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Research Note

Correlation and path coefficient analysis of grain yield and yield contributing traits in single cross hybrids of maize (*Zea mays* L.)

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Abstract:
The yield is a complex trait, which is highly influenced by the environment and hence indirect selection through component traits would be an advisable strategy to increase the efficiency of selection. Eighty seven single cross hybrids of maize were developed by crossing twenty nine newly developed inbred lines from the National Yellow Pool with three testers in a line x tester mating design and were evaluated in a randomized complete block design with two replications to assess the direct and indirect effects of grain yield among twelve quantitative traits. Plant height, ear length, ear circumference, number of kernel rows/ear, number of kernels/row, 100-grain weight, shelling per cent, grain yield per plant and fodder yield per *ha* recorded significantly positive genetic correlation with grain yield. However, path coefficient analysis revealed that days to 50 per cent silking, plant height, number of kernels rows/ear, number of kernels/row, 100-grain weight, shelling per cent, grain yield per plant and fodder yield have highest direct effect on grain yield.

Key words:
Maize, correlation, path coefficient analysis, grain yield.

Maize (*Zea mays L.*) is the third most important cereal food crop of the world belonging to the family Poaceae and tribe Maydeae after wheat and rice (Poehlman, 1997). In country like India, rapid growth in population outstrips our grain in cereal production. Increased production of maize and its alternate utilization in food channel can reduce the pressure on wheat, rice and its imports. Now a days, maize has also been recognized as an industrial crop because of the diversified products that can be developed like starch, syrup, glucose, gluten and oil. Nearly 49% of the total maize produced is being utilized as a raw material in the poultry feed industry.

Grain yield is a complex character which is highly influenced by the environment and is the result of interrelationships of its various yield components (Grafius, 1960). Thus, information on genotypic and phenotypic correlation coefficients among various plant traits help to ascertain the degree to which these are associated with economic productivity. The association between two characters can directly be observed as phenotypic correlation while genotypic correlation expresses the extent to which two traits are genetically associated. Both genotypic and phenotypic correlations among and between pairs of agronomic traits provide scope for indirect selection in a crop breeding programme.

Keeping in view many other factors, the genetic base of the material under study and the effects of environment are very important while studying genetic correlation among various quantitative characters in crop species. Such studies could lead plant breeders in the selection of traits contributing towards the character(s) of concern, and ultimately their improvement through hybridization. With increased industrial demand, it is necessary to maximize maize production at a much faster pace than the current. Cultivar with desirable traits is a major contributing factor in grain yield per unit area. In order to develop promising genotypes, it is essential to know the associations among different traits, especially with grain yield, which is the most important ultimate objective in any breeding programme. The present study was undertaken to derive information on correlations among yield and yield component traits and to estimate the direct and indirect effects of yield component traits on grain yield. This helps in selection of superior cross combinations in hybrid maize.

The parents used in the experiment comprised twenty nine promising newly developed inbred lines from the National Yellow Pool based on their performance in their S_4 generation. These selected twenty nine inbreds were used as females and were crossed with three testers *viz.,* Prabha (composite with broad genetic base), KDMI-10 and CI-5(inbred lines with narrow genetic base) at Main Agricultural Research Station, Agricultural collage, Dharwad during *kharif* 2007-08.

The 87 F_1 hybrids thus generated from the above Line x Tester crossing programme were evaluated in randomized complete block design with two replications along with parental lines and five commercial checks *viz.,* DMH-2 and EH-434042 (Arjun) (Public hybrids), 900M, Bio-9681 and Pinnacle (Private hybrids) at All India Co-ordinate Maize Improvement Project (AICMIP), Agricultural Research station (ARS), Arabhavi during *rabi/summer* 2008-09.

Each entry was raised in two rows with a row length of 4m and the spacing maintained was 75cm between the rows and 20cm between the plants. The recommended package of practices was followed to raise a good crop. Observations on grain yield and its 11 important component traits were recorded from five competitive plants which were selected randomly to record observations on days to 50 per cent tasseling, days to 50 per cent silking, plant height (cm), ear length (cm), ear circumference (cm), number of kernel rows per ear, number of kernels per row, 100-grain weight (g), shelling per cent, grain yield per plant, fodder yield (t/ha) and grain yield (q/ha). The mean values were used for statistical analysis. The phenotypic and genotypic correlation coefficients were worked out as per the method suggested by Johnson *et al*., (1955). Path analysis was 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) and illustrated by Dewey and Lu (1959).

Analysis of variance revealed significant differences for 12 quantitative traits. The phenotypic and genotypic correlation coefficients among 12 quantitative traits are presented in Table 1. The genotypic correlations in general were higher than the phenotypic correlation, revealing strong inherent relationship among the characters studied. Grain yield showed highly significant positive correlation with plant height (Sharma *et al*., 1982, Tyagi *et al*., 1988, Singh *et al*., 1991, Debnath and Khan 1991, Krishnan and Natrajan 1995, Packiaraj 1995, Swarnalatha Devi and Shaik Mohammad 2001), ear length, ear circumference (Appadurai and Nagarajan 1975, Alok Kumar *et al.,* 1999, Pradeep Kumar and Satyanarayana, 2001), number of kernel rows per ear, number of kernels per row (Appadurai and Nagarajan, 1975, Tyagi *et al.,* 1988, Geetha and Jayaraman 2000), 100-grain weight (Saha and Mukherjee, 1985, Tyagi *et al.,* 1988, Umakanth and Khan, 2001), grain yield per plant (Nawar *et al.,*1999), fodder yield per hectare (Krishnan and Nagarajan, 1995) and shelling per cent. A significant negative association was observed between grain yield and its component traits such as days to 50 per cent taselling and days to 50 per cent silking (Netaji *et al*., 2000). The 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.

Sometimes, correlation coefficients give misleading results because the correlation between two variables may be due to third factor. It is therefore necessary to analyze the cause and effect relationship between dependent and independent variables to entangle the nature of relationship between the variables. Path co-efficient analysis (Dewey and Lu 1957) furnished a method partitioning the correlation coefficient into direct and indirect effect and provides the information on actual contribution of a trait on the yield.

In the present study, path analysis was used to work out the direct and indirect effects of 11 characters on grain yield are presented in Table 2. The traits which not only have high positive correlation but also have high direct effects are expected to be useful as selection criteria in selection programme. Considering this point, days to 50 per cent silking, grain yield per plant, 100-grain weight, number of kernels per row, shelling per cent, fodder yield per hectare, number of kernel rows per ear and plant height had high positive direct effect on grain yield. The results were supported by the earlier findings of Packiaraj (1995) for plant height and 100-grain weight, Manivannan (1998) for number of kernel rows per ear, number of kernels per row, Gautam *et al* (1999) for ear circumference, Krishan and Natarajan (1995) for fodder yield per hectare and Umakantha and Khan (2001) for negative direct effects. Plant height, number of kernel rows per ear, number of kernels per row, 100 grain weight, shelling per cent and fodder yield per hectare had high positive indirect effect on grain yield and the findings were in accordance with Swaranalatha Devi and Shaik Mohmmed (2001). The residual effects permit precise explanation about the pattern of interaction of other possible components of yield. The genotypic and phenotypic residual effects recorded 0.3816 and 0.2354 respectively; it indicates the characters used in our experiment explain above 60 per cent of variations which may be contributed to higher yields in maize.

Genetic correlation between different characters of plant often also because of either linkage or plieotrophy (Harland, 1939). The data presented in Table 1 revealed that genotypic correlation coefficient were slightly higher in magnitude than phenotypic once. This low magnitude is due to modifying effects of environment on the associated characters. There was a general agreement in both sign and magnitude between estimates of genotypic and phenotypic correlations. The character which is genotypically but not phenotypically correlated may not be of practical value in selection since selection is based on phenotype.

It may be concluded that plant height, ear length, ear circumference, number of kernel rows per ear, number of kernels per row, 100-grain weight, shelling per cent, grain yield per plant and fodder yield had a significant positive association with yield both at the phenotypic and genotypic levels. Number of kernel rows per cob and number of kernels per row had a direct positive effect on yield both at the phenotypic and genotypic levels which also contributed maximum to higher grain yield compared to the other characters. Thus, selection for these characters could be considered as important selection criteria in improving hybrid maize for high grain yield.

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Table 1: Genotypic (G) and phenotypic (P) correlation coefficient for yield and yield contributing characters in hybrid maize

Characters		X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
X1	G	0.919**	0.201	-0.144	-0.304**	-0.164	-0.254*	-0.329**	-0.145	-0.606**	-0.101	-0.571**
	P	0.804**	-0.186	-0.161	-0.277*	0.024	-0.215*	-0.236*	-0.062	-0.370**	-0.124	-0.248*
X2	G	1.000	0.206	0.097	-0.189	-0.180	-0.202*	-0.361**	-0.202*	-0.442**	-0.014	-0.403**
	P	1.000	-0.189	-0.163	-0.223*	-0.022	-0.178	-0.205*	-0.089	-0.278*	-0.071	-0.223*
X3	G		1.000	0.233*	0.188	0.906**	0.627**	0.716**	0.362**	0.827**	0.998**	0.946**
	P		1.000	0.447**	0.565**	0.133	0.341**	0.369**	0.217*	0.344**	0.575**	0.297**
X4	G			1.000	0.720**	-0.468**	0.412**	0.362**	0.899**	0.948**	0.958**	0.911**
	P			1.000	0.741**	0.275**	0.449**	0.327**	0.216*	0.442**	0.378**	0.515**
X5	G				1.000	0.679**	0.752**	0.423**	0.553**	0.968**	0.928**	0.926**
	P				1.000	0.266**	0.517**	0.486**	0.225*	0.553**	0.509**	0.570**
X6	G					1.000	0.667**	0.493**	0.821**	0.797**	0.310**	0.962**
	P					1.000	0.700**	0.231*	0.323**	0.396**	0.143	0.515**
X7	G						1.000	0.473**	0.714**	0.898**	0.383**	0.954**
	P						1.000	0.418**	0.421**	0.761**	0.347**	0.803**
X8	G							1.000	0.306**	0.486**	0.320**	0.549**
	P							1.000	0.167	0.434**	0.300**	0.411**
X9	G								1.000	0.553**	0.303**	0.710**
	P								1.000	0.364**	0.176	0.399**
X10	G									1.000	0.523**	0.987**
	P									1.000	0.462**	0.946**
X11	G										1.000	0.527**
	P										1.000	0.389**
	P											1.000

*-Significant at 5% level **-Significant at 1% level

X1 - Days to 50% tasseling
X2 - Days to 50% silking
X3 - Plant height (cm)
X4- Ear length (cm)
X5 - Ear circumference (cm)
X6 – Number of kernel rows per cob
X7 – Number of kernels per row
X8- 100-grain weight (g)
X9 – Shelling percentage (%)
X10 – Grain yield per plant (g)
X11 – Fodder yield (t/ha)
X12-Grain yield (q/ha)

Table 2: Genotypic (G) and phenotypic (P) path coefficient for yield and yield contributing characters in hybrid maize

Characters		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	Correlation with grain yield
X1	P	**0.172**	-0.075	0.011	-0.016	-0.013	0.002	-0.012	0.003	-0.001	-0.326	0.008	-0.248*
	G	**-1.684**	1.207	0.009	0.033	0.098	-0.022	-0.137	-0.029	-0.072	0.076	-0.049	-0.571**
X2	P	0.138	**-0.093**	0.011	-0.017	-0.011	-0.002	-0.01	0.003	-0.002	-0.245	0.005	-0.223*
	G	-1.547	**1.314**	0.009	-0.022	0.061	-0.024	-0.109	-0.032	-0.101	0.055	-0.007	-0.403**
X3	P	-0.032	0.018	**-0.058**	0.046	0.027	0.012	0.02	-0.005	0.004	0.303	-0.038	0.297**
	G	-0.338	0.271	**0.043**	-0.053	-0.061	0.119	0.339	0.064	0.180	-0.103	0.486	0.946**
X4	P	-0.028	0.015	-0.026	**0.102**	0.036	0.026	0.026	-0.005	0.004	0.389	-0.025	0.515**
	G	0.242	0.127	0.010	**-0.227**	-0.232	-0.061	0.223	0.032	0.448	-0.118	0.466	0.911**
X5	P	-0.048	0.021	-0.033	0.076	**0.048**	0.025	0.03	-0.007	0.005	0.487	-0.033	0.570**
	G	0.512	-0.248	0.008	-0.163	**-0.322**	0.089	0.407	0.038	0.276	-0.121	0.452	0.926**
X6	P	0.004	0.002	-0.008	0.028	0.013	**0.093**	0.04	-0.003	0.007	0.349	-0.009	0.515**
	G	0.276	-0.237	0.039	0.106	-0.219	**0.409**	0.361	0.044	0.131	-0.100	0.151	0.962**
X7	P	-0.037	0.017	-0.02	0.046	0.025	0.065	**0.058**	-0.006	0.009	0.67	-0.023	0.803**
	G	0.428	-0.265	0.027	-0.093	-0.242	0.087	**0.541**	0.042	0.356	-0.112	0.186	0.954**
X8	P	-0.041	0.019	-0.021	0.033	0.024	0.022	0.024	**-0.014**	0.003	0.382	-0.02	0.411**
	G	0.089	-0.474	0.031	-0.082	-0.136	0.065	0.256	**0.554**	0.153	-0.061	0.156	0.549**
X9	P	-0.011	0.008	-0.013	0.022	0.011	0.03	0.024	-0.002	**0.02**	0.32	-0.012	0.399**
	G	0.244	-0.265	0.016	-0.204	-0.178	0.108	0.386	0.027	**0.498**	-0.069	0.147	0.710**
X10	P	-0.064	0.026	-0.02	0.045	0.027	0.037	0.044	-0.006	0.007	**0.88**	-0.03	0.946**
	G	-0.125	-0.581	0.035	-0.215	-0.312	0.104	0.486	0.043	0.276	**1.020**	0.255	0.987**
X11	P	-0.021	0.007	-0.033	0.039	0.025	0.013	0.02	-0.004	0.004	0.407	**-0.065**	0.389**
	G	0.170	-0.018	0.043	-0.217	-0.299	0.041	0.207	0.029	0.151	-0.065	**0.487**	0.527**

Genotypic Residual effects = 0.3816 & Phenotypic residual effects= 0.2354 *-Significant at 5% level **-Significant at 1% level

X1 - Days to 50% tasseling
X4- Ear length (cm)
X7 – Number of kernels per row
X10 – Grain yield per plant (g)
X2 - Days to 50% silking
X5 - Ear circumference (cm)
X8- 100-grain weight (g)
X11 – Fodder yield (t/ha)
X3 - Plant height (cm)
X6 – Number of kernel rows per cob
X9 – Shelling percentage (%)