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RESEARCH ARTICLE

ESTIMATE OF CORRELATED RESPONSES FOR SOME POLYGENIC PARAMETERS IN YELLOW MAIZE (*Zea mays* L.) HYBRIDS

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Abstract

Thirty hybrids of maize along with their parents (A-50-2, A-495, Antigua-I, W64-TMS, G.P.F-9 and N 18) were accessed to their genetic divergence, heritability, genetic gain, mutual behavior and magnitude of direct and indirect effects among nine quantitative traits through complete diallel. The experiment was conducted at the experimental area of the Department of Plant Breeding & Genetics, University of Agriculture, Faisalabad, Pakistan. All the traits showed significant variability among the genotypes. Grain yield was positively and significantly correlated with flag leaf area, ear diameter, number of kernel rows per ear, number of kernels per ear row and 100-grain weight at both correlation levels except with flag leaf area, to which it was only significant at phenotypic level. The path coefficient analysis indicated that those traits that showed significant positive correlation with grain yield, like flag leaf area, ear diameter, number of kernel rows per ear, number of kernels per ear row and 100-grain weight, also showing positive direct effects on the grain yield, which indicates that their direct selection would be good enough for the improvement in grain yield per plant. While other traits including plant height, number of leaves per plant, and grain to pith ratio showed negative direct effects on grain yield. High heritability along with high genetic advance was also exhibited by flag leaf area, ear diameter, number of kernel rows per ear, 100-grain weight which indicates their additive gene action.

Introduction

Maize (*Zea mays* L.) is the most widely grown cereal in the world. It is also the leading world cereal in terms of productivity. In Pakistan, it is the third most important cereal after wheat and rice. It is grown on 0.97 million hectares with a total production of 3.71 million tones with average yield of 3805 Kg/ha (Government of Pakistan, 2010-11). However, with its highest yield potential and the scope if increasing its yield in the country, its improvement deserves special attention. In countries like Pakistan, where rapid growth in population outstrips our gain in cereal production, maize offers the most opportunity for increasing cereal production. Increased production of maize and its alternate utilization in food channel can reduce the pressure on wheat and its imports.

Yield is a complex entity and is poly-genically controlled, multiplicative end product of many factors called yield components. For effective selection, information on nature and magnitude of variation in the population, association of characters with yield and among themselves and the extent of environmental influence on the expression of these characters is necessary. Correlation studies supply reliable and useful information on the nature, extent and direction of selection. With the inclusion of more variables in the correlation studies, indirect effects became complex and important (Khan *et al*., 1999).

In such situations path coefficient analysis may be an important tool to bring out the appropriate cause and effect relationship. Along with traits association other studies like their heritability and genetic advance confirms the genetic behavior of the traits. In order to select inbred lines of maize with high yielding capability, a plant breeder have to deal with hundreds of crosses before he is lucky enough to get a desired line with better combinations. Correlation and path coefficient studies between yield and yield components themselves, is a pre-requisite to plan a meaningful breeding programme. Several workers have attempted to determine linkage between the characters on which the selections for high yields can be made and emphasized the utility of the estimates of genetic components in the response prediction of quantitative characters to selection as well as the correlated response of various traits to grain yield. (Aziz *et al*., 1998; Alvi *et al*., 2003; Mohammadi *et al*., 2003; Kadubiec and Kuriata, 2004; Ali *et al*., 2006; Sadek *et al*., 2006; Saleem *et al*., 2007; Najeeb *et al*., 2009; Hefny, 2011; Pavan *et al*., 2011and Zarei *et al*., 2012).

Therefore, the present study of correlation and path coefficient analysis of various yield related traits was conducted that would certainly be valuable aid in selecting and breeding for improved maize hybrids.

Material and Methods

The study was conducted in the experimental area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan during the year 2006. Six yellow maize inbred lines viz., A 50-2, A 495, Antigua-I, W64-TMS, G.P.F-9 and N 18, were chosen for their wide divergence and crossed in all possible combination during spring season 2006, to make a 6 × 6 complete diallel. The F_1 hybrid seed along with parental lines was sown in a randomized complete block design with three replications during the kharif season 2006. Sowing was done in a two rows plot of 3m length by dibbler with two seeds per hill, later on thinned to one plant. Plant-to-plant and row-to-row distances were kept at 15 and 75cm respectively. Uniform cultural and agronomic practices were applied throughout the growing season of crop. Ten guarded plants from each parents and crosses were taken at random in each replication for the computation of the data regarding plant height (cm), number of leaves per plant and flag leaf area (cm^2) in the standing crop position at plant maturity stage. The ears were manually harvested of each selected plant from each replication, kept separated from each other and taken to the laboratory where data regarding ear diameter (cm), number of kernel rows per ear, number of kernels per ear row, 100-grain weight (g), grain to pith ratio and grain yield per plant (g) were taken. The recorded data were subjected to analysis of variance and covariance according to Steel *et al*. (1997). The genotypic and phenotypic correlation was computed according to the formulae given by Kown and Torrie (1964) and then path analysis was performed to check the direct and indirect effects of each parameter on the resultant variable, grain yield, as given by Dewey and Lu (1959). Heritability and genetic advance at 5% selection intensity were computed according to Singh and Chaudhry (1979).

Results

All the genotypes exhibited a significant difference for all the traits considered in this experiment as shown in the table 1 while viewing mean and range performances columns. The phenotypic and genotypic coefficients of variability values were close to each other. It can also be observed that all the traits exhibited high percentage of broad sense heritability and values ranged from 96% (flag leaf area) to 61% (ear diameter). Plant height, flag leaf area, number of kernel rows per ear, number of kernels per ear row, 100-grain weight, grain to pith ratio and grain yield per plant showed 85%, 96%, 88%, 90%, 88%, 82%, 91% broad sense heritability respectively. Ear diameter and number of leaves per plant are the only two traits that showed moderate amount of heritability (61% and 75% respectively). As far as genetic advance is concerned it can be seen from table 1 that high amount of genetic advance as percentage of mean was posted by all the traits except plant height (6.311). Maximum genetic advance as percent of mean was exhibited by grain to pith ratio (445.378) followed by ear diameter (224.80), number of kernel rows per ear (90.459), 100-grain weight (69.825), number of leaves per plant (67.968), flag leaf area (54.206), number of kernels per ear row (50.605) and grain yield per plant (30.212).

In general genotypic correlation is greater than phenotypic ones. While studying the table 2, it can be seen that grain yield was positively and significantly correlated with flag leaf area (0.494), ear diameter (0.443), number of kernel rows per ear (0.608), number of kernels per ear row (0.746) and 100-grain weight (0.545) both at genotypic and phenotypic levels except with flag leaf area to which it was only significant at phenotypic level. Grain yield per plant showed positive but non significant correlation with plant height at both levels (0.190). Similarly it showed negative but non-significant correlations with some traits like number of leaves per plant (-0.118) and grain to pith ratio (-0.041) at both the levels.

Among rest of the correlation a positive and significant genotypic correlation was observed among plant height and flag leaf area (0.454), plant height and 100-grain weight (0.223), ear diameter with number of kernel per ear row (0.358) and 100-grain weight (0.410) at both correlation levels. Number of leaves per plant and 100-grain weight was another combination that showed positive significant correlation. Number of leaves per plant and number of kernels per ear row both exhibited negative and significant genotypic (-0.217) and phenotypic correlations (-0.298). A significant negative correlation was observed among number of kernel rows per ear and 100-grain weight (-0.214). Plant height and grain to pith ratio also revealed a negative genotypic correlation among themselves (-0.172). As far as negative and non significant correlations are concerned some of the trait combinations also exhibited as that like, number of leaves per plant with flag leaf area and number of kernel rows per ear, flag leaf area with number of kernel rows per ear, 100-grain weight and grain to pith ratio. Similarly ear diameter also combined negatively and non-significantly with number of kernel rows per ear and grain to pith ratio. Trait combinations like number of kernel rows per ear with number of kernels per ear row and grain to pith ratio and number of kernels per ear row and grain to pith ratio also fall in the above category.

In this study direct and indirect effects are compiled in table 3. While studying the path table it can be observed that number of kernel rows per ear posted maximum direct effect on grain yield per plant (0.8114) followed by 100-grain weight (0.6918), flag leaf area (0.6337), number of kernels per ear row (0.5876) and ear diameter (0.1185). Among the negative direct contributors towards grain yield per plant; plant height stood at first place (-0.357) followed by grain to pith ratio (-0.0340) and number of leaves per plant (-0.0309). While studying the table 3 it can also be seen that indirect effect of plant height via flag leaf area was maximum (0.2877) towards grain yield per plant followed by the indirect effect of ear diameter via 100-grain weight (0.2836) and via number of kernels per ear row (0.2104). Maximum negative indirect effect was posted by 100-grain weight via number of kernel rows per ear (-0.1736) followed by ear diameter via number of kernel rows per plant (-0.1201).

Discussion

Grain yield is a complex character which is final product of many contributory factors. Therefore a detailed knowledge of these factors, their direct and indirect contribution to yield and knowledge of the behavior of these traits when combined into a single genotype would provide basis for effective breeding program. The closeness of the phenotypic and genotypic coefficient of variability was the indication of least influence of the environment on the genotypes under study. While studying the table 1, it can also be observed that all the traits exhibited high percentage of broad sense heritability that was indicating ample amount of heritable variation among the genotypes (Rafique *et al*., 2004; Najeeb *et al*., 2009; Hefny, 2011). Ali *et al*. (2006) supported the findings of maximum heritability for flag leaf area. High heritability along with high genetic advance is desirable component of breeding, but vice versa can also happen (Johnson *et al*., 1955). In our study high amount of heritability along with high genetic advance was presented by number of leaves per plant, flag leaf area, number of kernel rows per ear, number of kernels per ear row, 100-grain weight and grain to pith ratio; that confirms their additive nature of inheritance in this particular study.

Table 1. Mean, Mean squares, PCV, GCV, $h^2_{B.S}$ and GAPM of various traits in six inbreds and their hybrids of maize.

Agronomic Traits	Mean	Range	Mean Square	PCV	GCV	$h^2_{B.S}$	GAPM
Plant Height (cm)	151.948	169-134	186.246**	5.461	5.042	0.852	6.311
Leaves per plant	12.891	14.07-11.39	1.340**	5.683	4.916	0.748	67.968
Flag leaf area (cm^2)	110.108	186.3-50.17	3220.580**	30.153	29.557	0.961	54.206
Ear diameter (cm)	4.236	4.67-3.72	0.226**	7.515	5.894	0.615	224.802
Kernel rows per ear	13.195	15.5-11.53	2.078**	6.572	6.171	0.882	90.459
Kernels per ear row	36.281	42.65-28.0	36.007**	9.875	9.382	0.903	50.605
100 grain weight (g)	23.705	26.86-19.71	13.013**	9.174	8.585	0.876	69.825
Grain to pith ratio	5.438	6.86-4.4	1.585**	14.208	12.925	0.827	445.378
Grain yield per plant (g)	102.059	134.8-75.2	784.697**	16.295	15.618	0.919	30.212

Where ** = highly significant at 1% level of significance, PCV= Phenotypic coefficient of variability, GCV= Genotypic coefficient of variability, $h^2_{B.S}$ = Heritability in broad sense and GAPM= Genetic advance in percentage of mean.

Table 2. Genotypic (bold) and phenotypic (normal) correlation coefficients among traits in six inbreds and their hybrids.

Characters	Leaves / plant	Flag leaf area	Ear diameter	Kernel rows /ear	Kernels /ear row	100-grain weight	Grain to pith ratio	Grain yield / plant
Plant height	**0.136** 0.131	**0.454**** 0.154	**0.190** 0.188	**0.005** 0.0012	**0.120** 0.113	**0.223**** 0.221	**-0.172**** -0.176	**0.190** 0.180
Leaves per plant		**-0.113** -0.130	**0.138** 0.104	**-0.071** -0.104	**-0.217**** -0.298*	**0.291*** 0.079	**0.044** 0.028	**-0.118** -0.128
Flag leaf area			**0.033** 0.028	**-0.044** -0.169	**0.104** 0.102	**-0.025** -0.027	**-0.113** -0.123	**0.494**** 0.092
Ear diameter				**-0.148** -0.162	**0.358**** 0.352*	**0.410**** 0.407**	**-0.002** -0.013	**0.443**** 0.425**
Kernel rows /ear					**-0.022** -0.013	**-0.214**** -0.220	**-0.072** -0.080	**0.608**** 0.408**
Kernels /ear row						**0.146** 0.139	**-0.060** -0.070	**0.746**** 0.732**
100-grain weight							**0.144** 0.137	**0.545**** 0.445**
Grain to pith ratio								**-0.041** -0.046

*, ** = Significant at 5% and 1% probability level respectively.

Table 3. Direct (in parenthesis) and indirect effects of quantitative traits on grain yield.

Parameters	Plant height	Leaves / plant	Flag leaf area	Ear diameter	Kernel rows /ear	Kernels /ear row	100-grain weight	Grain to pith ratio	Grain yield / plant
Plant height	(-0.357)	-0.0042	0.2877	0.0225	0.0041	0.0705	0.1543	0.0058	0.190
Leaves / plant	-0.0477	(-0.0309)	-0.0716	0.0164	-0.0576	-0.1275	0.2013	-0.0015	-0.118
Flag leaf area	-0.1592	0.0035	(0.6337)	0.0039	-0.0357	0.0611	-0.0173	0.0038	0.494
Ear diameter	-0.0666	-0.0043	0.0209	(0.1185)	-0.1201	0.2104	0.2836	0.0001	0.443
Kernel rows /era	-0.0018	-0.0022	-0.0279	-0.0175	(0.8114)	-0.0129	-0.1480	0.0024	0.608
Kernels /ear row	-0.0421	0.0067	0.0659	0.0424	-0.0179	(0.5876)	0.1010	0.0020	0.746
100-grain weight	-0.0782	-0.0090	-0.0158	0.0486	-0.1736	0.0858	(0.6918)	-0.0049	0.545
Grain to pith ratio	0.0603	-0.0014	-0.0716	-0.0002	-0.0584	-0.0353	0.0996	(-0.0340)	-0.041

Rejoinder to the selection depends upon many aspects such as trait association and their causal effects upon the dependent variable that is grain yield. The interrelationship involving two characters can straightforwardly be observed as phenotypic correlation while genotypic correlation express the level to which traits are genetically associated. Strong inherent relation among traits was confirmed by greater values of genotypic correlation than phenotypic ones. The present study revealed that to increase grain yield one should have to increase those traits that are positively and significantly correlated with it like number of kernel rows per ear, number of kernels per ear row and 100-grain weight etc. The above results are coinciding with the findings of Aziz *et al*. (1998), Kadubiec and Kuriata (2004), Rafique *et al*. (2004), Malik *et al*. (2005), Sadek *et al*. (2006), Najeeb *et al*. (2009), Hefny (2011), Pavan *et al*. (2011) and Zarei *et al*. (2012). The present study revealed that to increase grain yield one should have to increase those traits that are positively and significantly correlated with it like number of kernel rows per ear, number of kernels per ear row and 100-grain weight etc.

Sometimes correlation coefficients endow with ambiguous results because correlation among two traits may be due to attachment of third variable. It is therefore indispensable to carry out further investigation about the causes and effects between reliant and sovereign variables. While studying the path analysis table it can be seen that all the above mentioned traits that showed positive direct effect were also showing positive and significant correlation with grain yield per plant hence proving that their direct contribution is more important than indirect and can be utilized as selection criteria for the improvement in grain yield per plant. Our results are in confirmatory with the early findings of Najeeb *et al*. (2009), Hefny (2011), İlker (2011), Pavan et al. (2011) and Zarei *et al*. (2012). As far as negative direct effects are concerned İlker (2011) and Srećkov *et al*. (2010) supported our results while some contradictory findings were also reported by Bello *et al*. (2010) and Pavan *et al*. (2011). The negative direct effect of plant height was more than compensated by its indirect effects hence resulting in positive correlation with grain yield per plant, suggesting that grain yield can be improved through plant height indirectly. Kump and Vasily (1978) supported our findings of negative direct effect of grain to pith ratio on grain yield per plant. Most of the indirect effects of grain to pith ratio was also negative, hence proving that the grain to pith ratio is not a desirable trait for the improvement in the grain yield per plant. Similar was the case of number of leaver per plant where it's direct and most of the indirect effects were negative. Saidaiah *et al*. (2008) did not support with our results for number of leaves per plant.

While concluding it can be said that those parameters that positive correlation and positive direct effect on grain yield per plant that includes number of kernel rows per ear, 100-grain weight, flag leaf area, number of kernel rows per ear and ear diameter; could be selection and breeding criteria to bring out improvements in maize hybrids and hence improving the grain yield per plant.

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