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Correlation and path analysis study between yield and yield components in colored pericarp sorghum (*Sorghum bicolor* (L.) Moench)

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Abstract
Eighty one genotypes including five checks were studied for character association for yield and its components. Correlation study estimates gives some idea as to the relative importance of each of the components to final grain yield, although it is an established fact that nature and magnitude of associations would vary with the composition of the material. In present study, simple correlation co-efficient were estimated at both the phenotypic and genotypic levels in eighty one genotypes. It was observed that the magnitude of association varied among the genotypes. Correlation studies revealed that, grain yield per plant had significant positive association with days to 50% flowering, plant height, number of primaries per panicle, panicle length, panicle width, days to physiological maturity, threshability, fodder yield per plant and non-significant positive association with panicle type, grain color, 100-seed weight point out that the importance of these characters in selection programme for selecting high yielding genotypes in sorghum.

Keywords: Correlation, path analysis, colored pericarp sorghum, phenotypic and genotypic

Introduction
Sorghum (*Sorghum bicolor* (L.) Moench) is one of the essential crop required for the survival of humankind. It is one of the most efficient, environment friendly, widely used and adapted crop grown mostly in tropical and sub-tropical climates. Sorghum is being cultivated during *rabi* and *kharif* season for grain as well as fodder purpose. Seed color ranges from shades of white to various shades of pink, orange, red and even brown, seed color occurs due to influences of pericarp thickness. Moderately high levels of phenolic compound but absence of tannin mainly associated with red sorghum. Usually red colored sorghum preferred in brewing industries. Whereas, flavanones which are loaded in yellow sorghum has somewhat higher total phenolic content than white sorghum. Due to existence of pigmented testa and high level of condensed tannins brown sorghum also known as tannin sorghum. The color is closely associated to the phenolic profile of the grain, mainly the bran layer of the grain. Colored sorghum with high levels of phenolic compounds, 3-deoxyanthocyanidins, and condensed tannins can be isolated and used as promising natural multifunctional additives and would be source of useful ingredients in drug industries and in broad food applications.
It is well established fact that the progress in improvement of crop depends on relationship among polygenic characters. It is important for assessing the practicability of joint selection of two or more traits and hence for evaluating the effect of selection foe secondary character on genetic gain foe the primary character under consideration. If two desirable traits shows positive genetic correlation it is easy for plant breeder for improving both traits side by side. To qualify direct and indirect contribution of yield contributing traits path analysis was performed.
Therefore the present investigation was undertaken to study relationship among quantitative traits and path coefficient analysis in selected genotypes of sorghum during 2019-20.

Material and Methods
The present investigation was undertaken to study correlation and character associated studies in eighty one genotypes of [*Sorghum bicolor* (L.) Moench] including five checks.
Eighty one genotypes of colored sorghum including five checks were sown during *rabi* 2019 in Randomized Block Design with two replications with row to row spacing 45cm and plant to plant 15cm. The experiment was conducted at Sorghum research station, VNMKV, Parbhani.

All the recommended cultural practices and packages were applied for growing healthy and good crop, in each entry, five plants are randomly selected from each replication and following observations were recorded for days to 50 percent flowering, plant height, number of primaries per panicle, panicle type, panicle length, panicle width, days to physiological maturity, 100-seed weight, threshability, grain color, glume color, grain yield per plant, fodder yield per plant.

The association between two or more polygenic characters is of great interest and brings much practical significance. Correlation is measure of the degree to which traits are correlated with yield or between themselves (Burton, 1952).Path coefficient were calculated by the method used by Dewey and Lu (1959) [5] by solving simultaneous equations which express the basic relationship between path coefficient and correlation coefficient.

Results and Discussion

In the present study, significant and positive correlation of grain yield per plant was recorded (Table 2) with traits *viz*., days to 50% flowering, number of primaries, days to physiological maturity, panicle length, panicle breadth, threshability, and fodder yield per plant. These traits had significant contribution in the expression of grain yield in same direction. Number of primaries, panicle length and breadth are important criteria for the indirect selection towards grain yield. Plant height shows positive and significant correlation at genotypic level only (G= 0.234, P= 0.219). Panicle type, grain color, 100-seed weight showed positive but non-significant association with grain yield per plant. While negative association with grain yield was exhibited by the character glume color at both genotypic and phenotypic levels. Days to 50 percent flowering has highly significant and positive with plant height (G= 0.312, P= 0.358), number of primaries per panicle (G= 0.279, P= 0.306), panicle length (G= 0.345, P= 0.401), panicle width (G= 0.252, P= 0.308), days to physiological maturity (G= 0.540, P= 0.613), threshability (G= 0.394, P=0.439). Plant had positive and significant association with panicle length (G= 0.277, P= 0.319) it showed positive significant correlation at genotypic level only with days to physiological maturity (G= 0.215, P=0.252) and it showed positive significant correlation at phenotypic level only with fodder yield per plant (G= 0.233, P= 0.211), number of primaries per panicle recorded significantly positive correlation with panicle length (G= 0.341, P= 0.385), threshability (G= 0.371, P= 0.409) it showed positively significant for panicle width (G= 0.203, P= 0.2240 and days to physiological maturity (G= 0.212, P= 0.234) at phenotypic level only. Panicle type had positive and significant association with 100-seed weight (G= 0.224, P= 0.276) whereas, it showed positively significant at phenotypic level with panicle length and grain color (G= 0.217, P= 0.221). Association of panicle width (G= 0.444, P= 0.510), days to physiological maturity (G= 0.371, P= P= 0.493), threshability (G= 0.598, P= 0.683), fodder yield per plant (G= 0.410, P= 0.445) at both levels. Panicle width recorded significant and positive correlation with days to physiological maturity (G= 0.317, P= 0.416), threshability (G= 0.598, P= 0.683) fodder yield per plant (G= 0.410, P= 0.445) at phenotypic and genotypic levels. Days to physiological maturity had recorded significant and positive correlation with threshability (G= 0.344, P= 0.441) at both levels whereas, it showed significant and positive correlation at phenotypic level only with 100-seed weight (G= 0.143, P= 0.243) and fodder yield per plant (G= 0.185, P= 0.259). Grain color showed negative and significant correlation with 100-seed weight (G= -0.336, P= -0.450) at genotypic and phenotypic level. Association of glume color was negative and significant with fodder yield per plant (G= -0.247, P= -0.273) at both levels whereas with 100-seed weight (G= -0.209, P= -0.269) association was negative and significant at phenotypic level only. 100-seed weight recorded weak positive correlation with threshability (G= 0.124, P= 0.163), fodder yield per plant (G= 0.124, P= 0.163) at both levels. Association of threshability was positive and significant with fodder yield per plant (G= 0.486, P= 0.543). Similar results obtained by Ramaling *et al.* (2016) [11] for days to 50% flowering and days to physiological maturity, Awari *et al.* (2003) [2] for plant height and panicle width, Cheralu and Rao (1989) [4] for number of primaries per panicle and fodder yield, Jimmy *et al.* (2017) [7] for panicle length, Ezeaku and Mohammed (2005) for 100-seed weight.

Partitioning of yield and yield components into direct and indirect effect (Table 3) revealed that presence of positive direct effect on grain yield for traits like days to 50% flowering (G= 0.088, P=0.068), panicle length (G= 0.55, P=0.032), panicle length (G=0.102, P=0.078), panicle width (G=0.098, P=0.125), days to physiological maturity (G=0.090,P=0.076), grain color (G=0.022, P=0.041), threshability (G=0.691, P=0.721), fodder yield per plant (G=0.128, P=0.0088) similar results were in accordance with Aml *et al.* (2012) [1] for days to 50% flowering, panicle length, panicle width, Potdukhe *et al.* (1992) [10] for panicle type and glume color, Patel *et al.* (1993) [9] for days to physiological maturity, Kandelwal *et al.* (2015) [8] for threshability, fodder yiled per plant. Positive direct effect on grain yield at phenotypic level reported for traits plant height (0.019), 100-seed weight (0.013). Among all traits plant height (-0.013) and 100-seed weight (-0.033) had negative direct effect. Similar results were in accordance with Patel *et al.* (1993) [9] and Wankhede *et al.* (1985) [12]. Number of primaries (G=-0.033, P=-0.003) recorded negative direct effect on grain yield at both levels. Maximum positive direct effect on grain yield recorded by threshability (G=0.691, P=0.721) at both levels whereas, maximum negative direct effect recorded by number of primaries per panicle and 100-seed weight (-0.033) at genotypic level for phenotypic level it was recorded by number of primaries per panicle (-0.003) while, minimum positive direct effect recorded by grain color (0.022) at genotypic level and at phenotypic level by 100-seed weight (0.013) and minimum negative direct effect recorded by number of primaries per panicle (-0.003).

The genotypic residual effect was 0.203 whereas. Phenotypic residual effect was 0.280. Moderate residual effect was observed in present study, it shows that there is some other factors that contribute to yield besides the character studied.

Table 1: Analysis of Variance for thirteen characters of colored pericarp sorghum

Sr. No	Sources of variation	Df	Days to 50% Flowering	Plant height (cm)	Number of primaries per panicle	Panicle type (1-9 score)	Panicle length (cm)	Panicle width (cm)	Physiological maturity	Grain color (1-5 score)	Glume Color (1-6 score)	100 seed weight (gm)	Threshability (%)	Grain yield/plant (g)	Fodder yield/ plant (g)
1	Replication	1	0.02	40.85	1.97	0.09	0.15	0.21	52.24	0.00	0.05	1.05	2.72	7.89	41.50
2	Treatments	80	35.97**	1166.19**	301.97**	9.08**	27.84**	2.32*	45.31**	3.79**	4.69**	0.99	24.60**	98.98**	1977.08**
3	Error	80	6.77	15.24	4.48	0.24	6.20	0.38	12.44	0.01	0.01	0.43	4.63	9.56	85.83

** and * Significant at 1 and 5 percent level respectively

Table 2: Genotypic and phenotypic correlation coefficient for grain yield and its attributing characters in colored pericarp sorghum

Characters		Days to 50% flowering	Plant height (cm)	No. of primaries per panicle	Panicle type 1-9score	Panicle length (cm)	Panicle width (cm)	Days to physiological maturity	Grain color (1-5score)	Glume color (1-6score)	100- seed weight	Threshability (%)	Fodder yield (g/plant)	Grain yield (g/plant)
Days to 50% flowering	G	1.000	0.312**	0.279*	-0.101	0.345**	0.252*	0.540**	0.008	-0.089	0.039	0.394**	0.176	0.516**
	P	1.000	0.358**	0.306**	-0.113	0.401**	0.308**	0.613**	0.012	-0.095	0.109	0.439**	0.192	0.468**
Plant height	G		1.000	0.042	-0.193	0.277*	0.065	0.215	0.021	-0.150	-0.024	0.168	0.233*	0.234*
	P		1.000	0.044	-0.201	0.319**	0.079	0.252*	0.021	-0.151	-0.046	0.192	0.211	0.219
No. of primaries per panicle	G			1.000	0.185	0.341**	0.203	0.212	-0.019	-0.182	0.072	0.371**	0.189	0.388**
	P			1.000	0.188	0.385**	0.224*	0.234*	-0.020	-0.184	0.091	0.409**	0.211	0.370**
Panicle type	G				1.000	0.028	0.100	-0.034	0.217	0.130	0.224*	0.121	0.023	0.146
	P				1.000	0.030	0.117	-0.057	0.221*	0.133	0.276*	0.134	0.017	0.139
Panicle length	G					1.000	0.444**	0.371**	0.086	-0.041	-0.024	0.598**	0.410**	0.748**
	P					1.000	0.510**	0.493**	0.097	-0.042	-0.013	0.683**	0.445**	0.662**
Panicle width	G						1.000	0.317**	0.029	-0.058	0.018	0.520**	0.292**	0.669**
	P						1.000	0.416**	0.031	-0.060	0.013	0.599**	0.333**	0.606**
Days to physiological maturity	G							1.000	0.032	-0.076	0.147	0.344**	0.185	0.550**
	P							1.000	0.044	-0.084	0.243*	0.441**	0.259*	0.450**
Grain color	G								1.000	0.183	-0.336**	-0.019	-0.084	0.050
	P								1.000	0.182	-0.450**	-0.016	-0097	0.042
Glume color	G									1.000	-0.209	-0.158	-0.247*	-0.119
	P									1.000	-0.269*	-0169	-0273*	-0.120
100- seed weight	G										1.000	0.115	0.124	0.103
	P										1.000	0.129	0.163	0.108
Threshability (%)	G											1.000	0.486**	0.950**
	P											1.000	0.543**	0.932**
Fodder yield (kg/plant)	G												1.000	0.597**
	P												1.000	0.530**
Grain yield (g/plant)	G													1.000
	P													1.000

Table 3: Direct and indirect effects (genotypic and phenotypic level) of yield components on grain yield in color pericarp sorghum

Characters		Days to 50% flow erring	Plant height(cm)	Number of prima ries per panicle	Panicle type (1-9score)	Panicle length (cm)	Panicle width (cm)	Days to physiological maturity	Grain color (1-5score)	Glume color (1-6score)	100 - seed weight (g)	Threshability (%)	Fodder yield/plant(g)	Grain yield/Plant (g)
Days to 50% flowering	G	0.088	0.031	0.027	-0.010	0.035	0.027	0.054	0.001	-0.008	0.009	0.038	0.017	0.516**
	P	0.068	0.021	0.000	-0.007	0.023	0.001	0.037	0.000	-0.006	0.002	0.027	0.012	0.468**
Plant height(cm)	G	-0.004	-0.013	-0.000	0.002	-0.004	-0.001	-0.003	-0.000	0.002	0.000	-0.002	-0.003	0.234*
	P	0.006	0.019	-0.003	-0.003	0.005	0.001	0.004	0.000	-0.002	-0.000	0.003	0.004	0.219
Number of primaries per panicle	G	-0.010	-0.001	-0.033	-0.006	-0.012	-0.007	-0.007	0.000	0.006	-0.003	-0.013	-0.007	0.388**
	P	-0.000	-0.000	-0.003	-0.000	-0.001	-0.000	-0.000	0.000	0.000	-0.000	-0.001	-0.000	0.370**
Panicle type (1-9 score)	G	-0.006	-0.011	0.010	0.055	0.001	0.006	-0.003	0.012	0.007	0.015	0.007	0.001	0.146
	P	-0.003	-0.006	0.006	0.032	0.000	0.003	-0.001	0.007	0.004	0.007	0.003	0.000	0.139
Panicle length (cm)	G	0.041	0.032	0.039	0.003	0.102	0.052	0.050	0.010	-0.004	-0.001	0.070	0.045	0.748**
	P	0.027	0.021	0.026	0.002	0.078	0.035	0.029	0.006	-0.003	-0.001	0.047	0.032	0.662**
Panicle width(cm)	G	0.030	0.007	0.022	0.011	0.050	0.098	0.040	0.003	-0.005	0.001	0.058	0.032	0.669**
	P	0.031	0.008	0.025	0.012	0.055	0.125	0.039	0.003	-0.007	0.002	0.065	0.036	0.606**
Days to physiological maturity	G	0.055	0.022	0.021	-0.005	0.044	0.037	0.090	0.004	-0.007	0.022	0.039	0.023	0.559**
	P	0.041	0.016	0.016	-0.002	0.028	0.024	0.076	0.002	-0.005	0.011	0.026	0.014	0.450**
Grain color(1-5score)	G	0.000	0.000	-0.000	0.004	0.002	0.000	0.001	0.022	0.004	-0.010	-0.000	-0.002	0.050
	P	0.000	0.000	-0.000	0.009	0.003	0.001	0.001	0.041	0.007	-0.001	-0.000	-0.003	0.042
Glume color(1-6score)	G	-0.002	-0.004	-0.005	0.004	-0.001	-0.001	-0.002	0.005	0.030	-0.008	-0.005	-0.008	-0.119
	P	-0.002	-0.004	-0.005	0.004	-0.001	-0.001	-0.002	0.005	0.031	-0.006	-0.005	-0.007	-0.120
100 seed weight(g)	G	-0.003	0.001	-0.003	-0.009	0.000	-0.000	-0.008	0.015	0.009	-0.033	-0.004	-0.005	0.103
	P	0.000	-0.000	0.001	0.003	-0.000	0.000	0.002	-0.004	-0.002	0.013	0.001	0.001	0.108
Threshability (%)	G	0.303	0.133	0.283	0.092	0.472	0.414	0.305	-0.011	-0.117	0.089	0.691	0.376	0.950**
	P	0.284	0.121	0.268	0.087	0.432	0.375	0.248	-0.014	-0.114	0.083	0.721	0.351	0.932**
Fodder yield/plant(g)	G	0.024	0.034	0.027	0.002	0.005	0.042	0.033	-0.012	-0.035	0.020	0.069	0.128	0.597**
	P	0.015	0.020	0.016	0.002	0.036	0.025	0.016	-0.007	-0.021	0.011	0.043	0.088	0.530**

Residual effect 0.280

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

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