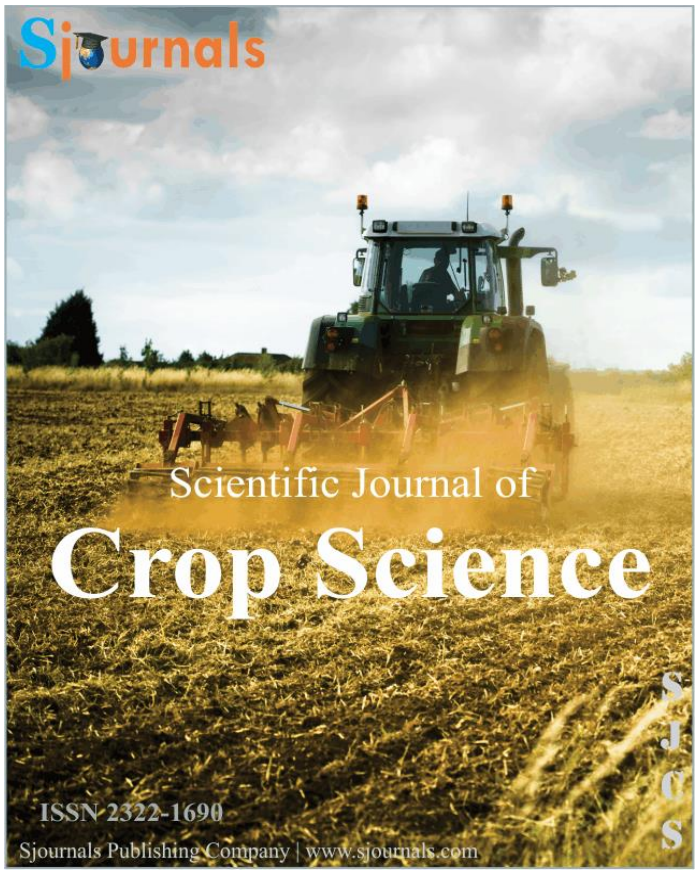

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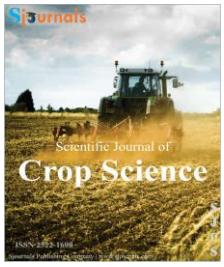

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Original article

New elite sugarcane varieties, 'Tafach Shenkora' and 'Kay Shenkora', for commercial production in Ethiopia

Esayas Tena[a,*], Firew Mekbib[b], Abebech Seife[a], Zinaw Dilnesaw[a], Feyissa Tadesse[a]
[a]*Ethiopian Sugar Corporation, Research and Development, Eastern Shewa Zone, P.O.Box 15, Wonji, Ethiopia.*
[b]*Haramaya University, College of Agriculture and Environmental Sciences, School of Plant Sciences, P.O.Box 138, Dire Dawa, Ethiopia.*

*Corresponding author: esutena11@gmail.com

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ABSTRACT

'Tafach Shenkora' and 'Kay Shenkora' sugarcane (*Saccharum* spp.) are the names assigned to sugarcane varieties with accession numbers Acc. 43 and Acc. 139, respectively. They were developed by Sugar Corporation, Research and Development and were registered and released in June 2019 by the National Variety Releasing Committee of Ethiopia to growers in three sugar estates in Ethiopia. 'Tafach Shenkora' and 'Kay Shenkora' were selected from local landraces collected during 2010/11 from different geographic regions across Ethiopia. The released varieties 'Tafach Shenkora' and 'Kay Shenkora' have high sugar yield (by 29.6% and 28.4%, respectively), early maturity and yield stability across locations compared to the standard check B52298. They also showed resistance to smut caused by *Ustilago scitaminea*. The average sugar yield for Tafach Shenkora and Kay Shenkora was 26.14 and 25.88 tons ha^{-1}, respectively. These cultivars are the first of their kind to be released from sugarcane landraces collected in Ethiopia.

1. Introduction

Sugarcane is the main sugar producing crop in Ethiopia and sugar industry plays a significant role in the socio economy of the country. Sugar consumption outstrips its production in Ethiopia. The per capita sugar consumption

in Ethiopia is very low (5-6 kg) which is below the African standard (15 kg) while the world average per capita consumption is 21 kg in 2016 (ISS, 2017). The commercial sugarcane sector in Ethiopia started in 1951 (ESC, 2019). Today, sugarcane plantations are expanding in different parts of the country with current area coverage of 105,000 hectares and production of 400,000 tons of sugar and 25,388m^3 of ethanol per annum. Currently, the average cane yield production from commercial varieties is around 114 t ha^{-1} (ESC, 2019).

New approaches and techniques are required to meet and to increase the sugar production based on sugar development projects (for both sugar and bio ethanol production). Accordingly, there are plans to increase sugar production to 4.17 m t, and ethanol production to 181 million liter, and factories contribute 709 Mega Watt electric power to the national grid (ESC, 2019).

Sugarcane has been cultivated in homesteads and farmers fields since the 16th century and preceded commercial production (Esayas et al., 2018). Currently sugarcane is produced by smallholder farmers in about 31,236.81ha with 1,565,060 holdings in different parts of the country (CSA, 2017). But the production is not usually used for industrial purposes. It is noticeably used for making confectioneries and household consumption (chewing).

The expansion of the sugarcane plantations in different agro-ecologies of the country necessitates the use of broad genetic based sugarcane varieties that are adaptable and stable under various biotic and abiotic stresses. Local constrains and limitations are also important to be considered in every breeding program (Souri and Hatamian, 2019; Hatamian et al., 2019). Consequently, it is vital to broaden the germplasm base for breeding locally adapted varieties.

At it has never had its own sugarcane breeding program, the sugar industry of Ethiopia since the start has been relying on importation of sugarcane varieties from many source countries to satisfy the varietal requirements of the sugarcane plantations. Importing variety per se is not an easy task and besides all the introduced varieties may not be a successful commercial cultivar or even the selected ones may fail through time. Currently, despite large number of varieties imported only few are in commercial production. These varieties also showed poor adaptability to new agro ecologies and less resistant to disease. This is because the varieties are released to meet objectives of the countries of sources and consequently are less adapted to the country's agro-ecologies and growing conditions (Esayas, 2014). Therefore emphasis should be to bred varieties with own requirements and objectives and locally adapted.

The development of high yielding and stable varieties requires a continuous supply of new germplasm as a source of desirable genes. One of these sources of germplasm are local sugarcane landraces which could be sources of desirable genes that adapt and coevolved with the country's own agro-ecologies and growing conditions.

Accordingly, more than 300 sugarcane landraces of Ethiopia were collected all across the country from different geographic regions (Esayas et al., 2018). These landraces were evaluated with exotic sugarcane varieties that has been introduced to the country since 1951. Promising genotypes were identified among these collections and evaluated in multi-location trials. The objective of the experiment was to evaluate 11 local sugarcane genotypes across locations to select clones with good agronomic performance, high sugar yield and stable across environments and with smut resistance.

'Tafach Shenkora' and 'Kay Shenkora' were selected among these genotypes for their high sugar yield, early maturity, broad adaptability and resistance to smut caused by *Ustilago scitaminea* (Sydow and P. Sydow) better than the standard variety. These varieties were registered by the national variety releasing committee of Ethiopia in June 2019.

2. Materials and methods

2.1. Early selection stages

Landrace sugarcane germplasm collection was made in all geographical regions across Ethiopia during 2010/11. Collections were made from homesteads, farmers' fields, and local markets. More than 300 clones were collected using stratified random sampling technique representing sugarcane growing districts and sub districts. The districts and sub districts were selected based on long agricultural history and relatively wide areas allocated to sugarcane production. Moreover, purposive sampling was also employed based on information supplied by key informants on the uniqueness and quality of sugarcane types grown in these areas. In the selected sub districts

sugarcane clones were collected following the methods proposed in Hawkes (1980). Each distinct morphotype in a village was randomly sampled. Information on the sampled sugarcane germplasm was recorded and passport data was collected following the method of Bioversity International (Hawkes, 1983).

The landraces were planted during 2010/11in a 10-15m double row for each clone at five separate locations across the country in the respective collection areas (Table 1). The planting locations served as quarantine sites where the germplasm stayed for 12 months and were evaluated for disease and insect pests and visual assessment. On the visual assessment (Stage 1), emphasis was placed on vigor and resistance to diseases. Later on the germplasm were transported to commercial fields and a designed experiment was conducted.

Table 1
Summary of the decision process leading to the release of sugarcane cultivars 'Tafach Shenkora and 'Kay Shenkora' in Sugar Estates of Ethiopia.

Year	Month	Stage and selection decision	Genotypes in stage	Locations
2010/11	February	Visual assessment at quarantine sites stage 1	300	5 locations namely: Wondogenet, Jimma, Merawi, Kobo, Dire Dawa
2012/13	February	Stage 2: Selected local clones and introduced varieties planted	400 (174 local and 226 introduced)	Wonji and Metehara Sugar Estates
2014/2015	January	Advanced from plant-cane stage 2 to stage 3	12 (10 local clones and 2 exotic varieties)	Wonji, Metehara and Fincha Sugar Estates
2018	February	Verification on genotypes advanced from stage 3 (first and second ratoon combined data across locations)	5 (4 local clones + 1 standard check)	Wonji, Metehara, Kesem and Fincha Sugar Estates
2019	June	Cultivar release	2 (local clones)	

2.2. Yield trials in commercial fields

Different selection stages were employed in commercial field trials through the routine variety trial procedures (Table 1). In stage 2, a total of 174 landrace clones were selected by visual assessment at quarantine stations and based on information collected from farmers during germplasm collection. These were planted together with 226 introduced varieties at two locations namely Wonji and Metehara Sugar Estates during the 2012/13 growing season. The introduced genotypes for the trial were selected based on place of origin i.e. source countries and different periods of introductions to the country and information from previous field evaluations. The 400 genotypes were planted in a partial balanced lattice design with two replications. Each accession was grown in a single row plot of 5m long and 1.45m between rows.

Data was collected on plant cane on 17 quantitative stalk characters and 4 juice quality parameters and 16 qualitative parameters. For every accession, ten plants were used for recording data for quantitative characters and juice quality parameters which include Brix%, Pol%, Purity% and Sucrose%. Count data and cane yield was recorded considering all cane stalks from the whole plot. Amount of sugar recovered from the cane was obtained by Winter Carp indirect method (James and Chou, 1993). Then, commercial sugar yield per hectare was calculated by the formula:

ESY (t/ha) = CYH (t/ha) x ERS (%); Where ESY=estimated sugar yield, CYH=cane yield per hectare, ERS=estimated recoverable sucrose (%).

From the stage 2 experiment 11 local clones were found to be superior to the standard check B52298 in sugar yield. On the basis of their cane and sugar yields, early maturity and their resistance to smut, 'Tafach Shenkora' and 'Kay Shenkora' were among the 11 genotypes advanced from Stage 2 to Stage 3 in January 2014. During stage 3, these were evaluated together with the standard check in multi-location trial at Wonji, Metehara and Fincha Sugar Estates during 2014/2015 cropping season. The experiment was laid out as RCBD with three replications. Each plot was comprised of six rows, each 5 m long and spaced 1.45 m apart with a plot area of 43.5m^2. The two

border rows were considered guard rows whereas the 4 middle rows were sampling rows and were used for data collection.

In the plant cane and first ratoon crops, ten plants were used for recording data for quantitative characters and juice quality characters as in stage 2. Furthermore, percent field brix was recorded every month until harvest from 10 stalk samples to determine maturity of the cultivars. Cane yield was also recorded in plant cane and first ratoon crops which was recorded on plot basis. Stalks were counted from the four sampling rows. Fifty stalk samples were collected randomly from the sampling rows and weighed and single stalk weight was calculated. The product of stalk weight by stalk number estimated cane yield. Sugar yield was calculated as in stage 2.

2.3. Agronomic and botanical descriptions

Data for the agronomic and botanical descriptions of the cultivars were recorded on 10 mature stalks sampled. Stalks were sampled from the inner rows and the agronomic and botanical characteristics were recorded according to sugarcane descriptors adopted from USDA-ARS (GRIN, 2004).

2.4. Characterization by microsatellite genotyping

Twenty two SSR markers designed in laboratory of department of biotechnology, Sugarcane Breeding Institute, Coimbatore, India were used (Table 2) to generate a genetic fingerprint for 'Tafach Shenkora' and 'Kay Shenkora'. Isolation of DNA was accomplished as described by (Walbot, 1988), and microsatellite amplification was performed using Polyacrylamide Gel Electrophoresis (PAGE). The PCR products were resolved using silver staining procedure. The amplification was visualized under UV illumination using Uvi Tech gel documentation system (DOL-008.XD, England). The genetic fingerprints for 'Tafach Shenkora' and 'Kay Shenkora' were compared with those of cultivar B522298 which was the standard check occupying most of the sugarcane production fields.

Table 2
Size range and number of fragments generated by each of 22 microsatellite primer pairs from sugarcane cultivars 'Tafach Shenkora', 'Kay Shenkora' and B522298.

Primer name	Size range of fragments (bp)	Number of fragments					
		Total (All 3 cultivars)	Polymorphic bands	Tafach Shenkora		Kay Shenkora	
				Total	Unique	Total	Unique
SOMS167	180-900	9	3	8	1	9	-
SOMS166	400-950	4	1	3	-	3	-
SOMS168	130-1400	6	2	5	-	5	-
SOGL37	290-500	7	3	6	2	4	-
SOGL15	250-450	11	8	6	5	8	1
SOGL36	280-1000	7	6	3	-	1	-
SOGL50	100-450	13	8	7	4	9	1
SOMS88	260-540	10	7	6	3	6	2
SOMS169	170-1200	10	5	9	2	5	2
SOMS96	540-780	2	2	1	1	1	1
SOMS119	350-850	4	3	3	2	1	-
SOMS109	280-780	7	6	6	3	1	1
SOMS68	175-1200	11	8	6	4	10	1
SOMS158	260-690	7	3	4	-	4	-
SOGL38	180-840	11	2	10	2	10	-
SOGL41	210-1700	10	7	4	1	10	5
SOMS29	165-650	14	3	11	-	11	-
SOMS143	230-400	5	2	3	1	5	1
SOMS147	240-820	20	9	12	3	17	2
SOMS148	120-700	2	0	2	-	2	-
SOMS173	100-1200	18	8	16	3	16	1
SOGL11	320-600	7	2	6	-	5	1

2.5. Disease reaction

The cultivars were screened for one of the common smut disease in sugarcane plantations of Ethiopia. Screening of the three cultivars was conducted by inoculation testing and/or monitoring for natural infection in the field. Sugarcane smut spore were collected from infected fields of sugarcane commercial farm and its viability was tested before it was used for inoculation. The incubated setts were immersed in the spore suspension (5 x 10^6 spores ml^{-1}) for 30 minutes (Lee-Lovick, 1978). To create favorable condition for infection, the inoculated setts were again incubated in a polythene bag filled with a liter of water just after inoculation.

A day after inoculation, the planting material were planted in Randomized Complete Block Design (RCBD) with three replications at Metehara Sugar Estate field during 2018. Plot size was six furrows of 6 m length each, i.e. $52.^2$ m^2.

During the course of the experiment, data on smuted stool count/observation begins six weeks after planting and continues at 10-day intervals till ten months after planting. Total number of stool count was taken at four months after planting. After recording smut affected stools, they were uprooted and buried at the edge of the field. Disease rating scale for smut was made based on percentage of infected stools by adopting the scale used by (Latiza et al., 1980).

2.6. Statistical analyses

Analyses were done using PROC GLM of SAS version 9.1 (SAS Institute, 2003). Data were analyzed for each crop cycle separately and analyses was also conducted with the combined data of the locations and plant-cane and first-ratoon crops. Differences among genotypes for yield components, cane yield and sugar quality traits were declared significant by comparison of means using the Least Significant Difference (LSD) at 5% probability. Principal component analysis was performed on the traits using SAS software V9 in order to study the relationship among the genotypes.

3. Results and discussion

3.1. Characteristics field performance

'Tafach Shenkora' and 'Kay Shenkora' were tested in multi-location trial in six harvests at three trial locations in Wonji, Metehara and Fincha Sugar Estates during the 2014-2015 (three plant cane harvests) and 2015-2016 (three first-ratoon harvests). Agronomic characters like single stalk weight, plant height and millable number of cane of 'Tafach Shenkora' and 'Kay Shenkora' were significantly higher than that of the respective reference cultivar B522298 in both plant cane and first ratoon crops. There was also significant difference when the data was combined across locations and crop cycles (Table 3). Cane and sugar yield of both new cultivars were also higher than the reference cultivar in both crop types when averaged over locations (Table 3). The cultivars also showed stability of performance for sugar yield across locations based on AMMI and GGE analysis (data not shown).

The same trend was found in principal component analysis regarding the traits most contributed to the variation. In this study, the first three components which had eigenvalues greater than one and cumulatively explained 95% of the total variation among the accessions were considered (Table 4). The first principal component (PC) alone explained 51% of the total variation, mainly due to variation in the stalk height, stem diameter, single cane weight, cane yield, pol percent and purity percent. Characters which contributed more to the second PC accounted for 31% of the total variation and were dominated by traits such as milleable cane number, stalk diameter, single cane weight, cane yield and brix percent. The first and second PC together explained 83% of the variation. High component loadings were also found due to cane and sugar yield and pol percent and sugar percent in the third PC. Muyco, (2000) found 4 principal components giving rise to 76% variation in the data, with the first component comprising juice quality, yield and stalk diameter traits. Mohammad et al. (2013) also found two principal components explaining 88% of the variation with high loading of yield on Component 1 and quality characters like sugar percent, pol%, and purity% loading well on Component 2.

This was further explained by the PCA biplot (Figure 1). The PCA biplot provide an overview of the similarities and differences between the quantitative traits of the different accessions and of

Table 3
Combined over locations of plant cane, ratoon crop and overall mean of major agronomic traits and yield of 'Tafach Shenkora', 'Kay Shenkora' and reference cultivar B52298.

	Crop cycle		
	Plant cane	**First ratoon**	**Mean**
Cultivar	**Single stalk weight (kg)**		
'Tafach Shenkora'	1.86**(SD±0.43)	1.52**(SD±0.49)	1.69**(SD±0.47)
'Kay Shenkora'	1.74**(SD±0.50)	1.52**(SD±0.29)	1.63**(SD±0.40)
B522298	1.57(SD±0.32)	1.14(SD±0.17)	1.36(SD±0.33)
F	3.90	24.49	2.49
P	<0.01	<0.01	<0.01
	Milleable cane number		
'Tafach Shenkora'	149425**(SD±41044)	102472**(SD±14425)	125948**(SD±38230)
'Kay Shenkora'	135403**(SD±49620)	111667**(SD±8331)	123535**(SD±36116)
B522298	118391(SD±24665)	116017(SD±2917)	117204(SD±16791)
F	3.00	31.94	2.58
P	<0.01	<0.01	<0.01
	Stalk height		
'Tafach Shenkora'	2.64**(SD±0.48)	2.21**(SD±0.34)	2.43**(SD±0.46)
'Kay Shenkora'	2.41**(SD±0.65)	2.36**(SD±0.18)	2.38*(SD±0.46)
B522298	1.92(SD±0.26)	1.91(SD±0.23)	1.92(SD±0.24)
F	3.14	33.78	14.4
P	<0.01	<0.01	<0.01
	Cane yield (t/ha)		
'Tafach Shenkora'	276.17**(SD±83.41)	152.13**(SD±40.25)	214.15**(SD±89.97)
'Kay Shenkora'	244.68**(SD±125.96)	170.15**(SD±40.47)	207.41**(SD±97.32)
B522298	175.7(SD±70.29)	132.83(SD±21.62)	154.26(SD±54.41)
F	1.16	4.40	3.4
P	NS	<0.01	<0.01
	Sugar yield (t/ha)		
'Tafach Shenkora'	36.55**(SD±12.18)	15.74**(SD±5.74)	26.15**(SD±14.16)
'Kay Shenkora'	33.07**(SD±18.43)	18.69**(SD±5.59)	25.88**(SD±15.00)
B522298	23.23(SD±9.60)	17.09(SD±3.92)	20.15(SD ±7.69)
F	1.12	3.08	5.31
P	NS	<0.01	<0.01

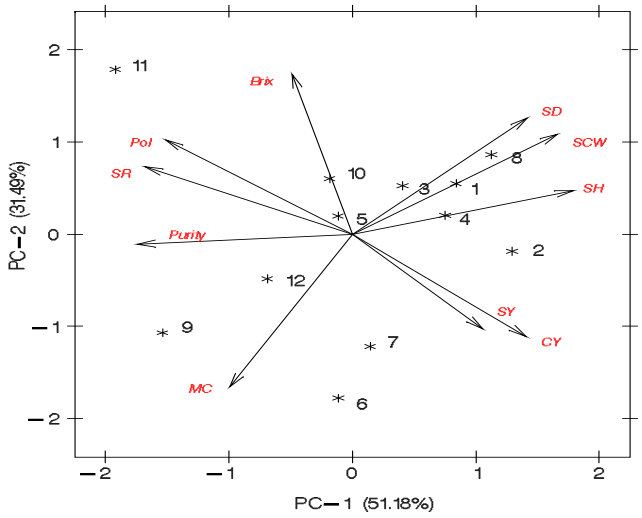

Fig. 1. Genotype by Trait (GT) biplot of 12 sugarcane genotypes. Characters are denoted by abbreviations as in

Table 4 (Genotypes: 1=Kay Sidancho; 2=Tafach Shenkora; 3=Wotete; 4=Kay Shenkora; 5=Nach Shenkora; 6=YeBeskula Shenkora; 7=Aladi; 8=Erero; 9=Bahir; 10=Wonji RD-1; 11=B52298; 12=NCO334).

Table 4
Principal component analysis of 10 quantitative characters in 12 sugarcane genotypes showing eigenvectors, eigenvalues, individual and cumulative percentage of variation explained by the first three PC axes.

	Eigenvectors		
Characters	**PC1**	**PC2**	**PC3**
Milleable cane number (MC)	-0.22	-0.47	0.14
Stalk height (SH)	0.40	0.13	0.26
Stem diameter (SD)	0.31	0.35	0.01
Single cane weight (SCW)	0.37	0.31	0.03
Cane yield (CY)	0.31	-0.31	0.39
Sugar yield (SY)	0.23	-0.29	0.62
Brix percent (Brix)	-0.11	0.49	0.34
Pol percent (Pol)	-0.34	0.29	0.32
Purity percent (Purity)	-0.39	-0.03	0.20
Sugar percent (SR)	-0.37	0.21	0.35
Eigen value	5.12	3.15	1.19
Individual%	0.51	0.31	0.12
Cumulative%	0.51	0.83	0.95

the interrelationships between the measured variables. The biplot demarcated the accessions with characteristics most explained by the first two dimensions. The first and the second PCs explained the most variation among the accessions, revealing a high degree of association among the characters studied. Millable stalk count, single cane weight, stalk diameter, cane yield, sugar yield and sugar quality parameters brix%, pol%, and sugar% showed high positive loading on these two PCs.

3.2. Agronomic, botanical and molecular descriptions

The agronomic and botanical descriptions of the released and reference cultivars is given in Table 5. The mean stalk height (ground level to top visible dewlap) of 'Tafach Shenkora' and 'Kay Shenkora' was 2.64 and 2.41 m, respectively, compared to the check (1.92 m) while the mean diameter of the stalk was 2.82 and 2.87 cm respectively which is larger than the reference cultivar (2.73). The recoverable sugar percent of Tafach Shenkora' (13.94) and 'Kay Shenkora' (14.03) was higher than that of the reference cultivar B52298 (12.72). The fiber and reducing sugar content of 'Tafach Shenkora' and 'Kay Shenkora' was (13.13% and 0.44%) and (12.13% and 0.40%), respectively (Table 5).

The released cultivars mature earlier than the reference cultivar (data not shown), where days to maturity in 'Tafach Shenkora' was 390-420 days after planting (DAP), 'Kay Shenkora' 420-450 DAP and 540-660 DAP in B52298.

The leaf shape of 'Tafach Shenkora' was erect where as that of 'Kay Shenkora' was ascending with drooping tip (Table 5). The leaf length of 'Tafach Shenkora' was higher than the other released cultivar and the check while the leaf width of all the three cultivars was comparable. The bud in 'Kay Shenkora' was medium and round; with bud cushion present and bud extends touching the growth ring and no bud groove was present. The auricle shape was long lanceolate.

Likewise in 'Kay Shenkora' it was medium and round with central germpore; with bud cushion present and bud extend below growth ring; it had also shallow short bud groove. The shape of auricle in this cultivar was falcate.

Table 5
Agronomic and botanical descriptions of 'Tafach Shenkora', 'Kay Shenkora' and reference cultivar B52298.

Characteristics	**'Tafach Shenkora'**	**'Kay Shenkora'**	**B522298**
Adaptation	Wonji, Metehara, Fincha and areas with similar agro-ecology		Wonji, Metehara, Fincha
Altitude (masl)	950-1650	950-1650	950-1650
Fertilizer rate			
DAP (kg ha^{-1})	0	0	0
Urea (kg ha^{-1})	Wonji (200), Metehara (400) and Fincha (125)	Wonji (200), Metehara (400) and Fincha (125)	Wonji (200), Metehara (400) and Fincha (125)
Seed rate (Number of setts ha^{-1})	68966	70000	89655
Spacing (inter x intra row)	0 (end-to-end) x 1.45m	0 (end-to-end) x 1.45m	0 (end-to-end) x 1.45m
Planting date	January to March	January to March	January to March
Stalk height (m)	2.83	2.82	1.97
Stalk diameter (cm)	2.85	2.89	2.76
Recoverable Sugar (%)	13.94	14.03	12.72
Fiber (%)	13.13	12.13	13.13
Reducing sugar (%)	0.44	0.40	0.36
Days to maturity	390-420	420-450	540-660
Leaf shape	erect	Ascending with drooping tip	Ascending with drooping tip
Leaf length (cm)	150.53	124.55	147.63
Leaf width (cm)	4.23	4.20	4.28
Buds	Medium and round; with bud cushion present and bud extends touching the growth ring	Medium and round with central germpore; with bud cushion present and bud extend below growth ring.	Tall deltoid with buds extending above growth ring.
Bud groove	No	Shallow short bud groove	Short bud groove
Auricle shape	Long lanceolate	Falcate	Transitional
Internode			
Length (cm)	9.92	9.85	7.68
Shape	Cylindrical	Conoidal	Tumescent
Shape of dewlap	Double crescent	Squarish deltoid	Double crescent
Ligule shape	Crescent with lozenge	Broad-crescent	Orbicular-crescent

The internode shape of 'Tafach Shenkora' was cylindrical compared to the conoidal shape of 'Kay Shenkora' with internode lengths of 9.92 and 9.85 cm, respectively. The dewlap and ligule shape in the two cultivars, respectively, were double crescent and squarish deltoid and crescent with lozenge and broad-crescent. The botanical description of the reference cultivar B522298 was different from those of the released cultivars (Table 5).

Twenty two microsatellite primer pairs amplified 195 fragments, ranging from 100 to 1700 bp, in 'Tafach Shenkora', 'Kay Shenkora' and B522298 (Table 2). Of these fragments, 98 were polymorphic and 97 were monomorphic among the three genotypes. The number of fragments amplified in 'Tafach Shenkora' ranged from 1 (SOMS96) to 16 (SOMS173) where as in 'Kay Shenkora' it ranged from 1 (SOGL36, SOMS96, SOMS119 and SOMS109) to 17 (SOMS147). Unique fragments were identified for each cultivar, but there were also some overlapping fragments (Table 2). Fragments unique to 'Tafach Shenkora' were identified in the fingerprints obtained with the primer pairs SOMS167 (400 bp), SOGL37 (1100 and 900 bp), SOGL15 (900 and 500-100 bp), SOGL50 (1100, 800, 360, 180 and 160 bp), SOMS88 (1500, 1100, 100 and 600 bp), SOMS169 (400 and 360 bp), SOMS96 (1500 bp), SOMS119 (1000 and 800 bp), SOMS109 (1300, 1100, and1000 bp) , SOMS68 (1100, 800 and

700 bp), SOGL38 (800 and 180 bp), SOGL41 (200 bp), SOMS143 (400 bp), SOMS147 (1500, 500 and 120 bp) and SOMS173 (100, 900 and 200 bp).

Similarly in 'Kay Shenkora' unique fragments were identified in SOGL15 (800 bp), SOGL50 (240 bp), SOMS88 (1300 and 900 bp), SOMS169 (800 and 320 bp), SOMS96 (900 bp), SOMS109 (800 bp), SOGL41 (900 and 700-400 bp), SOMS143 (240 bp), SOMS147 (240 and 200 bp), SOMS173 (500 bp) and SOGL11 (800 bp).

3.3. Disease reaction

The method of artificial inoculation by cuttings immersion in a suspension of smut spores of sugarcane, resulted to be effective to evaluate the resistant of this illness in experimental materials of sugarcane. In this study a total of 11 local sugarcane genotypes and one widely grown commercial check cultivar B52298 has shown variable reaction to sugarcane smut isolates. On the basis these results, 'Tafach Shenkora' and 'Kay Shenkora' were found resistant to smut (Table 6). The reference cultivar B52298 was moderately resistant. Different sugarcane cultivars in the world may react differently to sugarcane smut isolates depending on the environment Nzioki et al. (2010).

Table 6
Smut disease reactions of 'Tafach Shenkora', 'Kay Shenkora' and B52298.

Cultivar	Infected stool incidence (%)	Disease rating	Reaction
'Tafach Shenkora'	6.9	3	R*
'Kay Shenkora'	6.6	3	R
B52298	11.3	4	MR

*R=resistant; MR=moderately resistant; MS= moderately susceptible; S=susceptible.

4. Conclusion

'Tafach Shenkora' and 'Kay Shenkora' are elite sugarcane cultivars that are notable for their high cane and sugar yields compared with commercial reference cultivar. These cultivars also exhibit resistance to sugarcane smut disease which is an economical disease in Ethiopian sugarcane plantations and mature early. These cultivars are the first of their kind to be released from sugarcane landraces collected in Ethiopia. This is an important information asserting the need to maintain the diversity of the Ethiopian sugarcane germplasm for further improvement of the crop in future sugarcane breeding program of Ethiopia.

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