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Manish Chavhan
Department of Agricultural Botany, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

LN Jawale
Department of Agricultural Botany, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

SA Patil
Department of Agricultural Botany, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Corresponding Author:
Manish Chavhan
Department of Agricultural Botany, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Correlation and path analysis studies in kharif sorghum (*Sorghum bicolor* L. Moench) parental (B and R) Lines

Manish Chavhan, LN Jawale and SA Patil

Abstract

The present investigation was studied in eighteen parental (B and R) lines of kharif Sorghum (*Sorghum bicolor* L. Moench) hybrids. The experiment was laid out in randomized block design with three replications at Sorghum Research Station, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during kharif 2021. Fifteen characters or yield contributing traits were evaluated for correlation and path analysis studies in eighteen genotypes. In present investigation there is existence of higher genotypic correlation when compared to phenotypic correlation, this indicates the presence of inherent association among the characters. Studying association among the traits with each other and with yield component plays a major role in crop improvement program as yield is the dependent and complex trait which depends on various component traits. Significant and positive association was observed between grain yield and its yield contributing traits like plant height, grain no per panicle and fodder yield at both genotypic and phenotypic levels while stem dry weight and SPAD at genotypic and harvest index at phenotypic level, this association indicates increase in one or more of these traits results in increase in grain yield. Selection for a trait is effective when both the values of correlation and direct effect are higher and positive as this indicates its true association. In this investigation path analysis revealed at both genotypic and phenotypic level for leaf area, relative water content, stem dry weight, SPAD, grain no per panicle exhibited positive direct effect on grain yield there by it would play an important role in selection criteria for improving the character grain yield. Further selection of these characters will improve the breeding efficiency of the genotypes. Hence, due consideration should be given for the traits while selecting parental lines. Among the eighteen genotypes studied parental (B and R) lines *viz.* AKR 504, NR 39-15, KR 218, KR 219, PMS 100B, AKMS 90 B and INDORE 12 recorded better performance and these are considered as the superior genotypes.

Keywords: Association, correlation, path analysis, parental lines (B and R), *Sorghum bicolor* (L.) Monech

Introduction

Sorghum is a genus of about 25 species of flowering plants in the grass (poaceae) family. Sorghum (*Sorghum bicolor*), also called great millet, Indian millet, milo, durra, orshallu. It is high in carbohydrates, with 10 percent protein, 3.4 percent fat, and contains calcium and small amounts of iron, vitamin B_1, and niacin. It is a multipurpose crop belonging to the Poaceae family, which are C_4 carbon cycle plants with high photosynthetic efficiency and productivity. It is one of the five major cultivated species in the world because it has several economically important potential uses such as food (grain), feed (grain and biomass), fuel (ethanol production), fibre (paper), fermentation (methane production) and fertilizer (utilization 3 of organic by-products). Most varieties are drought- and heat-tolerant, nitrogen-efficient, and are especially important in arid regions, where the grain is one of the staples for poor and rural people.

USDA has projected world sorghum area as 40.97 million hectares (101.23 million acres) and production as 59.76 million tonnes for year 2020-21. For India, it was projected as 4.80 million hectares (11.86 lakh acres) and 4.40 million tonnes respectively. In India, as on 12th August 2020 area under kharif sorghum during 2020-21 was 14.53 lakh hectares. Among the five states, Maharashtra stood second with 2.67 lakh ha contributing 87% of country's total area and production. The study of relationships among traits is very essential for assessing the feasibility of joint selection for two or more traits. Path coefficient analysis partitions correlation coefficient into direct and indirect effects of various traits towards dependent variable, thus helps in effective selection.

The path analysis helps to resolve these correlations, further it throws more light on the way in which component traits contribute towards specifically identifying important component traits. Apart from correlation studies, path coefficient analysis is important to obtain information about different ways in which the component characters influences the improvement of grain yield.

This article reports the findings of a study conducted to determine the nature of relationships of grain yield and its yield contributing traits and to identify those traits with significant effects on yield with the intention of using them as selection criteria using path coefficient analysis (PCA) at both genotypic and phenotypic level.

Materials and Methods

The present investigation was undertaken to study correlation and path analysis in eighteen genotypes of sorghum (*Sorghum bicolor* L. Moench) parental (B and R) lines. The study was carried out at Sorghum Research Station, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during kharif 2021. The experimental material consists of 7B and 11R lines received from IIMR Hyderabad, ICRISAT Hyderabad, Akola and Parbhani listed in (table 1). The experiment was laid out in randomized block design with three replications.

Each line consists of four rows of 4 meters length at 45 cm apart. Plant to plant distance was maintained at 15cm. Seeds were initially treated with imidacloprid 48% FS in order to provide protection against sucking insects and pests. Field was prepared as per the requirement. The experimental material was sown by dibbling method. Recommended dose of fertilizer were applied @ 40:40:40 kg/ha N:P:K in the form of urea, single super phosphate, muriate of potash respectively as basal. The recommended agronomical and plant protection practices were followed regularly as per needed. Observations were recorded on 3 randomly selected plants from each genotype for days to fifty percent flowering, days to maturity, plant height at physiological maturity (cm), leaf dry weight at flowering (g/m^{2}), stem dry weight at flowering (g/m^{2}), leaf area at flowering (cm^{2}), relative water content (RWC) at flowering (%), total chlorophyll content (TCC), chlorophyll stability index (CSI) %, 1000 grain weight (g), grain no/panicle, grain yield (q/ha), fodder yield(q/ha), harvest index (%). The data was analysed statistically for genotypic and phenotypic correlation coefficient using path coefficient analysis studies.

Table 1: List of kharif parental (B and R) lines used for study

B-line	Source	R-line	Source
AKMS 30B	Akola	AKR 456	Akola
AKMS 33B	Akola	AKR 504	Akola
AKMS 70B	Akola	AKR 524	Akola
AKMS 90B	Akola	KR 192-2	Parbhani
PMS 100B	Parbhani	KR 218	Parbhani
PMS 237B	Parbhani	KR 219	Parbhani
PMS 28B	Parbhani	C 85	Hyderabad
		NR 10-15	Hyderabad
		NR 12-15	Hyderabad
		NR 39-15	Hyderabad
		INDORE 12	INDORE

Results and Discussion

Genotypic and Phenotypic correlation coefficient matrix between different traits are represented in (table 2). Results showed that most of genotypic correlations were found to be higher than phenotypic correlations, which indicate that though there is strong inherent association between the characters and its expression is minimized due to influence of environment. The non-significant values of studied characters at both phenotypic and genotypic levels clearly indicates the independent nature of the character.

Correlation

The dependant variable i.e. grain yield has recorded positive significant correlation with plant height (G=0.672, P=0.573), grain no per panicle (G=0.341, P=0.317) and fodder yield (G=0.379, P=0.333) at both genotypic and phenotypic level while stem dry weight (G=0.502) and SPAD (G=0.388) only at genotypic and harvest index (P=0.333) at phenotypic level. Negative significant correlation found with total chlorophyll content (G=-0.268). Similar results observed by Godbharle *et al.*, (2010) [1] recorded positive significant correlation for fodder yield and harvest index at both genotypic and phenotypic level.

Non-significant positive association was observed with grain yield for days to maturity (P=0.027), stem dry weight (P=0.267) and SPAD (P=0.150) at phenotypic level while trait like relative water content (G=0.199, P=0.004) at both genotypic and phenotypic level and harvest index (G=0.255) at only genotypic level showed non-significant positive correlation. Similar results observed by Ravali *et al.*, (2021) [2] recorded positive and non- significant association for relative water content at both genotypic and phenotypic level. Non-significant negative association was observed with days to fifty percent flowering (G=-0.203, P=-0.078), leaf dry weight (G=-0.087, P=-0.091), leaf area (G=-0.101, P=-0.080), chlorophyll stability index (G=-0.012, P=-0.018), 1000 grain weight (G=-0.119,P=-0.114) at both genotypic and phenotypic level while days to maturity (G=-0.023) only at genotypic and total chlorophyll content (P=-0.103) at phenotypic level.

Path analysis

Path coefficient analysis was carried out using genotypic and phenotypic level in order to find out the direct and indirect effects of various traits on the grain yield. Table (3 and 4) represents the direct (diagonal) and indirect (non-diagonal) effects of yield components on grain yield for parental lines at both genotypic and phenotypic level.

Present study revealed presence of positive direct effect on grain yield for traits like days to maturity (0.067), leaf area (0.334), relative water content (0.245), chlorophyll stability index (0.304), 1000 grain weight (0.23), fodder yield (1.782) and harvest index (1.864) at genotypic level and traits like days to fifty % flowering (0.006), stem dry weight (0.046), SPAD (0.027), total chlorophyll content (0.045), fodder yield (1.503) and harvest

Table 2: Genotypic (G) and Phenotypic (P) correlation coefficient matrix between different traits in kharif sorghum parental (B and R) lines

		DFIF	DTM	PH	LDW	SDW	LA	RWC	SPAD	TCC	CSI	TW	GN/P	FY	HI	GY
DFIF	G															
	P															
DTM	G	0.913**														
	P	0.750**														
PH	G	-0.218^{NS}	-0.008^{NS}													
	P	-0.172^{NS}	-0.053^{NS}													
LDW	G	0.419**	0.327*	0.106^{NS}												
	P	0.251^{NS}	0.255^{NS}	0.108^{NS}												
SDW	G	0.159^{NS}	0.424**	0.724**	-0.040^{NS}											
	P	0.027^{NS}	0.164^{NS}	0.511**	-0.020^{NS}											
LA	G	0.445**	0.349**	0.186^{NS}	0.753**	0.148^{NS}										
	P	0.319*	0.269*	0.187^{NS}	0.720**	0.058^{NS}										
RWC	G	0.236^{NS}	0.314*	-0.486**	-0.510**	-0.252^{NS}	-0.565**									
	P	0.078^{NS}	0.139^{NS}	-0.242^{NS}	-0.245^{NS}	-0.017^{NS}	-0.307*									
SPAD	G	-0.093^{NS}	-0.167^{NS}	0.063^{NS}	-0.029^{NS}	-0.001^{NS}	0.242^{NS}	-0.027^{NS}								
	P	-0.098^{NS}	-0.060^{NS}	0.069^{NS}	0.038^{NS}	-0.126^{NS}	0.132^{NS}	0.091^{NS}								
TCC	G	-0.633**	-0.190^{NS}	0.164^{NS}	-0.452**	0.448**	-0.203^{NS}	-0.951**	-0.361**							
	P	-0.053^{NS}	-0.031^{NS}	0.080^{NS}	-0.091^{NS}	0.211^{NS}	-0.049^{NS}	0.048^{NS}	-0.036^{NS}							
CSI	G	0.074^{NS}	0.114^{NS}	0.174^{NS}	0.314*	0.122^{NS}	0.184^{NS}	-0.681**	0.263^{NS}	0.557**						
	P	0.025^{NS}	0.079^{NS}	0.159^{NS}	0.304*	0.062^{NS}	0.178^{NS}	-0.398**	0.167^{NS}	0.171^{NS}						
TW	G	0.414**	0.177^{NS}	-0.290*	0.239^{NS}	0.159^{NS}	0.361**	-0.254^{NS}	-0.165^{NS}	-0.690**	-0.068^{NS}					
	P	0.296*	0.165^{NS}	-0.300*	0.232^{NS}	0.093^{NS}	0.329*	-0.090^{NS}	-0.043^{NS}	-0.262^{NS}	-0.090^{NS}					
GN/P	G	0.160^{NS}	0.088^{NS}	0.077^{NS}	0.037^{NS}	0.412**	0.135^{NS}	0.318*	0.067^{NS}	-0.034^{NS}	0.153^{NS}	0.226^{NS}				
	P	0.118^{NS}	0.058^{NS}	0.055^{NS}	0.033^{NS}	0.255^{NS}	0.125^{NS}	0.135^{NS}	0.049^{NS}	-0.033^{NS}	0.144^{NS}	0.229^{NS}				
FY	G	0.002^{NS}	0.144^{NS}	0.065^{NS}	-0.176^{NS}	0.411**	-0.014^{NS}	0.087^{NS}	0.401**	-0.826**	-0.010^{NS}	0.539**	0.155^{NS}			
	P	0.063^{NS}	0.108^{NS}	0.078^{NS}	-0.177^{NS}	0.281*	-0.013^{NS}	0.035^{NS}	0.295*	-0.272*	-0.013^{NS}	0.503**	0.154^{NS}			
HI	G	-0.108^{NS}	-0.134^{NS}	0.420**	0.179^{NS}	-0.017^{NS}	-0.010^{NS}	0.074^{NS}	-0.182^{NS}	0.667**	0.011^{NS}	-0.622**	0.095^{NS}	-0.793**		
	P	-0.077^{NS}	-0.046^{NS}	0.328*	0.159^{NS}	-0.097^{NS}	0.002^{NS}	-0.029^{NS}	-0.204^{NS}	0.163^{NS}	0.004^{NS}	-0.547**	0.090^{NS}	-0.765**		
GY	G	-0.203^{NS}	-0.023^{NS}	0.672**	-0.087^{NS}	0.502**	-0.101^{NS}	0.199^{NS}	0.388**	-0.268*	-0.012^{NS}	-0.119^{NS}	0.341*	0.379**	0.255^{NS}	
	P	-0.078^{NS}	0.027^{NS}	0.573**	-0.091^{NS}	0.267^{NS}	-0.080^{NS}	0.004^{NS}	0.150^{NS}	-0.103^{NS}	-0.018^{NS}	-0.114^{NS}	0.317*	0.333*	0.333*	

*Significant at 5 per cent. **Significant at 1 per cent, ^{NS}Non-significant.

Note: DFIF-Days to fifty % flowering, DTM-Days to maturity, PH-Plant height at physiological maturity (cm), LDW-Leaf dry weight at flowering (g/m^2), SDW-Stem dry weight at flowering (g/m^2), LA-Leaf area (cm^2), RWC-Relative water content (%), SPAD-SPAD value, TCC-Total chlorophyll content (mg/ml), CSI-Chlorophyll stability index (%), TW-Test weight i.e. 1000 grain wt (g), GN/P-Grain no per panicle, FY-Fodder yield (q/ha), HI-Harvest index (%), GY-Grain yield (q/ha).

Table 3: Direct (diagonal) and indirect (non-diagonal) effects of yield components on grain yield for kharif sorghum parental lines at genotypic level

Characters	Dfif	DTM	PH (cm)	LDW (g/m2)	SDW (g/m2)	LA (cm2)	RWC (%)	SPAD	TCC (mg/ml)	CSI (%)	1000 GW (g)	Grain no/panicle	Fodder yield (q/ha)	HI (%)	Grain yield (q/ha)
Dfif	-0.239	0.0615	0.0147	-0.1259	-0.0184	0.1489	0.0578	0.0098	0.0036	0.0226	0.0953	-0.0368	0.0041	-0.2014	-0.203^{NS}
DTM	-0.2181	0.067	0.0006	-0.0982	-0.0490	0.1168	0.0768	0.0175	0.0011	0.0347	0.0409	-0.0202	0.2570	-0.2498	-0.023^{NS}
PH (cm)	0.0521	-0.0006	-0.067	-0.0317	-0.0836	0.0623	-0.1188	-0.0066	-0.0009	0.0529	-0.0667	-0.0177	0.1162	0.7827	0.672**
LDW (g/m2)	-0.1000	0.0220	-0.0071	-0.301	0.0046	0.2518	-0.1248	0.0030	0.0026	0.0952	0.0549	-0.0084	-0.3141	0.3339	-0.087^{NS}
SDW (g/m2)	-0.0380	0.0286	-0.0487	0.0121	-0.115	0.0494	-0.0617	0.0002	-0.0025	0.0370	0.0366	-0.0948	0.7316	-0.0322	0.502**
LA (cm2)	-0.1063	0.0235	-0.0125	-0.2264	-0.0171	0.334	-0.1383	-0.0254	0.0012	0.0559	0.0832	-0.0311	-0.0242	-0.0178	-0.101^{NS}
RWC (%)	-0.0564	0.0211	0.0326	0.1533	0.0291	-0.1890	0.245	0.0029	0.0054	-0.2069	-0.0584	-0.0732	0.1549	0.1386	0.199^{NS}
SPAD	0.0222	-0.0112	-0.0042	0.0086	0.0002	0.0809	-0.0067	-0.105	0.0020	0.0797	-0.0380	-0.0155	0.7147	-0.3401	0.388**
TCC (mg/ml)	0.1512	-0.0128	-0.0110	0.1357	-0.0517	-0.0680	-0.2326	0.0378	-0.006	0.1689	-0.1588	0.0078	-1.4726	1.2434	-0.268*
CSI (%)	-0.0178	0.0077	-0.0117	-0.0943	-0.0141	0.0616	-0.1667	-0.0275	-0.0032	0.304	-0.0157	-0.0352	-0.0187	0.0204	-0.012^{NS}
1000 GW (g)	-0.0988	0.0120	0.0195	-0.0717	-0.0184	0.1208	-0.0620	0.0173	0.0039	-0.0207	0.23	-0.0520	0.9607	-1.1593	-0.119^{NS}
Grain no/panicle	-0.0381	0.0059	-0.0052	-0.0110	-0.0476	0.0452	0.0778	-0.0071	0.0002	0.0464	0.0520	-0.23	0.2754	0.1772	0.341*
Fodder yield (q/ha)	-0.0006	0.0097	-0.0044	0.0530	-0.0474	-0.0045	0.0213	-0.0420	0.0047	-0.0032	0.1241	-0.0356	1.782	-1.4783	0.379**
HI (%)	0.0258	-0.0090	-0.0282	-0.0539	0.0020	-0.0032	0.0182	0.0191	-0.0038	0.0033	-0.1432	-0.0219	-1.4136	1.864	0.255^{NS}

Residual effect = 0.01260.

*Significant at 5 per cent. **Significant at 1 per cent, ^{NS}Non-significant

Table 4: Direct (diagonal) and indirect (non-diagonal) effects of yield components on grain yield for kharif sorghum parental lines at phenotypic level

Characters	Dfif	DTM	PH (cm)	LDW (g/m2)	SDW (g/m2)	LA (cm2)	RWC (%)	SPAD	TCC (mg/ml)	CSI (%)	1000 GW (g)	Grain no/panicle	Fodder yield (q/ha)	HI (%)	Grain yield (q/ha)
Dfif	0.006	-0.0418	0.0136	-0.0041	0.0013	-0.0052	-0.0027	-0.0027	-0.0024	-0.0002	-0.0158	-0.0037	0.0940	-0.1144	-0.078^{NS}
DTM	0.0046	-0.056	0.0042	-0.0042	0.0076	-0.0044	-0.0049	-0.0016	-0.0014	-0.0007	-0.0088	-0.0018	0.1628	-0.0686	0.027^{NS}
PH (cm)	-0.0011	0.0029	-0.079	-0.0018	0.0236	-0.0031	0.0085	0.0019	0.0036	-0.0014	0.0160	-0.0017	0.1177	0.4873	0.573**
LDW (g/m2)	0.0016	-0.0142	-0.0086	-0.016	-0.0009	-0.0118	0.0087	0.0010	-0.0041	-0.0027	-0.0124	-0.0010	-0.2661	0.2363	-0.091^{NS}
SDW (g/m2)	0.0002	-0.0091	-0.0405	0.0003	0.046	-0.0010	0.0006	-0.0034	0.0095	-0.0006	-0.0050	-0.0079	0.4219	0.1445	0.267^{NS}
LA (cm2)	0.0020	-0.0150	-0.0148	-0.0119	0.0027	-0.016	0.0109	0.0036	-0.0022	-0.0016	-0.0176	-0.0039	-0.0193	0.0030	-0.080^{NS}
RWC (%)	0.0005	-0.0078	0.0191	0.0040	-0.0008	0.0050	-0.035	0.0025	0.0022	0.0036	0.0048	-0.0042	0.0533	-0.0433	0.004^{NS}
SPAD	-0.0006	0.0034	-0.0054	-0.0006	-0.0058	-0.0022	-0.0032	0.027	-0.0016	-0.0015	0.0023	-0.0015	0.4432	-0.3033	0.150^{NS}
TCC (mg/ml)	-0.0003	0.0017	-0.0063	0.0015	0.0097	0.0008	-0.0017	-0.0010	0.045	-0.0015	0.0140	0.0010	-0.4088	0.2424	-0.103^{NS}
CSI(%)	0.0002	-0.0044	-0.0126	-0.0050	0.0029	-0.0029	0.0141	0.0046	0.0078	-0.009	0.0048	-0.0045	-0.0194	0.0053	-0.018^{NS}
1000 GW (g)	0.0018	-0.0092	0.0237	-0.0038	0.0043	-0.0054	0.0032	-0.0012	-0.0118	0.0008	-0.053	-0.007	0.756	-0.812	-0.114^{NS}
Grain no/panicle	0.0007	-0.0032	-0.0044	-0.0006	0.0118	-0.0020	-0.0048	0.0013	-0.0015	-0.0013	-0.0122	-0.031	0.2308	0.1337	0.317*
Fodder yield (q/ha)	0.0004	-0.0060	-0.0062	0.0029	0.0130	0.0002	-0.0013	0.0080	-0.0123	0.0001	-0.0269	-0.0048	1.503	-1.1368	0.333*
HI (%)	-0.0005	0.0026	-0.0260	-0.0026	-0.0045	-0.0000	0.0010	-0.0056	0.0074	0.0000	0.0292	-0.0028	-1.1504	1.485	0.333*

Residual effect = 0.04083.

*Significant at 5 per cent. **Significant at 1 per cent, ^{NS}Non-significant.

index (1.485) at phenotypic level. Similar results observed by Tirkey *et al*., (2021) [3] recorded positive direct effect on grain yield for fodder yield at both genotypic and phenotypic level.

At genotypic level, negative direct effects on grain yield were observed for traits like days to fifty percent flowering (-0.239), plant height (-0.067), leaf dry weight (-0.301), stem dry weight (-0.115), SPAD (-0.105), total chlorophyll content (-0.006), grain no per panicle (-0.23), while traits like days to maturity (-0.056), plant height (-0.079), leaf dry weight (-0.016), leaf area (-0.016), relative water content (-0.035), chlorophyll stability index (-0.009), 1000 grain weight (-0.053), grain no per panicle (-0.031) showed negative direct effects at phenotypic level. Similar results observed by Tirkey *et al.,* (2021) [3] recorded negative direct effects for days to fifty % flowering at genotypic level only.

Positive indirect effects on grain yield were obtained for plant height, stem dry weight, relative water content, SPAD, grain no per panicle, fodder yield and harvest index at both genotypic and phenotypic level. Negative indirect effects on grain yield were obtained for days to fifty % flowering, days to maturity, leaf dry weight, leaf area, total chlorophyll content, chlorophyll stability index, 1000 grain weight at both genotypic and phenotypic level. Similar results observed by Hundekar *et al.,* (2016) [4] recorded negative indirect effects for days to fifty % flowering at both genotypic and phenotypic level.

Conclusion

Based on the correlation results in eighteen genotypes for 15 characters revealed that plant height, grain no per panicle, fodder yield, stem dry weight, SPAD has significant positive correlation with grain yield while negative association with total chlorophyll content. In path analysis study it can be concluded that traits like leaf area, relative water content, stem dry weight, SPAD, grain no per panicle would play an important role in selection criteria for improving the character grain yield. Further selection of these characters will improve the breeding efficiency of the genotypes. Hence, due consideration should be given for the traits while selecting parental lines.

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