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Correlation and path analysis for yield and yield components in single cross maize hybrids (*Zea mays* L.)

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Abstract: To study the relationship between different quantitative traits and grain yield 17 single cross hybrids of maize were evaluated along with three popular checks, *viz.,* Super 900 M, Bio 9681 and Arjun. The correlation study revealed that grain yield exhibited positive correlation with cob length (0.98), cob diameter (0.63), kernels per row (0.40), cob weight (0.60) and test weight (0.60). Whereas negative association was observed with plant height, days to anthesis, days to silking and days to brown husking. Path analysis further revealed that cob weight, shelling percent, plant height, kernels per row, days to silking exerted high direct effects on grain yield. 0.0723. The lower residual effect indicated that the characters chosen for path analysis were adequate and appropriate. Therefore these traits *viz.,* plant height, kernels per row, cob weight and test weight can be considered as principal yield contributing components and it is suggested to use these as selection criteria for grain yield improvement in maize. Four single cross hybrids DMH 100-10, DMH 100-11, DMH 100-14 and DMH 100-17 were found to be high yielding. The high grain yields of these genotypes can be explained due to their positive significant correlation of cob length, cob diameter, kernels per row, cob weight and test weight with grain yield. On the contrary they had negative association with days to anthesis, days to silking and days to brown husking.

Key words: Genotype, Hybrid, Maize, Phenotype

Introduction

Maize (*Zea mays* L. 2n=20) is known as "King of crops and Queen of cereals" is one of the most important crops of world agricultural economy and globally, it ranks third next to wheat and rice in production. Maize is not only an important human nutrient, but also a basic element of animal feed and raw material for manufacture of many industrial products. In India, about 23 per cent of the maize production is consumed directly as food**,** 63 per cent as cattle feed, poultry, piggery and fishmeal, 10-12 per cent in starch and oil and about 3 per cent in dry milling. Country has 5 per cent of corn acreage and contributes 2 per cent of world production. Maize crop occupies an area of 9.43 million hectares with the production of 24.26 million tones with national average productivity of 2583 kg/ha (Anon., 2014). Yield is a complex trait, which is a result of inter relationship between the quantitative traits, which determine the efficiency of selection in breeding programme. Correlation indicates the intensity of association between any two characters. It provides better understanding of yield components which helps the plant breeder during selection. Positive correlation between desirable characters is favorable to the plant breeder because improvement in one character automatically improves the other trait. Negative correlation, on the other hand will hinder the simultaneous expression of both the characters with high values (Saidaiah *et al.,* 2008). Knowledge of interrelationships between grain yield and its contributing components will improve the efficiency of breeding programs through the use of appropriate selection indices. Path coefficient analysis has been widely used in crop breeding to determine the nature of relationships between grain yield and its contributing components, and to identify those components with significant effect on yield and it is use as selection criteria. The present study was planned with the objectives to study the relationship between different quantitative traits and grain yield and to work out path coefficients to find out the relative contribution of different metric traits to the grain yield.

Material and methods

The materials used for the present study consisted of 17 single cross hybrids of maize along with three checks*, viz.,* Super 900 M, Bio 9681 and Arjun. The seed material of single cross hybrids were received from Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during summer and monsoon seasons of 2014. The experiment was laid out in three replications, with row length of 4 m, with inter and intra row spacing of 75cm and 20cm respectively. Each genotype was sown with 2 rows. The observations were recorded on 5 competitive plants for 13 characters, *viz.,* days to anthesis, days to silking, anthesis to silking interval, days to brown husking, plant height (cm), cob height (cm), cob length (cm), cob diameter (cm), kernel rows per cob, kernels per row, kob weight /ha (kg), test weight (gm), shelling percentage (%) and Grain yield /ha (kg). The analysis of correlation coefficient and path analysis were carried out by using indostat. The list of single cross hybrids used in the study along with their parents are presented in the following Table 1.

Results and discussion

The correlation coefficient provide a reliable measure of association among the characters and help to differentiate vital associates useful in breeding from those of the non-vital ones. In the present study, the genotypic correlation coefficients were higher in magnitude than their respective corresponding phenotypic correlation coefficients for most of the characters indicating the depression of phenotypic expression by the environmental influence. Phenotype of a plant is the result of

Table 1. List of single cross maize hybrids used in the study

Hybrids	Padigree	Hybrids	Padigree
DMH 100 -1	DMIL 061 x DMIL 001	DMH 100 -10	DMIL 749 x DMIL 055
DMH 100 -2	DMIL 065 x DMIL 096	DMH 100 -11	DMIL 318 x DMIL 150
DMH 100 -3	DMIL 069 x DMIL 008	DMH 100 -12	DMIL 055 x DMIL 749
DMH 100 -4	DMIL 055 x DMIL 326	DMH 100 -13	DMIL 765 x DMIL 031
DMH 100 -5	DMIL 090 x DMIL 051	DMH 100 -14	DMIL 122 x DMIL 112
DMH 100 -6	DMIL 326 x DMIL 055	DMH 100 -15	DMIL 147 x DMIL 150
DMH 100 -7	DMIL 150 x DMIL 001	DMH 100 -16	DMIL 150 x DMIL 124
DMH 100 -8	DMIL 001 x DMIL 318	DMH 100 -17	DMIL 160 x DMIL 103
DMH 100 -9	DMIL 136 x DMIL 326		

interaction of a large number of factors. Hence, the final yield is sum total of effects of several component factors. Therefore, it is important to know the extent and nature of interrelationship between grain yield and its contributing characters and also among themselves. The correlation coefficient helps the breeder in determining the nature of association and number of characters to be considered in improving the grain yield. The phenotypic correlation coefficient between Grain yield with 13 biometric characters such as yield and components presented in Table 2.

Days to anthesis exhibited negative and non significant association with grain yield. Negative association of days to anthesis and days to silking with grain yield is a desired for decreasing the duration of crop with increases in the the grain yield, thus helps in saving of time and inputs without losing the yield levels. Similar findings were obtained by Akbar *et al.* (2008) and Atnafua *et al.* (2013). Similarly, days to silking showed negative and non significant association with grain yield. Similar findings have been reported by Akbar *et al.* (2008) and Atnafua *et al.* (2013). Days to brown husking also exhibited negative and non significant association with grain yield. The results obtained by Atnafua *et al.* (2013) were in agreement with the present results. The present study indicated that genotypes late to to anthesis, silking and late to brown husking were low yielding genotypes compared to genotypes which flowered early. The plant height exhibited positive and non significant association with grain yield. Similar findings were obtained by Wali *et al.* (2006) and Dana and Sherwan (2014). Similarly non significant positive association was noticed between cob height and grain yield.

The cob length had positive significant association (0.98) with grain yield. Similar results of significant correlation between cob length and grain yield were reported by Sofi and Rather (2007) and Ali *et al.* (2010). It is confirmed that longer cobs enhances the grain yield. Hence highly positive and significant association of important trait cob length plays an important role in selection for higher maize grain yield. Positive and significant association of cob diameter (0.63) was also observed with grain yield. These results are in concurrence with Sofi and Rather (2007). Higher cob diameter could increase the grain yield so it is desirable to select such genotypes having high cob diameter as evidenced by the current study. Kernel rows per cob exhibited positive and non significant (0.40) association with grain yield. Similar findings were obtained by Sumathi *et al.* (2005). Kernels per row had positive and significant relation with grain yield, this is in line with the findings of Ali *et al.* (2010) and Dana and Sherwan (2014). Another important yield contributing trait cob weight showed significant positive association (0.60) with grain yield. Existence of strong positive association between these components was also reported by Dana and Sherwan (2014) indicates that selection of the genotypes based on higher cob weight could prove beneficial in improving grain yield. Test weight showed positive and significant association (0.60) with grain yield. Similar results were reported by Zhang Li *et al.* (2007) and Marouf *et al.* (2013). The correlation of shelling percentage was positive significant association with grain yield, it was also reported by Tan-Heping *et al.* (2006). Since yield is a dependent trait, certainly it will have the influence of other component traits through which it can become high yielding. In the present study, the genotypes *viz.,* DMH 100-10, DMH 100-11, DMH 100-14 and DMH 100-17 were found to be high yielding. The high grain yields of these genotypes can be explained due to their positive significant correlation of cob length, cob diameter, kernels per row, cob weight and test weight with grain yield. On the contrary they had negative association with days to anthesis, days to silking and days to brown husking.

The component of residual effect of path analysis in yield and component traits was 0.0723. The lower residual effect indicated that the characters chosen for path analysis were adequate and appropriate. The correlation co-efficient measures the sum total effects (direct and indirect) of all the characters to which it is correlated either positively or negatively and hence selection based on this value alone will be sometimes misleading unless the direct effect is very high and operates in the same direction. Hence, the study of direct and indirect effects through path analysis enables the breeders to judge the important component characters during selection (Singh *et al.*, 1999). In the present investigation, thirteen grain yield associated characters were subjected separately to path analysis for partitioning the correlation values into direct and indirect effects through alternative path ways and results are discussed below (Table 3).

All the characters under study showed direct significant association with grain yield at phenotypic level. The highest direct positive association on grain yield was exhibited in cob weight followed by shelling percent, plant height, kernels per row, days to silking. Similar results were obtained by Patel *et al.* (2005). While, Kumar *et al.* (2006) reported direct positive association of days to anthesis and negative direct association of days to silking with grain yield. The highest reverse direct

Table 2. Phenotypic correlation among different quantitative traits in single cross maize hybrids at Dharwad during summer 2014

Traits	Days to anthesis	Days to silking	Anthesis to silking interval	Days to brown husking	Plant height	Cob height	Cob length	Cob diameter	Kernel rows per cob	Kernel per row	Cob weight	Test weight	Shelling percentage	Grain yield
Days to anthesis	1.000	0.974**	-0.320*	0.664**	0.459**	0.251	-0.430**	-0.022	0.158	-0.156	0.006	-0.174	-0.182	-0.020
Days to silking		1.000	-0.097	0.709**	0.451**	0.257*	-0.368**	-0.037	0.144	-0.088	0.020	-0.178	-0.201	-0.011
Anthesis to silking interval			1.000	0.046	-0.129	-0.027	0.353**	-0.058	-0.096	0.318*	0.053	0.020	-0.042	0.041
Days tobrown husking				1.000	0.347**	0.275*	-0.238	-0.113	0.018	0.030	0.030	-0.119	-0.290 *	-0.018
Plant height					1.000	0.795**	-0.249	-0.229	-0.115	-0.097	0.065	-0.246	-0.245	0.051
Cob height						1.000	-0.234	-0.236	-0.107	-0.161	0.133	-0.259*	-0.254	0.105
Cob length							1.000	0.380**	-0.157	0.602**	0.420**	0.496**	0.469**	0.446**
Cob diameter								1.000	0.492**	0.111	0.628**	0.731**	0.677**	0.629**
Kernel rows per cob									1.000	-0.359**	0.018	0.122	0.146	0.002
Kernels per row										1.000	0.356**	0.202	0.311*	0.391*
Cob weight											1.000	0.616**	0.507**	0.986**
Test weight												1.000	0.440**	0.596 **
Shelling percentage													1.000	0.613**
Grain yield														1.000

* Significant at 0.05 probability level, Significant at 0.01 probability level

Table 3. Direct and indirect effects of grain yield component traits on grain yield at phenotypic level in maize at Dharwad during summer 2014

	Days to anthesis	Days to silking	Anthesis to silking interval	Days to brown husking	Plant height	Cob height	Cob length	Cob diameter	Kernel rows per cob	Kernels per row	Cob weight	Test weight	Shelling percentage
Days to anthesis	-0.0044	-0.0043	0.0014	-0.0030	-0.0020	-0.0011	0.0019	0.0001	-0.0007	0.0007	0.0000	0.0008	0.0008
Days tosilking	0.0037	0.0038	-0.0004	0.0027	0.0017	0.0010	-0.0014	-0.0001	0.0005	-0.0003	0.0001	-0.0007	-0.0008
Anthesis to silking interval	0.0009	0.0003	-0.0028	-0.0001	0.0004	0.0001	-0.0010	0.0002	0.0003	-0.0009	-0.0002	-0.0001	0.0001
Days tobrown husking	-0.0057	-0.0061	-0.0004	-0.0086	-0.0030	-0.0024	0.0021	0.0010	-0.0002	-0.0003	-0.0003	0.0010	0.0025
Plant height	0.0128	0.0125	-0.0036	0.0096	0.0278	0.0221	-0.0069	-0.0064	-0.0032	-0.0027	0.0018	-0.0068	-0.0068
Cob height	-0.0030	-0.0031	0.0003	-0.0033	-0.0096	-0.0121	0.0028	0.0028	0.0013	0.0019	-0.0016	0.0031	0.0031
Cob length	0.0068	0.0058	-0.0056	0.0037	0.0039	0.0037	-0.0157	-0.0060	0.0025	-0.0095	-0.0066	-0.0078	-0.0074
Cob diameter	0.0026	0.0043	0.0068	0.0131	0.0267	0.0274	-0.0442	-0.1163	-0.0572	-0.0129	-0.0730	-0.0851	-0.0787
Kernel rows per cob	0.0025	0.0023	-0.0015	0.0003	-0.0018	-0.0017	-0.0025	0.0077	0.0157	-0.0056	0.0003	0.0019	0.0023
Kernels per row	-0.0025	-0.0014	0.0050	0.0005	-0.0015	-0.0026	0.0096	0.0018	-0.0057	0.0159	0.0057	0.0032	0.0049
Cob weight	0.0061	0.0184	0.0503	0.0284	0.0619	0.1262	0.3984	0.5951	0.0169	0.3376	0.9476	0.5836	0.4803
Test weight	-0.0020	-0.0021	0.0002	-0.0014	-0.0029	-0.0030	0.0058	0.0085	0.0014	0.0023	0.0072	0.0116	0.0051
Shelling percentage	-0.0377	-0.0417	-0.0088	-0.0603	-0.0508	-0.0527	0.0973	0.1404	0.0304	0.0646	0.1051	0.0913	0.2074
Grain yield	-0.0202	-0.0114	0.0411	-0.0183	0.0507	0.1049	0.4462	0.6288	0.0020	0.3909	0.9860	0.5962	0.6129

Residual effect = 0.0723

association on seed yield was observed in case of cob diameter followed by cob length, cob height, anthesis to silking interval, days to anthesis and days to brown husking. Arun and Singh (2004) noticed similar results in their experiment. Vaezi *et al.* (2000) reported negative indirect effect of cob diameter with grain yield. Kumar *et al.* (2006) found direct positive association between anthesis to silking interval and grain yield. Days to anthesis showed negative indirect effect on grain yield through kernel rows per cob which is in agreement with the findings of Venugopal *et al.,* 2003. Cob diameter had a negative indirect effect on grain yield through days to silking and plant height, which is in agreement with the findings of Vaezi *et al.* (2000). Kernels per row had indirect negative influence on grain yield. Venugopal *et al.* (2003) noticed the similar results.In the light of results obtained in the present study, it may be concluded that improvement in grain yield per plant could be brought through by selection for component characters such as plant height, kernel rows per cob, kernels per row, test weight, cob weight and shelling percentage.Thus, the material studied is of diverse nature and information emanated would help in designing the selection methodology which can further be used in the breeding programme for improvement of seed yield.

Conclusion

Association studies indicated that grain yield exhibited positive correlation with cob length, cob diameter, kernels per row, cob weight and test weight. Whereas negative association was observed with plant height, days to anthesis, days to silking and days to brown husking. Positive correlations of cob length, cob diameter, kernels per row, cob weight and test weight increases maize grain yield levels, on the otherhand negative correlations of plant height, days to anthesis, days to silking and days to brown husking save time and other input use. Hence, selection based on these traits would be needed for improvement of grain yield. Path analysis indicated that cob weight, shelling percent, plant height, kernels per row, days to silking exerted high direct effect on grain yield. Therefore, these traits *viz.,* cob length, cob diameter, kernels per row, cob weight and test weight in one direction and plant height, days to anthesis, days to silking and days to brown husking in another direction can be considered as principal yield contributing components and it is suggested to use these as selection criteria for grain yield improvement in maize. It was also concluded that indirect selection via traits that have the highest direct effect on the grain yield ultimately incresaes the yield levels in maize. Four single cross maize hybrids *viz.*, DMH 100-10, DMH 100-11, DMH 100-14 and DMH 100-17 were promising for high grain yield. The high grain yields of these genotypes can be explained through their positive significant correlation of cob length, cob diameter, kernels per row, cob weight and test weight with grain yield. On the contrary they had negative association with days to anthesis, days to silking and days to brown husking to reduce maturity period.

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