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Studies on Character Association and Path Coefficient Analysis for Grain Yield and Its Contributing Characters in Maize (*Zea mays* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was undertaken at Agricultural Research Station, Tornala, Telangana, India during *rabi,* 2019-20 and *kharif,* 2020 to study the cause of association and direct & indirect effects for yield and its contributing traits in fifteen hybrids along with their eight parents and three checks of maize. The experiment was conducted in Randomised Block design with two replications. Correlation analysis revealed that, grain yield was found to be significant & positively correlated with these characters *viz.,* ear height, ear length, number of kernels row-1, ear diameter, plant height, number of kernel rows, 100 kernel weight, shelling % and significant & negatively correlated with characters days to 50% tasseling and days to 50% silking. Path coefficient analysis revealed that the characters days to 50% tasseling exhibited the largest direct effect on grain yield followed by number of kernels per row, 100 kernel weight and ear diameter. The traits like no. of

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kernels/row, ear diameter and 100 kernel weight displayed positive significant correlation as well as positive direct effect on yield. Hence, due emphasis should be given to these traits in formulating selection criteria to bring high yield.

Keywords: Maize; correlation; path coefficient analysis; grain yield.

1. INTRODUCTION

Maize (*Zea mays* L.) is known as "queen of cereals" and it is important food crop after rice and wheat in India. The green plants were utilised as forage or to make silage for the dairy and meat sectors, while maize grain provides vital nutrients for poultry feed. It is a cross-pollinated crop with greater genetic diversity that may thrive in temperate, tropical, and subtropical agro-climatic conditions throughout India. In India, it was cultivated in an area of 9.8 million ha with an average production of 31.5 million metric tonnes and productivity 3.21 Metric tons/ha (USDA, 2022).

Before beginning any breeding programme, it is essential to have a good understanding of character association and the direct and indirect effects that each character contributes to grain yield because yield is the result of multiplicative interaction between numerous yield components. The goal of crop improvement operations is to boost grain production. Studies on the correlation coefficients of various characteristics are helpful for identifying desirable traits that increase grain production and for determining the strength of these traits' links to economic productivity [1,2]. The extent of the observation having a relationship between two features is indicated by phenotypic correlation, whereas genotypic correlation offers an estimate of the intrinsic association between the genes governing any two traits [3,4]. To comprehend the numerous paths, i.e., the degree of each character's direct influence and the indirect influence through other characters, one can use path coefficient analysis, a standardised partial regression.

With this in mind, the current study was undertaken to investigate the genetic basis of grain yield components and to develop appropriate selection criteria for future maize breeding programmes.

2. MATERIALS AND METHODS

Land preparation was started with cultivator followed by rotovator in both during *rabi,* 2019-20 and *kharif* , 2020. Then layout was prepared for sowing of seed material. Five germplasm lines were taken as lines and 3 germplasm lines were taken as testers and sown in three rows of each entry of 4m length with a spacing of 60 cm x 20 cm between the rows and plants with in the row respectively. These five maize lines were crossed with three testers in a line x tester mating design at Agricultural Research Station, Tornala during *rabi,* 2019-20 to generate a total of 15 F_1s. During *kharif* , 2020 the resultant 15 test crosses and 8 parents along with 3 standard checks were evaluated in a Randomised Block Design (RBD) with 2 replications. Each entry was raised in two rows of three meter length with a spacing of 60 cm between rows and 20 cm between plants. In both the seasons, source of fertilizers for N:P:K: is urea: SSP: MOP respectively. The recommended package of practices were followed to raise a good crop.

The data was recorded on five randomly selected plants for plant height (cm), ear height (cm), ear length (cm), ear diameter (cm), no. of kernel rows, no. of kernels per row and shelling %. Whereas days to 50% tasseling and days to 50% silking were recorded on plot basis and 100 kernel weight was recorded per replication in each genotype. Yield (kg/ha) was calculated from plot basis. The mean values were used for statistical analysis. "The genotypic and phenotypic correlation coefficients were calculated using the method given" by Falconer [5] and path coefficient analysis were worked as suggested by Wright [6] and Dewey and Lu [7].

3. RESULTS

The analysis was done using the software Windostat Version 9.1 from Indostat services. The results of the analysis of variance showed that there were substantial differences between all of the genotypes for the attributes, showing that there was enough diversity in the subject matter under study. As a result, the data were also subjected to correlation and path coefficient analyses (Tables 1 and 2) in order to determine the relationship between yield and the qualities that contribute to it as well as the direct and indirect effects of each feature on yield.

Table 1. Estimates of genotypic and phenotypic correlation coefficients among different quantitative traits in maize

Character		Days to 50% Tasselling	Days to 50 % Silking	Plant Height (cm)	Ear Height (cm)	Ear Length (cm)	Ear diameter (cm)	No. of Kernel Rows	No. of Kernels/ Row	100 kernel wt.(g)	Shelling %	Yield (kg/ha)
Days to 50% Tasselling	G	1.0000	0.9947**	-0.4040**	-0.4267**	-0.6214**	-0.5036**	-0.5075**	-0.5974**	-0.2612	-0.4512**	-0.4512**
	P	1.0000	0.9930**	-0.4043**	-0.3945**	-0.5654**	-0.4500**	-0.3689**	-0.5721**	-0.1834	-0.2943*	-0.4175**
Days to 50 % Silking	G		1.0000	-0.4394**	-0.4614**	-0.6436**	-0.5200**	-0.5422**	-0.6212**	-0.2561	-0.4596**	-0.4834**
	P		1.0000	-0.4337**	-0.4210**	-0.5884**	-0.4665**	-0.3913**	-0.5946**	-0.1815	-0.2852*	-0.4467**
Plant Height (cm)	G			1.0000	0.9490**	0.8541**	0.8294**	0.6377**	0.8208**	0.6388**	0.1098	0.8183**
	P			1.0000	0.9256**	0.7663**	0.7118**	0.5192**	0.7705**	0.5353**	0.0128	0.7331**
Ear Height (cm)	G				1.0000	0.9384**	0.9592**	0.7997**	0.8851**	0.7251**	0.2591	0.8919**
	P				1.0000	0.7613**	0.7562**	0.5818**	0.7510**	0.5186**	0.0773	0.7261**
Ear Length (cm)	G					1.0000	0.8815**	0.8080**	0.9599**	0.6697**	0.4145**	0.8781**
	P					1.0000	0.8557**	0.7437**	0.9397**	0.5940**	0.2706	0.8649**
Ear diameter (cm)	G						1.0000	0.8160**	0.8335**	0.7288**	0.3231*	0.8688**
	P						1.0000	0.7389**	0.8009**	0.6479**	0.2189	0.8537**
No. of Kernel Rows	G							1.0000	0.6939**	0.7222**	0.2926*	0.7105**
	P							1.0000	0.6172**	0.6498**	0.1615	0.6448**
No. of Kernels/Row	G								1.0000	0.4657**	0.3976**	0.8720**
	P								1.0000	0.4005**	0.2140	0.8525**
100 kernel wt. (g)	G									1.0000	0.3060*	0.6122**
	P									1.0000	0.1213	0.5355**
Shelling%	G										1.0000	0.5789**
	P										1.0000	0.4236**

** Significant at 0.05 probability level (r = > 0.2732); **Significant at 0.01 probability level (r = > 0.3541); P:Phenotypic correlation; G: Genotypic correlation*

Table 2. Direct (bold & diagonal values) and indirect (normal values) effects of grain yield component traits on grain yield at phenotypic and genotypic level in maize

Character		Days to 50% Tasseling	Days to 50 % Silking	Plant Height (cm)	Ear Height (cm)	Ear Length (cm)	Ear diameter (cm)	No. of Kernel Rows	No. of Kernels/ Row	100 kernel wt.(g)	Shelling %	Yield (kg/ha)
Days to 50%	G	**5.5858**	5.5561	-2.2566	-2.3833	-3.4711	-2.8133	-2.8349	-3.3372	-1.4590	-2.5203	-0.4512
Tasseling	P	**0.9321**	0.9256	-0.3769	-0.3677	-0.5270	-0.4195	-0.3438	-0.5333	-0.1710	-0.2743	-0.4175
Days to 50 %	G	-5.8356	**-5.8668**	2.5776	2.7067	3.7759	3.0508	3.1809	3.6445	1.5022	2.6966	-0.4834
Silking	P	-0.7863	**-0.7919**	0.3435	0.3334	0.4659	0.3694	0.3098	0.4708	0.1437	0.2258	-0.4467
Plant Height	G	0.1623	0.1765	**-0.4018**	-0.3813	-0.3431	-0.3332	-0.2562	-0.3298	-0.2566	-0.0441	-0.8183
(cm)	P	-0.1239	-0.1329	**0.3065**	0.2837	0.2349	0.2182	0.1591	0.2361	0.1641	0.0039	0.7331
Ear Height (cm)	G	0.1133	0.1225	-0.2519	**-0.2655**	-0.2491	-0.2547	-0.2123	-0.2350	-0.1925	-0.0688	0.8919
	P	0.0689	0.0735	-0.1617	**-0.1747**	-0.1330	-0.1321	-0.1016	-0.1312	-0.0906	-0.0135	0.7261
Ear Length	G	1.6491	1.7080	-2.2666	-2.4904	**-2.6538**	-2.3392	-2.1443	-2.5475	-1.7773	-1.1001	0.8781
(cm)	P	0.0670	0.0698	-0.0908	-0.0903	**-0.1186**	-0.1014	-0.0882	-0.1114	-0.0704	-0.0321	0.8649
Ear diameter	G	-0.1647	-0.1700	0.2712	0.3136	0.2882	**0.3269**	0.2668	0.2725	0.2383	0.1056	0.8688
(cm)	P	-0.1842	-0.1909	0.2913	0.3095	0.3502	**0.4092**	0.3024	0.3277	0.2651	0.0896	0.8537
No. of Kernel	G	0.2379	0.2542	-0.2990	-0.3749	-0.3788	-0.3825	**-0.4688**	-0.3253	-0.3386	-0.1372	0.7105
Rows	P	-0.0083	-0.0088	0.0117	0.0131	0.0168	0.0167	**0.0226**	0.0139	0.0147	0.0036	0.6448
No. of	G	-1.8202	-1.8926	2.5006	2.6967	2.9246	2.5394	2.1141	**3.0467**	1.4188	1.2113	0.8720
Kernels/Row	P	-0.2838	-0.2949	0.3822	0.3725	0.4661	0.3973	0.3062	**0.4960**	0.1987	0.1062	0.8525
100 kernel wt.	G	-0.3872	-0.3795	0.9468	1.0748	0.9927	1.0803	1.0705	0.6903	**1.4823**	0.4536	0.6122
(g)	P	-0.0080	-0.0079	0.0234	0.0227	0.0260	0.0284	0.0285	0.0175	**0.0438**	0.0053	0.5355
Shelling%	G	0.0080	0.0082	-0.0020	-0.0046	-0.0074	-0.0058	-0.0052	-0.0071	-0.0055	**-0.0178**	0.5789
	P	-0.0910	-0.0881	0.0040	0.0239	0.0836	0.0676	0.0499	0.0661	0.0375	**0.3090**	0.4236

** Significant at 0.05 probability level; **Significant at 0.01 probability level; G: Genotypic level; P:Phenotypic level*

Genotypic residual effect = 0.2738 ; Phenotypic residual effect = 0.3146

Grain yield is a complicated character that depends on a number of other elements. As a result, character association was investigated in order to evaluate the link between yield and its components in order to improve the utility of selection [8,9]. Studies on association between traits that contribute to yield and seed yield were conducted. High genotypic correlations often showed a strong intrinsic relationship between the traits whereas low phenotypic expression was caused by environmental variables when compared to their phenotypic equivalents. The results (Table 1) indicated that grain yield showed positive significant association with ear height (G- 0.8919, P- 0.7261) which is in agreement with the findings of Archana et al*.,* [10]. Ear length (G- 0.8781, P-0.8649) expressed positive significant association with grain yield. Similar reports were recorded by Prasad et al*.,* [11] and Chaudhary et al., [12]. No. of kernels/row (G- 0.8720, P- 0.8525) showed positive significant association with grain yield, this is in consonance with the report of Jawaharlal et al*.,* (2017). Ear diameter (G- 0.8688, P- 0.8537) exhibited positive significant association with grain yield, similar results were reported by Soumya et al*.,* [13] and Yahaya et al*.,* [14].

Plant height (G- 0.8183, P- 0.7331), no. of kernel rows (G- 0.7105, P- 0.6448), 100 kernel wt.(G- 0.6122, P- 0.5355), shelling % (G- 05789, P- 0.4236) also has positive significant association with grain yield. These observations are in agreement with the findings of Kharel et al*.,* [15] and Reddy et al*.,* [16] for plant height, Synrem et al., [17] and Reddy et al., [18] for no. of kernel rows, Jawaharlal et al., (2017) for 100 kernel weight, Kumar et al., (2014) for shelling %.

The characters days to 50% tasseling (G- -0.4512, P- -0.4175) and days to 50% silking (G- -0.4834, P- - 0.4467) were significant and negatively correlated with grain yield and are similar to the results reported by Jilo et al*.,* [19].

Correlation studies give trustworthy information on the nature, extent, and direction of selection for choosing high yielding genotypes. The understanding of correlation between distinct yield attributes aids in determining the nature and extent of the link between these traits, which are commonly employed to improve crop output.

Association coefficients can often produce deceptive findings since the correlation between two variables may be attributable to a third component. To elucidate the nature of the link between the variables, it is required to study the cause and effect relationship between dependent and independent variables. Path coefficient analysis [7] provided a way for categorising correlation coefficients as direct or indirect effects and providing information on the actual contribution of a feature to yield. Path coefficient analysis (Table 2) showed that days to 50% tasseling (G-5.5858 , P- 0.9321) exhibited the largest positive direct effect on grain yield followed by no. of kernels per row (G-3.0467 , P- 0.4960), 100 kernel weight (G-1.4823 , P- 0.0438), ear diameter (G- 0.3269, P-0.4092). These results are in conformity with the findings of Archana et al*.,* [10] for days to 50% tasseling, Tejaswini et al., [20] for no. of kernels per row, Mogesse [21] for 100 kerenl weight and Ubi et al*.,* [22] for ear diameter, indicating that the selection for these characters was likely to bring improvement in the yield. Hence, direct selection for these traits would be effective.

Days to 50% silking (G- -5.8668, P- -0.7919), ear length (G- -2.6538, P- -0.1186) and ear height (G- -0.2655, P- -0.1747) exhibited negative direct effect on grain yield and indicated that selection for high yield can be done by indirect selection through other yield components, which are in agreement with the findings of Singh et al., [23] for days to 50% silking, Archana et al*.,* [10] for ear length and Tejaswini et al*.,* [20] for ear height.

The genotypic and phenotypic residual effects recorded 0.2738 and 0.3146 respectively, it indicates that all the characters studied in our experiment explain above 50 percent of variations which may be contributed for higher yields in maize.

4. DISCUSSION

Ear length expressed positive significant association with grain yield. As ear length increases, no. of kernels/row also increases indicating increase in the yield. Ear diameter exhibited positive significant association with grain yield, which in turn increases in no. of kernel rows, ultimately this had direct bearing on the yield. 100 kernel weight also shown positive significant association with grain yield, indicating increase in the yield. The characters days to 50% tasselling and days to 50% silking were significant and negatively correlated with grain yield. This negative correlation of grain yield with days to 50 per cent flowering is very much important for breeder to identify early and late maturing hybrids.

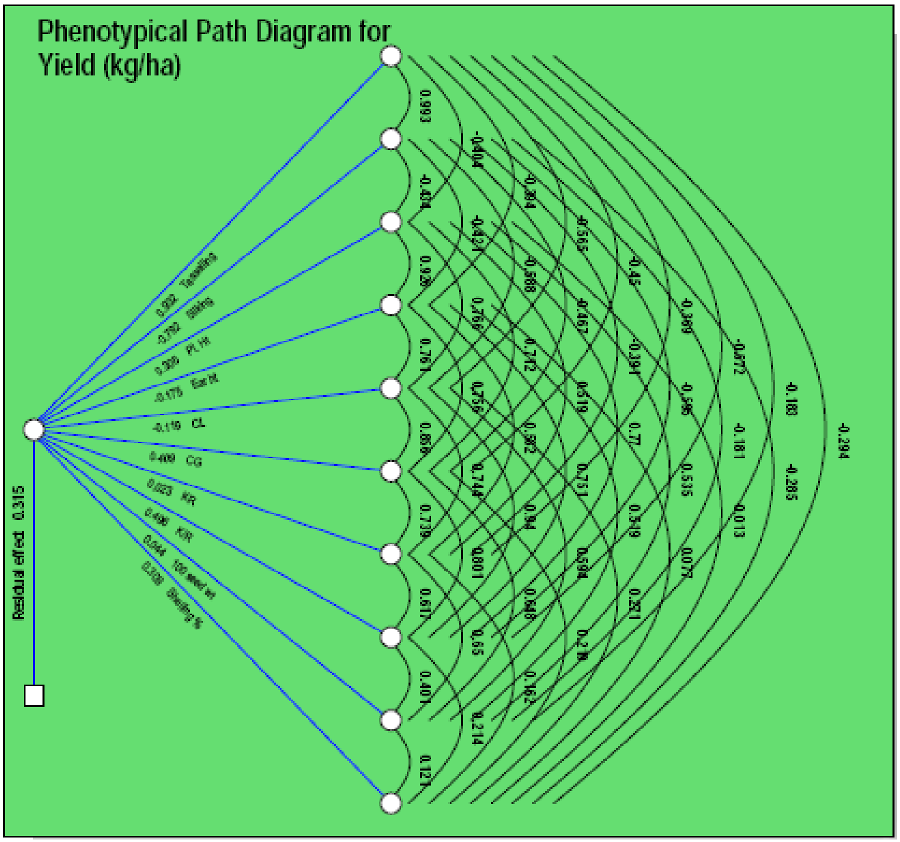

Fig. 1. Path coefficient analysis at phenotypic level

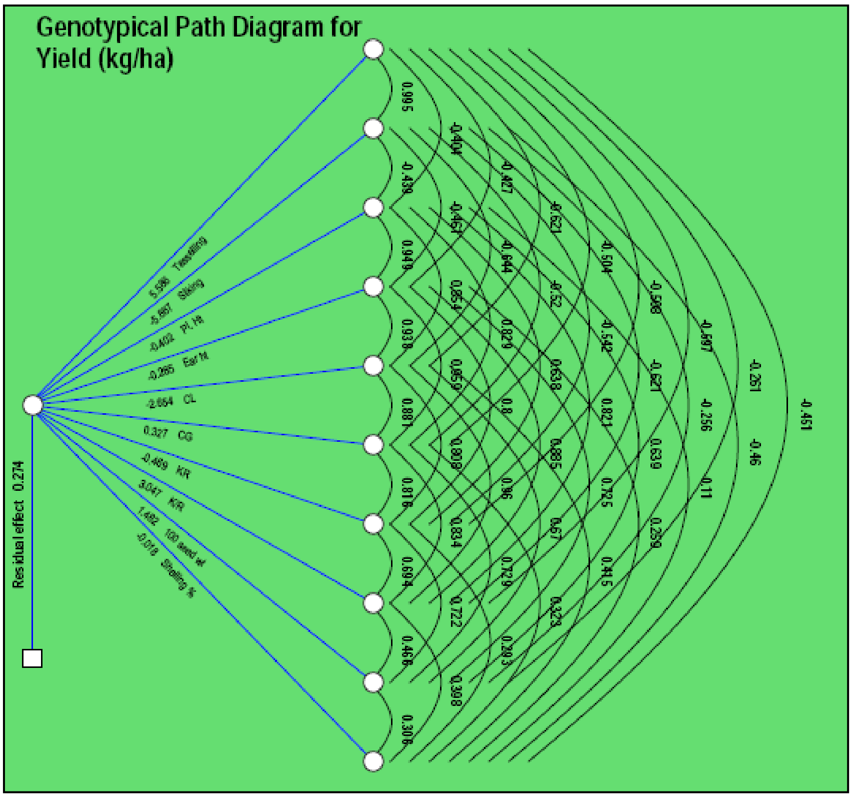

Fig. 2. Path coefficient analysis at genotypic level

Path coefficient analysis revealed that, days to 50% tasseling, no. of kernels per row, 100 kernel weight and ear diameter exhibited positive direct effect on grain yield. Hence, direct selection for these traits would be effective. Days to 50% silking, ear length and ear height exhibited negative direct effect on grain yield and indicated that selection for high yield can be done by indirect selection through other yield components.

5. CONCLUSION

In conclusion, critical analysis of results obtained from character association and path analysis indicated that, the traits no. of kernels/row, ear diameter and 100 kernel weight displayed positive significant correlation as well as positive direct effect on yield. These characters play a major role in development of high yielding genotypes in future maize breeding programmes.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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