Original Research Article

Path Coefficient and Correlation Analysis in Maize ~~(*Zea Mays* L.)~~ Hybrids over Southern Aravalli Regions of Rajasthan

ABSTRACT

~~A complex trait such as grain yield is highly influenced by environment~~The environment highly influences a complex trait such as grain yield, and indirect selection through component traits would be an advisable strategy to increase ~~the efficiency of selection~~selection efficiency. The 45 F_1s a~~long with their 18 parents and with~~nd their 18 parents and ~~2~~ two checks were evaluated in three environments *viz.*, E1, E2, and E3 in RBD design with three replications to assess the correlation among the yield components and direct and indirect effects of yield components ~~towards~~ on grain yield. The association analysis among the eleven traits ~~on pooled basis~~ (days to 50 percent silking, plant height, ear height, ear length, ear girth, grain rows per ear, 100-grain weight, and harvest index) revealed that the traits ~~days to 50 per cent silking, plant height, ear height, ear length, ear girth, grain rows per ear, 100-grain weight and harvest index had showed positive and~~showed a significant positive ~~significant~~ correlation with grain yield per plant. The perusal of the path coefficient analysis ~~on pooled basis~~ revealed that the maximum direct positive effect was depicted by the ~~trait~~ harvest index trait followed by the ~~traits~~ ear height, grain rows per ear, days to 50 per cent silking, 100-grain weight, days to 75 per~~-~~cent brown husk, ear girth, and plant height traits.

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Key~~-~~words: Path analysis, Correlation analysis, Maize hybrids, Southern Aravalli Regions of Rajasthan

1. Introduction: Maize is one of the three important cereal crops after wheat and rice are consumed as a staple food. It is a multipurpose cereal crop grown across the varied agro-ecological regions ~~of the world~~ due to its wider adaptability [1]. Th~~roughout the world, the crop is a key source of calories, protein, vitamins, and minerals~~e crop is a key source of calories, protein, vitamins, and minerals throughout the world, especially in Africa, South America, and Asia [2]. It is used extensively as animal feed, particularly for poultry and pigs, in industry, it is currently used for ethanol production. In India, it is grown in 9.20 M ha with a total production of 28.00 MMT~~,~~ and average productivity of 3.04 metric t/ha [3]. It is estimated that the maximum part of the increasing food demand in ~~near future will be fulfilled from maize [4] and half of the increased world food demand in terms of cereals as a whole~~the near future will be fulfilled from maize [4] and half of the increased world food demand in terms of cereals will be produced from maize [5]. It is challenging to quantify grain yield because it is highly influenced by the environment and ~~is a result of~~results from the interrelationship between various yield components [6]. Information on genotypic and phenotypic correlation coefficients between ~~various~~ different plant traits ~~is useful for determining~~helps determine ~~how they are related~~their relationship to economic productivity. The phenotypic correlation may depict the direct relationship between two variables or traits, while genotypic correlation ~~revealed~~ reveals the extent to which they are associated at the genetic level. Correlation at genotypic and phenotypic levels among the traits offers opportunities for indirect selection in ~~a~~ crop improvement breeding programm~~me~~s. The genetic basis of the material and the role of environments are ~~of great importance~~important while studying genetic correlation among various quantitative characters in crops. These studies may guide plant breeders ~~on the selection of~~in selecting traits that contribute to the character(s) of concern~~,~~ and improve ~~ultimately their improvement~~ through hybridization. Breeders need to understand the correlations among different traits, especially for grain yield, which is the ultimate goal of any breeding programm~~me~~. Thus, the purpose of the study was to estimate the direct and indirect effects of yield components on grain yield a~~s well to~~nd derive information about their correlation with grain yield. This helps in the selection of superior cross combinations in hybrid maize.

2. Materials and Methods: The experimental material comprised ~~of~~ 45 single cross hybrids generated by crossing 15 inbred lines with ~~3~~ three testers in Line x Tester mating design during *Rabi*-2017-18. Thus, ~~these~~ these 45 F_1s, along with their 18 parents and with ~~2~~ two checks, were evaluated in three environments *viz.*, E1 (*Kharif*-2019, Instructional Farm, Rajasthan College of Agriculture, Udaipur), E2 (*Kharif*-2019, Agriculture Research Sub-Station, Vallabh Nagar) and E3 (*Rabi*-2019-2020, Instructional Farm, Rajasthan College of Agriculture, Udaipur) in RBD design with three replications. Each genotype was sown in a single row plot of 4.0 m in length, and row to row and plant to plant distance was maintained at 60 cm and 20 cm, respectively. The Udaipur district is located in the Aravalli Hilly Ranges of the Southern part of the Rajasthan with a latitude of 24°35'31.5", longitudes 73°44'18.2" with an altitude of 582.17 meters above mean sea level. The Vallabhnagar is located in Bhinder town of Udaipur district of Rajasthan State with latitude 24°40′23″ longitudes 74°00′09″ with an altitude of 495.00 m above mean sea level. The soil of both experimental field locations ~~were~~ was clay loam, deep, ~~well~~ well-drained, alluvial in origin, and ~~have~~ has good ~~moisture~~ moisture-holding capacity. All the recommended package of practices of zone IV-A (Sub-Humid Southern Plains) was used to raise a healthy crop. The observations were recorded on five randomly selected plants from each plot to record the data on 11 traits in all the environments. ~~The data on three phenological traits *viz.*, days to 50 per cent tasseling, days to 50 per cent silking and days to 75 per cent brown husk and 100 grain weight were however, recorded on~~However, the data on three phenological traits viz., days to 50 percent tasseling, days to 50 percent silking, and days to 75 percent brown husk and 100-grain weight, were recorded on a whole plot basis. The standardized traits mean values were pooled and used to investigate character association between different pairs of characters at phenotypic and genotypic levels as ~~per method~~ described by [7]. The path analysis was also carried out using the simple correlation coefficient to know the direct and indirect effects of the yield and components of yield, as suggested by Wright, 1921 [8] and illustrated by Dewey and Lu, 1959 [9].

3. Results and Discussion: Analysis of variance revealed significant differences for all the eleven quantitative traits under the study. The estimates of correlation coefficients at both genotypic and phenotypic levels between different traits on the pooled basis are presented in Table 1. The magnitude of genotypic correlations was ~~found higher in general than the respective phenotypic correlation indicating~~generally higher than the respective phenotypic correlation, indicating a ~~strong~~ robust inherent relationship among the characters under study. The grain yield per plant ~~had~~ showed ~~highly significant positive correlation with days to 50 per cent silking, plant height, ear height, ear length, ear girth, grain rows per ear, 100-grain weight and harvest index at both genotypic and~~a significant positive correlation with days to 50 percent silking, plant height, ear height, ear length, ear girth, grain rows per ear, 100-grain weight, and harvest index at both genotypic phenotypic levels. The two phenological traits *viz.*, days to 50 per~~-~~cent tasseling and days to 75 per~~-~~cent brown husk had, showed positive but non-significant association with grain yield under the study. In some cases, correlation coefficients give misleading results because the correlation between two variables may be due to a third factor. For this reason, it is crucial to know the cause and effect relationship between dependent and independent variables to understand the relationship between them. Path analysis splits the correlation coefficient ~~among~~ into the ~~measures of direct and indirect effect~~direct and indirect effects measures and provides the actual contribution of a trait on the yield. The estimates of direct and indirect effects of yield component traits ~~towards~~ on grain yield per plant at both genotypic (G) and phenotypic path (P) level~~ are presented in Table 2 on pooled basis~~s are presented in Table 2. The estimates of a path analysis revealed that the harvest index had ~~showed~~ shown maximum direct effect followed by ear height, grain rows per ear, days to 50 per~~-~~cent silking, 100-grain weight, days to 75 per~~-~~cent brown husk, and ear girth and plant height. The one phenological trait as days to 50 per~~-cent tasseling had showed~~cent tasseling showed a negative direct effect on grain yield per plant under the study. Those traits that are not only correlated positively and significantly with grain yield but also have positive direct effects ~~towards~~ on grain yield are likely to be useful as selection criteria in selection program~~me~~s. Considering the above criteria, ~~the traits~~ days to 50 per~~-~~cent silking, plant height, ear height, ear girth, grain rows per ear, 100-grain weight, and harvest index traits were found suitable ~~as they had~~because they showed high positive and significant correlation as well as a high positive direct effect ~~towards~~ on grain yield per plant in maize. These results are found in accordance with the earlier findings of Manivannan, 1998 [10], Krishan and Natarajan, 1995 [11], Umakantha and Khan, 2001 [12], Sofi and Rather~~,~~ 2007 [13], Ali *et al.* 2010 [14] in maize. The estimates of residual effects ~~provide explanation of~~explain the ~~pattern of interactio~~interaction pattern between other possible components of yield. The estimates of genotypic and phenotypic residual effects were found to be 0.36841 and 0.42797, respectively. It indicates the characters used in the experiment explain approximately ~~above 60 per cent of variations which may be contributed~~60 percent of variations, which may contribute to higher yields in maize. The genetic linkage or pleiotropy effect may also ~~responsible for genetic correlation between different characters of plant~~be responsible for genetic correlation between different plant characters [15]. ~~The perusal of the Table 1 revealed that the magnitude of genotypic correlation coefficient were~~Table 1 revealed that the magnitude of the genotypic correlation coefficient was slightly higher~~ slightly higher in magnitude~~ than the phenotypic on~~e~~e. It is also observed there was a general agreement in the sign and magnitude between estimates of genotypic and phenotypic correlations. Since selection is based on phenotype, the correlation at the genetic level (genotypic correlation) alone may not be of practical value in selection.

Thus~~ in the present investigation it may be concluded that the traits ear girth, grain rows per ear, and 100-grain weight were the important yield components and selection for these traits could be considered as~~, in the present investigation, it may be concluded that the traits ear girth, grain rows per ear, and 100-grain weight were the important yield components. Selection for these traits could be considered important selection criteria in improving the yield of hybrid maize.

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Table 1 The estimates of genotypic (**r_g**) and phenotypic (**r_p**) correlation coefficients for grain yield and its components on pooled basis in maize.

Characters	**r**	**Days to 50 per cent silking**	**Days to 75 per cent brown husk**	**Plant height (cm)**	**Ear height (cm)**	**Ear length (cm)**	**Ear girth (cm)**	**Grain rows per ear**	**100-Grain weight (g)**	**Harvest index (%)**	**Grain yield per plant (g)**
Days to 50 per cent tasseling	r_g	0.771**	0.600**	0.062^{NS}	0.045^{NS}	0.138^{NS}	0.117^{NS}	-0.082^{NS}	0.024^{NS}	0.157*	0.171*
	r_p	0.756**	0.507**	0.037^{NS}	0.008^{NS}	0.102^{NS}	0.065^{NS}	-0.039^{NS}	0.044^{NS}	0.109^{NS}	0.100^{NS}
Days to 50 per cent silking	r_g		0.704**	0.120^{NS}	0.084^{NS}	0.002^{NS}	0.032^{NS}	0.002^{NS}	0.091^{NS}	0.075^{NS}	0.236**
	r_p		0.611**	0.096^{NS}	0.059^{NS}	-0.038^{NS}	0.002^{NS}	0.030^{NS}	0.106^{NS}	0.077^{NS}	0.144*
Days to 75 per cent brown husk	r_g			0.201**	0.174*	0.151*	0.137^{NS}	0.074^{NS}	0.315**	0.021^{NS}	0.216**
	r_p			0.134^{NS}	0.108^{NS}	0.046^{NS}	0.093^{NS}	0.054^{NS}	0.231**	-0.008^{NS}	0.130^{NS}
Plant height (cm)	r_g				0.813**	0.464**	0.425**	0.376**	0.197**	0.454**	0.547**
	r_p				0.811**	0.375**	0.316**	0.288**	0.165*	0.351**	0.496**
Ear height (cm)	r_g					0.528**	0.484**	0.341**	0.181*	0.400**	0.561**
	r_p					0.388**	0.326**	0.225**	0.148*	0.285**	0.481**
Ear length (cm)	r_g						0.990**	0.326**	0.001^{NS}	0.371**	0.409**
	r_p						0.843**	0.248**	-0.049^{NS}	0.290**	0.329**
Ear girth (cm)	r_g							0.325**	-0.026^{NS}	0.446**	0.479**
	r_p							0.238**	-0.048^{NS}	0.291**	0.328**
Grain rows per ear	r_g								0.011^{NS}	0.225**	0.379**
	r_p								0.027^{NS}	0.154*	0.308**
100-Grain weight (g)	r_g									0.104^{NS}	0.196**
	r_p									0.097^{NS}	0.174*
Harvest index (%)	r_g										0.780**
	r_p										0.662**

* and ** represent level of significance at 5 and 1%, respectively r = correlation NS= Non-significant

Table 2 The estimates of direct (diagonal values) and indirect effects for yield components towards grain yield per plant on pooled basis in maize.

Characters		Days to 50 per cent tasseling	Days to 50 per cent silking	Days to 75 per cent brown husk	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear girth (cm)	Grain rows per ear	100-Grain weight (g)	Harvest index (%)	Correlation with grain yield per plant (g)
Days to 50 per cent tasseling	G	**-1.10622**	0.92871	0.01883	-0.02919	-0.00224	0.82867	-0.68774	-0.00735	-0.00268	0.22990	**0.171***
	P	**-0.05073**	0.05886	0.02876	0.00165	0.00180	-0.00003	0.00330	-0.00543	0.00270	0.05915	**0.100**^{NS}
Days to 50 per cent silking	G	-0.85320	**1.20412**	0.02208	-0.05653	-0.00417	0.01237	-0.18926	0.00017	-0.01035	0.11077	**0.236****
	P	-0.03836	**0.07785**	0.03463	0.00431	0.01311	0.00001	0.00010	0.00424	0.00646	0.04173	**0.144***
Days to 75 per cent brown husk	G	-0.66377	0.84726	**0.03137**	-0.09486	-0.00861	0.90696	-0.80367	0.00656	-0.03574	0.03035	**0.216****
	P	-0.02572	0.04754	**0.05671**	0.00602	0.02408	-0.00001	0.00471	0.00761	0.01412	-0.00458	**0.130**^{NS}
Plant height (cm)	G	-0.06836	0.14408	0.00630	**-0.47244**	-0.04034	2.79341	-2.49309	0.03354	-0.02235	0.66652	**0.547****
	P	-0.00186	0.00746	0.00758	**0.04502**	0.18104	-0.00009	0.01610	0.04051	0.01007	0.19000	**0.496****
Ear height (cm)	G	-0.05003	0.10133	0.00545	-0.38426	**-0.04959**	3.17865	-2.83776	0.03045	-0.02050	0.58750	**0.561****
	P	-0.00041	0.00457	0.00612	0.03652	**0.22316**	-0.00010	0.01659	0.03167	0.00901	0.15391	**0.481****
Ear length (cm)	G	-0.15216	0.00247	0.00472	-0.21905	-0.02617	**6.02457**	-5.79871	0.02908	-0.00017	0.54464	**0.409****
	P	-0.00517	-0.00296	0.00260	0.01688	0.08648	**-0.00025**	0.04292	0.03498	-0.00300	0.15666	**0.329****
Ear girth (cm)	G	-0.12985	0.03890	0.00430	-0.20102	-0.02402	5.96234	**-5.85923**	0.02900	0.00299	0.65542	**0.479****
	P	-0.00329	0.00015	0.00525	0.01424	0.07277	-0.00021	**0.05089**	0.03347	-0.00292	0.15745	**0.328****
Grain rows per ear	G	0.09125	0.00236	0.00231	-0.17770	-0.01694	1.96530	-1.90580	**0.08916**	-0.00121	0.33027	**0.379****
	P	0.00196	0.00234	0.00306	0.01295	0.05018	-0.00006	0.01209	**0.14082**	0.00164	0.08324	**0.308****
100-Grain weight (g)	G	-0.02615	0.11003	0.00990	-0.09323	-0.00898	0.00896	0.15489	0.00095	**-0.11328**	0.15287	**0.196****
	P	-0.00224	0.00825	0.01313	0.00744	0.03298	0.00001	-0.00243	0.00378	**0.06099**	0.05231	**0.174***
Harvest index (%)	G	-0.17323	0.09085	0.00065	-0.21449	-0.01985	2.23501	-2.61579	0.02006	-0.01180	**1.46810**	**0.780****
	P	-0.00555	0.00601	-0.00048	0.01582	0.06352	-0.00007	0.01482	0.02168	0.00590	**0.54076**	**0.662****

Genotypic Residual=0.36841, Phenotypic Residual= 0.42797 * and ** represent level of significance at 5 and 1%, respectively
G= Genotypic Path P= Phenotypic Path NS= Non-significant