International Journal Of Engineering Research And Development
e- ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 16, Issue 8 (August 2020), PP. 48-53

Analysis Of Deterioration rate in Sugarcane varieties *(Saccharum officinarum sp. hybrid)* Under Different Environmental Conditions at Finchaa Sugarcane Plantation, Finchaa, Oromia region, Ethiopia

Gamechis Dugasa Urgesa[1], Vighneswara Rao.K[2]
[1&2] *Department of Chemical Engineering,Wollega University, Shambu Campus,Ethiopia.*
Corresponding Author: Vighneswara Rao.K

ABSTRACT: *Sugarcane is a perishable crop and must be processed into sugar quickly after it is harvested. Post harvest sucrose losses linked with low sugar recovery and several problems during sugar processing. The study was conducted at Finchaa sugar factory of Abbay choman District which is located in Horro Guduru Wollega Zone of Oromia regional state with the objective of investigating the effect of cane staling periods under open and shade conditions on juice quality of sugarcane varieties. Both D42 and N14 variety were collected from burnt harvested cane, tagged, numbered, their fresh weight were recorded and kept under open and shade conditions. The samples numbered from 1 to 24 were stored under open and another 24 samples numbered from 25 to 48 were kept under shade for each variety. Juice quality parameters were analyzed using standard procedures and the results were subjected to analysis of variance (ANOVA). Mean separation was done using the least significant difference (LSD). The analysis of juice quality parameters revealed variable value between varieties, storage conditions and storage periods. Loss in cane weight, brix% juice and reducing sugar was significantly increased within increasing staling periods. Maximum and significant loss in cane weight, brix% juice and reducing sugar occurred at 168 hrs of staling followed by 144, 120, 96 up to control (0) hr under open and shade conditions for both varieties. They were also superior under open than shade conditions. Similarly higher Loss in cane weight, brix% juice and reducing sugar were found in N14 as compared to D42 variety at each staling periods. On the other hand, pol percentage, purity, recoverable sugar and sugar yield were significantly decreased within increasing staling period. Maximum and significant pol percent juice, purity percent juice, recoverable sugar and sugar yield were found at 0 hrs followed by 24hrs, 48hrs, 72hrs up to the last date of staling periods (168hrs) both under open and shade conditions for each variety.. Pol percent juice, purity percent juice, recoverable sugar and sugar yield were maximum under shade than open air for both varieties and they were also higher in D42 as compared to N14 variety.*

KEYWORDS: *Staling, Deterioration, Saccharum, Shade, Open, Finchaa*

Date of Submission: 20-08-2020 Date of Acceptance: 06-09-2020

I. INTRODUCTION

Sugarcane belongs to the grass family, Gramineae or Poaceae, genus *Saccharum.* The cultivated varieties are of complex hybrid origin (*Saccharum* spp. hybrid) (Stevenson, 1965). It is a moderately hot, sunny weather loving plant that can be grown up to 1600 m elevation near to the equator and up to 600 m elevation between 35^{o} N and S latitudes under varied soil and climatic conditions (Kakdae, 1985). Cane quality represents the main priorities in sugarcane postharvest management which is deteriorated in field, cut to crush delay, during transportation, other factors such as ambient temperature, humidity, cane variety, period of storage activities of soluble invertases in cane, maturity status etc. (Uppal *et al.*, 2008 Solomon, 2009 Reddy *et al.*, 2014).

Sugarcane is harvested when it is matured or ripened. The topped and stripped off canes are supplied to sugar mills for extraction of juice and its processing for recovering crystallized sugar. However, sugarcane suffers heavy losses in recoverable sugar due to post harvest deterioration in cane quality (Solomon, 2009). Several factors contribute in post harvest deterioration of cane juice quality viz., variety, maturity status, temperature and relative humidity, method of harvesting and condition of the cane prior to reach factory site, delay in lifting of the canes from the field and delay in crushing of cane at sugar mills. Sugarcane harvesting in some countries including Ethiopia is harvested manually and involves the following series of operations: pre-harvest burning, cutting, topping, staking, and loading from field into trolleys and their transport to the Sugar mill and unloading at the mill (Cornu, 1977). The efficient handlings of these operations are critical to maintaining the quality of cane after harvesting.

Staled cane had a significant impact on recovery and processing activities in the mill. For example, due to the production of dextran, a product of the microbial degradation of sucrose, the mill faced increased viscosity, reduced evaporation and crystallization, and clarification challenges (Cox and Sahadeo, 1992; Ravno and Purchase, 2005; Eggleston *et al*., 2008). Increasing delay from the burnt harvested cane to crush resulted in deterioration. Brix and reducing sugars were increased by increasing staling periods. On the other hand, cane weight, juice extraction percentage, sucrose percentage and purity percentage significantly decreased with increasing the staling period. Thus, post-harvest cane deterioration affects both growers because of loss cane weight and sugar industry due to reduced in sugar recovery. The overall reduction in milling efficiency resulted in negative outcomes for the entire sugarcane supply chain (Loubser, 2005; Walford and Nel, 20101.3.

II. MATERIAL AND METHODS

II.1 Descriptions of the Study Area

The experiment was conducted at Finchaa Sugar Estate, which is located in Oromia Regional State, Horro Guduru Wollega Zone, and Abbay Chommen District. The plantation is situated at 9^0 3o' to 10^0 North and 37^0 20' to 37^0 30' East. It is located at about 340 km North West of Addis Ababa at an altitude of about 1350-1650 m above sea level (Worku, 1995). The average annual precipitation at the area is 1309 mm and the average maximum and minimum daily temperatures are 30.6^0 and 14.5^0C, respectively. The highest monthly maximum temperature occurs in March (34.1^0C) and the lowest in December (11.5%) with average relative humidity of about 83.8% (Ademe. 2001).

II.2. Materials

II.2.1. Materials chosen for Experiment.

The materials for this study consist of two widely grown sugarcane varieties D42 and N14 at Finchaa sugarcane plantation. The variety D42 gives high cane and sugar yields at Finchaa Sugar Estate (FSE).

II.2.2. Treatments and experimental design:

The treatments for the study comprised of pre harvest burnt canes of two (2) varieties (V_1:D42, V_2: N14) two (2) storage conditions (SC_1: open air and SC_2: under shade) and eight (8) storage periods after harvesting (SP_1:0, SP_2:24, SP_3:48, SP_4: 72, SP_5: 96, SP_6: 120, SP_7: 144 and SP_8: 168 hours). The experiment with 2 x 2 x 8 in three replications was conducted in split-split plot design with varieties as main plot, storage conditions (environments) as sub-plot and staling periods as sub-sub plots.

II.3. Data collection methods

II.3.1. Cane weight loss % at storage periods

.Cane weight losses% (CWL %) for each sample was calculated by subtracting the weight of a sample after storage from the fresh weight and multiply by 100 as following equation.

$$\text{CWL\%} = \frac{\text{Fresh weight} - \text{weight after storage}}{\text{fresh weight}} \text{X100}$$

II.3.2. Brix % juice

Brix % juice for all samples of treatment combinations was determined by using brix hydrometer of the following standard methods.

II.3.3. Pol % juice

Pol percent juice was determined by using Polari meter. Pol percent was calculated from Schmitz's Table using (Home's Dry lead methods 1961)

II.3.4. Purity percentage

Juice Purity percentage was calculated according to the following formula (Satisha *et al.*, 1996)

$$\text{Purity percentage} = \frac{pol\%\ juice}{Brix\%\ juice} X100$$

II.3.5. Reducing sugar percentage (RS %)

Reducing sugar contents in juice for each of the samples was determined by using the Lane and Eynon volumetric methods as outlined by (ICUMSA, 1994)

$$\text{Reducin sugar(RS\%)} = \frac{\text{pol\% diluted factor} - \text{pol\% undiluted}}{\text{dilution factor}/100}$$

II.3.6. Estimated recoverable sugar (ERS %)

Sugar recovery is the amount of sugar recovered from a fixed amount of sugarcane during the crushing process. It was calculated as follows (Hundito *et al*., 2009).

ERS % = {pol% juice - (Brix % juice - pol % juice) NSF} * CF

Where: NSF is Non sugar factor with constant value of 0.70, CF is cane factor with constant value of 0.57

II.3.7. Estimated sugar yield

Estimated cane yield was obtained by multiplying cane weight with estimated sugar recovery percent.

Estimated sugar yield = Cane weight X estimated sugar recovery.

II.4. Data analysis

The data obtained was subjected to analysis of variance (ANOVA) adapted for Split- split plot design according to (Sedecor and Cochran, 1981). Treatment means was compared using LSD test at 5% level of probability and appropriate software SAS 9.2 version was used for these analysis.

III. RESULTS AND DISCUSSION

III.1. Effect of Cane Staling Periods on Cane Weight of Burnt Harvested Cane under Open and Shade

The loss in cane weight of burnt harvested cane was significantly higher under open than shade condition. This indicated that the direct exposure of harvested cane to sun radiation under open condition resulted in significantly more cane weight loss than the shade condition. This was due to faster loss of moisture or drying up under open air condition. The present results were in agreement with those by (Mayo *et al*., 1988) who found that the bundles of cane exposed to sun light resulted in loss in cane weight after harvest.

The varieties differed in cane weight loss over 7days (168 hrs) of staling periods. Cane weight loss was significantly higher in variety N14 than variety D42. This can be the difference in cane characteristics like rind thickness (hardness), cane density, fiber content and water or moisture content of the cane. Similar to the present results obtained (Ahmed and El-sogheir, 2002) also reported that the evaluated sugarcane varieties varied significantly in the magnitude of cane weight loss.

Maximum and significant loss in cane weight occurred at 168 hrs of staling followed by 144 hrs, 120 hrs up to control (0 hrs) under open and shade conditions for both varieties. The loss in cane weight within 24hrs of staling was significantly different from fresh weight at 0 hrs. The loss in cane weight within first 24 hrs varied from 4.87% to as high as 14.1% and 5.08% to 16.42% at 168 hrs (7days) under open air condition in D42 and N14 varieties respectively. Similarly loss in cane weight on cane staling from 24 hrs to 168 hrs (7days) under shade varied from 3.16% to 12.55% and 3.01% to 13.69% in varieties D42 and N14 respectively. The mean values showed that loss in cane weight was maximum under open than shade conditions in both varieties. Total loss in cane weight under natural condition to the extent of 37.79% at 14 days storage has also been reported by (Magadum and Kadam, 1996).

III.2. Effect of Cane Staling Periods on Brix Percent Juice under Open and Shade

Brix percentage juice represents total dissolved solids including all sugars and non sugars in the juice. There were significant differences in brix% juice over staling period of cane under open and shade conditions for both varieties D42 and N14. Brix% juice was significantly more under open condition than shade condition. These could be due to, more evaporation of water, concentration of total soluble solids, the formation of more reducing sugars and dextran in open than shade condition.Increased in brix (TSS) was observed in each variety kept under open and shade conditions from 0 to 168 hr of staling periods. Maximum and significant brix% juice was observed in N14 than D42 variety. This was due to more loss in cane weight and concentration of total soluble solids from N14 than D42 variety.

The brix% juice increased significantly under open and shade after 24 hrs of cane staling. It continued to increase with the staling periods up to 168 hrs (7 days) which varied from 15.87 and 15.83% in fresh cane to 18.71 to 18.55% at 168 hrs of cane staling under open and shade conditions in variety D42. Similarly it varied from 16.31 and 16.1% to 18.7% and 18.56% under open and shade in variety N14. The increased in brix% during 7 days of staling was about 3 units in variety D42, whereas it was more than 2 units in N14 variety which indicated difference between varieties for increased in brix% juice (Table III.1 and Table III.2)

Table.III.1: Effect of cane staling periods, varieties and storage conditions on quality characteristics of sugarcane juice during February,2019

Treatments	CWL%	Brix%	Pol%	Purity%	RS(mg/ml)	RCS%	SY%
Varieties							
D42	7.49b	17.1b	13.63a	81.39a	1.60a	6.56a	36.24a
N14	9.47a	17.28a	13.38b	75.95b	1.71a	6.51b	35.00b
LSD 5%	0.50	0.062	0.093	0.37	0.078	0.12	0.87
Storage cond.							
Open	9.00a	17.26a	13.3b	75.81b	1.78b	6.48a	34.55b
Shade	7.96b	17.13b	13.71a	81.50a	1.52b	6.64a	36.68a
LSD 5%	0.50	0.062	0.093	0.37	0.078	0.12	0.87
Staling periods							
0 hr	0g	16.03h	14.77a	92.16a	0.53h	7.96a	50.12a
24 hr	4.03f	16.43g	14.44b	87.92b	0.69g	7.40b	43.40b

48 hr	7.06e	16.66f	14.28b	85.68c	0.96f	7.19c	39.81c
72 hr	8.86d	16.92e	14.08c	83.19d	1.30e	7.03c	38.49c
96 hr	10.07c	17.24d	13.98c	80.50e	1.47d	6.59d	33.96d
120 hr	11.0c	17.67c	13.68d	77.14f	1.83c	6.154e	30.42e
144 hr	12.08b	17.96b	13.20e	72.32g	2.82b	5.66f	26.85f
168 hr	14.19a	18.63a	12.99f	68.02h	3.40a	5.15g	21.91g
SE ±	0.47	0.08	0.06	0.78	0.10	0.09	0.9
LSD 5%	0.82	0.12	0.18	0.74	0.15	0.24	1.75
CV	14.68	0.87	1.64	1.13	11.82	4.46	6.05

Means with the same letters are not significantly different from each other at 5% of probability level

Table III.2: Effect of cane staling periods, varieties and storage conditions on quality characteristics of sugarcane juice during May, 2019

Treatments	CWL%	Brix%	Pol%	Purity%	RS(mg/ml)	RCS%	SY%
Varieties							
D42	8.58b	17.43a	13.34a	74.81a	2.36b	5.81a	32.92a
N14	10.00a	17.97a	13.17b	73.93b	2.50a	5.58b	31.55b
LSD 5%	0.44	0.17	0.15	0.58	0.11	0.10	1.22
Storage cond.							
Open	9.77a	18.02a	12.96b	72.92b	2.58a	5.53b	30.94b
Shade	8.82b	17.38a	13.52a	75.82a	2.28a	5.86a	33.51a
LSD 5%	0.44	0.17	0.15	0.58	0.11	0.10	1.22
Staling periods							
0 hr	0g	15.86h	14.31a	90.77a	0.77h	7.64a	48.73
24 hr	5.20f	16.54g	14.16a	85.60b	1.08g	7.11b	42.87
48 hr	8.17e	17.23f	13.68b	79.46c	1.64f	6.37c	36.38
72 hr	9.78d	17.93e	13.43b	74.97d	2.01e	5.86d	31.73
96 hr	11.37c	18.37d	13.08c	71.19e	2.74d	5.34e	27.60
120 hr	12.16c	18.80c	12.73d	67.20f	3.34c	4.82f	24.03
144 hr	13.01b	19.18b	12.48d	65.47g	3.99b	4.43g	21.51
168 hr	14.67a	19.58a	12.21e	61.83h	5.03a	4.05h	18.74
SE ±	0.47	0.13	0.08	0.99	0.14	0.12	1.06
LSD 5%	0.88	0.35	0.31	1.17	0.23	0.20	2.48
CV	11.77	2.40	2.91	1.93	11.05	4.36	9.58

Means with the same letters are not significantly different from each other at 5% of probability level

III.3. Effect of Cane Staling Periods on Pol Percent Juice under Open and Shade

During staling of cane inversion of sucrose starts and resulted in the formation of invert sugar and thus there was direct loss of recoverable sugar. Pol percent juice was significantly affected by storage periods, storage conditions and variety. A significant decline in pol% juice was also found in staled cane with advancement in storage periods (Table III.1 and Table III.2).

There was significant reduction in pol percent juice at interval of 24 hrs of cane staling under open and shade conditions in both varieties. Pol percent juice continued to decline significantly up to 168 hrs (7 days) of cane staling. Pol percent juice declined from 14.72 and 14.78 at 0 hrs of cane staling to 12.74 and 12.82 at 168 hrs (7days) of staling, which indicate that there was about 2 units decrease in pol percent juice on cane staling for 7 days (168 hrs).

The decrease in pol % resulted in decrease in sugar recovery and thereafter purity. Once the stalk was cut, no further synthesis of sucrose took place, but the accumulated sugar was gradually depleted. Decline in pol percent juice was slow during first 2 days of staling; however, it was faster afterward. During 7 days (168 hrs) of staling a loss of pol% juice was 2.10 to 13.45% and 1.89 to 13.2% under open and shade in variety D42. Similarly a loss of pol% juice from 2.83 to 15.34% and 2.22 to 14.76% were observed in open and shade conditions from variety N14

III.4. Effect of Cane Staling Periods on Juice Purity Percent under Open and Shade Conditions

It was evident from the table that the juice quality undergoes a substantial change as far as the pol % or sucrose % was concerned. Juice purity percent over 168 hrs (7 days) of cane staling periods was significantly lower under open than shade conditions in both varieties. Further the juice purity over cane staling periods declined sharply under open (75.81%) than shade environment (81.50%). Juice purity at interval of 24 hrs up to 168 hrs (7 days) of cane staling periods under open and shade conditions for both varieties is given in Table 8. The juice purity of burnt harvested cane at 0hrs (fresh) under open and shade was 92.77 and 93.38 in variety D42 and 90.69 and 91.80 in variety N14. Juice purity declined significantly in both varieties. It further went on declining trend at interval of 24 hrs reaching significantly lowest at 168 hrs of staling. It declined to 68.12% and 69.1% under open and shade in D42 and 66.97% and 68.12% in variety N14 after 168 hrs of staling periods.

This finding was in agreement with (Sing and Solomon, 2003) who reported that significantly higher decline in purity % juice in open air as compared to under shade. The purity of freshly harvested cane juice was higher.

III.5. Effect of Cane Staling Periods on Reducing Sugar (mg/ml) Juice under Open and Shade Conditions

The contents of reducing sugars in juice are one of the most important parameter for determination of the extent of deterioration of staled cane (Uppal *et al,* 1997). A progressive increase in reducing sugars on account of inversion of sucrose was observed in each variety of both storage conditions.

Reducing sugar over staling periods increased significantly under open than shade conditions in both varieties D42 and N14. Reducing sugars at 0hrs and 24 hrs of staling were statistically on par. These increased significantly at 48 hrs (2 days) of staling. Thereafter reducing sugar increased significantly at 24 hrs of interval up to 168 hrs (7 days). Reducing sugar increased from 0.52mg/ml and 0.45mg/ml at 0 hrs under open and shade in variety D42 to 3.57mg/ml and 3.4mg/ml after 7 days of cane staling under open and shade conditions. Similarly reducing sugar increased from 0.64mg/ml and 0.47mg/ml at 0 hrs under open and shade to 3.66mg/ml and 3.3mg/ml for variety N14. The current study was in line with (Solomon *et al.,* 1990) who found that the accumulation of reducing sugars was not appreciable up to 48 hrs of staling, but thereafter dramatic increase in reducing sugars was noticed.

III.6. Effect of Cane staling Periods on Recoverable Sugar Percent under Open and Shade Conditions

The amount of sugar that can be recovered from sugarcane depends upon the amount and the quality of the juice. Recoverable sugar percent over cane staling periods under open condition was significantly less than shade. Variety D42 recorded higher recoverable sugar than N14 both under open and shade conditions. There was significant decline in sugar recovery within 24 hrs of cane staling under open and shade in both varieties. Sugar recovery percent continued to decline significantly at the interval of 24 hrs up to 168 hrs (7 days) of cane staling periods. After 7 days of staling sugar recovery declined 3 to 4 units under open and shade conditions. On two days of cane staling (48 hrs) decline in sugar recovery was about 2 units which declined further 3 to 4 units at 6 days (144 hrs) to 7 days (168 hrs). There were also significant differences in recoverable sugar under open and shade for both varieties. A maximum reduction in recoverable sugar of 29.05% was recorded in open air which was 14.18 % at 0 hrs in N14 variety and the minimum decrease of 25% was observed under shade which was 14.36% at 0 hrs in D42 variety after 168 hrs of staling (Table III.1 and III.2).

III.7. **Effect of Cane Staling Periods on Estimated Sugar Yield under Open and Shade Conditions**

Estimated sugar yield over 7 days of staling periods was significantly less under open than shade conditions. It was also less under open condition in variety N14, but it was on par with that under shade. There was significantly decline in estimated sugar yield within 24 hrs of burnt harvested cane staling under open and shade in both varieties recording about 10% less estimated sugar yield. Sugar yield declined further at latter cane staling periods. On 4 days (96 hrs) of staling estimated sugar yield declined significantly recording more than 26% less sugar yield, on 6 days (144 hrs) of cane staling sugar yield declined more than 37% and on 7 days (168 hrs) of staling sugar yield declined 50% under open and shade in both varieties.

There were significant differences in sugar yield at different staling periods. During 7 days (from 24 to168 hrs) of stealing a loss of sugar yield from 15 to 51.94% and 10.07 to 50.07% under open and shade were observed in D42 variety. Similarly a loss of sugar yield from 9.8 to 50.72% and 10.99 to 50.12% under open and shade conditions were found from N14 variety. The decrease in sugar yield was more under open than shade conditions. A maximum reduction of 42.6% was recorded from open in N14 variety, which was 86.46 % at 0 hrs and decreased to 50.72 % after 168 hrs of staling and the minimum decrease of 45.73 % was observed under shade in D42 variety. The decline in sugar yield was 15% and 10.07% under open and shade in D42 variety at 24 hrs which was further increased to 51.94% and 50.07% respectively after 168 hrs of staling periods.

IV. CONCLUSION AND RECOMMENDATION

Sugarcane is a perishable crop and must be processed into sugar quickly after it is harvested, because it could lose its sugar (sucrose) within a few days after harvesting. Inversion processes accompanying harvest operations and subsequent delay in delivery can cause substantial losses.

The loss in cane weight increased gradually within increasing staling time due to lose of water from harvested cane that resulted in loss in quantity (cane weight) and quality (shriveling and wilting). The loss in cane weight of burnt harvested cane was significantly higher under open than shade condition.

Brix% juice was significantly more under open than shade condition and Maximum and significant brix% juice was observed in variety N14 than variety D42.

Pol% juice was decreased within increasing staling periods. Maximum and significant pol% juice was found at 0 hrs followed by 24, 48, 72 up to last date of staling (168 hrs). Reduction in pol percent was less under shade than open air condition in both varieties during staling periods

Reducing sugar over staling periods increased significantly under open than shade conditions in both varieties D42 and N14. It was found to be higher in variety N14 than D42.

Generally, brix and reducing sugars were increased within increasing in staling periods. On the other hand cane weight, pol percent, purity percent, recoverable sugar percent and sugar yield were significantly decreased within increasing in staling periods. Further, brix and reducing sugars were more under open than shade condition, whereas cane weight, pol percent, purity percent, recoverable sugar percent and estimated sugar yield were more under shade condition. Based on staling periods and storage conditions of two sugarcane varieties the following suggestion could be drawn:

- In case of unavoidable delay in crushing, the harvested staled cane should be stored in small heaps with minimum ground contact, covered with thick layer of trash and should be stored under shade. This method has been found to suppress the activations of intermodal invertases. The cane piles should be stacked in such a way so as to facilitate proper ventilation
- For each variety the harvested cane must be brought to mill and processed as quickly as possible. For open air it is better to be processed with in 24 hrs and for under shade within 36 hrs and the waiting time for Lorries, tractor or bullock carts in the yard should not be more than 2 hrs
- Variety with high sucrose content is more prone to deterioration than variety with less sucrose content. Therefore, in case of delay in crushing (staling), variety with less sucrose content is more preferable.

REFERENCES

[1]. Verma, R. S, 2004. Sugarcane production technology in India. International book distributing Co. Lucknow. India
[2]. Ahmed, A.Z. and K. S. El Sogheir, 2002. Studies on post harvest changes in sugarcane cultivars under Upper Egypt conditions. Proc. Mini. 1st*conf. Agric. & Environ. Sci.*, 25-28, 22 (2-A), 279-289.
[3]. AdemeAdinew 2001. Summary of Meteorological Data (1979-2008), Finchaa Research station, Finchaa, Ethiopia.
[4]. Cornu, A.1977. Is the quality of sugarcane affected by mechanical harvesting? *International* sugar Journal, 91:12-13
[5]. Cox and Sahadeo, 1997. Cane deterioration. Proceedings of the International Society of SugarCane Technologists 70:287-289
[6]. Eggleston, 2006. Determination of sugarcane deterioration at the factory: Development of a rapid, easy and inexpensive enzymatic method to determine mannitol. Food Chemistry 98(2): 366–367
[7]. Kakdae, J.R, 1985. Sugarcane production. Metropolitan Book Co Prvt. Ltd., New York.
[8]. Magadum, D. N. and Kadam, S. K, 1996. Post harvest deterioration in sugarcane, Bharatiya Sugar. 21(4): 45-50.
[9]. Ravno, AB and Purchase, BS. 2005. Dealing with dextran in the South African sugar industry. *Proceedings of the South African Sugar Technologists Association*, 79: 28-47.
[10]. Reddy *et al*, 2014. Evaporation and deterioration of cut cane in Egypt. Minst. agric. Technol. Serv. Bulletin No 155, pp. 22
[11]. Solomon, 2009 Post-harvest cane deterioration and its impact on Sugar Industry. In Sugarcane Crop Production and Management (Eds: S.B.Singh, G.P.Rao, S.Solomon and P.Gopalasundram) Stadium Press LLC, Houston, Texas-USA. Pp. 629-674
[12]. Solomon, S. 2002. Post harvest sugar losses and their management. *Indian Farming*, 51(11): 52-56
[13]. Solomon, S. and Madan, V. K, 1997. Management of problems associated with sucrose accumulation and pre-processing losses in sugarcane to enhance sucrose recovery. Indian J. of Sugarcane Technol. 12 (2): 64-76.
[14]. Solomon, S., Srivastava, A. K., Bhatnagar, S. and Madan, V. K. 1990. Post harvest changes in invertase activity and juice quality in sugarcane. Indian Sugar. 39 (12): 895-899.
[15]. Uppal, S. K, Sharma, S. and Sharma, K. P, 1997. Post-harvest loss in cane weight and formation of mollasogenic sugars in sugarcane on staling during hot weather months. Cooperative Sugar. 29(3): 172-174.

Gamechis Dugasa Urgesa, et. al. "Analysis Of Deterioration rate in Sugarcane varieties (Saccharum officinarum sp. hybrid) Under Different Environmental Conditions at Finchaa Sugarcane Plantation, Finchaa, Oromia region, Ethiopia." *International Journal of Engineering Research And Development*, vol. 16(8), 2020, pp 48-53.