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Performance of Different Commercial Varieties of Sugarcane (*Saccharum officinarum*) for Yield and Quality Trait Influenced by Various Harvest Age under Peninsular Zone of Maharashtra

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Abstract

A field experiment was carried out at Vasantdada Sugar Research Institute (VSI), Manjari, Pune, India during 2019–20, 2020–21 and 2021–22 crop seasons (36 months) to evaluate the performance of different harvesting periods of advanced varieties on yield and quality of sugarcane (*Saccharum officinarum* L.) under agro-climatic condition of peninsular zone of Maharashtra. Three harvesting dates i.e. H_1-10 month, H_2-12 month and H_3-14 month and 10 different varieties including five early maturing sugarcane varieties V_1-MS10001, V_2-CoM 9057, V_3-Co 09004 with two zonal check namely V_4-CoC 671 and V_5-VSI434 and five midlate maturing varieties V_6-VSI08005, V_7-CoVSI18121, V_8-VSI12003 with two zonal check namely V_9-CoM 0265 and V_{10}-Co 86032 were evaluated in the split plot design with three replications. The varieties differed in stalk diameter and weight, and millable stalk number. Improvements in internodes number, stalk diameter and weight were increased with harvest age. Varieties produced better juice quality in canes harvested at 14 months. On the basis of pooled results obtained from three plant cane, it can be concluded that, Maximum cane yield (140.15 t ha^{-1}) and CCS yield (19.33 t ha^{-1}) can be secured by harvesting the sugarcane at 14 months after planting. With respect to varieties CoM 0265 recorded significantly higher cane yield (156.36 t ha^{-1}) as well as CCS yield (18.81 t ha^{-1}) which was followed by varieties VSI 08005 and CoVSI 18121. Whereas, significantly improved sucrose percentage was observed in VSI 434 (19.38%) which was harvested at 14 months after planting.

Keywords: Harvesting age, Maharashtra, peninsular zone, quality, sugarcane, varieties, yield

1. Introduction

Sugarcane (*Saccharum officinarum* L.) is a Worldwide industrial crop cultivated for its diverse uses, among which the most important is sugar. Sugarcane is harvested in the subtropical regions under conditions of low temperature (early harvesting) and high temperature (late harvest). The adaptation and success of a sugarcane variety depends on their adaptability to the area's agro-climate conditions. Harvesting of sugarcane at a proper time by adopting the right age is necessary to realize the maximum weight of the millable canes produced with the least possible field losses under the given growing environment (Muchow et al., 1998). The variables of climate elements, temperature, solar radiation, relative humidity, and total rainfall accounting for a major difference in harvest age among sugarcane growing countries (Jorge et al., 2010). Some varieties of sugar cane have relatively high concentrations of sucrose in the early season and are defined as early maturation, while others are known as late maturation (Calderon et al., 1996). The crop season also ranges from 20 to 24 months in Hawaii, 13 to 19 months in Jamaica, 12 to 18 months in India, 16 months in Mauritius and 15 months in Queensland, Australia (Abu-Ellail et al., 2020). Other factors such as varieties, weather conditions, and soil type may have a more direct bearing on the real maturity of canes than the crop age. However, the percentage of quality of cane juice mainly depends on various factors such as the sugarcane variety, the maturity of the sugarcane in the case of plant cane, weather, and harvesting conditions (Liuand Bull, 2001). On the other hand, harvesting of either under-aged or over-aged cane with the improper time of harvest leads to a loss in cane yield, sugar recovery, poor juice quality, and problems in milling (Khandagave and Patil, 2007). Cane and sugar yield are determined by the age of harvesting at which the cane matures (Verma, 2004), basically, sugarcane varieties differ inherently in their time of maturity. Some cane is harvested before achieving maximum sucrose levels due to an increase of cane supply in early-season milling operations (Miller and James, 1977). A longer harvesting season may allow industry to manage increasing production or to support investment

opportunities in value-added by-products. Harvesting time is one of the most important factors affects productivity, and varietal differences in growth and maturity rates.(Donaldson et al., 2008), so Sundara (2000) and Verma (2004) classified varieties to early, mid and late maturing based on the time taken for maturity. Some sugarcane varieties must be harvested before achieving maximum sucrose levels to sustain early-season milling operations. "Early maturing" varieties are preferentially harvested during this time, recognizing that they may not have reached their peak sucrose content, but may have higher sucrose content than other later-maturing varieties (Gilbert et al., 2004). The peak sucrose content of sugarcane at harvest time is affected by different growing and plant physiological conditions during the maturation period. Furthermore, the variation among soil on cane fields causes considerable differences in soil moisture holding capacity, degree of drying, and, consequently, the rate at which cane fields ripen (Muchow et al., 1993).

Therefore, the present work was carried out with an aim to determine the optimum harvesting age and the suitable promising sugar cane variety and the commercial one with respect to yield and quality under different harvest dates under peninsular condition of Maharashtra.

2. Materials and Methods

The experiment was conducted at the research & development farm of Vasantdada Sugar Institute, Manjri, Pune, India during, 2019–20, 2020–21 and 2021–22 crop seasons (36 months) (Latitude: 18.52. Longitude: 73.97). The experimental material consisted of three harvesting dates i.e. H_1-10 month, H_2-12 month and H_3-14 month and 10 different varieties including five early maturing sugarcane varieties V_1-MS10001, V_2-CoM 9057, V_3-Co 09004 with two zonal check namely V_4-CoC 671 and V_5-VSI434 and five midlate maturing varieties V_6-VSI08005, V_7-CoVSI 18121, V_8-VSI 12003 with two zonalcheck namely V_9-CoM 0265 and V_{10}-Co 86032 were evaluated in the Split plot design with three replications. Each variety had plot size 8.00 m (L) X 5.40 m having 4 rows at 1.35 meters row to row distance. The varieties were planted first and second week of February in 2019, 2020 and fourth week of December 2020 respectively. All recommended agronomical practices were applied as per suru planting. Two budded sets were planted in single row system. Recommended dose of suru season sugarcane crop were applied i.e., 250:115:115 kg N, P_2O_5 and K_2O ha^{-1}. The application nitrogen in four splits and P_2O_5 and K_2O application-50% at planting and 50% at final earthing up. The nutrient status of soil tested before each planting of crop which gives on an average 8.12 pH (slightly saline), 0.43 EC, moderately high Organic Carbon (0.65), low nitrogen (273.97) and very high phosphorus (51.59) and potassium (592.46) having medium black in nature. The yield performance and quality parameter were recorded as per schedule and at the time of maturity. The observations taken in field on yield characters like single cane weight, length of nodes, diameter of cane and cane yield quintal ha^{-1}and other quality parameters viz. brix percentage, sucrose percentage, CCS percentage and CCS yield t ha^{-1}. The sugar quality will be analyzed as per the procedure outlined by Spencer and Meade (1963). The data on cane yield and yield parameters were analyzed statistically using analysis of variance and LSD test was applied to discriminate the superiority of the means of different varieties as suggested by Gomez and Gomez (1984).

3. Results and Discussion

3.1. Effect of harvesting age on yield attributes and quality of sugarcane

The pooled data on tiller count at 120 DAP and millable cane count, total cane height, no. of internodes, girth of internodes, single cane weight and cane yield at harvest as influenced by three harvesting age are presented in Table 1. The data on tiller count at 120 DAP, millable cane population, as influenced by different harvesting periods are presented in Table 1 which was found to be non-significant. A perusal of data (Table 1) on yield attributes as influenced by different harvesting periods was found to be non-significant except plant height and cane weight. Both the attributes was significantly higher (283.17 cm and 1.89 kg) in cane harvesting at 14 months after planting and statistically at par (277.63 cm and 1.76 kg) with cane harvesting at 12 months after planting. Jadhav et al. (2000) they found that stalk height and single cane weight were increased gradually as harvesting time was delayed.The data on cane yield revealed that, it was significantly influenced by different harvesting periods. Harvesting of crop at 14 months after planting gained significantly maximum (140.15 t ha^{-1}) cane yield, but it was at par with 12 months after planting (133.25 t ha^{-1}).

Data onjuice quality parameters (Table 2) confirmed that among the all quality parameter only CCS% were significantly influenced by harvesting periods in pooled results. It was statistically higher (15%) in treatment H_3 (Cane harvesting at 14 months after planting).Appraisal of data (Table 2 indicated that, different harvesting periods did not impart their significant influence on CCS yield in pooled results.

3.2. Effect of varieties on yield attributes and quality of sugarcane

The pooled data on tiller count at 120 DAP and millable cane count, total cane height, no. of internodes, girth of internodes, single cane weight and cane yield at harvest as influenced by different varieties are presented in Table 1. The data pertaining to tiller count at 120 DAP found non-significant due to different varieties in pooled results.In pooled results significant differences were observed in millable cane population due to varieties (Table 1). Variety Co 86032 showed significantly higher (84 thousand ha^{-1}) cane population as compared to rest, but it was on same bar with several varieties except CoC 671 and VSI 434.

The pooled data pertaining to growth and yield attributes

Table 1: Tiller count at 120 DAP and millable cane count, total cane height, no. of internodes, girth of internodes, single cane weight and cane yield at harvest as influenced by different harvesting age and varieties (Pooled)

Treatment	Tiller count at 120 DAP (000'ha^{-1})	Millable cane count at harvest (000'ha^{-1})	Total cane height (cm)	No. of internodes	Girth of internodes (cm)	Single cane weight (kg)	Cane yield (t ha^{-1})
Factor A: Harvesting period							
H_1: 10 months	100.00	79.00	264.49	22.93	10.31	1.70	128.93
H_2: 12 months	104.00	78.00	277.63	25.03	10.59	1.76	133.25
H_3: 14 months	104.00	78.00	283.17	26.28	10.71	1.89	140.15
Sem±	2.00	1.00	4.97	0.77	0.14	0.05	2.58
CD (p=0.05)	NS	NS	14.98	NS	NS	0.15	7.96
Factor B: Varieties							
V_1: MS 10001	104.00	75.00	277.01	25.00	10.94	1.99	139.54
V_2: CoM 09057	110.00	82.00	273.95	24.09	10.54	1.71	142.73
V_3: Co 9004	92.00	77.00	272.86	23.46	10.19	1.62	125.58
V_4: CoC 671	98.00	72.00	268.90	24.37	10.49	1.68	121.11
V_5: VSI 434	87.00	72.00	261.01	24.48	9.99	1.52	108.43
V_6: VSI 08005	111.00	83.00	283.052	25.40	10.35	1.97	145.61
V_7: CoVSI 18121	111.00	75.00	279.723	24.62	11.20	2.02	148.05
V_8: VSI 12003	98.00	77.00	264.13	24.27	9.83	1.50	120.90
V_9: CoM 0265	111.00	80.00	300.251	26.43	11.20	2.26	156.36
V_{10}: Co 86032	105.00	84.00	270.08	23.83	10.69	1.75	132.81
Sem±	6.00	3.00	4.65	0.73	0.25	0.09	4.65
CD (p=0.05)	NS	9.00	12.98	2.16	0.75	0.30	12.98
Interaction H×V							
Sem±	5.00	3.00	8.05	1.06	0.24	0.13	11.95
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS

are presented in Table 1 revealed that, CoM 0265 showed significantly improved growth attributes viz. plant height (300.25 cm), No. of internodes (26.43), girth (11.20 cm), same can observed in CoVSI 18121 and cane wt. (2.26 kg) and it was similar with MS 10001, VSI 08005 and CoVSI 18121. These differences could be attributed to the genetic structure of the varieties assessed for cane yield. Sohu et al. (2008) and Abu-Ellail et al. (2018), pointed out that the significant variance between the sugarcane varieties in stalk height in three plant seasons. The data confirmed that (Table 1) variety CoM 0265 registered significantly higher cane yield (156.36 t ha^{-1}) but it does not make significant difference as compared to VSI 08005 (145.61 t ha^{-1}) and CoVSI 18121 (148.05 t ha^{-1}) in pooled results.

An appraisal of data (Table 2) showed that variety Co 09004 recorded significantly higher brix (22.21°), Sucrose (20.62%) and CCS (14.78%) as compared to the rest of the varieties. Among the varieties CoM 0265 recorded significantly higher CCS (18.81 t ha^{-1}) yield in pooled results (Table 2). Also, MS 10001 (17.18 t ha^{-1}), CoM 9057 (18.28 t ha^{-1}), Co 09004 (17.19 t ha^{-1}), VSI 08005 (18.72 t ha^{-1}) and CoVSI 18121 (17.97 t ha^{-1}) was not statistically different from superior.The increase in sugar yield may be attributed to an increase in the percentage of sucrose, the percentage of sugar recovery that represented the yield of sugar as a final product. Kumara and Bandara (2002) they found significant differences among evaluated sugarcane varieties for Brix and sucrose percentages. Nayamuth et al. (2005) proposed that varieties could be classified into three distinct maturity groups (early, mid, and late) based on their sucrose accumulation patterns. Endris et al. (2016) observed that maximum sugar yield value (t ha^{-1}) was reported at 14 months of harvesting age. Jadhav et al. (2000) noted major differences among harvesting ages in reducing sugars percentage.

3.3. Interaction effect

Interaction among H×V (harvesting periods and varieties) found to be significant for sucrose percentage in pooled results (Table 3). Harvesting of VSI 434 at 14 months after planting showed significantly higher sucrose (19.38%) percentage but it was on same bar with MS 10001 (19.06%), Co9004

Table 2: CCS yield and quality parameters as influenced by different harvesting age and varieties (Pooled)

Treatment	CCS (t ha^{-1})	Brix (0°)	Sucrose (%)	CCS (%)
Factor A: Harvesting period				
H_1: 10 months	14.83	20.44	18.94	12.88
H_2: 12 months	17.47	21.40	19.43	14.47
H_3: 14 months	19.33	21.84	20.72	15.00
Sem±	1.71	0.68	0.85	0.36
CD (p=0.05)	NS	NS	NS	1.11
Factor B: Varieties				
V_1: MS 10001	17.18	21.04	19.45	13.92
V_2: CoM 09057	18.28	20.83	19.27	13.80
V_3: Co 9004	17.19	22.21	20.62	14.78
V_4: CoC 671	16.35	22.01	20.49	14.72
V_5: VSI 434	14.85	22.13	20.54	14.73
V_6: VSI 08005	18.72	20.90	19.40	13.87
V_7: CoVSI 18121	17.97	20.88	19.19	13.70
V_8: VSI 12003	16.17	21.23	19.83	14.26
V_9: CoM 0265	18.81	20.47	18.96	13.59
V_{10}: Co 86032	16.57	20.92	19.20	13.81
Sem±	0.72	0.39	0.37	0.28
CD (p=0.05)	2.01	1.17	1.11	0.84
Interaction H×V				
Sem±	1.82	0.30	0.34	0.37
CD (p=0.05)	NS	NS	NS	NS

(19.22%), CoC 671 (18.88% and 19.31%), VSI 12003 (18.70%) and Co 86032 (18.48%) for the same period of harvesting.The increase could be due to positive impact of harvest age on the yield components (plant height and cane yield) which allow accumulation of additional soluble solids (brix) or sucrose by delaying the harvest age (Rostron, 1972). These results are in agreement with those obtained by Muchow et al. (1998), and Hagos et al. (2014) who reported the harvest age had a very significant influence on the percentage of brix, sucrose, and purity.

4. Conclusion

The results obtained from three year pooled data, the maximum cane yield (140.15 t ha^{-1}) and CCS yield (19.33 t ha^{-1}) secured by harvesting the sugarcane at 14 months after planting. With respect to varieties CoM 0265 recorded significantly higher cane yield (156.36 t ha^{-1}) and CCS yield (18.81 t ha^{-1}); followed by varieties VSI 08005 and CoVSI 18121. Whereas, significantly improved sucrose percentage was observed in VSI 434 (19.38%).

Table 3: Interaction effect of different harvesting period and varieties on sucrose percentage

Treatment	H_1: 10 months	H_2: 12 months	H_3: 14 months	Mean
V_1: MS 10001	16.35	17.13	19.06	17.51
V_2: CoM 09057	16.55	17.37	18.13	17.35
V_3: Co 9004	17.80	18.65	19.22	18.56
V_4: CoC 671	17.15	18.88	19.31	18.45
V_5: VSI 434	17.93	18.16	19.38	18.49
V_6: VSI 08005	16.75	17.31	18.33	17.46
V_7: CoVSI 18121	16.71	16.85	18.27	17.28
V_8: VSI 12003	17.08	17.78	18.70	17.86
V_9: CoM 0265	16.77	16.79	17.66	17.07
V_{10}: Co 86032	16.55	16.83	18.48	17.29
Mean	17.05	17.49	18.66	
Sem±		0.34		
CD (p=0.05)		0.94		

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