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Qualitative Assessment of Sweet Sorghum [*Sorghum bicolor* (L.) Moench] Cultivars for Ethanol Production

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ABSTRACT

Qualitative characters like total soluble sugars (TSS), reducing sugars, non-reducing sugars, fermentable sugar yield and ethanol production were significantly higher in cultivars SSV 84, SSV74,NTJ_2 and S35 than those exhibited by the other cultivars both at flowering and harvesting.

Key words : Brix (%), Ethanol, Fermentable Sugars, Non Reducing Sugars, Reducing Sugars, Sorghum, TSS (Total Soluble Sugars(%)

Sweet Sorghum is one of the substitutive sugary crop for sugarcane for ethanol production. As the quantity of molasses from sugar industry is inadequate to meet the demand, search for alternative sources showed the solution of suitable sweet sorghum cultivars. The present forecast on the exhaust of fossil fuel by 2050 needs search for exploring alternative source of fuels, which should be economical and eco-friendly to reduce carbon emission that causes global warming. Biofuels offer on alternate remedy and source of energy as these are renewable resources. With the encouragement from the Government of India to blend ethanol with petrol(5%), the demand for production of ethanol is increasing.

MATERIAL AND METHODS

A field experiment was carried out at Agricultural College Farm, Bapatla during *Maghi* season of 2004-05 for the physiological assessment of sweet sorghum cultivars and their suitability for ethanol production in coastal Andhra Pradesh. Fifteen Sweet Sorgum cultivars *viz.*, SSV84, SSV 74, Seredo, NTJ_2, ICSV 574, Ent64 DTN, ICSV 700, ICSV 93046, ICSR37, ICSV 56, ICRR108, ICSR 196, ICSV 96117, S 35 and ICSR 93034 were tried as treatments in randomized block design with 3 replications.

Quality parameters such as total soluble sugars (brix) in juice, reducing sugars, non-reducing sugars, fermentable sugars in juice and ethanol production at flowering stage and maturity stages were estimated from the 15 sweet sorghum cultivars. By using a twin roll mill the stalks were pressed to extract juice into clean juice bottles. The TSS was measured by using hand refractometer in brix (B^0) scale from the raw juice. The content of glucose in the stalk juice was estimated by titrating the filtered juice with 5ml of Fehlings A (Alkaline tartrate solution) and 5ml of Fehlings B solution, 173g of Rochelle salt and 50g of sodium hydroxide, dissolved in 500ml of water and kept standing for two days and filtered through prepared asbestos.

To estimate glucose percent in stalk, 4ml of Fehlings A and 5ml of Fehlings B solutions were taken in a cleaned erlenmayer flask and added 40ml of distilled of water. A few glass beads were put into the flask to regulate the boiling and avoid bumping the contents of flasks and titrated against corresponding stalk juice until the solution acquired slight brick red colour. A few drops of methylene blue was added to the solution and titrated against stalk juice till the blue colour of the methylene blue disappeared and the volume (V) of the juice was noted. The per cent of glucose in stalk juice was calculated as per the formula (Brown and Zerban, 1941) given. *i.e.*,

$$\text{Glucose \%} = \frac{0.05 \times 100 \times 250 \times 2.5}{V \times 325}$$

where V = Volume of juice

After taking the brix readings from raw stalk juice, the juice was transferred in to a 100cc measuring flask and added 3g of lead acetate. The contents were shaken well, filtered and polarized in a 200mm tube through Bosch and Lomb polariscope. The polariscope reading gives the pole percent of the stalk juice. The sucrose values in the juice were determined with uncorrected brix values and pole readings by using the table values as indicated by Brown and Zerban (1941) and expressed in percent. Fermentable sugar was measured by taking B^0 (brix) reading using hand

Table. Quality parameters of sweet sorghum cultivars at flowering and maturity.

Cultivars	TSS (Brix) %		Fermentable sugar yield (t ha^{-1})		Reducing sugar (%)		Non-reducing sugar (%)		Ethanol estimation (L ha^{-1})	
	Flowering	Maturity	Flowering	Maturity	Flowering	Maturity	Flowering	Maturity	Flowering	Maturity
SSV84	12.50	14.50	4.90	5.00	4.40	3.00	7.10	7.50	3012.00	3072.00
SSV74	12.30	14.30	4.80	4.90	4.30	3.00	7.00	7.40	2944.00	3002.00
Seredo	11.00	10.30	3.40	3.10	4.90	2.40	6.20	3.50	2071.00	1923.00
NTJ2	11.50	10.20	4.50	3.30	4.00	3.00	6.60	4.20	2779.00	2057.00
ICSV574	10.00	8.30	3.50	2.60	3.50	2.20	5.50	3.10	2139.00	1876.00
Ent 64DTN	11.30	9.20	4.20	3.00	4.00	2.50	6.30	3.70	2596.00	1676.00
ICSV700	7.20	4.50	3.00	1.70	2.50	1.50	3.70	1.70	1675.00	1078.00
ICSV93046	5.70	4.80	2.40	1.60	1.90	1.50	2.60	1.70	1481.00	971.00
ICSV37	5.30	4.20	1.60	0.70	1.90	1.00	2.60	1.80	959.00	451.00
ICSV56	9.20	8.10	2.60	1.80	3.20	2.10	5.60	3.00	1591.00	1089.00
ICRR108	8.70	5.80	2.40	1.50	3.00	1.90	4.70	2.50	1468.00	935.00
ICSR196	8.90	7.70	2.50	1.70	3.10	2.00	4.70	2.70	1565.00	1057.00
ICSV96117	10.80	9.00	3.30	2.30	3.90	2.20	6.20	3.30	2031.00	1421.00
S35	11.30	10.60	3.90	3.30	4.00	2.50	6.30	3.80	2368.00	2045.00
ICSR 93034	11.00	8.70	3.50	2.60	3.90	2.30	6.30	3.20	2170.00	1589.00
S Em +-	0.25	0.24	0.40	0.66	0.27	0.63	0.14	0.18	83.60	67.00
CP (p=0.05)	0.72	0.69	1.09	1.80	0.77	1.83	0.41	0.52	252.10	203.80
CV (%)	4.42	0.50	5.04	4.82	1.31	4.98	4.50	10.02	8.24	8.27

refractometer after allowing the fermentization. The fermentable sugar yield was estimated by multiplying total plant sap content (extractable juice) with TSS (B^0) (Almodares *et.al.*, 1997). Fermentable carbohydrates concentration was measured at flowering and harvesting stages. By using Reichert temperature compensated hand refractometer of model 10430 individual plant parts were placed in a forced air-oven at 150^0F until they became dry. Total carbohydrated yields were calculated by B^0 (brix) multiplied by total estimated sap yields from stalks, excluding leaves and heads. Ethanol yield was calculated from fermentable carbohydrates using the conversion factor *i.e* 14.7 lb fermentable sugar yield was equal to 1 gallon of ethanol (South Eastern Gasohol Association, 1980).

RESULTS AND DISCUSSION

The total soluble sugars (TSS) were higher in SSV 84, SSV 74, NTJ_2, S35, Ent 64 DTN, Seredo, ICSR 93034 and ICSV 96117 and the least being in cultivars ICSV 93046 and ICSR 37 at flowering stage. However, sweet sorghum cultivars SSV84, SSV74, Seredo, NTJ_2, and S35 recorded significantly more TSS contents at maturity. In sweet sorghum cultivars TSS accumulation was more during reproductive phase, as favourable climate conditions of low temperature, high relative humidity prevailed during reproductive stage, which favoured the conversion of glucose to sucrose and ultimately led to increased juice quality. Thus the sweet sorghum cultivars stored most of its carbohydrates as soluble sugars distributed through out the stalk. These results are in confirmation with Singh and Reddy (1996), Perish *et al.* (1985) Bapat *et al.* (1986) Almodares *et al.* (1996) and Seetharama *et al.* (2000). The cultivars like SSV 84, SSV 74, Seredo, S35, NTJ_2, recorded more TSS content even at maturity while decline in TSS was observed in Ent64DTN, ICSR 93034 and ICSV 96107. In the sweet sorghum cultivars produced high level of carbohydrates and sugars accumulated in the stem might be re-distributed to the other economic sink grains during grain filling, resulting in a decrease in TSS from anthesis to black layer formation in grain sorghum. At flowering stage reducing sugars were significantly higher in Seredo, SSV 84, SSV 74, NTJ_2, S35, Ent 64 DTN, ICSV 96117, ICSV 93034 and ICSV 56. A slight reduction in reducing sugars in all cultivars was observed at maturity. The cultivars SSV84, SSV74, NTJ_2, S35, Ent 64DTN recorded more reducing sugars at maturity also when compared to ICSV 700, ICSV

93046 and ICSR 37 in conformity with Huilgol *et.al.,* (2002) and Seethrama *et.al*., (2002). The reducing sugars decreased from flowering to harvesting.

During flowering, vegetative growth was still vigorous. Reducing sugars in the cane juice was high due to increase in the activity of vascular acid invertase enzyme for the conversion of cytoplasmic hexoses to reducing sugars (Almodares *et.al*., 1997). The quality characters of juice was mostly dependent on the factors like age of the crop, soil type, variety and agroclimatic factors (Almodares *et.al.,* 1997). Non-reducing sugars were significantly higher in SSV 84, SSV 74, NTJ_2, Ent 64DTN, S35, ICSR 93034, ICSV 96117 and Seredo at flowering stage. At maturity also the cultivars SSV 84, SSV74 and NTJ_2 recorded more non-reducing sugars. The non-reducing sugars in juice were mostly dependent on the properties of reducing sugars, in agreement with Bapat *et.al.,* (1986). The fermentable sugar yield ranged from 1.6 to 4.9 t/ha and 0.7 to 5.0 t/ha in 15 sweet sorghum cultivars at flowering and maturity, respectively. These findings are in agreement with results of Smith *et al*., (1987). More fermentable sugar yields (t/ha) were recorded by the cultivars SSV 84, SSV74, NTJ_2, and S35 at flowering but reduced at maturity. The fermentable sugar yields ultimately depend on total juice quality and TSS content of cane juice. It is evident from data, (Table 1) that among all the cultivars, SSV 84, SSV74, NTJ_2, Ent 64 DTN and S35 recorded more ethanol at flowering while SSV 84, SSV74, NTJ_2, and S35 recorded more ethanol at maturity. The cultivar ICSR 37 produced less ethanol at both the stages. These observations are in agreement with Seetharama *et.al.,* (2002) who, reported that ethanol production was more in varieties like Keller and SSV 84 at flowering and reduced in some other varieties at maturity. The ethanol content was purely determined by the total fermentable sugar yields of the juice TSS content and total dry matter production of the cultivar, which also depend on plant height to increase more stalk yield and inturn more fermentable sugar yields of the cane (Putnam 1991). The quality characters of juice was mostly dependent on the factors like genotype, age of the crop, soil type and agro climatic factors (Altmodares *et al.*, 1997) for conversion of sugars.

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