



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(8): 293-298
Received: 11-06-2026
Accepted: 15-07-2026

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Evaluation of promising sugarcane genotypes under differential irrigation regimes

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DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i8d.6244>

Abstract

The field experiment entitled “Evaluation of Sugarcane Varieties for Drought Tolerance” was conducted at Vasantdada Sugar Institute, Manjari, Pune during 2022-23 to 2024-25 to evaluate the performance of eight sugarcane genotypes under different irrigation regimes. The experiment was laid out in strip plot design with three replications comprising two irrigation levels (0.3 and 1.0 IW/CPE ratio) and eight genotypes. Irrigation at 1.0 IW/CPE ratio recorded higher growth, yield attributes, cane yield (134.59 t ha⁻¹) and CCS yield (21.15 t ha⁻¹). Among the genotypes, VSI 21121 recorded the highest cane yield (137.34 t ha⁻¹), whereas MS 10001 recorded higher CCS yield (20.97 t ha⁻¹). Co 11015 exhibited superior juice quality parameters. The study revealed significant genetic variation among sugarcane genotypes for yield performance and drought tolerance response under different moisture regimes.

Keywords: Sugarcane, drought tolerance, genotypes, irrigation regimes, growth performance, cane yield and CCS yield

Introduction

Sugarcane is one of the world's most important commercial crops, contributing significantly to sugar, ethanol, and bioenergy production. India is the world's second-largest producer of sugarcane after Brazil and plays a vital role in the global sugar industry. The states of Uttar Pradesh, Maharashtra, and Karnataka together contribute more than 80% of the country's total sugar production. Sugarcane is a C₄ crop, and drought is one of the major abiotic stresses limiting its productivity. Increasing water scarcity, climate change, and erratic rainfall have intensified drought stress in sugarcane-growing regions. Water deficit during critical growth stages adversely affects plant growth, photosynthesis, cane yield, and sucrose accumulation, resulting in significant yield losses.

Developing drought-tolerant sugarcane varieties is an effective strategy for sustaining productivity under water-limited conditions. Drought tolerance is governed by several morphological, physiological, and biochemical mechanisms, including efficient root development, osmotic adjustment, regulation of stomatal conductance, and improved water-use efficiency. Furthermore, the selection of suitable cultivars, together with appropriate crop management practices, plays a crucial role in reducing drought-induced yield losses. Therefore, the present study was undertaken to evaluate the performance of different sugarcane varieties under drought stress by assessing their growth, physiological, and yield attributes. The findings will aid in identifying drought-tolerant genotypes and support varietal improvement programmers for sustainable sugarcane production under water-limited environments.

Materials and Methods

The present investigation entitled “Evaluation of Promising Sugarcane Genotypes under Differential Irrigation Regimes” was carried out during 2022-23 to 2024-25 at the Research and Development Farm, Vasantdada Sugar Institute, Manjari (Bk.), Pune, Maharashtra, India. The experimental site is located at 18°31'34.32" N latitude and 73°58'28.56" E longitude, with an altitude of 190 m above mean sea level. The soil of the experimental field was classified as medium deep black soil having an alkaline reaction (pH 8.2), electrical conductivity of 0.32 dS

m⁻¹ and organic carbon content of 1.21 per cent. Initial soil analysis indicated that the soil contained available nitrogen (213.2 kg ha⁻¹), available phosphorus (61.7 kg ha⁻¹) and available potassium (538.7 kg ha⁻¹).

The field experiment was laid out in a strip plot design with three replications. The treatments consisted of two factors. Factor A consisted of two irrigation regimes, viz., I₁: Irrigation at an IW/CPE ratio of 0.3 and I₂: Irrigation at an IW/CPE ratio of 1.0 and Factor B comprised eight sugarcane genotypes, viz., V₁: MS 10001, V₂: CoM 09057, V₃: Co 11015, V₄: Co 09004, V₅: Co 12009, V₆: CoVSI 9805, V₇: CoVSI 16121 and V₈: VSI 21121.

The crop was planted at a wider row spacing of 135 cm following the recommended package of practices for Suru sugarcane. A recommended fertilizer dose of 250:115:115 NPK kg ha⁻¹ was applied. Nitrogen was applied in four equal splits, whereas phosphorus (P₂O₅) and potassium (K₂O) were applied in two equal splits, with 50 per cent at planting and the remaining 50 per cent at the final earthing-up. All the observations recorded during the course of investigation will be subjected to analysis of variance (ANOVA) appropriate for a strip plot design as per Fisher's method.

Results and Discussion

Effect of Irrigation regimes

The data pertaining to tiller count, number of millable canes, cane yield, CCS yield, growth and yield attributes, juice quality and physiological attributes as influenced by different irrigation levels are presented in Fig. 1-3 and Tables 1-5. The pooled data revealed that irrigation levels significantly influenced most of the growth, physiological and yield parameters, whereas juice quality parameters remained non-significant. Irrigation at 1.0 IW/CPE ratio (I₂) recorded significantly higher tiller count (104.87 and 85.29 thousand ha⁻¹) at 120 and 150 DAP, respectively, while the effect at 90 DAP was non-significant. Likewise, irrigation at 1.0 IW/CPE ratio produced significantly higher number of millable canes (74.14 thousand ha⁻¹), cane yield (134.59 t ha⁻¹) and CCS yield (21.15 t ha⁻¹) than irrigation at 0.3 IW/CPE ratio (I₁). The higher tiller population, millable cane number and yield under adequate irrigation may be attributed to improved soil moisture availability, enhanced nutrient uptake and photosynthetic activity. Similar findings were reported by Patil *et al.* (2023) [14] and Biradar *et al.* (2023) [2].

Growth and yield attributes were also significantly influenced by irrigation levels. Irrigation at 1.0 IW/CPE ratio recorded significantly higher number of internodes (25.42), internodal girth (10.76 cm), millable cane height (283.66 cm) and single cane weight (1.90 kg). These improvements may be attributed to better moisture availability, nutrient uptake and plant growth. Similar findings were reported by Patil *et al.* (2023) [14] and Mohan Naik *et al.* (2020) [12].

The pooled data indicated that irrigation levels did not significantly influence juice quality parameters, viz., brix, sucrose, purity and CCS per cent. The non-significant response may be due to the greater influence of varietal characteristics and crop maturity on juice quality than irrigation treatments. Similar observations were reported by Patil *et al.* (2023) [14].

Among the physiological attributes, irrigation at 1.0 IW/CPE ratio recorded significantly higher leaf area index (1.25 and 1.73 at 150 and 200 DAP, respectively) and root dry weight (27.89 g clump⁻¹ at 200 DAP). However, significantly higher dry matter

accumulation at harvest (1099.11 g clump⁻¹) was recorded under irrigation at 1.0 IW/CPE ratio.

Effect of genotypes

The pooled data presented in Fig 1 to 3 and Tables 1 to 5 revealed that sugarcane genotypes significantly influenced tiller count, number of millable canes, cane yield, CCS yield, growth and yield attributes, juice quality, leaf area index and root dry weight, whereas specific leaf weight and dry matter accumulation remained non-significant at most of the growth stages.

Among the genotypes, CoM 09057 recorded the highest tiller count at 90 DAP (71.17 thousand ha⁻¹), whereas VSI 21121 at 120 and 150 DAP (107.44 and 94.28 thousand ha⁻¹, respectively). The higher tiller production observed in these genotypes may be attributed to their superior genetic potential, early vigour, efficient utilization of available resources, and better adaptability to the prevailing environmental conditions. Similarly, VSI 21121 recorded the maximum number of millable canes (82.72 thousand ha⁻¹). The higher number of millable canes in this genotype could be due to improved tiller survival, reduced mortality of shoots during the grand growth phase, and its inherent genetic capacity to retain productive tillers until harvest. Since the number of millable canes is largely determined by tiller production and survival, the superior performance of VSI 21121 in these traits ultimately resulted in a higher millable cane population. Similar findings were reported by Vasantha *et al.* (2005) [17], Salim *et al.* (2021) [15], and Patil *et al.* (2023) [14].

Genotype VSI 21121 recorded the highest cane yield (137.34 t ha⁻¹), whereas MS 10001 recorded the highest CCS yield (20.97 t ha⁻¹). The superior yield performance may be due to higher millable cane population and better growth attributes. Similar results were reported by Vasantha *et al.* (2005) [17], Naidu and Venkataramana (1989) [13] and Patil *et al.* (2023) [14].

Among growth and yield attributes, CoVSI 9805 recorded maximum internodal girth (11.11 cm), Co 12009 recorded maximum cane height (303.05 cm), and MS 10001 recorded maximum single cane weight (1.98 kg). Juice quality parameters were significantly influenced by genotypes, wherein Co 11015 recorded the highest brix (24.35°), sucrose (23.10%) and CCS (17.17%). Similar genotypic variations were reported by Hoang *et al.* (2019) [11] and Vasantha *et al.* (2005) [17].

Physiological parameters also varied among genotypes. Co 12009 recorded higher leaf area index (0.23 and 1.79 at 50 and 200 DAP, respectively) and root dry weight (20.63 and 28.66 g clump⁻¹ at 150 and 200 DAP), whereas VSI 21121 recorded higher dry matter accumulation (35.52 g clump⁻¹) at 50 DAP. These variations may be attributed to differences in canopy development, root growth and genetic adaptability. Similar findings were reported by Salim *et al.* (2021) [15] and Patil *et al.* (2023) [14].

Interaction effect

The interaction effect between irrigation levels and genotypes was non-significant for growth and yield attributes as well as juice quality parameters. However, root dry weight at 200 DAP was significantly influenced by the interaction effect. Under 0.3 IW/CPE ratio, the genotypes VSI 21121 and Co 12009 recorded significantly higher root dry weight of 26.34 and 26.33 g clump⁻¹, respectively. Similarly, under 1.0 IW/CPE ratio, same genotypes performed better.

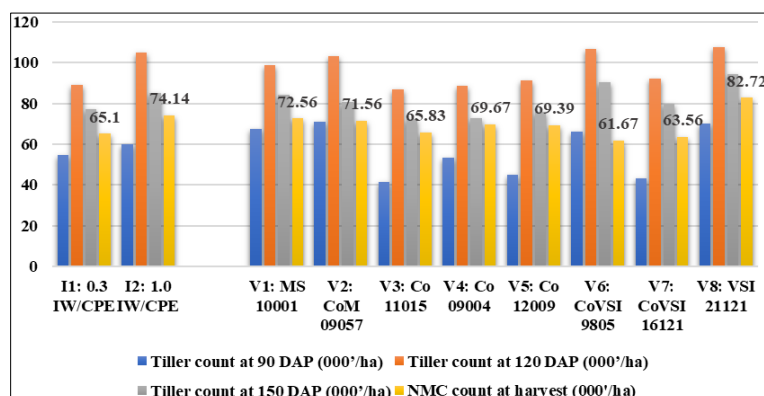


Fig 1: Sugarcane population, as influenced by different irrigation levels and genotypes

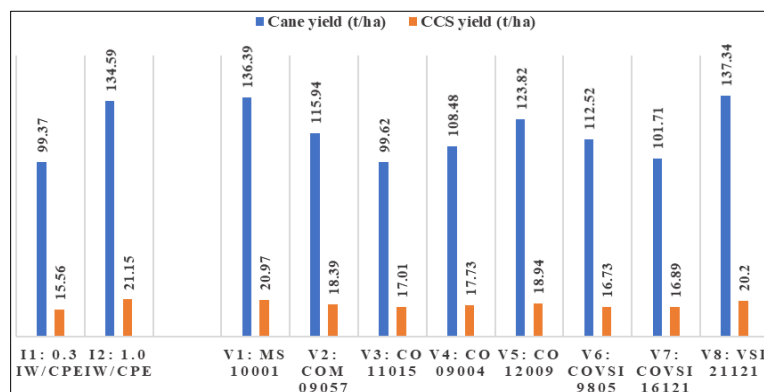


Fig 2: Cane and CCS yield as influenced by different irrigation levels and genotypes

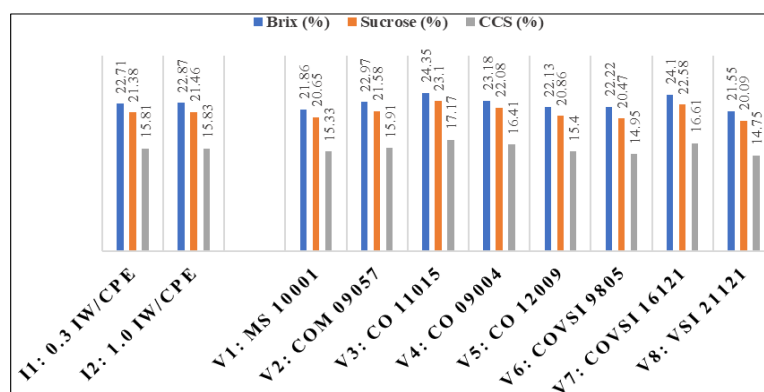


Fig 3: Quality parameters as influenced by different irrigation levels and genotypes

Table 1: Growth & yield attributes as influenced by different irrigation levels and genotypes (Pooled 2022-23 to 2024-25)

Treatment details	No. of Internodes	Internode girth (cm)	Total cane height (cm)	Cane wt. (kg)
Irrigation levels				
I ₁ : 0.3 IW/CPE	23.43	10.27	248.19	1.55
I ₂ : 1.0 IW/CPE	25.42	10.76	283.66	1.90
Sem±	0.24	0.33	3.97	0.04
C.D. @ 5%	0.86	NS	13.75	0.16
Genotypes				
V ₁ : MS 10001	25.98	10.83	276.31	1.98
V ₂ : CoM 09057	24.18	10.86	267.69	1.85
V ₃ : Co 11015	24.33	9.92	245.70	1.46
V ₄ : Co 09004	24.67	10.25	272.19	1.51
V ₅ : Co 12009	24.68	10.06	303.05	1.82
V ₆ : CoVSI 9805	23.40	11.11	243.77	1.83
V ₇ : CoVSI 16121	23.52	10.15	252.66	1.60
V ₈ : VSI 21121	24.65	10.93	266.03	1.75
S.E.m±	0.64	0.14	6.05	0.05
C.D. @ 5%	NS	0.40	17.27	0.16
Interaction I×V				
Sem±	0.44	0.17	9.30	0.06
C.D. @ 5%	NS	NS	NS	NS

Table 2: Leaf Area Index as influenced by different irrigation levels and genotypes (Pooled 2022-23 to 2024-25)

Treatment details	Leaf Area Index			
	50 DAP	100 DAP	150 DAP	200 DAP
Irrigation levels				
I ₁ : 0.3 IW/CPE	0.20	0.54	1.10	1.59
I ₂ : 1.0 IW/CPE	0.19	0.61	1.25	1.73
Sem±	0.005	0.02	0.015	0.009
C.D. @ 5%	NS	NS	0.054	0.031
Genotypes				
V ₁ : MS 10001	0.18	0.53	1.19	1.68
V ₂ : CoM 09057	0.21	0.63	1.28	1.79
V ₃ : Co 11015	0.13	0.56	1.17	1.50
V ₄ : Co 09004	0.22	0.64	1.17	1.72
V ₅ : Co 12009	0.23	0.64	1.23	1.79
V ₆ : CoVSI 9805	0.23	0.53	1.15	1.74
V ₇ : CoVSI 16121	0.14	0.54	1.12	1.49
V ₈ : VSI 21121	0.22	0.57	1.09	1.58
Sem±	0.022	0.03	0.047	0.06
C.D. @ 5%	0.06	NS	NS	0.19
Interaction I×V				
Sem±	0.01	0.02	0.05	0.06
C.D. @ 5%	NS	NS	NS	NS

Table 3: Specific Leaf Weight as influenced by different irrigation levels and genotypes (Pooled 2022-23 to 2024-25)

Treatment details	Sp. Leaf Wt. at (g/cm ²)			
	50 DAP	100 DAP	150 DAP	200 DAP
Irrigation levels				
I ₁ : 0.3 IW/CPE	3.14	3.88	4.05	4.66
I ₂ : 1.0 IW/CPE	2.98	4.10	4.45	5.32
Sem±	0.10	0.08	0.15	0.05
C.D. @ 5%	NS	NS	NS	0.19
Genotypes				
V ₁ : MS 10001	2.70	3.44	3.86	4.61
V ₂ : CoM 09057	3.29	4.22	4.30	5.28
V ₃ : Co 11015	2.53	3.87	4.01	4.69
V ₄ : Co 09004	3.39	4.63	4.73	5.53
V ₅ : Co 12009	3.43	4.86	4.12	5.15
V ₆ : CoVSI 9805	3.21	3.52	4.61	5.36
V ₇ : CoVSI 16121	2.85	4.00	4.38	4.66
V ₈ : VSI 21121	3.11	3.37	4.00	4.62
Sem±	0.26	0.49	0.21	0.28
C.D. @ 5%	NS	NS	NS	NS
Interaction I×V				
Sem±	0.31	0.27	0.11	0.19
C.D. @ 5%	NS	NS	NS	NS

Table 4: Dry matter accumulation as influenced by different irrigation levels and genotypes (Pooled 2022-23 to 2024-25)

Treatment details	Dry matter accumulation (g/clump)				
	50 DAP	100 DAP	150 DAP	200 DAP	At Harvest
Irrigation levels					
I ₁ : 0.3 IW/CPE	31.58	128.46	495.81	733.67	935.66
I ₂ : 1.0 IW/CPE	31.14	148.32	564.22	839.43	1099.11
Sem±	0.25	5.53	23.08	23.61	10.07
C.D. @ 5%	NS	NS	NS	NS	34.85
Genotypes					
V ₁ : MS 10001	33.31	140.16	540.84	791.73	1056.45
V ₂ : CoM 09057	33.87	143.76	595.04	884.33	1150.01
V ₃ : Co 11015	29.92	123.83	515.28	711.78	972.45
V ₄ : Co 09004	31.06	156.01	521.86	795.00	1020.25
V ₅ : Co 12009	29.88	146.27	670.75	1002.98	1170.87
V ₆ : CoVSI 9805	29.23	127.70	499.58	710.27	924.81
V ₇ : CoVSI 16121	31.06	124.17	432.83	672.38	896.63
V ₈ : VSI 21121	32.52	145.24	463.95	723.93	947.61
Sem±	0.94	8.16	57.14	74.96	66.58
C.D. @ 5%	2.87	NS	NS	NS	NS
Interaction I×V					
Sem±	1.68	10.79	57.92	66.62	76.71
C.D. @ 5%	NS	NS	NS	NS	NS

Table 5: Root dry wt. as influenced by different irrigation levels and genotypes (Pooled 2022-23 to 2024-25)

Treatment details	Root dry wt. (g/clump)			
	50 DAP	100 DAP	150 DAP	200 DAP
Irrigation levels				
I ₁ : 0.3 IW/CPE	2.73	6.90	14.47	23.88
I ₂ : 1.0 IW/CPE	3.08	8.04	18.62	27.89
Sem±	0.18	0.25	1.29	0.26
C.D. @ 5%	NS	NS	NS	0.91
Genotypes				
V ₁ : MS 10001	2.64	7.56	13.58	26.90
V ₂ : CoM 09057	3.40	7.63	15.52	27.09
V ₃ : Co 11015	2.40	6.29	14.74	22.52
V ₄ : Co 09004	2.69	8.02	18.54	25.87
V ₅ : Co 12009	2.80	7.93	20.63	28.66
V ₆ : CoVSI 9805	3.37	7.12	18.65	24.05
V ₇ : CoVSI 16121	2.75	6.13	14.07	23.57
V ₈ : VSI 21121	3.19	9.12	16.65	28.45
Sem±	0.27	0.76	0.18	0.41
C.D. @ 5%	NS	NS	0.53	1.17
Interaction I×V				
Sem±	0.19	0.35	0.69	0.88
C.D. @ 5%	NS	NS	NS	2.51

Table 5.1: Interaction effect of different irrigation levels and genotypes on root dry matter at 200 DAP (g/clump)

Treatment	I ₁ : 0.3 IW/CPE	I ₂ : 1.0 IW/CPE
V ₁ : MS 10001	24.50	29.31
V ₂ : CoM 09057	24.04	30.15
V ₃ : Co 11015	21.04	24.00
V ₄ : Co 09004	21.63	30.11
V ₅ : Co 12009	26.33	30.98
V ₆ : CoVSI 9805	23.15	24.95
V ₇ : CoVSI 16121	23.09	24.05
V ₈ : VSI 21121	26.34	30.57
Sem±	0.88	
C.D. at 5%	2.51	

Conclusion

Based on the pooled data of the present investigation, it can be concluded that irrigation scheduled at an IW/CPE ratio of 1.0 was the most effective, resulting in the highest cane yield (134.59 t ha⁻¹) and CCS yield (21.15 t ha⁻¹). Among the evaluated genotypes, VSI 12121 recorded the highest cane yield (137.34 t ha⁻¹), while, MS 10001 produced the highest CCS yield (20.97 t ha⁻¹). With respect to juice quality, Co 11015 exhibited superior performance. Furthermore, improved physiological traits were observed in the genotypes MS 10001, CoM 09057, Co 12009, Co 09004, and VSI 21121, indicating their potential for enhanced growth and productivity. Overall, irrigation at an IW/CPE ratio of 1.0, coupled with the selection of suitable genotypes, can significantly improve sugarcane productivity, juice quality, and physiological performance under the conditions of the present study.

Acknowledgement

We are thankful to Mr. Sambhaji Kadupatil, Director General, Vasantdada Sugar Institute, Pune for his encouragement during this research work and giving permission to publish this article. Authors are also thankful to scientists and supporting staff of crop production division for their help during the field experimentation.

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