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Research Note

Correlation and path coefficient analysis of various sorghum genotypes (*Sorghum bicolor* L. Moench) for quality traits

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Abstract

The study was conducted on 25 sorghum genotypes grown in Randomized Block Design during Kharif 2015 to evaluate, categorize and classify them for fodder yield and quality traits. Correlation and path analysis studies were conducted to determine the association among various fodder yield and its component traits, and the direct and indirect contribution towards fodder yield in 25 sorghum (*Sorghum bicolor* L. Moench) genotypes grown at forage section in CCS Haryana Agricultural University, Hisar (Haryana, India) during Kharif, 2015. Plant height up to the base of flag leaf was positively associated with green fodder yield (0.30), dry fodder yield(0.91), digestible dry matter(0.96), IVDMD(0.54), and negatively associated with the time of panicle emergence. The number of tillers per plant was found to be positively associated with the number of leaves(0.37), crude protein(0.25), green fodder yield(0.26), dry fodder yield(0.30), and lignin content and negatively with stem girth. Green fodder yield was positively associated with plant height(0.30), the no. of leaves(0.27), stem girth, dry fodder yield, IVDMD, DDM and protein yield. Dry fodder yield was positively associated with GFY, plant height, stem girth, the no. of tillers, IVDMD, DDM and protein yield and negatively with panicle length visible above sheath. Lignin was positively associated with plant height and the no. of tillers and negatively with ADF, IVDMD and stem girth. The IVDMD content was positively associated with GFY, DFY, the no. of leaves, DDM and protein yield while, negatively with lignin. Crude protein was positively associated with the no. of leaves, stem girth, the no. of tillers, lignin, IVDMD and protein yield and negatively with ADF. The NDF was positively associated with crude protein. The DDM was positively associated with GFY, stem girth, DFY, IVDMD and protein yield. Protein yield was positively associated with GFY, the no. of leaves, stem girth, DFY, IVDMD, crude protein and DDM and negatively with stigma length. Therefore, these traits could be considered as the best selection criteria in sorghum breeding programmes for the development of high yielding varieties.

Keywords

Sorghum, Correlation coefficient, Path coefficient, IVDMD

Sorghum (Sorghum bicolor L. Moench) originated in Africa is one of the five top cereal crops in the world. Its extremely drought tolerant ability makes it an excellent choice for arid and dry areas. Its quick growing habit, high yield, regeneration potential, better palatability, digestibility and drought tolerance makes it a good choice of fodder for the farming community on which the livestock industry depends. It can grow in the areas where all other major cereal crops could not grow successfully.In India, the area under cultivated sorghum is 5.82 million hectares with a production of 5.39 million ton and productivity of 926 kg/ha. In Haryana, 72 thousand hectares area was under sorghum with the production of 40 thousand tons and productivity of 500 kg/ha (Anonymous, 2014-2015).Veerabadhiran and Kennedy (2001) studied correlation and path analysis in 75 sorghum genotypes and observed that genotypic correlation was generally higher than phenotypic.

Chaudhary and Arora (2001) evaluated 23 genotypes of sorghum in four environments and observed that grain yield was positively correlated with biological yield, stover yield and the number of leaves per plant. Path analysis revealed the importance of stover yield, harvest index, the number of leaves per plant and flag leaf area.Umakanth *et. al.,* (2004) studied 40 landraces and 3 established lines from the national programme on sorghum. High heritability estimates coupled with high genetic advance were observed for panicle length and 100-seed weight. Bini and Bai (2005) observed that sorghum green fodder yield had a positive correlation with all the characters except leaf: stem ratio. Leaf weight per plant exhibited the maximum direct effect on green fodder yield.Iyanar and Khan (2005) evaluated 109 genotypes of multi-cut fodder sorghum and reported that all the traits were positively correlated with green fodder yield per plant. Among these traits, dry fodder yield exhibited a high correlation coefficient with green fodder yield per plant followed by leaf length, plant height and the number of leaves.

Borad *et al.,* (2007) revealed a high positive and significant association of stem girth, stem weight, leaf weight and crude protein yield with green fodder as well as dry matter yields both at phenotypic and genotypic levels in 49 sorghum lines. Buttar *et. al*., (2008) evaluated 31 sorghum genotypes and reported the seed yield per plant, biological yield, the number of branches per plant, and plant height exhibited significant genetic coefficients of variation (>20 %) along with high estimates of heritability.

Jadhav *et. al.,* (2009) studied 62 diverse genotypes of forage sorghum and revealed that green fodder yield per plant had a positive and significant association with days to 50 per cent flowering, plant height, leaves per plant, leaf length, leaf width, crude protein content and dry matter yield per plant. The correlation of green fodder yield per plant with the number of tillers per meter row length was negative but significant. Hence, the emphasis should be given to the traits like tallness, late maturity, more leaves having broad and longleaf size, less number of tillers coupled with high dry matter yield and increased crude protein in developing the genotypes having high green fodder yield. Path coefficient analysis revealed that dry matter yield per plant exhibited the highest positive direct effect on green fodder yield per plant indicating that direct selection for trait would be effective in improving green fodder yield. Dry matter (%) had a high magnitude of the negative and direct effect on green fodder yield per plant.Jain *et. al.,* (2009) observed that most of the characters had a higher genotypic and phenotypic coefficient of variation. Characters such as grain yield per plant, dry fodder yield per plant and height responded positively to selection because of high broad-sense heritability and high genetic advance.

Twenty-five forage sorghum genotypes Bmr1, Bmr-2, Bmr-3, Bmr-4, Bmr-5, COFS 29, HJ 513, HC 260, IS 2205, IS 2389, DUGGI, CSV 21F, S 490, S 437, S 651, G 46, SSG 593, HC 136, HC 171, HJ 541, PC 5, PC 7, PC 8, ICSV 700, HC 308 were used in present study. The material was collected from Forage Section, Department of Genetics and Plant Breeding CCSHAU, Hisar and sowing was done on July 4, 2015. The field experiment was conducted at Research Area of Forage Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar. Observations were recorded on different quantitative variables. Correlation coefficients at phenotypic and genotypic levels were calculated using the variances and co-variances according to Al-Jibouri *et al.* (1958) and path coefficients were obtained according to Dewey and Lu (1959).

Correlation coefficients were calculated to study the association among different characters and are presented in **Table 1.**Plant height up to the base of flag leaf was positively associated with green fodder yield, dry fodder yield, digestible dry matter, lignin, IVDMD, length of branches and negatively associated with the time of panicle emergence. The number of tillers per plant was found to be positively associated with the number of leaves, crude protein, green fodder yield, dry fodder yield, and lignin and negatively with stem girth. Green fodder yield was positively associated with plant height, the no. of leaves, stem girth, dry fodder yield, IVDMD, DDM and protein yield. Dry fodder yield was positively associated with GFY, plant height, stem girth, the no. of tillers, IVDMD, DDM and protein yield and negatively with panicle length visible above sheath. Lignin content was positively associated with plant height and no. of tillers and negatively with ADF, IVDMD and stem girth. IVDMD content was positively associated with GFY, DFY, the no. of leaves, DDM and protein yield while, negatively with lignin. Crude protein was positively associated with the no. of leaves, stem girth, the no. of tillers, lignin, IVDMD and protein yield and negatively with ADF. NDF was positively associated with crude protein. DDM was positively associated with GFY, stem girth, DFY, IVDMD and protein yield. Protein yield was positively associated with GFY, the no. of leaves, stem girth, DFY, IVDMD, crude protein and DDM and negatively with stigma length.

Direct and indirect effects of different characters on dry fodder yield (q/ha) were calculated which have been presented in **Table 2**

A critical perusal of path coefficient analysis exhibited high direct and positive effects of DDM (0.830), panicle length of branches (0.132), green fodder yield (0.321), plant height up to the base of flag leaf (0.362), NDF (0.072) and crude protein (0.120) while stem girth (-0.042), the number of tillers (-0.612). Days to 50% flowering (-0.656) had the highest negative direct effect. This indicated that green fodder yield, crude protein, panicle length of branches and DDM were important traits so far their association with dry fodder yield is concerned.

Green fodder yield (0.096) and DDM (0.346) had high positive indirect effects *via* plant height. DDM (0.149) had high positive indirect effects *via* the number of leaves. Green fodder yield (0.218) had high positive indirect effects *via* stem girth. DDM (0.799) had high positive indirect effects *via* green fodder yield. IVDMD (0.030) had high positive indirect effects while DDM (-0.207) and green fodder yield (-0.062) had high negative indirect effects *via* crude protein. The DDM (0.492) had high positive indirect effects via IVDMD. DDM (-0.023) had high negative indirect *via* NDF. The DDM (-0.031) had high

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negative indirect effects *via* ADF. The IVDMD (0.050) had high positive indirect effects while DDM (-0.004) had high negative indirect effects *via* lignin Green fodder yield (0.079) and IVDMD (0.049) had high positive indirect effects *via* DDM. Days to 50% flowering (0.009) had high positive indirect effect while panicle length of branches (-1.008), plant height (-0.030), stem diameter (-0.004) had high negative indirect effect *via* green fodder yield. Panicle length of branches (1.526) and 50% flowering (0.869) had the high positive indirect effect, however, panicle length of branches (-1.395) and plant height (-0.643) had a high negative indirect effect on dry fodder yield. Residual effect calculated was 0.0447. This indicated that a considerable magnitude of variation was presented for an association of dry fodder yield with dependent traits.

Table 1. Phenotypic (above diagonal) and genotypic (below diagonal) correlation coefficients of various traits

	GFY	P.H	NOL	S.G	NOT	DFY	NOD	S.L	A.L	L. B	P.L	LIGNIN	IVDMD	C.P	NDF	ADF	DDM	P.Y
GFY	1	0.305**	0.212*	0.491**	0.220*	0.868**	0.027	0.136	0.211	-0.096	-0.151	-0.064	0.499**	0.129	-0.014	-0.072	0.887**	0.874**
P.H	0.301*	1	-0.086	0.099	0.02	0.291*	-0.270*	0.095	0.309	0.367**	0.474	0.302**	0.483**	0.149	-0.117	0.151	0.384**	0.193
NOL	0.273*	-0.165	1	-0.257*	0.362**	0.126	-0.126	0.395	0.238	0.055	0.048	0.038	0.245*	0.084	-0.208	0.019	0.161	0.295**
SG	0.517**	0.116	-0.296**	1	-0.399**	0.515**	0.047	0.005	0.037	-0.267*	-0.095	-0.221	0.151	0.173	-0.047	-0.122	0.470**	0.399**
NOT	0.266*	0.082	0.376*	-0.450**	1	0.309*	0.171	0.041	0.337	0.216	0.153	0.529**	-0.094	-0.256	-0.126	0.563**	-0.193	-0.175
DFY	**0.941****	0.322**	0.147	0.548**	0.212*	1	-0.009	0.178	0.134	-0.174	-0.226*	-0.039	0.486**	0.178	-0.04	-0.058	0.935**	0.867**
NOD	0.029	0.314**	-0.146	0.061	0.185	-0.005	1	0.144	0.049	-0.374**	0.276	0.097	0.007	-0.277*	0.173	0.238*	-0.058	-0.006
S.L	0.122*	0.151	0.454	0.012	0.017	0.189*	0.147	1	0.314	-0.162	-0.124	-0.095	-0.146	-0.029	-0.071	0.062	-0.205	-0.275*
A.L	0.218	0.377	0.358	0.011	0.412	0.168	0.064	0.352	1	0.151	0.104	-0.351**	0.111	0.319**	0.058	-0.373**	0.159	0.124
L. B	-0.105	0.448**	0.049	-0.274*	0.255*	-0.188	-0.402**	-0.161	0.165	1	0.608**	0.177	0.02	0.11	-0.034	0.135	-0.003	-0.039
P.L	-0.162	0.556	0.053	-0.088	0.186	-0.235*	0.294	-0.145	0.136	0.631**	1	0.158	0.134	0.179	-0.121	0.068	-0.05	-0.162
LIGNIN	-0.056	0.408**	0.117	-0.242*	0.583**	-0.039	0.111	0.107	0.418	0.191	0.171	1	-0.277*	0.139	0.015	-0.589**	-0.121	-0.060
IVDMD	0.544**	0.541**	0.303**	0.166	-0.097	0.491**	0.005	0.162	0.121	0.015	0.138	-0.169*	1	0.224	-0.098	0.151	0.573**	0.480**
C.P	0.195	0.164	0.169*	**0.197***	**0.320****	0.239*	-0.316**	0.041	0.408	0.156	0.212	**0.169***	0.256*	1	-0.132	-0.267*	0.174	0.288*
NDF	-0.003	-0.147	-0.247*	-0.051	-0.14	-0.037	0.179	0.084	0.062	-0.027	0.122	0.013	-0.098	**-0.116***	1	0.042	-0.026	0.033
ADF	**-0.074**	-0.178	0.024*	-0.127	0.612**	-0.057	0.244*	0.065	0.437	0.136	0.067	0.606**	0.153	-0.319**	0.143**	1	-0.041	-0.072
DDM	**0.963****	0.418**	0.181	0.488**	**-0.221***	**0.954****	-0.054	0.220	0.192	0.342	0.047	0.005	**0.593****	**0.249***	-0.029	-0.038	1	0.887**
PY	0.936**	0.201	0.344**	0.418**	-0.209	0.887**	-0.005	0.303	0.123	-0.037	0.164	-0.064	0.495**	0.380**	0.031	-0.069	0.899**	1

* Significant at 5% level   ** Significant at 1% level

Table 2. Direct (diagonal) and indirect (off-diagonal) path coefficients on dry fodder yield

	GF	P.H	NOL	SG	NOT	NOD	S.L	A.L	L.B	P.L	LIGNIN	IVDMD	C.P	NDF	ADF	DDM	P.Y
G.F	**0.32114**	-0.41001	-0.13406	0.2187	-0.16296	0.01897	-0.01285	0.16503	0.01387	-0.00883	-0.04508	0.39505	-0.02348	0.00023	0.01635	0.79952	0.46912
P.H	0.09664	**36248**	0.08077	0.04893	0.05042	0.20604	0.01588	0.2855	-0.05936	-0.03038	0.33018	0.39276	-0.01969	0.01061	-0.0394	0.34691	0.10083
NOL	-0.08771	0.2242	**0.49081**	-0.1252	0.23036	0.09575	-0.04773	-0.27076	-0.00645	-0.00291	0.09477	0.21988	-0.02029	0.01785	-0.00526	0.14914	0.17228
S.G	-0.16605	-0.15762	0.14529	**-0.42296**	-0.27582	-0.04018	0.00107	-0.00806	0.03632	-0.00482	-0.19582	0.1207	0.02365	0.00365	0.0281	0.40498	0.20932
NOT	0.08537	-0.11207	-0.18446	-0.19032	**-0.61297**	-0.12172	-0.00183	-0.3118	-0.03374	0.01019	0.47221	-0.07006	0.03853	0.01014	-0.13567	-0.18315	-0.10491
NOD	0.00928	0.42775	0.07161	0.0259	0.11369	**-0.6563**	0.0154	-0.04807	0.05322	-0.01606	0.08972	0.00343	0.03796	-0.01298	-0.05412	-0.04458	-0.00258
S.L	0.03928	-0.20596	0.22301	0.00431	-0.01068	-0.09623	**0.10504**	0.26613	0.02135	0.00791	-0.08689	-0.11787	0.0049	0.00606	-0.01442	-0.18295	-0.15192
A.L	-0.07006	-0.51424	0.17568	-0.00451	-0.25266	0.04171	0.03696	**0.75643**	-0.02181	0.00744	-0.33855	0.08742	-0.04903	-0.00449	0.09687	0.15906	0.06165
L.B	0.03361	-0.6104	-0.02389	-0.11595	0.1561	0.26358	-0.01692	0.12453	**0.13251**	0.03445	0.15478	0.01095	-0.01882	0.00194	-0.03022	-0.00038	-0.01841
P.L	-0.05191	-0.75774	0.02611	-0.03732	0.11432	0.19294	0.01522	0.10308	-0.08357	**0.05462**	0.1377	0.10039	-0.02552	0.00878	-0.01488	-0.03896	-0.08197
LIGNIN	0.01787	-0.55536	-0.05742	-0.10225	0.35733	-0.0727	-0.01127	-0.31615	-0.02532	0.00928	**0.81003**	0.05024	0.02035	-0.00096	-0.13446	-0.00432	-0.03212
IVDMD	-0.17483	-0.73745	-0.14872	0.07035	-0.05918	-0.0031	-0.01706	0.09113	-0.002	0.00756	0.05608	**0.72564**	0.03084	0.0071	-0.03387	0.49232	0.24785
C.P	-0.06268	-0.22303	-0.08279	-0.08318	-0.19638	0.2071	-0.00428	0.30836	-0.02074	0.01159	-0.13702	0.18603	**0.12028**	-0.01157	0.07074	-0.20704	0.19053
NDF	0.00101	0.2001	0.12122	-0.02136	-0.086	-0.11747	-0.00881	0.04697	0.00355	-0.00664	0.01081	-0.07129	-0.01926	**0.07227**	-0.00948	-0.02376	0.01535
ADF	0.02366	-0.24196	-0.01165	-0.05358	0.37486	-0.1601	0.00683	-0.33032	-0.01805	0.00366	0.49096	0.11077	0.03835	-0.00309	**-0.22185**	-0.03121	-0.03461
DDM	-0.30928	-0.56935	-0.08817	0.20633	-0.13524	0.03525	-0.02315	0.14493	0.00006	-0.00256	-0.00422	0.43083	-0.03	0.00207	0.00834	**0.83017**	0.45046
P.Y	-0.30063	-0.27414	-0.16874	0.17667	-0.12833	0.00337	-0.03185	0.09306	0.00487	-0.00893	-0.05192	0.3589	-0.04573	-0.00221	0.01532	0.74624	**0.50112**

Residual effects: P = 0.047 ; *, ** significant at 5 and 1 per cent level respectively Diagonal values (**bold**) are direct effects

Positive significant correlations were recorded between dry fodder with green fodder yield. Days to 50% flowering had a positive correlation with plant height up to the base of the flag leaf. Plant height was positive by correlated with the neck of panicle visible above sheath, panicle length of branches and length of the flag leaf. Whereas, dry fodder yield and green fodder yield had a negative significant correlation with plant height and leaf length of the blade. Iyanar and Khan (2005) studied on 109 genotypes of sorghum and found a high positive correlation of dry fodder yield with green fodder yield and plant height. A critical perusal of path coefficient analysis exhibited high direct and positive effects of DDM (0.830), panicle length of branches (0.132), green fodder yield (0.321), plant height up to the base of flag leaf (0.362), NDF (0.072) and crude protein (0.120) while stem girth (-0.042), the number of tillers (-0.612), days to 50% flowering (-0.656) had high negative direct effects. This indicated that green fodder yield, crude protein, panicle length of branches and DDM were important traits so far their association with dry fodder yield is concerned.

Green fodder yield (0.096) and DDM (0.346) had high positive indirect effects *via* plant height. DDM (0.149) had high positive indirect effects via the number of leaves. Green fodder yield (0.218) had high positive indirect effects *via* stem girth. DDM (0.799) had high positive indirect effects *via* green fodder yield. IVDMD (0.030) had high positive indirect effects while DDM (-0.207) and green fodder yield (-0.062) had high negative indirect effects *via* crude protein. DDM (0.492) had high positive indirect effects *via* IVDMD. DDM (-0.023) had high negative indirect *via* NDF. DDM (-0.031) had high negative indirect effects *via* ADF. IVDMD (0.050) had high positive indirect effects while DDM (-0.004) had high negative indirect effects *via* lignin Green fodder yield (0.079) and IVDMD (0.049) had high positive indirect effects *via* DDM. Days to 50% flowering (0.009) had high positive indirect effect while panicle length of branches (-1.008), plant height (-0.030), stem diameter (-0.004) had high negative indirect effect *via* green fodder yield. Panicle length of branches (1.526) and 50% flowering (0.869) had a high positive indirect effect, however, panicle length of branches (-1.395) and plant height (-0.643) had a high negative indirect effect on dry fodder yield.

Residual effect calculated was 0.0447. This indicated that a considerable magnitude of variation was present for an association of dry fodder yield with dependent traits

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