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GENOTYPIC VARIATION, COVARIATION AND PATH COEFFICIENT ANALYSIS IN MAIZE

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Variability, heritability, genetic advance, interrelationships and path coefficients were estimated for grain yield and eight other agronomic traits in 21 maize genotypes. The genotypes differed significantly for all traits studied. High genotypic coefficient of variation was exhibited by ear height and 1000-kernel weight. Broad sense heritability was high for days to silk, plant height, ear height and 1000-kernel weight; moderate for ear diameter and number of kernels per row; and low for ear length, kernel rows per ear and grain yield. High genetic advance in percentage of mean was observed in ear height and 1000-kernel weight. Grain yield showed positive and significant genetic correlation with days to silk, plant height, ear height, ear diameter and 1000- kernel weight. Days to silk, plant height, number of kernels per row and 1000-kernel weight had strong positive direct contribution towards grain yield. Thousand kernel weight seemed to be most effective for selection in improving towards high grain yield.

Key words: Maize, Variability, Path analysis.

Introduction

Maize (*Zea mays* L.) is a multipurpose crop which can be grown in Bangladesh to rapidly increase the total production of food and feed for animals from the available area under cultivation.

The grain yield in maize is polygenetically controlled and also influenced by its component characters, direct selection for grain yield is often misleading. Knowledge in genetic variability of yield contributing characters and the inter relationship between grain yield and components and their relative contribution is necessary for the improvement of grain yield. Correlations in combination with path coefficient analysis quantify the direct and indirect influences of one character upon another [1]. Keeping all these in mind, the present study was undertaken with 21 maize genotypes obtained from the Maize Breeding Project, Bangladesh Agricultural University, Mymensingh, Bangladesh to determine the genotypic and phenotypic variability, heritability, genetic advance and coefficients of correlation among different characters. Path coefficient analysis was also conducted to ascertain the direct and indirect contributions of different characters working on grain yield.

Materials and Methods

The investigation was carried out at the Bangladesh Agricultural University Farm, Mymensingh, Bangladesh during Rabi 1987-88. Each genotype was grown in 4m long single rows with a plant-to-plant and row-to-row distances of 25 and 75 cm, respectively. The design followed was randomized complete block with three replications. Ten plants per plot in each replication were selected at random for recording data on nine characters, *viz.*, days to 75% silk emergence, plant height (cm), ear height (cm), ear length (cm), ear diameter (cm), kernel rows per ear, number of kernels per row, 1000-kernel weight (gm) and grain yield per plant (gm).

The phenotypic, genotypic and error variances for nine characters were worked out for calculating phenotypic and genotypic coefficients of variation, heritability and genetic advance following Burton [1], Hanson *et al.* [2] and Johnson *et al.* [3]. The formulae suggested by Miller *et al.*[4] were adopted to estimate phenotypic and genotypic correlation coefficients. The genotypic correlation coefficients of grain yield along with other characters studied were partitioned into their direct and indirect effects through path coefficient analysis involving nine-variable model as suggested by Dewey and Lu [5]. The matrix procedure of the Statistical Analysis System [6] was used to solve the simultaneous equations involving in the calculation of path coefficients. A generalized path diagram for grain yield is given in Fig. 1. The dependent variable (grain yield) is designated trait number 9. Traits 1 through 8 for the model are also identified in the figure.

In the diagram, the r_{ij}'s represent correlation coefficients between $_i$th and $_j$th traits, and the P_{i9}'s represent direct effect of the $_i$th trait on trait number 9. The 'X' variable represents all residual factors affecting trait 9 which are not accounted for by the variables used in the model. The indirect effect of one variable upon another is measured by the appropriate $r_{ij}P_{i9}$ component.

Results and Discussion

Significant differences were observed among the genotypes for all traits studied. The estimates of genetic parameters for different characters are presented in Table 1. A marked difference between the phenotypic and genotypic coefficients of variation for ear length, ear diameter, kernel rows per ear, number of kernels per row, and grain yield indicated considerable influence of environment upon the expression of these characters. Days to silk was, however, least affected by the environment followed by 1000- kernel weight, ear height and plant height. The highest phenotypic and genotypic coefficients of variation existed for ear height and it was closely followed by 1000-kernel weight. Grain yield also showed high phenotypic coefficient of variation. Moderate phenotypic coefficient of variability was shown by plant height, ear length and ear diameter. This value was, however, low for days to silk, kernel rows per ear and number of kernels per row. The genotypic coefficient of variation was moderate for grain yield and low for days to silk, plant height, ear length, ear diameter, kernel rows per ear and number of kernels per row.

The heritability estimate, calculated in the broad sense, was the highest for days to silk (96.05%), followed by 1000-kernel weight (76.45%), ear height (74,61%) and plant height

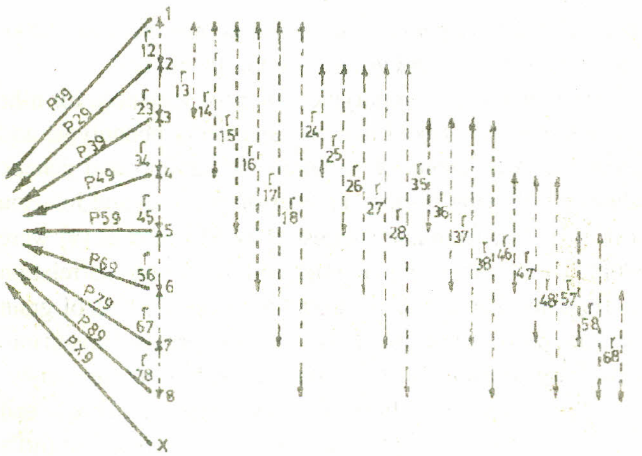

Fig. 1. Path diagram showing causal relationship of (1), Days to silk; (2), Plant height; (3), Ear height; (4), Ear length; (5), Ear diameter; (6), Kernel rows per ear; (7), Number of kernels per row; (8), 1000-Kernel weight and (9), Grain yield; and X represents residual factors.

(71.15%). Similar results were also obtained by Malhotra and Khehra [7] and Ron and Ordas [8]. Ear diameter and number of kernels per row showed moderate heritability estimates. The heritability values were low for ear length, kernel rows per ear and grain yield confirming the findings of Bohm and Schuster [9] and Shahi *et al.* [10] for grain yield. As many other crops, grain yield in maize is also subjected to high degree of non-genetic influence and consequently results in low heritability estimate. But the heritability alone does not count much in finding the effectiveness of the characters in breeding, for as pointed out by Johnson *et al.* [4], high heritability accompanied by similar genetic gain could be used as a reliable criterion for predicting the effect of selection.

The expected genetic advance, expressed as percentage of mean, was found to be highest in case of 1000-kernel weight closely followed by ear height. Moderate genetic gain was expected for days to silk, plant height, ear diameter and grain yield. Low genetic advance was expected for rest of the characters studied.

In the present study, high heritability was associated with high genetic advance in case of 1000 kernel weight followed by plant height and ear height. This is an indication of variation being due to high degree of additive effects [11]. Predominant role of additive genetic variance in the inheritance of ear height and kernel weight in maize was also reported by Nawar *et al.* [12] and Murthy [13], respectively. It appears likely, therefore, that individual plant selection for ear height and 1000-kernel weight should be effective.

The phenotypic and genotypic correlations among various characters are presented in Table 2. The genotypic correlation coefficients were, in general, higher in magnitude than the corresponding phenotypic correlation coefficients for most of the cases. This indicated that the association among these traits was genetically inherited. Grain yield was positively and

TABLE 1. ESTIMATES OF GENETIC PARAMETERS FOR DIFFERENT CHARACTERS IN MAIZE.

Character	Range	Mean± SE.	Variance		Co-efficients of variation		Broad sense heritability (%)	Genetic advance	Genetic advance in % of mean
			Phenotypic	Genotypic	Phenotypic	Genotypic			
Days to silk	79.00 - 110.00	98.33 ± 0.77	45.22	43.44	6.84	6.70	96.05	13.31	13.53
Plant height(cm)	145.88 - 215.62	189.11 ± 6.24	404.31	287.65	10.63	8.97	71.15	29.47	15.58
Ear height (cm)	30.50 - 80.74	61.57 ± 3.51	145.95	108.90	19.62	16.95	74.61	18.57	30.16
Ear length(cm)	10.00 - 21.40	14.80 ± 0.92	3.40	0.89	12.45	6.36	26.05	0.99	6.68
Ear diameter(cm)	3.04 - 4.80	3.96 ± 0.64	0.21	0.12	11.55	8.89	59.31	0.56	14.11
Kernel rows/ear	9.81 - 17.42	13.11 ± 0.43	1.00	0.46	7.64	5.14	45.36	0.94	7.14
No. of kernels/row	20.92 - 34.05	28.37 ± 0.84	5.75	3.62	8.45	6.70	62.93	3.11	10.95
1000-kernel wt. (g)	158.25 - 340.30	253.54 ± 13.71	2392.66	1829.08	19.29	16.87	76.45	77.03	30.38
Grain yield/plant (g)	74.60 - 140.60	114.85 ± 9.02	400.98	156.74	17.43	10.90	39.09	16.12	14.04

significantly associated with days to silk, plant height, ear height, ear diameter and 1000-kernel weight at genotypic level, and with plant height, ear diameter and 1000-kernel weight at phenotypic level. Tyagi *et al.* [14] also reported positive association of grain yield with days to silk, plant height and 1000-kernel weight. Plant height was significantly and positively associated both at genotypic and phenotypic levels with days to silk, ear height, ear length and ear diameter. Ear length showed significant and positive correlation with ear height at genotypic level; and with number of kernels per row at phenotypic and genotypic levels. The phenotypic and genotypic correlations between ear diameter and 1000-kernel weight were also significant and positive. Other remaining associations were non-significant both at phenotypic and genotypic levels.

Path coefficient analysis (Table 3) revealed that days to silk had high positive direct contribution on grain yield, confirming the findings of Paramathma and Balasubramanian [15]. This trait had also high indirect effect via plant height, which caused the significantly positive correlation between days to silk and grain yield. Plant height had the maximum direct positive effect on grain yield. Similar results were also obtained by Verma and Singh [16]. Its indirect effects through days to silk and 1000-kernel weight were consider-

TABLE 2. PHENOTYPIC (r_p) AND GENOTYPIC (r_g) CORRELATION CO-EFFICIENTS BETWEEN PAIRS OF CHARACTERS IN MAIZE.

Characters	Correlation co-efficients	Plant height	Ear height	Ear length	Ear diameter	Kernel rows/ear	Number of kernels/row	1000-kernel weight	Grain yield/ plant
Days to silk	r_p	0.526*	0.355	0.173	0.200	0.088	-0.091	0.165	0.414
	r_g	0.659**	0.433	0.391	0.296	0.182	-0.123	0.194	0.645**
Plant height	r_p		0.782**	0.468*	0.460*	0.173	-0.020	0.256	0.459*
	r_g		0.807**	0.568**	0.461*	0.168	-0.170	0.342	0.705**
Ear height	r_p			0.425	0.364	0.203	0.182	0.179	0.413
	r_g			0.527*	0.302	0.275	0.094	0.284	0.604**
Ear length	r_p				0.271	0.108	0.459*	-0.064	0.224
	r_g				0.113	0.003	0.637**	-0.131	0.233
Ear diameter	r_p					0.300	0.131	0.519*	0.477*
	r_g					0.267	0.083	0.748**	0.805**
Kernel rows/ear	r_p						-0.060	0.160	0.116
	r_g						-0.038	0.269	0.312
No. of kernels/row	r_p							-0.023	0.56
	r_g							0.061	-0.020
1000-Kernel weight	r_p								0.546*
	r_g								0.858**

*, ** Significant at 5% and 1% levels, respectively.

TABLE 3. PATH ANALYSIS BASED ON GENOTYPIC CORRELATION CO-EFFICIENTS FOR COMPONENTS OF GRAIN YIELD PER PLANT IN MAIZE.

Characters	Days to silk	Plant height	Ear height	Ear length	Ear diameter	Kernel rows/ear	Number of kernels/ row	1000-Kernel weight	Genotypic correlation coefficient
Days to silk	0.367	0.444	0.009	- 0.229	0.049	0.003	-0.059	0.061	0.645**
Plant height	0.242	0.674	0.017	- 0.333	0.076	0.003	-0.081	0.108	0.705**
Ear height	0.159	0.544	0.021	- 0.309	0.050	0.005	0.045	0.090	0.604**
Ear length	0.143	0.383	0.011	- 0.587	0.019	0.001	0.305	-0.041	0.233
Ear diameter	0.109	0.311	0.006	- 0.066	0.165	0.005	0.040	0.237	0.805**
Kernel rows/ear	0.067	0.113	0.006	- 0.002	0.044	0.017	-0.018	0.085	0.312
No. of kernels/row	- 0.045	- 0.115	0.002	- 0.374	0.014	-0.001	0.479	0.019	-0.020
1000-Kernel weight	0.071	0.230	0.006	0.077	0.122	0.005	0.029	0.317	0.858**

Residual effect = 0.026, Significant at 1% level of probability. Underlined figures indicate direct effects.

able and positive. Plant height, however, showed considerable negative indirect contribution via ear length. Although ear height had significant positive association with grain yield, its direct effect on grain yield was negligible. But it contributed significantly towards grain yield via plant height. As was for plant height, its contribution via ear length was also considerable and negative. The negative direct effect of ear length was counterbalanced with the indirect positive effects via days to silk, plant height and number of kernels per row, showing non-significant association with grain yield. The direct effect of ear diameter on grain yield was comparatively low but considerable. It was correlated with grain yield by its indirect effects via days to silk, plant height and 1000-kernel weight. Kernel rows per ear exhibited very low direct contribution to grain yield. Although number of kernels per row had a high positive direct effect, but its indirect effects via plant height and ear length were negative and considerable, which minimized the correlation coefficient between number of kernels per row and grain yield to be non-significant. Thou-sand kernel weight had positive direct effect on grain yield as well as considerable positive indirect effects through plant height and ear diameter.

Results from the present study indicated that days to silk, plant height, ear height, ear diameter and 1000-kernel weight were genetically correlated with grain yield. Out of these traits, days to silk, plant height and 1000-kernel weight possessed high and positive direct contribution on grain yield. Thousand kernel weight had also high heritability estimate accompanied by high genetic advance in percentage of mean. Selection for 1000-kernel weight might, therefore, be most effective for improvement towards the yield potential of maize.

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