

PERFORMANCE OF SUGARCANE VARIETIES UNDER DIFFERENT IRRIGATION REGIMES IN PRE- MONSOON PERIOD IN NORTH WESTERN INDO GANGETIC PLAINS

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Abstract: Drought is the most limiting environmental factor to reduce potential sugarcane productivity among various biotic and abiotic constraints. A field experiment was conducted to investigate the effect of water stress on early and mid-late categories of six sugarcane varieties with three irrigation regimes (IW/CPE) i.e. at 1.0, 0.6 and 0.3 with four replications during 2020-21 at Chaudhary Charan Singh Haryana Agricultural University, Regional Research Station, Karnal (Haryana), India. The results showed that germination per cent did not differ significantly among different irrigation regimes at 30 and 45 days after planting (DAP). At 0.3 irrigation regime, maximum number of tillers were recorded in Co 05011 (120.3 and 113.2), while in CoH 160 (150.4, 131.3) at 0.6 IW/CPE at 100 and 150 DAP, respectively. The results have shown that varieties Co 0238, CoH 167, Co 05011 and Co 0118 recorded significantly highest dry matter accumulation in early as well as grand growth phase than CoH 160 and CoH 119. CoH 167 followed by Co 05011 and Co 0238 produced significantly higher NMC and noted 19.21% and 7.21% reduction in NMC at 0.3 and 0.6 irrigation regime as compared to 1.0 irrigation regime level. Cane yield was significantly affected under low irrigation regime in all the tested varieties. Significant reduction of 31.13 and 12.3% in cane yield was recorded at 0.3 and 0.6 irrigation regime as compared to 1.0 irrigation regime. Among the varieties, CoH 167 (104.5 t ha⁻¹) produced significantly higher cane yield which was at par with Co 0238 (104.3 t ha⁻¹) and the lowest cane yield was reported in varieties Co 0118 (77.6 t ha⁻¹).

Keywords: Cane yield, Drought, Irrigation regimes, IW/CPE ratio, Sugarcane

INTRODUCTION

Sugarcane (*Saccharum* species complex) is one of the important commercial crop of the world. It belongs to genus *Saccharum* L. in the Poaceae family. Sugarcane is grown not only for sugar production, but also increasingly as a livestock feed, fibre and energy, particularly biofuels (sugar-based ethanol) and co-generation of electricity (Solomon, 2011; 2014; Shrivastava *et al.*, 2011). The sugar juice is used for making brown sugar (Khandsari) and jaggery (gur) that is two significant industries providing employment to over a million of people directly or indirectly besides contributing significantly to the national exchequer. In India, sugarcane is grown on an area of about 4.73 million hectares with average productivity of 79.68 t ha⁻¹ (Anonymous, 2018). The annual water requirement for sugarcane ranges from about 1000 to 2900 mm, and this variation mainly depends on the agro-ecological conditions, cultivation practices, and crop cycle. The application of water on these desired

growth phases is much important as farmers applying irrigation in the sugarcane on availability of irrigations from the source. The variety and environment interaction in sugarcane is highly important to screen resilient variety adjusted to different locations (Kumar *et al.*, 2004). Sugarcane varieties with improved tolerance to adverse environmental conditions are highly desirable. Adoption of improved varieties not only increases cane productivity but also boosts sugar production. The selection of variety alone improves the cane yield in range of 28 to 60 per cent (Kathiresan *et al.*, 2001). Generally, under same input and environmental conditions all the varieties do not show same performance level. In a changing climate scenario, the delay or failure of monsoons will have a direct effect on the water available for irrigation in India. Generally low productivity in sugarcane in sub-tropical regions is associated with unfavorable climatic conditions such as more temperature fluctuation, limited irrigation supply along with aberrant weather conditions prevailing during the

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crop growth period (Chand *et al.*, 2010). Sugarcane crop encounters with different types of abiotic and biotic stress throughout the year due to longer presence in the field under different agro-climatic conditions (Singh *et al.*, 2020). Amongst various abiotic stresses, drought is the most limiting environmental factor to crop productivity. Water stress causes significant damage to sugarcane production worldwide, because physiologically and compositionally water is the major constituent of cane. According to an estimate, nearly 65% area under sugarcane cultivation in India is directly affected by water stress or drought at one or other stage of crop growth and reduces 15–20% of cane production. Plant metabolic processes are mainly dependent on internal water relations involving water potential and water content of various tissues. The capacity of tolerance to stress by any crop mainly depends upon their morphological adaptations, physiological and biochemical adjustment. Drought is considered as the most deleterious abiotic stress, affecting plant vigour, yield, millable cane, quality and the sucrose content in sugarcane production (Qing *et al.*, 2001). Generally, the adverse effects of water stress diminish various physiological and biochemical mechanisms of the plant resulted in high mortality of tillers, reduced growth, cane yield and its contributing traits (Wiedenfeld, 2000). A variety of physiological processes altered due to drought stress, such as radiation capture, leaf temperature, stomatal conductance, transpiration, electron transport, photosynthesis and respiration which ultimately determine final cane yield (Qing *et al.*, 2001; Graca *et al.*, 2010; Inman-Bamber *et al.*, 2012). Morphological and physiological responses against stress in sugarcane plants varies according to the genotype, duration (rapid or gradual) and intensity (severe or mild) of stress and also nature of the tissue affected (Bartels and Sunkar, 2005; Smit and Singels, 2006; Graca *et al.*, 2010; Inman-Bamber *et al.*, 2012). Initially, the expansive growth of leaves and stalks is affected through reduction in cell turgor pressure thus restricting cell expansion (Koonjah *et al.*, 2006; Smit and Singels, 2006). Restricted water supply has detrimental effect on the velocity and the rate of sucrose translocation that aids in sugar accumulation in leaves. This causes increase of reducing sugar in leaves but decrease in the stalks which ultimately reduces the productivity of sugarcane up to 60% (Ramesh, 2000; Basnayake *et*

al., 2012). The susceptibility of sugarcane to water stress is greater in tillering and stem elongation phase (40–120 days after planting) with both stem and leaf growth are most affected than other organs. The knowledge of response of sugarcane varieties to water stress under field conditions is relatively limited (Hemaprabha *et al.*, 2006; Silva *et al.*, 2007; Sudhakar *et al.*, 2010). Most studies on water deficits in sugarcane have focused on irrigation management practices. Keeping these points the present investigation was conducted with objective to study morphological traits, yield attributes and identify drought tolerant suitable varieties for north western Indo-Gangetic Plains in response to variable irrigation regime.

MATERIALS AND METHODS

Experimental Site Characteristics

A field experiment was conducted at Chaudhary Charan Singh Haryana Agricultural University, Regional Research Station, Uchani, Karnal-132001, Haryana, India. The research farm is located at an altitude of 257 m above mean sea level and is intersected at longitude of 67° 58' North and latitude 29° 43' East.

Weather and Climate Details

Karnal has a semi-arid subtropical climate with a severe cold during winter and hot days often with desiccating winds of average intensity during summers. Average rainfall was 600 mm and 70–80% of it received from July to September (Fig.1). The crop received 1028 mm total rainfall during the crop season out of which 358 mm during pre-monsoon, 824.6 during monsoon (July 2020 to September 2020) and 45.2 mm during post monsoon (October 2020 to March 2021). Maximum rainfall of 440.6 mm and 384 was recorded during the month of July and August 2020. Monthly average maximum temperature of 25.3, 33.3, 36.7 and 35.9°C was recorded during March, April, May and June 2020 (Pre-monsoon period), respectively. Maximum monthly average temperature values ranges from 36.7°C (May 2020) to 16.7°C (January 2021) during crop season. Minimum monthly average temperature values ranges from 34.1°C (June 2020) to 7.0°C (December 2020) during the crop growth season. Total evaporation during the crop season was recorded as 1416.2 mm. The crop was harvested on March 18, 2021.

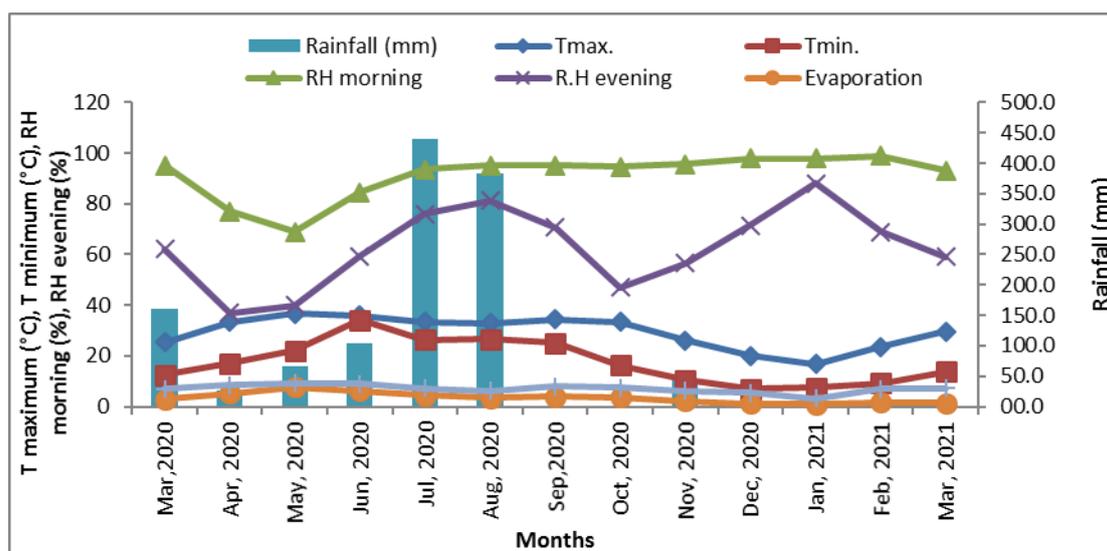


Fig 1: Mean monthly meteorological data of from March, 2020 to March, 2021 recorded at CSSRI, Karnal

Experimental Methodology

The soil of the experiment field was sandy loam in texture, alkaline in reaction (pH 8.6), normal in EC (0.36 dSm^{-1}), medium in organic carbon (0.42%) and nitrogen (124.44 kg/ha), medium in phosphorus (11.7 kg/ha) and high in potassium (171.6 kg/ha). The experiment was laid out in strip plot design with four replications to study the effect of water stress on six sugarcane varieties of different maturity group as early (Co 0118, Co 0238, CoH 160) and mid-late (CoH 167, CoH 119 and Co 05011) with three irrigation regimes (IW/CPE) 1.0 (normal), 0.6 (mild) and 0.3 (severe stress). Planting was done in spring season during last fortnight of March (date) by ridge (75 cm row to row spacing) irrigation method of planting and seed rate was 14 buds (7 Two budded setts) per running meter. Common irrigation was applied at 30 days after planting and the stress treatments were imposed only during pre-monsoon (in the month of April, May and June) period. Thereafter, irrigation was scheduled using a meteorological approach based upon IW/CPE ratio, where IW refers to irrigation water and CPE is the cumulative pan evaporation. CPE was calculated as the sum of daily evaporation from standard USWB Class A open pan, and irrigation was applied at attaining the pre-calculated value of CPE for a constant depth of irrigation water (80 mm). After complete germination (45 days after planting), drought stress was created only during pre-monsoon period (in the month of April, May and June) by withholding irrigation and later on, i.e., post-monsoon period (from July) crop was irrigated for stress revival as per the requirement. At pre monsoon period 6, 4 and 2 irrigations were applied under control, mild and drought treatment, respectively. The crop was irrigated as per requirement during monsoon and post monsoon season. Gross plot size was 51.22 m^2 ($6.83 \text{ m} \times 7.5 \text{ m}$) with 75 cm row to row spacing and crop planted on 23-03-2020 during spring season with two budded setts. Standard package of

practices recommended by CCS Haryana Agricultural University were followed to raise a healthy crop during crop season.

Data recording

Morphological parameters *viz.*, per cent germination was recorded at 30 and 45 days after planting, whereas, number of tillers were recorded at different time intervals. For tillers, five middle rows in all the replications of each treatment were counted at 50, 100 and 150 DAP and converted to thousand per hectare. In a running meter of row length, plants were harvested randomly at different growth stages *i.e.* 50, 100, 150 DAP and harvest with the help of sickle without disturbing the roots, and sun dried. Plant samples were oven dried at $70^\circ\text{C} \pm 5^\circ\text{C}$ for 72 hours till constant weight was attained. Thereafter, the final dry matter accumulation ($\text{g running meter}^{-1}$) was recorded.

Statistical analysis

Data were analyzed using strip plot design with four replications. Irrigation regimes and varieties were compared using critical difference (CD) at 5 per cent level of significance with using OPSTAT software.

RESULTS AND DISCUSSION

Germination and Growth parameters

Germination is one of the best indices for evaluating plant responses to environment stress. During this study, germination per cent did not differ significantly among different irrigation regimes at 30 and 45 days after planting (DAP) as common irrigation was applied after planting to achieve uniform crop stand. Among the different sugarcane varieties, significantly higher per cent germination was recorded in variety Co 0118 (51.1%) as compared to Co 0238 (46.8%), CoH 167 (45.6%) and Co 05011 (45.5%) at 30 DAP. However, at 45 DAP significantly higher per cent germination was recorded in varieties Co0118 (53.7%) as compared to

CoH 167(47.8%), but it was statistically at par with varieties Co 05011 (53.0%), CoH 160 (51.3%), CoH 119 (51.1%) and Co 0238 (50.7%) at 45 DAP (Table 1). This was primarily due to inherent genetic

potential of different varieties. The interaction effect of irrigation regimes and varieties was found non-significant for percent germination during the study.

Table 11 Effect of irrigation regimes and varieties on per cent germination at 30 and 45 DAP, number of tillers ($\times 1000 \text{ ha}^{-1}$), dry matter accumulation ($\text{g running meter}^{-1}$) in sugarcane

Treatments	Germination (%)		Number of tillers ($\times 1000 \text{ ha}^{-1}$)			Dry matter accumulation ($\text{g running meter}^{-1}$)		
	At 30 DAP	At 45 DAP	50 DAP	100 DAP	150 DAP	50 DAP	100 DAP	150 DAP
Irrigation regimes (IW/CPE)								
1.0	48.2	51.3	107.3	139.5	124.7	42.4	514.3	1460.8
0.6	47.7	51.1	100.0	131.7	117.8	39.4	448.6	1309.4
0.3	48.3	51.4	99.6	110.2	101.6	39.1	367.4	1100.5
CD (p=0.05)	NS	NS	5.3	7.6	4.4	2.4	34.3	76.5
Varieties								
Co 0118	51.1	53.7	108.1	124.3	109.6	42.1	367.1	1075.7
Co 0238	46.8	50.7	93.7	126.0	107.6	42.2	483.0	1484.4
CoH 160	49.0	51.3	108.4	141.2	128.1	37.3	322.4	1021.1
Co 05011	45.5	53.0	104.8	134.4	124.3	41.4	487.8	1420.9
CoH 119	50.5	51.1	103.3	113.2	102.1	38.4	508.7	1314.6
CoH 167	45.6	47.8	95.6	120.7	116.4	40.6	501.8	1424.5
CD (p=0.05)	3.7	3.4	9.7	8.7	7.2	2.9	9.9	65.3

The formation of tillers in sugarcane is most important attribute that directly contribute to sugarcane yield by acting as a sink (Ramesh and Mahadevaswamy, 2000). Among different irrigation regimes, maximum numbers of tillers (1000 ha^{-1}) were observed with 1.0 IW/CPE at 50, 100 and 150 DAP than 0.3 and 0.6. This might be due to the reduction in available soil moisture during critical water-demand period *i.e.* formative phase or early grand growth phase for irrigation regime 0.3 and 0.6 IW/CPE. Higher tiller production leads to higher number of stalks at harvest, irrespective of environmental conditions or cultivar (Joshi *et al.*, 1996). Among the different sugarcane varieties, maximum number of tillers was recorded with variety CoH 160 which was significantly higher than Co 0238 and CoH 167 at 50 DAP and statistically at par with Co 05011 at 100 and 150 DAP (Table 1). At 0.3 irrigation regime, maximum number of tillers were recorded in Co 05011 (120.3 and 113.2), while in CoH 160 (150.4, 131.3) at 0.6 IW/CPE at 100 and 150 DAP, respectively. It may be due to the inherent high tillering ability of CoH 160 during the initial growth stages. The similar results were also reported by Yadav and Prasad (1988) who found maximum reduction in tillering of variety CoJ 64, whereas least in Co 1148 under deficit irrigation in sandy loam soil.

The data pertaining to dry matter accumulation ($\text{g running meter}^{-1}$) given in Table 1 at 50, 100 and 150 DAP was significantly affected by the different irrigation regime and sugarcane varieties during the study. Dry matter accumulation was increased with the advancement of crop growth and reached its peak at harvest. Among the irrigation regimes, maximum dry matter was found with irrigation at 1.0 IW/CPE which was significantly higher as compared to irrigation at 0.3 and 0.6 IW/CPE at all the observation stages. This was due to the higher availability of soil moisture at critical growth stages with scheduling irrigation at 1.0 than 0.3 and 0.6 IW/CPE.

In a similar study, Ramesh (2000) also reported that moderate drought (irrigation at 80 % depletion of available soil moisture) and severe drought (withholding irrigation) during the formative, grand growth and maturity phases resulted in 15-46 and 26-61% reduction in cane dry matter accumulation as compared to control, however, magnitude of reduction varies with the nature of sugarcane cultivars. Among the varieties, dry matter was recorded highest in variety Co 0238 at different time intervals *i.e.* 50 DAP (42.2 g), 100 DAP (483.0g), 150 DAP (1484.4 g), which was found statistically at par with Co 0118, Co 05011, CoH 167 at 50 DAP and Co 05011 and CoH 167 at 150 DAP.

Table 2. Effect of irrigation regimes and varieties on cane yield, yield attributes and yield of sugarcane

Treatment	NMC (000' ha ⁻¹)	Single stalk weight (g)	Cane yield (t ha ⁻¹)
Irrigation regime (IW/CPE)			
1.0	110.9	990	107.3
0.6	102.9	943	94.1
0.3	89.6	834	73.9
CD (p=0.05)	5.6	26	6.0
Varieties			
Co 0118	76.3	878	77.6
Co 0238	95.7	1030	104.3
CoH 160	89.8	776	79.4
Co 05011	99.7	901	95.9
CoH 119	75.8	944	88.8
CoH 167	100.5	1006	104.5
CD (p=0.05)	5.8	33	5.7

In this study, the percent reduction in cane yield (t ha⁻¹) was higher at 0.3 IW/CPE (31.13 %) followed by 0.6 IW/CPE (12.30 %) in comparison to 1.0 IW/CPE (Table 2). Among the varieties, CoH 167 (104.5 t ha⁻¹) produced significantly higher cane yield among rest of the varieties but found statistically at par with Co 0238 (104.3 t ha⁻¹). At 0.3 irrigation regime, maximum cane yield was recorded in variety CoH 167 (90.5) followed by Co 0238 (88.1), while minimum in Co 0118 (59.3 t ha⁻¹) during the year of study. Similar results were also reported by Meena *et al.* (2013), Jongrunklang *et al.* (2008) and Songsri *et al.* (2009) who concluded that genotypes with better water use efficiency and water resulted in higher dry matter accumulation (source development) and cane yield (sink strength).

CONCLUSION

Based upon present investigation, it is concluded that varieties Co 0238 followed by CoH 167, Co 05011 are identified as relatively more tolerant at 0.3 IW/CPE and 0.6 IW/CPE than CoH 160, Co 0118 and CoH 119. These varieties maintained higher values of growth parameters i.e. tillers, dry matter accumulation that resulted in higher cane yield and yield attributes at harvest.

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