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Correlation and Path Coefficient Analysis of Component Characters on Juice Yield in Sweet Sorghum Genotypes (*Sorghum bicolor* (L.) Moench)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present experimentation was conducted to assess correlation and direct indirect relation between juice yield and its contributing traits in 33 sweet sorghum genotypes at Sorghum Research Station, VNMKV, Parbhani during *kharif* 2019. Analysis revealed that juice yield exhibited highest significant and positive correlations with Millable cane weight (G=0.9018, P=0.8938) at genotypic and phenotypic levels followed by total fresh biomass, juice extraction percentage, Stem girth, plant height, Days to maturity and internodal length. Grain yield per plant exhibited negative but non-significant association with juice yield. Millable cane weight, juice extraction percentage and days to 50 per cent flowering showed highest positive direct effect on juice yield. While days to maturity,

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plant height and grain yield per plant had negative direct effect on juice yield per plant. Millable cane weight showed maximum indirect effect via total fresh biomass, juice extraction percentage and plant height. Considering both correlation and path coefficient, it can be concluded that the traits stem girth, internode length and high total fresh biomass, millable cane weight and juice extraction percentage should give importance for increasing the juice yield in sweet sorghum genotypes.

Keywords: Sweet sorghum genotypes; correlation; character association; juice yield.

1. INTRODUCTION

Sorghum is a major cereal crop in semi arid tropics. Cultivated sorghum are grouped in four main types based on primary use of sorghum viz., Grain sorghum, sweet sorghum or Sorgos, Broom Sorghum and Sudan grass etc. sweet sorghum is a particular variety of sorghum with an ability to accumulate 10-25 percent sugar in its stalk juice. It is also called as sorgos. Alike normal grain sorghum, being a C4 plant with very low photorespiration sweet sorghum has a high biomass production capacity. Besides having rapid growth, high biomass production potential and high sugar accumulation, sweet sorghum offers comparable grain yields under rainfed conditions (Reddy et al., 2008). Hence along with traditional use as grain and fodder, sweet sorghum can be used to obtain several alternate products like syrup jaggary, ethanol, sugar, alcohol, vine and sweetener. It is a special type of sorghum that can be grown for food, fuel, fodder and fibre (a crop of 4 FFFF' s). The government of India has approved the National Policy on biofuels on December 24, 2009 and permitted blending of ethanol in petrol at the rate of 20 % which in turn increased the demand for ethanol. This created grounds to search for an alternative source for ethanol production, as traditional source of ethanol is unable to meet the existing and future demand. Eventually, sweet sorghum emerged as a potential alternate raw material for fuel-grade ethanol production. because of its shorter growing period (about four month), and low water requirement (8,000 cu m) for raising two crops, unlike sugarcane which has a growing period of 12 to 18 months and a water requirement of 36,000 cu m per crop and its cultivation cost is also four times lower than that of sugarcane, therefore there is increased interest in the utilization of sweet sorghum for ethanol production in recent years. In this regard, genetic enhancement of sweet sorghum for increased stalk yield, sugar yield and its associated traits is very critical to make more remunerative to the farmers and the industry [1]. The juice yield in sweet sorghum is a complex quantitative trait and the expression of which depends upon its component traits and environment. Thus selection may not be useful for such characters; however efficiency of selection under such circumstances could be improved by taking into consideration simultaneously the phenotypic values of a number of plant attributes which are correlated with the genotypic values (high heritability) of the characters under consideration. Estimates of correlations alone may be often misleading due to mutual cancellation of component traits. So, it becomes necessary to study path coefficient analysis, which takes in to account the casual relationship in addition to degree of relationship [2]. The path coefficient analysis initially suggested by Wright [3] and described by Dewey and Lu [4] allows partitioning of correlation coefficient in direct and indirect effects followed by assessing the cause effect relations and contribution of each component character to juice yield. Considering the future needs an experiment was under taken to evaluate the character association and path analysis between green stalk yield and its contributing characters.

2. MATERIALS AND METHODS

Thirty genotypes of sweet sorghum collected from Indian Institute of Millet Research along with three checks PVK 400, SSV 84 and CSH 22 SS were used as experimental material for the present study. All the genotypes were evaluated in randomized block design with two replication. Two rows of each genotype was sown with a distance of 60 cm between two rows and 15 cm between plant to plant and all recommended agronomical practices were followed to grow healthy crop. Observations were recorded on randomly selected five plants from each entry from each replication for eleven characters days to 50 per cent flowering, days to maturity, plant height (cm), stem girth (cm), internode length (cm), total fresh biomass (g/plant), millable cane weight (g/plant), grain yield (g/plant), brix at physiological maturity, juice extraction percentage (%) and juice yield (ml/plant).

2.1 Statistical Analysis

The mean values of all traits under consideration were used for statistical analysis. The mean data for different characters was statistically analysed by the statistical procedure provided by Panse and Sukhatme, [5]. Covariance analysis between all pairs of characters under study was carried out as per the analysis of variance and covariance as declared by Singh and Chowdary [6]. The appropriate variances and co-variances were used to calculate phenotypic and genotypic correlation [7]. The estimates of direct and indirect contribution of various characteristics to seed yield were calculated through path coefficient analysis as suggested by Wright [3] and elaborated by Dewey and Lu [4].

3. RESULTS AND DISCUSSION

3.1 Correlation Coefficients among Different Juice Yield Traits

The correlation coefficients among juice yield and its component traits at genotypic and phenotypic level tabulated in Table 1 revealed highly significant positive association between juice yield with Total Fresh Biomass (G=0.8916, P=0.8862), Millable cane weight (G=0.9018, P=0.8938), Juice extraction percentage (G=0.7171, P=0.6950), Stem girth (G=0.6907, P=0.6860), days to maturity (G=0.2565, P=0.2512), plant height (G=0.2943, P=0.2866) and internode length (G=0.2528, P=0.2463). This indicated that emphasis should be given for selection of plant type comprising traits such as high biomass, more cane weight, tallness with more number of internodes and thick stem as well as high juice extraction percentage to increase juice yield in sweet sorghum. Kavya et al., [8] reported positive significant contribution of Juice yield for ethanol yield at both genotypic and phenotypic level. Juice yield directly contributes to the ethanol yield and simultaneous improvement could be possible because of positive association. Iraddi et al. [9] and Kachapur et al [10] observed similar results for of juice yield. Grain yield exhibited negative but non significant corelation with juice yield indicating. Reddy et al. [11] also reported that both sweet sorghum hybrids and varieties had higher stalk sugar yields (50 and 89 %) and lower grain yields (25 and 2 %).

3.2 Path Analysis

Days to maturity and plant height had shown significant positive association with stem girth, millable cane weight and total fresh biomass at both genotypic and phynotypic level. signifying high biomass can be achieved in late maturing tall genotypes. Similar results were reported by Iraddi et al. [9] for days to maturity, plant height, stem girth and total fresh biomass. Plant height had also showed significantly positive corelation with stem girth and internode length at both the levels. Bangarwa et al. [12] reported similar results for stem girth and plant height. Furthermore stem girth and internode length exhibited positive significant association with millable cane weight, total fresh biomass at both the levels while stem girth further showed positive association with total soluble sugar indicating thick stem accumulates more sugars. Millable cane weight showed significant and positive association with juice extraction percentage, non reducing sugar and total sugar percentage and non reducing sugar with total sugar percentage. While non reducing and reducing sugars were found negatively correlated. Justice et al [13] obserevd negative relationship between juice extractability and non-reducing, plant height and total sugar and between reducing sugar and non-reducing sugar. Sucrose (non-reducing sugar) is the predominant stalk sugar in sweet sorghum and is converted to reducing sugars (glucose and fructose) by invertase, thus a negative relationship is likely to be observed between reducing and non-reducing sugar. Brix was positively correlated with total sugar and non-reducing sugar. The results on association of sugar yield with its attributing traits indicated importance of these characters in improving juice yield. As these traits had direct correlation with juice yield improvement in these traits automatically improve sugar yield. Hence, the above correlated traits can be effectively utilized in formulating indirect selection schemes.

3.3 Correlation between Juice Yield and Its Component-Characters

The correlation between yield and its component-character is often miss-leadings, since it is affected by the inter- relationship among the component traits. Direct effect of any component trait on juice yield gives an idea about reliability of indirect selection to be made through that character to bring about improvement in juice yield. Hence results on direct and indirect path coefficient is presented in Table 2. Millable cane weight, juice extraction percentage, days to 50% flowering, stem girth, internodal length, brix at physiological maturity, total fresh biomass and non reducing sugar had shown positive direct

Table 1. Genotypic and phenotypic correlation coefficient for Juice yield with its attributing traits studied in sweet sorghum

	Days to 50% flowering	Days to Maturity	Plant height (cm)	Stem girth (cm)	Internode length (cm)	Total Fresh Biomass (g/plant)	Millable cane weight (g/plant)	Grain yield (g/plant)	Brix at 50% flowering	Brix at physiological maturity	Juice Extraction %	Reducing sugar (%)	Non Reducing Sugar (%)	Total Soluble Sugar (%)	Juice Yield (ml/plant
Days to 50% flowering (g)	1.0000	0.975**	0.0253	0.2594*	-0.1093	0.2573*	0.2403	-0.0886	0.0355	-0.0681	0.0479	0.0055	0.0558	0.0574	0.2216
(p)	1.000	0.935**	0.0199	0.2536*	-0.1234	0.2451*	0.2255	-0.0831	0.0095	-0.0747	0.0622	0.0128	0.0481	0.0515	0.2190
Days to Maturity (g)		1.0000	0.0049	0.2582*	-0.0824	0.2788*	0.2709*	0.1500	0.0686	-0.0341	0.0981	0.1164	0.0245	0.0524	0.2565*
		1.0000	0.0122	0.2529*	-0.0961	0.2696*	0.2611*	-0.1411	0.0517	-0.0373	0.1001	0.0985	0.0303	0.0551	0.2512*
Plant height(cm) (g)			1.0000	0.399**	0.6260**	0.4064**	0.3495**	0.0687	0.0627	0.1884	0.0228	0.0801	-0.0687	-0.0500	0.2943*
			1.0000	0.392**	0.6028**	0.3955**	0.3373**	0.0634	0.0678	0.1872	0.0202	0.0796	-0.0610	-0.0414	0.2866*
Stem girth(cm) (g)				1.0000	0.2426*	0.8734**	0.8819**	0.2124	0.1364	0.0583	0.0440	0.0891	0.2313	0.2537 *	0.6907**
				1.0000	0.2395	0.8674**	0.8713**	0.2098	0.1316	0.0523	0.0359	0.0881	0.2346	0.2579*	0.6860**
Internode length(cm) (g)					1.0000	0.2509*	0.2576*	0.2338	0.1761	0.1561	0.1199	0.1360	0.0050	0.0374	0.2528*
					1.0000	0.2440*	0.2514*	0.2236	0.1816	0.1514	0.1050	0.1174	0.0088	0.0383	0.2463*
Total Fresh Biomass (g) (g/plant)						1.0000	0.9823**	0.1097	0.0792	0.1065	0.363**	0.0431	0.1889	0.2002	0.8916**
						1.0000	0.9776**	0.1082	0.0705	0.1036	0.330**	0.0346	0.1879	0.1975	0.8862**
Millable cane (g) weight(g/plant)							1.0000	0.0916	0.0771	0.0520	0.368**	0.0190	0.2797*	0.2857*	0.9018**
							1.0000	0.0940	0.0680	0.0518	0.324**	0.0161	0.2725*	0.2779*	0.8938**
Grain yield (g/plant) (g)								1.0000	0.1238	0.0630	-0.1350	0.2267	0.1700	0.2250	-0.0036
								1.0000	0.1072	0.0610	-0.1350	0.2134	0.1613	0.2156	-0.0020
Brix at 50%flowering (g)									1.0000	0.6496**	0.0670	0.0720	0.0690	0.0866	0.1086
									1.0000	0.6088**	0.0491	0.0861	0.0731	0.0950	0.0963
Brix at physiological (g) maturity										1.0000	0.1073	0.2370	-0.2336	-0.1783	0.1256
										1.0000	0.1017	0.2227	-0.2367	-0.1821	0.1234
Juice Extraction% (g)											1.0000	-0.0072	0.0354	0.0339	0.7171**
											1.0000	-0.0175	0.0301	0.0259	0.6950**
Reducing Sugar (%) (g)												1.0000	-0.1408	0.0970	0.0215
												1.0000	-0.1446	0.1053	0.0178

	Days to 50% flowering	Days to Maturity	Plant height (cm)	Stem girth (cm)	Internode length (cm)	Total Fresh Biomass (g/plant)	Millable cane weight (g/plant)	Grain yield (g/plant)	Brix at 50% flowering	Brix at physiological maturity	Juice Extraction %	Reducing sugar (%)	Non Reducing Sugar (%)	Total Soluble Sugar (%)	Juice Yield (ml/plant
Non Reducing Sugar (g) (%)													1.0000	0.9717**	0.2298
													1.0000	0.9688**	0.2242
Total Soluble Sugar (%) (g)														1.0000	0.2362
														1.0000	0.2298
Juice Yield (ml/plant) (g)															1.0000
															1.0000

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

Table 2. Direct and indirect effect (genotypic) of fourteen components on juice yield in sweet sorghum

Genotypes	Days to 50% flowering	Days to Maturity	Plant height (cm)	Stem girth (cm)	Internode length (cm)	Total Fresh Biomass (g/ plant)	Millable cane weight (g /plant)	Grain yield (g /plant)	Brix at 50% flowering	Brix at physiological maturity	Juice Extraction %	Reducing sugar (%)	Non Reducing Sugar (%)	Total Soluble Sugar (%)	Correlation coefficient (r) with Juice Yield
Days to 50% flowering	0.3636	0.3544	0.0092	0.0943	-0.397	0.0935	0.0874	-0.0322	0.0129	-0.0247	0.0174	0.0020	0.0203	0.209	0.2216
Days to Maturity	-0.3473	-0.3563	-0.0017	-0.0920	0.0293	-0.0993	-0.0965	0.0534	-0.0245	0.0122	-0.0349	-0.0415	-0.0087	-0.0187	0.2565
Plant height(cm)	-0.0005	-0.001	-0.0192	-0.0077	-0.0120	-0.0078	-0.0067	-0.0013	-0.0012	-0.0036	-0.0004	-0.0015	0.0013	0.0010	0.2943
Stem girth (cm)	0.0329	0.0327	0.0506	0.1268	0.0308	0.1107	0.1118	0.0269	0.0173	0.0074	0.0056	0.0113	0.0293	0.0322	0.6907
Internode length(cm	-0.0035	-0.0027	0.0202	0.0078	0.0323	0.0081	0.0083	0.0075	0.0057	0.0050	0.0039	0.0044	0.0002	0.0012	0.2528
Total Fresh Biomass (g/plant)	0.0192	0.0208	0.0303	0.0651	0.0187	0.0745	0.0732	0.0082	0.0059	0.0079	0.0270	0.0032	0.0141	0.0149	0.8916
Millable cane weight(g/ plant)	0.1296	0.1461	0.1885	04757	0.1389	0.5299	0.5394	0.0494	0.0416	0.0281	0.1983	0.0103	0.1509	0.1541	0.9018
Grain yield(g/plant)	0.0061	0.0103	-0.0047	-0.0145	-0.0160	-0.0075	-0.0063	-0.0684	-0.0085	-0.0043	0.0092	-0.0155	-0.0116	-0.0154	0.0036
Brix at 50%flowering	-0.0004	-0.0008	-0.0008	-0.0017	-0.0021	-0.0010	-0.0009	-0.0015	-0.0121	-0.0079	-0.0008	-0.0009	-0.0008	-0.0011	0.1086
Brix at physiological maturity	-0.0035	-0.0017	0.0096	0.0030	0.0080	0.0054	0.0027	0.0032	0.0331	0.0510	0.0055	0.0121	-0.0119	-0.0091	0.1256
Juice Extraction%	0.0233	0.0476	0.0110	0.0213	0.0582	0.1761	0.1785	-0.0655	0.0325	0.021	0.4854	-0.0035	0.0172	0.0164	0.7171
Reducing Sugar (%)	0.0004	0.0083	0.0057	0.0064	0.0097	0.0031	0.0014	0.0162	0.0051	0.0169	-0.0005	0.0714	-0.0101	0.0069	0.0215
Non Reducing Sugar (%)	0.0079	0.0035	-0.0098	0.0329	0.0007	0.0269	0.0398	0.0242	0.0098	-0.0332	0.0050	-0.0200	0.1423	0.1383	0.2298
Total Soluble Sugar (%)	-0.0061	-0.0055	0.0053	-0.0268	-0.0039	-0.0211	-0.0302	-0.0237	-0.0091	0.0188	-0.0036	-0.0102	-0.1026	-0.1055	0.2362

Residual effect =0.071

effect on juice yield. Both correlation and the direct effect are high and positive for these traits hence, correlation explains its true relationship and selection for these character will be effective. Days to maturity, plant height, grain yield per plant and brix at 50 % flowering exhibited negative direct effect on juice yield however these traits had positive correlation with juice yield except for grain yield indicating indirect causal factor are to be considered simultaneously for selection. Similar results were reported by Iraddi et al. [9] for stalk yield and total biomass.

Stem girth, internode length, milable cane weight, fresh biomass, had positive direct effect on juice yield via indirect positive effect of almost all the traits. So indirect selection through these traits would be rewarding for juice yield improvement.

While plant height and grain yield had exhibited indirect negative effect on juice yield via stem girth, internode length, total fresh biomass, millable cane weight, brix at 50% flowering and brix at physiological maturity. Kalpande et al. [14] also observed negative indirect effect on cane yield via total fresh biomass and days to maturity. However positive correlation between these traits and juice yield indicate that direct selection for such traits should be practiced to reduce the undesirable indirect effects.

Reducing and Non reducing sugar had positive direct effect on juice yield while it was positively correlated with juice yield. Total soluble sugar had negative direct effect on juice yield while it was positively correlated with juice yield. The residual effect determines how best the causal factors account for variability of the dependent factor. moderate value of residual effect indicates that beside the character studied there are some other attributes which contributes for juice yield [15].

4. CONCLUSION

Hence on the basis of the results it can be concluded that due importance should be given to characters viz. stem girth, internode length, total fresh biomass, millable cane weight, juice extraction percentage for improving the juice yield in sweet sorghum. selection for the character will be effective for these traits due to its true relationship confirmed through significant positive correlation and direct effect on juice yield.

CONFERENCE DISCLAIMER

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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