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Full Length Research Paper

Studies on character association and path analysis of certain quantitative characters among parental lines of pearl millet (*Pennisetum glaucum*) and their f_1 hybrids in a diallel cross

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A two- year study was conducted during the cropping season of 2004 and 2005 at Maiduguri (11⁰ 53ˡ N, 13⁰ 16ˡ E) and at Yola (9⁰ 8ˡ N, 12⁰ 29ˡ E), Nigeria. The study was conducted to determine the correlation and path coefficients among the yield and yield component characters in 10 parental lines and 45 hybrids of pearl millet (*Pennisetum glaucum* L. R. Br), formulated by a diallel cross excluding recipro-cals. Strong and significant genotypic and phenotypic correlations were observed between total grain yield with yield/plant, number of tillers/plant, number of leaves/plant, plant height, panicle length and number of seeds/panicle. The path analysis indicated that, grain yield/plant, days to 50% flowering and plant height had the highest direct effects on total grain yield. The panicle length and the threshing percentage had the least direct effects on total grain yield. The direct effect of yield/plant was greatly reduced by the negative indirect effects through days to 50% flowering and downy mildew incidence, even though it was not significant. Similarly, the direct effect of plant height was very much influenced by the negligible indirect effects of threshing percentage, downy mildew incidence and 100-grain weight. The grain yield/plant, number of seed/panicle, and plant height in this study has been identified as selection criteria for obtaining good parental lines and hybrids in a pearl millet breeding program.

Key words: pearl millet, total grain yield, correlation, path analysis, parental lines, hybrids.

INTRODUCTION

Pearl millet *(Pennisetum glaucum* L. R. Br.), known as bulrush or cattail millet is also known as 'gero' in Northern Nigeria. It is a cereal primarily grown as a food grain in the warmer and drier regions of Africa and Asia. Beside as the principal food cereal in these regions, it also has the potential as an early-maturing summer grain crop in temperate regions (Anand Kumar and Andrews, 1993, Yoshida and Sumida, 1996). Pearl millet like many other cereal crops has received but little attention in the past from the point of view of its genetic improvement and consequently the grain yield.

The ultimate aim in most plant breeding programs is the improvement in the productivity of grains as measured in terms of the yield per unit area. From a physiological point of view, all crop plants offer a great scope for yield impro-vement. The possibilities of achieving this goal through genetic manipulation have been elucidated by evolving high yielding varieties of pearl millet in West Africa and a number of countries in Asia. These newly evolved varieties owe their high yielding ability to a reconstruction of an ideal plant type. It is now widely recognized that the improve-ment in plant type can make a very significant contribution

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to a higher total grain yield, particularly in most cereal crops in Nigeria.

Grain yield character in pearl millet and as in all crop plants is quantitative in nature and is polygenically controlled. Selection on the basis of grain yield character alone is usually not very effective and efficient. However, selection based on its component characters could be more efficient and reliable. Knowledge of the association between yield and its component characters and among the component characters themselves can improve the efficiency of selection in plant breeding. Owing to a complex situation, selection for an optimum advance on grain yield should be on the basis of judiciously computed index. The correlation studies taken alone are often misleading and the actual dependence of grain yield on the correlated yield component characters needs confirmation, which can easily be untangled and unraveled by path coefficient analysis.

The path coefficient analysis is simply a standardized partial regression coefficient and as such it measures the direct influence of one variable upon the other and permits the separation of correlation coefficients into components of direct and indirect effects. Studies of correlation and path analysis were conducted in groundnut, by (Izge et al*.,* 2004), in sorghum, by (Ezeaku and Mohammed, 2006), Singh and Singh (1973), Bello et al*.* (2001), in cowpea, by (Oseni, 1994), and in rice by Kumar and Saini (1973). However, there are no tangible studies to that effect in relation to pearl millet and especially in northern Nigeria where it is prominently grown. It is for this reason the present research was undertaken to study the correlations and path analysis in different lines and hybrids of pearl millet to develop a criterion for selection that could be effectively used for selecting the desirable genotypes or lines with high yield potential in the future.

MATERIALS AND METHODS

Ten (10) pearl millet lines, ACC-1022-1-2SPT, BONKOK-SHORT, D2P29, DMR43, DMR22, EX-BORNO, IMV11-3-3SPT, LCIC9702, LCIC9703- 27 and SOSAT-C88, chosen based on their considerable level of variability in yield and yield component characters together with their 45 hybrids obtained from a diallel cross excluding reciprocals at the Lake Chad Research Institute (LCRI), Maiduguri, Nigeria, were used for the study. The experiments were conducted at two locations i.e. in Maiduguri (11^0 53^I N, 13^0 16^I E) and Yola (9^0 8^I N, 12^0 29^I E), representing the major pearl millet growing areas in Nigeria, during the cropping seasons of 2004 and 2005.

The experiments were made up of 55 treatments (10 parental lines + 45 hybrids) laid out in randomized complete block design (RCBD) with three replications. In each replication the size of the plot consisted of 4 rows with a length of 5 meters. The two central rows i.e. the net rows were used for data collection and observation. The spacing between and within the rows is maintained at 75 cm and 50 cm, respectively. Seeds were sown by by hand as a pinch after seed treatment with Apron Star WS at the rate of 15 grams for every 1 kg of pearl millet seeds to prevent seedling damage by disease and ensure good establishment. Seeds after germination were thinned down to two plants per hill 2-3 weeks after sowing. Compound fertilizer (NPK 27: 10: 10) at the rate of 600 kg/ha was applied in two split doses, one at planting and the other at 3-5 weeks after sowing. Weed control was done by hoe as necessary. Harvesting was done when the plants has reached maturity.

Data collection and observations were done on the net plot, from each plot for the eleven yield and yield component characters studied i.e. days to 50% flowering, number of tillers/plant, number of leaves /plant, downy mildew incidence, plant height, panicle length, number of seeds/panicle, 1000-grain weight, threshing %, grain yield/plant and total grain yield/ha.

Phenotypic and genotypic linear correlation coefficients were calculated for all the possible comparisons using the formula suggested by Al-jibouri et al*.* (1958). The correlation coefficients were partitioned into direct and indirect effects using the path coefficient analysis according to Dewey and Lu (1959) and Wright (1921).

RESULTS AND DISCUSSION

The genotypic and phenotypic correlations between all the pairs of characters studied are presented in Table 1. The correlation coefficients for most of the pairs of characters revealed the presence of strong positive genotypic association between yield/ha with number of tillers/plant, number of leaves/plant, plant height, panicle length, number of seed/panicle and yield/plant. Strong and positive phenoltypic association also exist between yields/ha, with number of tillers/plant, number of leaves/plant, plant height, panicle length, number of seeds/panicle and yield/plant. Even though, both the types of correlations are comparable in magnitude, the genotypic correlations are of higher magnitude than their corresponding phenotypic correlations, indicating a strong inherent relationship among the characters studied. This result corroborates the one of Bello et al. (2001), Ezeaku and Mohammed, (2006), in sorghum and Khairwal et al. (1999), in pearl millet. However, there were generally negative and insignificant genotypic and phenoltypic relationship between yield/ha with days to 50% flowering, downy mildew incidence and 1000-grain weight. Generally, the genotypic correlations showed more signifycant difference between pairs of characters than the phenotypic correlations.

The genotypic and phenotypic correlation coefficients of 0.834 and 0.764 respectively of grain yield/ha with grain yield/plant were among the highest values obtained in this study. Significant and positive correlations between yield and other yield variables are quite desirable in plant breeding, because it facilitates the selection process. Similar observations were reported by Rajni et al*.* (1978), Bello et al. (2001), and by Aba and Obilana (1994). The result also revealed the presence of positive and highly significant genotypic correlations of days to 50% flowering with plant height (0.786), panicle length, (0.715), and number of seeds/panicle (0.796). Negative and highly significant genotypic correlations were also observed between days to 50% flowering with 1000-grain weight (-0.706) and threshing % (-0.638). Similar result was reported by Bello et al. (2001). Most correlation studies reported however, did not

Table 1. Analysis of genotypic (upper triangle) and phenotypic (lower triangle) correlations for eleven yield and yield components characters in pearl millet combined across locations (Maiduguri and Yola) and years (2004 and 2005**).**

Characters	DTF	NTP	NLP	DMI	PLH	PNL	NSP	TGW	THP	GYP	GYH
DTF		-0.579**	0.045	0.157	0.786**	0.715**	0.796**	-0.706**	-0.638**	0.139	-0.150
NTP	-0.261		0.598**	0.142	0.264	-0.104	-0.107	0.195	-0.256	0.696**	0.497**
NLP	0.077	0.575**		0.041	0.516**	0.251	0.307*	-0.139	-0.405**	0.516**	0.560**
DMI	0.037	0.042	0.005		-0.004	0.078	-0.300	-0.105	-0.540	-0.194	-0.147
PLH	0.413**	0.178	0.417**	0.038		0.660**	0.730**	-0.235	-0.560**	0.563**	0.603**
PNL	0.560**	-0.055	0.223	0.069	0.615**		0.654**	-0.571**	-0.558**	0.329**	0.339*
NSP	0.566**	-0.065	0.245	-0.212	0.625**	0.588**		-0.551**	-0.253	0.560**	0.571**
TGW	-0.480**	0.139	-0.085	-0.076	-0.184	-0.486**	-0.448**		0.528**	0.037	-0.092
THP	-0.391**	-0.184	-0.234	-0.281	-0.357**	-0.392**	-0.017	0.367**		0.063	0.035
GYP	0.001	0.477**	0.451**	-0.146	0.506**	0.276*	0.451**	0.063	0.033		0.834**
GYH	-0.102	0.408**	0.503**	-0.126	0.540**	0.308*	0.491**	-0.041	-0.006	0.764**	

DTF: Days to 50% flowering
NTP: No. of tillers/plant
DMI: Downy mildew incidence (%)
NLP: No. of leaves/plant
PLH: Plant height (cm)
PNL: Panicle length (cm)
NSP: No. of seeds/panicle
TGW: 1000 grain weight (g)
THP: Threshing percentage
GYP: Grain yield per plant (g)
GYH: Grain yield (kg/ha)

correlate days to 50% flowering with yield e.g. Chaudhary (1992), Ezeaku and Mohammed (2006), Izge et al. (2004) etc. The difference of opinion in the various studies undertaken by many authors could be attributed to the differences in the materials used and the prevailing weather conditions. Significantly positive correlation, but have relatively lower magnitude of 0.339 was observed between total grain yield with panicle length.

The path coefficient analysis of yields and its components are presented in Table 2. The path coefficient analysis revealed that grain yield/plant and plant height gave the highest direct effect on total grain yield at 0.582 and 0.139 respectively. In spite of the fact that yield/plant had a very strong correlation with total grain yield/ha, there was no much indirect effects through number of tillers/plant (0.2541), panicle length (0.2518), 1000-grain weight (0.0848) and threshing % (0.2371). However, yield/plant exhibited relatively much indirect effect through number of leaves/plant (0.4849), plant height (0.4282), and number of seeds/panicle (0.4261). The highest indirect effect of 0.5551 toward total grain yield/ha was made by number of leaves/plant, through number of tillers/plant, while the minimum indirect effect of -0.6164 was made by days to 50% flowering through 1000-grain weight. Higher indirect values could most likely be neutralized in most cases by the negative indirect effects via other characters and this can lead to their low and non significant genotypic correlation with total grain yield. In that regard therefore, selection for such characters may not enhance yield improvement and are not to be encouraged.

Number of tillers/plant had the highest indirect effect of 0.3389 towards total grain yield/ha through grain yield/plant. While it had the lowest indirect effect value of -0.3332 through panicle length. The indirect contributions by downy mildew incidence through most of the characters were negative. The low and negative genotypic correlation of grain yield and downy mildew incidence coupled with its weak and negative direct effect implies that selecting for this character will not be beneficial for yield improvement in this particular pearl millet population.

Plant height and panicle length were also important yield determinant characters because of their positive and highly significant levels of correlations with yield. Plant height had a direct effect of 0.139 toward total grain yield and indirect effects of 0.3984 and 0.3160 through panicle length and number of seeds/panicle respectively. Panicle length however, exhibited the highest indirect effect (0.3869) through number of seeds / panicle and the lowest indirect effect of –0.4319 through 1000-grain weight. The correlation coefficient between number of seeds/panicle and total grain yield is also high. Number of seeds/panicle contributed positively indirectly through panicle length (0.3031), num-ber of leaves/plant (0.2758) and plant height (0.2749).

Grain yield per plant, number of seeds/panicle and plant height appeared to be the prominent characters when selecting for total grain yield in pearl millet, because of their highly significant genotypic and phenotypic correlations with total grain yield. These characters also had the highest direct effects on total grain yield and high indirect effects through most of the other characters. This investigation therefore suggest that grain yield/plant, number of seeds/panicle and plant height should be given maximum consideration for total yield improvement as the appropriate selection indices. The selection procedure should be formulated so that the advance in one component is not jeopardized by the deterioration effect of the other.

Table 2. Path coefficient analysis of grain yield per hectare [direct (diagonal) and indirect effects] with other yield components in pearl millet, combined across locations and years.

Characters	Days to 50 % flowering	Number of tillers/plant	Number of leaves /plant	Downy mildew incidence	Plant height	Panicle length	Number of seeds/ panicle	1000-grain weight	Threshing percentage	Grain yield/ plant	Genotypic correlation with grain yield/ha
Days to 50 % flowering	0.1140	0.1678	0.1995	-0.1646	-0.4006	0.1259	0.1474	-0.0244	0.0186	-0.0732	-0.150
Number of tillers/plant	-0.2972	0.103	0.5551	-0.0865	0.0675	0.1262	0.0617	0.0518	-0.0332	0.2541	0.497**
Number of leaves/plant	-0.2685	-0.0601	0.018	-0.0435	0.1995	0.1966	0.2758	0.0161	0.2082	0.4849	0.560**
Downy mildew incidence	0.2076	0.1255	0.0155	-0.008	-0.1646	0.0373	0.0704	0.0230	0.1093	-0.0229	-0.147
Plant height	0.5294	0.0935	0.2985	0.1686	0.139	-0.4006	0.2749	0.0704	-0.0006	0.4282	0.603**
Panicle length	0.4751	-0.3332	0.0364	0.0487	0.3984	-0.036	0.3031	-0.1150	-0.0377	0.2518	0.339*
Number of seeds/panicle	0.5346	-0.2717	0.0132	-0.1890	0.3160	0.3869	0.106	-0.1422	0.5424	0.4261	0.571**
1000-grain weight	-0.6164	0.0402	-0.1731	-0.0990	-0.0256	-0.4139	-0.5148	0.061	0.1092	0.0848	-0.092
Threshing percentage	-0.5054	-0.3258	-0.1788	-0.4387	-0.4216	-0.1474	-0.3950	0.3578	-0.111	0.2371	0.035
Grain yield/plant	0.0982	0.3389	0.0131	-0.1630	-0.0042	0.1132	0.0279	-0.1088	-0.0631	0.582	0.834**

*, ** Significant at 5 % and 1 % level of probabilities respectively.

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