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Research Note

Correlation and path coefficient analysis for agronomical traits in sorghum [*Sorghum bicolor* (L.) Moench] under shallow saline soil condition in arid region

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Abstract
Genetic variability and interrelationships of characters in 224 genotypes of sorghum were studied during *Kharif*-2013, revealed highly significant genotypic differences for all the characters among the accessions. All the characters had higher genotypic and phenotypic coefficient of variation which is indicative that character expression in this sorghum population was genetic and can be exploited in breeding programme. High heritability coupled with high genetic advance was observed for fresh weight per plant, leaf area, plant height and dry weight per plant indicating that these characters are controlled by additive gene action and phenotypic selection for these characters will be effective. Fresh weight per plant was positively correlated with days to flowering, number of leaves per plant, leaf area, panicle length, dry weight per plant, grain yield per plant and 1000 seed weight. The path coefficient analysis indicated positive and significant correlation as well as high or moderate direct effects of dry weight per plant, panicle length, number of leaves per plant, plant height, grain yield per plant and 1000 seed weight on fresh weight per plant.

Keywords
Sorghum, Arid, Variability, Correlation, Path coefficient

Sorghum crop [*Sorghum bicolor* (L.) Moench) is genetically suited to hot and dry agro-ecologies with frequent drought, where it is difficult to grow other crops (Jain *et al.*, 2010). Sorghum is preferred over maize in kharif season because of its high tolerance to various stresses and its superiority to pearlmillet in having lower oxalate and fiber content. Sorghum stover is valued over all other sources of fodder (paddy straw, pearlmillet straw and wheat straw). Thus sorghum is also used as fodder to the domestic animals for its better performance. At present the country faces a net deficit of 61.1% green fodder, 21.9% dry crop residues and 64% feeds. In last 15 years, area under grain sorghum is decreasing in favour of other crops. However, it still occupies first position (2.6 million ha) among the forage crops and in addition supply significantly large quantity of stover from grain crop for live stock. It is therefore of paramount importance that technological developments are extended to increase the productivity and sustainability of sorghum production. Landraces or farmer varieties constitute the basic material for developing any variety or hybrid. An autochthonous landrace is a variety with a high capacity to tolerate biotic and abiotic stress, resulting in high yield stability and an intermediate yield level under a low input agricultural system. Fodder yield is a complex trait which depends upon many independent contributing traits. Knowledge of the magnitude and type of association between fodder yield and its components themselves greatly help in evaluating the contribution of different characters towards fodder yield.

Quantitative trait like fodder yield is highly influenced by the fluctuations in environment. Hence, selection of plants based directly on fodder yield would not be very reliable. Breeders are sometimes concerned with the selection of superior genotypes which is dependent on the phenotype expression. Often selection based on phenotypic performance does not lead to expected genetic advance mainly due to presence of genotype x environment interactions as well as due to undesirable association between the component charecters at genetic level. Thus, knowledge of correlation between complex traits and genetic variability will be helpful in designing an efficient selection criterion for isolating ideal plant types. The path coefficient analysis 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. Therefore the present investigation was undertaken to study the variability in sorghum under shallow saline soil condition of arid region.

Two-hundred twenty four sorghum genotypes collected from Directorate of sorghum, Hyderabad, Sorghum Research Station, Dessa, SDAU, and NAU, Surat, Gujarat, Rajasthan College of Agriculture, Udaipur and local landraces of Rajasthan were used for present study. The trial was grown in a Randomized Complete Block Design (RCBD) with three replications at CAZRI-

Regional Research Station, Pali Marwar (25°46′N, 73°50′E; 225 masl) Rajasthan during *Kharif*-2013. The experimental soil was fine sandy clay loam in texture, mixed hyper thermic belonging to the family Lithic calciorthids having shallow depth of 25-45 cm and underlying dense layer of murrum (highly calcareous weathered granite fragments coated with lime) up to 10-15 m depth. The soil of the experimental farm was moderately saline with pH 8.2 and contains low organic carbon 0.37%. Nutrient profile of soil contains 215 kg ha^{-1} available N, 11.3 kg ha^{-1} Olesn's extractable P and 225 kg ha^{-1} available K at the time of sowing. The experiment unit was a single row plot of 3.5 m long, spaced 0.5 m apart. The standard agronomic practices were followed throughout the period of crop growth. Data was taken on time to 50% flowering (days), maturity (days), plant height (cm), number of leaves per plant, leaf area (cm^2), fresh weight per plant (g), dry weight per plant (g), panicle length (cm), panicle width (cm), grain yield per plant (g) and 1000 seed weight (g). Analysis of variance was done by method suggested by Panse and Sukhatme (1978). Genotypic and phenotypic coefficient of variability, heritability, genetic advance, genotypic coefficient and path coefficient using standard method suggested by Burton (1952), Johnson *et al*., (1955); Al-Jibouri *et al*., (1958) and Dewey and Lu (1959) respectively.

Analysis of variance indicated significant differences among genotypes for all the characters studied indicating thereby the presence of wide range of variability. All the characters studied showed wide range for individual character. This indicated that there is enormous scope for selection of desirable genotypes for higher fodder yield from material evaluated. These results corroborated with the earlier findings reported in fodder sorghum by Jadhav *et al.,* (2011) and Jain and Patel (2012).

The range was highest for fresh weight per plant (78.67-625.87) followed by leaf area (172.77-629.27), plant height (128.87-323.33), dry weight per plant (22.47-204.67), days to flowering (49.33-96.00), grain yield per plant (2.53-38.23), days to maturity (95.33-125.67), panicle length (7.73-33.87), 1000 seed weight (7.13-33.37), panicle width (4.20-18.13) and number of leaves per plant (9.00-17.33). The genetic constants for the characters revealed that the magnitude of phenotypic coefficient of variation (PCV) was higher than the corresponding genotypic coefficient of variation (GCV) for all the characters denoting environmental factors influencing their expression to some degree or other. In the present study, the GCV and PCV were higher for grain yield per plant, dry weight per plant, fresh weight per plant, panicle length, and panicle width and leaf area (Table-1). High amount of GCV and PCV suggested greater scope for selection of superior genotypes for these traits. Whereas moderate values of PCV and GCV for plant height, 1000 seed weight, number of leaves per plant and days to flowering. The least value for PCV and GCV was recorded by days to maturity.

The estimate of GCV and PCV alone is not much helpful in determining the heritable portion. The amount of advance to be expected from selection can be achieved by estimating heritability along with coefficient of variability. Burton also suggested that GCV and heritability estimate would give better information about the efficiency of selection (Burton, 1952). The heritability ranged from 63.6% for panicle width to 96.3% for days to flowering. The high degree of heritability estimate for most of the characters suggested that the characters are under genotypic control. Similar result was also reported by Jain *et al.,* (2010). High heritability coupled with high genetic advance was observed for fresh weight per plant, leaf area, plant height and dry weight per plant indicating that these characters are controlled by additive gene action and phenotypic selection for these characters will be effective. High heritability and high genetic advance for fresh weight per plant, leaf area, plant height and dry weight per plant have been reported by Jain *et al.,* (2010) and Jadhav *et al.,* (2011).

The phenotype of plant is the result of interaction of a large number of factors. Therefore, final yield is the sum total of several component characters. The phenotypic and genotypic correlation coefficients are worked out among different characters (Tabe-2) revealed that genotypic correlation coefficients were higher than phenotypic correlations. High correlation suggested that there was inherent relationship between characters under study. In general the signs and magnitude of correlation at both phenotypic and genotypic level is similar. Fresh weight per plant were positively correlated with days to flowering, number of leaves per plant, leaf area, panicle length, dry weight per plant, grain yield per plant and 1000 seed weight. Fresh and dry weight per plant had a strong association with number of leaves per plant, leaf area and panicle length. This indicated that when the number of leaves is many, there will be a greater surface area for photosynthesis; greater photosynthesis can translate into more photosynthates, ultimately resulting in increased fodder yield (Alhassan *et al*., 2008; Jain *et al.*, 2010 and Jain and Patel, 2014).

Due to mutual cancellation of component traits, the estimation of correlation alone may be often misleading, so it is necessary to study the path coefficient 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 and Fig.1). The higher residual effect [residual (G) =0.47 and residual (P) = 0.49] indicated the inadequacy of the trait chosen for the path analysis. The path coefficient analysis indicated positive and significant correlation as well as high or moderate direct effects of dry weight per plant, panicle length, number of leaves per plant, plant height, grain yield per plant and 1000 seed weight on fresh weight per plant . Such results are in concurrence with the results of Kumar and Singh (2012) and Jain and Patel (2014). Results from the present study indicated that selection for plant height, leaf area, number of leaves per plant and panicle length will be the best indirect selection indices for increasing fresh and dry weight yield.

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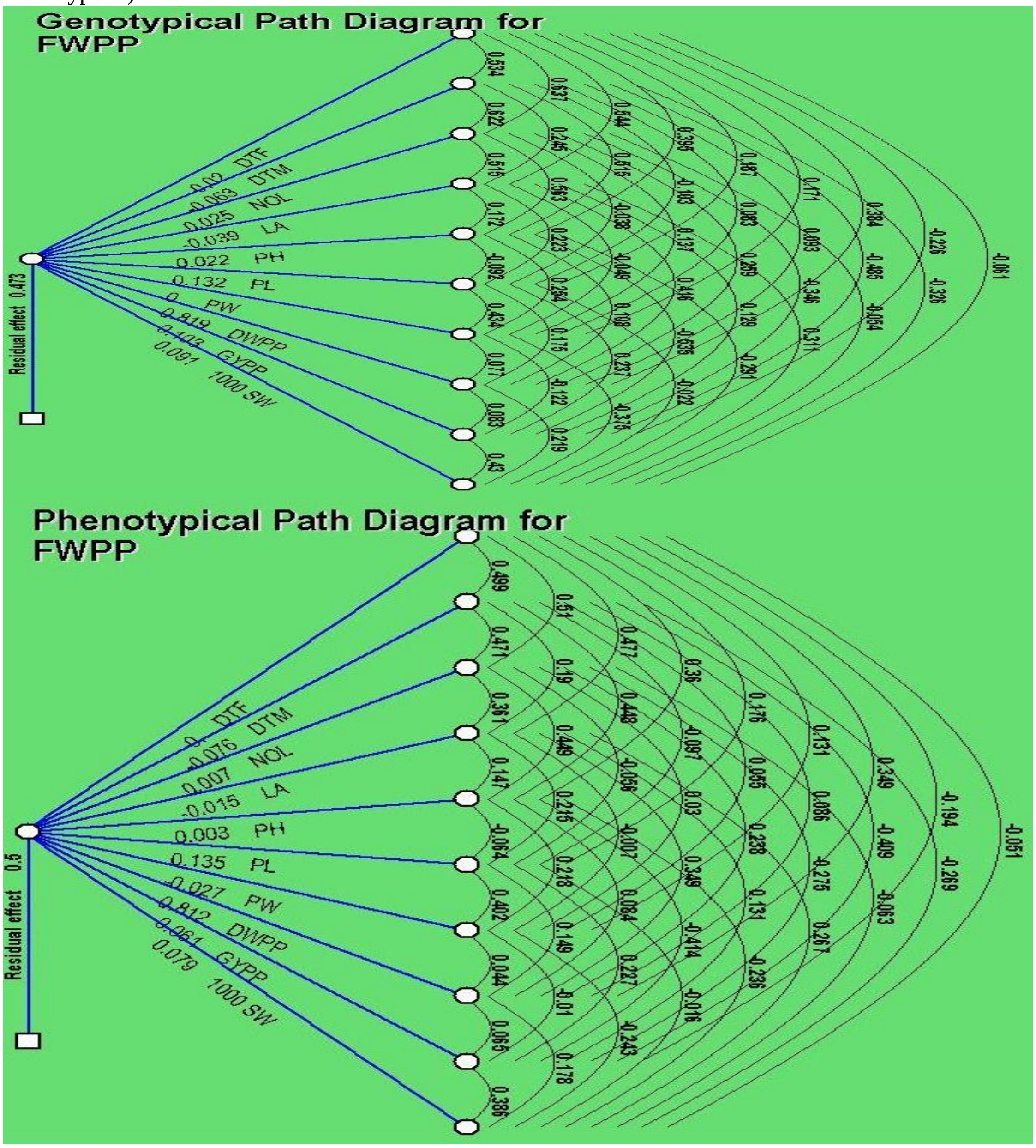
Fig-1 Direct, indirect and residual effects of different traits on fresh weight per plant (Genotypical and Phenotypical)



DTF-Days to 50% flowering, DTM-Days to maturity, NOL-Number of leaves per plant, LA-Leaf area, PH-Plant height, PL-Panicle length, PW-Panicle width, DWPP-Dry weight per plant, GYPP-Grain yield per plant, 1000 SW- Thousand seed weight

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Table-1: Genetic parameters of variability for fresh weight per plant and other traits

Characters	Range	Mean	GCV (%)	PCV (%)	Heritability (%)	Genetic Advance (GA)	Expected mean next generation
Days to flowering	49.33-96.00	67.91	12.73	12.97	96.3	17.48	85.39
Days to maturity	95.33-125.67	108.07	5.40	5.78	87.3	11.24	119.31
No of leaves/plant	9.00-17.33	12.74	11.90	14.48	67.6	2.57	15.31
Leaf area (cm^2)	172.77-629.27	370.89	21.48	23.99	80.2	147.01	517.89
Plant height (cm)	128.87-323.33	243.45	16.92	18.10	87.3	79.28	322.73
Panicle length (cm)	7.73-33.87	18.94	30.48	31.74	92.2	11.42	30.35
Panicle width (cm)	4.20-18.13	6.66	22.01	27.60	63.6	2.41	9.07
Fresh weight/plant (g)	78.67-625.87	207.84	37.55	38.83	93.5	155.51	363.35
Dry weight/plant (g)	22.47-204.67	76.22	41.76	45.01	86.1	60.84	137.06
Grain yield/plant (g)	2.53-38.23	13.27	53.64	62.03	74.8	12.68	25.95
1000 Seed weight (g)	7.13-33.37	22.05	16.05	17.77	81.5	6.58	28.64

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Table-2: Phenotypic and Genotypic correlation between different quantitative traits in sorghum

Characters		Days to flowering	Days to maturity	No of leaves/plant	Leaf area	Plant height	Panicle length	Panicle width	Dry weight/plant	Grain yield/plant	1000 seed weight	Fresh weight/plant
Days to flowering	P	1.000	0.499**	0.510**	0.477**	0.36**	0.176**	0.131**	0.345**	-0.194**	-0.050	0.248**
	G		0.534	0.637	0.544	0.395	0.187	0.171	0.384	-0.226	-0.061	0.260
Days to maturity	P		1.000	0.47**	0.190**	0.448**	-0.097*	0.055	0.086*	-0.41**	-0.27**	-0.066
	G			0.622	0.245	0.515	-0.103	0.083	0.093	-0.485	-0.326	-0.074
No of leaves/plant	P			1.000	0.361**	0.449**	-0.056	0.030	0.238**	-0.275**	-0.063	0.13**
	G				0.515	0.563	-0.038	0.137	0.259	-0.346	-0.054	0.132
Leaf area	P				1.000	0.147**	0.215**	-0.007	0.349**	0.131**	0.267**	0.315**
	G					0.172	0.223	-0.049	0.417	0.129	0.311	0.363
Plant height	P					1.000	-0.063	0.218**	0.084*	-0.413**	0.236**	-0.02
	G						-0.092	0.254	0.108	-0.535	-0.291	-0.017
Panicle length	P						1.000	0.401**	0.149**	0.228**	-0.016	0.261**
	G							0.434	0.175	0.237	-0.022	0.289
Panicle width	P							1.000	0.044	-0.009	- 0.243**	0.04
	G								0.077	-0.122	-0.375	0.076
Dry weight/plant	P								1.000	0.064	0.178**	0.839**
	G									0.083	0.219	0.849
Grain yield/plant	P									1.000	0.386**	0.201**
	G										0.430	0.252
1000 Seed weight	P										1.000	0.266**
	G											0.314
Fresh weight/plant	P											1.000
	G											

*, ** Significant at 5%, 1% level, respectively.

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Table-3: Genotypic and Phenotypic path analysis for direct (diagonal) and indirect (off diagonal) effects of fresh weight per plant

Characters		Days to flowering	Days to maturity	No of leaves/ plant	Leaf area	Plant height	Panicle length	Panicle width	Dry weight/ plant	Grain yield/ plant	1000 Seed weight	Correlation coefficient with fresh weight/plant
Days to flowering	P	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.248**
	G	-0.0201	-0.0108	-0.0128	-0.0110	-0.0080	-0.0038	-0.0034	-0.0077	0.0045	0.0012	0.260
Days to maturity	P	-0.0379	-0.076	-0.0358	-0.0144	-0.0341	0.0074	-0.0042	-0.0065	0.0311	0.0205	-0.066
	G	-0.0339	-0.0634	-0.0395	-0.0155	-0.0327	0.0065	-0.0053	-0.0059	0.0308	0.0207	-0.074
No of leaves/plant	P	0.0033	0.0031	0.0066	0.0024	0.0029	-0.0004	0.0002	0.0016	-0.0018	-0.0004	0.13**
	G	0.0159	0.0155	0.0249	0.0128	0.0140	-0.0009	0.0034	0.0065	-0.0086	-0.0013	0.132
Leaf area	P	-0.0072	-0.0029	-0.0054	-0.015	-0.0022	-0.0032	0.0001	-0.0052	-0.002	-0.004	0.315**
	G	-0.0210	-0.0095	-0.0199	-0.0387	-0.0067	-0.0086	0.0019	-0.0161	-0.0050	-0.0120	0.363
Plant height	P	0.001	0.0012	0.0012	0.0004	0.0027	-0.0002	0.0006	0.0002	-0.0011	-0.0006	-0.02
	G	0.0086	0.0112	0.0122	0.0037	0.0217	-0.0020	0.0055	0.0023	-0.0116	-0.0063	-0.017
Panicle length	P	0.0238	-0.0131	-0.0076	0.0291	-0.0087	0.1353	0.0544	0.0201	0.0308	-0.0022	0.261**
	G	0.0247	-0.0136	-0.0050	0.0294	-0.0121	0.1319	0.0572	0.0231	0.0313	-0.0029	0.289
Panicle width	P	-0.0036	-0.0015	-0.0008	0.0002	-0.0059	-0.0109	-0.0271	-0.0012	0.0003	0.0066	0.04
	G	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000	0.0000	0.076
Dry weight/plant	P	0.2838	0.0696	0.1935	0.2832	0.0686	0.1208	0.0357	0.8123	0.0524	0.1446	0.839**
	G	0.3142	0.0764	0.2123	0.3409	0.0881	0.1433	0.0629	0.8186	0.0683	0.1791	0.849
Grain yield/plant	P	-0.0119	-0.025	-0.0168	0.008	-0.0253	0.0139	-0.0006	0.0039	0.0612	0.0236	0.201**
	G	-0.0233	-0.0501	-0.0357	0.0133	-0.0553	0.0245	-0.0126	0.0086	0.1033	0.0445	0.252
1000 Seed weight	P	-0.004	-0.0212	-0.005	0.021	-0.0186	-0.0013	-0.0191	0.014	0.0304	0.0786	0.266**
	G	-0.0055	-0.0295	-0.0049	0.0282	-0.0264	-0.0020	-0.0340	0.0198	0.0390	0.0906	0.314

RESIDUAL EFFECT (G) = 0.4732, RESIDUAL EFFECT (P) = 0.4996