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Character association and path analysis in advanced breeding lines of rabi sorghum [*Sorghum bicolor* (L.) Moench]

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Abstract: The field experiment was carried out using advanced breeding lines of rabi sorghum to study association among the yield and its component traits, direct and indirect effects of traits on the yield. Association studies indicated that seed yield per plot showed significant positive correlation with traits *viz.,* plant height (rp=+0.7243, rg=+0.7409), ear head length (rp=+0.6002, rg=+0.6021), 100 seed weight (rp=+0.1593, rg=+0.1880), fodder yield (rp=+0.9434, rg=+0.9476) and lodging percentage (rp=+0.5263, rg=+0.5646) at both phenotypic and genotypic level. Genotypic correlation was higher magnitude than phenotypic correlation. Revealed increase in ear head length will increase the seed yield. Partitioning of yield and yield components both at phenotypic and genotypic levels into direct and indirect effects revealed that positive direct effects of ear head length (Ppi=+0.2533, Pgi=+0.5241), ear head diameter (Ppi=+0.0669, Pgi=+0.2580), days to maturity (Ppi=+0.0338, Pgi=+0.1193), fodder yield (Ppi=+0.6484, Pgi=+0.7461) were relatively high and followed by less lodging percentage (Ppi=+0.1751, Pgi=+0.2263). Residual effects were Pr=0.1303 and Gr=0.0624 at phenotypic and genotypic levels. Indicating importance of these characters and can be strategically used to improve the seed yield of sorghum.

Keywords: Correlation, Grain yield, Path analysis, Sorghum

INTRODUCTION

Sorghum bicolor (L.) Moench is an important food and feed crops in the semi-arid regions of the world. It occupies an area of 10.76 lakh hectare with a production of 12.21 lakhs tonnes and productivity of 1135 kg per hector in Karnataka state (Anonymous, 2015). Whereas Hyderabad – Karnataka region occupies half of the area of 6.29 lakh hectors with contribution production of 6.09 lakh tones (Anonymous, 2012). Yield improvement in sorghum is mainly based on selection of other characters. Because grain yield is complex character, which intern depends on many independent attributing characters. Yield potential accompanied with desirable combination of traits has always been the major objective of sorghum breeding program. Sorghum exhibits considerable differences in plant traits, panicle and grain characteristics to selection and is highly influenced by environmental factors (Ezeaku *et al*., 1997)

Improvement in sorghum yield depends on the nature and extent of genetic variability, heritability and genetic advance in the base population. The information on the nature of association between yield and its components helps in simultaneous selection for many characters associated with yield improvements. Correlation measure the level of dependence traits and out of numerous correlation coefficients. A positive genetic correlation between two desirable traits makes the job of the plant breeder easy for improving both traits simultaneously. Mahajan *et al.* (2011) indicated the positive association of plant height and panicle length with grain yield per plant of sorghum.

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

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

MATERIALS AND METHODS

The 23 sorghum lines comprised of selection from local lines, advanced generation lines developed by crossing local, exotic lines with M-35-1(Table 1). Lines were developed at Agricultural Research Station, Gulbarga, University of Agricultural Sciences, Raichur with inclusion of two varietal checks viz., M-35-1 and Muguthi. The trial was conducted in a Randomized Complete Block Design with three replications at Agriculture Research Stations Gulbarga receiving annual average rainfall of 729mm representing diverse agro climatic conditions during *rabi*-2012-13. The plot size was 6 rows of 4m length with inter row and inter spacing of 0.45m X.0.15m. Each row was over planted later thinned to 1 plants/hill 15days after emergence. 50kg Nitrogen per hactor and 25 kg phosphorus per hactor of Diamonimum Phosphate was applied as basal fertilizer. All other crop cultural management practices were followed to raise successful crop. Observations were recorded on 10 different characters *viz.,* plant height (cm), stem diameter (cm), ear head length (cm), ear head diameter (cm), days to 50 per cent flowering, days to maturity, 100 seed weight (g), fodder yield per plot (kg), seed yield per plot (kg) and lodging percentage. The genotypic and phenotypic correlation co-efficient, path co- efficient analysis was carried out to partition the genotypic correlation co-efficient into direct and indirect effects. Knowledge of the relationship among yield components is essential for the formulation of breeding programmes aimed at achieving the desired combinations of various components of yield.

The analysis of covariance was calculated by the following method designed by Singh and Chaudhary (1977). Genotypic and phenotypic correlation coefficients among different characters for which variance ratio was significant were estimated from the variance and covariance components following the method given by Hayes *et al* (1955). Test of significance was carried out with (n-2) degrees of freedom for genotypic and phenotypic correlation by referring to the table given by Snedecor and Cochran (1961). Path Coefficient direct and indirect effect of component characters on grain yield were computed using appropriate correlation coefficient of different component characters suggested by Wright (1921a) and elaborated by Dewey and Lu (1959). Data for all these attributes were subjected to window MSTAT computer ver. 13.0 software. Abbreviatios- Ppi: Path phenotypic direct effect, Pgi: Path genotypic direct effect. pril: Path phenotypic indirect values through other trait, gril: Path genotypic values via other trait, Pr: Path phenotypic residual value whereas Gr: Path genotypic residual values.

RESULTS AND DISCUSSION

Correlation coefficient is a statistical measure, which denotes the degree and magnitude of association between any two casually related variables. This association is due to pleiotropic gene action or linkage or

Table 1. Origin of 23 advanced lines of sorghum.

S. N.	Lines	Pedigree	Region adapted	Kg/ha
1	GS-1	Kodikal-3	North Karnataka	2372
2	GS-2	Chincholi-2	North Karnataka	2353
3	GS-3	Mudbal-1	North Karnataka	2611
4	GS-4	M X Niralkodi-10-14-2	North Karnataka and Maharashtra	2684
5	GS-5	M X Niralkodi-9-14-1	North Karnataka and Maharashtra	2518
6	GS-6	JP-1-5	North Karnataka	2364
7	GS-7	M X Bommnahalli-4-2	North Karnataka	2303
8	GS-8	M X Bommnahalli-4-3	North Karnataka	2597
9	GS-9	(M X D) X M	North Karnataka	2674
10	GS-10	(M X D) -4-1-29-2	North Karnataka	2415
11	GS-11	(M X D)-4-2-1	North Karnataka	2536
12	GS-12	(M X Sapnapalli) X M -4-5	North Karnataka	2327
13	GS-13	(M X Sapnapalli)-4-5	North Karnataka	2279
14	GS-14	M X Bommnahalli-4-1	North Karnataka	2204
15	GS-15	M X Hottigudar-2 -4-5-2	North Karnataka	2732
16	GS-16	(M X Hottigudar-2) X M -2-1	North Karnataka	2454
17	GS-17	M X Hottigudar-2 -4-6	North Karnataka	2503
18	GS-18	Phule mule X M-18-1	North Karnataka	2621
19	GS-19	(IS26779 X M) X M -1-1-5-1	North Karnataka	2663
20	GS-20	(IS26779 X M) X M -1-1-5-2	North Karnataka	2810
21	GS-21	(IS26779 X M) X M -1-1-5-3	North Karnataka	2511
22	GS-22	(IS26779 X M) X M -1-1-5-4	North Karnataka	2775
23	GS-23	IS26779 X M -1-2-2-1	North Karnataka	2978
24	M-35-1	Land race selection	North Karnataka and Maharashtra	2549
25	Muguthi	Historical variety	North Karnataka and Maharashtra	2196

* M= M-35-1; D = DSV– 4

Table 2. Phenotypic and genotypic correlations among different quantitative traits in sorghum.

Traits		PH	SDM	EHL	EHD	DFF	DM	SW	FY	LDG	SY
PH	P	1	-0.3731**	0.5006**	-0.4592**	-0.6827**	-0.0339	0.4707**	0.5356**	0.3450**	0.7243**
	G		-0.5083**	0.5105**	-0.4735**	-0.7212**	-0.0358	0.6089**	0.5433**	0.372**	0.7409**
SDM	P		1	-0.8139**	0.8302**	0.4211**	-0.1643*	-0.2090**	-0.4995**	0.1312*	-0.5759**
	G			-0.9902**	0.9235**	0.5372**	-0.1734*	-0.3294	-0.6145**	0.1687*	-0.7060**
EHL	P			1	-0.9867**	-0.5701**	0.0358	0.3653**	0.4693**	-0.2158**	0.6002**
	G				-0.9926**	-0.5878**	0.0513	0.4665**	0.4707**	-0.2277**	0.6021**
EHD	P				1	0.4982**	-0.0780	-0.3710**	-0.5054**	0.2067**	-0.6098**
	G					0.5185**	-0.0912	-0.4644**	-0.5078**	0.2190**	-0.6136**
DFF	P					1	0.4374**	-0.0345	-0.2488**	-0.0884	-0.4803**
	G						0.4208**	-0.0539	-0.2534**	-0.1143*	-0.4875**
DM	P						1	0.3064**	-0.0128	-0.2176**	-0.0533
	G							0.4499**	-0.009	-0.2843**	-0.0405
SW	P							1	0.0488	-0.1063	0.1593*
	G								0.0398	-0.1537*	0.1880*
FY	P								1	0.5221**	0.9434**
	G									0.5545**	0.9476**
LDG	P									1	0.5263**
	G										0.5646**
SY	P										1

**Correlation is significant at the 0.01 level; *Correlation is significant at the 0.05 level; P-Phenotypic level; G- Genotypic level; PH : Plant height (cm); SDM : Stem Diameter (cm); EHL : Ear head length (cm); EHD: Ear head Diameter (cm); DFF : Days to 50% flowering; DM : Days to maturity; SW : 100 Seed weight (g); FY : Fodder yield per plot (kg); LDG : Lodging (%); SY : Seed yield per plot (kg).

Table 3. Direct and indirect effects of seed yield component traits on grain yield per plot at phenotypic and Genotypic level in sorghum.

Traits		PH	SDM	EHL	EHD	DFF	DM	SW	FY	LDG	r_{SY}
PH	P	0.1585	-0.0591	0.0794	-0.0728	-0.1082	-0.0054	0.0746	0.0849	0.0547	0.7243**
	G	-0.0470	0.0239	-0.0240	0.0223	0.0339	0.0017	-0.0286	-0.0255	-0.0175	0.7409**
SDM	P	0.0095	-0.0254	0.0207	-0.0211	-0.0107	0.0042	0.0053	0.0127	-0.0033	-0.5759**
	G	-0.0651	0.1280	-0.1267	0.1283	0.0688	-0.0222	-0.0422	-0.0786	0.0216	-0.7060**
EHL	P	0.1268	-0.2062	0.2533	-0.2500	-0.1444	0.0091	0.0925	0.1189	-0.0547	0.6002**
	G	0.2676	-0.5190	0.5241	-0.5202	-0.3081	0.0269	0.2445	0.2467	-0.1193	0.6021**
EHD	P	-0.0307	0.0556	-0.0661	0.0669	0.0334	-0.0052	-0.0248	-0.0338	0.0138	-0.6098**
	G	-0.1222	0.2587	-0.2561	0.2580	0.1338	-0.0235	-0.1198	-0.131	0.0565	-0.6136**
DFF	P	0.0606	-0.0374	0.0506	-0.0442	-0.0888	-0.0388	0.0031	0.0221	0.0078	-0.4803**
	G	0.1783	-0.1328	0.1453	-0.1282	-0.2472	-0.1041	0.0133	0.0627	0.0283	-0.4875**
DM	P	-0.0011	-0.0056	0.0012	-0.0026	0.0148	0.0338	0.0104	-0.0004	-0.0074	-0.0533
	G	-0.0043	-0.0207	0.0061	-0.0109	0.0502	0.1193	0.0537	-0.0011	-0.0339	-0.0405
SW	P	-0.0070	0.0031	-0.0054	0.0055	0.0005	-0.0045	-0.0148	-0.0007	0.0016	0.1593*
	G	0.0439	-0.0238	0.0337	-0.0335	-0.0039	0.0325	0.0722	0.0029	-0.0111	0.1880*
FY	P	0.3473	-0.3239	0.3043	-0.3277	-0.1613	-0.0083	0.0317	0.6484	0.3385	0.9434**
	G	0.4053	-0.4585	0.3512	-0.3789	-0.1891	-0.0067	0.0297	0.7461	0.4137	0.9476**
LDG	P	0.0604	0.0230	-0.0378	0.0362	-0.0155	-0.0381	-0.0186	0.0914	0.1751	0.5263**
	G	0.0842	0.0382	-0.0515	0.0496	-0.0259	-0.0644	-0.0348	0.1255	0.2263	0.5646**

Residual effect at phenotype level= 0.1303; Residual effect at genotype level= 0.0624; **Correlation is significant at the 0.01 level; *Correlation is significant at the 0.05 level; P-Phenotypic level; G- Genotypic level; PH : Plant height (cm); SDM : Stem Diameter (cm); EHL : Ear head length (cm); EHD: Ear head Diameter (cm); DFF : Days to 50% flowering; DM : Days to maturity; SW : 100 Seed weight (g); FY : Fodder yield per plot (kg); LDG : Lodging (%)

more likely both. In plant breeding correlation coefficient analysis measures the mutual relationship between two characters and it determines character association for improvement yield and other economic characters. Since the association pattern among yield components help to select the superior genotypes from divergent population based on more than one interrelated characters. Phenotypic and Genotypic correlations among different quantitative traits are presented in table 2. In general the genotypic correlation was generally of higher magnitude than phenotypic correlation, indicating that inherent association between various characters studied. The seed yield showed significant positive correlation with plant height (rp= +0.7243, rg=+0.7409), ear head length (rp=+ 0.6002, rg=+0.6021), seed weight (rp=+0.1593, rg=+ 0.1880), fodder yield (rp=+0.9434, rg=+0.9476) and lodging percentage (rp=+ 0.5263, rg=+ 0.5646) at both genotypic and phenotype level. Significant positive correlation for plant height was reported by Yazdani (2012), whereas negative significant association reported by Reddy *et al.* (2009). Mahajan *et al.* (2011) reported increase in ear head length was correlated with grain yield. Warkad *et al.* (2010) indicated the increase in seed weight associated with grain yield. Jain and Patel (2013) expressed green fodder yield showed positive correlation with dry fodder yield, number of leaves per plant, plant height, leaf length and stem girth.

Days to 50 per cent flowering (rp= -0.4803, rg= -0.4875), days to maturity (rp=-0.0533, rg=-0.0405), ear head diameter (rp= -0.6098, rg=-0.6136) and stem diameter (rp= -0.5759, rg=-0.7060) were negatively associated with gain yield. Negative association of grain yield and days to 50% flowering reported by Kenga *et al*. (2006). Contrast results of no association between between grain yield and days to maturity by Warkad *et al.* (2010). Opposite results of positive association of earhead diameter and grain yield reported by Gebeyehu and Geremew (1993). Jain and Patel (2013) reported stem girth was positively correlated with green fodder. Warkad *et al.* (2010) not observed any association of stem girth with gain yield.

Due to mutual cancellation of component traits, the estimation of correlation alone may be often misleading so it is necessary to study the path co-efficient analysis, which takes into account the casual relationship in addition to the degree of relationship. Hence genotypic and phenotypic correlation was partitioned into direct and indirect effects to know the relative importance of the components (Table 3). Path coefficient analysis revealed that the high positive direct effect at phenotypic and genotypic level were observed for ear head length (Ppi=+ 0.2533, Pgi=+0.5241), ear head diameter (Ppi=+0.0669, Pgi= +0.2580), days to maturity (Ppi=+0.0338, Pgi=+0.1193), fodder yield (Ppi=+0.6484, Pgi= +0.7461) and lodging percentage (Ppi=+0.1751, Pgi=+0.2263). Further low positive direct effect on seed yield was observed *via* of days to maturity. Considerable positive indirect effects were observed *via* through ear head length (pril=+0.0012, gril=+0.0061), days to 50 per cent flowering (pril=+0.0148, gril=+0.0502) and seed weight (pril=+0.0104, gril=+0.0537). While negative indirect effects on grain yield were recorded through plant height (pril=-0.0011, gril=-0.0043), stem diameter (pril=-0.0056, gril= -0.0207), ear head diameter (pril=-0.0026, gril=-0.0109), fodder yield (pril=-0.0004, gril=-0.0011) and lodging percentage (pril=-0.0074, gril=-0.0339). El-Din *et al*. (2012) revealed panicle length (Ppi=0.0111) had positive direct effect on sorghum grain yield. Its positive indirect effect was through plant height (pril=0.0064), days to flowering (pril=0.0041), days to maturity, leaf area (pril=0.0004), 1000 kernal weight (pril=0.0432) and kernal numbers per head (pril=0.1784). Whereas its indirect effect was negative through panicle internodes (pril=-0.0017) and panicle width (pril=-0.00006.). Residual effects were Pr=0.1303 and Gr=0.0624 at phenotypic and genotypic levels.

Conclusion

The traits like plant height stem diameter, ear head length, ear head diameter, seed weight and fodder yield had higher correlation and direct effect on seed yield. Therefore, due concern should be set to these characters, while scheduling a breeding strategy for increased grain yield per plant.

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