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Path Coefficient and Correlation Assessment of Yield and Yield Associated Traits in Sorghum (*Sorghum bicolor* L.) Genotypes

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Abstract: An investigation was carried out with 25 restorer lines of sorghum to asses association of grain yield components and their direct and indirect effects on grain yield/panicle during 2008 and 2009 growing seasons in the Arab El-Awamer Research Station, Assiut, Egypt. Results of combined analysis showed that highly significant ($p<0.01$) variation were recorded among the genotypes for various morphological and yield traits studied. The highest values of 1000-kernel weight (25.8 g), number of kernels/panicle (2114) and grain yield/panicle (54.4g) were obtained from ICSR-94006 genotype, while the lowest values of mentioned traits (28.4g, 688 and 19.5g, respectively) were obtained from GZR4 genotype. Results of correlation analysis indicated that number of kernels/head had positive and highly significant ($p<0.01$) correlation with grain yield (0.920), whereas, the positive and significant ($p<0.05$) correlation was found between panicle length and grain yield (0.233). On the other hand there are negative and non-significant correlation (-0.034) between panicle width and grain yield/panicle. The path analysis showed that panicle length had low but positive direct effect on grain yield (0.0111), whereas number of kernels/head had high positive direct effect on grain yield (0.9977) and positive indirect effect was through days to flowering (0.0033), plant height (0.0001), panicle length (0.0002), panicle width (0.0013) and panicle internodes (0.0002), whereas its indirect effect was negative through leaf area (0.0002) and 1000- kernel weight (0.0824).

Key words: Sorghum · Grain yield · Correlation · Path analysis

INTRODUCTION

Sorghum (*Sorghum bicolor* L. Moench) is one of the important food crops in the world. It is cultivated in many parts of Asia and Africa, where its grains are used to make flat breads that form the staple food of many cultures. The species can be used as a source for making ethanol fuel and in some environments may be better than maize or sugarcane, as it can grow under harsher conditions. It typically has protein levels of around 9 percent, enabling dependent human populations to subsist on it in times of famine, in contrast to regions where maize has become the staple crop. Grain yield is complex trait, depend on many attributes characters. Yield potential accompanied with desirable combination of traits has always been the major objective of sorghum breeding program. Correlation measure the level of dependence traits and out of numerous correlation coefficient it is often difficult to determined the actual mutual effects among traits [1]. The estimates of correlations alone may be often misleading due to mutual cancellation of component traits. So, it becomes necessary to study path coefficient analysis, which takes in to account the casual relationship in addition to degree of relationship [2]. The path coefficient analysis initially suggested by Wright [3] and described by Dewey and Lu [4] 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. Path analysis is necessary for better understanding of correlations among traits, which is a pathway for knowledge on specificity of the genetic material being studied. Ikanovic [5] concluded that even if correlation values are similar for certain pairs of traits, direct effects for some of them and especially indirect effects via other traits, can differ for some traits.

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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 [6]. Mahajan *et al.* [2], Wankhede *et al.* [7], Mallinath *et al.* [8] and Ambekar *et al.* [9] stated that panicle length, panicle width, plant height, number of primary branches/panicle, number of grains/panicle, test weight, harvest index and grain yield/panicle had showed positive significant association at both levels with all characters except days to 50% flowering and days to maturity.

Therefore, this study aims to analyze and determine the traits having greater interrelationship with grain yield utilizing the correlation and path analysis.

MATERIALS AND METHODS

Twenty five of local and international restorer sorghum lines were obtained from Shandwil Research Station was used for this study. The experiments were carried out at Arab El-Awamer Research Station, Assiut, Egypt during 2008 and 2009 growing seasons in a randomized complete block design with three replications. The experimental unit was sowing at 15th June a five-row plot (10.5 m^2) of 3.5 m long, spaced at 0.60 m apart and hill to hill distance of 0.20 m. The two central rows of the plot were used for observation. Plots were thinned down to two plants per hill two weeks after crop emergence. Nitrogen fertilizer was applied at the rate of 120 kg N/feddan (one feddan= 4200 m^2) in the form of Urea (46 % N), phosphorus was applied at the rate of 30 kg P_2O_5/feddan in the form of triple superphsphate (46 % P_2O_5), while K fertilizer was added at the rate of 50 kg/feddan in the form of potassium sulfate (50% K_2O). All other cultural practices were carried out as recommended for sorghum production in both seasons. Data was taken from two inner rows for hill count, leaf area (cm^2), 50% flowering, plant height (cm), panicle length (cm), panicle width (cm), panicle internodes, 1000-grain weight (g), number of grains panicle^{-1} and grain yield /panicle (g).

Statistical Analysis: Data for all these attributes were subjected to analysis of variance according to Steel and Torrie [10] to evaluate the significant differences among the genotypes. Estimation of variation components and phenotypic correlations were calculated as suggested by Burton [11], Wright [12, 13] and Narasimharao and Rachie [14]. The correlation coefficient was partitioned into direct and indirect causes according to Dewey and Lu [4] and Turner and Stevens [15]. Test of significance was carried out with (n-2) degree of freedom for phenotypic correlation by referring to the table given by Snedecor and Cochran [16].

RESULTS AND DISCUSSION

Data presented in Table 1 indicated that mean squares in the combined analysis of variance of analyzed traits in 25 restores lines of sorghum. The analysis of variance for yield and its attributes traits revealed that the differences among genotypes were highly significant (P<0.01) for all the studied traits. The data regarding means of grain yield and other characters of 25 restorer lines of grain sorghum over two years are presented in Table 2. The presented data in Table 2 focused the highly significant (P<0.01) variation between sorghum genotypes in all studied characters. Thus, the highest range individual character was registered with regard to plant height (from 94.2 to 195.5 cm), leaf area (from 293.8 to 487.5 cm^2), number of days to flowering (from 79.8 to 101.7 day), panicle length (from 16.8 to 23.6 cm), panicle width (from 4.6 to 7.8 cm), panicle internodes (from 7.3 to 13.6 node), 1000- kernel weight (from 20.1 to 28.6 g), number of kernels/head (from 688 to 1657) and grain yield/ plant (from 19.5 to 54.4 g). These variation between genotypes in all studied traits may be due to the genetic behavior combination with environment factors, which were suitable for one genotype than other. These finding are in agreement with those obtained by House [17] and Mahdy *et al.* [18]. Furthermore, data in Table 1 showed highly significant interaction between years and genotypes in leaf area, days to 50% flowering, plant

Table 1: Mean squares for combined analysis of variance for different studied characters

S.O.V	d.f	Leaf Area	No. of days to 50% flowering	Plant height	Panicle length	Panicle width	Panicle internodes	1000 kernel weight	No. of kernels/ head	Grain yield/ plant
Year	1	10766.2	1362.03	0.43	1514.95	1.162	33.99**	200.68**	29204^{ns}	227.92**
error a	4	2732.25	3.39	149.545	3.70	0.338	0.79	2.85	5285.75	8.95
Genotypes	24	16667.5**	241.23**	5308.56**	24.47**	4.471**	9.02**	25.61**	493928**	335.45**
Year x genotypes	24	9224.7**	86.11**	977.98**	12.07**	3.095**	4.88**	0.76	9702	5.38
Error b	96	527.8	6.79	43.83	2.37	0.054	0.47	1.03	10671	3.82

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

Table 2: Means of grain yield and other characters over two years

Traits ----------------------- Restorer lines	Leaf area (cm^2)	Days to 50% flowering	Plant height (cm)	Panicle length (cm)	Panicle width (cm)	Panicle internodes	1000 kernel weight (g)	No. of kernels / head	Grain yield/ plant (g)
87-EO-366 sis	354.3	83.0	195.5	17.0	6.0	10.0	28.6	1495	42.5
EO 328	431.6	93.8	143.5	19.4	5.4	11.2	27.5	1336	36.7
ICSR-121	399.0	94.8	128.7	17.4	5.1	11.5	24.5	1359	33.1
ICSR-16	416.0	97.5	143.8	22.3	5.9	12.0	25.6	1795	46.0
ICSR-89028	413.8	94.3	114.8	21.0	5.5	13.5	25.0	1155	28.8
R-89037	354.3	92.7	127.7	20.5	5.8	10.8	26.4	1466	38.7
ICSR-89064	381.3	97.2	141.5	21.1	6.4	10.9	25.2	1452	36.6
ICSR-90010	443.8	98.5	146.0	20.3	6.7	10.1	24.6	893	22.0
ICSR-90015	318.8	95.5	159.8	20.6	5.3	10.6	20.1	1588	31.9
R-90018	460.0	90.5	126.8	22.6	6.3	11.2	26.1	1657	43.3
ICSR-91002	350.4	88.7	110.5	20.6	6.2	10.9	26.5	1289	34.1
ICSR-93018	320.8	79.8	135.2	16.9	5.1	9.5	22.1	1514	33.5
ICSR-93021	311.4	80.7	96.7	18.7	5.1	7.3	21.5	1496	32.1
R-93022	450.0	96.0	94.2	19.8	7.3	10.9	25.2	931	23.4
ICSR-94006	450.6	96.8	161.2	19.6	7.4	10.5	25.8	2114	54.4
ICSR-94008	359.0	88.3	111.5	21.6	6.1	10.5	24.7	1572	38.8
P-37-3	353.6	95.3	127.7	21.7	6.3	10.0	23.1	1488	34.3
P-46-1	366.9	93.7	101.8	19.9	4.9	10.3	25.8	1547	39.7
GZR1	371.9	80.7	194.5	21.8	6.2	11.1	26.3	1298	33.9
GZR2	487.5	84.8	140.0	23.6	7.8	13.6	27.0	1443	38.9
GZR3	402.7	93.3	106.8	21.0	6.5	10.9	27.5	1418	39.0
GZR4	434.8	81.8	172.3	18.0	7.5	10.8	28.4	688	19.5
GZR5	373.5	101.7	184.5	16.8	5.8	11.6	22.8	1387	31.5
GZR6	322.2	85.5	180.0	16.9	7.1	9.5	26.1	1251	32.5
RTX-2817	293.8	91.3	125.7	22.9	4.6	11.5	25.3	1277	32.1
Revised L.S.D 0.01	42.54	4.83	12.27	2.91	0.43	1.31	2.01	191.46	2.96

Table 3: Phenotypic correlations for yield and yield contributing characters in sorghum

Traits	Grain yield/ panicle	Days to 50% flowering	Plant height	Panicle length	Panicle width	Panicle internodes	Leaf area	1000 kernel weight	No. of kernels/ head
Grain yield/panicle									
Days to 50% flowering	0.094								
Plant height	0.049	-0.156							
Panicle length	0.233*	0.174	-0.344**						
Panicle width	-0.034	-0.054	0.257*	0.092					
Panicle internodes	0.075	0.330**	0.040	0.478**	0.160				
Leaf area	0.085	0.273*	-0.014	0.255*	0.618**	0.526**			
1000 kernel weight	0.190	-0.183	0.176	0.108	0.437**	0.338**	0.460**		
No. of kernels/head	0.920**	0.140	-0.004	0.179	-0.204	-0.068	-0.108	-0.206	

*, ** significant at 5% and 1% level of probabilities, respectively

Table 4: Direct (diagonal) and indirect effect of different traits on grain yield

Traits	Days to 50% flowering	Plant height	Panicle length	Panicle width	Panicle internodes	Leaf area	1000 kernels weight	Kernels number/ head
Days to 50% flowering	0.0233	0.0029	0.0019	0.0003	-0.0012	0.0005	-0.0733	0.1400
Plant height	-0.0036	-0.0186	-0.0038	-0.0016	-0.0001	0.0001	0.0703	-0.0035
Panicle length	0.0041	0.0064	0.0111	-0.0006	-0.0017	0.0004	0.0432	0.1784
Panicle width	-0.0013	-0.0048	0.0010	-0.0063	-0.0006	0.0011	0.1750	-0.2040
Panicle internodes	0.0077	-0.0007	0.0053	-0.0010	-0.0035	0.0009	0.1351	-0.0680
Leaf area	0.0064	0.0003	0.0028	-0.0039	-0.0019	0.0017	0.1842	-0.1079
1000- kernel weight	-0.0043	-0.0033	0.0012	-0.0028	-0.0012	0.0008	0.4001	-0.2054
Kernels number/head	0.0033	0.0001	0.0020	0.0013	0.0002	-0.0002	-0.0824	0.9977

height, panicle length and panicle width; while the interaction doesn't reached significant level with regard to 1000-kernel weight, number of kernels/ panicle and grain yield / panicle. Phenotypic correlations are presented in Table 3 showed significant ($p<0.05$) and positive association of panicle length with grain yield (0.232), whereas highly significant ($P<0.01$) and negative association with plant height (-0.344). Panicle width showed positive and significant correlation with plant height (0.257), whereas positive but non-significant association with grain yield (-0.034) or with days to flowering (-0.054). The correlation of panicle internodes was positive and highly significant ($P<0.01$) with days to flowering and panicle length, whereas positive but non-significant with grain yield, plant height and panicle width. Furthermore, leaf area had a positive highly significant ($P<0.01$) correlation with panicle width (0.618), panicle internodes (0.526) and thousand kernel weight (0.460), whereas positive but non-significant with grain yield (0.085). Number of kernels/head had positive and highly significant ($P<0.01$) correlation with grain yield (0.920), whereas positive but non-significant association with days to flowering (0.140) and panicle length (0.179) furthermore, number of kernel head^{-1} had negative but non-significant association with plant height (-0.004), panicle width (-0.204), panicle internodes (-0.068), leaf area (-0.108) and thousand kernel weight (-0.206).

The path analysis (Table 4) showed that panicle length had low but positive direct effect on grain yield (0.0111). Its positive indirect effect was through plant height (0.0064), days to flowering (0.0041), leaf area (0.0004), 1000- kernel weight (0.0432) and kernel numbers/head (0.1784), whereas its indirect effect was negative through panicle internodes (-0.0017) and panicle width (-0.0006). Kernel numbers/head had high positive direct effect on grain yield (0.9977). Its positive indirect effect was through days to flowering (0.0033), plant height (0.0001), panicle length (0.0002), panicle width (0.0013) and panicle internodes (0.0002) whereas its indirect effect was negative through leaf area (0.0002) and thousand kernel weight (0.0824). Wankhede *et al.* [19], Patil and Thombre [20] showed positive direct effect of panicle length on grain yield. Veerabadbiran *et al.* [21] stated that number of grains/panicle had the highest positive effect on grain yield. Similar results were obtained by Mahajan *et al.* [2], who found that panicle length and number of grains/ panicle has positive direct effect on grain yield/ panicle. Thus it is revealed from the present study that the traits like panicle length and number of grains/ panicle had greater importance. Hence, due consideration should be given to these characters, while planning a breeding strategy for increased grain yield/ panicle.

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