



## Character association studies in *rabi* sorghum (*Sorghum bicolor* L.)

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**Abstract:** An experiment was conducted to determine the character association for grain yield and its component characters and their direct and indirect effects to provide necessary information that could be useful in *rabi* sorghum improvement programme aimed at improving grain yield during *rabi* 2012. Significant and positive association ( $P < 0.01$ ) of grain yield per plant with panicle dry weight ( $r = 0.784$ ), days to 50% flowering ( $r = 0.770$ ) and total biomass ( $r = 0.635$ ). Grain yield per plant was positively correlated with plant height ( $r = 0.160$ ), SCMR ( $r = 0.110$ ), leaf dry weight ( $r = 0.335$ ), 1000 grain weight ( $r = 0.256$ ), RLWC ( $r = 0.094$ ) and number of leaves per plant ( $r = 0.089$ ) at genotypic level. Whereas total biomass ( $r = 0.602$ ) and panicle dry weight ( $r = 0.743$ ) exhibited significant and positive association ( $P < 0.01$ ) with grain yield per plant. While stem dry weight ( $r = 0.864$ ) and panicle dry weight ( $r = 0.780$ ) showed positive and significant association ( $P < 0.01$ ) with total biomass per plant at phenotypic level. Stem dry weight had highest direct effect (17.59), followed by panicle dry weight (15.81), leaf dry weight (2.51) and days to 50% flowering (0.326). While total biomass per plant (-28.33) showed highest negative direct effect on grain yield. Stem dry weight and panicle dry weight showed maximum negative indirect effect via total biomass while indirect effect of total biomass was positive via stem weight and panicle dry weight.

**Key words:** *Rabi* sorghum, Correlation coefficient and Path coefficient analysis

### Introduction

Sorghum is one of the main staples for the world's poorest and most food insecure people. The crop is genetically suited to hot and dry agro-ecologies, where it is difficult to grow other food grains and these are also areas subject to frequent drought which allows farmers to use one third less water than similar crops in its cultivation (Kumar *et al.*, 2012). In Maharashtra State sorghum is truly a dual-purpose crop; both grain and stover are highly valued outputs. Therefore, it can play a vital role for the uplift of socio-economic status of the farmers residing in these areas. Various morpho-physiological and growth parameters have been hypothesized to affect yield in sorghum, but the evidence have been inconsistent. Association of these parameters with yields is considered to be very useful for selecting genotypes under drought condition. Strategies for obtaining higher yields should lay emphasis on tapping the biological potential of the crops, for which various morpho-physiological and growth parameters that influence crop, yield needs to be identified, so that they can be used as selection indices. Indian *rabi* sorghum landraces are rich repository of genetic variability and are preserved by the farmers due to local adaptability, good grain quality and for specific food products. Thus, it becomes more relevant to utilize such typical landraces in breeding programs.

The trait grain yield, being an important and complex character, is a function of several component characters. In the integrated structure of a plant, most of the characters are interrelated.

The direct selection based on yield alone is not very effective (Grafius 1964) and it has been pointed out that it would be more meaningful if the structure of yield is probed through its components rather than directly. Hence, it is necessary to study these yield components, their inter-relationship with yield and their contribution. The phenotype of a plant is the result of interaction of a large number of factors. Final yield is the sum of effects of several component factors. Correlation coefficient helps in determining the direction of selection and number of characters to be considered in improving the grain yield. Mallinath *et al.* (2004) stated that, plant height, test weight, and grain yield/panicle had showed positive significant association at both levels with all characters except days to 50% flowering and days to maturity. 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 into account the casual relationship in addition to degree of relationship (Mahajan 2011). The path coefficient analysis 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. Ikanovic (2010) 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. The present study was conducted to assess correlation and path coefficient analysis for

yield and its component characters to provide necessary information that could be useful in sorghum improvement programmes aimed at improving grain yield of *rabi* sorghum.

**Materials and Methods**

The experiment was conducted in complete randomized block design with three replications during *rabi* season of 2012 under rainfed condition at Sorghum Research Station, Vasantrya Naik Krishi Marathwada Krishi Vidyapeeth, Parbahani. The experimental material comprised of total 48 lines consisted of advanced breeding lines, land races and varieties for post flowering drought tolerance of *rabi* sorghum (*Sorghum bicolor* L.). Each genotype was sown in a single row per plot of 3 m length in each replication. The row to row and plant to plant distance was kept at 45 and 15 cm, respectively. Only pre-sowing irrigation was applied to ensure proper seed germination. The all other recommended agronomical practices were followed to raise a good crop. Observations were recorded on twelve characters *viz.*, Plant height (cm), Seed vigor, Days 50% flowering, Total number of leaves per plant, Leaf dry weight per plant (g) at physiological maturity, Stem dry weight per plant (g) at physiological maturity, panicle dry weight per plant (g) at physiological maturity, Relative water content (%), SCMR at 50% flowering, Total biomass per plant (g at physiological maturity), 1000 grain weight, Grain yield per plant (g).

The statistical procedure as suggested by Wright (1921) and elaborated by Dewey and Lu (1959) was adopted for the

estimation of direct and indirect contribution of various characteristics to seed yield calculated through path coefficient analysis.

**Results and Discussion**

Correlation analysis provides the information of interrelationship of important plant characters and hence, leads to a directional model for direct and/or indirect improvement in grain yield (Khan *et al.*, 2004). Although direct selection for various parameters could be misleading, indirect selection *via* related parameters with high heritability might be more effective than direct selection (Toker *et al.*, 2004).

Genotypic correlation was generally of higher magnitude than phenotypic correlation (Table-1) indicating that inherent association between various characters studied. Table 1 indicates the significant and positive association (P<0.01) of grain yield per plant with panicle dry weight (r=0.784), days to 50 % flowering (r=0.770) and total biomass (r=0.635) at genotypic level. The contribution of panicle dry matter to grain yield in Sorghum was also reported by Sriram and Rao (1983). Similar results were also obtained by Sanjana Reddy *et al.* (2012). A significant and positive correlation of 50% flowering with grain yield (r=0.770) suggested that the late maturing genotypes accumulates more dry matter for maximum expression of these characters (Saini and Paroda 1978). Grain yield per plant was positively correlated with plant height (r=0.160), SCMR (r=0.110), leaf dry weight (r=0.335), 1000 grain weight (r=0.256), RLWC (r=0.094) and number of leaves per plant

**Table-1:** Genotypic and Phenotypic correlation coefficient between grain yield and its component characters in Sorghum

Characters	Correlation	Plant height (cm)	Seed vigor	Days 50% flowering	Total No. of leaves /plant	Leaf dry weight (g/plant)	Stem dry weight (g/plant)	Panicle dry weight (g/plant)	Relative water content (%)	SPAD chlorophyll meter reading at 50% flowering	Total biomass (g/plant)	1000 grain weight (g)	Grain yield (g/plant)
Plant height (cm)	G	1	0.066	0.186	0.11	0.007	0.033	0.173	0.087	-0.152	0.113	-0.1	0.16
	P	1	0.026	0.176	0.107	-0.004	0.027	0.167	0.087	-0.125	0.105	-0.113	0.139
Seed vigor	G		1	0.022	-0.382	-0.126	0.05	-0.302	-0.102	0.055	-0.137	-0.112	-0.115
	P		1	0.055	-0.191	-0.127	0.021	-0.216	-0.045	0.047	-0.113	-0.077	-0.117
Days 50% flowering	G			1	0.085	-0.003	-0.650**	0.074	-0.02	-0.364	-0.002	0.11	0.770**
	P			1	0.011	-0.031	-0.048	0.029	0.002	-0.311	-0.018	0.036	0.043
Total No. of leaves/plant	G				1	0.207	0.055	0.267	0.217	0.218	0.192	-0.115	0.089
	P				1	0.118	0.6	0.152	0.101	0.114	0.129	-0.125	0.041
Leaf dry weight (g/plant)	G					1	0.463	0.244	-0.079	0.265	0.498	0.133	0.335
	P					1	0.378	0.188	-0.117	0.141	0.433	0.116	0.258
Stem dry weight (g/plant)	G						1	0.39	0.105	0.178	0.868**	0.088	0.312
	P						1	0.369	0.097	0.122	0.864**	0.071	0.293
Panicle dry weight (g/plant)	G							1	0.114	0.092	0.791**	0.186	0.784**
	P							1	0.11	0.09	0.780**	0.123	0.743**
Relative water content (%)	G								1	0.002	0.119	0.131	0.094
	P								1	-0.03	0.109	0.102	0.059
SPAD chlorophyll meter reading at 50% flowering	G									1	0.181	-0.268	0.11
	P									1	0.138	-0.225	0.029
Total biomass (g/plant)	G										1	0.164	0.635**
	P										1	0.12	0.602*
1000 grain weight (g)	G											1	0.256
	P											1	0.173
Grain yield (g/plant)	G												1
	P												1

Significant at 0.05 (\*) and 0.01 (\*\*)

**Table-2:** Direct and indirect effects of characters on grain yield/plant in sorghum

Characters	Plant height (cm)	Seed vigor	Days 50% flowering	Total No. of leaves /plant	Leaf dry weight (g/plant)	Stem dry weight (g/plant)	Panicle dry weight (g/plant)	Relative water content (%)	SPAD chlorophyll meter reading at 50% flowering	Total biomass (g/plant)	1000 grain weight (g)
Plant height (cm)	0.038	0.011	-0.060	-0.020	0.004	0.595	2.750	-0.008	0.011	-3.208	0
Seed vigor	0.002	0.18	-0.007	0.067	-0.318	0.896	-4.779	-0.001	0.004	3.897	-0.001
Days 50% flowering	0.007	0.004	0.326	-0.010	-0.009	-1.150	1.170	-0.002	0.026	0.057	0
Total number of leaves/plant	0.004	-0.069	-0.027	-0.180	0.052	0.970	4.237	0.022	-0.015	-5.450	0
Leaf dry weight (g/plant)	0	-0.022	0.001	-0.040	2.514	8.152	3.860	-0.008	-0.019	-14.120	-0.001
Stem dry weight (g/plant)	0.001	0.009	0.021	-0.010	1.165	17.592	6.182	0.010	-0.013	-24.600	0.000
Panicle dry weight (g/plant)	0.006	-0.054	-0.024	-0.050	0.614	6.877	15.812	0.011	-0.006	-22.41	0
Relative water content (%)	-0.003	-0.018	0.006	-0.040	-0.200	1.589	1.802	0.102	0	-3.386	0.000
SPAD at 50% flowering	-0.005	0.001	0.118	-0.040	0.668	3.132	1.467	0	-0.073	-5.137	0.111
Total biomass (g/plant)	0.004	-0.024	0	-0.030	1.253	15.279	12.509	0.012	-0.013	-28.33	0.000
1000 grain weight (g)	-0.003	-0.02	-0.036	0.020	0.334	1.56	2.944	0.013	0.0196	-4.65	0.000

( $r=0.089$ ). A positive correlation of SPAD chlorophyll meter reading (SCMR) at 50% flowering with grain yield indicated that higher chlorophyll concentration is vital for adaptation to water deficit conditions during post flowering growth period. Plant height exhibited significant positive correlation with days to flowering (Abraha *et al.* 2015). Seed vigor showed positive correlation with days to 50% flowering ( $r=0.22$ ), stem dry weight ( $r=0.50$ ) and SCMR ( $r=0.55$ ). Whereas Days to 50 % flowering showed positive but non-significant association with 1000 grain weight ( $r=0.85$ ), panicle dry weight ( $r=0.74$ ) and test weight ( $r=0.110$ ) but negative and significant association ( $P<0.01$ ) with stem dry weight ( $r=-0.650$ ). Total number of leaves per plant showed positive correlation with leaf dry weight ( $r=0.207$ ), panicle dry weight ( $r=0.267$ ), stem dry weight ( $r=0.55$ ) relative water content ( $r=0.217$ ), SCMR ( $r=0.218$ ) and total biomass ( $r=0.192$ ) stating its importance in the expression of these characters in positive direction. Tesso *et al.* (2011) and Abubakar and Bubuche (2013) reported that, leaf number had positive correlation with straws weight, plant height had high negative correlation with 100- grain weight. Positive association between leaves per plant and dry plant weight was also observed by Khandelwal *et al.* (2015) and Jain *et al.* (2013). Moreover leaf dry weight had positive correlation with total biomass ( $r=0.498$ ), stem dry weight ( $r=0.463$ ), panicle dry weight ( $r=0.244$ ), SCMR ( $r=0.265$ ) and 1000 grain weight ( $r=0.133$ ). Stem dry weight exhibited positive and significant correlation ( $P<0.01$ ) with total biomass ( $r=0.868$ ) and positive but non significant correlation with panicle dry weight ( $r=0.390$ ), RLWC ( $r=0.105$ ) and SCMR ( $r=0.178$ ) indicating the importance of these characters when crop is grown under moisture deficit condition. Whereas, panicle dry weight showed positive and significant ( $P<0.01$ ) correlation with total biomass ( $r=0.791$ ) but it was non-significantly correlated with RLWC ( $r=0.114$ ), 1000 grain weight ( $r=0.186$ ). RLWC is the ability of a plant to maintain high water in the leaves under moisture stress conditions and has been used as an index to determine drought tolerance in crop plants (Barrs *et al.* 1962). Blum *et al.* (1989) reported that higher leaf RLWC allows the plant to maintain turgidity, and this would exhibit relatively less reduction in biomass and yield. Relative water content was positively correlated

with total biomass ( $r=0.119$ ) and 1000 grain weight ( $r=0.131$ ). Whereas total biomass ( $r=0.602$ ) and panicle dry weight ( $r=0.743$ ) exhibited significant and positive association ( $P<0.01$ ) with grain yield per plant. While stem dry weight ( $r=0.864$ ) and panicle dry weight ( $r=0.780$ ) showed positive and significant association ( $P<0.01$ ) with total biomass per plant at phenotypic level. Furthermore test weight showed positive association with grain yield both at genotypic and phenotypic level. The results obtained are similar to the results obtained by Aml *et al.* (2012) and Godbharle *et al.* (2010). Correlation studies suggest that panicle dry weight, days to 50 % flowering and total biomass are the important traits in improving plant productivity. While, physiological characters like RLWC, SCMR plays a vital role in improving grain yield under moisture stress condition by maintaining optimum turgor pressure at cellular level and photosynthetic activities, respectively.

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. Partitioning of total correlation into direct and indirect effects provides actual information on contribution of characters and thus forms the basis for selection to improve the yields (Table-2).

Path coefficient analysis suggest that out of 12 characters, nine exhibited positive direct effect on grain yield per plant. Stem dry weight had highest direct effect (17.59), followed by panicle dry weight (15.81), leaf dry weight (2.51) and days to 50% flowering (0.326). Similar results were found by Veerbhadhiran and Kennedy (2001) for days to 50 % flowering. While total biomass per plant (-28.33) showed highest negative direct effect on grain yield.

Indirect effect on grain yield/plant were also estimated it was found that stem dry weight and panicle dry weight showed maximum negative indirect effect *via* total biomass while indirect effect of total biomass was positive *via* stem weight and panicle dry weight. Similarly indirect effect of panicle dry weight *via* stem dry weight, number of leaves per plant *via* panicle dry weight, SCMR

via stem dry weight and RLWC via panicle and stem dry weight were positive on grain yield per plant.

The path coefficient analysis revealed the direct and indirect contribution of total biomass, stem dry weight, panicle dry weight, leaf dry weight, days to 50% flowering and relative water content on grain yield. The above findings suggest that improvement in grain yield could be achieved mainly through these traits. The residual effect was found to be moderate which indicates that there may be some more components that are contributing towards grain yield.

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