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Pakistan Journal of Biological Sciences, 2 (4): 1419-1422, 1999 **Research Article**

Correlation and Path-coefficient Analysis in Diallel Crosses for Yield Components of Maize (*Zea mays* L.)

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bstract

he diallel analysis of variance indicated highly significant differences among the genotypes for all the characters except umber of ears per plant. The correlation studies on seven characters of 4 parents and 6 hybrids revealed highly significant enotypic positive association between yield and yield components, whereas the phenotypic association of yield omponents with yield was positive and significant except number of ears per plant, where it was positive but nongnificant. Among the characters studied, the number of rows per ear reflected the highest direct contribution of 0.636 nd indirect average contribution of 0.605 towards grain yield. Number of ears per plant and number of rows per ear pressed the highest positive coefficient of correlation of 1.409 and 1.018 with grain yield, respectively.

ntroduction

eld is a complex entity and is poly genically controlled ultiplicative end product of many factors called yield mponents. For effective selection, information on nature d magnitude of variation in the population, association of aracters with yield and among themselves and the extent environmental influence on the expression of these aracters is necessary. Correlation studies supply reliable d useful information on the nature, extent and direction selection. With the inclusion of more variables in the rrelation studies, indirect effects become complex and portant (Nandan and Pandya, 1980). In such situation, th-coefficient analysis may be an important tool to bring ut the appropriate cause and effect relationship. In order select inbred lines of maize with high yielding entiality, a plant breeder and an agronomist have to deal th hundreds of crosses before they are lucky enough to kup desired lines for better combinations. Keeping in w the resources at his command, a plant breeder is ays forced to look for such techniques as may help him electing the desired parental lines for crossing purpose screening his material in early generations. The diallel ss techniques developed by Hayman (1954) provided rmation on genetic variation of parental lines in cross nbinations right in F_1 generation. Well equipped with this rmation a breeder can safely reduce his breeding terial without affecting the efficiency.

terials and Methods

material consisted of 4 inbred lines of maize, viz., N-I (P_1), USSR-3135 (P_2), A-637 (P_3) and ASE-204 (P_4), duced from University of Agriculture, Faisalabad. These types were inter crossed in all possible combinations uding reciprocals to obtain a diallel set at Agriculture , Chilas, Diamer district, Northern Areas, Pakistan g summer, 1988. Six hybrids alongwith their parents planted in a randomized complete block design with lications. A plot accommodating 4 rows of F_1 and ts each having 10 plants per row, spaced 25 cm apart 60 cm spacing between the rows were used. Data recorded on 10 guarded plants randomly from each or plant height (PH), ear height (EH), number of ears ant (E/P), number of rows per ear (R/E) and number of grains per rows (G/R). Three samples of 100 grains from each plot were taken for 100-grain weight (GW). Total grain weight from a net plot of 4.80 m^2 by harvesting two central rows for calculation of grain yield (mt/ha) was recorded. Normal local recommended cultural practices for maize crop were adapted to maintained the crop throughout the growing season. The data on F_1 hybrids and parental lines were analysed according to the method suggested by Steel and Torrie (1960) and individual comparisons of genotypic means were accomplished by using Duncan's New multiple range test at 5 percent level of significance. The methods described by Johnson *et.al.,* (1955) and Dewey and Lu (1959) were followed to calculate phenotypic and genotypic correlation coefficients and path-coefficient, respectively. Path-diagram was obtained by using formulae given below:

1. $ray = ray + rab\,pby + rac\,pcy + rad\,pdy + rae\,pey + raf\,pfy,$
2. $rby = rab\,pay + pby + rbc\,pcy + rbd\,pdy + rbe\,pey + rbf\,pfy,$
3. $rcy = rac\,pay + rbc\,pby + pcy + rcd\,pdy + rce\,pey + ref\,pfy,$
4. $rdy = rad\,pay + rbd\,pby + rcd\,pcy + pdy + rde\,pey + rdf\,pfy,$
5. $rey = rae + rbe\,pby + rce\,pcy + rde\,pey + rae\,pey + ref\,pfy,$
6. $rfy = raf\,pay + rbf\,pby + rcf\,pcy + rdf\,pdy + ref\,pef + pfy,$

Where r is genotypic correlation coefficient and pay, pby, pcy, pdy, pey and pfy are standard partial regression coefficients. Heritability in broad sense was estimated from the result of variance analysis according to the formula used by Burton and DeVane (1953).

Results and Discussion

The analysis of variance for grain yield and its components presented in Table 1, revealed highly significant mean squares due to treatments indicating the presence of wide genetic differences among the genotypes for all characters except number of ears per plant. Highly significant genotypic differences advocated further genetic analysis of data to find out character associations, partitioning of variance and covariance into its components. The data on mean performance of genotypes mentioned in Table 2 indicated that mean values for plant height, ear height, number of ears per plant, number of grain rows per ear,

Table 1: Analysis of variance, covariance, heritability and coefficient of genotypic variability

Source of variance	DF	PH	EH	EP	RE	GR	100-GW	Yie
		Mean squares for seven different traits in maize						
Replications	2	0.044	0.001	0.056	1.552	17.450	0.063	0.0
Genotypes	9	0.096	0.034	0.061	3.428	45.424	28.136	30.8
Error	18	0.013	0.006	0.045	0.614	5.924	2.084	0.4
F. ratio (R)		3.533*	0.105^{ns}	1.259^{ns}	2.528^{ns}	2.946^{ns}	0.030^{ns}	0.0
F. ratio (G)		7.623**	6.086**	1.373^{ns}	5.584**	7.668**	13.503**	71.9
St. error		0.066	0.045	0.122	0.452	1.405	0.833	0.3
G. variance		0.028	0.009	0.006	0.938	13.166	8.684	10.1
Ph. variance		0.040	0.015	0.050	1.552	19.091	10.768	10.5
G. covariance		8.493	11.626	6.625	6.676	13.474	13.914	70.1
Ph. covariance	11	10.237	14.659	19.622	8.587	16.224	15.494	71.6
Heritability (%)		68.290	60.000	10.000	60.490	68.970	80.650	95.9
Coe. genotypic variability (%)		5.820	9.410	18.860	5.400	9.040	6.820	14.4

ns = Non-significant , * = Significant at 5% level and ** = Significant at 1% level

Table 2: Mean values for 4 maize inbred lines and 6 single crosses for yield and yield components in 4 x 4 diallel cross maize

Genotypes USSR-3135 x A-637	PH	EH	E/P	R/E	G/R	100-GW	Yield
	Mean values for seven different traits in maize						
$P_2 \times P_3$	2.00 abc	0.92 b	1.25 ns	16.13 a	27.00 bcde	24.22 a	8.000
$P_2 \times P_4$	2.01 abc	0.87 ab	1.42 ns	15.44 ab	33.97 a	23.89 a	7.467
$P_1 \times P_2$	2.06 abc	0.83 ab	1.17 ns	15.50 ab	30.47 abc	24.33 a	7.127
$P_1 \times P_4$	2.12 a	1.03 a	1.08 ns	14.63 abcd	31.07 ab	20.22 b	6.880
$P_1 \times P_3$	2.22 a	0.82 b	1.08 ns	15.13 abc	26.23 cde	21.00 b	6.853
$P_3 \times P_4$	2.08 ab	0.92 b	1.25 ns	14.30 bcd	27.43 bcd	25.34 a	5.507
USSR 3135 (P_2)	1.72 dc	0.74 b	1.00 ns	13.80 cde	23.22 de	16.56 c	1.071
IMAN-1 (P_1)	1.86 bcd	0.69 b	1.00 ns	14.17 bcde	22.49 e	18.67 c	1.023
A-637 (P_3)	1.84cde	0.80 b	1.00 ns	12.80 e	24.72 de	18.33 c	0.767
ASE-204 (P_4)	1.67 e	0.71 b	1.00 ns	13.17 de	22.70 de	19.22 bc	0.673

Genotype are arranged according to descending order of their merit in grain yield

Table 3: Phenotypic (P), genotypic (G) and environmental (E) correlation coefficients among various pairs of 7 variables in 4 x 4 diallel cross of maize.

Variables		PH	EH	E/P	R/E	G/R	100-GWt.	Yield
PH	P		0.517^{ns}	0.217^{ns}	0.561^{ns}	0.567^{ns}	0.576^{ns}	0.706*
	G		0.831**	1.158**	0.769**	0.706*	0.678*	0.942**
	E		-0.086^{ns}	-0.194^{ns}	0.187^{ns}	0.259^{ns}	0.288^{ns}	-0.525^{ns}
EH	P			0.414^{ns}	0.323^{ns}	0.465^{ns}	0.451^{ns}	0.695**
	G			0.925*	0.648*	0.929**	0.643*	0.819**
	E			0.295^{ns}	-0.200^{ns}	-0.433^{ns}	0.036^{ns}	0.473^{ns}
E/P	P				0.248^{ns}	0.352^{ns}	0.551^{ns}	0.523^{ns}
	G				1.766**	1.798**	1.629**	1.409**
	E				-0.353^{ns}	-0.245^{ns}	0.152^{ns}	0.335^{ns}
R/E	P				0.526^{ns}	0.533^{ns}	0.734^{ns}	
	G				0.721*	0.852**	1.018^{ns}	
	E				0.172^{ns}	-0.223^{ns}	-0.326^{ns}	
G/R	P					0.516^{ns}	0.704^{ns}	
	G					0.770**	0.890^{ns}	
	E					-0.238^{ns}	-0.177^{ns}	
100-Gwt.	P						0.736^{ns}	
	G						0.845**	
	E						-0.081^{ns}	

* Significant at 5% level and ** Significant at 1% level

number of grains per row, 100 grain weight and total grain yield ranged from 1.67 to 2.22 m, 0.69 to 1.03 m, 1 to 1.42 ears, 12.80 to 16.13 rows, 22.49 to 33.97 grains, 16.56 to 25.34 grams and 0.673 to 8 mt ha $^{-1}$, respectively. The data revealed a tremendous scope for improvement in grain yield over the average yield of 1.8 and 1.00 mt ha $^{-1}$ in Northern Area and Pakistan, respectiv The number of ears per plant expressed the low heritability of 10 percent whereas it was the highest (95 percent) for grain yield. Number of rows per ear, numbe grains per row and 100-grain weight are important y components as these showed high heritability of 60.

able 4. Path-coefficient and co-relation efficient analysis of grain yield vs different agronomic traits studied in maize genotypes.

athway of association	Direct effect (p)	Indirect effect (p x r)	Cor. coefficient with yield (r)
lant height vs grain yield			
irect effect of PH on yield	0.317		
direct effect via EH	-	0.149	
" " E/P	-	0.139	
" " R/E	-	0.489	
" " G/R	-	-0.005	
" " 100-Gwt.	-	0.147	
Total	-	-	0.942**
ar height vs grain yield			
irect effect of EH on yield	0.179		
direct effect via PH	-	0.263	
" " E/P	-	0.111	
" " R/E	-	0.412	
" " G/R	-	-0.007	
" " 100-Gwt.	-	-0.140	
Total	-	-	0.819**
umber of Ear/plant vs grain yield			
irect effect of E/P on yield	0.120		
direct effect via PH	-	0.367	
" " EH	-	0.166	
" " R/E	-	1.123	
" " G/R	-	-0.014	
" " 100-Gwt.	-	-0.354	
Total	-	-	1.409**
umber of Rows/ear vs grain yield			
irect effect of R/E on yield	0.636		
direct effect via PH	-	0.244	
" " EH	-	0.116	
" " E/P	-	0.212	
" " G/R	-	-0.006	
" " 100-Gwt.	-	-0.185	
Total	-	-	1.018**
umber of grain/row vs grain yield			
irect effect of G/R on yield	0.008		
direct effect via PH	-	0.224	
" " E/H	-	0.167	
" " E/P	-	0.216	
" " R/E	-	0.458	
" " 100-Gwt.	-	-0.167	
Total	-	-	0.890**
00-grain weight vs grain yield			
irect effect of 100-Gwt. on yield	0.214		
direct effect via PH	-	0.215	
" " EH	-	0.115	
" " E/P	-	0.196	
" " R/E	-	0.542	
" " G/R	-	-0.006	
Total	-	-	0.845*

8.97 and 80.65 percent, respectively. These characters serve more attention in yield component analysis. Plant d ear height also exhibited high heritability of 68.29 and percent, respectively. Hanson *et.al.,* (1956) reported t heritability estimates alongwith genetic advance was re valuable than the former alone in predicting the effect selection. The present results for heritability estimates contrary to the findings of Nawar (1986), who reported t high heritability was associated with additive gene on whereas in the present studies over dominance and tial dominance gene action was observed. Genotypic and notypic correlation coefficients provided a quantitative luation of the effects of environment on particular character. The association of grain yield with other characters was estimated by genotypic, phenotypic and environmental correlation coefficients (Table 3). Grain yield had a highly significant positive genotypic correlations with all the characters studied whereas it had a significant positive phenotypic correlations with all characters except number of ears per plant.

These results are in agreement with those reported by Ahmad *et.al.* (1978 b), Sharma and Kumar (1987) and Verma and Singh (1979), who reported significant positive association between grain yield and yield components. 100-grain weight had also highly significant positive genotypic correlation with number of grains per row, number of rows per ear and number of ears per plant, whereas it had a significant positive genotypic correlation with ear height and plant height, but phenotypically it exhibited non-significant positive correlations with all the characters. Number of grains per row expressed highly significant genotypic positive correlation with ear height and number of ears per plant, while it had significant genotypic positive correlations with plant height and number of rows per ear. The phenotypic correlations between number of grains per row, ear height, plant height, number of ears per plant and number of rows per ear were positive but non-significant. Number of rows per ear also showed highly significant positive genotypic correlations with plant height and number of ears per plant, whereas it expressed significant genotypic correlation with ear height. Number of ears per plant showed highly significant positive genotypic correlations with plant and ear height but phenotypically it was positive and non-significant. Similarly ear height indicated highly significant positive genotypic correlation with plant height. The highest positive correlation of 1.798 was exhibited between number of grains per row and number of ears per plant, whereas the lowest positive genotypic correlation of 0.643 was expressed between 100-grain weight and ear height. Normally the values of correlation coefficient between any pairs of characters should be less than 1, but in some cases deviation from this principle is possible as reported by Ehdaie and Waines (1986) in bread wheat, where they recorded the correlation coefficient values of 1.27 between the traits days to maturity and straw yield, 1.22 between days to maturity and total dry matter and 1.00 between number of grains per head and harvest index. The correlation coefficients highlighted the pattern of association among yield components and growth attributes depicting how yield as a complex character was analysed.

Grain yield had a negative environmental correlation with 100-grain weight,number of grains per row, number of rows per ear and plant height whereas it had positive environmental correlation with ear height and number of ears per plant. 100-grain weight expressed positive environmental correlation with number of rows per ear and number of grains per row. Similarly number of grains per row exhibited negative environmental correlation with ear height and number of ears per plant, but positive correlation with plant height and number of rows per ear. Number of rows per ear indicated positive environmental correlation with plant height and negative correlation with ear height and number of ears per plant. Number of ears per plant was positively associated with ear height and negatively with plant height. Path-coefficient analysis in the end have given a clue to the contribution of various components of yield to over all grain yield in the genotypes under study. It provides an effective way of finding out direct and indirect sources of correlations (Table 4). The direct contribution of number of rows per ear to grain yield was the highest (0.636), followed by plant height (0.317), ear height (0.179), number of ears per plant (0.120), 100-grain weight (0.214) and grains per row (-0.008). Khehra *et.al.* (1975) and Panchanathan *et al.* (1978) also categorized the characters like ear length, grain rows, shelling percentage, 1000 grain weight and ear girth to be the direct contributors of yield. Number of ears per plant had the highest indirect effect (1.123) via number of rows per ear followed by plant height and ear height. Plant height also had an appreciable indirect effect via rows per ear followed by ear height and numb of ears per plant. Ear height had also considerable indire effect via number of rows per ear followed by plant heigh Number of rows per ear and number of grains per row h also considerable indirect effect via plant height and numb of rows per ear, respectively but number of grains per ro and 100 grain weight had the highest indirect contributio of 0.458 and 0.542 via number of rows per ear.

The standard partial regression (pay, pby, pcy, pdy, pey a pfy) indicate the direct effects of individual characters yield keeping other characters constant, while the indire effect of a character through another character was show by the regression and correlation (rab, rac, rad, rae, r etc.,) found along the detour route.

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