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The Effect of Sugarcane Portions and Varieties on Growth, Yield and Quality of Sugarcane (*Saccharum spp*. L) in Western Ethiopia

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Abstract: A field experiment was conducted from January2020 to February 2021 at Finchaa Sugar Factory with the objective of to investigate the effect of sugarcane portion and varieties on the growth, yield and quality of sugarcane. The experiment was laid out in RCBD with three replications in factorial combination of four sugarcane varieties (B80-250, C86-56, C90-501, and C132-80) and three sugarcane portions (top, middle and bottom). Analysis of variance showed that tillering, plant height, number of internodes per stalk, sugarcane height, sugarcane diameter, brix %, pol %, purity % and recoverable sucrose % were highly significantly ($p<0.01$) affected by sugarcane varieties and plant population significantly ($p<0.05$) affected by sugarcane varieties. The highest tiller (175441ha^{-1}), number of internodes per stalk (18.33), sugarcane diameter (28.56mm) and plant population (107088 ha^{-1}) were obtained from variety C132-80. But the highest plant height (205.03cm) and sugarcane height (187.89cm) were obtained from variety B80-250. Percent of germination was highly significantly ($P<0.01$) affected by the interaction of main effects. The highest percent of germination (65%) was obtained from the combination of variety C132-80 and the top portion of sugarcane. Tillering, plant population and sugarcane diameter were highly significantly affected by sugarcane portion. The highest tiller (171552ha^{-1}), Plant Population (108885 ha^{-1}) were recorded from top sugarcane portion but the highest sugarcane diameter (27.67 ha^{-1}) was obtained from the bottom sugarcane portion. A number of millable canes, cane yield and sugar yield were significantly ($p<0.05$) affected by sugarcane varieties. The highest number of millable canes (106255) and sugarcane yield (112.44 t/ha) was obtained from variety C132-80. However the highest sugar yield (13.00 t/ha and 12.98t/ha) was obtained from varieties C86=56 and C132-80 respectively. Sugarcane portion had significant effect on number of millable canes. The highest number of millable canes (108063) was obtained from the top sugarcane portion. The sugarcane variety C132-80 took dominance over the counterpart varieties (B80-250, C86-56, and C90-501) in germination %, tillering capacity, stalk population, cane diameter, number of millable canes, and sugar yield. C86-56 also showed better sugar yield. Therefore top sugarcane portion and variety of C132-80 and C86-56 are suitable for sugarcane production at Finchaa sugar factory.

Keywords: Saccharum Officinarum L., Sugarcane, Sugarcane Portion, Sugarcane Variety

1. Introduction

The genus Saccharum includes sugarcane (Saccharum officinarum L.), a grass that is a part of the Poaceae family. [1]. Sugarcane has the highest output levels and is the most significant industrial crop in the world, according to Kinkema *et al*. [2]. Modern sugarcane cultivars produced for sugar production include complex interspecific hybrids (Saccharum spp.). These hybrids, which mostly resulted from crossings between the species Saccharum officinarum L. and Saccharum spontaneum L., were created through extensive selective breeding of species within the Saccharum genus. [3]

As it has been reported by Ethiopian Sugar Industry Support centre share company, when the Wonji Sugar Factory was put into operation, Ethiopian sugar production began in 1954–

1955. This campaign saw the factory produce 15,843 tons of white sugar. Sugarcane is often cultivated on Ethiopian sugarcane plantations under conditions that include high temperatures, frequent irrigation, broad inter row spacing (1.45 m), and a high rate of inorganic fertilizer application [4].

Despite the fact that sugarcanes can generate seeds, vegetative propagation through stem cuttings is the main technique used in modern commercial sugarcane farming. Germination, tillering (formative), grand growth, maturity, and ripening are the four basic growth phases of sugarcane. It would be easier to manage the crop if you had a basic understanding of these growth stages.

Numerous variables limit sugarcane production. The ability of seed cane to germinate is one of these that is crucial. In light of this, the single-bud sett's germination capability is extremely low due to moisture loss from the cut ends on each side. In addition, the plants growing from single-bud setts are weaker and yield less than those from three-bud setts [5]. According to experimental data, 3-bud setts have a greater germination percentage than setts with more or fewer than three buds. In a 3-bud sett, the middle bud has the greatest ability to germinate, followed by the top end bud and the bottom end bud, respectively [6]. The preference for three-budded setts over single-bud setts is therefore based in part on the ability to germinate as well as in part on the initial vigor of the germination-stage plants and sugarcane production. When a sugarcane stalk is planted entire, without being divided into setts, only a few of the buds at the top end often germinate, while the buds at the bottom remain dormant due to top dominance.

It is evident that planting material has a significant impact on sugarcane sprouting since sugarcane, Saccharum spp., is commercially propagated vegetatively via stem cuttings known as setts, seed-pieces, or seed canes [7]. The rate at which buds sprout varies depending on where on the stalk they are located [8]. The upper and the middle portions of the stalk cuttings gave higher germination percentage with higher number of tillers and cane height than the lower portion [9].

At Finchaa Sugarcane Plantation, a mixture of top, middle, and bottom portions of a stalk are used as planting material but no investigations were made on which one is a more suitable cane portion for planting purpose. In addition the effect of sugacane portion of different new uncommercialized varieties of sugarcane was not known at Finchaa sugar factory on growth, yield and quality of sugarcane. Therefore, this experiment was carried out with the objective of;

To investigate the effect of sugarcane portion and varieties on growth, yield and quality of sugarcane at Finchaa sugarcane factory.

2. Materials and Methods

2.1. Description of the Study Site

A field experiment was conducted at Finchaa Sugar estate, which is located in Oromia Regional State, Horo Guduru Wollega Zone, Abbay Chommen district. The site is situated at 9°30' to 10°N latitude and 37° 15' to 37° 30' E longitude with altitude of 1650 m. a. s. l (Figure 1). The monthly meteorological data (amount of rainfall, temperature and relative humidity) for growing year of 2020 at the experimental site is presented in (Figure 2). The total rainfall in the cropping season was 1315 mm, with average maximum and minimum monthly temperatures of 31,47°C and 14.5°C respectively (Figure 3). The monthly average highest relative humidity is about 83.1% and the average lowest relative humidity is about 39%. The daily average sunshine is 7.66 hr.

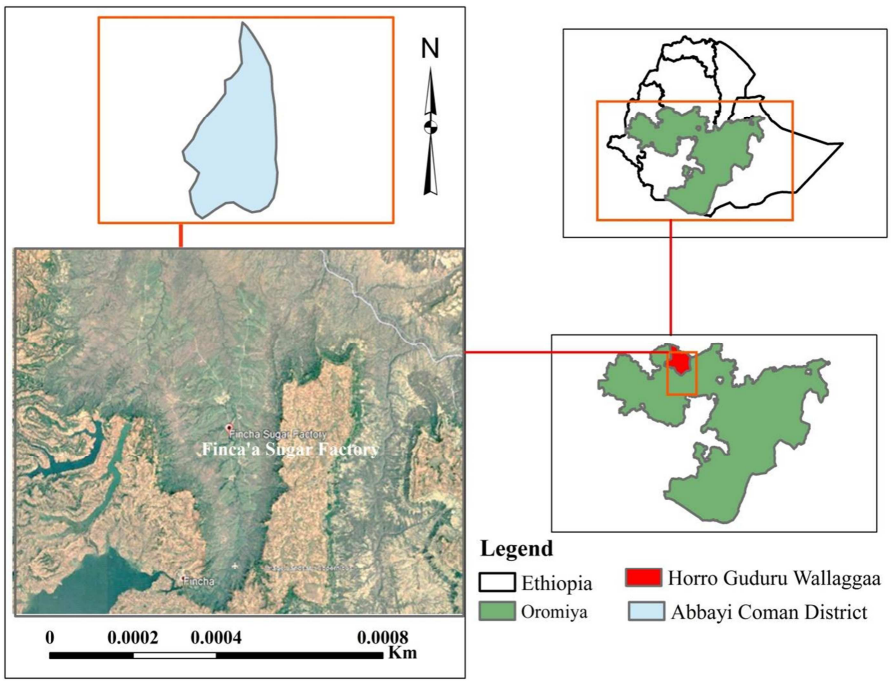

Figure 1. *Map of the study area.*

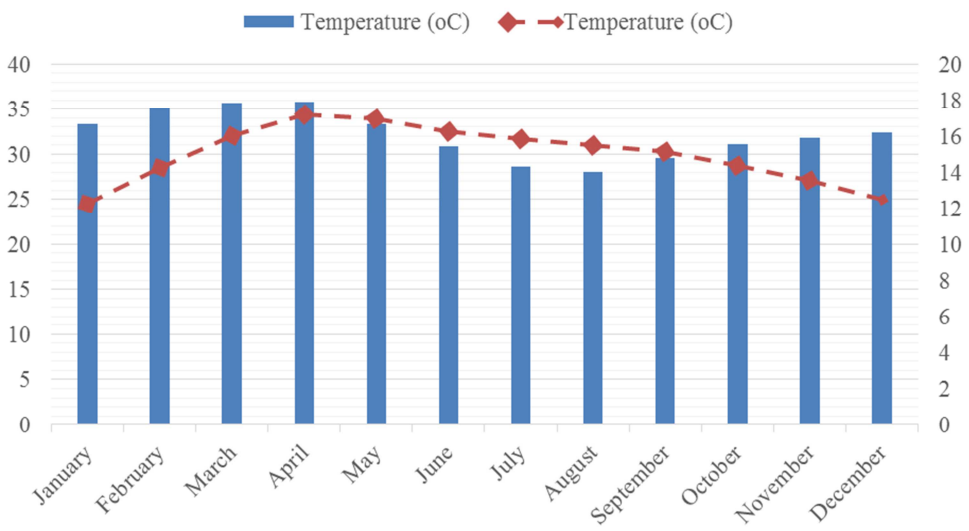

Figure 2. *Temperature of growing period of experimental site.*

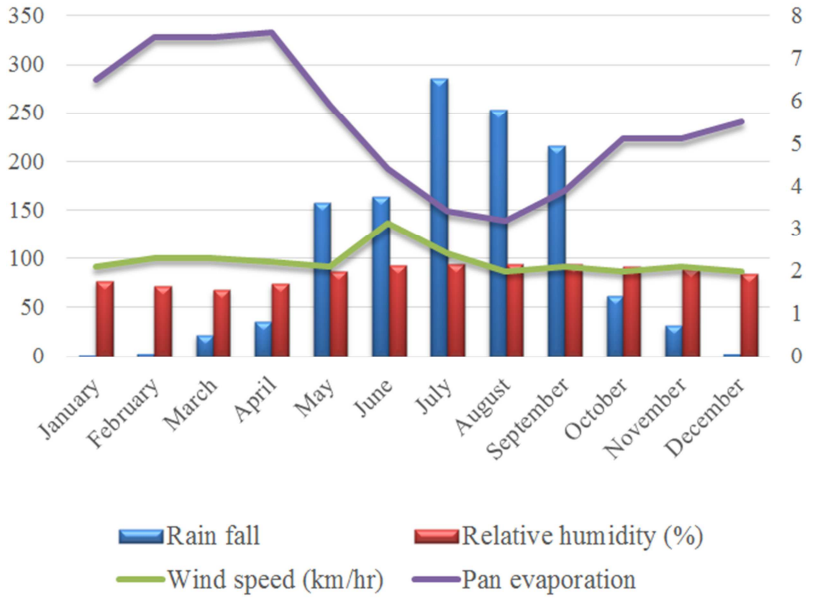

Figure 3. *Rainfall and relative humidity of experimental site.*

2.2. Treatments and Experimental Design

The experiment consists of two factors. Four varieties of sugarcane (B80-250, C86-56, C90-501 and C132-80) and three levels of sugarcane portions (top, middle and bottom). A total of 12 treatments were laid out in a Randomized Complete Block Design with three replications in 4x3 factorial arrangements. The space between furrows and the length of furrows was 1.45m and 5m respectively. The treatment was planted in a plot area of 29 m^2 (4x5x1.45) and each plot consisted of four furrows of five meters in length. In each furrow 20 seed canes with three-budded treatments were planted at 5cm overlap. The distance between adjacent plots and replications is 1.45m and 2.9m respectively.

2.3. Experimental Procedures

The experimental field was prepared following the conventional Finchaa sugar Factory practices. The land was mechanically plowed three times before planting. Twelve months old healthy and three budded sugarcane portions of four varieties were prepared from the PC (planted cane) field of the state. The sugarcane portion were prepared one day before planting. The chopped knives were disinfected with ethanol solution before and during the chopping of the sugarcane stalk in order to prevent diseases from the sugarcane portion. The treated sugarcane portion were planted in the furrow with 5cm overlapping of sett arrangement at 30cm depth on the pre-irrigated experimental. At planting, the conventional recommended rate of 300 kg ha^{-1} NPS fertilizer was equally applied for all experimental plots manually in the furrow. Similarly, as conventional recommended 125kg ha^{-1} of urea (46%N) fertilizer was also applied at 2.5 months (75 days after planting) of the crop age. Sprinkler irrigation was applied two times before planting, at four days intervals during

vegetative growth and at seven days intervals near maturity. Weeding was carried out periodically depending up on the intensity of the weeds. Earthen up was executed at four and half months of the plant age.

2.4. Data Collection and Measurements

Germination percentage, Number of tillers Plant height, plant population, sugarcane weight per stalk, number of internodes per stalk, sugarcane height, sugarcane diameter, number of millable sugarcanes and sugarcane yield Brix Percent Juice and Estimated Recoverable Sucrose.

2.5. Statistical Data Analysis

The data was subjected to General Linear Models (GLM) procedure using SAS software statistical package [10].

3. Results and Discussion

3.1. Crop phenology and Growth Parameter

3.1.1. Germination Percentage

The study revealed that the germination percentage was highly significant (*P<.01*) affected by the interaction effect of sugarcane varieties and sugarcane portions (Table 1). The highest germination percentage (65%) was recorded from top sugarcane portions with C132-80 sugarcane varieties. The lowest germination percentage (19.72) was recorded from the bottom sugarcane portion with C90-501 sugarcane varieties.

Table 1. *Germination (%) of sugarcane as influenced by the interaction of sugarcane varieties and sugarcane portions.*

Sugarcane varieties	Sugarcane portions		
	Top	Middle	Bottom
C90-501	57.22bc	31.96f	19.72h
B80-250	57.78bc	36.13f	25.83g
C86-56	56.00cd	51.00d	43.00e
C132-80	65.00a	61.11ab	34.17f
LSD (0.05)		5.00	
CV (%)		6.61	

Means within the same column and rows followed by the same letter do not differ significantly at 5% probability level; LSD = Least Significant Difference; CV = Coefficient of Variation

3.1.2. Plant Height

Analysis of variance indicated that plant height was highly significantly (p<0.01) affected by the main effect of sugarcane varieties but not affected by the main effect of sugarcane portion and their interaction effect. The tallest plant height (205.03cm) was recorded from variety B80-250 (Table 2). This could be due to genetic difference among varieties in the activity of enzymes and growth regulating hormones. In agreement with this, Habib *et al.* (1991) observed a varietal difference in plant height among sugarcane varieties.

3.1.3. Tillering

Analysis of variance showed that tillering was highly significantly (p<0.01) influenced by the main effect of sugarcane portions and varieties but not affected by their interaction effect. The Highest number of tillers (171552 ha^{-1}) due to the sugarcane portion was obtained from the top portion, while the lowest number of tillers (140029 ha^{-1}) was obtained from the bottom portions (Table 2). The number of tillers per hectare obtained from the sugarcane portion showed an increasing trend from the bottom to the top of the sugarcane portion. This might be due to the presence of very active primordial cells in young buds. The top and middle sugarcane portions contain enzymes that are easily activated under favorable environmental conditions. In agreement with this, Mathur and Singh (1969) [11] found that a higher number of tillers per hectare was obtained from younger sugarcane portions than older ones. Similarly [12] indicated that sugarcane portion age had a significant effect on the number of tillers.

With regards to varieties, the highest number of tillers (175441 ha^{-1}) was obtained from variety C132-80, followed by C86-56 (169425 ha^{-1}). and the lowest number of tillers (128370 ha^{-1}) was obtained from variety C90-501 (Table 2). This could be due to a genetic difference in tillering ability among sugarcane varieties. In line with this,[13] reported that there is a marked clonal difference in sugarcane cuttings taken from different varieties. According to Gilbert [14], sugarcane Varieties differ greatly in their tillering capabilities. Tillering is related to the phenomenon of apical dominance and therefore plant hormones are involved in the process of tillering.

3.2. Yield and Yield Component

3.2.1. Plant Population

Analysis of variance showed that plant populations were highly significantly (P<0.01) influenced by sugarcane portions and significantly (P<0.05) influenced by sugarcane varieties. The highest plant population (108885.00 ha^{-1}) was obtained from the top sugarcane portion (Table 2). The plant population showed a decreasing order from top to bottom in sugar cane portions. The trend of decreasing order of plant population from top to bottom seems to have been seen in the behavior of germination and tillering. The number of plant populations might depend on the tillering potential of the sugarcane variety and portion. Similarly, reports indicated that sugarcane portions had a significant effect on plant population as a result of their effect on sprouting and tillering ability [12].

With regards to sugarcane varieties, the highest plant populations (107088.00 ha^{-1}) were obtained from the sugarcane variety of C132-80. However among the three varieties (C90-501, B80-250 and C86-56) there was no statistical difference in plant population (Table 2). The highest plant population from variety C132-80 might be due to the highest germination and tillering capacity than the remaining three varieties.

Table 2. *The main effect of sugarcane portions and sugarcane varieties on plant height, population and tiller at Fincha sugar factory in 2020-2021.*

Treatment	Plant height (cm)	Plant Population ha^{-1}	Tiller ha^{-1}
sugarcane portion			
Top	183.46	108885.00a	171552.00a
Middle	183.33	99664.00b	162340.00a
Bottom	173.882	94319.00b	140029.00b
LSD	NS	8386	13035.00
Sugarcane Varieties			
C90-501	177.73b	95226.00b	128370.00c
B80-250	205.03a	96887.00b	158659.00b
C86-56	171.81b	104621.00ab	169425.00ab
C132-80	166.32b	107088.00a	175441.00a
LSD	12.26	9683	15051.00
CV	8.66	9.81	9.74

Means within the same column followed by the same letter or by no letters of each factor do not differ significantly at 5% probability level; LSD = Least Significant Difference (P< 0.05); CV = Coefficient of Variation; NS =Non Significant

3.2.2. Sugarcane Weight Per Stalk

Analysis of variance showed that sugarcane weight per stalk was not significantly affected by the main effects of sugarcane portions and varieties and their interaction effects. Even though they are statically non-significant; numerically they are different. Accordingly, the highest sugarcane weight per stalk (1.08kg and 1.05kg) was obtained from the bottom sugarcane portion and variety C132-80 respectively. The lowest sugarcane weight per stalk (0.97 kg and 0.98kg) was obtained from the middle sugarcane portion and variety C90-501 respectively (Table 3). In agreement with this [7] stated that cane weight is more affected by external factors like nutrition, temperature and water supply than sugarcane portion.

3.2.3. Number of Internodes Per Stalk

Analysis of variance indicated that the number of internodes per stalk was highly significantly (P<0.01) affected by the main effect of sugarcane varieties but not affected by the main effect of the sugarcane portion and their interaction effect. The highest number of internodes Per Stalk (18.33 and 18.00) was obtained from varieties C132-80 and C86-56 respectively. The lowest number of internodes per stalk (16.11) was obtained from variety B80-250 (Table 3). This could be due to internal factors affecting the number of internodes. This is in conformity with the findings of [12] which state that sugarcane portion (different portions of the same stalk) has no significant effect on the number of internodes but there is a significant effect of sugarcane varieties on the number of internodes per stalk.

3.2.4. Sugarcane Height

Sugarcane height was highly significantly (p<0.01) affected by the main effect of sugarcane varieties but not significantly affected by the main effect of sugarcane portions and their interaction. The tallest sugarcane height (187.89 cm) was recorded from variety B80-250 whereas the shortest sugarcane height (146.67cm) was obtained from variety C132-80 (Table 3). The difference in sugarcane height might be due to genetic variations in varieties. A similar finding was reported by [7] that, sugarcane height has varietal characteristics which could not be affected by sugarcane portion.

3.2.5. Sugarcane Diameter

Analysis of variance revealed that sugarcane diameter was highly significantly (p<0.01) affected by the main effect of sugarcane varieties and significantly (p<0.05) affected by sugarcane portions. However sugarcane diameter was not significantly affected by the interaction effect. The highest cane diameter (27.67mm) was obtained from the bottom sugarcane portion (Table 3). The highest cane diameter in the bottom could be due to poor germination in the bottom portions that led to the primary shoots being sparsely populated and receiving an adequate quantity of light, water and nutrients for their development. Such favorable growing conditions might have attributed for the higher diameter. In agreement with [15] wider spacing between tillers yields canes with thicker stalks.

With regard to variety, the highest sugarcane diameter (28.56mm and 27.33mm) were obtained from C132-80 and C86-56 respectively (Table 3). The difference could be due to genetic variations. In line with this [12] stated that sugarcane diameter is a varietal characteristic that could not be affected by seed cane age.

Table 3. *The main effect of sugarcane portions and sugarcane varieties on cane weight, number of inter node, cane height and cane diameter at Finchaa sugar factory in 2020/2021.*

Treatment	SCWPS	NIPS	SCH	SCD (mm)
Sugarcane portion				
Top	1.02	17.42	166.83	26.25b
Middle	0.97	16.83	162.00	26.08b
Bottom	1.08	17.83	165.25	27.67a
LSD	NS	NS	NS	1.30
Sugarcane Varieties				

Treatment	SCWPS	NIPS	SCH	SCD (mm)
C90-501	0.98	17.00ab	165.56b	25.67b
B80-250	1.04	16.11b	187.89a	25.11b
C86-56	1.01	18.00a	158.67bc	27.33a
C132-80	1.05	18.33a	146.67c	28.56a
LSD	NS	1.44	14.09	1.50
CV	15.64	8.47	8.74	5.77

Means within the same column followed by the same letter or by no letters of each factor do not differ Significantly at 5% probability level, LSD = Least Significant Difference; NS= Non Significant; CV= Coefficient of Variation; SCWPS=Sugarcane Weight Per Stalk; NIPS = Number of Inter node Per Stalk; SCH = Sugarcane height; SCD = Sugarcane Diameter

3.2.6. Number of Millable Canes

The analysis of variance showed that the number of millable canes was highly significantly ($p<0.01$) affected by the main effect of sugar cane portion and significantly ($p<0.05$) affected by the main effect of sugarcane varieties; but not affected by the interaction effect. The highest number of millable canes (108063 ha^{-1}) was obtained from the top sugarcane portion (Table 4). This could be due to the higher germination and tillering capacity and population of the top portion than the middle and bottom portions of the sugarcane as they were responsible for determining the number of millable canes. This is in agreement with the finding of [16] who stated that germination, number of tillers and stalk population were highest in setts taken from the upper portion of the cane.

With regarding to sugarcane varieties, the highest number of millable canes (106255 ha^{-1}) was recorded from the sugarcane variety C132-80 (Table 4). This might be due to the fact that variety C132-80 was the highest in germination, tillering ability and stalk population than other varieties. This observation is consistent with the finding of [5] that tillering is a critical stage as it determines the number of millable canes.

3.2.7. Sugarcane Yield

Analysis of variance indicated that sugarcane yield was significantly ($p<0.05$) affected by the main effect of sugarcane varieties but not affected by the main effect of sugarcane portions and their interaction. Among the varieties, the highest can yield (112.44 t/ha) was recorded from variety C132-80 (Table 4). The highest sugarcane yield from the C132-80 variety might be due to its higher stalk population, number of millable canes, stalk weight, and stalk diameter than the other three varieties. In line with this [17] stated that Sugarcane yield is primarily dependent on the number of millable canes and sugarcane weight, while sugarcane weight is a function of stalk diameter, stalk length and stalk density. Similarly, the finding of (1990) [18] indicated that both stalk weight and stalk number are important predictors of cane yield. Furthermore [19] stated that yield components are the morphological components that finally make up or decide the sugarcane yield, such as the number of millable canes, average cane weight, cane diameter and stalk length.

3.2.8. Sugar Yield

Sugar yield was significantly ($p<0.05$) affected by the main effect of sugar cane varieties but not by the main effect of sugarcane portions and by the interaction effect. The highest sugar yield (13.00 t/ha and 12.98) was recorded from varieties C86-56 and C132-80 respectively. The lowest sugar yield (10.12 t/ha) was obtained from variety C90-50 (Table 4). The difference in sugar yield among varieties could be due to the inherent characteristics of sugarcane varieties. In agreement with this. [20] stated that sugarcane variety plays a key role in determining sugar yield. Moreover, the better sugar yield might also be due to the better cane weight, cane diameter and stalk number.

Table 4. *The main effect of sugarcane portions and sugarcane varieties on cane yield and sugar yield at Finchaa sugar factory in 2020/2021.*

Treatment	Number of millable canes	Cane yield (t/ha)	Sugar yield (t/ha)
Sugarcane portion			
Top	108063a	106.70	12.44
Middle	98842b	101.89	11.81
Bottom	93505b	97.40	11.20
LSD	8365.70	NS	NS
Sugarcane Varieties			
C90-501	94404b	89.03b	10.12b
B80-250	96088b	97.63ab	11.17ab
C86-56	103799ab	108.89b	13.00a
C132-80	106255a	112.44a	12.98a
LSD	9659.9	16.99	2.28
CV	9.86	17.04	19.73

Means within the same column followed by the same letter or by no letters of each factor do not differ Significantly at 5% probability level, LSD = Least Significant Difference; NS= Non Significant; CV= Coefficient of Variation

3.3. Sugarcane Juice Quality Parameters

Analysis of variance showed that the cane juice brix percent, pol percent, purity percent and recoverable sucrose percent were highly significantly ($p<0.01$) affected by the main effect of sugar cane varieties but not affected by sugarcane portions and their interaction.

Varieties C90-501, C132-80, and C86-56 were not statistically different from each other in brix percent but numerically different. The highest brix percent (19.77%) was obtained from C90-501 whereas the lowest brix (18.59%) was recorded from B80-250 (Table 4). Similarly, in pol present, the lowest pol present (16.18%) was obtained from variety B80-250. However, varieties C90-501, C132-80, and C86-56 were not statistically different from each other but numerically different. The highest pol percent (17.76%) was recorded from variety C90-501 (Table 4). Purity percent also showed that C90-501, C86-56, and C132-80 were not statically different from each other; but numerically different. The highest value of purity percent (89.87%) was recorded from C90-501whereas the lowest value (86.96%) was recorded from B80-250 (Table 4). Similar to the percent of purity, varieties C90-501, C86-56, and C132-80 were not statistically different from each other in recoverable sucrose percent. The lowest recoverable sucrose percent (10.80%) was obtained from variety B80-250. (Table 5). Generally from the above investigation of the four juice quality parameters (brix, pol, purity and recoverable sucrose) variety C90-501 showed the highest value while B80-250 had the lowest value.

According to the South African Sugar Technologists Association [21] the standard recommended values range for brix (18-23%) pol (14-21%) and apparent purity (77-93.5%) As per [22] for a recoverable sucrose level, more than 16% is recommended in the ripening sugarcane juice. In this investigation the three sugarcane juice quality parameters (brix, pol and purity) were found in the required standard values in both treatments; sugarcane portions and varieties. This was an indicator of the ripening of the sugarcane.

The recoverable sucrose percent of the sugarcane for the three sugarcane portions (top, middle, bottom) and sugarcane varieties (C90-501, C132-80, C86-56, B80-250) were lower than the required standard values because the sample was taken as the plant was found under irrigation not entered into the dry off list. This might cause an inversion and dilution of sugar.

Table 5. *The main effect of sugarcane portions and sugarcane varieties on Brix, pol, purity and sucrose of cane juice at Finchaa Sugar Factory in 2020/2021.*

Treatment	Brix (%)	Pol (%)	Purity (%)	Recoverable sucrose (%)
sugarcane portion				
Top	19.26	17.07	88.62	11.55
Middle	19.26	16.93	88.19	11.42
Bottom	19.33	17.35	89.34	11.76
LSD	NS	NS	NS	NS
Sugarcane Variety				
C90-501	19.77a	17.76a	89.87a	12.07a
B80-250	18.59b	16.18b	86.96b	10.80b
C86-56	19.35a	17.25a	89.16a	11.72a
C132-80	19.42a	17.27a	88.89a	11.71a
LSD	0.68	0.64	1.24	0.54
CV	3.60	3.84	1.44	4.77

Means within the same column followed by the same letter or by no letters of each factor do not differ Significantly at 5% probability level, LSD = Least Significant Difference; NS= Non

4. Summary and Conclusions

Sugarcane (*Saccharum officinarum* L.) is the main industrial crop in the world and also the leading crop in terms of production. It is an important crop widely cultivated for multiple purposes by smallholder farmers in sub-Saharan Africa (SSA), including in Ethiopia. The experiment was conducted from January 2020 to February 2021 at Finchaa Sugar Factory to determine the effect of different sugarcane portions and varieties on growth, yield and quality of sugarcane that will enhance the growth and productivity of sugarcane. Based on the results of this study, the top sugarcane portion was superior over the middle and bottom portions in germination capacity, tillering ability and plant population, number of millable canes, sugarcane yield and sugar yield. Sugarcane variety C132-80 was superior over the remaining three treated varieties in germination, growth, and yield. Therefore the top portion and variety C86-56 and C132-80 were recommended for sugarcane production regarding to yield but regarding to sugarcane juice quality parameters (brix, pol, purity and recoverable sucrose), varieties C90-501, C86-56 and C132-80 were recommended for the stud area.

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