



## Performance of promising sugarcane varieties under water stress condition

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### ABSTRACT

Performance of 10 promising varieties of sugarcane, viz. CoS 07250, CoS 07240, CoS 08279, CoS 08272, CoS 10239, CoS 09240, CoSe 01434, CoSe 06455, CoSe 06456 and UP 05125 was studied under water stress condition, at the research farm of UP Council of Sugarcane Research, Shahjahanapur, UP, India during spring seasons of 2012-13, 2013-14 and 2014-15. Sugarcane varieties CoS 07250 and CoSe 01434 were used as standard. Statistically pooled data of three years revealed that physiological and biochemical parameters such as transpiration rate (TR), stomatal diffusive resistance (SDR), leaf water potential (LWP) and total chlorophyll content in leaf varied significantly due to moisture stress, however, the differences were only significant in case of SDR expressing high total chlorophyll content, leaf water potential and significantly greater stomatal diffusive resistance and lower rate of transpiration under deficient moisture condition. Varieties CoS 08279, and CoS 07240 gave an indication about their drought endurance capacity. All the varieties showed significant reduction in shoot population, number of millable canes (NMC) and cane yield under deficient irrigation (two pre monsoon) as compared to normal irrigation (five irrigation pre monsoon). Varieties CoS 08279, CoS 07240 and CoSe 06455 produced significantly more numbers of shoots, NMC and cane yield (63 tonnes/ha) under water stress condition along with less yield reduction percent (below 10 %), confirming thereby their drought tolerant nature. Sucrose percent in juice was not affected significantly due to water stress.

**Key words:** Drought, Leaf water potential, Stomatal diffusive resistance, Transpiration rate

Sugarcane is an important agro-industrial crop grown in India under diverse agro-climatic conditions with varied crop management practices prevalent in different states across the country. In northern India, particularly in Uttar Pradesh, sugarcane plants are grown under extreme drought conditions caused due to high temperature (40.0°C was average temp. in May), low relative humidity (32 was average humidity in May) and high soil moisture stress. Crop passes through hard and dry months, i.e. April, May and June. Out of three main types of drought associated with soil, atmospheric or physiological, the first one is considered most important, which is caused by a deficiency of soil moisture. Water deficiency during the formative phase of sugarcane reduces growth and yield of sugarcane (Singh 1974, Srivastava *et al.* 1995, 1996, 1997, Johari *et al.* 1998, 2005). Various morphological and physiological characteristics of sugarcane in relation to drought tolerance have been studied in India (Gill 1959, Singh and Verma 1975, Naidu and Venketramana 1987, Singh and Srivastava 1992). Chen and Bor (1966) and Dwivedi *et al.* (1988) laid stress on osmotic potential and epidermal bulliform cell for rapid selection of varieties for deficient moisture condition. Gill (1962) reported that tillering and growth were adversely

affected by deficient irrigation, the cane quality was not greatly influenced by frequency of irrigation. Singh *et al.* (1984) observed that the third order of tillering required irrigation necessarily. Selection of varieties suitable for cultivation under drought condition was initiated in recent years. Sugarcane being a long duration crop, requires large amount of water for its growth and development and the crop requires from 148-300 g to produce 1g dry matter under different situations (Singh 1974). The most dominant factor governing the drought resistance in sugarcane is the variety (Dillewijn 1952). Keeping in view, it was desirable to find out the drought resistance promising varieties suitable for cultivation in northern India where water stress prevails almost every year. In the present investigation 10 promising varieties have been studied on the basis of yield reduction percent and physiological and biochemical characters, for selection of drought tolerant varieties for general cultivation.

### MATERIALS AND METHODS

A field experiment was conducted with ten promising sugarcane varieties, viz. CoS 07250, CoS 07240, CoS 08279, CoS 08272, CoS 10239, CoS 09240, CoSe 01434, CoSe 06455, CoSe 06456 and UP 05125 in spring season of 2012-13, 2013-14 and 2014-15 at the research farms of UP Council of Sugarcane Research, Shahjahanapur (UP), India. Two budded setts were planted in strip plot design replicated thrice in rows 90 cm apart. Nitrogen was given

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Table 1 Effect of water stress on physiological and biochemical characters of sugarcane (Pooled data of three years 2012–13 to 2014-15)

Varieties	Total chlorophyll (mg/g fr. Leaf weight)			Transpiration rate (m.mol.cm <sup>2</sup> /s)			Stomatal deffusive reistance (s/cm)			Leaf water potential (-bars)		
	N	D	Mean	N	D	Mean	N	D	Mean	N	D	Mean
CoS 07250	1.821	1.744	1.782	12.258	6.822	9.540	1.471	1.871	1.671	6.414	7.628	7.021
CoSe 01434	1.734	1.726	1.730	11.955	6.863	9.409	1.505	1.872	1.688	6.538	7.542	7.031
CoSe 06455	1.633	1.564	1.598	10.823	7.304	9.063	1.430	1.771	1.600	6.712	7.348	7.030
UP 05125	1.649	1.522	1.585	11.411	8.212	9.811	1.511	1.638	1.574	6.474	8.204	7.339
CoS 07240	1.654	1.587	1.620	11.118	7.631	9.374	1.510	1.705	1.607	6.415	7.622	7.018
CoS 08279	1.883	1.784	1.833	12.043	6.624	9.333	1.494	1.854	1.674	6.694	7.549	7.121
CoSe 06456	1.680	1.575	1.627	10.605	8.349	9.477	1.537	1.646	1.591	6.411	8.291	7.351
CoS 08272	1.679	1.576	1.627	10.667	7.712	9.189	1.512	1.644	1.578	6.335	8.397	7.366
CoS 10239	1.659	1.569	1.614	11.411	8.123	9.767	1.538	1.440	1.489	6.522	8.426	7.474
CoS 09240	1.678	1.564	1.621	10.877	7.551	9.214	1.547	1.688	1.617	6.384	8.151	7.267
Mean	1.707	1.621	1.664	11.316	7.519	9.417	1.505	1.712	1.608	6.489	7.914	7.201
SEm	0.06/0.05			0.31/0.40			0.03/0.03			0.15/0.19		
CD (P=0.05)	0.13/0.11			0.65/0.85			NS/0.06			0.32/0.40		

N- Normal, D- Deficient.

as urea @ 180kg/ha in two equal doses, one at planting and other before the onset of monsoon (Srivastava *et al.* 2002). Planting of experiments was done in the month of March, each year and recommended package of practices was followed. Varieties CoS 07250 and CoSe 01434 were used as standard.

Two moisture levels, one normal (5 Pre-monsoon irrigations) and the other deficient (2 Pre-monsoon irrigations) were maintained during the formative stage of the crop. Two common irrigations were applied to both normal and deficient plots, maintaining 50% available soil moisture (ASM). Normal plot were given three more irrigations; whereas the deficient plots did not receive any further irrigation, till the onset of monsoon. The intensity of water stress was measured around 20% ASM in the deficient plots during the formative phase of the crop. Observations on physiological and biochemical were taken just after the completion of irrigational treatments. Crop was harvested in the month of March, each year for cane yield while sucrose per cent in juice was estimated at 10<sup>th</sup> month of crop age, using conventional laboratory methods (Meade and Chen 1977).

Stomatal diffusive resistance (SDR) and transpiration rate (TR) on abaxial leaf surface on mid portion of first fully expanded leaf was measured in normal and deficient plants in the third week of June (at water stress phase) between 7 to 9 AM by Li-16000 steady state porometer by using narrow leaf apparatus (1cm.<sup>2</sup>) simultaneously (Singh and Srivastava 1992). Leaf water potential was measured by plant water status console model 3005, soil moisture equipment corporation (USA), chlorophyll content was taken in the month of May (first week) following the method of Arnon (1949).

## RESULTS AND DISCUSSION

Pooled data of three years (2012-13, 2013-14, 2014-15) as analyzed statistically and shown in Tables 1 and 2 revealed that the effect of moisture stress on different growth attributes were statistically significant on most of the attributes.

### *Biochemical and physiological characters*

Total chlorophyll content in leaf was decreased due to moisture stress, and the differences statistically significant. Varieties CoS 08279, CoS 07240 and CoSe 06455 expressed higher total chlorophyll contents in both crops receiving normal as well as deficient irrigations (Table 1) indicating that higher chlorophyll content in leaves during formative phase seems to be a protective mechanism in coping with the drought condition.

Varieties CoS 08279, CoS 07240 and CoSe 06455 showed the lower rate of transpiration and maintained higher water in leaves under deficient soil moisture, indicating that these varieties have a capacity to conserve moisture during adverse condition. Moreover, these three varieties demonstrated significantly higher stomatal diffusive resistance during moisture stress than rest of the varieties (Table 1). Johari *et al.* (2005) also observed that drought tolerant varieties had high total chlorophyll content, leaf water potential and stomatal diffusive resistance along with minimum rate of transpiration under deficient moisture condition during the formative phase of the crop in some other cultivars.

### *Morphological characters*

Significant reduction in shoot population, NMC and cane yield was observed under deficient moisture stress,

Table 2 Effect of water stress on growth, yield and quality of sugarcane (Pooled data of 2012–2015)

Varieties	Shoot population (000/ha)			NMC (000/ha)			Sucrose %			CCS%			Cane yield (t/ha)			Yield reduction %
	N	D	Mean	N	D	Mean	N	D	Mean	N	D	Mean	N	D	Mean	
CoS 07250	174.7	147.5	161.1	123.9	106.6	115.2	16.46	16.35	16.40	11.19	11.14	11.16	90.86	83.43	87.14	8.17
CoSe 01434	176.7	147.6	162.1	124.1	100.2	121.1	16.43	16.36	16.39	11.17	11.16	11.16	91.36	84.69	88.02	7.30
CoSe 06455	144.6	139.8	142.2	106.6	89.8	98.2	16.40	16.34	16.37	11.20	11.14	11.17	77.33	70.83	74.08	8.40
UP 05125	152.3	131.5	141.9	104.6	88.3	96.4	17.05	17.13	17.09	11.64	11.72	11.68	78.50	71.47	69.98	21.69
CoS 07240	158.7	139.1	148.9	112.5	97.2	104.8	16.63	16.53	16.58	11.32	11.26	11.29	79.52	73.95	76.73	7.00
CoS 08279	189.3	154.0	171.6	131.5	109.0	120.2	16.56	16.45	16.50	11.27	11.24	11.25	90.62	84.69	87.65	6.54
CoSe 06456	148.4	121.4	131.4	101.7	84.6	93.1	16.82	16.65	16.73	11.47	11.33	11.38	75.31	62.46	68.88	17.06
CoS 08272	143.4	122.4	132.9	102.4	82.1	92.2	17.22	17.16	17.19	11.79	11.76	11.40	78.06	59.73	68.89	23.48
CoS 10239	143.1	118.4	130.7	100.2	81.4	90.8	16.29	16.21	16.25	11.06	11.06	11.77	77.04	62.21	69.63	19.24
CoS 09240	143.6	128.6	136.1	107.8	88.0	97.9	16.39	16.31	16.35	11.13	11.14	11.05	76.52	61.24	68.88	19.96
Mean	156.78	135.03	145.9	113.5	92.7	103.0	16.62	16.54	16.58	11.32	11.29	11.30	81.51	70.47	75.99	13.54
SEm	4.86/5.60			3158.74/3681.30	0.13/0.10		0.01/0.03						2.50/1.56			
CD (P=0.05)	10.22/11.77			6636.52/7734.42	0.28/0.21		0.06/0.08						5.26/3.28			

N- Normal, D- Deficient.

where only two pre- monsoon irrigations were applied, however, CoS 08279, CoSe 07240 and CoSe 06455 produced significantly higher number of shoots, NMC and cane yield under water stress condition than other varieties tested. These varieties also maintained minimum yield reduction (below 10%) which further confirm their drought tolerant behavior. Sucrose percent in juice was not affected due to moisture stress however CoSe 08272 and UP 05125 showed significantly higher sucrose per cent. Conclusively the varieties CoS 08279, CoS 07240 and CoSe 06455 have been considered relatively more tolerant to soil moisture stress (Srivastava *et al.* 1995).

REFERENCES

Chen M T and Bor. 1966. Studies on drought resistance in sugarcane. Report 40, Taiwan Sugar Experimental station, pp-34.

Dillewijn C V. 1952. Botany of sugarcane P-871, Chron, Botanica co. Waltham, Mass, the USA.

Dwivedi R S, Srivastava K K, Soloman S and Singh K. 1988. Rapid test for drought resistance in sugarcane. Sugarcane UK Spring Suppl: 31-2.

Gill H S and Singh H 1959. Physiological basis of drought resistance in sugarcane. *Indian Journal of Sugarcane research and Development* 4: 14-21.

Gill H S. 1962. The influence of soil drought on the growth, yield and quality of cane varieties in relation to their drought endurance. *Indian Journal of Agronomy* 7: 148-59.

Johari D, Srivastava R P, Agrawal M L and Singh G P. 1998. Effect of moisture stress on growth yield and juice quality of sugarcane. *Co-operative Sugar* 30(4): 280-3.

Johari, D, Srivastava R P, Lal K and Singh S B. 2005. Evaluation of sugarcane hybrid varieties under water conservation. *Proceeding of 8<sup>th</sup> annual convention of STAI, SISSTA*, held at Hyderabad, 13-15, August 2005, pp 137-42.

Meade G P and Chen J C P. 1977. *Sugarcane Handbook*, edn, pp 10 658-665. A Willy Interscience Publication, New York.

Naidu K M and Veketaramana S. 1987. Diurnal stomatal functioning in sugarcane varieties in response to water and atmospheric stresses. *Sugarcane* No.5:8-11.

Singh G B, Motiwala M P, Prasad S R and Singh A B. 1984. Critical stages when sugarcane requires irrigation in subtropical India. *Indian Journal of Agricultural Sciences* 54(5): 387-9.

Singh Sudama and Srivastava R P. 1992. Studies on stomatal behavior on sugarcane under moisture stress. National Seminar On Plant Physiology, 15-17 Jan. Jaipur (Raj), p 28.

Singh, Sudama and Verma H P. 1975. Studies in drought capacity of cane varieties in relation to their drought endurance. *Indian Journal of Agronomy* 7: 148-9.

Singh U S. 1974. Efficient use of water in sugarcane. *Sugar News* 5(9-10): 17-20.

Srivastava R P, Tiwari T N, Johari D, Singh S P and Singh S. 1996. Varietal differences in stomatal diffusive resistance and transpiration under soil moisture stress in sugarcane. *Indian Journal of plant physiology* (NS): 54-6.

Srivastava R P, Johari D, Singh S P, Sindhant and Sharma M L. 2008. Varietal evaluation of soil moisture stress condition. STAI, All India seminar held at Kodai Kenal (Tamilnadu), 26-27 March 2008.

Srivastava R P, Lal K and Singh S B. 2002. Effect of ste size and nitrogen doses on sugarcane productivity. National symposium

- on sugarcane and sugarcane productivity. *Present scenario and future strategies with conventional and biotechnological approaches*, held on 21-22, March 2002 at UPCSR, Shahjahanpur, India, p-100.
- Srivastava R P, Tiwari T N, Johari D and Singh S P. 1997. After effect of water stress on stomatal opening potential in sugarcane. *Sugar Technology* 2(1): 52-8.
- Srivastava R P, Tiwari T N, Johari D, Singh S P and Singh S. 1995. After effect of water stress on stomatal opening potential in sugarcane. *National symposium on strategies to enhance sugar productivity*, held during 14-16 1995 at India Institute of Sugarcane Research, Lucknow, p 20.
- Veketaramana S, Rao P N G and Naidu K M. 1987. Use of stomatal diffusive resistance measurement in Sugarcane varieties a selection for drought resistance. *Indian Journal of Agricultural Research* 21: 27-32.