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Screening of the Early Maturing Sugarcane Clones for high Cane Yield & Brix content in First Clonal Generation

Dipannita Guchhait and Balwant Kumar*

Genetics and Plant Breeding, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur 848125

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ABSTRACT

During 2023-24 at Research Farm, RPCAU, Pusa, Samastipur, Bihar sixty clones from six different bi-parental crosses along with three checks were planted in Augmented Design to study variability among the clones for productive traits viz germination percentage at 45 days after planting, number of tillers at 120 days after planting, Stalk height at harvest, cane diameter at harvest, single cane weight at harvest, number of millable canes at harvest, brix value in October, November and December and cane yield. The analysis of variance indicated a significant difference among the entries for all parameters in the first clonal generation. The bi-parental cross, Co 58189 × CoSe 01434 showed maximum variation for the five character viz, number of tillers at 120 DAP, number of millable canes, brix value at middle of Oct., Nov., Dec. & stalk height followed by BO 91× Co 62198, evidenced maximum variation in cane diameter and single cane weight and the cross BO91× Co775 exhibited the highest degree of variance in cane yield. Ten clones, namely CoX 23091, CoX 23094, CoX 23099, CoX 23100, CoX 23123, CoX 23112, CoX 23125, CoX 23126, CoX 23233 and CoX 23234 were effectively selected from the first clonal generation bearing high brix coupled with high cane yield and they can be utilised for further varietal development programme.

Keywords: Bi-parental crosses, Early maturing clones, Augmented design, Variability, Brix, Cane yield, Selection.

INTRODUCTION

“Sugarcane is sweetest at its joint,” a well-known African proverb, signifies that the most rewarding outcomes often arise after overcoming challenges. This analogy aptly reflects the significance of sugarcane as a globally important crop. Sugarcane is cultivated extensively for sugar, ethanol, and several value-added by-products, contributing substantially to the agricultural economies of countries such as Brazil and India. Beyond its economic value, sugarcane cultivation contributes to sustainable agricultural systems by improving soil moisture conservation and acting as a windbreak for companion crops. Sugarcane is one of the most important cash crops, and its breeding programme generally begins with hybridization followed by clonal selection across successive generations. Bi-parental crosses play a crucial role in sugarcane improvement by enabling the accumulation of desirable traits such as high brix content and enhanced cane yield in progenies. In the present agricultural scenario, there is an increasing demand for early maturing sugarcane varieties. Early maturing genotypes complete their growth cycle within eight to ten months, allowing earlier harvest and faster economic returns to farmers. This shorter crop duration also facilitates flexible crop planning and the possibility of multiple cropping within a year. Keeping these objectives in view, screening early maturing sugarcane clones for high cane yield and superior brix content is essential for effective selection and acceleration of the varietal improvement programme.

MATERIALS AND METHODS

The experimental material comprised sixty clones derived from six different bi-parental crosses along with three standard checks: CoP 16437, CoP 09437, and CoP 18437 listed in Table 2 The experiment was conducted during 2023–24 at the Chawania plot of Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar. All sixty clones were planted in six blocks following an Augmented Block Design as proposed by William Federer (1956). Each block consisted of ten test clones and three replicated checks. The row-to-row spacing was maintained at 90 cm with a row length of 3 m. Observations were recorded on ten quantitative traits namely ,Germination percentage at 45 days after planting (DAP), Number of tillers at 120 DAP (000/ha), Number of millable canes (000/ha) at harvest, Brix percentage in mid-October. Brix percentage in mid-November. Brix percentage in mid-December. Stalk height at harvest (cm). Cane diameter at harvest (cm). Single cane weight at harvest (kg) and Cane yield (t/ha). Statistical analysis was performed using analysis of variance (ANOVA) based on mean values of each clone across blocks. Descriptive statistical parameters were used for selection based on high-resolution (HR) brix and yield-contributing traits., Selection Criteria for screening for early maturing clones was carried out based on following traits;

- High HR brix in mid-October
- High cane yield (t/ha)
- Non-flowering habit
- Non-lodging nature and
- Low pest infestation

Separate rankings were computed for HR brix and cane yield, and a pooled ranking was derived for final selection listed in table 3.

RESULT AND DISCUSSION

Genetic variability is of paramount importance to plant breeders as it facilitates effective selection. Augmented Designs (specifically Randomized Complete Block Designs with check varieties) for evaluating new sugarcane clones, finding it efficient for comparing many untested varieties against a few standard checks, helping streamline selection in breeding programs by reducing experimental units needed (Shanmugasundaram et. al.1980) here the variability across several genotypes for distinct quantitative characteristics was examined in the early clonal generation. The analysis of variance revealed significant differences among clones (Table 1) it indicted there were wide range of variations among the clones of six different bi-parental crosses for most of the traits. The results of Table 2 indicated a continuous trend of considerable variation for all characters in the early clonal generation across all entries. Among the six different bi-parental crosses the Co 58189 × CoSe 01434 showed maximum variation for the four characters viz. number of tillers at 120 DAP, number of millable canes, brix value at mid October, November and December and stalk height. Whereas, in case of cane diameter and single cane weight maximum variation observed among the clones derived from the cross of BO 91× Co 62198. But for the cane yield, maximum degree of variation showed by the cross BO91× Co775. A substantial degree of variance in germination at 45 days after planting was seen in the early clonal generation. A comparable variation germination % was noted by Bora *et al.* (2014), Gowda *et al.* (2016), Patil *et al.* (2017), Negi *et al*. (2018), Prasanth *et al*. (2019) and Kumar *et al.* (2021). A significant variance was seen among the clones regarding the number of tillers at 120 days post-planting. The occurrence of heterogeneity in the number of tillers has also been documented by Puneet *et al*. (2002), Singh *et al.* (2010), Bora *et al.* (2014), Negi *et al.* (2018), and Kumar *et al.* (2021). Significant heterogeneity exists among the clones regarding the number of millable canes in the early clonal generation. Likewise, Singh *et al.* (2010), Ahmed *et al*. (2012), Bora *et al.* (2014), Patil *et al.* (2017), Negi *et al.* (2018), and Kumar *et al*. (2021) all noted variations in the quantity of millable canes. There was a considerable variance among the clones regarding stalk height during harvest. A comparable variety in stalk height was also noted by Singh *et al.* (2010), Ahmed *et al.* (2012), Bora *et al.* (2014), Patil *et al.* (2017), Ranjan *et al.* (2017). There was a notable degree of diversity among the clones regarding cane diameter at harvest. A similar outcome was also noted by Ali *et al*. (2021) and Patil *et al*. (2017). A significant degree of variance was noted among the early generation clones regarding single cane weight at harvest. Likewise,

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fluctuation in single cane weight was noted by Singh *et al.* (2010), Ahmad *et al*. (2012),Ijaz *et al*. (2013),Bora (2014), Hiremath and Nagaraja (2016), Patil *et al*. (2017), and Negi *et al*. (2018) Singh *et al*. (2024).here was a notable degree of diversity across the clones forBrix value in October, November, December. Likewise, heterogeneity in quality parameters, such as brix value, was also observed by Puneet *et al.* (2002), Negi *et al. (*2018), Singh *et al.* (2020). There was a substantial degree of diversity among the clones regarding cane yield. This was also noted by Puneet *et al*. (2002),Singh *et al.* (2010), Tyagi *et al*. (2011), Khan *et al.* (2012),Ijaz *et al*. (2013)**,** Bora*et al*. (2014), Hiremath and Nagaraja (2016), and Kumar *et al*. (2021),Prashant *et al.* (2021). It indicates adequate variety and the potential for additional selection, hence enabling the production of superior clones and desired genotypes. The variations were attributable to genetic differences across clones, and all these traits can undergo substantial enhancement through selection. The cane yield of sugarcane is deemed a crucial characteristic for farmer's while the more brix percentage is regarded as significant from an industrial perspective. Several outstanding clones were preliminarily selected from the sixty clones based on elevated cane yield, high brix content, and other readily apparent morphological characteristics such as non-flowering and non-lodging. The flowering of sugarcane is harmful to commercial agriculture; therefore, this study solely focuses on non-flowering sugarcane clones. By computing these two distinct rankings together, a consolidated ranking was derived. On the basis of this pooled ranking, the top ten performing clones were selected among them. They were all non-lodging and non-flowering in nature. Ten selected clones were derived from four distinct bi-parental crosses out of a total of six different bi-parental crosses**.**

Therefore, the combination of both traits is regarded as a significant criterion for crop improvement programs. For the early maturing purpose 10 better clones were screen out. The CoX 23234 had the highest brix percentage in middle October followed by CoX 23112, CoX 23100, CoX 23233, CoX 23091, CoX 23094, CoX 23099, CoX 23126,CoX 23125 and CoX 23123. The clone CoX 23094 exhibited the highest cane production, succeeded by CoX 23099, CoX 23100, CoX 23091,CoX 23234,CoX 23233, CoX 23125,CoX 23126, CoX 23123 and CoX 231112.To expedite the selection cycle for the varietal improvement program of early maturing sugarcane, brix percentage and cane yield are regarded as essential parameters for effective selection. Four clones namely CoX 23091, CoX 23094, CoX 23099, CoX 23100 selected from the cross BO91× Co775, other four namely CoX 23123, CoX 23125, CoX 23126, CoX 23233 from the cross Co 58189 × CoSe 01434 while rest of the two CoX 23112 and CoX 23234 selected from the cross BO91× Co62198 and CoLk 8102 × BO 91 respectively. Ten clones viz.CoX 23091, CoX 23094, CoX 23099, CoX 23100,CoX 23123,CoX 23112 and CoX 23234, CoX 23125, CoX23126, CoX 23233 selected from first clonal generation according to the pooled ranking estimated from computing two separate ranking based on both high cane yield and high brix value respectively. In all the clones, cane was non flowering, non-lodging and low infestation of pest. Therefore, it is important to note that all of these selected clones will prove to be beneficial in the ongoing breeding program for the development of the variety.

Table- 1. Analysis of variance for ten quantitative characters of 60 sugarcane clones in six blocks with 3 checks.

Sl. No.	Degree of freedom	MSS			
		Block	Checks	Entries	Error
		5	2	59	10

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	Characters /Parameters				
1.	Germination at 45DAP(%)	2.14	0.68	4.57**	2.77
2.	Tiller at 120 DAP (000/ha)	88.74	55.53	57.89*	30.18
3.	NMC at harvest	6868.13	950.50	2966.79**	163.50
4.	Brix % in middle Oct.	0.043	0.13	0.015**	0.017
5.	Brix % in middle Nov.	0.02	0.16	0.03*	0.01
6.	Brix % in middle Dec.	131.65	913.30	102.56*	0.60
7.	Stalk height(cm) at harvest	6.00	1.56	8.45**	0.44
8.	Cane diameter (cm) at harvest	5.13	2.18	7.18**	0.52
9.	Single cane weight (kg.) at harvest	5.14	2.30	7.21**	0.60
10.	Crop Yield (t/ha)	62.20	3.70	40.90**	25.45

Abbreviations: * = Significant at P ≤ 0.05; ** = Significant at P ≤ 0.01

Table- 2. Performance of 60 clones of bi-parental crosses for ten quantitative traits along with replicated checks in six blocks

Sl.No.	Clones	Germi-nation % 45DAP	Tiller 120 DAP(000/ha	NMCat harvest	Brix during Month (%)			Stalk height (cm)	Cane diameter (cm)	Single cane weight (kg)	Crop Yield (t/ha)
					Oct.	Nov.	Dec.				
1.	CoX 23089	37.14	96.27	66.21	12.27	13.63	14.37	236	1.46	1.30	96.27
2.	CoX 23090	39.24	82.18	80.34	11.47	12.43	13.37	273	1.92	1.26	96.84
3.	CoX 23091	39.03	96.42	90.85	19.37	20.23	21.57	290	2.30	1.11	97.30
4.	CoX 23092	36.36	88.27	85.39	12.27	16.23	17.67	247	2.49	0.85	79.70
5.	CoX 23093	34.58	97.87	86.70	12.26	15.23	16.77	250	1.71	0.71	68.90
6.	CoX 23094	39.63	91.09	80.67	18.47	20.23	20.37	288	2.43	1.31	102.15
7.	CoX 23095	33.15	79.49	74.14	17.27	19.43	20.17	255	1.65	1.15	79.88

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8.	**CoX 23096**	36.56	92.08	89.12	15.27	15.63	16.37	213	2.10	0.81	87.57
9.	**CoX 23097**	34.01	84.44	77.03	13.27	16.23	17.27	206	2.29	1.04	81.39
10.	**CoX 23098**	37.53	96.98	67.24	17.27	18.73	19.37	243	1.45	1.31	87.41
11.	**CoX 23099**	37.35	92.33	88.07	17.91	18.59	19.97	255	1.73	1.15	101.01
12.	**CoX 23100**	35.17	86.87	99.66	19.91	20.39	21.77	261	1.93	1.13	98.52
	Crosses Mean	**36.65**	**90.36**	**82.12**	**15.58**	**17.25**	**18.25**	**251.42**	**1.96**	**1.09**	**89.75**
13.	**CoX 23104**	33.50	97.21	80.89	13.91	14.99	15.57	127	2.13	1.10	90.96
14.	**CoX 23105**	37.13	96.40	89.43	14.91	14.79	15.57	156	1.83	0.87	91.22
15.	**CoX 23106**	36.28	97.43	83.57	13.91	14.59	16.67	206	2.23	0.54	82.31
16.	**CoX 23107**	33.06	84.35	80.78	14.91	16.39	18.17	185	2.73	1.06	86.69
17.	**CoX 23108**	38.06	83.25	70.16	10.91	14.89	16.57	283	2.13	1.21	85.52
18.	**CoX 23109**	35.95	89.55	67.33	10.31	11.39	13.57	212	1.63	1.28	87.61
19.	**CoX 23110**	37.44	87.22	70.85	12.91	15.79	17.57	257	2.13	1.23	86.65
20.	**CoX 23111**	36.44	91.69	60.76	15.11	16.39	18.57	257	1.63	1.38	80.62
21.	**CoX 23112**	**37.94**	95.49	76.59	20.01	21.53	22.23	191	2.05	1.06	79.33
22.	**CoX 23113**	33.82	84.90	74.80	16.81	17.23	17.83	**287**	2.85	1.11	82.21
	Crosses Mean	**35.96**	**90.75**	**75.52**	**14.37**	**15.80**	**17.23**	**216.1**	**2.13**	**1.08**	**85.31**
23.	**CoX 23114**	34.69	94.47	83.32	15.81	17.23	17.83	225	2.95	1.06	86.04
24.	**CoX 23115**	32.34	89.47	71.59	13.81	15.63	16.23	167	1.85	1.34	89.06
25.	**CoX 23116**	31.41	72.49	76.64	15.01	15.73	15.83	195	2.05	1.03	78.10
26.	**CoX 23117**	33.56	79.03	73.68	11.81	12.63	12.83	164	2.55	0.93	80.33
27.	**CoX 23118**	31.27	82.67	68.51	13.81	14.23	14.83	211	2.15	1.23	79.77

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28.	**CoX 23119**	33.47	86.17	81.73	17.81	16.03	16.63	189	2.35	1.01	81.34
29.	**CoX 23120**	33.03	87.81	72.49	11.81	12.53	12.63	197	2.95	0.87	82.75
30.	**CoX 23121**	33.49	81.80	64.66	13.81	15.93	16.60	82	3.15	1.31	79.92
31.	**CoX 23122**	31.97	99.76	84.66	14.44	14.66	15.00	181	2.58	0.92	90.01
32.	**CoX 23123**	33.55	90.41	88.47	14.04	15.16	16.00	276	2.48	0.89	82.53
33.	**CoX 23124**	32.67	100.25	91.53	20.04	19.96	20.40	94	2.78	0.90	84.68
34.	**CoX 23125**	32.99	98.75	89.56	15.04	15.96	16.40	128	2.38	0.84	85.46
35.	**CoX 23126**	33.76	100.47	93.37	16.04	17.86	20.64	126	2.28	0.87	83.48
36.	**CoX 23127**	31.26	96.51	95.35	19.04	19.46	20.00	210	2.08	0.88	85.40
37.	**CoX 23128**	34.90	97.51	74.23	16.04	18.76	20.00	113	2.48	1.22	85.48
	Crosses Mean	**32.86**	**87.67**	**77.94**	**14.75**	**15.43**	**15.89**	**180.10**	**2.53**	**1.05**	**83.14**
38.	**CoX 23080**	32.73	99.29	94.93	13.04	15.96	17.00	95	2.28	0.81	79.53
39.	**CoX 23081**	31.94	100.72	93.57	15.04	16.96	17.40	112	2.38	0.74	79.03
40.	**CoX 23082**	32.70	96.34	88.30	17.04	18.96	19.80	207	2.18	0.83	82.49
41.	**CoX 23083**	34.61	84.16	94.69	11.64	15.89	16.63	179	1.85	0.90	87.26
42.	**CoX 23084**	33.53	83.06	74.15	10.64	12.89	14.83	232	1.35	1.11	86.15
43.	**CoX 23085**	31.70	89.94	72.43	15.44	18.09	18.83	85	1.75	1.11	81.87
44.	**CoX 23086**	32.65	91.20	69.22	14.24	15.89	17.33	227	1.45	1.23	85.07
45.	**CoX 23087**	31.74	95.47	78.53	16.04	17.89	18.43	288	1.95	1.17	87.90
	Crosses Mean	**32.70**	**92.52**	**83.23**	**14.14**	**16.57**	**17.53**	**178.13**	**1.90**	**0.99**	**83.65**
46.	**CoX 23234**	38.02	104.58	96.85	20.34	21.79	23.20	258	2.02	0.93	97.19
47.	**CoX 23235**	34.07	98.18	97.70	18.34	20.49	20.60	209	2.32	0.78	82.36
48.	**CoX**	33.20	94.75	85.	18.94	20.49	20.	227	1.92	0.86	87.0

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	23236			51			40				3
49	**CoX 23237**	32.15	95.53	87.20	19.64	20.49	20.80	261	2.12	0.81	82.92
50.	**CoX 23238**	29.69	89.89	84.44	13.94	14.49	14.80	258	2.02	1.16	95.93
51.	**CoX 23239**	33.54	84.21	75.58	15.14	16.49	17.10	288	2.02	1.30	94.90
	Crosses Mean	**33.45**	**94.52**	**87.88**	**17.72**	**19.04**	**19.48**	**250.17**	**2.07**	**0.97**	**90.06**
52.	**CoX 23223**	36.92	104.58	101.18	19.64	20.89	21.83	211	2.35	0.97	97.10
53.	**CoX 23224**	36.99	97.51	89.61	18.74	20.69	20.73	263	1.65	0.99	89.84
54.	**CoX 23225**	31.73	99.16	95.19	19.64	19.89	21.53	178	1.95	1.01	96.16
55.	**CoX 23226**	37.51	96.83	89.85	20.64	21.89	21.83	255	2.45	0.92	90.54
56.	**CoX 23227**	30.71	93.64	87.15	10.44	11.39	12.13	230	1.75	0.95	85.09
57.	**CoX 23230**	29.99	77.48	70.78	13.74	15.49	16.10	306	2.52	1.16	81.89
58.	**CoX 23231**	29.49	99.08	73.18	14.34	15.49	15.60	231	2.22	0.78	84.10
59	**CoX 23232**	32.22	93.48	88.18	17.54	18.49	19.40	258	2.32	0.85	83.90
60.	**CoX 23233**	35.77	101.18	93.40	19.84	21.39	22.00	248	1.62	0.92	90.61
	Crosses Mean	**33.48**	**95.88**	**87.61**	**17.17**	**18.40**	**19.02**	**242.22**	**2.09**	**0.95**	**88.80**
Check 1	**CoP16437(C_1)**	38.26	96.72	86.51	20.08	20.57	21.28	290.67	1.99	1.31	**94.73**
Check 2	**CoP09437(C_2)**	37.01	95.44	76.93	19.12	19.78	20.05	288.17	1.80	1.00	93.91
Check 3	**CoP18437(C_3)**	37.67	93.64	74.06	19.32	19.83	20.57	289.67	2.08	1.24	93.16
	Check Mean	**37.34**	**95.27**	**79.17**	**19.51**	**20.06**	**20.63**	**289.50**	**1.96**	**1.18**	**93.93**
	Gen Mean	**34.40**	**89.52**	**84.69**	**15.55**	**16.99**	**17.83**	**217.94**	**2.14**	**1.03**	**86.35**
	Max.	39.63	104.58	101.18	20.64	21.89	23.20	306	3.15	1.38	102.15
	Min.	29.49	72.49	60.	10.31	11.39	12.	82	1.35	0.54	68.9

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				76			13				0
	CD(P=0.05)	3.62	16.51	15.27	1.84	1.78	2.16	35.53	0.14	0.26	14.02

Represent the Crosses in bracket the clones from serial no 1 to 12 (**BO 91× Co 775**), serial no 13 to 22 (**BO 91× Co62198**), serial no 23 to 37 (**BO155 × Co775**),

serial no 38 to 45 (**Co 0238 × Co 775)** serial no 46 to 51 **(CoLk 8102 × BO 91) and** serial no 52 to 60 **(Co 58189 × CoSe 01434) while C_1 ,C_2 and C_3 are Checks**

Table.3. Selection of early maturity clones from 24 best clones for cane yield and HR brix along with Plant behaviour and pest infestation

Clones	**HR Brix reading**		**Cane Yield**		**Pooled Ranking**	**Plant Behaviour**		
	Oct.	**Ranking**	t/ha	**Ranking**		**Flowering**	**Lodging**	**Pest infestation**
CoX 23091	19.37	**6**	97.3	4	3	NF	NL	**NI**
CoX 23094	18.47	11	102.15	1	5	NF	NL	**NI**
CoX 23095	17.27	18	79.88	22	21	F	NL	**LI**
CoX 23098	18.73	12	82.21	19	10	NF	L	**MI**
CoX 23099	17.91	14	101.01	2	6	NF	NL	**NI**
CoX 23100	19.91	**3**	98.52	3	2	NF	NL	**NI**
CoX 23111	15.11	23	80.62	21	22	F	NL	**LI**
CoX 23112	20.01	**2**	87.91	10	7	NF	NL	**NI**
CoX 23113	16.81	19	79.33	23	17	F	NL	**LI**
CoX 23116	15.01	24	78.1	24	24	F	L	**LI**
CoX 23123	19.64	**5**	97.1	6	4	NF	NL	**NI**
.CoX 23125	18.94	**7**	87.03	12	9	NF	NL	**NI**
CoX 23126	18.74	**8**	89.84	9	8	NF	NL	**NI**
CoX 23128	16.64	19	85.48	13	13	F	NL	**LI**
CoX 23082	17.04	17	82.49	16	15	NF	L	**MI**
CoX 23087	16.04	22	87.9	11	14	NF	L	**MI**
CoX 23223	17.81	15	81.34	20	16	F	NL	**LI**
CoX 23224	16.24	21	83.48	18	20	F	NL	**LI**
CoX 23225	15.04	23	85.46	14	18	NF	NL	**LI**
CoX 23232	17.54	16	83.9	15	12	F	L	**MI**
.CoX 23233	19.84	**4**	90.61	8	6	NF	NL	**NI**
CoX 23234	20.34	**1**	97.19	5	1	NF	NL	**NI**
CoX 23235	18.34	**13**	82.36	17	11	F	L	**MI**
CoX 23236	15.04	24	85.46	14	23	NF	L	**MI**

Symbol: F- flowering; NF - Non flowering; L- lodging ; NL - Non lodging ; NI- Non Infested; LI- Low Infested; MI- Moderate infestation

CONCLUSION

Significant genetic variability was observed among sixty sugarcane clones derived from six bi-parental crosses in the first clonal generation. Based on pooled ranking for high cane yield and high HR brix, along with desirable agronomic behaviour, ten superior clones CoX 23091, CoX 23094, CoX 23099, CoX 23100, CoX 23123, CoX 23112, CoX 23234, CoX 23125, CoX 23126, and CoX 23233were selected. These clones possess strong potential for advancement in the ongoing sugarcane breeding programme aimed at developing early maturing, high-yielding, and high-sugar varieties.

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Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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