Identification of Mid-Season Moisture Stress Tolerant Sweet Sorghum Material

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Sweet sorghum – Importance

- Sorghum with C_4 photosynthetic pathway, tolerance to drought, water logging, high salinity and acidic soils, it is a preferred crop for cultivation on marginal lands and an important source of food, fodder and income to the farmers.
- Sweet sorghum is similar to grain sorghum but accumulates sweet juice in the stalk vascular tissues; traditionally used as livestock fodder - excellent silage. With its short growing period (four months), low water requirement, high biomass and bio-product potential and greater income opportunity from cultivation, it is a preferred raw material for ethanol production (from the stalk juice) as it also provides grain for human consumption.
- Sweet sorghum is recognized as an alternate feedstock for bioethanol production by Govt. of India (National Biofuel Policy, December, 2009).

Mid-season moisture stress

- The production of sorghum is affected by a range of biotic and abiotic yield constraints (drought, temperature and nutritional stresses). Among these, drought is the primary constraint throughout the semi-arid tropics (SAT) due to erratic rainfall. Moisture stress can occur at any growth stage - the frequency of occurrence of mid-season (during rainy season) and terminal drought (during postrainy season) is high.
- Symptoms of mid-season moisture stress are leaf rolling, leaf erectness, leaf bleaching, leaf tip and margin burn (leaf firing), delayed flowering, poor panicle exertion, panicle blasting and floret abortion, and reduced panicle size.

Materials

400 sweet sorghum genotypes comprising 100 B-lines and 170 R-lines/ varieties, 65 hybrids, and 58 germplasm accessions, five checks (ICSV 112: high grain yielding variety, R 16: drought susceptible check, B 35: stay green (drought tolerant) check, E 36-1: both stay green and sweet sorghum variety and NTJ 2: sweet sorghum variety).

Screening method

The material was planted on 6 February 2009 in an augmented design at ICRISAT with checks repeated at an interval of 10 genotypes. Irrigation was stopped three weeks after sowing for 24 days (till crop was 45 days old) and data was recorded for the drought related traits. Stress was relieved by irrigating the crop on the 46th day after sowing and the juice related traits were recorded at physiological maturity. The selected entries from this screening are to be evaluated for rainy season adaptation in SAT areas.

Significant outcomes

The best performing lines/hybrids for the candidate traits of mid-season drought tolerance are given in Table-1.

- **Promising genotypes with high sugar yield (t ha^{-1}):** check E 36-1 (0.7)

Germplasm accessions	B-lines	R-lines	Hybrids
IS 23530 (0.7)	SP 93035 (1.1)	SP 08 2061-1 (2.3)	ICSA 324 × SSV 74 (1.4)
IS 23525 (0.5)	ABT 2036-2 (0.8)	SP 08 2057-1 (1.9)	ICSA 502 × SP 4481-1 (1.3)

- **Promising genotypes with high grain yield (t ha^{-1}):** check NTJ 2 (3.4)

Germplasm accessions	B-lines	R-lines	Hybrids
IS 2325 (2.42)	SP 93035 (4.94)	SP 08 2054-3 (4.76)	ICSA 502 × SP 4511-2 (3.63)
IS 23530 (2.36)	ICSB 516 (4.47)	SP 08 1041-3 (4.14)	ICSA 511 × IS 15335 (3.4)

- **Promising genotypes with drought tolerance traits:** leaf rolling score of >4 and firing score <2

Germplasm accessions	B-lines	R-lines	Hybrids
IS 23574	SP 2411	SP 08 2015-3	ICSA 675 × SSV 74
IS 23573	ICSB 24001	SP 4495	ICSA 502 × SP 4511-2

Mean performance of top three genotypes in each breeding group in mid season drought screening, 2009 summer season.

S. No.	Type of material	Genotype	Vigour score[1]	Leaf rolling-score[2]	Leaf firing score[3]	Plant height (m)	Days to 50% flowering	Stalk weight (t ha^{-1})	Cane weight (t ha^{-1})	Juice weight (t ha^{-1})	Brix	Sugar yield (t ha^{-1})[4]	Grain yield (t ha^{-1})
1	B-line	PBT A1 12	1.0	4.1	1.9	1.2	77	34.12	26.4	7.8	14.8	1.15	4.94
2	B-line	ICSB 84	2.0	1.3	1.5	0.9	97	22.94	17.3	5.4	14.8	0.79	1.1
3	B-line	SP 08 2036-2	1.0	0.9	2.7	1.2	81	26.92	20.7	5.3	14.7	0.79	1.8
4	Variety/R-line	SP 08 2061-1	0.8	4.9	1.9	1.5	74	53.44	44.8	18.4	11.8	2.17	3.97
5	Variety/R-line	SP 08 2057-1	0.8	1.9	1.9	1.1	*	41.04	32.5	10.1	17.0	1.77	-0.53
6	Variety/R-line	SP 08 2070-1	0.8	4.9	2.9	2.0	75	36.04	30.0	9.2	15.0	1.41	1.63
7	Hybrid	ICSA 324 x SSV 74	1.0	3.1	1.9	1.6	80	53.64	44.5	10.6	13.7	1.36	0.37
8	Hybrid	ICSA 502 x SP 4481-1	2.0	3.3	2.5	1.8	77	45.94	32.6	9.8	13.7	1.35	0.54
9	Hybrid	ICSA 702 x SSV 84	2.0	2.3	2.5	1.5	74	39.34	30.3	8.2	15.8	1.28	1.85
10	Germplasm accession	IS 23530	1.6	1.7	3.7	1.6	69	24.18	18.7	5.1	14.2	0.72	2.36
11	Germplasm accession	IS 23525	1.6	2.7	2.7	1.8	72	21.28	16.2	3.4	18.3	0.6	2.07
12	Germplasm accession	IS 14942	1.6	3.7	1.7	2.1	75	27.78	22.3	3.6	15.6	0.55	1.26
13	Check	ICSV 112	2.6	5.2	4.8	1.2	69	52.9	14.0	2.5	18.5	0.3	2.7
14	Check	R 16	2.4	6.6	4.8	1.2	76	62.6	20.3	3.8	19.4	0.5	1.6
15	Check	B 35	2.0	3.9	3.1	0.9	68	70.4	14.3	2.6	19.8	0.3	1.7
16	Check	E 36-1	2.6	6.9	3.6	1.5	77	65.5	22.4	4.6	20.6	0.7	2.2
17	Check	NTJ 2	2.6	5.5	4.8	1.5	79	61.5	20.2	3.9	18.0	0.5	3.4
Grand Mean			1.4	3.1	2.5	1.4	75	22.9	17.8	3.6	14.4	0.5	1.5
LSD			0.9	2.4	1.5	0.2	6.7	43.1	6.5	1.9	4.6	0.2	1.1
CV%			0.2	0.7	0.2	0.1	0.6	6.1	2.2	1.5	0.4	0.2	0.7

[1]Vigour score taken on a 1 to 5 scale, where 1= seedlings with more vigour and 5= seedlings with less vigour
[2]Leaf rolling score taken on a 1 to 5 scale, where 1= completely rolled leaves and 5= flat leaves
[3]Leaf firing score taken on a 1 to 5 scale, where 1= no firing seen and 5= >80% of the leaf area fired
[4]Sugar yield calculated as a product juice weight and Brix% factored at 0.75

- **Character associations:** The sugar yield was significantly correlated with drought tolerance traits (Table-2) such as high vigor score (0.15), more leaf rolling (0.14), less leaf firing (0.15) and agronomic and sugar yield related traits such as more plant height (0.27), late flowering (0.16), more plant girth (0.33), more cane weight (0.82), more juice weight (0.96) and more grain yield (0.17) under moisture stress. Therefore, these component traits need to be emphasized while breeding for sugar yield in the areas prone to mid-season moisture stress in the semi-arid tropics.

Table 2. Correlation of sugar yield, grain yield and flowering time with traits governing drought tolerance and sugar yield related traits among the sweet sorghum genotypes evaluated in mid season drought screening, 2009 summer season.

	Vigour score	Plant height (m)	Days to flower	Leaf angle	Leaf rolling	Leaf firing	Cane weight (t ha^{-1})	Juice weight (t ha^{-1})	Brix%	Sugar yield (t ha^{-1})	Grain yield (t ha^{-1})	Plant Girth (mm)
Days to 50% flowering	0.10	-0.06	1.000	-0.35**	-0.21**	-0.28**	0.11*	0.12*	0.10*	0.16**		0.115
Sugar yield (t ha^{-1})	-0.15**	0.27**	0.16**	0.032	0.14**	-0.15**	0.82**	0.96**	0.12*	1.000	0.17**	0.33**
Grain yield (t ha^{-1})	-0.09	1.00**	-0.35**	0.43**	0.25**	0.22**	0.22**	0.25**		0.17**	1.000	0.11*

(n-2= 398)

Conclusion

*The hybrid parents (B-/R-lines) such as **SP 93035 , ABT 2036-2, SP 08 2061-1, SP 08 2057-1** as well as germplasm accessions **IS 2353 and IS 23525** can be utilized in the breeding programs for pre-flowering moisture stress while the identified mid-season stress tolerant varieties **SP 08 2061-1, SP 08 2057-1.** Hybrids **ICSA 324** × **SSV74 (1.4), ICSA 502** × **SP 4481-1** can be deployed for large scale cultivation after conducting multi-location adaptation trials.*

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Drought susceptible lines showing leaf drying and wilting.

Drought tolerant line with well filled grains.

Drought tolerant sweet sorghum hybrid with high biomass and grain.

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