking and physiological maturity showed the highest heritability but low genotypic variance suggesting the preponderance of non-additive gene action. The grain yield was positively and strongly correlated with 100seed weight, shelling%, cob length, plant height, kernels per row and kernel rows per cob. Path analysis was used to partition the genetic correlations between grain yield and related characters. Days to 50% silking, physiological maturity, shelling% and 100-seed weight showed positive direct effect on grain yield. The highest direct effect belonged to days to 50% silking the highest direct effect (0.3032), followed by physiological yield (0.1586).

Key words: Maize, Heritability, Correlation coefficient, Path coefficient analysis and Grain Yield

INTRODUCTION

Maize (*Zea mays* L.) is the third most important cereal in India after rice and wheat (Centre for Monitoring Indian Economy, 2015). It provides food, feed, fodder, fuel and severe as a source of basic raw material for a

number of industrial products viz., starch, oil, protein, alcoholic beverages, food sweeteners, cosmetics and bio-fuel etc. Maize being a C_4 plant is physiologically more efficient, has higher grain yield and wider adaptation over wide range of environmental conditions.

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Because of very wide utilization of maize, the main goal of all maize breeding programs is to obtain new inbred and hybrids that will outperform the existing hybrids with respect to a number of traits. In working towards this goal, particular attention is paid to grain yield as the most important agronomic characteristic. Grain yield is a complex quantitative trait that depends on a number of factors. Thus, knowledge of interrelationships between grain yield and its contributing components will improve the efficiency of breeding programs through the use of appropriate selection indices¹².

The mean values, genotypic and phenotypic variances, heritability, correlation coefficients and path coefficient analysis of the traits are some of the key parameters which determine the efficiency of a breeding program. The phenotypic variance explicates the total variance among phenotypes tested in different environments of interest to the plant breeder, while, the total genotypic variance explains the portion of phenotypic variance attributable to the failure of homogeneity among genotypes in different environments²⁴. The heritability measures the value of selection for a particular trait in various types' progenies¹⁰. It encompasses the phenotypic variance attributable to genetic causes which have a predictive function in plant breeding leading to permanent genetic improvement. This is because a genotype could be selected based on the phenotype given that the environmental effect is separated from the total variability¹. The knowledge of heritability establishes appropriate selection method coupled with the prediction of any gains from selection, while, also helping to establish the magnitude of the genetic effects. Larger genotypic variance is most preferred given that high heritability value can be obtained with genotypes with either small or large genetic progress. High heritability is associated with additive gene effect whereas low heritability is due to dominance and epistasis. The coefficient of variance shows that extent of variability represented by the different characters but it excludes the heritable portion. Conversely, the

coefficient of correlations help to measure the level of relationships between the traits and also establish the level at which these traits are mutually different^{2, 13}. The correlations also give reliable and useful information on nature, extent and direction of selection²⁶. Path analysis showed direct and indirect effects of cause variables on effect variables. In this method, the correlation coefficient between two traits is separated into the components which measure the direct and indirect effects⁵. Generally, this method provides more information among variables than do correlation coefficients since this analysis provides the direct effects of specific yield components on yield, and indirect effects via other yield components⁶. This study aimed at understanding the genetic parameters which determine the relationship between maize yield and other related traits.

MATERIALS AND METHODS

Fifteen diverse inbred lines (Table-1) of maize were crossed in line x tester mating design during rabi, 2013 and F₁ seeds of all the resultant crosses were procured. All the 45 F₁s and their parents (15 lines and 3 testers) were grown in a randomized complete block design with three replications during Kharif, 2015 with one standard check (31Y45) at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh. The observation were taken for grain yield per plant, days to 50% tasseling, days to 50% silking, plant height (cm), cob length (cm), physiological maturity, shelling%, kernel rows per cob, kernels per row and 100-seed weight (g) on five randomly selected competitive plants of each entry in each replication. Analysis of variance (ANOVA) was carried out to establish the level of significance among genotypes. The phenotypic and genotypic coefficient of variability measured according¹, heritability in broad sense², genetic advance according to¹⁸. Correlation coefficients were determined as described by²¹.

RESULT AND DISCUSSION

Analysis of variance revealed significant differences for all of the 10 quantitative traits studied which was presented in Table 2. Genetic parameters of yield and their components are given in table-3. Genotypic coefficient of variation (GCV) was the highest in case of grain yield per plant (22.61) followed by 100-seed weight (12.72) and kernels per row (8.61), while, lowest genotypic coefficient of variances was found for days to 50% tasseling (3.22) and days to 50% silking (3.27). Phenotypic coefficient of variation (PCV) was the highest in case of grain yield per plant (22.87) followed by 100-seed weight (13.40) and kernels per row (9.84), while, lowest phenotypic coefficient of variance was found for days to 50% tasseling (3.44) and days to 50% silking (3.47). The highest environmental coefficient of variances was found for kernels per row (4.76) and 100-seed weight (4.20), while, lowest was found for days to 50% silking (1.16) and days to 50% tasseling (1.20)^{7, 20, 17}. The higher values of genetic advance were found for grain yield per plant (46.05%), 100-seed weight (24.89%) and kernels per row (15.54%) and lowest for days to 50% tasseling (6.21) and days to 50% silking (6.35). The greater values of genetic advance indicated that 100-seed weight and kernels per row can be used for selecting higher yielding genotypes^{14, 11}. The highest heritability (98%) was found for grain yield per plant. The ranges of heritability varied from 72 to 98%. The greater values of heritability were found for all the characters. The higher value of heritability for grain yield per plant, shelling% and 100-seed weight indicates that these characters can be used as the genetic parameters for the improvement and selection of higher yielding genotypes^{19, 11, and 17}. Crop improvement could be possible by simple selection because high heritability coupled with high genotypic variation revealed the presence of an additive gene effect.

Genotypic correlations reveal the existence of real associations, whereas phenotypic correlations may occur by chance. Significant phenotypic correlations without significant genotypic associations are of no value. If the

genotypic correlation is significant and phenotypic is not, it means that the existing real association is masked by environmental effect. In general, genotypic correlations were of higher magnitude than the corresponding phenotypic values and hence only the genotypic correlations are discussed. The coefficient correlations among the various characters are presented in Table 4.

The results indicated that grain yield was positively and significantly associated with 100-seed weight (0.785), shelling% (0.608), cob length (0.618), kernels per row (0.656), plant height (0.586) and kernel rows per cob (0.315)^{9, 17, 23}. The characters days to 50% tasseling, days to 50% silking and physiological maturity were negatively correlated with grain yield per plant and are similar to the results reported by^{25, 17}. The developmental characters, namely days to 50% tasseling, days to 50% silking and to physiological maturity were positively correlated but these traits negative correlation with plant height, con length, shelling%, kernel row per cob, kernels per row and 100-seed weight. Plant height correlated significant and positively with cob length (0.471), shelling% (0.691), kernel rows per cob (0.643), kernels per row (0.351) and 100-seed weight (0.449). Cob length correlated significantly positively with shelling% (0.721), kernel rows per cob (0.580), kernels per row (0.526) and 100-seed weight (0.858)^{22, 8}. Also, shelling% showed positive and significantly correlation with kernel rows per cob (0.708), kernels per row (0.754) and 100-seed weight (0.548). Kernel rows per cob correlated significant and positively with kernels per row (0.369), 100-seed weight (0.518) and kernels per row correlated significant and positively with 100-seed weight (0.506)^{23, 17}.

The coefficient correlations were analyzed further by the path coefficient technique, which involves partitioning the correlation coefficients into direct and indirect effects via alternative characters or pathways. The direct and indirect effects of the grain yield related characters are shown in Table 5. Days to 50% silking, physiological maturity, shelling% and

100-seed weight showed positive direct effect on grain yield. Days to 50% tasseling, plant height, cob length, kernel rows per cob and kernels per row showed negative direct effect on grain yield per plant. The lowest direct effect belonged to 100-seed weight (0.0047) followed by shelling% (0.0920). Also, the highest direct effect belonged to days to 50% silking (0.332), followed by physiological maturity (0.1586). The relatively high positive

direct effect of days to 50% silking on grain yield was counterbalanced by its negative indirect effect via days to 50% tasseling, shelling% and 100-seed weight. The higher magnitude of positive indirect effect on grain yield per plant was 100-seed weight followed by kernels per row, cob length, shelling% and plant height. Similar findings have also been reported by^{15, 16, 17}.

Table 1: Source and pedigree of the parents under investigation

Line Code	Parents	Source
L1	CIMMYT-K12-8-1	CIMMYT, Mexico
L2	CIMMYT-K12-8-2	CIMMYT, Mexico
L3	CIMMYT-K12-40-1	CIMMYT, Mexico
L4	CIMMYT-K12-40-2	CIMMYT, Mexico
L5	CIMMYT-K12-40-3	CIMMYT, Mexico
L6	CIMMYT-K12-40-4	CIMMYT, Mexico
L7	CIMMYT-K12-40-5	CIMMYT, Mexico
L8	CIMMYT-3	CIMMYT, Mexico
L9	CIMMYT-K12-13	CIMMYT, Mexico
L10	CIMMYT-K12-13-1	CIMMYT, Mexico
L11	CIMMYT-K12-13-2	CIMMYT, Mexico
L12	CIMMYT-K12-13-3	CIMMYT, Mexico
L13	CIMMYT-14-1	CIMMYT, Mexico
L14	BLACK DIAMOND	CSAUA&T, Kanpur
L15	TSK-79	CSAUA&T, Kanpur
Testers		
T1	AZAD UTTAM	CSAUA&T, Kanpur
T2	Azad Kamal	CSAUA&T, Kanpur
T3	HKI-163	Karnal

Table 2: Analysis of variance for quantitative and qualitative characters in F₁ of maize

Traits			Days to 50% tasseling	Days to 50% silking	Plant Height (cm)	Cob Length (cm)	Physiological Maturity	Shelling (%)	Kernel Rows/ Cob	Kernels/ Row	100-Seed Weight (g)	Grain yield/ plant (g)
Mean	Source	df	2.07	1.97	0.77	0.04	16.94	3.63	0.04	0.74	0.04	5.26
sum of	Replication	2										
Squares	Treatment	63	29.25**	31.94**	434.35**	3.47**	116.67**	48.59**	1.71**	789.37**	27.61**	770.58**
	Error	12	1.32	1.28	16.56	0.18	6.39	1.17	0.19	145.60	0.96	5.81
		6										

Table 3: Estimates of mean, phenotypic (PCV), genotypic (GCV), and environmental (ECV) coefficient of variation, heritability in broad sense (H² %) and genetic advance (GA) in per cent of mean for eight characters in F₁ generation of maize

Characters/Parameters	Mean	H ² (%)	GA (%)	PCV	GCV	ECV
Days to 50% tasseling	94.78	88.00	6.21	3.44	3.22	1.21
Days to 50% silking	97.70	89.00	6.35	3.47	3.27	1.16
Plant Height (cm)	164.27	89.00	13.99	7.60	7.18	2.48
Cob Length (cm)	14.17	86.00	14.10	7.98	7.39	3.01
Physiological Maturity	137.18	85.00	8.40	4.79	4.42	1.84
Shelling (%)	67.11	93.00	11.78	6.14	5.92	1.61
Kernel Rows/ Cob	13.25	72.00	9.35	6.33	5.36	3.36
Kernels/ Row	22.60	77.00	15.54	9.84	8.61	4.76
100-Seed Weight (g)	23.42	90.00	24.89	13.40	12.72	4.20
Grain yield/ plant (g)	70.62	98.00	46.05	22.87	22.61	3.41

Table 4: Genotypic (G) and phenotypic (P) correlation coefficients among yield and quantitative traits in maize

Characters	Correlation coefficients	Days to 50% tasseling	Days to 50% silking	Plant Height (cm)	Cob Length (cm)	Physiological Maturity	Shelling (%)	Kernel Rows/ Cob	Kernels/ Row	100-Seed Weight (g)	Grain yield/ plant (g)
Days to 50% tasseling	G	1	0.997**	-0.128	-0.436**	0.976**	-0.537**	-0.516**	-0.578**	-0.368*	-0.381*
	P	1	0.983**	-0.101	-0.376*	0.848**	-0.493**	-0.423*	-0.432*	-0.321*	-0.352*
Days to 50% silking	G		1	-0.166	-0.469**	0.992**	-0.570**	-0.540**	-0.618**	-0.403*	-0.420*
	P		1	-0.140	-0.404*	0.878**	-0.528**	-0.438**	-0.477**	0.354*	-0.390*
Plant Height (cm)	G			1	0.471**	-0.226*	0.691**	0.643**	0.351*	0.449*	0.586**
	P			1	0.407*	-0.184*	0.626**	0.451**	0.297*	0.422*	0.547**
Cob Length (cm)	G				1	-0.543**	0.721**	0.580**	0.526**	0.858**	0.618**
	P				1	-0.479**	0.630**	0.455*	0.433*	0.744**	0.568**
Physiological Maturity	G					1	-0.673**	-0.594**	-0.724**	-0.472**	-0.476*
	P					1	-0.596**	-0.484**	-0.596**	-0.409*	-0.437*
Shelling (%)	G						1	0.708**	0.754**	0.548**	0.608**
	P						1	0.589**	0.634**	0.494**	0.580**
Kernel Rows/ Cob	G							1	0.369*	0.518**	0.315*
	P							1	0.260*	0.378*	0.263*
Kernels/ Row	G								1	0.506**	0.656**
	P								1	0.423*	0.562**
100-Seed Weight (g)	G									1	0.785**
	P									1	0.733**
Grain yield/ plant (g)	G										1
	P										1

*, ** - significant at 5% and 1% probability level, respectively.

Table 5: Direct and indirect effect of nine characters on grain yield per plant (g) at genotypic and phenotypic level

Characters	Correlation coefficients	Days to 50% tasseling	Days to 50% silking	Plant Height (cm)	Cob Length (cm)	Physiological Maturity	Shelling (%)	Kernel Rows/ Cob	Kernels/ Row	100-Seed Weight (g)
Days to 50% tasseling	G	-0.4330	-0.4332	0.0554	0.1887	-0.4228	0.2324	0.2236	0.2503	0.1592
	P	-0.0047	-0.0046	0.0005	0.0017	-0.0039	0.0023	0.0020	0.0020	0.0015
Days to 50% silking	G	0.3033	0.3032	-0.0503	-0.1421	0.3009	-0.1729	-0.1636	-0.1873	-0.1221
	P	0.0183	0.0186	-0.0026	-0.0075	0.0163	-0.0098	-0.0081	-0.0089	-0.0066
Plant Height (cm)	G	0.0039	0.0051	-0.0306	-0.0144	0.0069	-0.0211	-0.0197	-0.0107	-0.0137
	P	-0.0009	-0.0012	0.0088	0.0036	-0.0016	0.0055	0.0040	0.0026	0.0037
Cob Length (cm)	G	0.0036	0.0039	-0.0039	-0.0082	0.0045	-0.0059	-0.0048	-0.0043	-0.0071
	P	-0.0043	-0.0046	0.0046	0.0114	-0.0054	0.0071	0.0052	0.0049	0.0085
Physiological Maturity	G	0.1549	0.1574	-0.0358	-0.0861	0.1586	-0.1067	-0.0942	-0.0049	-0.0748
	P	-0.0072	-0.0075	0.0016	0.0041	-0.0085	0.0051	0.0041	0.0051	0.0035
Shelling (%)	G	-0.0494	-0.0525	0.0636	0.0664	-0.0619	0.0920	0.0651	0.0694	0.0505
	P	-0.0056	-0.0060	0.0071	0.0072	-0.0068	0.0114	0.0067	0.0072	0.0056
Kernel Rows/ Cob	G	0.0203	0.0212	-0.0252	-0.0228	0.0233	-0.0278	-0.0392	-0.0145	-0.0203
	P	0.0037	0.0039	-0.0040	-0.0040	0.0043	-0.0052	-0.0089	-0.0023	-0.0033
Kernels/ Row	G	0.0042	0.0045	-0.0026	-0.0038	0.0053	-0.0055	-0.0027	-0.0073	-0.0037
	P	-0.0001	-0.0001	0.0001	0.0001	-0.0001	0.0002	0.0001	0.0002	0.0001
100-Seed Weight (g)	G	-0.0017	-0.0019	0.0021	0.0040	-0.0022	0.0026	0.0024	0.0024	0.0047
	P	-0.0030	-0.0033	0.0040	0.0070	-0.0038	0.0046	0.0035	0.0040	0.0094
Correlation with Grain yield/ plant (g)	G	-0.3806**	-0.4200**	0.5859**	0.6181**	-0.4762**	0.6082**	0.3147**	0.6561**	0.7854**
	P	-0.3524**	-0.3900**	0.5469**	0.5681**	-0.4375**	0.5796**	0.2626**	0.5620**	0.7335**

Residual effect = 0.0627

CONCLUSION

The success of any breeding program depends upon the genetic variation in the materials at hand. The greater the genetic variability, the higher would be the heritability and hence the better the chances of success to be achieved through selection. There was considerable variability present in the materials used. The high direct effects of these traits appeared to be the main reason for their strong association with grain yield. Hence, direct selection for these traits would be effective. As such these results will be useful for choosing populations to be used in developing new improved maize populations.

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