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Correlation and Path Coefficient Analysis for 'Yield Contributing' Traits in Quality Protein Maize (*Zea mays* L.)

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Authors' contributions

This work was carried out in collaboration among all the authors. Authors DS, AK and RK designed, executed the experiment and performed the statistical analysis. Author SKS provided technical support in interpretation of results. Authors TAM and NK proof read the manuscript and prepared the final draft. All authors read and approved the final draft of the manuscript.

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ABSTRACT

Character association studies will help to assess the relationship among the yield and its components for enhancing the usefulness of the selection. In view of this, the present research work was carried out to assess the correlation coefficient and path analysis among twenty five maize genotypes using eleven quantitative parameters. Correlation studies indicated that plant height (cm), ear height (cm), ear length (cm), ear girth (cm), number of kernel rows per ear, number of kernels per row showed significant positive association with grain yield (Kg/ha) as well as among themselves at phenotypic and genotypic level. Hence, selection for any one of these characters would bring in simultaneous improvement of other characters and also finally improvement in grain yield (kg/ha). Path coefficient analysis revealed that the highest positive direct effects on grain yield was exhibited by days to 75% tasseling, ear length, days to 75% brown husk, ear height and ear

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girth. Therefore, present investigation could be helpful in a reliable selection of parental lines based on the above given traits as well as for the development of high yielding verities for further breeding programs.

Keywords: Correlation coefficient; path analysis; phenotypic; genotypic; positive.

1. INTRODUCTION

Maize is one of the most widely and diversified crops grown throughout the world having wide economic importance. It also serves as a source of animal feed and raw materials for many agro-based industries. Grain yield, without doubt, is the most economically important character in maize; the major reason its improvement is the focus of many maize breeding programmes. However, grain yield is a complex trait; a product of many components which subjects it to high environmental influence. As a result, direct selection would not be effective and efficient. Only a better understanding and knowledge of the interrelations between grain yield and its contributing components through the use of correlation and path coefficient analysis can significantly improve the efficiency of breeding programmes through the use of appropriate selection indices. Studies on correlation coefficients of different characters are useful criterion to identify desirable traits that may contribute to improve the grain yield in Quality Protein Maize (QPM). Path analysis is also equally beneficial since it is an efficient biometrical tool which indicates the direct contribution of characters and its influence through other traits in influencing the yield [1]. 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 components [2]. Therefore, the present work has been undertaken to study the correlations and path coefficient analysis between morphological traits affecting the grain yield and its associated traits in maize.

2. MATERIALS AND METHODS

The experiment was conducted in Kharif, 2018 at TCA, Dholi, Farm. The experimental materials consist of 25 QPM inbred which were grown in Randomized Block Design (RBD) with three replications having plot size of 1.5 x 4.0 = 6 m^2. Each plot consisting of two rows of 4 m length spaced at 75 cm row to row and 20 cm plant to plant. All necessary precautions were taken to maintain uniform plant population in each treatment per replication. All the recommended package of practices was followed along with necessary prophylactic plant protection measures to raise a good crop. Observations were recorded on 11 quantitative traits from each replication. The traits which were studied include days to 75% tasseling, days to 75% silking, days to 75% brown husk, plant height, ear height, tassel length, cob length, cob diameter, number of kernel rows per cob, Number of kernels per row and grain yield. Out of the 11 quantitative characters, days to 75% tasseling, days to 75% silking and days to 75% brown husk were recorded on plot basis. Rest of the traits was recorded on the basis of five randomly chosen plants at appropriate stage. The data recorded on different characters were statistically analyzed using software WINDOSTAT version 7.0 developed by Indostat Services Ltd., Hyderabad, India. The phenotypic (rp), genotypic (rg) and environmental (re) correlation coefficients for various characters were calculated by the method suggested by [3]. To establish a cause and effect relationship the first partition genotypic and phenotypic correlation coefficient into direct and indirect effects by path analysis as suggested [4] and developed by Wright.

2.1 Genotypic Correlation Coefficient

Genotypic correlation between traits x and y:

$$Rxy\ (p) = \frac{\sigma_g^2\ (xy)}{\sqrt{\sigma_g^2(x)\ x\sigma_g^2(y)}}$$

2.2 Phenotypic Correlation Coefficient

Phenotypic correlation between traits x and y:

$$Rxy\ (p) = \frac{\sigma_p^2\ (xy)}{\sqrt{\sigma_p^2(x)\ x\sigma_p^2(y)}}$$

Where,

$\sigma^2{}_g$ (x y) = genotypic covariance between traits x and y

$\sigma^2{}_p$ (x y) = phenotypic covariance between traits x and y

3. RESULTS AND DISCUSSION

Correlation coefficients at genotypic and phenotypic level were worked out among eleven characters in present studied and has been presented in (Tables 2 and 3). Out of eleven characters pairs the magnitude of genotypic correlation coefficient was higher than the corresponding phenotypic correlation coefficients.

From the perusal of correlation at genotypic level (Table 2) it was evident that Plant height have highly and positive correlation with ear height (0.8172), ear girth (0.4747), ear length (0.3214) and Grain yield (0.2600). Ear height showed strong and positive correlation with ear girth (0.3622) and No. of kernels per row (0.3256). Days to 75% tasseling exhibited highly positive correlation with days to 75% silking (0.9912), ear girth (0.2076), days to 75% brown husk (0.1955). High and Positive correlation of days to 75% silking was observed with ear girth (0.2959), tassel length (0.2547) and days to 75% brown husk (0.1656). Days to 75% Brown husk showed highly positive correlation with ear girth (0.3694), and tassel length (0.2456). Tassel length showed highly positive correlation with ear length (0.1976), ear girth (0.1448). Ear length showed highly positive association with ear girth (0.6349), number of kernel rows per ear (0.5120) and number of kernels per row (0.2152) and grain yield (0.6775). Ear girth exhibited high and positive association with number of kernel per rows (0.2747) and grain yield (0.5584). Number of kernel rows per ear exhibited highest and positive association with grain yield (0.8021). Number of kernels per row exhibited highest and positive association with grain yield (0.7890).

From the perusal of correlation at phenotypic level (Table 3) it was evident that Plant height had positive and significant correlation with ear height (0.6966**). Ear height exhibited positive and significant correlation with No. of kernels per row (0.2416*). Positive and significant correlation of days to 75% tasseling was observed with Days to 75% silking (0.9622**) and days to 75% brown husk (0.7052**). Days to 75% silking showed positive and significant correlation with

Table 1. List of the materials and their source

S. no.	Inbred lines	Abbreviation	Source
1.	[CL-G2501*CML170]-B-2-2-2-B-1-1-BBB-#	CLG-2501-170	AICRP, Dholi, Centre
2.	CML161*165-18-2-1-2-BBB-#	CML61*65-18	AICRP, Dholi, Centre
3.	CML161*165-50-1-3-B*4-#	CML61*65-50	AICRP, Dholi, Centre
4.	(CML161*165)-F2-21-3-1-B*5-#	CML61*65-21	AICRP, Dholi, Centre
5.	(CML176*CLG2501)-B-55-1-5-2-BBB-#	CML*CLG-55	AICRP, Dholi, Centre
6.	(CML165*CL-02843)-B-12-2-4-B-3-BBB-#	CML*CL02843-12	AICRP, Dholi, Centre
7.	(CLQ-6601*CL-02843)-B-23-2-1-B-1-BBB-#	CLQ*CL-23	AICRP, Dholi, Centre
8.	(CLQ-6601*CL-02843)-B-26-1-1-BB-1-B*6-#	CLQ*CL-26	AICRP, Dholi, Centre
9.	P70C0-BBB-6-B*6-#	P70C0-6	AICRP, Dholi, Centre
10.	CLQ-RCYQ28-B-3-B*6-#	CLQ-RCYQ-28	AICRP, Dholi, Centre
11.	CLQ-RCYQ41-BB-2-B*6-#	CLQ-RCYQ-41	AICRP, Dholi, Centre
12.	CLQ-RCYQ035-B*11-#	CLQ-RCYQ-035	AICRP, Dholi, Centre
13.	CLQ-RCYQ12-B-1-B*6-#	CLQ-RCYQ-12	AICRP, Dholi, Centre
14.	CML161*165-3-2-3-B*4-#-B1	CML61*65-B*4	AICRP, Dholi, Centre
15.	G34QC24-BBB-16-B*8-#-B	G34QC-BB-16	AICRP, Dholi, Centre
16.	POO117C8(TEYFQPM)-B-117-B*10	POO-TEYFQM	AICRP, Dholi, Centre
17.	CML161*165-16-2-1-B*10	CML61*65-16	AICRP, Dholi, Centre
18.	G33QMH103-3-1-5-1-B*14	G33QMH-103	AICRP, Dholi, Centre
19.	(CML176*CLG2501)-B-55-1-2-B*4	CML76*CLG-B*4	AICRP, Dholi, Centre
20.	CLQRCYQ44-B*4-1-#-B	CLQ-RCYQ-44	AICRP, Dholi, Centre
21.	CML161-1-B*8-#-B	CML61-B*8	AICRP, Dholi, Centre
22.	CML451Q-B*8	CML451-B*8	AICRP, Dholi, Centre
23.	CML165-B*9-#	CML65-B*9	AICRP, Dholi, Centre
24.	CML193-B*6-#	CML93-B*6	AICRP, Dholi, Centre
25.	(CML161*CLQ-RCYQ31)-B-22-2-B*5	CML61*CLQ-B*5	AICRP, Dholi, Centre

days to 75% brown husk (0.7061**). Ear length showed highly significant and positive association with ear girth (0.4575*) and number of kernel per row (0.2320*). Ear girth showed positive correlation with grain yield per plot (0.3719) and No. of kernels per row (0.1273). Positive association of No. of kernels row per ear was observed with grain yield (0.1392) and No. of kernels per row. No. of kernels per row showed positive correlation with grain yield (0.4624*). Similar finding were reported earlier by [5-16].

3.1 Path Coefficient Analysis

3.1.1 Genotypic path coefficient (Table 4)

Path coefficient analysis at genotypic level (Table 4) revealed that the highest positive direct effects on grain yield per plot was exhibited by Days to 75% tasseling (5.3447) followed by ear length (3.0313). Days to 75% brown husk (2.1708) and Ear height (1.2155) had small but positive direct effect on grain yield, while positive indirect effect via days to 75% tasseling (0.8215), ear length (0.7378) and days to 75% brown husk (0.4310). Days to 75% tasseling had indirect positive effect on grain yield via Days to 75% brown husk (2.5952), no. of kernels per row (0.4677), ear height (0.1868) and no of kernel rows per ear (0.001). Days to 75% silking showed indirect positive correlation via, days to 75% tasseling (5.2979), days to 75% brown husk (2.5304), No. of kernels per row (0.5933), ear height (0.1716) and No. of kernel rows per ear (0.0944) on grain yield. Days to 75% brown husk possessed indirect positive effect via days to 75% tasseling (6.3894), no. of kernel rows per ear (0.5964), no. of kernels per row (0.5414) and ear height (0.2414). Tassel length had shown indirect positive effect via days to 75% tasseling (0.9480), ear length (0.5990), days to 75% brown husk (0.5332), no. of kernels per row (0.3040), no. of kernel rows per ear (0.1804) and ear height (0.1407). Ear length possessed indirect positive effect via days to 75% silking (0.6853) and ear height (0.2958). Ear girth possessed indirect negative effect on grain yield via ear length (1.9246), days to 75% tasseling (1.1097), days to 75% brown husk (0.8019), number of kernel rows per ear (0.7161) and ear height (0.4403). Number of kernel rows per cob possessed indirect positive correlation via ear length (1.5521), Number of kernels per row (0.8848), ear girth (0.4573), ear height (0.3664) and tassel length (0.0422). Number of kernels per row had indirect positive effect via days to 75% silking (2.8020), number of kernel rows per ear (1.1596), ear length (0.6524), ear height (0.3958) and tassel length (0.0933). Similar finding were reported earlier by [5,10-12,17-24] for improving the grain yield of maize.

3.1.2 Phenotypic path coefficient (Table 5)

The positive direct effect on grain yield was showed by ear length (0.3756), No. of kernels per row (0.3487), plant height (0.1694), ear girth (0.1452), No. of kernel rows per ear (0.1260), days to 75% tasseling (0.0628), days to 75% silking (0.0178). Plant height showed positive indirect effect on grain yield (0.2846) through ear length (0.0998), No. of kernels per row (0.0749), ear girth (0.0429), days to 75% brown husk (0.0023), days to 75% tasseling (0.0011). Ear height exhibited positive indirect association on grain yield via plant height (0.1180), No. of kernels per row (0.0842), ear length (0.0759), ear girth (0.0301), ear length (0.0759), days to 75% tasseling (0.0055), no. of kernel rows per ear (0.0019). Days to 75% tasseling showed positive indirect effect on grain yield (0.0976) through ear girth (0.0221), days to 75% silking (0.171), days to 75% tasseling (0.0030). Days to 75% brown husk was found to have positive indirect effect on grain yield (0.1089) through days to 75% tasseling (0.0433), days to 75% silking (0.0125). Tassel length showed positive indirect effect on grain yield (0.1557) through ear length (0.0079), ear girth (0.0072), days to 75% tasseling (0.0071), No. of kernel rows per ear (0.0068), days to 75% silking (0.0032) and plant height (0.0015). Ear length exhibited positive indirect effect on grain yield (0.5434) through No. of kernels per row (0.0809) followed by ear girth (0.0664), plant height (0.0450), No. of kernel rows per ear (0.0108) and days to 75% brown husk (0.0055). Ear girth showed positive indirect effect on grain yield (0.3719) via ear length (0.1718), plant height (0.0493), No. of kernels per row (0.0444), days to 75% tasseling (0.0096), days to 75% silking (0.0031) and days to 75% brown husk (0.0023). No. of kernel rows per ear showed positive indirect effect on grain yield via ear length (0.0322), days to 75% brown husk (0.0085), No. of kernels per row (0.0081) and plant height (0.0004). No. of kernels per row exhibited positive indirect effect on grain yield (0.4624) through ear length (0.0871), plant height (0.0364), tassael length (0.0186), ear girth (0.0185), days to 75% brown husk (0.0043) and No. of kernel rows per ear (0.0029). Similar findings were reported earlier by [5,10-12,17,19,21,24-26].

Table 2. Genotypic correlation coefficient among eleven yield attributing characters in QPM inbred lines

Character	Plant height (cm)	Ear height (cm)	Days to 75% tasseling	Days to 75% silking	Days to 75% brown husk	Tassel length (cm)	Ear length (cm)	Ear girth (cm)	No. of kernel rows/Ear	No. of kernels/Row
Ear Height (cm)	0.8172									
Days to 75% tasseling	0.0463	0.1537								
Days to 75% silking	0.0301	0.1412	0.9912							
Days to 75% Brown husk	0.0476	0.1986	0.1955	0.1656						
Tassel length (cm)	0.1382	0.1157	0.1774	0.2547	0.2456					
Ear length(cm)	0.3214	0.2434	-0.1262	-0.0853	-0.0390	0.1976				
Ear girth (cm)	0.4747	0.3622	0.2076	0.2959	0.3694	0.1448	0.6349			
No. of kernel rows per ear	0.1493	0.3014	-0.0005	-0.0423	-0.2676	-0.0809	0.5120	-0.3213		
No. of kernels per row	0.3200	0.3256	-0.2750	-0.3488	-0.3183	-0.1788	0.2152	0.2747	-0.5202	
Grain yield (kg/ha)	0.2600	0.1129	-0.1466	-0.1637	-0.2052	-0.0956	0.6775	0.5584	0.8021	0.7890

Table 3. Phenotypic correlation coefficient among eleven yield attributing characters in QPM inbred lines

Character	Plant height (cm)	Ear height (cm)	Days to 75% tasseling	Days to 75% silking	Days to 75% brown husk	Tassel length (cm)	Ear length (cm)	Ear girth (cm)	No. of kernel rows/Ear	No. of kernels/Row
Ear Height (cm)	0.6966**									
Days to 75% Tasseling	0.0174	0.0869								
Days to 75% Silking	-0.0009	0.0886	0.9622**							
Days to 75% Brown Husk	-0.0307	0.0850	0.7052**	0.7061**						
Tassel length (cm)	0.0091	0.0555	0.1130	0.1800	0.0532					
Ear length (cm)	0.2656*	0.2022	-0.1021	-0.0849	-0.0740	0.0210				
Ear girth (cm)	0.2909*	0.2071	0.1525	0.1728	-0.0315	0.0493	0.4575**			
No. of kernel rows/Ear	0.0021	0.0147	-0.0956	-0.1078	-0.1159	0.0539	0.0858	-0.1321		
No. of kernels /row	0.2148	0.2416*	-0.2094	-0.2766*	-0.0586	-0.1480	0.2320*	0.1273	0.0232	
Grain yield (kg/ha)	0.2846	0.1544	-0.0976	-0.1268	-0.1089	-0.1557	0.5434	0.3719	0.1392	0.4624

**Significant @ 5% level of significance, ** Significant @ 1% level of significance*

Table 4. Genotypic path coefficient analysis for eleven yield attributing characters in QPM inbred lines

Character	Plant height (cm)	Ear height (cm)	Day to 75% tasseling	Day to 75% silking	Day to 75% brown husk	Tassel length (cm)	Ear length (cm)	Ear girth (cm)	No. of kernel rows/Ear	No. of kernels/Row
Plant Height (cm)	**-0.1920**	-0.1569	-0.0089	-0.0058	-0.0091	-0.0265	-0.0617	-0.0912	-0.0287	-0.0614
Ear Height (cm)	0.9934	**1.2155**	0.1868	0.1716	0.2414	0.1407	0.2958	0.4403	0.3664	0.3958
Day to 75% Tasseling	0.2477	0.8215	**5.3447**	5.2979	6.3894	0.9480	-0.6743	1.1097	-0.0024	-1.4697
Day to 75% Silking	-0.2418	-1.1343	-7.9624	**-8.0327**	-9.3632	-2.0462	0.6853	-2.3766	0.3400	2.8020
Day to 75% Brown Husk	0.1034	0.4310	2.5952	2.5304	**2.1708**	0.5332	-0.0846	0.8019	-0.5809	-0.6910
Tassel length (cm)	-0.0721	-0.0604	-0.0926	-0.1330	-0.1282	**-0.5220**	-0.1031	-0.0756	0.0422	0.0933
Ear length(cm)	0.9744	0.7378	-0.3825	-0.2586	-0.1182	0.5990	**3.0313**	1.9246	1.5521	0.6524
Ear girth (cm)	-0.6758	-0.5156	-0.2956	-0.4212	-0.5259	-0.2061	-0.9038	**-1.4236**	0.4573	-0.3911
No. of kernel rows/Ear	-0.3328	-0.6719	0.0010	0.0944	0.5964	0.1804	-1.1413	0.7161	**-2.2289**	1.1596
No. of kernels /row	-0.5443	-0.5538	0.4677	0.5933	0.5414	0.3040	-0.3660	-0.4673	0.8848	**-1.7009**
Grain yield (kg/ha)	0.2600	0.1129	-0.1466	-0.1637	-0.2052	-0.0956	0.6775	0.5584	0.8021	0.7890

Table 5. Phenotypic path coefficient analysis for eleven yield attributing characters in QPM inbred lines

Character	Plant height (cm)	Ear height (cm)	Days to 75% tasseling	Days to 75% silking	Days to 75% brown husk	Tassel length (cm)	Ear length (cm)	Ear girth (cm)	No. of kernel rows/Ear	No. of kernels/ Row
Plant Height (cm)	**0.1694**	0.1180	0.0030	-0.0001	-0.0052	0.0015	0.0450	0.0493	0.0004	0.0364
Ear Height (cm)	-0.1041	**-0.1495**	-0.0130	-0.0132	-0.0127	-0.0083	-0.0302	-0.0310	-0.0022	-0.0361
Days to 75% Tasseling	0.0011	0.0055	**0.0628**	0.0604	0.0443	0.0071	-0.0064	0.0096	-0.0060	-0.0131
Days to 75% Silking	0.0000	0.0016	0.0171	**0.0178**	0.0125	0.0032	-0.0015	0.0031	-0.0019	-0.0049
Days to 75% Brown Husk	0.0023	-0.0063	-0.0520	-0.0521	**-0.0738**	-0.0039	0.0055	0.0023	0.0085	0.0043
Tassel length (cm)	-0.0011	-0.0070	-0.0142	-0.0226	-0.0067	**-0.1255**	-0.0026	-0.0062	-0.0068	0.0186
Ear length(cm)	0.0998	0.0759	-0.0383	-0.0319	-0.0278	0.0079	**0.3756**	0.1718	0.0322	0.0871
Ear girth (cm)	0.0423	0.0301	0.0221	0.0251	-0.0046	0.0072	0.0664	**0.1452**	-0.0192	0.0185
No. of kernel rows/Ear	0.0003	0.0019	-0.0120	-0.0136	-0.0146	0.0068	0.0108	-0.0166	**0.1260**	0.0029
No. of kernels /row	0.0749	0.0842	-0.0730	-0.0965	-0.0204	-0.0516	0.0809	0.0444	0.0081	**0.3487**
Grain yield (kg/ha)	0.2846	0.1544	-0.0976	-0.1268	-0.1089	-0.1557	0.5434	0.3719	0.1392	0.4624

4. CONCLUSION

A perusal of the results of both correlation and path analysis revealed that most important characters accounting for cause and effect relationship on yield are days to 75% tasseling, ear length, number of kernel rows per ear, number of kernels per row, ear height and ear girth. Thus, these traits were identified to be the major yield factors and major emphasis may be given towards selection of these traits for improvement of grain yield in Quality Protein Maize (QPM). Hence, emphasis should be given to these traits while formulating selection criteria for improvement in grain yield.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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