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RESEARCH PAPER

Correlation and path analysis of yield traits in B & R lines of *rabi* sorghum [*Sorghum bicolor* (L.) Moench]

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Abstract: The present investigation was carried out for correlation and path coefficient analysis using 32 *rabi* sorghum hybrid parents including maintainers (B) and restorer (R) lines for grain yield and its attributes. The experimental material was evaluated during *rabi* season 2021-22 at Regional Agricultural Research Station, Vijayapur in randomized block design with two replications. The character association studies revealed that grain yield per plant was found to be significantly and positively correlated with days to 50% flowering, plant height, panicle breadth, panicle weight, harvest index, panicle harvest index, seed set percentage and grain number per plant both at genotypic and phenotypic level. Path analysis revealed that characters such as panicle weight, panicle harvest index, harvest index, fodder yield per plant, days to 50% flowering and SPAD at physiological maturity showed a positive direct effect on grain yield per plant. These traits can be considered as principal yield determining components and it is suggested to use these as indirect selection criteria for B and R-line improvement.

Key words: Correlation, Hybrid parents, Maintainers (B), Path analysis, *Rabi* sorghum, Restorer (R)

Introduction

Grain sorghum [*Sorghum bicolor* (L.) Moench] is one of the five important cereal crops cultivated across the world. In India it is a third cereal crop after wheat and rice. It is grown mainly in semi-arid areas of the tropics and sub-tropics. Grain sorghum is a basic human food crop in many developing African and Asian countries. It is a multi purpose crop exploited for its grain, fodder and biofuel potential. It has outcrossing up to (6%) depending on the genotype and growing conditions and considered as an often-cross- pollinated crop.The crop is grown on 4.37 mha in India, with yields of 4.8 million metric tonnes and productivity of 1099 kg/ha. In Karnataka it is grown in 0.75 mha with a production and productivity of 4.80 million metric tonnes and 1205 kg/ha, respectively (Anon, 2021). In India, sorghum is cultivated during both *kharif* (rainy) and *rabi* (post-rainy) seasons.

Rabi sorghum is highly valued because of its excellent grain and fodder quality. The low grain productivity in the *rabi* season sorghum in India is due to both biotic and abiotic constraints coupled with low genetic variability among the post rainy season sorghum germplasm. Much of the area cultivated during the post rainy season is under landraces that have a poor yield potential. Moreover, sorghum is grown under receding soil moisture after the cessation of the rains. So, end of season moisture stress is also a major production constraint. Sowing of post-rainy season sorghum in India starts from first week of September and extends up to first week of November depending upon the rainfall pattern. This season is characterized by reduced sunshine hours and cooler nights which affect the crop growth and productivity.

Understanding the nature of association of the characters, cause and effect relationship will help indirect improvement through selection for component traits.The study of relationships among traits is very essential for assessing the feasibility of joint selection for two or more traits. Grain yield per plant is the result of direct and indirect effects of several yield contributing characters. Path coefficient analysis partitions correlation coefficient into direct and indirect effects of various traits towards dependent variable, thus helps in effective selection.This will provide more precise information for the selection of important traits, which may contribute more towards grain yield.

Material and methods

The present investigation was carried out during *rabi* season 2021–22 at the Regional Agricultural Research Station, Vijayapur. The study included 32 elite sorghum genotypes, including hybrid parents (B and R lines) and check varieties. The experiment was laid out in a randomized block design with two replications. Each line consists of two rows of three meters each, spaced 60 cm apart. All recommended agronomic and plant protection practices were followed regularly as per need for better crop stand and expression. Observations on plant height (cm),SPAD at physiological maturity, panicle length (cm), panicle breadth (cm), panicle weight (g), grain yield per plant (g/plant), fodder yield per plant (g/plant), seed set percentage and pollen fertility percentage and 100 seed weight (g) were recorded on randomly chosen five plants in each entry. Days to fifty percent flowering was recorded on plot basis.

Results and discussion

For the majority of crops, knowledge of the degree of interrelationship between yield and yield components is necessary in order to breed high yielding varieties. The magnitude and direction of the associations between the

component traits and yield highly influence the effectiveness of yield selection. In order to develop efficient selection techniques, correlation studies provide estimates of the degree of relationship between yield and its component. Genotypic correlation refers to the correlation between the genetic values of two traits in a population. It measures the degree of similarity or dissimilarity in the genetic factors that influence the expression of those traits. It quantifies the tendency of genes to be inherited together or independently. Phenotypic correlation, on the other hand, measures the strength and direction of the relationship between the observable traits of individuals within a population. These traits may or may not have a shared genetic basis, and their correlation can be influenced by genetic factors, environmental factors, or a combination of both.The estimates of phenotypic and genotypic correlations coefficients among the fourteen traits are discussed below.

Correlation coefficient

The correlation coefficient is a statistical measure that indicates the degree and magnitude of association between two variables. This association is likely due to pleiotropic gene action, linkage, or both. Correlation coefficient analysis in plant breeding determines character association for improved yield and other economic characters. Thus, information on the degree and magnitude of association between characters is critical for the breeder to kickstart any selection strategy. Phenotypic and Genotypic correlation coefficient matrix between yield and yield attributing traits are represented in Table 1. Results showed that most of genotypic correlations were found to be higher than phenotypic correlations.

Grain yield per plant was found to be significantly and positively correlated withdays to 50% flowering (r_g=0.541**, r_p=0.387**), plant height (r_g=0.411*, r_p=0.349**), panicle breadth (r_g=0.428*, r_p=0.428**), panicle weight (r_g=0.877**, r_p=0.918**), panicle harvest index (r_g=0.797**, r_p=0.706**), harvest index (r_g=0.878**, r_p=0.829**), grain number per plant (r_g=0.936**, r_p=0.941**) and seed set percentage (r_g=0.605**, r_p=0.483**) at both genotypic and phenotypic level, respectively.The results are in concordance with Baviskar *et al.* (2005) for panicle weight and breadth, Rajkumar *et al.* (2007) for days to 50% flowering, Umakanth *et al.* (2004) for plant height, Tag El-Din *et al.* (2012) for grain number per plant and Chavan *et al.* (2011) for harvest index. The results indicate that these traits are most important for yield *per se* and should be selected for the study as indirect selection criteria.

Table 1. Genotypic (G) and Phenotypic (P) correlation coefficients between yield and yield component traits in hybrid parents (B and R lines) of *rabi* sorghum

		DFF	SPAD	PH	PL	PB	PW	100SW	PHI	F W	HI	NSP	SSP	PVP	GW
DFF	G	1.00**	-0.221	0.314	-0.018	-0.108	0.440*	-0.126	0.439*	0.622**	0.204	0.553**	0.568**	0.300	0.541**
DFF	P	1.00**	-0.079	0.263*	0.036	0.032	0.307*	-0.207	0.341**	0.387**	0.207	0.437**	0.354**	0.198	0.387**
SPAD	G		1.00**	-0.105	0.285	0.122	0.182	0.027	0.106	0.100	0.094	0.234	0.555**	0.237	0.218
SPAD	P		1.00**	-0.023	0.010	0.014	-0.022	0.133	0.089	-0.113	0.11	0.000	0.022	-0.071	0.036
PH	G			1.00**	-0.337	0.169	0.125	0.485**	0.699**	0.610**	0.205	0.253	0.238	0.383*	0.411*
PH	P			1.00**	-0.260*	0.137	0.189	0.294*	0.537**	0.327**	0.235	0.260*	0.262*	0.263*	0.349**
PL	G				1.00**	0.272	0.389*	-0.173	-0.364*	-0.157	-0.046	0.125	-0.334	-0.201	0.083
PL	P				1.00**	0.254*	0.312*	-0.229	-0.264*	-0.098	0.041	0.184	-0.105	-0.043	0.122
PB	G					1.00**	0.556**	0.369*	0.166	-0.054	0.372*	0.311	-0.085	-0.119	0.428*
PB	P					1.00**	0.506**	0.180	0.170	-0.027	0.381**	0.359**	0.111	-0.132	0.428*
PW	G						1.00**	0.075	0.422*	-0.115	0.705**	0.852**	0.256	0.325	0.877**
PW	P						1.00**	0.004	0.384**	0.063	0.700**	0.890**	0.353**	0.218	0.918**
100SW	G							1.00**	0.339	0.386*	0.081	-0.146	0.238	0.044	0.202
100SW	P							1.00**	0.289*	0.238	0.057	-0.211	0.062	-0.044	0.116
PHI	G								1.00**	0.104	0.785**	0.690**	0.835**	0.325	0.797**
PHI	P								1.00**	0.218	0.715**	0.611**	0.518**	0.185	0.706**
F W	G									1.00**	-0.435*	-0.156	0.206	0.557**	-0.026
F W	P									1.00**	-0.345**	0.060	0.027	0.243	0.142
HI	G										1.00**	0.849**	0.580**	0.031	0.878**
HI	P										1.00**	0.796 **	0.496**	0.076	0.829**
NSP	G											1.00**	0.541**	0.321	0.936**
NSP	P											1.00**	0.470**	0.229	0.941**
SSP	G												1.00**	0.346	0.605**
SSP	P												1.00**	0.233	0.483**
PVP	G													1.00**	0.338
PVP	P													1.00**	0.206
GW	G														1.00**
GW	P														1.00**

DFF - Days to 50% flowering PVP - Pollen fertility (%) SPAD - SPAD@ physiological maturity PH - Plant height (cm)
PL - Panicle length (cm) PB - Panicle breadth (cm) PW - Panicle weight (g)
GW - Grain yield per plant(g)100 SW - 100 seed weight (g) PHI - Panicle Harvest Index (%) FW - Fodder yield per plant (g)
HI - Harvest Index (%) NSP - Grain number per plant (no.) SSP - Seed set percentage (%)

Table 2. Genotypic (G) and phenotypic (P) path coefficient analysis showing direct (diagonal and bold) and indirect effects of different traits on grain yield per plant in hybrid parents (B &R lines) of *rabi* sorghum

		DFF	SPAD	PH	PL	PB	PW	100SW	PHI	F W	HI	NSP	SSP	PVP
DFF	G	0.043	-0.033	0.089	0.003	0.014	0.515	0.021	0.153	-0.048	-0.002	-0.224	0.078	-0.067
	P	0.007	-0.001	-0.001	0.000	-0.001	0.132	-0.027	0.052	0.032	0.030	0.173	-0.002	-0.007
SPAD	G	-0.010	0.150	-0.030	-0.042	-0.016	0.213	-0.005	0.037	-0.008	-0.001	-0.095	0.076	-0.053
	P	-0.001	0.006	0.000	0.000	0.000	-0.009	0.017	0.014	-0.009	0.016	0.000	0.000	0.003
PH	G	0.014	-0.016	0.282	0.050	-0.022	0.146	-0.082	0.243	-0.047	-0.002	-0.103	0.033	-0.086
	P	0.002	0.000	-0.004	0.002	-0.005	0.081	0.039	0.082	0.027	0.034	0.103	-0.001	-0.010
PL	G	-0.001	0.043	-0.095	-0.148	-0.036	0.456	0.029	-0.127	0.012	0.000	-0.051	-0.046	0.045
	P	0.000	0.000	0.001	-0.006	-0.009	0.134	-0.030	-0.040	-0.008	0.006	0.073	0.001	0.002
PB	G	-0.005	0.018	0.048	-0.040	-0.130	0.651	-0.062	0.058	0.004	-0.003	-0.126	-0.012	0.027
	P	0.000	0.000	-0.001	-0.002	-0.036	0.218	0.023	0.026	-0.002	0.055	0.142	-0.001	0.005
PW	G	0.019	0.027	0.035	-0.057	-0.073	1.172	-0.013	0.147	0.009	-0.005	-0.345	0.035	-0.073
	P	0.002	0.000	-0.001	-0.002	-0.018	0.430	0.000	0.059	0.005	0.101	0.352	-0.002	-0.008
100SW	G	-0.005	0.004	0.137	0.026	-0.048	0.088	-0.168	0.118	-0.030	-0.001	0.059	0.033	-0.010
	P	-0.001	0.001	-0.001	0.001	-0.006	0.002	0.131	0.044	0.020	0.008	-0.083	0.000	0.002
PHI	G	0.019	0.016	0.197	0.054	-0.022	0.495	-0.057	0.348	-0.008	-0.006	-0.280	0.114	-0.073
	P	0.002	0.001	-0.002	0.002	-0.006	0.165	0.038	0.153	0.018	0.103	0.242	-0.003	-0.007
F W	G	0.027	0.015	0.172	0.023	0.007	-0.135	-0.065	0.036	-0.077	0.003	0.063	0.028	-0.125
	P	0.003	-0.001	-0.001	0.001	0.001	0.027	0.031	0.033	0.083	-0.050	0.024	0.000	-0.009
HI	G	0.009	0.014	0.058	0.007	-0.048	0.826	-0.014	0.273	0.033	-0.008	-0.344	0.079	-0.007
	P	0.001	0.001	-0.001	0.000	-0.014	0.301	0.007	0.109	-0.029	0.144	0.315	-0.002	-0.003
NSP	G	0.024	0.035	0.071	-0.018	-0.041	0.998	0.025	0.240	0.012	-0.006	-0.406	0.074	-0.072
	P	0.003	0.000	-0.001	-0.001	-0.013	0.383	-0.028	0.094	0.005	0.114	0.395	-0.002	-0.008
SSP	G	0.025	0.083	0.067	0.049	0.011	0.300	-0.040	0.291	-0.016	-0.004	-0.219	0.137	-0.078
	P	0.002	0.000	-0.001	0.001	-0.004	0.152	0.008	0.079	0.002	0.071	0.186	-0.005	-0.008
PVP	G	0.013	0.036	0.108	0.030	0.016	0.381	-0.007	0.113	-0.043	0.000	-0.130	0.047	-0.224
	P	0.001	0.000	-0.001	0.000	0.005	0.094	-0.006	0.028	0.020	0.011	0.090	-0.001	-0.036

Residual effect 0.0022 (G) and 0.0036 (P) DFF - Days to 50% flowering PVP - Pollen fertility (%)SPAD - SPAD@ physiological maturity
PH - Plant height (cm) PL - Panicle length (cm) PB - Panicle breadth (cm) PW - Panicle weight (g) GW - Grain yield per plant(g)
100 SW - 100 seed weight (g) PHI - Panicle Harvest Index (%) FW - Fodder yield per plant (g) HI - Harvest Index (%)
NSP - Grain number per plant (no.) SSP - Seed set percentage (%)

Fodder yield per plant was found to be significantly and positively correlated with days to 50% flowering (r_g=0.622**, r_p=0.387**), plant height (r_g=0.610**, r_p=0.327**), 100 seed weight (r_g=0.386*) and pollen fertility percentage (r_g=0.557**). Chavhan *et al.* (2022) also observed similar observations for days to 50% flowering and plant height and Goswami *et al.* (2020) for days to flowering and plant height with fodder yield per plant. Harvest index (r_g= -0.435*, r_p= -0.345**) was found to be significantly and negatively correlated with fodder yield per plant. This result is in accordance with Vinutha (2021) and Chavhan *et al.* (2022).

Path analysis

Path analysis divides the total correlation coefficients into direct and indirect effects and determines the relative importance of each causal factor separately. Results of phenotypic and genotypic path coefficient analysis showing direct and indirect effects of traits on grain yield per plant are presented in Table 2. Among the thirteen traits studied as independent variables influencing the grain yield per plant, maximum direct effect was recorded for panicle weight (1.172) followed by panicle harvest index (0.348), plant height (0.282), SPAD at physiological maturity (0.150), seed set percentage (0.137) and days to 50% flowering (0.043) and negative direct effect on yield was recorded for some of the traits *viz.,* grain number per plant (-0.406), pollen fertility percentage (-0.224), 100 seed weight (-0.168), panicle length (-0.148) and panicle breadth (-0.130) at genotypic level. Similar results were observed by Arunkumar (2013) for plant height and seed set percentage, Goswami *et al.* (2020) for panicle length and Deshmukh *et al.* (2021) for days to 50% flowering.

At phenotypic level panicle weight (0.430), grain number per plant (0.395), panicle harvest index (0.153), harvest index (0.144), 100 seed weight (0.131) and fodder yield per plant (0.083) had positive direct effect on grain yield per plant. Verma and Biradar (2021) noticed similar results for panicle weight, grain number per panicle and 100 seed weight and Khadakabhavi *et al.* (2017) for test 1000 seed weight. The characters, panicle weight showed a positive indirect effect on grain yield through all the other traits *viz.,* days to 50% flowering (0.132), plant height (0.081), panicle length (0.134), panicle breadth (0.218), panicle harvest index (0.165), harvest index (0.301), grain number per plant (0.383), seed set percentage (0.152) and pollen fertility percentage (0.094).

The Residual effect (at genotypic level = 0.0022 and at phenotypic level = 0.0036) in path coefficient analysis was considerably low, indicating a high contribution of independent traits to the dependent trait (grain yield per plant).

Conclusion

The character association studies revealed that grain yield per plant was found to be significantly and positively correlated with days to 50% flowering, plant height, panicle breadth, panicle weight, harvest index, panicle harvest index, seed set percentage and grain number per plant both at both genotypic and phenotypic level. Panicle weight, panicle harvest index, harvest index, 100 seed weight, fodder yield per plant, days to 50% flowering and SPAD at physiological maturity showed positive direct effect on grain yield per plant indicating importance of these characters, which can be strategically used for genetic improvement of grain yield.

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