

1 **Correlation and path coefficient analysis of component characters on juice**
2 **yield in Sweet Sorghum Genotypes (*Sorghum bicolor* (L.) Moench)**
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6 **ABSTRACT**

7 The present experimentation was conducted to assess correlation and
8 direct indirect relation between juice yield and its contributing traits in 33 sweet
9 sorghum genotypes at Sorghum Research Station, VNMKV., Parbhaniduring *kharif*
10 2019. Analysis revealed that juice yield exhibited highest significant and positive correlations
11 with Millable cane weight ($G=0.9018$, $P=0.8938$) at genotypic and phenotypic levels followed
12 by total fresh biomass, juice extraction percentage, Stem girth, plant height, Days to maturity
13 and internodal length. Grain yield per plant exhibited negative but non-significant association
14 with juice yield. millable cane weight, juice extraction percentage and days to 50 per cent
15 flowering showed highest positive direct effect on juice yield. While days to maturity, plant
16 height and grain yield per plant had negative direct effect on juice yield per plant. Millable
17 cane weight showed maximum indirect effect via total fresh biomass, juice extraction
18 percentage and plant height. Considering both correlation and path coefficient, it can be
19 concluded that the traits stem girth, internode length and high total fresh biomass, millable
20 cane weight and juice extraction percentage should give importance for increasing the juice
21 yield in sweet sorghum genotypes.

22 **Key words: Sweet sorghum genotypes, correlation, character association, juice**
23 **yield**

24 **1. Introduction**

25 Sorghum is a major cereal crop in semi arid tropics. Cultivated sorghum are grouped into four
26 main types based on primary use of sorghum viz., Grain sorghum, sweet sorghum or Sorgos,
27 Broom Sorghum and Sudan grass etc. sweet sorghum is a particular variety of sorghum with
28 an ability to accumulate 10-25 percent sugar in its stalk juice. It is also called as sorgos. Alike
29 normal grain sorghum, being a C4 plant with very low photorespiration sweet sorghum has a
30 high biomass production capacity. Besides having rapid growth, high biomass production
31 potential and high sugar accumulation, sweet sorghum offers comparable grain yields under
32 rainfed conditions (Reddy et al., 2008). Hence along with traditional use as grain and
33 fodder, sweet sorghum can be used to obtain several alternate products like syrup jaggary,
34 ethanol, sugar, alcohol, vine and sweetener. It is a special type of sorghum that can be grown
35 for food, fuel, fodder and fibre (a crop of 4 FFFF's). The government of India has approved

36 the National Policy on biofuels on December 24, 2009 and permitted blending of ethanol in
37 petrol at the rate of 20 % which in turn increased the demand for ethanol. This created
38 grounds to search for an alternative source for ethanol production, as traditional source of
39 ethanol was unable to meet the existing and future demand. Eventually, sweet sorghum
40 emerged as a potential alternate raw material for fuel-grade ethanol production. because of its
41 shorter growing period (about four months), and low water requirement (8,000 cu m) for
42 raising two crops, unlike sugarcane which has a growing period of 12 to 18 months and a
43 water requirement of 36,000 cu m per crop and its cultivation cost is also four times lower
44 than that of sugarcane, thus there is increased interest in the utilization of sweet sorghum for
45 ethanol production in recent years. In this regard, genetic enhancement of sweet sorghum for
46 increased stalk yield, sugar yield and its associated traits is very critical to make more
47 remunerative to the farmers and the industry (Murray et al., 2009). The juice yield in sweet
48 sorghum is a complex quantitative trait and the expression of which depends upon its
49 component traits and environment. Thus selection may not be useful for such characters;
50 however efficiency of selection under such circumstances could be improved by taking into
51 consideration simultaneously the phenotypic values of a number of plant attributes which are
52 correlated with the genotypic values (high heritability) of the characters under consideration.
53 Estimates of correlations alone may be often misleading due to mutual cancellation of
54 component traits. So, it becomes necessary to study path coefficient analysis, which takes in
55 to account the casual relationship in addition to degree of relationship (Mahajan et. al., 2011).
56 The path coefficient analysis initially suggested by (Wright 1921) and described by Dewey
57 and Lu (1959) allows partitioning of correlation coefficient into direct and indirect effects
58 followed by assessing the cause effect relations and contribution of each component character
59 to juice yield. Thus considering the future needs an experiment was under taken to evaluate
60 the character association and path analysis between green stalk yield and its contributing
61 characters.

62 2. Materials and Methods

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

73 2.1 Statistical analysis

74 The mean values of all traits under consideration were used for statistical analysis. The mean
75 data for different characters was statistically analysed by the statistical procedure provided by
76 Panse and Sukhatme, (1961). Covariance analysis between all pairs of characters under study
77 was carried out as per the analysis of variance and covariance as declared by Singh and
78 Chowdary (1979). The appropriate variances and co-variances were used to calculate
79 phenotypic and genotypic correlation (Johnson et al. 1955). The estimates of direct and

80 indirect contribution of various characteristics to seed yield were calculated through path
81 coefficient analysis as suggested by Wright (1921) and elaborated by Dewey and Lu (1959).

82 **3. Results and Discussion**

83 **3.1 Correlation coefficients among different juice yield traits**

84 The correlation coefficients among juice yield and its component traits at genotypic and
85 phenotypic level tabulated in Table 1 revealed highly significant positive association between
86 juice yield with Total Fresh Biomass ($G=0.8916$, $P=0.8862$), Millable cane weight
87 ($G=0.9018$, $P=0.8938$), Juice extraction percentage ($G=0.7171$, $P=0.6950$), Stem girth
88 ($G=0.6907$, $P=0.6860$), days to maturity ($G=0.2565$, $P=0.2512$), plant height ($G=0.2943$,
89 $P=0.2866$) and internode length ($G=0.2528$, $P=0.2463$). This indicated that emphasis should
90 be given for selection of plant type comprising traits such as high biomass, more cane weight,
91 tallness with more number of internodes and thick stem as well as high juice extraction
92 percentage to increase juice yield in sweet sorghum. Iraddiet *al.* (2014) and Kachapuret *al*
93 (2009) observed similar results for of juice yield. Grain yield exhibited negative but non
94 significant correlation with juice yield indicating. Reddy et al. 2012 also reported that both
95 sweet sorghum hybrids and varieties had higher stalk sugar yields (50 and 89 %) and lower
96 grain yields (25 and 2 %).

97 **3.2 Path analysis**

98 Days to maturity and plant height had shown significant positive association with
99 stem girth, millable cane weight and total fresh biomass at both genotypic and phynotypic
100 level. signifying high biomass can be achieved in late maturing tall genotypes. Similar
101 results were reported by Iraddiet *al.* (2014) for days to maturity, plant height, stem girth and
102 total fresh biomass. Plant height had also showed significantly positive corelation with stem
103 girth and internode length at both the levels. Bangarwaet *al.* (1985) reported similar results for
104 stem girth and plant height. Furthermore stem girth and internode length exhibited positive
105 significant association with millable cane weight, total fresh biomass at both the levels while
106 stem girth further showed positive association with total soluble sugar indicating thick stem
107 accumulates more sugars. Millable cane weight showed significant and positive association
108 with juice extraction percentage, non reducing sugar and total sugar percentage and non
109 reducing sugar with total sugar percentage. While non reducing and reducing sugars were
110 found negatively correlated. Justice etal 2018 obserevd negative relationship between juice
111 extractability and non-reducing, plant height and total sugar and between reducing sugar and
112 non-reducing sugar. Sucrose (non-reducing sugar) is the predominant stalk sugar in sweet
113 sorghum and is converted to reducing sugars (glucose and fructose) by invertase, thus a
114 negative relationship is likely to be observed between reducing and non-reducing sugar. Brix
115 was positively correlated with total sugar and non-reducing sugar. The results on association
116 of sugar yield with its attributing traits indicated importance of these characters in improving
117 juice yield. As these traits had direct correlation with juice yield improvement in these traits
118 automatically improve sugar yield. Hence, the above correlated traits can be effectively
119 utilized in formulating indirect selection schemes.

120 **3.3 Correlation between yield and its component-characters**

121 The correlation between yield and its component-character is often miss-
122 leadings, since it is affected by the inter- relationship among the component traits. Direct
123 effect of any component on juice yield gives an idea about reliability of indirect selection to

124 be made through that character to bring about improvement in juice yield. Hence results on
125 direct and indirect path coefficient is presented in Table 2. Millable cane weight, juice
126 extraction percentage, days to 50% flowering, stem girth, internodal length, brix at
127 physiological maturity, total fresh biomass and non reducing sugar had shown positive direct
128 effect on juice yield. Again, both correlation and the direct effect are high and positive for
129 these traits hence, correlation explains its true relationship and selection for these character
130 will be effective. Days to maturity, plant height, grain yield per plant and brix at 50 %
131 flowering exhibited negative direct effect on juice yield however these traits had positive
132 correlation with juice yield except for grain yield indicating indirect causal factor are to be
133 considered simultaneously for selection. Similar results were reported by Iraddiet *al.* (2014)
134 for stalk yield and total biomass.

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

139 While plant height and grain yield had exhibited indirect negative effect on juice yield
140 via stem girth, internode length, total fresh biomass, millable cane weight, brix at 50%
141 flowering and brix at physiological maturity. Kalpande et al.(2014) also observed
142 negative indirect effect on cane yield via total fresh biomass and days to maturity.
143 However positive correlation between these traits and juice yield indicate that direct
144 selection for such traits should be practiced to reduce the undesirable indirect effects.

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

151 4. Conclusion

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

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UNDER PEER REVIEW

Table1: Genotypic and phenotypic correlation coefficient for Juice yield with its attributing traits studied in sweet sorghum.

	Days to 50% flowering (g)	Days to Maturity (g)	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 weight(g/plant) (g)							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 maturity (g)										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
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	0.4757	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