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Correlation and path coefficient analysis in sorghum [*Sorghum bicolor* (L.) Monech] for ethanol yield

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Abstract
In order to understand the association of ethanol and its attributing traits, 110 diverse genotypes of sorghum were studied for Character association and Path coefficient analysis. Based on the correlations for characters studied revealed that brix percent, total soluble sugars, juice yield has significant positive correlation with ethanol yield while negative association with grain yield, plant height, days to 50% flowering and days to maturity. In path analysis study it can be concluded that juice yield, total soluble sugars content, brix%, Fresh stalk yield and 1000 grain weight play an important role in selection criteria for improving the character ethanol content.

Keywords: Correlation, *Sorghum bicolor* (L.) Monech, coefficient analysis

Introduction
Sorghum [*Sorghum bicolor* (L.) Moench] has diverse forms like grain sorghum, fodder sorghum and sweet sorghum. At world level, sorghum is the 5th most important cereal crop. However, it is the second most important cereal in India. However grain sorghum has gained popularity but knowledge on sweet sorghum is limited. The grain of sorghum forms a stable food in the diets of the rural people and used as fodder for livestock. (Elangovan and Babu, 2015) [5]. This crop is well adapted to drought-prone regions with poor soil than other cereal crops. Profuse alternative of sorghum is not only as food and feed but also bioenergy crop which has rich amounts of sugars in stalks (10-20%) as in sugarcane (Hunter and Anderson, 1997) [7] terming it as sweet sorghum. In European countries like Brazil it is grown as a source crop for ethanol production (Doggett, 1988) [2]. Currently, the ethanol blending with gasoline in Brazil is 18 to 27.5 per cent. (Lopes *et al*. 2016) [6]. The present commercial ethanol production in India is only through sugarcane, where the by-product from sugar refineries *i.e.*, molasses which is utilised for the ethanol production. In 2019, India has produced 634.01 million gallons of ethanol (Satyanarayana and Rameshchandra 2014) [12]. When compared to sugarcane, the juice from sweet sorghum is possessing high amounts of reducing sugars which aids in the efficient fermentation and high ethanol content. This in turn demands a need for identifying a suitable strategy required for obtaining high yield potential. In addition, the mutual interactions of each character over the other character plays an important role, because characters showing association in a determining fashion play a vital role in the selection of varieties. Correlation analysis in plant breeding is expected to offer precise information pertaining to various yield components and there by facilitate breeders to select superior genotypes from diverse genetic populations. The association of different component characters among themselves and with yield is quite important for devising an efficient selection criterion for yield. The total correlation between yield and component characters may be sometimes misleading, as it might be an over-estimate or under estimate because of its association with other characters. Hence, indirect selection by correlated response may not be sometimes fruitful. When many characters are affecting a given character, splitting the total correlation into direct and indirect effects of cause as devised by wright (1921) [17] would give more meaningful interpretation to the cause of association between the dependent variable like yield and independent variables like yield components. This kind of information will be helpful in formulating the selection criteria. Path coefficient analysis is basically designed on the assumptions of linearity and additivity and to measure the causes of association between two variables and provides information about the direct and indirect effect of independent variables on dependent variable.

Material and Methods

The present investigation was undertaken to study the Correlation, Path analysis in 110 sorghum genotypes for ethanol yield and yield contributing characters at Agricultural college farm, Bapatla, ANGRAU during *Kharif* 2017 which is located at an altitude of 5.49 m above mean sea level, 15^0 55' N latitude, 80^0 28^{0}' E longitude and about 12 Km from the Bay of Bengal. Each genotype consisted of two rows, each of three meter length with plant to plant distance of 15 cm. The rows were spaced 45 cm, apart. The experimental material for present investigation was obtained from the germplasm maintained at IIMR and ICRISAT, Hyderabad. Five randomly selected plants were used for recording the observations on thirteen characters mostly at Physiological maturity *viz*., Days to 50% flowering (Days), Days to maturity (Days), Plant height (cm), Number of nodes per plant, Stem girth (cm), Panicle weight (g), 1000 grain weight (g), Fresh stalk yield (T ha^{-1}), Juice yield (l ha^{-1}), Brix per cent, Total soluble sugars (%), Ethanol yield (l ha^{-1}), Grain yield (T ha^{-1}). The analysis was carried out by Indo-stat software.

Results and Discussion

Results of the study revealed that most of genotypic correlations were found to be higher than phenotypic correlations, which indicate that though there is strong inherent association between characters studied, its expression is minimized due to influence of environment. The insignificant values of studied characters at both phenotypic and genotypic levels clearly indicates the independent nature of the character.

The dependant variable ethanol yield has recorded positive significant correlation with Brix per cent (0.4781 G,0.4825 P); Total soluble sugars (0.4788 G, 0.4812 P) and Juice yield (0.8383 G, 0.8284 P) while negative significant association was with grain yield (-0.1820 G, -0.1589P) and non - significant positive association with Fresh stalk yield (0.0169 G, 0.0181 P),1000 grain weight (0.0848 G, 0.0622 P) at both levels and Panicle weight (0.0068 P) at phenotypic level only. Negative non-significant association with days to 50% flowering (-0.0266 G, -0.0242 P), days to maturity (-0.0819 G, -0.0770 P), plant height (-0.0469 G, -0.0327 P), number of nodes (-0.0666 G, -0.0721 P), Stem girth (-0.0404 G, -0.0349 P) at both levels and panicle weight (-0.0102 G) at genotypic level.

It clearly indicate that simultaneous improvement of grain yield and ethanol yield couldn't be possible because they have a negative association with brix, juice and ethanol yield. The results given are in accordance with Makanda *et al.* (2017) [10].

The association of days to 50% flowering and days to maturity is negative with ethanol yield. Based on the above results, it can be inferred that selection of early maturing types could bring improvement in the grain yield only as it has positive association but not in the juice and ethanol content as the association is negative which means conversion of sucrose requires time so medium to late flowering types are preferred for ethanol purpose. This result signifies that selection for early maturity may result in high grain yield which is advantageous to drought prone areas at the cost of compromising for juice and ethanol yield. Swamy *et al.* (2018a) [14] and Hundekar *et al.* (2016) [6] reported similar results for grain yield. Therefore, selection for medium to late maturing types possessing high brix and juice yield which is desirable.

The association of plant height with ethanol yield and brix is negative. The desirable trait is more plant height and high biomass producing types. Since the association of plant height with brix and ethanol yield is significantly negative, it referred that tall genotypes have recorded low brix and ethanol yield. The results recorded by Hundekar *et al.* (2016) [6] and Makanda (2017) [10] are deviating from the above quoted results. However, by making a little bit compromise for medium tall, plant type with more stem girth and biomass yield are desirable. When the desired selection criteria is for a high biomass type then, plant height can be considered as advantageous because genotypes with maximum number of nodes and stem girth could yield high biomass types but again compromising for juice and ethanol yield. Direct selection from these genotypes could be made desirable if the criteria is for high biomass type. But with ethanol and juice yield the association being negative which indicates tall types are not preferable in this study. Stem girth had negative association with juice and ethanol yield while positive correlation with brix content. Tomar and Sivakumar (2012b) [15] reported similar results.

Panicle weight contributes to the grain yield positively while ethanol attributing traits like brix has positive association but negative association with juice and ethanol. Chalachew and Rebuma (2018) [1], Mulualem *et al.* (2018) [11] and Swamy *et al.* (2018a) [14] had shown similar results with grain yield per plant. 1000 grain weight showed negative correlation with grain yield and positive correlation with brix and juice and ethanol yield. Khakabhavi *et al.* (2017) and Deshmukh *et al.* (2018) recorded deviating results from the above quoted results.

Juice yield had shown negative contribution with fresh stalk weight, which means high biomass type are low yielders for juice but, positive association with brix and ethanol content. Results quoted here are deviating from the results given by Vemana *et al.* (2014) [16]. Juice yield has recorded positive significant contribution with ethanol yield (0.8383 G, 0.8284 P) at both the levels. Juice yield directly contributes to the ethanol yield and simultaneous improvement could be possible because of positive association. Similar results are reported by Chalachew and Rebuma (2018) [1] for ethanol yield while contradictory result to brix content.

Brix per cent has shown significant positive correlation with ethanol yield (-0.4781 G, 0.4825 P), total soluble sugars and Negative correlation was observed with juice yield at both the levels. Simultaneous improvement of the genotype for ethanol yield is possible by increasing the brix and total soluble sugars. The results displayed are not in tune with Vemana *et al.* (2014) [16]. Total soluble sugars also recorded positive significant correlation with ethanol yield (0.4788 G, 0.4812 P) and negative non-significant association was observed for juice yield at both levels.

Simultaneous improvement of the traits like brix, juice yield and ethanol yield is possible as they are showing positive correlation. The possible reason for these type of combinations (high brix and low juice, ethanol / high juice, ethanol and low brix) could be high brix with high grain yield might have maximum conversion of sugars to the grain sink compromising on the juice yield. High biomass types with high plant heights would have maximum utilization of the plant energy for vegetative growth where nothing is left for conversion of sugars which results in low brix content.

Table 1: Genotypic and phenotypic correlations for 13 characters in 110 sorghum [*Sorghum bicolor* (L.) Monech] genotypes.

		DAF 50%	D.M	N.N.S	PH	FSTK	S.G	GY	1000 GW	PW	BRIX	TSS	JY	EY
DAF 50%	G	1.0000	0.9384**	0.6217**	0.4632**	0.4735**	0.3883**	0.1510**	-0.0721	0.2215**	0.0100	0.0099	-0.0627	-0.0266
	P	1.0000	0.9046**	0.5479**	0.3952**	0.4439**	0.3578**	0.1221*	-0.0628	0.1551**	0.0083	0.0085	-0.0577	-0.0242
D.M	G		1.0000	0.5595**	0.4145**	0.4390**	0.3119**	0.1101*	-0.0531	0.1425**	0.0376	0.0374	-0.1293*	-0.0819
	P		1.0000	0.4946**	0.3525**	0.4134**	0.2921**	0.0895	-0.0339	0.0910	0.0345	0.0348	-0.1206*	-0.0770
N.N.S	G			1.0000	0.5326**	0.4760**	0.3779**	0.0553	-0.0565	0.1429**	-0.0020	-0.0027	-0.1410**	-0.0666
	P			1.0000	0.4280**	0.3975**	0.3342**	0.0525	-0.0313	0.0551	-0.0020	-0.0007	-0.1364*	-0.0721
P.H	G				1.0000	0.2264**	0.1581**	0.0386	-0.1225*	0.2768**	0.0036	0.0034	-0.1426**	-0.0469
	P				1.0000	0.1856**	0.1363*	0.0318	-0.0801	0.1329*	0.0089	0.0093	-0.1146*	-0.0327
FSTK	G					1.0000	0.8719**	0.1083*	-0.1543**	0.2450**	0.0920	0.0918	-0.0464	0.0169
	P					1.0000	0.7990**	0.0948	-0.1337*	0.1558**	0.0823	0.0828	-0.0394	0.0181
S.G	G						1.0000	0.1302*	-0.2263**	0.2476**	0.0107	0.0109	-0.0763	-0.0404
	P						1.0000	0.0919	-0.1908**	0.1488**	0.0055	0.0049	-0.0622	-0.0349
GY	G							1.0000	-0.0453	0.7853**	-0.1273*	-0.1309*	-0.0843	-0.1820**
	P							1.0000	-0.0260	0.4850**	-0.0932	-0.0882	-0.0803	-0.1589**
1000 GW	G								1.0000	-0.0240	0.2345**	0.2345**	-0.0209	0.0848
	P								1.0000	-0.0407	0.1836**	0.1838**	0.0198	0.0622
PW	G									1.0000	0.0530	0.0538	-0.0391	-0.0102
	P									1.0000	0.0512	0.0501	-0.0220	0.0068
BRIX	G										1.0000	1.0003	-0.0245	0.4781**
	P										1.0000	0.9995**	-0.0213	0.4825**
TSS	G											1.0000	-0.0237	0.4788**
	P											1.0000	-0.0226	0.4812**
JY	G												1.0000	0.8383**
	P												1.0000	0.8284**
EY	G													1.0000
	P													1.0000

DAF 50%= Days to 50% flowering (Days), D.M= Days to maturity (Days), PH= Plant height (cm), N.N.S= Number of nodes per plant, SG= Stem girth (cm), PW= Panicle weight (g), 1000 GW= 1000 grain weight (g), FSTK= Fresh stalk yield (T ha^{-1}), JY= Juice yield (l ha^{-1}), Brix %, TSS = Total soluble sugars (%), EY= Ethanol yield (l ha^{-1}), GY = Grain yield (T ha^{-1}).

NOTE:* and ** Significant at 5 and 1 per cent level respectively

Table 2: Phenotypic (P) and Genotypic (G) Path coefficient analysis indicating direct (bold and diagonal) and indirect effects of Characters on ethanol yield in 110 sorghum [*Sorghum bicolor* (L.) Monech] genotypes.

		DAF 50%	D.M	N.N.S	PH	FSTK	S.G	GY	1000 GW	P.W	BRIX	TSS	JY	EY
DAF 50%	G	0.0268	-0.0465	0.0282	0.0248	-0.0272	0.0186	-0.0124	0.0004	0.0095	-0.0012	0.0061	-0.0536	-0.0266
	P	0.0406	-0.0515	0.0171	0.0195	-0.0063	0.0043	-0.0072	0.0005	0.0030	0.0018	0.0024	-0.0485	-0.0242
D.M	G	0.0252	-0.0496	0.0254	0.0222	-0.0252	0.0149	-0.0090	0.0003	0.0061	-0.0045	0.0229	-0.1105	-0.0819
	P	0.0368	-0.0570	0.0155	0.0174	-0.0058	0.0035	-0.0053	0.0003	0.0018	0.0076	0.0097	-0.1014	-0.0770
N.N.S	G	0.0167	-0.0277	0.0453	0.0285	-0.0274	0.0181	-0.0045	0.0003	0.0061	0.0002	-0.0017	-0.1205	-0.0666
	P	0.0223	-0.0282	0.0313	0.0212	-0.0056	0.0040	-0.0031	0.0002	0.0011	-0.0004	-0.0002	-0.1146	-0.0721
PH	G	0.0124	-0.0205	0.0242	0.0535	-0.0130	0.0076	-0.0032	0.0007	0.0118	-0.0004	0.0021	-0.1219	-0.0469
	P	0.0161	-0.0201	0.0134	0.0494	-0.0026	0.0017	-0.0019	0.0006	0.0026	0.0020	0.0026	-0.0964	-0.0327
FSTK	G	0.0127	-0.0218	0.0216	0.0121	-0.0575	0.0417	-0.0089	0.0008	0.0105	-0.0111	0.0563	-0.0396	0.0169
	P	0.0180	-0.0235	0.0124	0.0092	-0.0141	0.0097	-0.0056	0.0010	0.0030	0.0181	0.0230	-0.0331	0.0181
S.G	G	0.0104	-0.0155	0.0171	0.0085	-0.0501	0.0479	0.0062	-0.0118	0.0118	0.0005	0.0005	-0.0037	-0.0404
	P	0.0145	-0.0166	0.0105	0.0067	-0.0113	0.0121	0.0011	-0.0023	0.0018	0.0001	0.0001	-0.0008	-0.0349
GY	G	0.0041	-0.0055	0.0025	0.0021	-0.0089	0.0062	-0.0818	0.0002	0.0336	0.0153	-0.0803	-0.0721	-0.1820
	P	0.0050	-0.0051	0.0016	0.0016	-0.0056	0.0011	-0.0588	0.0002	0.0093	-0.0205	-0.0246	-0.0675	-0.1589
1000 GW	G	-0.0019	0.0026	-0.0026	-0.0066	0.0089	-0.0118	0.0037	-0.0054	-0.0010	-0.0282	0.1439	-0.0179	0.0848
	P	-0.0026	0.0019	-0.0010	-0.0040	0.0119	-0.0023	0.0015	-0.0074	-0.0008	0.0403	0.0511	-0.0166	0.0622
P.W	G	0.0059	-0.0071	0.0065	0.0148	-0.0141	0.0118	-0.0642	0.0001	0.0427	-0.0064	0.0330	-0.0334	-0.0102
	P	0.0063	-0.0052	0.0017	0.0066	-0.0022	0.0018	-0.0285	0.0003	0.0193	0.0112	0.0139	-0.0185	0.0068
BRIX	G	0.0003	-0.0019	-0.0001	0.0002	-0.0053	0.0005	0.0104	-0.0013	0.0023	-0.1202	0.6140	-0.0209	0.4781
	P	0.0003	-0.0020	-0.0001	0.0004	-0.0012	0.0001	0.0055	-0.0014	0.0010	0.2195	0.2782	-0.0179	0.4825
TSS	G	0.0003	-0.0019	-0.0001	0.0002	-0.0053	0.0005	0.0107	-0.0013	0.0023	-0.1202	0.6139	-0.0203	0.4788
	P	0.0003	-0.0020	0.0000	0.0005	-0.0012	0.0001	0.0052	-0.0014	0.0010	0.2194	0.2783	-0.0190	0.4812
JY	G	-0.0017	0.0064	-0.0064	-0.0076	0.0027	-0.0037	0.0069	0.0001	-0.0017	0.0029	-0.0146	0.8549	0.8383
	P	-0.0023	0.0069	-0.0043	-0.0057	0.0006	-0.0008	0.0047	0.0001	-0.0004	-0.0047	-0.0063	0.8405	0.8284

DAF 50%= Days to 50% flowering (Days), D.M= Days to maturity (Days), PH= Plant height (cm), N.N.S= Number of nodes per plant, SG= Stem girth (cm), PW= Panicle weight (g), 1000 GW= 1000 grain weight (g), FSTK= Fresh stalk yield (T ha-1), JY= Juice yield (l ha-1), Brix %, TSS = Total soluble sugars (%), EY= Ethanol yield (l ha-1), GY = Grain yield (T ha-1).

Path coefficient analysis

The data collected from replicated trials on thirteen polygenic traits in 110 sorghum genotypes was subjected to statistical analysis described by Dewey and Lu, 1959 [3] has revealed the (i) Direct effect (effect of an independent character on dependent character), Indirect effect (effect from independent character on dependent character via other independent characters and Residual effect (effect of other possible independent variables not included in the study on dependent variables)

A path diagram is constructed using simple correlation coefficients among the characters included in the study to depict the cause and effect situation in a simple yet attractive presentation of results and association between different traits and helps in understanding the direct and indirect contribution of different independent variables against a dependent variable *i.e.*, yield in addition to the estimation of direct effects through simultaneous equations.

Ethanol yield, brix percent, Juice yield, panicle weight, 1000 grain weight and fresh stalk yield has recorded positive direct effect on ethanol yield while correlation studies recorded positive significant contribution with ethanol yield at both the levels which is due to the positive indirect effects of days to 50% flowering, plant height, stem girth, grain yield and Panicle weight. Similar results are reported by Chalachew and Rebuma (2018) [1] for ethanol yield, Shukla *et al.* (2017) reported that total sugar yield had negative direct effect with ethanol yield.

Fresh stalk yield had exhibited the positive indirect effect through days to 50% flowering; number of nodes per plant; plant height; stem girth; 1000 grain weight; Panicle weight; Total soluble sugars, 1000 grain weight exhibited positive indirect effect through days to maturity; Fresh stalk yield; grain yield; total soluble sugars and brix % content. While the rest of the characters like days to 50% flowering, days to maturity, number of nodes per plant, plant height, stem girth, grain yield. 1000 grain weight, panicle weight, brix, total soluble sugars, juice yield had similar correlation and path results. These results are in accordance with Shukla *et al.* (2017), Makanda *et al.* (2017) [10] and Mulualem *et al.* (2018) [11].

The residual effect determines how best the causal factors account for the variability of the dependent factor. If the residual effect is high, some other factors which have not been considered here need to be included in this analysis to account fully for the variation in yield. In this case, residual factor was 0.23P, 0.19G.

Path coefficient analysis revealed that juice yield exerted the highest positive direct effect on ethanol yield followed by brix %, total soluble sugars along with positive correlation for all the above mentioned characters.

Conclusion

Based on the correlation results in 110 genotypes for 13 characters revealed that brix percent, total soluble sugars, juice yield has significant positive correlation with ethanol yield while negative association with grain yield, plant height, days to 50% flowering and days to maturity. In path analysis study it can be concluded that juice yield, total soluble sugars content, brix%, Fresh stalk yield and 1000 grain weight would play an important role in selection criteria for improving the character ethanol content.

References

1. Chalachew E, Rebuma M. Productivity of Sweet Sorghum Genotypes under Contrasting Fertility Management for Food and Ethanol Production. Advances in Crop Science and Technology. 2018; 6(2):1-7.
2. Doggett HH. Sorghum. Longman Scientific and Technical, London, 1988.
3. Dewey OR, Lu KH. A correlation and path coefficient analysis of component of crested wheat grass seed production. Agronomy Journal. 1959; 57:515-518.
4. Deshmukh SB, Bagade AB, Choudhari AK. Correlation and Path Analysis Studies among Rabi Sorghum (*Sorghum bicolor* L. Moench) Mutants. International Journal of Current Microbiology and Applied Sciences. 2018; 6:1014-1020.
5. Elangovan M, Babu PK. Genetic variability and diversity of sorghum land race collected from Uttar Pradesh India. Indian Journal of plant genetic re-sources. 2015; 28(2):213-222.
6. Hundekar R, Kamatar MY, Mallimar M, Brunda SM. Correlation and path analysis in rainy season sorghum [*Sorghum bicolour* (L.) Moench]. Electronic Journal of Plant Breeding. 2016; 7(3):666-669.
7. Hunter EL, Anderson IC. Horticulture Reviews. 1997; 21:73-104.
8. Khadakabhavi S, Girish G, Yashoda. Character association and path analysis studies in germplasm lines of rabi sorghum (*Sorghum bicolor* (L.) Moench). Journal of Applied and Natural Science. 2017; 9(1):206-210.
9. Lopes ML, Paulillo SCDL, Godoy A, Cherubin RA, Lorenzi MS, Giometti FHC *et al*. Ethanol production in Brazil: a bridge between science and industry. Brazilian Journal of Microbiology. 2016; 47(1):64-76.
10. Makanda I. Development of dual purpose sorghum: correlation and path-coefficient analysis of grain yield and stem sugar traits. African Crop Science Journal. 2017; 25(3):263-275.
11. Mulualem T, Alamrew S, Tadesse T, Wegary D. Correlation and Path Coefficient Analysis for Agronomical Traits of Lowland Adapted Ethiopian Sorghum Genotypes [*Sorghum bicolor* (L.) Moench] Genotypes. Greener journal of Agricultural Sciences. 2018; 8:155-159.
12. Satyanarayana DNV, Rameshchandra K. Production of ethanol from sweet potatoes. International Journal of Engineering Sciences and Research Technology. 2014; 3(5):428-434.
13. Shukla S, Felderhoff T, Saballos A, Vermerris W. The relationship between plant height and sugar accumulation in the stems of Sweet Sorghum (*Sorghum bicolor* (L.) Monech). Field Crops Research. 2017; 203:181-191.
14. Swamy N, Biradar BD, Sajjanar GM, Ashwathama VH, Sajjan AS, Biradar AP. Genetic variability and correlation studies for productivity traits in *Rabi* sorghum [*Sorghum bicolor* (L.) Moench]. Journal of Pharmacognosy and Phytochemistry. 2018a; 7(6):1785-1788.
15. Tomar SS, Sivakumar S. Correlation and path analysis in sweet sorghum (*S. bicolor*) for sucrose yield and it's attributing quantitative traits. Green Farming. 2012b; 3(2):147-150.
16. Vemana I, Dayakar RT, Umakanth AV, Narasimhulu R. Correlation and path analysis studies for juice yield and its associated traits in sweet sorghum [*Sorghum bicolor* (L.) Monech]. Bioinfolet. 2014; 11(2):358-36.
17. Wright S. Correlation and causation. Journal of Agricultural Research. 1921; 20:557-585.