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Agronomic performance evaluation of sugarcane varieties under Finchaa Sugar Estate agro-ecological conditions

Abiy Getaneh*, Feyissa Tadesse, Netsanet Ayele and Mijena Bikilla

Sugar Corporation, Research and Training Directorate, Wonji, P. O. Box 15, Ethiopia.

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Field experiment was conducted at Finchaa Sugar Estate, to evaluate and select sugarcane varieties with better agronomic performances under Finchaa agro-ecological condition. Eleven sugarcane varieties are namely, :B58 230, N53 216, N52 219, M202/46, CP47/193, DB386/60, B59 250, COK 30, B60 163, CO 1148, BO 60349 and NCo334 (Check variety) were evaluated in completely randomized block design with three replications. Result indicated that sugarcane variety N53 216 produced significantly highest sugar yield of 1.7 and 1.8 tha^{-1} month^{-1} in Luvisol and Vertisol respectively, and it gave 25 to 28% yield advantage over the check variety NCo 334. The next best variety in sugar yield was BO 60349 (1.4 tha^{-1}month^{-1}) for Luvisol and B60 163 (1.5 tha^{-1}month^{-1}) for Vertisol and it was on par with B58 230 (1.4 tha^{-1}month^{-1} for both Luvisol and Vertisol). Furthermore, except for sugarcane varieties B59 250 in both soil types and varieties N52 219, M202/46 and COK 30 in luvisol the rest were not significantly different from the check variety NCo 334. Thus, the sugarcane varieties N53 216, B58 230, BO 60349, B60 163, CP47/193, DB386/60, and CO 1148 in both soil; whereas N52 219, M202/46 and COK 30 only in luvisol selected to be verified further in large commercial fields at Finchaa Sugar Estate.

Key words: Luvisol, plant cane, ratoon, sugarcane, variety, vertisol.

INTRODUCTION

Sugarcane (*Saccharum* spp.) is an important economic crop in the tropics and sub-tropics due to its high sucrose content and bioenergy potential. Sugarcane in Ethiopia so far the industry does not have its own breeding program it has always been dependent on importing sugarcane varieties and locally evaluating their performance on yield and diseases.

According to Sundara (2000), in order to enhance productivity and profitability of commercial scale sugarcane cultivation, adoption of high yielding varieties and improved production packages are highly demanding. There are number of reasons for lower cane yield and one of those is the planting of low yielding varieties. Therefore, it is need of the time to introduce

*Corresponding author. E-mail: abiygz@gmail.com.

new high yielding varieties with good ratoon ability in the country (Chattha and Ehsanullah, 2003). Variety plays a key role in both increasing and decreasing per unit area sugar yield, while use of unapproved, inferior quality cane varieties affect sugarcane production negatively as situation prevails today (Mian, 2006). The solution of low cane yield and sugar recovery problem lies in the planting of improved cane varieties (Chattha et al., 2006). Varieties differ not only in their yield of cane but also in their juice quality. They also differ in the length of time required to reach maturity. There are also very marked responses to the environment, and even different ecological zones within a country. It is for this reason that, if the best selection is to be made, the final stages in a varietal selection program must incorporate trials in a country that must be representative of all the main ecological zones (James, 2004). Important considerations in choosing an appropriate variety are: cane yield, juice quality, age group, suitability to the growing condition (that is, soil type, irrigation level, season etc.), ratooning potential, and resistance to disease and pest and adverse growing condition (Sundara, 2000).

Efforts are being made to increase cane production by introducing high yielding varieties and adoption of improved crop production techniques (Gill, 1999). Success of variety depends upon its adaptability to agro-climatic conditions of the area. Selection of a proper variety to be sown in a particular agro-ecological zone is a primary requisite to explore its yield and sugar recovery potential. Ratoons are important for overall profitability of sugarcane cultivation as they save about 30% in the operational cost, mainly that of seed and reduced expenses for soil management (Sundara et al., 1992). The inherent potential of a variety to give better yields in plant and ratoon crops is of paramount importance for sustaining high productivity. Acceptance of a variety by the farmers now depends very much on its ratooning potential. Thus, sugarcane varieties, which show good performance in plant and ratoon crops, should be promoted for commercial cultivation. In Ethiopia, even if the country has a fertile soil and favorable environmental condition for sugarcane production its average cane yield is limited to about 104 ton/ha/year (Sugar Corporation, 2011) this could be attributed by many factors, of which lack of improved varieties play central role. For this purpose, the variety improvement strategy should guarantee proper substitution of declining or poor performing commercial varieties from its sugarcane germplasm pool following proper field evaluation. Therefore, the government has developed a strategy to import divers improved sugarcane varieties from around similar ecological locations of the glob to secure the upcoming huge development and expansion in sugar industry.

Accordingly, 10 promising sugarcane varieties from the introduced materials, were promoted and tested under two soil types of Finchaa agro-ecological condition to identify elite candidate for pre-commercial release. Therefore, the present study was conducted to identify better performer variety/varieties in sugar yield under Finchaa agro-ecological condition.

MATERIALS AND METHODS

Description of the study area

The study was conducted at Fincha'a Sugar Estate during 2003/4 to 2008/9 cropping season. The area is found 330 km west of Addis Ababa, and is located at 9° 31' to 10° N latitudes and 37° 15' to 37° 30' E longitude with an elevation between 1350 and 1650 m a.s.l. The area characterized by average annual rainfall of 1280 mm with a mean minimum and maximum temperature of 14.5°C and 30.6°C, respectively. Moisture demand of the crop is supplemented by sprinkler irrigation.

Experimental design and treatments

The study comprised, eleven test varieties that were promoted from disease evaluation trial and a check variety with better adaptation were considered: B58 230, N53 216, N52 219, M202 46, CP47 193, DB386 60, B59 250, COK 30, B60 163, CO 1148, BO 60349 and NCO334 (Check variety).

All the varieties considered in this study were newly introduction to Finchaa Sugar Estate and were selected based on their performance on variety adaptability trials conducted at Wonji - Shoa and/or Metahara Sugar Estates (Aregaw, 1997, 2000). The evaluation was made based on plant cane and two ratoon crops on the two major soil types of Finchaa (Vertisol and Luvisol). The experiment was laid out in a Randomized Complete Block Design with three replications. Each experimental plot had a size of 29.0 m^2 (four furrows of 5 m length and 1.45 m space between furrows). For data collection and observation, only the two middle rows were considered. The distance between plots and within replication was 1.5 and 2.9 m, respectively.

Parameters collected and data analysis

During the course of the experiment sprout percent, tiller count, number of millable canes and growth (height) measurement were taken. Moreover cane yield, cane thickness (girth), number of internodes, percent sucrose and estimated sugar yield were measured at harvest by taking 10 random samples from each plot. Except for the varieties used as treatments in this trial other inputs and field operations on the site were made following conventional practices of the Estate.

Finally, data were subjected to General Linear Models Procedure (GLM) using SAS software statistical package (SAS, 2002) following a procedure appropriate to the design of the experiment (Gomez and Gomez, 1984). The treatment means that were significantly different at 5% levels of significance were separated using the Duncan Multiple Rang Test (DMRT).

RESULTS AND DISCUSSION

Sprouting, tillers and millable canes

Combined analysis of the data on plant cane, 1st and 2nd

Table 1. Pooled mean performance for 9 traits of 12 sugarcane varieties grown at 2 soil types - plant cane.

Varieties (V)	Sprouting (%)	Tiller no. ('000' ha^{-1})	No. of internode	Cane height (cm)	Cane thickness (mm)	Millable cane ('000' ha^{-1})	Cane yield (t ha^{-1} month^{-1})	Sucrose %cane	Sugar yield (t ha^{-1} mon^{-1})
B58 230	60.3^{c}	246.27^{ef}	17.6^{def}	214.5^{fg}	26.6^{b}	130.518^{ef}	11.26^{a}	11.75^{cd}	1.384^{ab}
N53 216	82.5^{a}	289.32^{bcd}	18.5^{cd}	224.8^{ef}	24.7^{c}	148.967^{bc}	10.66^{a}	13.79^{a}	1.483^{a}
N52 219	33.3^{d}	158.35^{h}	20.4^{a}	234.5^{de}	24.8^{c}	103.739^{h}	10.08^{ab}	12.46^{bc}	1.332^{ab}
M202 46	67.0^{bc}	332.53^{a}	16.6^{fg}	206.2^{g}	30.8^{a}	92.531^{h}	9.45^{abc}	10.09^{e}	1.195^{bc}
CP47 193	73.5^{ab}	335.97^{a}	19.9^{ab}	250.9^{bc}	21.0^{e}	167.185^{a}	9.60^{abc}	12.22^{bcd}	1.261^{ab}
DB386 60	73.5^{ab}	319.48^{ab}	17.1^{efg}	228.8^{def}	23.2^{d}	134.080^{def}	7.94^{c}	12.63^{b}	0.983^{cd}
B59 250	43.0^{d}	258.52^{def}	16.4^{g}	240.7^{cd}	19.1^{f}	158.506^{ab}	8.81^{bc}	7.13^{f}	0.793^{d}
COK 30	65.2^{bc}	302.87^{abc}	17.3^{efg}	270.8^{a}	21.6^{e}	143.852^{dc}	11.06^{a}	11.60^{d}	1.384^{ab}
B60 163	73.7^{ab}	190.63^{gh}	17.8^{de}	261.7^{ab}	27.3^{b}	115.575^{g}	8.32^{bc}	11.55^{d}	0.936^{d}
CO 1148	69.5^{bc}	335.37^{a}	19.1^{bc}	273.0^{a}	23.5^{d}	134.600^{de}	10.88^{a}	10.53^{e}	1.243^{ab}
BO 60349	60.7^{c}	268.10^{cde}	18.0^{de}	228.6^{def}	27.0^{b}	121.954^{fg}	9.82^{ab}	11.78^{cd}	1.244^{ab}
NCo 334	42.0^{d}	223.68^{fg}	19.5^{abc}	219.5^{efg}	24.0^{cd}	141.438^{cde}	10.74^{a}	11.60^{d}	1.414^{ab}
LSD (0.5%)	**10.2**	**34.13**	**1.02**	**13.75**	**0.86**	**11.63**	**1.59**	**0.72**	**0.22**
Soils (S									
Luvisol	65.2^{a}	276.30^{a}	18.41^{a}	241.3^{a}	24.7^{a}	126.880^{b}	9.89^{a}	11.47^{a}	1.221^{a}
Vertisol	58.8^{b}	267.203^{a}	17.93^{b}	234.4^{b}	24.3^{b}	138.611^{a}	8.67^{b}	11.38^{a}	1.088^{b}
LSD (0.5%)	**3.9**	**13,933**	**0.42**	**5.6**	**0.35**	**4.75**	**0.58**	**0.29**	**0.078**
V x S	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
CV (%)	**14.14**	**4.84**	**4.84**	**4.97**	**3.03**	**7.54**	**13.84**	**5.40**	**15.33**

Means with the same letter are not significantly different at P≤.05.

ratoon; except tillers of 1st ratoon revealed no interaction between varieties and soil types on percent sprouting, number of tillers and number of millable canes (Appendix Tables 1). Whereas, sugarcane varieties were significantly different from each other on percent sprouting, number of tillers and number of millable canes in all the three cuttings (Tables 1, 2 and 4).

Percent sprouting for twelve sugarcane varieties and the difference among them are presented in Table 1. Remarkably higher percent of sprouting for all varieties were obtained from Luvisol than the one obtained from Vertisol (Table 1), and this result agrees with previous result reported by Worku and Chinawong (2006). Greater percent of sprouting was obtained for varieties N53 216 (82.5%), B60 163(73.7%), CP47 193 (73.5%), DB386 60 (73.5%) and CO 1148 (69.5%).

On plant cane significantly higher number of tillers per hectare was recorded from variety CP47 193 (335. 977 × 10^3), CO1148 (335.345 × 10^3) and DB386 60 (319.483 × 10^3). But there was no statistical difference between the two soil types (Table 1). In first ratoon cane of Luvisol significantly more number of tillers was recorded from variety CO1148 (400 X 10^3), B59 250 (377.24 X 10^3), M202 46 (373.908 × 10^3), and DB386 60 (366.092 × 10^3). On Vertisol, Variety N53 216 (352.299 × 103) produced relatively higher number of tillers followed by M202 46 (346.552 × 10^3), COK 30 (333.334 × 10^3), and B59 250 (320.46 × 10^3) (Table 2). Again N53 216 (345.575 ×10^3) was the 1st in number of tillers of second ratoon, followed by B59 250 (340.345 × 10^3).

Statistically, significantly more number of tillers per hectare was recorded in Luvisol (325.489 × 10^3) than Vertisol (Table 4). In all cuttings variety N52 219 show inferior number of tillers per

Table 2. Pooled mean performance for 8 traits of 12 sugarcane varieties grown at 2 soil types - 1st Ratoon.

Varieties	Tiller no. ('000' ha^{-1})	No. of inter-node	Cane height (cm)	Cane thickness (mm)	Millable cane ('000' ha^{-1})	Cane yield (tha^{-1} $month^{-1}$)	Sucrose % cane	Sugar yield (tha^{-1} $month^{-1}$)
B58 230	314.48[cd]	25.0[bcd]	253.7[e]	25.5[b]	148.80[cde]	12.25[ab]	13.16[cd]	1.61[b]
N53 216	363.39[a]	25.0[bcd]	271.6[de]	23.5[c]	173.16[ab]	13.59[a]	14.06[a]	1.91[a]
N52 219	249.37[e]	26.7[abc]	290.7[bcd]	23.0[c]	133.28[efg]	10.71[bc]	12.65[cd]	1.35[cd]
M202 46	360.23[a]	24.8[bcd]	257.3[e]	29.2[a]	114.19[g]	10.08[bc]	12.12[d]	1.33[d]
CP47 193	318.97[bcd]	27.5[a]	300.2[abc]	20.2[d]	192.99[a]	11.83[bc]	12.67[cd]	1.50[bcd]
DB386 60	330.75[abc]	24.3[cd]	274.6[de]	22.7[c]	141.44[def]	10.63[bc]	13.52[abc]	1.44[cd]
B59 250	348.85[ab]	24.3[cd]	321.4[a]	18.5[e]	191.55[a]	9.05[d]	9.35[e]	0.86[e]
COK 30	343.79[abc]	23.3[d]	317.6[a]	19.7[de]	158.16[bcd]	10.38[cd]	13.30[abc]	1.38[bcd]
B60 163	227.24[e]	25.0[bcd]	285.6[cd]	25.2[b]	128.85[efg]	11.79[bc]	13.58[abc]	1.60[bc]
CO 1148	351.72[a]	25.2[bcd]	313.2[ab]	22.8[c]	133.96[efg]	11.67[bc]	12.83[bcd]	1.50[bcd]
BO 60349	254.77[e]	24.8[bcd]	260.2[e]	25.0[b]	121.54[fg]	10.39[cd]	13.84[ab]	1.44[bcd]
NCo 334	298.62[d]	26.8[ab]	257.0[e]	22.2[c]	168.58[bc]	12.01[bc]	13.13[abcd]	1.58[bc]
LSD (0.5%)	29,192	2.04	23.2	1.33	21.32	1.42	0.95	0.21
Soils (S)								
Luvisol	327.59[a]	30.36[a]	316.1[a]	23.97[a]	142.12[b]	10.82[b]	12.75[a]	1.38[b]
Vertisol	299.44[b]	20.11[b]	251.1[b]	22.25[b]	158.97[a]	11.74[a]	12.93[a]	1.54[a]
LSD (0.5%)	11.92	0.83	9.5	0.54	8.70	0.58	0.39	0.09
V x S	*	**NS**	**NS**	**NS**	**NS**	**NS**	***	**NS**
CV (%)	8.01	6.95	7.04	4.96	12.19	10.87	6.36	12.45

Means with the same letter are not significantly different at P≤0.05.

hectare (Tables 1, 2 and 4), except in Luvisol of 1st ratoon, that is, B60 163 (Table 2). Furthermore both plant cane and first ratoon of all the test varieties were superior in number of tillers than the check variety NCO 334.

The survival of the tillers and reaching the status of millable cane was significantly higher in CP47 193 (167.185×10^3, 192.99×10^3 and 163.74×10^3 in PC, 1St ratoon and 2nd ratoon, respectively) and B59250 (158.506×10^3, 191.55×10^3, and 187.19×10^3 in PC, 1St ratoon and 2nd ratoon, respectively) while it was significantly least in M202 46 in all the three cuttings. The increment in numbers at the early stage of growth and the reduction of stalk population during the growth of sugarcane is a characteristic of several gramineous.

This reduction of stalk population (mortality of cane) could be attributed to the factors which induce competition for light, moisture and nutrient; and the survival of the tillers after the competition is a character of a variety. Thus, in the present finding the variation in survival and mortality rate could be probably attributed to the differences in the genetic makeup of the varieties (Worku and Chinawong, 2006).

Number of inter- node, cane height, and cane thickness (girth)

Analysis of variance of number of inter-nodes, cane height, and cane thickness resulted in significant main effects of varieties and soil types on all the traits for all the three cuttings (plant cane, first and second ratoon). However, their interaction was not significant on any of the traits except on the cane height of the second ratoon (Appendix Table 1).

In number of inter- node variety N52219 and CP47 193 were not significantly different from the

Table 3. The effects of variety and soil type on tiller number and sucrose content - 1st ratoon.

Varieties	Tiller no.		Sucrose % Cane	
	Luvisol	Vertisol	Luvisol	Vertisol
B58 230	323.91^{cd}	305.06^{ab}	13.49^{ab}	12.83^{cd}
N53 216	374.48^{ab}	352.30^{a}	13.37^{ab}	14.76^{a}
N52 219	266.67^{e}f	232.07^{c}	12.14^{bc}	13.15^{bc}
M202 46	373.91^{ab}	346.55^{a}	12.54^{abc}	11.70^{d}
CP47 193	327.701^{cd}	310.23^{ab}	11.02^{cd}	14.31^{ab}
DB386 60	366.09^{ab}	295.40^{ab}	13.30^{ab}	13.74^{abc}
B59 250	377.24^{ab}	320.46^{a}	10.30^{d}	8.40^{e}
COK 30	354.25^{bc}	333.33^{a}	13.21^{ab}	13.39^{abc}
B60 163	220.58g	233.91^{c}	13.82^{ab}	13.34^{bc}
CO 1148	400.00^{a}	303.45^{ab}	12.72^{ab}	12.94^{bcd}
BO 60349	252.87fg	256.67^{bc}	14.12^{a}	13.55^{abc}
NCo 334	293.33^{e}	303.91^{ab}	13.01^{ab}	13.25^{bc}
CV (%)	**6.02**	**9.99**	**7.22**	**5.73**
LSD (0.5%)	**33.38**	**50.69**	**1.56**	**1.26**

Means with the same letter are not significantly different at P≤0.05.

check variety NCO 334 but they were superior when compared with other varieties in all cuttings (PC, 1st and 2nd ratoon), While B59 250, DB386 60, and COK 30 had got the least value.

Regarding cane thickness, significantly thicker cane was obtained from variety M202 46, of all the cuttings (PC, 1st and 2nd ratoon) followed by B60 163, BO60 349, and B58 230. Taller plants were produced by variety CO 1148 in all the three cuttings followed by variety COK 30. The plant height and cane girth are the major contributing factors for high cane yield (Rehman et al., 1992). Similarly, in this work, the variety M202 46 and CO 1148, which recorded the highest in cane girth and plant height, respectively were grouped in the first category for cane yield ha^{-1} month^{-1} (Table 1).

Sucrose content, cane yield, and sugar yield

Combined analysis of variance of the data on cane yield, sucrose content and sugar yield revealed that there is an interaction effect of variety and soil on sucrose content and sugar yield for 1st ratoon crop and sucrose content for 2nd ratoon crop, while no interaction in plant cane, cane yield in 1st ratoon and cane yield and sugar yield in 2nd ratoon (Appendix Table 1).

In plant cane, when both soil types were combined, variety N53 216 was rich in sucrose (13.79%) than other varieties followed by DB386 60 (12.63%), in addition except few varieties like B59 250 (7.13%), M202 46 (10.09%) and CO1148 (10.53%) the rest were better in sucrose content than the check variety NCO 334 (11.60%).

In 1st and 2nd ratoon, B59 250 was the least in sucrose content for both soil types, while M202 46 did so in Vertisol only (Tables 2 and 4). Variety N53 216 is also significantly superior in sucrose content than the check variety in Vertisol of 1st and 2nd ratoon (Tables 3 and 5).

Except lower values of DB386 60, B59 250 and B60 163 for plant cane, B59 250 for 1st ratoon and M202 46 and 386 60 for 2nd ratoon, the total tonnage of the cane per hectare per month of sugarcane varieties were not significantly different from the check variety NCO 334 (Table 1, 2 and 4). Variety N53 216 and B58 230 got the highest ton per hectare per month cane yield consistently over the three cuttings (Table 1, 2 and 4). Same wise when data for both soil types were combined, variety N53 216 outperformed the existing commercial sugarcane varieties in sugar yield (1.48, 1.91, and 1.50 t ha^{-1} month^{-1} for plant cane, 1st ratoon and 2nd ratoon respectively) (TableS 1, 2 and 4). Except DB386 60, B59 250 and B60 163 for plant cane, N53 216 (significantly higher than the check), B59 250 and M202 46 for 1st ratoon and M202 46, DB386 60, B59 250 and B60 163 for 2nd ratoon, the total tonnage of sugar yield per hectare per month of sugarcane varieties were not significantly different from the check variety NCO 334. Variety B59 250 produced the least sugar yield compared to any other variety in all the three cuttings (Table 1, 2 and 4).

Generally, the mean values of cane and sugar yield of the three cuttings indicated that, among the evaluated eleven sugarcane varieties N53 216 and B58 230 were the best performing varieties in both soil types viz. luvisol and vertisol. Beside, BO-60349 and B60/163 were also outstanding sugarcane varieties in sugar yield on luvisol and vertisol, respectively (Table 6). On Luvisol, variety N53 216, BO 60349 and B58 230 gave a sugar yield advantage of 25.7, 5.4 and 4.9% over the check variety

Table 4. Pooled mean Performance for 8 traits of 12 sugarcane varieties grown at 2 soil types - 2nd Ratoon.

Varieties	Tiller no. ('000' ha^{-1})	No. of inter-node	Cane height (cm)	Cane thickness (mm)	Millable cane ('000' ha^{-1})	Cane yield (t ha^{-1} month^{-1})	Sucrose % Cane	Sugar yield (t ha^{-1} month^{-1})
B58 230	302.82^{bcde}	22.9^{cd}	230.7^{d}	24.6^{b}	130.35^{de}	10.22^{ab}	12.43^{de}	1.27^{bc}
N53 216	345.57^{a}	23.9^{bc}	233.1^{d}	24.2^{b}	154.82^{b}	10.78^{a}	13.86^{a}	1.50^{a}
N52 219	245.57^{f}	25.9^{a}	265.3^{b}	22.8^{c}	127.18^{de}	9.38^{abc}	12.95^{bcd}	1.22^{bcd}
M202 46	307.53^{bcd}	24.6^{abc}	256.2^{bc}	29.2^{a}	80.92^{g}	8.32^{c}	12.07^{e}	1.02^{d}
CP47 193	289.94^{cde}	25.4^{ab}	259.6^{bc}	19.2^{e}	163.74^{b}	8.77^{bc}	12.63^{cde}	1.11^{bcd}
DB386 60	292.36^{cde}	22.1^{d}	236.6^{d}	22.3^{c}	121.15^{ef}	8.00^{c}	13.09^{bc}	1.05^{d}
B59 250	340.34^{ab}	21.9^{d}	285.5^{a}	18.4^{e}	187.19^{a}	8.60^{bc}	8.26^{f}	0.71^{e}
COK 30	326.84^{abc}	21.9^{d}	288.6^{a}	21.1^{d}	138.18^{cd}	9.59^{abc}	12.65^{cde}	1.21^{bcd}
B60 163	265.80^{ef}	22.9^{cd}	256.1^{bc}	25.2^{b}	108.39^{f}	8.62^{bc}	12.28^{e}	1.06^{cd}
CO 1148	315.46^{abcd}	25.0^{ab}	292.2^{a}	22.8^{c}	119.65^{ef}	10.25^{ab}	12.06^{e}	1.23^{bcd}
BO 60349	284.77^{de}	24.0^{bc}	241.9^{cd}	25.1^{b}	114.43^{ef}	8.72^{bc}	13.29^{b}	1.15^{bcd}
NCo 334	306.44^{bcd}	24.4^{abc}	233.3^{d}	22.5^{c}	151.09^{bc}	10.10^{ab}	12.95^{bcd}	1.31^{ab}
LSD (0.5%)	**33.67**	**1.55**	**17.25**	**1.10**	**15.21**	**1.43**	**0.525**	**0.19**
Soils (S)								
Luvisol	325.49^{a}	20.97^{b}	263.3^{a}	24.02^{a}	122.17^{b}	9.89^{a}	12.22^{b}	1.22^{a}
Vertisol	278.42^{b}	26.48^{a}	249.9^{b}	22.21^{b}	144.01^{a}	8.67^{b}	12.53^{a}	1.09^{b}
LSD (0.5%)	13.75	0.63	7.04	0.45	6.21	0.58	0.214	0.08
V x S	**NS**	**NS**	**	**NS**	*	**NS**	***	**NS**
CV (%)	9.59	5.62	5.78	4.08	9.83	13.24	3.65	14.31

Means with the same letter are not significantly different at P≤0.05.

NCo 334, respectively. On the other hand, variety N53 216, B60 163 and B58 230 gave a sugar yield advantage of 27.9, 2.1 and 1.5% over the check variety NCo 334 on Vertisol. According to Worku and Chinawong (2006) different performances of the same variety on distinct two soil types might have been attributed to the differential response potential to the environment in which it was grown. In agreement with this result, Dillewijn (1952) and Kakde (1985) reported that the differences in the ability of a variety to extract nutrients from different soil types affected its potential to grow under a given soil condition. Better performance of some varieties on both soil types could perhaps indicate their wide adaptation to different soil types.

CONCLUSION AND RECOMMENDATIONS

Result clearly showed that variety N53 216 and B58 230 produced higher mean cane and sugar yields (ton ha^{-1} month^{-1}) than the check variety NCo 334 in both Vertisol and Luvisol fields of Finchaa.

Besides, variety B60 163 responded well in vertisol in either of cane and sugar yield unlike BO60349 which was better in Luvisol. Whereas variety B59 250 in Luvisol and variety N52 219, B59 250, and COK 30 in Vertisol were significantly inferior in cane and sugar yield. Further, variety M202/46 also significantly inferior in sugar yield than the check variety NCo 334 in Vertisol. On Luvisol, variety N53 216, BO 60349 and B58 230 gave a sugar yield advantage of 25.7, 5.4 and 4.9% over the check variety NCo 334, respectively. On the other hand, variety N53 216, B60 163 and B58 230 gave a sugar yield advantage of 27.9, 2.1 and 1.5% over the check variety NCo 334 on Vertisol. In all the three cuttings (plant cane, first ratoon and second ratoon) apart from other varieties N53 216 had

Table 5. The effect of variety and soil type on cane height, millable cane and sucrose content - 2nd ratoon.

Varieties	Cane height (cm)		Millable cane ('000' ha^{-1})		Sucrose % cane	
	Luvisol	Vertisol	Luvisol	Vertisol	Luvisol	Vertisol
B58 230	229.4^{e}	232.1^{c}	120.92^{bcd}	139.78^{de}	12.19^{c}	12.66^{bc}
N53 216	237.4^{de}	228.8^{c}	140.77^{b}	168.86^{bc}	13.85^{a}	13.86^{a}
N52 219	282.0^{b}	248.6^{bc}	127.59^{bc}	126.78^{ef}	13.15^{ab}	12.74^{bc}
M202 46	271.4^{bc}	241.0^{bc}	71.84^{f}	90.00^{g}	12.42^{bc}	11.72^{d}
CP47 193	273.3^{bc}	245.8^{bc}	140.12^{b}	187.36^{ab}	13.05^{abc}	12.21^{cd}
DB386 60	235.7^{de}	237.5^{c}	104.37^{de}	137.93^{de}	12.34^{bc}	13.83^{a}
B59 250	273.1^{bc}	297.9^{a}	174.49^{a}	199.89^{a}	9.16^{e}	7.36^{e}
COK 30	313.8^{b}	263.3^{b}	128.48^{bc}	147.87^{cde}	12.41^{bc}	12.89^{bc}
B60 163	262.0^{bcd}	250.3^{bc}	86.21^{ef}	130.57^{ef}	11.21^{d}	13.35^{ab}
CO 1148	292.6^{ab}	291.8^{a}	112.42^{cd}	126.90^{ef}	11.34^{d}	12.78^{bc}
BO 60349	246.3^{cde}	237.6^{c}	116.67^{cd}	112.18^{f}	12.54^{bc}	14.05^{a}
NCo 334	242.2^{cde}	224.5^{c}	142.19^{b}	160.00^{cd}	13.02^{abc}	12.89^{bc}
CV (%)	**6.35**	**5.35**	**10.07**	**9.03**	**3.93**	**3.35**
LSD(0.5%)	**28.32**	**22.62**	**20.84**	**22.01**	**0.81**	**0.71**

Means with the same letter are not significantly different at P≤0.05.

Table 6. The 3 cutting mean values of cane and sugar yield of 12 sugarcane varieties grown at 2 soil types.

Var.	Cane Yield (t ha^{-1} month^{-1})								Sugar Yield (t ha^{-1} month^{-1})							
	Luvisol				Vertisol				Luvisol				Vertisol			
	C - I	C - II	C - III	Mean	C - I	C - II	C - III	Mean	C - I	C - II	C - III	Mean	C - I	C - II	C - III	Mean
B58 230	11.48	11.21	11.26	11.32^{AB}	12.55	13.29	9.18	11.67^{AB}	1.344	1.524	1.384	1.417^{B}	1.470	1.702	1.162	1.445^{B}
N53 216	13.43	13.47	10.66	12.52^{A}	13.76	13.70	10.91	12.79^{A}	1.822	1.789	1.483	1.698^{A}	1.927	2.021	1.518	1.822^{A}
N52 219	9.83	11.22	10.09	10.38^{BC}	8.59	10.20	8.68	9.16^{DE}	1.208	1.368	1.332	1.303^{BC}	1.089	1.342	1.111	1.181^{CD}
M202/46	10.04	10.01	9.46	9.83^{CD}	11.11	12.15	7.19	10.15^{BCD}	1.036	1.256	1.195	1.162^{C}	1.085	1.397	0.848	1.110^{D}
CP47/193	10.33	11.29	9.60	10.41^{BC}	11.24	12.38	7.94	10.52^{BCD}	1.246	1.231	1.261	1.246^{BC}	1.378	1.771	0.968	1.372^{BC}
DB386/ 60	10.77	9.99	7.94	9.57^{CD}	10.28	11.26	8.06	9.87^{CD}	1.431	1.336	0.983	1.250^{BC}	1.225	1.548	1.114	1.295^{BCD}
B59 250	6.52	9.81	8.81	8.38^{D}	7.67	8.29	8.39	8.12^{E}	0.478	0.998	0.794	0.756^{D}	0.563	0.712	0.623	0.633^{E}
COK 30	10.38	10.47	11.06	10.64^{BC}	9.75	10.29	8.12	9.39^{DE}	1.186	1.384	1.384	1.318^{BC}	1.145	1.377	1.042	1.188^{CD}
B60 163	12.66	10.36	8.32	10.45^{BC}	12.87	13.21	8.91	11.66^{AB}	1.505	1.432	0.936	1.291^{BC}	1.417	1.765	1.181	1.454^{B}
CO 1148	12.06	10.80	10.88	11.25^{AB}	11.02	12.54	9.62	11.06^{BC}	1.259	1.376	1.243	1.293^{BC}	1.147	1.623	1.215	1.328^{BC}
BO 60349	12.97	10.16	9.82	10.98^{ABC}	12.80	10.61	7.62	10.34^{BCD}	1.597	1.432	1.244	1.424^{B}	1.422	1.440	1.063	1.308^{BCD}
NCo 334	10.46	11.02	10.74	10.74^{BC}	11.36	13.00	9.45	11.27^{ABC}	1.204	1.436	1.413	1.351^{BC}	1.328	1.731	1.212	1.424^{B}

C-I, Cutting one; C-II, cutting two; C-III, cutting three.

got significantly higher amount of cane yield, sucrose percent cane and sugar yield in both soil types, that is, Vertisol and Luvisol. Therefore the present finding clearly indicates that variety N53 216 was performing better than the rest test varieties including the check in both soil types. Furthermore, except for sugarcane varieties B59 250 in both soil types and varieties N52 219, M202/46 and COK 30 in luvisol the rest were not significantly different from the check variety NCo 334. Hence, the sugarcane varieties N53 216, B58 230, BO 60349, B60 163, and CP47/193, DB386/60, and CO 1148 in both soil; whereas N52 219, M202/46 and COK 30 only in Luvisol were selected to be verified further on large commercial fields at Finchaa Sugar Estate.

Conflicts of Interests

The authors have not declared any conflict of interests.

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APPENDIX

Table 1. Combined analysis and their significance from analysis of variance for different parameters of 12 sugarcane varieties grown at 2 soil types (Luvisol and Vertisol).

Source of variation	DF	Sprouting (%)	Tiller no. per ha	Number of inter-node	Cane height	Cane thickness	Millable cane	Cane yield	Sucrose % cane	Sugar yield
Plant cane										
Soil (S)	1	**	NS	**	*	*	***	***	NS	**
Varieties (V)	11	***	***	***	***	***	***	**	***	***
S * V	11	NS	NS	NS	NS	NS	NS	NS	NS	NS
First ratoon										
Soil (S)	1	-	***	***	***	***	***	**	NS	***
Varieties (V)	11	-	***	**	***	***	***	***	***	***
S * V	11	-	*	NS	NS	NS	NS	NS	***	*
Second ratoon										
Soil	1	-	***	***	***	***	***	***	**	**
Varieties	11	-	***	***	***	***	***	**	***	***
S * V	11	-	NS	NS	**	NS	*	NS	***	NS

NB: NS means not significant, * means significant at 0.01% significant level, ** means significant at 1% significant level, ***means significant at 5% significant level