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Inheritance of Sugar Yield and Character Association Study in Sweet Sorghum [*Sorghum bicolor* (L.) Moench]

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ABSTRACT

Inheritance and character association study of sugar content in sweet sorghum was carried out during 2010 - 12 at Directorate of Sorghum Research, Hyderabad. Two newfangled crosses of sweet sorghum were generated during *kharif,* 2010 by crossing parents which are contrasting for the trait of interest *i.e.,* low sugar content (27 B and ICSB 38) with high sugar content (SSV 84 and SSV 74). F_1 generation was raised during *rabi,* 2010 - 11 and F_2, B_1 and B_2 crosses were attempted. On the basis of sugar yield, plants were grouped into two distinct classes *i.e.,* high sugar and low sugar content. Chi square test was applied to test the goodness of fit for the segregation ratio and it was evident that sugar content in both the crosses governed by simple monogenic pattern (3High sugar: 1low sugar) of inheritance for this trait with high sugar content being governed by dominant and low sugar by recessive allele. Further, correlation studies in F_2 generation revealed significant positive correlation of sugar yield with juice yield, fresh stalk yield, total biomass, grain yield, total soluble sugars, brix per cent and bioethanol yield. These correlated traits can be effectively utilized in formulating indirect selection schemes.

Key words : Inheritance, chi square test, monogenic, dominant, recessive, correlation.

Sorghum being fifth most important crop among cereals after maize, rice, wheat and barley, cultivated on a global scale for various purposes. In India, it is traditionally cultivated for food in dryland area under subsistence farming; of late demand for sorghum is increasing as sorghum is being utilized in many industries, especially as poultry feed for broiler and layer production. It is also being used for production of potable ethanol, syrup, starch and cellulose and other industrial products. The higher cost of cultivation of sugar stalk or sugar beets has created grounds to search for an alternative source for ethanol production. Eventually, sweet sorghum emerged as a potential raw material for fuel-grade ethanol production due to its rapid growth rate, early maturity, greater water-use efficiency and wide adaptability. Economic superiority (high ethanol production) of this crop is attributed to few characters such as green cane yield, sugar content (brix or stalk sucrose percentage), stalk juice extractability, content of non-reducing and reducing sugars and grain yield. In this regard, information on genetics of sugar content and character association of this trait with other component traits is helpful in breeding of cultivars with high ethanol yield. Keeping this in view, the present investigation was carried out to find inheritance of sugar content and its association with other agronomic traits.

MATERIAL AND METHODS

The material for this experiment comprised of six populations *viz.,* P_1, P_2, F_1, F_2, B_1 and B_2 of two sweet sorghum crosses *viz.,* 27 B × SSV 84 and ICSB 38 × SSV 74, developed at Directorate of Sorghum Research farm, Rajendranagar, Hyderabad. During *kharif* 2010, the F_1 was produced by crossing 27 B with SSV 84 through hand emasculation and pollination. Later in *rabi* 2010 - 11, the F_1 plants were selfed to produce F_2 population as well as backcrossed to both the parents to produce B_1 [(27 B × SSV 84) × 27 B] and B_2 [(27 B × SSV 84) × SSV 84] populations. Similarly B_1 [(ICSB 38 × SSV 74) × ICSB 38] and B_2 [(ICSB 38 × SSV 74) × SSV 74] were also produced. In non-segregating generations which are replicated *viz.,* parents, check and F_1's, the data was recorded on five randomly tagged plants in each replication, where as in case of segregating generations, the data was recorded on 200 competitive plants in F_2

generation and 50 competitive plants each in B_1 and B_2 generations across three blocks. The inheritance pattern was studied in these two crosses, where all the six generations were available by fitting the genetic ratios for sugar content. The sugar content was classified into two groups, those with high sugar content (more than 13 g / plant) and low sugar content (less than 13 g / plant) in both F_2 as well as backcross generations. The segregation ratios were subjected to chi-square test, which tests the goodness of fit between expected and observed segregation ratios (Snedecor and Cochran, 1967).

Besides this, in two F_2 populations, observations on total biomass, fresh stalk yield, grain yield, brix per cent, juice yield, total soluble sugars, bioethanol yield and sugar yield were recorded on single plant basis. The data were used to estimate correlation co-efficient (Al-Jibourie *et al.,* 1958) of sugar yield and its component traits.

RESULTS AND DISCUSSION

The results of studies on the inheritance of sugar content using six generations of the two inter-varietal crosses *viz.,* '27 B × SSV 84 and ICSB 38 × SSV 74', have been tabulated in Table 1 and presented below. In the present investigation, all the plants in each of the segregating generation were classified into two categories based on sugar content as high sugar (more than 13 g / plant) and low sugar (less than 13 g / plant) content plants.

All the 15 plants of the parent '27 B' had low sugar content, while all the 15 plants of 'SSV 84' had high sugar content. In the F_1 generation of this cross, all 15 plants were found to have high sugar content confirming the dominance of high sugar content over low sugar content. Out of 200 F_2 plants studied, 147 plants had high sugar content, while 53 plants had low sugar content, giving a good fit for the monogenic ratio of 3:1 for high sugar Vs low sugar content as indicated by low, non-significant Chi-square value of 0.24. In the backcross (B_2) progenies, all the 50 plants had high sugar content confirming dominance of high sugar content which gives a good fit to the expected backcross ratio of 1:0 for the high sugar content and low sugar content ones, respectively, with a Chi-square value of 0.00. Out of 50 test cross progenies, 28 plants had high sugar content, while 22 plants had low sugar content. Thus, the data gives a good fit to the expected test cross ratio of 1:1 with a Chi-square value of 0.72 which confirm the F_2 monogenic ratio of 3:1.

Similarly in another cross 'ICSB 38 × SSV 74', all the 15 plants of the parent 'ICSB 38' had low sugar content, while all the 15 plants of 'SSV 74' had high sugar content. In the F_1 generation of this cross, all 15 plants were found to have high sugar content confirming the dominance of high sugar content over low sugar content. Out of 200 F_2 plants studied, 145 had high sugar content, while 55 plants had low sugar content, giving a good fit for the monogenic ratio of 3:1 for high sugar Vs low sugar content as indicated by low, non-significant Chi-square value of 0.67. In the backcross (B_2) progenies, 45 plants had high sugar content and only 5 plants had low sugar content out of a total 50 plants confirming dominance of high sugar content which gives a good fit to the expected backcross ratio of 1:0 for the high sugar content and low sugar content ones, respectively, with a Chi-square value of 0.50. Out of 50 test cross progenies, 27 plants had high sugar content, while 23 plants had low sugar content. Thus, the data gives a good fit to the expected test cross ratio of 1:1 with a Chi-square value of 0.32, which confirm the F_2 monogenic ratio of 3:1.

The above segregation pattern indicates that parents (SSV 84 and SSV 74) possessing high sugar have homozygous dominant alleles for high sugar (SS), while, the other parents (27 B and ICSB 38) would therefore have homozygous recessive allele (ss) for low sugar content. The crosses between these respective two parents would result in heterozygous progeny having both dominant and recessive allele (Ss) and since dominant allele is contributing for high sugar content, all the plants in F_1's, had high sugar content. In F_2 generations, the segregation process lead to form three genotypes, one with homozygous dominant allele (SS), two dominant heterozygous (Ss) and one homozygous recessive (ss) in 1SS:2Ss:1ss ratio. Since, the high sugar content is governed by dominant allele, both homozygous dominant and heterozygous types yielded high sugar plants, thereby confirming to 3:1 ratio in F_2 for high sugar and low sugar, respectively. Hence, it can be inferred from this study that, the high sugar content was inherited through dominant gene (SS) and low sugar content through recessive gene (ss).

Table 1. Observed and Expected Frequencies of High and Low sugar content plants in F_2 and back cross generations of the crosses '27 B × SSV 84 and ICSB 38 × SSV 74' of Sweet Sorghum along with "Test of goodness of fit".

Cross	Generation	Observed Frequency		Expected Frequency		Expected Ratio	X^2 Value	Probability
		High Sugar	Low Sugar	High Sugar	Low Sugar	High : Low		
27 B × SSV 84	F_2	147	53	150	50	3 : 1	0.24	0.6242
	B_1	28	22	25	25	1 : 1	0.72	0.3961
	B_2	50	0	50	0	1 : 0	0.00	1.0000
ICSB 38 × SSV 74	F_2	145	55	150	50	3 : 1	0.67	0.4131
	B_1	27	23	25	25	1 : 1	0.32	0.5716
	B_2	45	05	50	0	1 : 0	0.50	0.4795

Table 2. Correlation coefficients of sugar yield with its attributing characters in F_2 generations of the crosses '27 B × SSV 84 (C_1) and ICSB 38 × SSV 74 (C_2)' in sweet sorghum.

Character	Crosses	Total biomass (g / plant)	Fresh stalk yield (g / plant)	Grain yield (g / plant)	Brix per cent	Juice yield (g / plant)	Total soluble sugars (%)	Bioethanol yield (ml / plant)	Sugar yield (g / plant)
Total biomass (g / plant)	C_1	1.000	0.976**	0.849**	0.166**	0.958**	0.166**	0.166**	0.945**
	C_2	1.000	0.980**	0.855**	0.239**	0.904**	0.243**	0.278**	0.875**
Fresh stalk yield (g / plant)	C_1		1.000	0.883**	0.159*	0.979**	0.159*	0.159*	0.961**
	C_2		1.000	0.860**	0.203**	0.913**	0.207**	0.245**	0.877**
Grain yield (g / plant)	C_1			1.000	0.022	0.868**	0.022	0.022	0.834**
	C_2			1.000	0.277**	0.865**	0.284**	0.318**	0.844**
Brix per cent	C_1				1.000	0.208**	1.000**	1.000**	0.332**
	C_2				1.000	0.266**	0.982**	0.978**	0.381**
Juice yield (g / plant)	C_1					1.000	0.209**	0.208**	0.989**
	C_2					1.000	0.274**	0.292**	0.981**
Total soluble sugars (%)	C_1						1.000	1.000**	0.333**
	C_2						1.000	0.995**	0.390**
Bioethanol yield (ml / plant)	C_1							1.000	0.332**
	C_2							1.000	0.406**
Sugar yield (g / plant)	C_1								1.000
	C_2								1.000

*Significant at P = 0.05 **Significant at P = 0.01

The genetic ratio obtained is just an indication, since sugar yield is a complex quantitative trait, is likely to be governed by many genes. Hence, present study needs further confirmation by analyzing larger segregating population of more number of crosses involving other diverse genotypes as parents with respect to this trait.

Further, the correlation co-efficients among all the characters related to sugar yield in two F_2 populations of sweet sorghum crosses were estimated and were tabulated in Table 2 and briefly described in the following paragraphs.

Association of sugar yield was highly significant and positive with juice yield per plant, fresh stalk yield per plant, total biomass per plant, grain yield per plant, total soluble sugars, brix per cent and bioethanol yield per plant. These associations were in corroborative with the reports of Mallikarjun *et al.* (1998), Singh and Khan (2004), Kadian and Mehta (2006) and Unche *et al*. (2008).

Association among sugar yield attributing characters revealed that the association of total biomass with fresh stalk yield per plant, juice yield per plant, grain yield per plant, brix per cent, total soluble sugars and bioethanol yield per plant; fresh stalk yield per plant with juice yield per plant, grain yield per plant, brix per cent, total soluble sugars and bioethanol yield per plant; grain yield per plant with juice yield per plant; brix per cent with total soluble sugars, bioethanol yield per plant and juice yield per plant; juice yield per plant with total soluble sugars and bioethanol yield per plant; total soluble sugar with bioethanol yield per plant were positive and significant. The reports of Singh and Khan (2004), Kadian and Mehta (2006), Kachapur and Salimath (2009), Unche *et al*. (2008) and Sandeep *et al*. (2010) were in agreement with the above results.

From the forgoing discussion on association of sugar yield with its attributing traits indicated importance of juice yield, fresh stalk yield, total biomass, grain yield, total soluble sugars, brix per cent and bioethanol yield in improving sugar yield as these traits had direct relation with sugar yield, hence improvement in these traits automatically improve sugar yield. Thus, the above correlated traits can be effectively utilized in formulating indirect selection schemes.

LITERATURE CITED

Al-Jibourie H A, Miller P A and Robinson H F 1958 Genotypic and environmental variances in an upland cotton cross of interspecific origin. *Agronomy Journal,* 50: 633-637.

Kachapur R M and Salimath P M 2009 Genetic studies on correlation and character association in sweet sorghum [*Sorghum bicolor* (L.) Moench]. *Green Farming,* 2: 343-346.

Kadian S P and Mehta A S 2006 Correlation and path analysis in sugarcane. *Indian Journal of Agricultural Research,* 40: 47-51.

Mallikarjun H, Khanure S K and Kachapur M D 1998. Correlation and path analysis for juice quality parameters in sweet sorghum genotypes. *The Madras Agricultural Journal,* 85: 207-208.

Sandeep R G, Gururaja Rao M R, Chikkalingaiah and Shivanna H 2010 Association and path analysis for ethanol yield in sweet sorghum [*Sorghum bicolor* (L.) Moench]. *Mysore Journal of Agricultural Sciences,* 44: 28-30.

Singh S P and Khan A Q 2004 Inter-relationship and path analysis in sugarcane (*Saccharum* spp. Complex). *Environment and Ecology,* 22: 903-911.

Snedecor G W and Cochran W G 1967 *Statistical methods*. 6th ed., Oxford and IBH Pub. Co., New Delhi.

Unche P B, Misal M B, Borgaonkar S B, Chavan B D and Sawant D R 2008 Correlation studies in sweet sorghum [*Sorghum bicolor* (L.) Moench]. *International Journal of Plant Sciences,* 3: 69-72.

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