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GENOTYPIC AND PHENOTYPIC VARIANCE AND CORRELATIONS IN S_5 LINES OF A PEARL MILLET POPULATION *(Pennisetum americanum* (L.) Lcckc)

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ABSTRACT

There were 78 S_5 lines of a nutlet population evaluated in two locations for two years in 1998 and 1992 using a simple 9x9 lattice design because of the great number of genotypes involved. Mean performance over the two locations were similar for some traits, hut different for certain others. Analysis of variances pooled over the years and locations indicated that genotypic mean square estimates were significant at 1% level of probability for plant height, car length, ear weight and threshing percentage, and at 5% level for grain yield per ear, days to 50% heading and days to 50%, blooming. Over the locations, the estimates were significant at 1% level for noding and threshing percentage. Both negative and positive correlation coefficients were observed and for a larger number of the associations in the population, the genotypic correlation coefficients were slightly higher than the phenotypic. The highest correlation coefficient was obtained between the ear weight and threshing percentage. The tallest plants were also positively correlated with plant noding (rg 0.910). Based on the correlation coefficient obtained in this study, plant nodding and ear characters would be best selection indices for obtaining a high yielding millet population. The closeness between phenotypic and correlation coefficient will render efficient any selection based on the phenotype,

Keywords: Pearl millet, genotypic, phenotypic variances, correlations

INTRODUCTION

The choice of a population and breeding system to use in initiating an improvement programme will depend on the mean performance of the population and on the magnitude and quantity of genetic variation present (Eckebil *et al.*, 1977). This is because the presence of genetic variability in the base population is an essential requirement for achieving success in the selection programme (Singh, 1970). Since the breeder is concerned with selecting superior genotypes, but of necessity must choose individuals from their phenotypic expressions, estimates of the genotypic and phenotypic variances for various characters are needed.

Most of the characters of economic importance, such as yield, are complex in inheritance and may involve several related characters; hence, the degree of genotypic and phenotypic correlation of characters is important (Robinson *et al.*, 1951). To obtain these correlations it is necessary to have estimates of the genotypic and phenotypic covariance in addition to the variances for the various characters. These correlations are not only of interest from a theoretical consideration of the quantitative inheritance of the characters, but of practical value since selection is usually concerned with changing two or more traits simultaneously. Improvement in one trait as a result of selection for another depends not only upon the genotypic and phenotypic correlations between the two traits, but also upon the genotypic and phenotypic variances associated with them (Shivaji and Gritton, 1975). Sodani *et al.* (1981) reported large variations in some varieties of pearl millet for growth period, plant height, grain yield and four yield components, and Nwasike (1988) reported variations in the spike while Diz and Schank (1985), in millet hybrids, observed large phenotypic variations for a number of agronomic characters. Positive correlations between plant height and grain yield and correlations among seed-yield related characters have been reported by Rai (1990), Mangat and Satiya (1991), and Diz and Schank (1995).

This study is set out to estimate the genotypic and phenotypic variances and to estimate the amount of correlations among certain agronomic characters.

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MATERIALS AND METHODS

The material for this study is a synthetic pearl millet population consisting of 78 S_5 lines. This was planted in two locations; Institute for Agricultural Research (IAR) farm in Samaru - Zaria (11°11'N; 07°38'E and 686m above sea level) and in Minjibir (IAR research farm in Kano, 12°11'N; 08°40'E, 500m above sea level). The design was a simple 9 x 9 lattice design replicated twice with dummies used to give a balanced lattice. All cultural practices were according to recommendations (Egharevba, 1983).

Data were taken on three randomly chosen plants on each family line; these were plant height, number of nodes per plant, days to ear emergence, days to 50% heading, ear length, ear girth, ear weight and grain yield per plant. Means were calculated from the data, and the data, pooled over the years and locations were used to calculate the estimates of variance components. The general outline followed in the estimation of the variance components and covariance is given in Table 1. Variance components were estimated by equating the observed mean squares to their expectations.

Correlation coefficients were estimated from components of variance and covariance; according to Shivaji and Gritton (1975). Thus, the genotypic, phenotypic and environmental correlations were calculated using the following formulae;

$$\textit{Genotypic correlation: } rg = \frac{COV_{g1.2}}{\sqrt{(\delta^2{}_{g1})(\delta^2{}_{g2})}}$$

$$\textit{Phenotypic correlation: } rp = \frac{COV_{ph\delta 1.2}}{\sqrt{(\delta_{ph1}{}^2)(\delta^2{}_{ph2})}}$$

$$\textit{Environmental correlation: } re = \frac{COV_{e\delta 1.2}}{\sqrt{(\delta^2{}_{e1})(\delta^2{}_{e2})}}$$

Where rg, rph and re are genotypic, phenotypic and environmental (error) correlation coefficients, respectively.

$Cov_{g1,2}$, $Cov_{ph1,2}$, $Cov_{e1,2}$, are the estimates of genotypic, phenotypic and environmental covariances for traits 1 and 2, respectively.

$\delta^2{}_{g1}$, $\delta^2{}_{ph1}$, $\delta^2{}_{e1\ 2}$ are the estimates of genotypic, phenotypic and error variances for trait 1, respectively.

RESULTS AND DISCUSSION

The mean performance in each of the two separate years and locations are presented in Table 2. The mean performances in the first and second year followed the same trend; plants were significantly taller with greater number of nodes in Kano than in Zaria. Plants in this former location also headed at a much later date. The situation was reversed over the locations for threshing percentage and days to 50% heading in the years.

The estimates of the mean squares from the combined data analysis for years and locations are presented in Table 3. Variance component for year was significant for plant height and highly significant for ear girth and days to 50% heading. Over the locations, the mean square estimates were either significant or highly significant, but for virtually all the grain yield components, the estimates were not significant. Estimates due to the year x location interaction were highly significant for ear length and days to 50% heading and significant at 5% level of probability for plant highly only. Genotypic mean square estimates were significant at 1% level of probability for plant height, ear length, ear weight and threshing percentage, and at 5% level for grain yield per ear, days to 50% heading and days to 50% blooming. Over the locations, the estimates were significant at 1% level for plant height, ear length and days to 50% blooming, and at 5% level for noding and threshing percentage.

Significant negative genotypic correlation coefficients were observed in the population between plant height and ear weight (rg = -0.262) and between ear length and threshing percentage (rg = -0.247) (Table 4). The other negative genotypic correlation coefficients observed were not significant. Perfect correlation coefficient was

Table 1: Form of ANOVA and ANCOVA with EMS and EMCP for two years and two locations

Source of variance	df	MS	Expected mean square (EMS)	Expected mean cross product
Years	y - 1			
Locations	l - 1			
Replication in years and location	y(r-1)			
Genotypes	g-1	M_5	$\delta^2_e + r\,\delta^2_{gly} + ry\,\delta^2_{gl} + rl\,\delta^2_{gy} + rly\,\delta^2_g$	$COV_e + rCOV_{gly} + ryCOV_{gl} + rl\,COV_{gy} + rly\,COV_g$
Years x locations	(y-1)(l-1)	M_4	$\delta^2_e + r\delta^2_{gly} + ry\delta^2_{gl} + r\delta^2_{gy}$	$COV_e + rCOV_{gly} + ryCOV_{gl}$
Genotypes x years	(g-1)(y-1)	M_3	$\delta^2_e + r\delta^2_{gly} + rl\delta^2_{gy}$	$COV_e + rCOV_{gly} + rlCOV_{gy}$
Genotypes x years x locations	(g-1)(y-1)(l-1)	M_2	$\delta^2_e + r\delta_g^2\,ly$	$COV_e + rCOV_{gly}$
Error	r(g-1)(y-1)(l-1)	M_1	δ^2_e	COV_e

Where:
δ^2_e = Variance component due to genetic difference among lines.
δ^2_{gl} = Variance component arising from interaction of lines and locations.
δ^2_{gy} = Variance component arising from interaction of lines and years.
δ^2_{gly} = Variance component arising from interaction of lines, locations and years.
δ^2_e = Variance component arising from a composite of remaining effects including plot effects, errors due to sampling within plots and error of measurements
r = number of replications.
l = number of locations.
y = number of years.
g = number of lines.

Table 2: Mean performance in two years (1998 and 1999) for nine agronomic Traits in a population of S_5 pearl millet

Plant Population	Agronomic traits								
	Plant height (cm)	No. of nodes per plant	Ear length (cm)	Ear girth (*mm*)	Ear weight (*gm*)	Grain yield *ear (g)*	Threshing *percentage*	Days to 50 *heading*	Days to 50% *blooming*
Year 1 (1998)									
Samaru	136.978b	6.160b	42.626a	24.989a	61.760a	36.173a	54.845b	44.551b	57.942a
Minjibir (Kano)	221.951a	6.688a	31.448b	24.812a	45.624b	25.893b	57.363a	49.064a	53.801b
Year 2 (1999)									
Samaru	159.444b	6.039b	40.397a	22.810b	69.384a	47.756a	58.024a	49.205a	59.756a
Minjibir (Kano)	206.560a	6.666a	34.802b	25.252a	49.538b	27.996b	54.731b	48.096b	50.532b

Means with the same letter are not significantly different from each other at 5% level of probability (Duncan's Multiple Range Test) obtained between the ear weight and threshing percentage and between plant noding and threshing percentage. The tallest plants in this population were associated with the highest plant noding (rg = 0.905). Other significant and positive genotypic correlation coefficients were observed between plant height and grain yield per ear, plant height and threshing percentage, plant noding and ear girth, plant noding and grain yield per ear and also ear characters and grain yield per ear were positively associated among themselves. The correlation coefficients for these associations variously ranged from rg = 0.230 to rg = 0.910.

If the years are considered as random samples from the years millet will normally be grown, the mean performance of some characters of the millet population was higher in Kano than Zaria since more mean values were consistently significantly higher in Kano. On a closer look however, direct yield components such as ear length, ear girth ear weight and grain yield were consistently higher in Zaria. The taller plants in Kano did not translate into higher yielding millet plants.

As a general observation, genotypic variance for this population was low, comparatively; plant height had the greatest genotypic variance. This is however of little economic importance to a breeder who intends to breed shorter and higher yielding cereals. Since genetic variation is small in the population, further improvement of the population is practicable only via hybridization with inbred lines or any other breeding procedure that will generate maximum genetic variabilities to afford opportunities for a meaningful selection as suggested by Habgood (1983).

Interactions containing genotype x year terms are particularly interesting to applied plant breeders. This is because they reflect fluctuations in environments which for the most part cannot be predicted in advance (Allard and Bradshaw, 1964). For the population, genotype x year was not significant. This picture indicates that testing of the genotype x location interaction; variance indicates an adequate buffering capacity in the genotype for the two environments. This is also to be expected because of lack of inherent genetic variation in the population (Erickson *et al.*, 1982).

For a larger number of associations in the population, the genotypic correlation coefficients were slightly higher than phenotypic correlation coefficients. Gupta and Dhillon (1974) also obtained in pearl millet generally higher genotypic correlation coefficients. Diz and Schank (1995) on the other hand, obtained genotypic and phenotypic correlation coefficients which in some cases differed in magnitude and sign, and in other cases did not differ and had the same sign. Higher genotypic than phenotypic correlation coefficients indicated that there are strong inherent relationships between those characters. The internode number was positively and significantly correlated with many of the plant characters. Theoretically, it means plant noding could be used as a selection index. Kamala *et al.* (1986) had reported in pearl millet significant and positive correlation between grain yield and internode number. The negative genotypic correlation coefficients observed between nodes and ear weight deserves no serious attention since they were not significant. However, the negative coefficients between plant height and ear weight and between ear length and threshing percentage were significant. This implies that in this population, the longer the ears on the plant the more loose the grains were on the ear, and that as plants became increasingly taller, the weight of the ear became smaller. This latter condition related to the loose ears, which obviously would weigh less than the compact ears. The practical implication of this negative association is that simultaneous improvement of these two characters may not be possible (Sidwell, 1975). Sandhu *et al.* (1974) similarly observed negative association between primary tillers and length of ear and circumstance of the ear.

The correlations obtained in this study indicated that apart from plant noding, ear characters would be best selection indices for obtaining a high yielding millet population. And because of the closeness between magnitudes of the phenotypic and genotypic correlation coefficients for these characters, any selection based on their phenotypes will be very effective.

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Table 3: Mean square estimates for the combined analyses of Nine characters in S_5 of P370 pearl millet population

Plant Population	Sources of Variation								
	Replication	Year	Location	Yr. Loc	Genotypes	Genotype x year	Genotype x location	Genotype x year x location	Error
	df 1	1	1	1	77	77	77	77	1556
Plant height	3470.80	5877.40**	2043825**	167639.5*	1342.44**	840.30	634.28	785.09	387.365
Nodes per plant	21.580	2.398	155.93*	1.08	1.58	1.16	10.04	1.14	0.953
Ear length	986.56**	0.06	26845.04**	5673.65**	174.67*	83.05	118.26	120.28	58.213
Ear girth	990.94	300.48**	551.42	748.85	41.96	18.59	29.05	21.11	15.174
Ear weight	15286.10	102.9	64641.3	8732.1	828.45**	131.82	500.68	489.53	306.179
Grain yield per ear	3730.16	519.58	26129.24	1815.65	245.67*	12.33	211.22	172.99	92.985
Threshing percentage	203.27	7.66	2701.71*	237.21	30.38**	12.36	21.65*	10.98	9.276
Days to 50% heading	59.69	497.19**	483.01**	1182.50**	17.79*	12.33	11.74	10.99	12.94
Days to 50% blooming	233.56	68.01	6893.39	1005.23	27.35*	21.83	18.44	14.85	19.85

* Significant at 5%
** Significant at 1%

Table 4: Genotype, phenotypic and environment correlation coefficients among seven agronomic characters in a population of S_5 pearl millet

	Number of nodes per plant	Ear length	Ear girth	Ear weight	Grain yield per ear	Threshing percentage
Plant height	0.905** 0.778** 0.778**	0.171ns 0.034na 0.026ns	0.108ns o.145** 0.168**	-0.262* 0.120** 0.010ns	0.230* 0.025ns 0.005ns	0.259* 0.105* 0.097*
Number of nodes/plant		0.060ns 0.039ns -0.038ns	0.309** 0.102** 0.093*	-0.119ns 0.051ns 0.053ns	0.365** 0.039ns 0.021ns	1.000** 0.176** 0.140**
Ear length			0.018ns 0.026ns 0.031ns	0.519** 0.168** 0.161**	0.910** 0.837** 0.030**	-0.247** 0.0017ns 0.031ns
Ear girth				0.085ns 0.005ns 0.291**	-0.080ns 0.023ns 0.053ns	0.286** 0.524** 0.524**
Ear weight					0.524** 0.528** 0.587*	1/000** 0.822** 0.784
Grain yield/ear						0.528** 0.322** 0.305**

First, Second and Third figure in each column indicate the genotypic, phenotypic and environmental correlation coefficient, respectively.
* = Significant at 5%
** = highly significant at 1%
ns = not significant

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