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Full Length Research Paper

Character association and path analysis in grain sorghum

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Association and path analysis between hill count, bloom, plant height, panicle length, panicle count, 1000 seed mass, head weight and grain yield of thirty sorghum varieties were studied over two locations and years. There is significant high positive correlation between grain yield and head weight (r=0.976), grain yield and 1000 grain mass (r=0.522) and 1000 grain mass and head weight (r=0.528). Similarly, significant but negative correlation exists between panicle count and panicle length. Partitioning of yield and yield components into direct and indirect effects revealed that head weight had the highest direct effect on grain yield (0.961) while 1000 grain mass contributed indirectly to grain yield via head weight (0.507). Panicle count also contributed to grain yield indirectly through head weight (0.420) indicating the importance of head weight as one of the most important yield components followed by 1000 grain mass and then panicle count. There is high positive phenotypic and genotypic correlation coefficient between hill and panicle count, panicle count and head weight, panicle count and grain yield and head weight and grain yield. Plant height has high positive phenotypic and genotypic correlation coefficients with head weight (r_p= 0.550, r_g=0.881) and grain yield (r_p=0.555, r_g=0.904).

Key words: Sorghum, grain yield, correlation, path analysis.

INTRODUCTION

Sorghum [*Sorghum bicolor* (L.) Moench] is an important food and feed crop in the semi-arid regions of the world where it is grown under rain fed and irrigated conditions (House, 1985). Sorghum crop exhibits considerable differences in plant traits, panicle and grain characteristics including physiological responses to selection and is highly influenced by environmental factors (Ezeaku et al., 1997).

The study of relationships among quantitative traits is important for assessing the feasibility of joint selection of two or more traits and hence for evaluating the effect of selection for secondary traits on genetic gain for the primary trait under consideration. A positive genetic correlation between two desirable traits makes the job of the plant breeder easy for improving both traits simultaneously. Even the lack of correlation is useful for the joint improvement of the two traits. On the other hand, a negative correlation between two desirable traits impedes or makes it impossible to achieve a significant improvement in both traits. However, simple correlations do not give an insight into the true biological relationships of these traits with yield. Yield, being quantitative in nature is a complex trait with low heritability and depends upon several other components with high heritability (Grafius, 1959). These traits are in turn interrelated. Their interdependence influences the direct relationship with yield and as a result the information obtained on their association becomes unreliable (Khairwal et al., 1999).

The path coefficient analysis initially suggested by Wright (1921) and described by Dewey and Lu (1959)

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Table 1. Combined correlation coefficients between some yield and yield characters in sorghum.

Yield characters	Grain yield	Panicle length (cm)	Panicle count	Head weight (g)	100 grain mass (g)
Grain yield	1.0				
Panicle length	0.0390^{ns}	1.0			
Panicle count	0.4317**	-0.2019**	1.0		
Head weight	0.9763**	0.0466 ^{ns}	0.4373**	1.0	
1000 grain mass	0.5219**	0.0054 ^{ns}	-0.1840**	0.5278**	1.00

Ns = not significant
** = significant at 1%

Table 2. Path coefficient analysis showing direct and indirect effects of yield and yield component in sorghum

Cause and effect	Correlation	Cause and effect	Correlation
Panicle length vs yield	0.0390	Head weight vs yield	0.9763
Direct effect	-0.0031	Direct effect	0.9614
Indirect via panicle count	-0.0028	Indirect via panicle length	0.0001
Indirect via head weight	0.0448	Indirect via panicle count	0.0060
Indirect via 1000 grains mass	0.0001	Indirect via 1000 grain mass	0.0090
Total effect	**0.0390**	**Total effect**	**0.9763**
Panicle count vs yield	0.4317	1000 grain mass vs yield	0.5219
Direct effect	0.0138	Direct effect	0.0171
Indirect via panicle length	0.0006	Indirect via panicle length	0.00002
Indirect via head weight	0.4204	Indirect via panicle count	0.0025
Indirect via 1000 grain mass	0.0031	Indirect via head weight	0.5074
Total effect	**0.4317**	**Total effect**	**0.5219**

allows partitioning of correlation coefficient into direct and indirect contributions (effects) of various traits towards dependent variable and thus helps in assessing the cause-effect relationship as well as effective selection. Hence, this study is aimed to analyze and determine the traits having greater interrelationship with grain yield utilizing the correlation and path analysis.

MATERIALS AND METHODS

Thirty sorghum varieties originating from International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Kano were used for the study. The trials were grown at Minjibir and Bagauda in 2000 and 2001 wet season in a randomized complete block design with four replications. The experimental unit was a four-row plot of 5 m long, spaced at 0.75 m apart and plant-to-plant distance of 0.25 m. The two central rows of the plot were used for observation.

NPK 15:15:15 fertilizer was applied as a basal dose at the rate of 300 kg per hectare. Plots were thinned down to two plants per hill two weeks after crop emergence. Three weeks post crop emergence 100 kg urea per hectare was top dressed in each plot.

Data was taken from two inner rows for hill count, bloom, plant height, panicle length, panicle count, head weight, 1000 seed mass and grain yield following recommendations by International Board for Plant Genetic Resources (IBPGR) and ICRISAT descriptor list for sorghum (IBPGR/ICRISAT, 1993).

Correlation coefficient was computed from variance and covariance components as suggested by Burton (1952), Wright (1960 and 1968) and Narasimharao and Rachie (1964). The correlation coefficient was partitioned into direct and indirect causes according to Dewey and Lu (1959), Turner and Stevens (1959), and Wright (1960).

RESULTS AND DISCUSSION

The correlation between all the pairs of variables in 2000 and 2001 combined are shown in Table 1. There is significant (P=0.01) high positive correlation between grain yield and head weight (r=0.976), grain yield and 1000 grain mass (r= 0.522) and 1000 grain mass and head weight (r=0.528). Previous workers have reported sorghum grain yield as a function of grain mass (Aba and Obilana, 1994; Beil and Atkins, 1967), and head weight (Aba and Zaria, 2000; Kambel and Webster, 1966). On the other hand, significant (p=0.01) but negative correlation exists between panicle count and panicle length (r= -0.202). This indicates the compensation mechanism and trade-offs between this pair of traits in determining the panicle characteristics in sorghum.

Partitioning of yield and yield components into direct and indirect effects (Table 2) revealed that head weight had the highest direct effect on grain yield (0.961) while 1000 grain mass contributed indirectly to grain yield via head weight (0.507). Panicle count also contributed to grain yield indirectly through head weight (0.420) indica-

Table 3. Partitioning of correlation coefficient into phenotypic (r_p), genotypic (r_g) and environmental (r_e) between seven quantitative characters in sorghum

Character	Bloom	Plant height	Panicle Length	Panicle count	1000 grain mass	Head weight	Grain yeild
Hill r_p	-0.4741	0.3551	-0.2685	0.6868	0.2119	0.4434	0.4358
r_g	-0.7962	0.5404	-0.4670	0.8657	0.6239	0.7249	0.7460
r_e	-0.2733	0.1687	-0.0459	0.4099	0.0742	0.2829	0.2745
Bloom r_p		-0.2477	0.3117	-0.6395	-0.2854	-0.5307	-0.5452
r_g		-0.3192	0.6030	-0.8428	-0.7232	-0.7356	-07673
r_e		-0.1947	-0.0551	-0.3037	-0.1372	-0.4100	-0.4270
Plant height r_p			-0.0206	0.3298	0.2420	0.5547	0.5499
r_g			-0.0642	0.4746	0.6203	0.8807	0.9036
r_e			0.1330	0.2027	0.0329	0.2459	0.2633
Panicle length r_p				-0.4090	-0.1078	-0.0410	-0.0597
r_g				-0.6864	-0.3759	-0.1030	-0.1308
r_e				-0.1137	0.0672	0.0329	0.0118
Panicle count r_p					0.1985	0.6637	0.6532
r_g					0.5641	0.7703	0.7920
r_e					0.0782	0.6039	0.5831
1000 grain mass r_p						0.4244	0.4408
r_g						0.6519	0.7005
r_e						0.3603	0.3688
Head weight r_p							0.9546
r_g							0.8085
r_e							0.9545

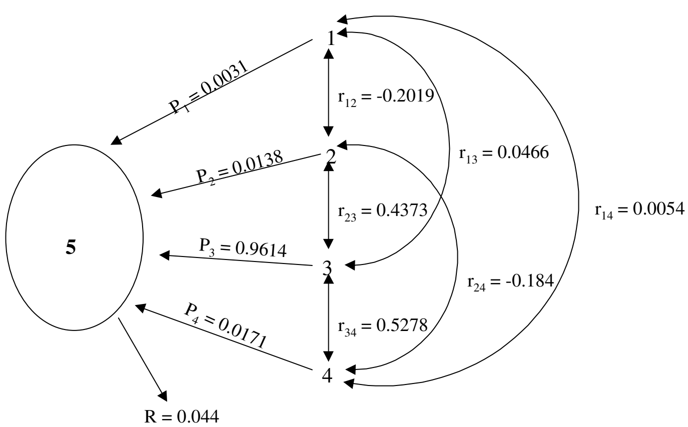

Figure 1. Nature of causal system of variables for the path-coefficient analysis in sorghum (1) Panicle length (2) Panicle count (3) Head weight (4) Grain mass (5) Grain yield (R) residual factors (r) correlation coefficient (p) unilateral path way. Double arrowed lines denote mutual association as measured by correlation coefficients, while single arrowed lines denote direct influence and measured by the path coefficient analysis.

ting the importance of head weight as one of the most important yield components followed by 1000 grain mass and then panicle count. These traits should be considered simultaneously when developing selection criteria for yield improvement in sorghum. Several other workers, (Rao and Damodaran, 1964; Singh and Govila, 1989; Bidinger et al., 1993; Jindla and Gill, 1984) also found similar results in pearl millet. Panicle length exhibited the least association with grain yield (0.039). Its low association with grain yield was mainly due to its negative direct effect (-0.003) and also negative indirect effect (-0.003) through panicle count. This shows that increasing panicle length through selection may not necessarily lead to proportionate increase in grain yield. The similarities between high positive correlations of head weight and grain yield (0.976), 1000 grain mass and grain yield (0.522), 1000 grain mass and head weight (0.528) in Table 1 and the direct effects between these pairs of traits in Table 2 justifies the need to clarify the nature of relationships between yield and yield components using path analysis. This further confirms a true relationship between these traits and grain yield; hence their direct selection will be effective in improving sorghum grain yield (Figure 1). The residual factor R is low (0.044) when compared to those obtained by Reddy et al. (1988) in rice (0.463). The low R reported in this study reveals that the independent factors explains over 90% of the variability in grain yield, hence, most of the essential yield components are included in this study.

The phenotypic, genotypic and environmental correlation coefficients between grain yield and seven other metric traits are presented in Table 3. Genotypic correlation coefficients were of higher magnitude than their corres-pondding phenotypic and environmental correlation suggesting that there was inherent relationship between the traits studied. This finding is in agreement with Reddy et al. (1988) and Khairwal et al. (1999). There are high positive phenotypic and genotypic correlation coefficients between hill and panicle count, panicle count and head weight, panicle count and grain yield and head weight and grain yield showing that these characters are less influenced by the environment and they could be improved in diverse environments. The implication of high positive genotypic correlation between hill and panicle count (r_g= 0.866), 1000 grain mass (r_g=0.624), head weight (r_g=0.725) and grain yield (r_g=0.746) suggests that optimum plant population will translate to higher panicle number, 1000 grain mass, head weight and grain yield. There is high negative phenotypic correlation coefficient (r_p=-0.545) genotypic correlation coefficient (r_g=-0.767) and environmental correlation coefficient (r_e=-0.427) between bloom and grain yield. This could be due to poor adaptation of very late flowering materials included in this experiment. This finding is supported by Gupta (1968), Gupta and Dhillon (1974) and Rao (1981). Plant height has high positive phenotypic and genotypic correlation coefficient with head weight (r_p= 0.550, r_g=0.881) and grain yield (r_p=0.555, r_g=0.904) indicating that taller plants possess heavier head weight and greater grain yield than shorter plants, probably due to greater mobilization of assimilates to the panicle in taller plants. This is in agreement with the findings of Gupta and Sidhu (1972), Burton (1951) and Shankar et al. (1963).

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