Methodology, Results and Discussion

C. Ganesh Kumar and P. Srinivasa Rao

Abstract There are many research and review articles published on sweet sorghum. However, no single publication gives a detailed account of the morpho-biochemical traits of improved tropical sweet sorghum cultivars. This chapter gives detailed account of the materials used, methods followed for data collection and analysis to characterise sweet sorghum genotypes following the guidelines of Protection of Plant Varieties and Farmers Rights Act, 2001 (PPVFRA). The pooled analysis of variance for quantitative traits revealed that these cultivars had significant differences between them for the expression of all the quantitative characters under study for both the seasons. The results revealed that the productivity levels of tropical sweet sorghums during post-rainy season (October–March) are generally low due to photo-sensitivity and thermo-sensitivity of the genotypes *vis-a-vis* that of rainy season (June–October) and necessitates identifying new sources/alleles contributing to both biomass and sugar yield.

Keywords Methodology · Discussion · Restorers · Varieties · Hybrids · Breeding · Quantitative traits · Glucose · Fructose · Sucrose · Brix%

The chapter is discussed under three sections, i.e. materials, data collection, result and discussion.

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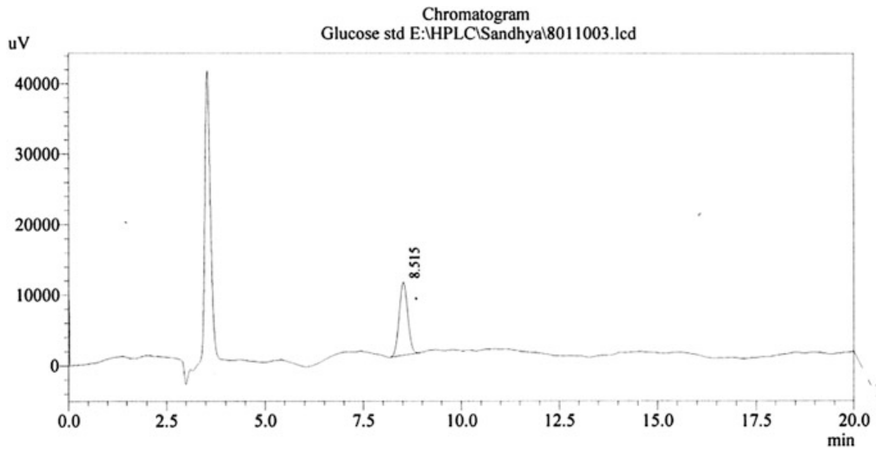
1 Materials

Eleven established restorers/varieties (ICSV 700, ICSV 25272, ICSV 25274, ICSV 25275, ICSV 25280, ICSV 93046, SPV 422, SSV 74, SSV 84 and CSV 24SS), six female hybrid parents (ICSB 38, ICSB 474, ICSB 675, ICSB 702, ICSB 724 and ICSB 731) and six hybrids adapted to rainy season (ICSSH 25, ICSSH 28, ICSSH 29, ICSSH 30, ICSSH 31, ICSSH 39, ICSSH 58 and CSH 22SS) and seven established restorers/varieties (ICSV 700, ICSV 25279, ICSV 25284, ICSV 93046, SSV 74, SSV 84 and CSV 24SS), five female hybrid parents (ICSB 38, ICSB 474, ICSB 502, ICSB 675 and ICSB 731) and five hybrids (ICSSH 25, ICSSH 28, ICSSH 58, ICSSH 76 and CSH 22SS) adapted to post-rainy season bred at ICRISAT, Directorate of Sorghum Research (DSR), University of Agricultural Sciences (UAS) Dharwad and Mahatma Phule Krishi Vidyapeeth (MPKV), were evaluated during 2010 rainy season (June–October) and 2010–2011 post-rainy season (October–March) in vertisols (deep black soils) at the research farm, ICRISAT, Patancheru, India. The experimental site is located at an altitude of 545 m above mean sea level, latitude of 17.53°N and latitude of 78.27°E. The site receives an average annual rainfall of 897 mm (average of 32 years from 1974 to 2005). The entries were planted in four rows, 4 m long, with a row spacing of 0.60 and 0.15 m between the plants within a row, following a randomized complete block design (RCBD) in three replications. The recommended crop production and protection packages were followed to raise a healthy crop.

2 Data Collection

The observations on twenty two quantitative traits were taken on 10 random plants in each plot for plant height (m), panicle length (cm), stalk diameter (cm), leaf blade length (cm), leaf blade width (cm), exersion length (cm), time to panicle emergence (days), panicle length (cm), panicle primary branch length (cm), glume coverage (%), stalk yield (t ha^{-1}), juice yield (t ha^{-1}), total soluble solids (TSS) or Brix (%), sugar yield (t ha^{-1}), seed restoration (%) and 1000-grain weight (g). The seed restoration (%) was collected only in hybrids as varieties are self-compatible (Srinivasarao et al. 2009; Wortmann et al. 2010). The restoration problems in sorghum hybrids arises due to incompatible reaction male sterile cytoplasm with fertility restorer genes of restorers, which is common in A_2, A_3 and A_4 male sterile cytoplasms. The days to 50 % flowering was recorded on plot basis when the main panicles of 50 % of the plants in the plots had full stigma emergence. The sugar concentration in the stems was estimated in terms of Brix% using a hand-held pocket refractometer (Model PAL, Atago Co. Ltd., Tokyo, Japan) based on the extracted juice samples taken from each plot. The pH was recorded using a microprocessor-based pH meter (Model DPH506, Global Electronics, Hyderabad, India). The electrical conductivity (EC) probe is dipped in the juice sample and measurements were done using a microprocessor-based EC analyzer



PeakTable

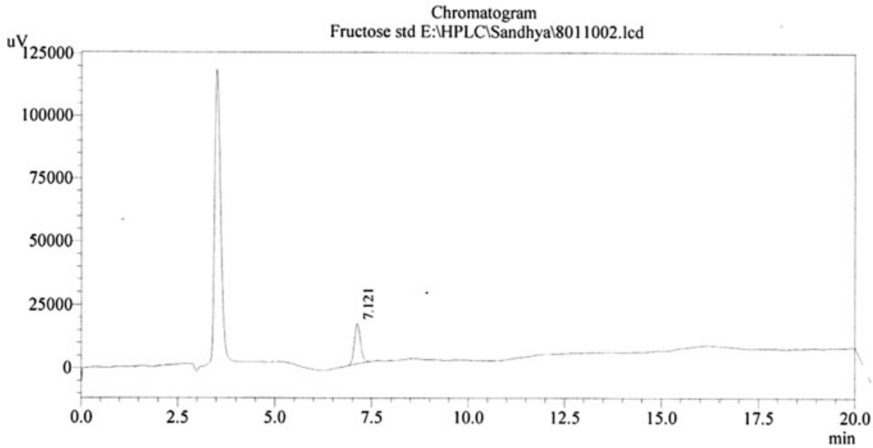
Detector A Ch1

Peak#	Name	Ret. Time	Area	Area %
1		8.515	157649	100.000
Total			157649	100.000

Fig. 1 Standard chromatogram of glucose

(Model CM 180, Elico Limited, Hyderabad, India). Between two different sample readings, the refractometer, pH and EC probes were cleaned with distilled water and dried with a paper towel. Sugar profiling to determine the relative percentages of hexose sugars like glucose, fructose and sucrose present in the sweet sorghum juice of each genotype were analyzed on a HPLC system (Shimadzu, Kyoto, Japan) equipped with a Lichro CART 250-4,6 Lichrospher 100 NH_2 (5 μm, Merck KGaA, Darmstadt, Germany). The detection of the separated sugars was carried out with a refractive index detector (Model RID-10A, Shimadzu, Kyoto, Japan) using a mobile phase of acetonitrile–water (78:22, v/v) at a flow rate of 2.0 ml min^{-1} under isocratic mode and the column temperature was maintained at 40 °C. All solvents for mobile phase optimization were degassed before use. Standard stock solution (1,000 μg ml^{-1}) of different sugars was prepared in Milli-Q distilled water as a diluent for calibrating the HPLC system. The juice sample analysis was carried out by manual injection of 20 μl of pre-filtered sample. The data acquisition and analysis was carried out using LC solutions software (version 1.24 SP2) (Shimadzu, Kyoto, Japan). The concentration of each sugar in the juice was determined using peak area from the chromatograms and expressed in terms of percentage of total sugars (Kumar et al. 2010). The standard chromatograms for glucose, fructose and sucrose are given in Figs. 1, 2 and 3.

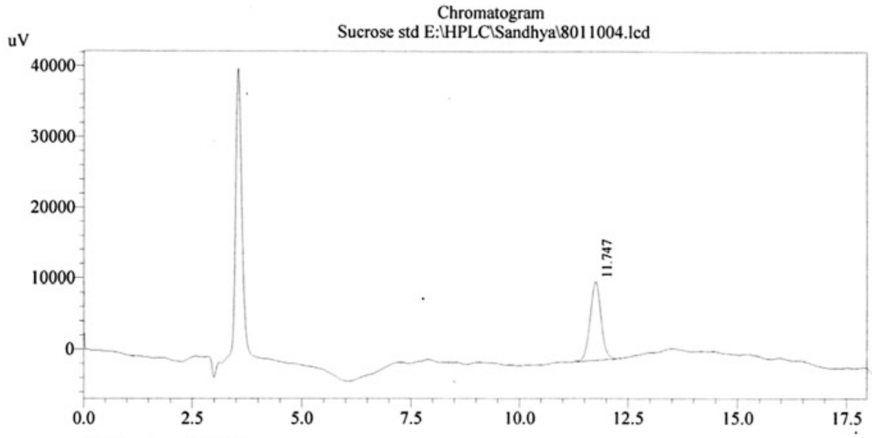
Data were also recorded on 16 other traits which included anthocyanin colouration of coleoptile, anthocyanin colouration of leaf sheath, leaf midrib colour, flag leaf midrib colouration, presence/absence of awns on lemma, anthocyanin



Detector A Ch1

Peak#	Name	Ret. Time	Area	Area %
1		7.121	178635	100.000
Total			178635	100.000

Fig. 2 Standard chromatogram of fructose



Detector A Ch1

Peak#	Name	Ret. Time	Area	Area %
1		11.747	194813	100.000
Total			194813	100.000

Fig. 3 Standard chromatogram of sucrose

colouration of stigma, yellow colouration of stigma, length of stigma, length of floret, anther length, color of anther, glume color, panicle density, panicle shape, panicle neck length, threshability, caryopsis (grain) color, grain shape-profile view and dorsal view, germ size on the grain, endosperm texture, albumen color and grain lustre for which data were recorded (Reddy et al. 2006) on the basis of visual assessment of individual plants (or parts of plants) within a plot; or it was based on visual assessment of group of plants (or parts of plants) in a plot for traits such as plant growth habit, panicle shape, panicle density, grain color and grain shape. The mean plot values of the quantitative traits measured were subjected to analysis of variance (ANOVA) for each season using Genstat 14.1 software. The data analysis was done separately for varieties and hybrids as one group and treating all female hybrid parents (B-lines) as another group owing to their distinct genetic differences.

3 Results and Discussion

In sweet sorghum improvement program at ICRISAT, hybrid parental lines (A/B pairs) and varieties are developed with considerable morphological diversity and then designated based on agronomic performance and resistance to shootfly. The tropical sweet sorghums are photo- and thermo-sensitive and flowers when the day length is less than 12 h 15 min. The biomass yield and sugar yield are high during rainy season as compared to that of post-rainy season. The extent of variation attributable to seasonal effect on these genotypes may vary depending on the environments (Srinivasarao et al. 2011). However, pooled analysis of variance for quantitative traits revealed that these cultivars had significant differences between them for the expression of all the quantitative characters under study (Table 1). Further the magnitude of variation is highly influenced by the environment, particularly for sugar yield and related traits (Srinivasarao et al. 2011). The mean performance of sweet sorghum varieties and hybrids adapted to rainy season are presented in Table 2. The mean of key sugar related traits are plant height: 3.39 m (range: 3–3.8 m), days to 50 % flowering: 80 days (range: 72–87 days), stalk yield: 47.9 t ha^{-1} (range: 36.6–60.6 t ha^{-1}), juice yield:18.9 t ha^{-1} (range: 13.5–29.4 t ha^{-1}), Brix%: 17.3 (range: 16–20) and sugar yield: 2.6 t ha^{-1} (range: 1.8–3.5 t ha^{-1}). The mean of the key biochemical parameters are pH: 5.0 (range: 4.0–5.0), electrical conductivity: 8.6 mS cm^{-1} (range: 7.1–10.3 mS cm^{-1}), fructose: 0.8 % (range: 0.2–2.83 %), glucose: 0.96 % (range: 0.23–1.86 %) and sucrose: 6.29 % (range: 2.63–9.90 %). In general varieties have recorded 5.6 % more Brix% while hybrids are taller by 0.2 m and flower 5.4 days earlier. The hybrids have recorded 12.8 % higher stalk yield, 24.4 % more juice yield and 17 % higher sugar yield *vis-a-vis* varieties in rainy season. Hence, the available heterosis for traits like plant height, stalk yield and juice yield needs to be exploited favorably to develop high sugar yielding hybrids (Srinivasarao et al. 2009, 2010; Reddy et al. 2011; Kumar et al. 2011). As the distillery needs to be operated for longer period of the year to be economically viable, the earliness in rainy season hybrids cannot be ignored to develop hybrids of choice with different maturity groups.

The mean performance of sweet sorghum female hybrid parents (6) adapted to rainy season are presented in Table 3. The mean of key sugar related traits are

Table 1 Mean squares for quantitative traits for sweet sorghum varieties and hybrids during 2010 rainy season

Source of variation	d.f	Plant height (m)	Stem diameter (mm)	Leaf length (cm)	Leaf width (cm)	Exersion length (cm)	Panicle branch length (cm)	Panicle length (cm)	Glume coverage (%)	1,000 grain weight (g)	Days to 50 % flowering
Replication	2	0.02	12.42	142.47	15.52	16.54	1.02	26.58	8.75	0.25	0.8
Genotype	19	0.03*	10.37**	130.21*	3.97*	86.80**	10.98**	34.83**	840.43**	179.59**	79.01**
Residual	38	0.02	4.2	63.52	2.06	9.32	1.42	6.54	3.93	0.05	2.31

Source of variation	Stalk yield (t ha^{-1})	Juice yield (t ha^{-1})	Juice extraction (%)	Brix (%)	Grain yield (t ha^{-1})	Seed restoration (%)	pH	EC (ms/cm)	Fructose (%)	Glucose (%)	Sucrose (%)
Replication	0.2	0.18	16.09	4.77	0.11	71.64	0.8	0.47	2.77	5.04	7.07
Genotype	1651.22**	329.55**	88.09**	17.90**	2.92**	117.23**	0.19*	2.49**	1.60**	0.82*	12.10**
Residual	0.45	0.12	1.4	0.86	0.01	2.26	0.09	0.29	0.45	0.34	3.38

d.f. degrees of freedom; *significant at $P < 0.05$; **significant at $P < 0.01$

Table 2 Mean performance of sweet sorghum varieties and hybrids for quantitative traits during 2010 rainy season

S.No	Genotype	Plant height (m)	Stem diameter (mm)	Leaf length (cm)	Leaf width (cm)	Exersion length (cm)	Panicle branch length (cm)	Panicle length (cm)	Glume coverage (%)	1,000 grain weight (g)	Days to 50 % flowering	Stalk yield (t ha^{-1})
1	SPV 422	3.1	21.60	88	7	4	7	20	25	35	86	47.58
2	ICSV 25274	3.5	19.65	90	11	8	7	23	23	49	87	49.08
3	ICSV 25280	3.3	15.11	71	8	6	6	17	50	34	83	45.41
4	ICSV 25275	3.3	15.20	70	8	7	5	16	50	30	81	46.57
5	ICSV 25272	3.1	14.50	81	7	14	9	23	47	33	74	55.57
6	RSSV 9	3.3	17.75	75	10	3	5	18	47	26	85	58.87
7	ICSV 700	3.4	17.62	73	8	5	6	20	50	28	84	45.63
8	SSV 84	3.2	18.34	88	11	7	**7**	21	50	25	87	38.74
9	SSV 74	3.3	18.21	76	9	7	8	19	25	36	84	41.54
10	ICSV 93046	3.6	17.89	74	8	5	7	18	50	27	86	53.96
11	ICSSH 31	3.1	14.16	85	8	12	8	28	75	32	75	51.16
12	ICSSH 25	3.5	18.05	77	9	8	8	24	25	28	77	54.77
13	ICSSH 39	3.3	16.37	82	10	10	10	26	25	36	74	46.90
14	ICSSH 30	3.5	18.78	82	10	13	8	24	25	44	77	52.02
15	ICSSH 29	3.8	17.76	91	10	9	7	25	25	27	82	58.49
16	ICSSH 58	3.7	14.97	88	9	9	7	21	50	25	79	57.50
17	ICSSH 28	3.8	17.47	80	10	12	7	25	25	47	76	63.64
18	CSH 22 SS	3.3	18.54	86	9	19	8	25	25	30	84	51.27
	Mean	3.4	17.26	81	9	10	8	22	40	33	80	46.69
	Minimum	3.1	14.16	70	7	3	5	16	23	25	74	38.74
	Maximum	3.8	21.60	91	11	19	10	28	75	49	87	63.64
	LSD (5 % Level)	0.24	3.39	13.17	2.37	5.05	1.97	4.23	3.28	0.37	2.51	1.10
	CV (%)	1.00	4.60	3.30	10.00	9.20	3.00	5.20	1.70	0.30	0.20	0.20

(continued)

Table 2 (continued)

S.No	Genotype	Juice yield (t ha^{-1})	Juice extraction (%)	Brix (%)	Sugar yield (t ha^{-1})	Grain yield (t ha^{-1})	Seed restoration (%)	pH	EC (ms/cm)	Fructose (%)	Glucose (%)	Sucrose (%)
1	SPV 422	18.71	39	20	2.8	3.1	*	5	8.8	0.23	0.55	3.59
2	ICSV 25274	19.59	40	20	2.9	2.6	*	5	8.1	0.44	0.96	2.63
3	ICSV 25280	24.35	54	17	3.1	2.4	*	5	7.6	0.42	1.86	4.91
4	ICSV 25275	23.51	50	16	2.8	2.7	*	5	7.7	0.44	1.72	7.73
5	ICSV 25272	26.34	47	16	3.2	3.4	*	5	9.5	1.09	0.81	6.4
6	RSSV 9	21.43	36	16	2.6	1.5	*	4	9.4	2.83	1.62	4.68
7	ICSV 700	17.4	38	16	2.1	3.1	*	5	8.4	0.21	0.71	4.94
8	SSV 84	13.53	35	19	1.9	3.3	*	5	7.1	0.38	0.69	3.71
9	SSV 74	14.86	36	16	1.8	1.5	*	5	7.8	0.32	1.49	4.99
10	ICSV 93046	25.58	47	16	3.1	2.7	*	5	8.9	0.2	0.65	4.01
11	ICSSH 31	22.36	44	16	2.7	3.3	91	5	9.3	1.38	0.23	8.41
12	ICSSH 25	28.45	52	17	3.6	3.1	86	5	10.3	0.29	1.28	6.25
13	ICSSH 39	22.45	48	18	3	2.2	83	5	9.5	0.37	1.1	8.07
14	ICSSH 30	24.5	47	18	3.3	2.2	92	5	7.5	2.01	0.56	7.77
15	ICSSH 29	25.44	43	19	3.6	2.8	82	5	7.5	1.53	0.37	7.61
16	ICSSH 58	29.43	51	17	3.8	2.9	93	5	8.2	1.19	0.34	9.9
17	ICSSH 28	28.34	45	16	3.4	2.4	82	5	9.6	0.54	1.52	6.32
18	CSH 22 SS	23.38	46	19	3.3	3.5	77	5	8.9	1.57	0.3	8.48
	Mean	18.85	33	17.3	2.9	2.7	85	5	8.6	0.8	0.96	6.29
	Minimum	13.53	35	16	1.8	1.5	77	4	7.1	0.2	0.23	2.63
	Maximum	29.43	54	20	3.8	3.5	93	5	10.3	2.83	1.86	9.9
	LSD (5 % Level)	0.57	1.96	1.53	0.3	0.16	2.6	0.49	0.89	1.11	0.97	3.04
	CV (%)	0.5	2.7	3	7.9	3.1	2.2	4	1.8	16.3	12.4	9.5

LSD least significant difference; *CV* coefficient of variation

Table 3 Mean performance of sweet sorghum female hybrid parental lines for quantitative traits during 2010 rainy season

S.No	Genotype	Plant height (m)	Stem diameter in (mm)	Leaf length (cm)	Leaf width (cm)	Exersion length (cm)	Panicle branch length (cm)	Panicle length (cm)	Glume coverage (%)	1,000 grain weight (g)	Days to 50 % flowering	Stalk yield (t ha^{-1})
1	ICSB 38	1.4	17.67	81	8	24	8	32	25	26	74	16.0
2	ICSB 474	2.1	14.1	71	8	10	6	21	50	43	70	23.1
3	ICSB 675	1.2	15.02	86	9	0	0	21	25	16	76	21.4
4	ICSB 702	1.6	15	79	7	16	7	23	25	37	67	17.4
5	ICSB 724	1.9	14.98	76	8	9	7	20	25	27	76	24.8
6	ICSB 731	2	16.38	82	8	11	6	22	25	29	74	20.3
	Mean	1.9	15.53	79	8	12	6	23	29	30	73	20.5
	Minimum	1.2	14.1	71	7	0	0	20	25	16	67	16.0
	Maximum	2.1	17.67	86	9	24	8	32	50	43	76	24.8
	LSD (5 % Level)	0.22	4.6	10.65	2.34	3.23	1.94	3.78	*	*	2.73	0.72
	CV (%)	1.8	9.6	1.7	19.3	9.7	13	9.6	0	0	0.9	0.7

S.No	Genotype	Juice yield (t ha^{-1})	Juice extraction (%)	Brix (%)	Sugar yield (t ha^{-1})	Grain yield (t ha^{-1})	pH	EC (ms/cm)	Fructose (%)	Glucose (%)	Sucrose (%)
1	ICSB 38	4.4	27.5	9	0.3	2.3	5.5	14.7	0.65	2.07	1.71
2	ICSB 474	8	34.4	11	0.66	1.4	5.1	10.2	0.28	1.17	5.67
3	ICSB 675	6.7	31.3	12	0.6	0.6	5.3	12.2	0.72	2.39	1.74
4	ICSB 702	7.6	43.6	13	0.74	4.1	5.3	11.5	0.2	1.02	4.83
5	ICSB 724	9.7	39.1	13	0.94	4.3	5.3	9.7	0.37	1.41	4.62
6	ICSB 731	9.2	45	14	0.96	3.9	5.1	9.1	0.34	0.86	8.87
	Mean	7.6	36.8	12	0.7	2.8	5.2	11.2	0.43	1.49	4.57
	Minimum	5.4	27.5	9	0.3	0.6	5.1	9.1	0.2	0.86	1.71
	Maximum	9.7	45	14	0.96	4.3	5.5	14.7	0.72	2.39	8.87
	LSD (5 % Level)	0.49	1.4	1.09	0.1	0.43	0.17	1.66	0.27	0.78	2.3
	CV (%)	1.6	3.2	5.8	11.4	0.4	1	5.6	39.7	36.7	33.9

LSD least significant difference; *CV* coefficient of variation

plant height: 1.7 m (range: 1.2–2.1 m), days to 50 % flowering: 73 days (range: 67–76 days), stalk yield: 20.5 t ha^{-1} (range: 16–24.8 t ha^{-1}), juice yield:7.6 t ha^{-1} (range: 5.4–9.7 t ha^{-1}), Brix%: 12 (range: 9–14) and sugar yield: 0.7 t ha^{-1} (range: 0.3–0.96 t ha^{-1}). The mean of the key biochemical parameters are pH: 5.2 (range: 5.1–5.5), electrical conductivity: 11.2 mS cm^{-1} (range: 9.2–14.7 mS cm^{-1}), fructose: 0.43 % (range: 0.2–0.72 %), glucose: 1.49 % (range: 0.86–2.39 %) and sucrose: 4.57 % (range: 1.71–8.87 %). The high sugar yielding B-lines such as ICSB 474, ICSB 702, ICSB 724 and ICSB 731 can be utilized in the breeding programmes to develop highly productive hybrids for ethanol production. The detailed characteristics of sweet sorghum cultivars and female hybrid parents adapted to rainy season were discussed in Chap. 3.

The productivity levels of tropical sweet sorghums during post-rainy season (October–March) are generally low due to photo-sensitivity and thermo-sensitivity of the genotypes (Srinivasarao et al. 2009; Kumar et al. 2010). As the sugar accumulation is a function of diurnal and nocturnal temperature differences besides complex genotype × environment (G × E) interactions. The pooled analysis of variance for quantitative traits revealed significant differences among the cultivars studied (data not shown). The mean performance of sweet sorghum varieties and hybrids adapted to post-rainy season are presented in Table 4. The cultivar mean for sugar related traits are plant height: 1.87 m (range: 1.5–2.3 m), days to 50 % flowering: 78 days (range: 69–83 days), stalk yield: 29.9 t ha^{-1} (range: 20.1–38.1 t ha^{-1}), juice yield:10.9 t ha^{-1} (range: 6.9–15.8 t ha^{-1}), Brix%: 14 (range: 10–17) and sugar yield: 1.16 t ha^{-1} (range: 0.67–2.02 t ha^{-1}). The mean of the key biochemical parameters are pH: 5.3 (range: 5.2–5.4), electrical conductivity: 13.66 mS cm^{-1} (range: 9.6–18.0 mS cm^{-1}), fructose: 1.33 % (range: 0.95–2.04 %), glucose: 1.11 % (range: 0.79–1.47 %) and sucrose: 4.5 % (range: 2.38–7.35 %).

The post-rainy season adapted hybrids exhibited 30.1 % superiority for stalk yield, 59 % higher sugar yield besides 10 % higher grain yield over that of varieties. The Brix% levels are same in both the groups; however there is a reduction of total soluble solids by 25 % in post-rainy season as compared to that of rainy season. In case of sugar yield across two seasons, the average post-rainy season sugar productivity (1.16 t ha^{-1}) is 156 % which is lower that of the rainy season level (2.98 t ha^{-1}). This data further reiterates that the genetic pool of sweet sorghums needs to be broadened by attempting novel approaches of either creating variability (Targeting Induced Local Lesions IN Genomes-TILLING) or introgression of novel alleles by wide hybridization etc. (McCallum et al. 2000; Rooney et al. 2007).

The performance of female hybrid parents adapted to post-rainy season is presented in Table 5. The mean values for sugar related traits of B-lines are plant height: 1.02 m (range: 0.8–1.5 m), days to 50 % flowering: 78 days (range: 74–76 days), stalk yield: 14.6 t ha^{-1} (range: 9.6–17 t ha^{-1}), juice yield: 4.42 t ha^{-1} (range: 2.8–5.9 t ha^{-1}), Brix%: 10.8 (range: 9–13) and sugar yield: 0.35 t ha^{-1} (range: 0.27–0.44 t ha^{-1}). The mean of the key biochemical parameters are pH: 5.3 (range: 5.2–5.4), electrical conductivity: 16.66 mS cm^{-1} (range: 13.47–18.77 mS cm^{-1}), fructose: 1.55 % (range: 1.04–2.23 %), glucose: 1.07 %

Table 4 Mean performance of sweet sorghum varieties and hybrids for quantitative traits during 2010 post-rainy season

S.No	Genotype	Plant height (m)	Stem diameter (mm)	Leaf length (cm)	Leaf width (cm)	Exersion length (cm)	Panicle branch length (cm)	Panicle length (cm)	Glume coverage (%)	1000 grain weight (g)	Days to 50 % flowering	Stalk yield (t ha^{-1})
1	RSSV 9	1.9	14.43	69	7	6	5	13	33	33	69	27.5
2	ICSV 25272	2	15.43	67	8	14	5	16	48	33	83	25.8
3	ICSV 25274	1.8	14.08	67	8	13	7	18	25	41	72	29.7
4	SSV 84	1.5	13.65	77	8	11	6	17	25	32	72	20.9
5	SSV 74	1.7	12.77	63	7	11	8	18	25	43	73	23.2
6	ICSV 700	2	13.22	54	8	8	6	17	67	30	81	24.7
7	ICSV 93046	2	15.29	51	7	11	6	16	42	33	83	33.9
8	ICSSH 28	2.1	12.06	65	8	17	8	23	25	36	73	31.7
9	ICSSH 58	2,3	14.55	64	8	15	7	17	25	26	89	38.1
10	ICSSH 25	1.9	14.39	66	7	21	9	22	33	32	77	31.7
11	CSH 22SS	2.1	13.81	63	8	27	8	23	25	25	73	36.7
12	ICSSH 76	1.6	13.61	83	8	22	8	25	33	31	93	34.4
	Mean	1.87	13.94	66	8	15	7	19	34	33	78	29.9
	Minimum	1.5	12.06	51	7	6	5	13	25	25	69	20.9
	Maximum	2.3	15.43	83	8	27	9	25	67	43	93	38.1
	LSD (5 % Level)	0.15	4.44	13.24	1.64	7.76	1.42	2.93	21.15	4.14	6.44	3.49
	CV (%)	6.1	3.6	3	2.6	6.2	3.9	3.4	7.8	1	0.6	8.6

S.No	Genotype	Juice yield (t ha^{-1})	Juice extraction (%)	Brix (%)	Sugar yield (t ha^{-1})	Grain yield (t ha^{-1})	Seed restoration (%)	pH	EC (ms/cm)	Fructose (%)	Glucose (%)	Sucrose (%)
1	RSSV 9	10.6	38.7	14	1.12	3.1	93	5.2	16	1.17	1.45	4.08
2	ICSV 25272	9.1	35.1	16	1.09	3.5	93	5.3	12.9	1.15	0.79	7.35
3	ICSV 25274	7.7	25.7	14	0.8	2.7	93	5.3	14.87	1.67	1.33	3.88
4	SSV 84	9.1	43.4	10	0.68	3	93	5.2	16.6	1.06	1.15	2.71

(continued)

Table 4 (continued)

S.No	Genotype	Juice yield (t ha^{-1})	Juice extraction (%)	Brix (%)	Sugar yield (t ha^{-1})	Grain yield (t ha^{-1})	Seed restoration (%)	pH	EC (ms/cm)	Fructose (%)	Glucose (%)	Sucrose (%)
5	SSV 74	8.4	36	13	0.82	2.7	93	5.2	12.87	1.14	1.47	5.14
6	ICSV 700	6.9	27.7	13	0.67	2.6	93	5.3	11.27	2.04	1	4.93
7	ICSV 93046	11.2	32.9	16	1.34	3.1	93	5.3	10.53	1.71	0.97	5.59
8	ICSSH 28	11.9	37.5	15	1.34	2.6	91	5.2	15.43	1.05	0.95	3.92
9	ICSSH 58	15.8	41.5	17	2.02	3.2	85	5.2	9.6	1.49	1.09	6.87
10	ICSSH 25	13.3	41.9	14	1.39	2.7	94	5.2	13.03	1.23	1.26	3.84
11	CSH 22SS	13.1	35.6	13	1.27	3.7	100	5.3	18	0.95	0.79	2.38
12	ICSSH 76	14.2	41.4	13	1.39	4.2	97	5.4	12.87	1.29	1.07	3.34
	Mean	10.9	36.4	14	1.16	3.09	93	5.3	13.66	1.33	1.11	4.5
	Minimum	6.9	27.7	10	0.67	2.6	85	5.2	9.6	0.95	0.79	2.38
	Maximum	15.8	43.4	17	2.02	4.2	100	5.4	18	2.04	1.47	7.35
	LSD (5 % Level)	4.46	5.05	2.92	0.3	1.03	6.19	0.12	3.35	0.66	0.37	2.44
	CV (%)	13.7	8	4.1	8.6	3.2	1.6	0.1	2.9	8.2	6	12.4

LSD least significant difference; *CV* coefficient of variation

Table 5 Mean performance of sweet sorghum female hybrid parental lines for quantitative traits during 2010 post-rainy season

S.No	Genotype	Plant height (m)	Stem diameter (mm)	Leaf length (cm)	Leaf width (cm)	Exersion length (cm)	Panicle branch length (cm)	Panicle length (cm)	Glume coverage (%)	1,000 grain weight (g)	Days to 50 % flowering	Stalk yield (t ha^{-1})
1	ICSB 38	0.9	15.98	71	7	20	9	27	25	28	75	9.6
2	ICSB 474	1	12.58	70	7	12	7	24	67	27	74	17
3	ICSB 502	0.9	16.4	75	7	6	6	25	25	31	78	15.7
4	ICSB 731	1.5	16.38	62	7	12	6	18	25	31	77	17
5	ICSB 675	0.8	19.69	73	8	7	9	27	25	35	76	13.7
	Mean	1	16.21	70	7	11	7	24	33	31	76	10.2
	Minimum	0.8	12.58	62	7	6	6	18	25	27	74	9.6
	Maximum	1.5	19.69	75	8	20	9	27	67	35	78	17
	LSD (5 % Level)	0.05	7.2	15.62	1.79	13.32	1.72	4.7	12.15	4.16	2.41	4
	CV (%)	1.2	9	2	5.2	28.7	2.9	5.1	8.7	3.5	0.8	21.8

S.No	Genotype	Juice yield (t ha^{-1})	Juice extraction (%)	Brix (%)	Sugar yield (t ha^{-1})	Grain yield (t ha^{-1})	pH	EC (ms/cm)	Fructose (%)	Glucose (%)	Sucrose (%)
1	ICSB 38	3.3	34.1	11	0.27	3.8	5.3	16.87	1.47	0.96	3.04
2	ICSB 474	4.2	24.4	11	0.34	3.3	5.2	17.37	1.04	1.19	2.68
3	ICSB 502	3.9	24.8	13	0.38	2.5	5.4	13.47	2.23	0.98	4.11
4	ICSB 731	5.9	34.8	10	0.44	2.5	5.3	16.83	1.45	1.2	2.64
5	ICSB 675	4.8	34.8	9	0.32	3.5	5.3	18.77	1.54	1.01	1.4
	Mean	3.4	33.3	11	0.28	3.1	5.3	16.66	1.55	1.07	2.77
	Minimum	2.8	24.4	9	0.27	2.5	5.2	13.47	1.04	0.96	1.4
	Maximum	4.2	34.8	13	0.44	3.8	5.4	18.77	2.23	1.2	4.11
	LSD (5 % Level)	1.52	14.88	3.2	0.06	1.11	0.19	4.41	0.87	0.51	2.74
	CV (%)	21.7	7.1	17	12.4	9.3	0.6	10.1	11.2	13.8	34.1

LSD least significant difference; *CV* coefficient of variation

(range: 0.96–1.20 %) and sucrose: 2.77 % (range: 1.40–4.11 %). The B-lines during post-rainy season have recorded 66 % lower plant height, 40 % lower stalk yield, 10 % lower Brix% and 100 % lower sugar yield as compared to that of the rainy season. The poor performance of both female hybrid parents and cultivars during post-rainy season necessitates identifying new sources/alleles contributing to both biomass and sugar yield. The detailed characteristics of sweet sorghum cultivars and female hybrid parents adapted to post-rainy season are discussed in Chap. 4.

In summary the characterization of hybrid parental lines and cultivars helps to understand the available variability for sugars and biomass related traits in the available genotypes besides their adaptation to different seasons and further aids in stream lining the breeding objectives to improve the productivity traits in a sweet sorghum improvement program.

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