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Character Association and Path Analysis for Drought Tolerance in Post Rainy Sorghum (*Sorghum bicolor* (L). *Moench*)

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ABSTRACT
The present study was conducted to assess correlation and path coefficient analysis for drought contributing traits and yield in 28 post rainy sorghum genotypes (Sorghum bicolor (L). Moench).These 28 genotypes along with two checks (B-35 and CSV-23) were grown at Sorghum Research Station, Vasantrao Naik Marathwada Agricultural University, Parbhani during rabi 2016-17 in randomized block design with three replications. The agronomic and plant protection measures were followed as and when required during the period of crop growth. Observations were recorded on five randomly selected plants in each entry from each replication. Significant and positive association with grain yield per plant (g) was exhibited by total 13 traits viz.,plant height, panicle dry weight and total biomass at 50% flowering, leaf dry weight and panicle dry weight at maturity (g), total biomass at maturity, harvest index, grain number per panicle, 1000 grain weight, leaf area (cm)and leaf area index at flowering both at genotypic and phenotypic level. Days to 50 per cent flowering and days to physiological maturity showed negative and significant correlation with grain yield per plant suggesting late maturing genotypes accumulates more dry matter for maximum expression of these characters. Chlorophyll content at flowering had significantly positive correlation with leaf area and leaf area index while traits relative water content, chlorophyll content, stay green trait and stomatal index had non-significant correlation with grain yield per plant. Traits days to physiological maturity, total biomass at maturity, dry stover yield at maturity, grain number per panicle, 1000 grain weight and leaf area index at flowering had positive direct effect on grain yield. Significantly positive correlation for these traits explains its true relationship and selection for the character will be effective. Indirect positive effect of total biomass and dry stover yield at maturity was observed via panicle dry weight, dry stover yield at maturity, 100 seed weight, leaf area at 50% flowering and leaf area index.
Key words: *correlation, path analysis, drought, post rainy sorghum*

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INTRODUCTION

Sorghum (*Sorghum bicolor* (L). *moench*) is the fifth most important cereal crop of the world following Rice, Wheat, Maize, and Barley [1]. India contribute twenty one per cent of the world sorghum area (www.icrisat.org) andlargest share (>70%) of global sorghum producers [2]. With its C_4 photosynthetic pathway, it is adapted to a wide range of environmental conditions. It is one among the climate resilient crops that can better adapt to climate change conditions [3]. Sorghum is unique to adapt to environmental extremes of abiotic and biotic stress. So this makes the crop to minimize the risk and enables to fit to a sustainable and economical profitable dry land production system. Hence, it is well known for its versatile use, hardiness, drought tolerance, stability of yield and adaptability over a wide range of soils and climatic conditions. In India, the productivity of *rabi* sorghum is very low and highly variable from year to year mainly due to post flowering drought which severely influences the grain filling, grain productivity, quality and storage quality. Delayed senescence (or stay green) in sorghum is considered to be a valuable trait as it improves genotypes adaption to post flowering drought stress particularly in environment in which the crop depends largely on stored soil moisture to fill and mature grain. The knowledge of association among the drought contributing traits and yield would be of great help in constructing a suitable plant type to cope up drought condition and in planning breeding programme. 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 [4]. The path coefficient analysis allows partitioning of correlation coefficient into direct and indirect contributions (effects) of various traits towards dependent variable [5] and thus helps in assessing the cause-effect relationship as well as effective selection [6]. 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 drought contributing traits and yield to provide necessary information that could be useful in sorghum improvement progarmmes aimed at improving grain yield of rabi sorghum under drought condition.

MATERIAL AND METHODS

Experimental materials comprised of 28 genotypes with 2 checks (B-35 and CSV-23). The experiment was conducted in randomized block design (RBD) with three replications at Sorghum Research Station, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani.The crop was given an uniform basal dose of 40N : 40P : 40K kg/ha. Seed treatment with 70% thiamethoxam @ 3 g per kg of seed was given to protect the crop from shoot fly infestation. The agronomic and plant protection measures were followed as and when required during the period of crop growth. Top dressing with 40 kg N/ha with urea was given 30 days after sowing. Observations were recorded on five randomly selected plants in each entry from each replication.The data subjected to different statistical analysis viz., Phenotypic and genotypic correlation coefficients of all the characters [7] and path coefficient analysis [5].

RESULT

Correlation

In present investigation, results depicted in table 1 revealed higher genotypic correlation than phenotypic correlation indicating the inherent association between various traits. Characters contributing towards growth and drought tolerance viz., plant height at maturity (0.320), panicle dry weight at 50% flowering (0.231), total biomass at 50% flowering (0.219), leaf dry weight (0.262)and panicle dry weight at maturity (g) (0.970), total biomass at maturity (0.576), harvest index (0.682), grain number per panicle (0.687), 1000 grain weight (0.269) leaf area (cm)(0.243) and leaf area index at flowering (0.275).

Days to 50 per cent flowering and days to physiological maturity showed negative and significant correlation with grain yield per plant, panicle dry weight, stem dry weight, leaf dry weight at flowering and maturity, 1000 grain weight, total biomass, dry stover yield and plant height both genotypic and phenotypic level. Chlorophyll content at flowering had significantly positive correlation with leaf area and leaf area index. Leaf dry weight, stem dry weight, total biomass both at flowering and maturity are significantly and positively correlated to chlorophyll content, while harvest index had significantly negative association with chlorophyll content (-0.264). The traits relative water content, chlorophyll content, stay green trait and stomata index hadnon-significant correlation with grain yield per plant. stay green score at physiological maturity showed significantly positive association with traits leaf dry weight, total biomass, dry Stover weight per plant at maturity, 1000 seed weight and stomata index.

Path analysis

Path coefficient analysis outlined was carried out (5) to find out the direct and indirect effect of various components on grain yield (Table 2).

In the present investigation, the character viz., days to physiological maturity (0.3104), total biomass at maturity(2.563), dry stover yield at maturity (0.8224), grain number per panicle (0.395), 1000 grain weight (0.297)and leaf area index at flowering (1.154) had positive direct effect on grain yield. The characters days to 50%flowering, leaf dry weight and panicle dry weight at 50% flowering, plant height, leaf dry weight, stem dry weight and panicle dry weight at maturity, harvest index, chlorophyll content, relative water content, leaf area at flowering and stomatal index had negative direct effect on grain yield.

Indirect positive effect of total biomass and dry stover yield at maturity was observed via panicle dry weight, dry stover yield at maturity, 100 seed weight, leaf area at 50% flowering and leaf area index.

DISCUSSION

Correlation

Correlation coefficient is an important statistical constant, which indicates the degree of association among the various characters. It provide better understanding of yield component which helps the plant breeder during selection (8 and 9).The traits exhibiting significant and positive association with grain yield (g) both at genotypic and phenotypic level indicates increase in grain yield is due to increase in one

or more of the above characters. The results reported for plant height(10), number of leaves, leaf area index and panicle width (11) for harvest index, (12) for 100 seed weight, (13) for fodder yield per plant and (14) for harvest index and leaf area. Panicle dry matter contributes towards grain yield in sorghum (15). The genotypes attaining late maturity accumulate more dry matter for maximum expression of these characters (16).

Plants with the stay green trait are able to maintain green leaves for longer when water stress occurs during grain filling. This phenotype is associated with reduced stalk lodging, reduced susceptibility to charcoal rot, and maintenance of seed size (17,18, and 19). Similar finding have also been reported for relative water content and stay green at maturity (20).

Path analysis

Path analysis is useful for partitioning of direct and indirect causes of correlation and also enables breeders to compare the component factors on the basis of their relative contributors. Direct effect of any component characters on yield gives an idea about reliability of indirect selections to be made through that character to bring about improvement in yield. Direct positive correlation of days to physiological maturity, total biomass at maturity, dry stover yield at maturity, grain number per panicle, 1000 grain weight and leaf area index at flowering with grain yield explains its true relationship. Selection for the character will be effective (12), (21)and(14).

As plant height at maturity, leaf dry weight, stem dry weight and panicle dry weight at maturity and harvest index are positively associated with grain yield but had negative direct effect. For such traits indirect causal factors are to be considered simultaneously for selection (22 & 23).

Table 1. Genotypic and phenotypic Correlation Coefficient for 15 characters studied in *rabi* sorghum

Characters		Days to 50% flowering	Days to physiological maturity	Plant height at maturity (cm)	Panicle dry wt Maturity (g)	Total biomass Maturity (g)	Dry stover Yield maturity (g)	Harvest index (%)	Grain number/panicle	1000 grain wt	Chlorophyll content (SPAD)	Relative water content (%)	Leaf area at flowering (cm²)	Leaf area index at flowerin g	Stomatal index	Grain yield (g/plant)
Days to 50% flowering	G	**1.000**	0.997**	-0.496**	-0.283**	-0.423**	-0.344**	-0.058	-0.131	-0.238*	0.133	0.172	-0.189	-0.259*	-0.227*	**-0.310****
	P	**1.000**	0.981**	-0.458**	-0.239*	-0.376**	-0.317**	-0.042	-0.118	-0.224*	0.081	0.127	-0.173	-0.248*	-0.182	**-0.274****
Days to physiological maturity	G		**1.000**	-0.523**	-0.286**	-0.463**	-0.393**	-0.028	-0.144	-0.236*	0.138	0.185	-0.231	-0.301**	-0.260*	**-0.320****
	P		**1.000**	-0.476**	-0.241*	-0.406**	-0.354**	-0.012	-0.354**	0.988	-0.354**	0.126	-0.207*	-0.276**	-0.183	**-0.275****
Plant height at maturity (cm)	G			**1.000**	0.331**	0.627**	0.570**	-0.099	0.232*	0.258*	-0.005	-0.133	0.392**	0.472**	0.200	**0.316****
	P			**1.000**	0.320**	0.619**	0.563**	-0.098	0.230*	0.254*	-0.006	-0.112	0.388**	0.460**	0.156	**0.311****
Panicle dry wt Maturity (g)	G				**1.000**	0.619**	0.129	0.684**	0.586**	0.394**	0.015	-0.058	0.275**	0.299**	-0.091	**0.970****
	P				**1.000**	0.622**	0.117	0.684**	0.579**	0.381**	0.003	-0.057	0.264*	0.279**	-0.051	**0.949****

0.576**	**0.573****	**0.096**	**0.093**	**0.682****	**0.679****	**0.687****	**0.683****	**0.269***	**0.267***	**-0.015**	**-0.019**	**-0.122**	**-0.110**	**0.243***
0.089	0.081	0.187	0.133	-0.157	-0.125	-0.035	-0.029	0.029	0.031	-0.165	-0.101	-0.055	-0.014	-0.094
0.556**	0.532**	0.515**	0.489**	-0.117	-0.108	0.248*	0.238*	0.042	0.426**	0.334**	0.240*	-0.030	-0.017	0.969**
0.518**	0.511**	0.488**	0.482**	-0.132	-0.129	0.214*	0.213*	0.037	0.038	0.371**	0.302**	-0.026	-0.025	**1.000**
0.001	-0.003	0.034	0.027	-0.070	-0.060	-0.211*	-0.187	0.085	0.078	-0.433**	-0.361**	**1.000**	**1.000**	
0.243*	0.201	0.307**	0.269*	-0.264*	-0.234*	-0.084	-0.078	0.125	0.111	**1.000**	**1.000**			
0.411**	0.405**	0.266*	0.262*	0.177	0.172	-0.457**	-0.456**	**1.000**	**1.000**					
0.312**	0.313**	0.012	0.010	0.421**	0.418**	**1.000**	**1.000**							
-0.121	-0.105	-0.606**	-0.593**	**1.000**	**1.000**									
0.858**	0.845**	**1.000**	**1.000**											
1.000	**1.000**													
G	P	G	P	G	P	G	P	G	P	G	P	G	P	G
Total biomass at maturity (g)		Dry stoveryieild at maturity (g))		Harvest index (%)		Grain number/panicle		1000 grain wt		Chlorophyll content (SPAD)		Relative water content (%)		area at flowerin

	Leaf area index at flowering		Stomatal index	
P	G	P	G	P
1.000				
0.947**	**1.000**	**1.000**		
-0.078	0.039	0.023	**1.000**	**1.000**
0.240*	**0.275****	**0.267***	**-0.113**	-0.088

* **Significant** at 5 per cent level**, ** Significant** at 1 per cent level.

Table 2 direct and indirect effect of growth and drought parameter son grain yield per plant in *rabi* sorghum

Characters	Days to 50% flowering	Days to physiological maturity	Plant height at maturity (cm)	Panicle dry wt maturity (g)	Total biomass at maturity (g)
Days to 50% Flowering	**-0.327**	0.3105	0.1219	0.124	-1.0842
Days to physiological maturity	-0.3271	**0.3104**	0.1287	0.1255	-1.187
Plant height at maturity (cm)	0.1623	-0.1626	**-0.2457**	0.1454	1.6082
Panicle dry wt maturity (g)	0.0925	-0.0889	-0.0816	**-0.4381**	1.5873
Total biomass at maturity (g)	0.1383	-0.1438	-0.1542	-0.2713	**2.5633**
Dry stoveryieild at maturity (g)	0.1127	-0.1222	-0.1401	-0.0569	2.2009
Harvest index %)	0.0191	-0.0074	0.0244	-0.2997	-0.3107
Grain umber/panicle	0.043	-0.045	-0.057	-0.2567	0.8014
1000 grain wt	0.078	-0.0735	-0.0636	-0.1729	1.054
Chlorophyll content (SPAD)	-0.0438	0.043	0.0014	-0.0066	0.6251
Relative water content (%)	-0.0563	0.0577	0.0327	0.0256	0.001
Leaf area at flowering (cm^2)	0.062	-0.0719	-0.0964	-0.1207	1.329
Leaf area index at flowering	0.085	-0.0936	-0.116	-0.1313	1.4257
Stomatal index	0.0745	-0.081	-0.0493	0.04	0.2297
Grain yield (g/plant)	**-0.3107**	**-0.3203**	**0.3164**	**0.97**	**0.5766**

0.0963	**0.6822**	**0.687**	**0.2698**	**-0.015**	**-0.1225**	**0.2435**	**0.2756**	**-0.1134**
0.1539	0.0786	-0.014	0.0089	0.0453	0.0088	0.0898	0.046	**-0.2369**
0.4237	0.0589	0.0978	0.0126	-0.0918	0.0049	-0.9195	**1.1537**	-0.0095
0.4016	0.0661	0.0848	0.0113	-0.102	0.0041	**-0.9483**	1.1183	0.0224
0.0281	0.0354	-0.0832	0.0254	0.119	**-0.1582**	0.0247	-0.0355	0.0131
0.2526	0.132	-0.0332	0.0374	**-0.2745**	0.0686	-0.3523	0.3859	0.0391
0.2189	-0.0888	-0.1803	**0.2975**	-0.0345	-0.0135	-0.0359	0.0487	-0.0071
0.0105	-0.2102	**0.3946**	-0.1359	0.0231	0.0334	-0.2037	0.2861	0.0084
-0.4989	**-0.4991**	0.1661	0.0529	0.0726	0.0112	0. 1257	-0.136	0.0373
0.8224	0.3028	0.005	0.0792	-0.0843	-0.0054	-0.4631	0.5945	-0.0443
0.7061	0.0605	0.1234	0.1223	-0.0669	-0.0001	-0.4917	0.6417	-0.0212
0.1067	-0.3415	0.2312	0.1174	-0.0041	0.0092	-0.2612	0.3459	0.0216
0.4689	0.0497	0.0916	0.077	0.0016	0.0211	-0.3721	0.5448	-0.0475
-0.3238	0.0119	-0.0572	-0.0704	-0.038	-0.0294	0.2196	-0.3478	0.0618
-0.2833	0.0291	-0.0519	-0.0709	-0.0368	-0.0272	0.1799	-0.2999	0.0539
Dry stoveryieild at maturity (g)	Harvest index (%)	Grain number/panicle	1000 grain wt	Chlorophyll content (SPAD)	Relative water content (%)	Leaf area at flowering (cm^2)	Leaf area index at flowering	Stomatal index

Residual effect 0.146

CONCLUSION

Direct selection for the traits viz., total biomass and dry stover yield at maturity, harvest index, grain number per panicle, 1000 grain weight and leaf area index at flowering exhibiting significant positive association and direct positive effect on grain yield will be effective in improving plant productivity.

While, physiological characters like stay green trait, chlorophyll content, relative water content plays a vital role in improving grain yield under moisture stress condition by maintaining optimum turgor pressure at cellular level and photosynthetic activities, respectively .The interrelationship among yield components would help in increasing the yield levels and therefore, more emphasis should be given to these components while selecting better types in sorghum.

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