Evaluation of Some New Sugarcane Varieties for Yield and Yield Components under Coastal Climatic Conditions

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DOI:10.5281/zenodo.4009374

Abstract

Commercial sugarcane production entails the cultivation of varieties characterized with high cane yield content for specific agro-ecological conditions. A Field study was conducted at Ramisi area, Kwale county in the coastal lowlands of Kenya, during the 2015-2017 cropping seasons to evaluate the yield components and yield of seven sugarcane varieties; KEN 82-808, KEN 83-737, CO 945, CB 38-22, N14, D8484, CO 421 was used as control. The trial was laid out in a randomized complete block design and replicated 4 times. Significant differences (p<0.05) were observed among test varieties on parameters measured; stalk length, stalk diameter, number of millable cane, and fresh cane yield in both plant and ratoon crops. Plant cane recorded higher mean values on quantitative parameters investigated compared to ratoon crops. Varieties D8484 136.8 tons of cane per hectare (tha-1) 39% and CO 945 (130.9 tha-1) 10% yielded higher than control CO 421 (119.4tha-1) in plant crop, while CO 945 surpassed the yield of control in the ratoon crop. In the pooled analysis, KEN 82-808 recorded longest stalk length of 270 cm which was statistically at par with control 241 cm, CB 38-22, CO945, and KEN 83-737, and the lowest stalk length 222.2 cm posted on N14. Mean stem diameter was significant amongst test varieties, highest 2.86cm (D 8484) that surpassed check 2.64 cm, which was significantly at par with CO 945 and CB 38-22 while the lowest diameter 2.31 cm was on KEN 82-808. The response of varieties to millable cane was significant with variety N14 - 92.8 (000 ha-1) surpassing CO 421(control) 80.3 (000 ha-1) and lowest was 56.7 (000 ha-1) D 8484. Cane yield, CO 945 yielded the highest 118.7 tch surpassing check CO 421 at 108.4 tcha-1 and the lowest yield was 84.5 tch by KEN83-737.

Key words: cane yield, sugarcane, variety, coastal lowlands, Kenya.

Introduction

Sugarcane (*Saccharum officinarum L.*) is a commercial crop grown in tropical and sub-tropical regions for sugar production. In Kenya, the sugar industry plays an important role in the country's economy, it employs approximately over 14 % percent of Kenyan population both directly and indirectly. It is the main source of income to over 260,000 small scale farmers who supply over 90% of milled cane while remaining is by large scale farmers and factories nucleus estates. Area under sugarcane production is approximately 283,523 hectares, with an approximate annual sugar production of 550,000 metric tons against annual requirement of 750,000 metric tons [18] Wawire et al. (2011)). The deficit is met through imports mainly from Common Market for Eastern and Southern Africa (COMESA) member countries of which Kenya is a member.

In Kenya sugarcane is cultivated in 14 counties across diverse agro-ecological zones at elevations 15-2000 meters above sea level. In coastal part of the country, sugarcane is currently grown in Kwale county with potential in Tana River and Lamu counties. Although sugarcane production at the coast began in 1927 in Ramisi area, Kwale County, disruptions in mid 1980s led to closure of the only milling factory. However, in 2007 the government, revived sugarcane production to help bridge the existing deficit, through establishment of a sugar factory in the coastal region, Kwale international Sugar company (KISCOL) which commenced milling in 2015.Currently area under cane production is approximately 7000 hectares in nucleus and 3000 hectares in out growers respectively.

Upon revival of commercial cane production, six varieties were identified to jump start commercial production in the region; CO 945, D 8484, N14, KEN 83-737, CB 38-22 and CO 421 [17] (Ong'injo & Olweny,2009). Varieties D8484, KEN 83-737 and KEN 82-808 were released for commercial production in last decade see table 1, the last 2 varieties are products of Kenyan breeding program run by Sugar research institute. Variety CO 421 which has been cultivated for over 7 decades [9] Jamoza, (2005) occupies approximately 40% of area under cane production in the region table 1, however it is highly susceptible to smut, with poor ratooning ability [16] Ong'ala et al. (2016).

Sugarcane yield is complex and important quantitative trait influenced by interplay of many contributing components, which are largely associated with variety, genetic and environmental interactions. The components for cane yield are; stalk length, stalk diameter, number of millable stalks and weight of individual cane stalks at harvest. Previous studies have indicated yield of cane to be associated with stalk height, number of internodes, number of millable stalks, stalk weight of individual stalks and correlation among these traits. [13]Milligan et al. (1996.) suggested sugarcane traits such as stalk length, stalk diameter, number of millable cane and stalk weight as being indicative of cane and sugar yield. [3] Amolo & Abayo (2011) while evaluating effect of plant populations and planting patterns on yield components reported variety influenced stalk weight, girth and stalk numbers. [15] Omoto, Rono & Abayo (2011) reported cane yield was positively correlated to stalk numbers, stalk diameter and stalk length in some varieties and that varieties differ in their performance in quality and quantitative traits largely due to variation in their genetic makeup and responses to environment in which they are cultivated.
Sugarcane ratoon crops are equally important because they contribute to the overall profitability of sugarcane production enterprise, since ratoon crops are less costly due to savings of about 30% on operational costs such as reduced expenses on seed cane, land preparation and soil amelioration [9] Jamoza, (2005). The inherent ability of a variety to give good yields in ratoon and plant crop is important in sustaining high productivity both for growers and millers is desired. The choice of suitable variety for cultivation in particular agro-ecological zone offers an opportunity to exploit its full cane yield potential per unit area. Therefore, its important varieties chosen for cultivation in a given agro-ecological zone exhibit and sustain good performance in terms of high cane yields in plant and subsequent ratoon crops.
Coastal region presents a unique agroclimatic conditions in terms of heat units, humidity and precipitation suitable for sugarcane production, depending on cultivar plant crops matures between12-14 months and ratoons 8-11 months compared to average of 18 months in other regions in the country [18] Wawire et al. (2011).There is need to identify, promote and preserve cultivation of climate smart and resilient varieties, resistant to smut, with the ability to produce good cane yield across crop cycles in the region. The objective of the study therefore was to evaluate yield and yield components of some new sugarcane varieties under coastal lowland agro climatic conditions.

Materials and Methods

The study was conducted during 2015 to 2017 cropping seasons in Kwale County at the Kenyan coast. Site is located at 4°31'46.0"S, 39°23'43.0"E., at an elevation of 50 feet above sea level. Mean annual temperature ranges between 24^0 - 26.6^0 c, average annual rainfall is 1200 mm per annum and is bimodal pattern with long rains starting in April – August while short rains season runs from October to December. Area is categorized as coastal lowlands (CL3) agroecological zone as described by [10] Jaetold et al. (2012). The soils are predominantly sandy to sandy loam with PH range 6-7.

2.1 Experimental materials, layout and design:

The trial composed of seven commercial sugarcane varieties namely Varieties KEN 82-808, KEN 83-737 are both bred in Kenya and rest introduced from outside the country (table 1). Randomized complete block design was used and replicated four times. The experimental plots consisted of three double rows, 8 m long and 1.9 m row to row spacing with paths of 2 m between adjacent plots and spacing of 2.5 m between replications.

Table 1: Sugarcane varieties origin and area under cultivation by percentage - Coastal belt.

No	Variety	Country of origin	Year of release	area coverage %
1	KEN 82-808	Kenya	2002	20
2	KEN 83-737	Kenya	2002	26
3	D8484	Demerara, Guyana	2007	1
4	N 14	Natal, South Africa	1998	3
5	CO 421	Coimbatore, India	-	39.2
6	CO 945	Coimbatore, India	1990	5.5
7	CB 38-22	Coimbatore. Brazil	1998	0.3

Source: AFFA sugar directorate.

2.2 Crop establishment and management

Planting fields were disc ploughed, harrowed and furrows made at depth of 20 - 25 cm at distance of 1.9m furrow to furrow. Forty-six (46) 3 eye bud setts were planted in each row using overlapping planting method, insecticide confidor WG 70 150 gm ha^{-1} and bayleton (Triadimefon) a water emulsion was sprayed on the setts in furrows at the rate of 3 litre ha^{-1} and grams ha^{-1} to control insects and soil born fungal diseases. During planting, fertilizers diammonium phosphate (DAP) applied at 200kg ha^{-1} (92kg P_2O_5 ha^{-1}) and Muriate of potash (MOP) 200kg ha^{-1} (120 kg, K ha^{-1}). Urea (46% N) fertilizer was used as a source of nitrogen, applied at rate of 300 kg ha^{-1} in two equal splits when the crop was 2 and 4 months after planting. Manual weeding was done monthly for first 4 months and later at 2 months interval.

2.3 Data collection

Parameter for data collection were; plant heights, diameter, number of millable stalks at 7, 9 months and at 12 and 11 months after planting for plant and first ratoon crops respectively. Ten millable sugarcane stalks were randomly selected from middle rows and one meter from borders for final measurements of stalk height, stalk thickness(diameter). Stalk thickness was measured at the midpoint of stalks sampled with reference to eye bud using a Vernier caliper. The stalk length was determined by measuring stalks using a graduated ruler from the ground level to the top visible dewlap, while stalk population was determined by counting all stalks per net plot per treatment and converted to stalks per hectare. Cane yield was done by manual harvesting, weight obtained on fresh cane yield per plot, thereafter computed to tons of cane per hectare (tcha^{-1}).

2.4 Data analysis.

Data were subjected to analysis of variance first individual crop cycles (plant crop (PC)and ratoon crop (FRC) and there after pooled crops data (PC and FRC) using General Linear Model procedure of statistical analysis for randomized complete blocks design using GenStat version 15.0. The treatment means were separated using the least significance difference (LSD) at 5 % level.

Results and Discussions

Table 2. Means of agronomic traits by variety and crop cycles of 7 Genotypes.

Treatments (Variety)	Plant crop (PC)				First ratoon crop (FRC)			
	Stalk length (cm)	Stalk girth (cm)	Stalk population ('000' ha^{-1})	Tons of cane ha^{-1}	Stalk length (cm)	Stalk girth(cm)	Stalk population ('000' ha^{-1})	Tons of cane per hectare (TCH)
CB 38-22	267.6a	2.63b	66.1d	103.6bcd	261.6	2.63ab	57.7c	68.9d
CO 421	251.2ab	2.73b	77.4c	119.4abc	232.2	2.55abc	83.2ab	97.4ab
CO 945	256.5ab	2.66b	82.8b	130.9a	248.7	2.65ab	77.6b	106.4a
D 8484	279.6ab	2.93a	65.9d	136.8a	258.4	2.79a	47.20c	82.6bc
KEN 82-808	290.3a	2.37c	85.5ab	120.3ab	249.7	2.26c	80.9ab	80.7bc
KEN 83-737	260ab	2.3c	77.9c	91.5d	230.5	2.39b	78.4b	77.5c
N14	229b	2.31c	90.6a	98.6bcd	215.4a	2.36b	91.10a	92.1abc
Overall mean	262.2	2.56	77.7	114.5	242.2	2.52	73.7	86.5
CV%	3.7	2.4	6.5	10.2	5.1	2.3	4.4	10.7
LSD	59.8	0.22	6.9	27.1	33.37	0.29	12.6	17.7

Means values followed by same letter are not significantly different p<0.05.

3.1 Yield components.

3.1.1 Stalk length

Results in table 2 revealed significant differences in stalk length among cultivars investigated. In plant crop KEN 82-808 (290.3 cm) measured 39.1cm more compared to CO 421 (control) (251.2 cm), while N14 (229 cm) posted significantly shorter stalk length by 22.1 cm than control. Longer stalk lengths were observed on varieties KEN 82-808, KEN 83-737 and D 8484 in descending order. However, in ratoon crop response of varieties to stalk length showed mixed response, and was statistically insignificant among six test varieties except on N14. CB 38-22 posted longest stalk length 256.5cm compared to shortest 215 cm on variety N14 and 233cm on CO 421 (check). There was reduction in stalk length between test varieties in plant and first ratoon crops that varied from 2% (CB 38-22) and 13% N14. Shorter stalk lengths on variety N14 both in plant and first ratoon crops, may be attributed to its genetic makeup and ratooning ability of the variety under this environment, similar to results reported by [6] Feyissa et al. (2014) and [11] Masri et al. (2015).

3.1.2 Stalk diameter

Stalk diameter was significantly different in both plant and first ratoon crops, D8484 posted thickest stalk diameter 2.93 cm followed by 2.73 cm CO 421(check) and lowest 2.3 cm on KEN 83-737. CO 945 and CB 38-22 were significantly at par in terms of stalk diameter with check, while KEN 83-737 and KEN 82-808 recorded less thick cane stalks. Stalk diameter in ratoon crop took similar trend as in plant cane with stalk thickness ranging from 2.79 cm on D 8484 to 2.26 cm on KEN 83-737 table 2. Phenotypically cultivar D 8484 possess thick cane stalks, a trait used in describing it, thick cane stalks in both plant and ratoon crop cycles could be attributed to inherent genetic makeup of this variety. Generally, there was mixed response in stalk girth among varieties in ratoon crop compared to plant crop. KEN 82-808, D 8484, CO 945 recorded reduced stalk girth in ratoon crop compared to plant crop cycle (table 2) with check recording highest at 6%, while CB 38-22 remained constant across crop cycles. KEN 83-737 and N14 reported a 4% and 2% increase in stalk diameters respectively. This could be attributed genetic makeup of the varieties and their ability to utilize available crop nutrients, similar findings were reported by [15] Omoto et al. (2008), [2] Ahmed et al. (2011), [12] Mahareb et al. (2016).

3.1.3 Millable cane

In sugarcane, millable cane (stalk numbers) is a key indicator and a contributor to sugarcane yield, analysis of variance revealed there were significant differences in stalk numbers among test varieties table 2. N14 recorded highest number of millable cane 90.0 (000'ha^{-1}) surpassing CO 421(check),77.4(000'ha^{-1}), D 8484 posted the least 65.0 (000'ha^{-1}) in plant crop and similar trend repeated the ratoon crop. There were mixed responses of test varieties to millable cane in plant crop and ratoon crop with decline in population per hectare. Millable cane declined 18% (D 8484) and least was 4.6% (KEN 82-8080. However, CO 421 (check), N14, CO 945 and KEN 83-737 recorded 5% increase in number of millable stalks in ratoon crop. The reduced number of millable stalks in ratoon crop compared to plant cane, can be attributed to crop management related aspects such as; trampling of cane stools during transportation and poor stubble shaving resulting in fewer tillers developing into mature millable cane stalks. In addition, individual genetic makeup of genotypes determines the ratooning ability of cultivar and number of millable stalks at harvest. Findings of this study are in agreement with studies done [14] Netsanet et. al (2012).

3.1.4 Cane yield

Cane yield for test varieties was significantly different in plant and first ratoon crop, in plant crop variety D 8484 (136 tch) yielded significantly higher than KEN 83-737 (91.5 tch) but statistically at par check CO 421(119.4 tch) in terms of fresh cane weight (table 2). D 8484 recorded highest cane tonnage despite posting lower stalk population, this was attributed to thick stalk diameters an inherent genetic trait of this variety. Indicating individual heavier cane stalk weight contributed to high cane yield of this variety. While low yield posted by KEN 83-737 could collaborated to thin stalk diameters and possibly lighter individual stalk weights. Cane yield in the first ratoon crop was statistically significant among the varieties tested, CO945 posted highest yield 106.4 tch, which was significantly at par with CO 421(check) 97.4 tch and lowest 69.8 tch observed on CB 38-22.

A trend of declining tonnage in first ratoon crop (FRC) compared to plant crop (PC) was observed within individual varieties. Yield reduction within varieties in ratoon crop compared to plant crop varied from highest 39.5% (D 8484) to lowest 6.5% (N14), other varieties registered yield reduction of 33.4 % (CB 33-22), 18.7 % (CO 945), 32 % (KEN 82-808), 15.3 % (KEN 83-737) compared to check 18.4% (CO 421). The low cane yield across varieties in the ratoon crop could be due to reduced stalk numbers, shorter cane stalks lengths and reduced stalk thickness (diameter) concomitantly resulting in low cane yields. Naturally ratoon crops tend give yields of 10 – 30 % less than the plant crop in sugarcane due to factors such as low and differential ratooning potential of individual cultivars, increased disease and insect infestation, poor crop husbandry practices and inherent genetic make-up of the cultivars, [3]Amolo & Abayo (2011), [12]Mahareb et al. (2016).

Table 3: Pooled means of agronomic for plant and first ratoon crops

Treatments Variety	Parameters means			
	Stalk length (cm)	Stalk diameter (cm)	Number milleable can e(population) ('000' ha^{-1})	Tons of cane per hectare (TCH)
CB 38-22	264.6a	2.63b	61.9c	86.3cd
CO 421(check)	241.6ab	2.64b	80.3b	108.4abc
CO 945	252.6ab	2.65b	80.2b	118.7a
D8484	269a	2.86a	56.5c	109.7ab
KEN 82-808	270a	2.31c	82.2b	100.5abcd
KEN83-737	245ab	2.34c	78.2b	84.5d
N14	222.2b	2.33c	90.8a	95.4bcd
Grand mean	252.2	2.54	75.7	110.5
CV%	4	2.1	5.1	9.5
LSD	32.03	0.16	7.86	22.73

Means followed with the same letter are not significantly different $p<0.05$.

Polled analysis of plant crop and first ratoon crop was done and results in table 3 revealed KEN 82-808 recorded longest stalk length of 270 cm which was statistically at par with check 241 cm and varieties CB 38-22, CO945 and KEN 83-737 while N14 (222.2 cm) measured significantly shorter stalk length than check. Stalk length observed on KEN 82-808 could be attributed to thin stalk diameter resulting in more pronounced apical growth than lateral growth and inherent genetic makeup of the cultivar.

Mean stem diameter was significant amongst test varieties, highest 2.86 cm (D 8484) that surpassed check 2.64 cm, which was however significantly at par with CO 945 and CB 38-22 while lowest diameter 2.31 cm was associated with KEN 82-808. Thickest stalk diameter on variety D8484 could also be attributed to low tillering ability of the cultivar resulting in fewer stalk numbers per unit area. In addition, phenotypically D 8484, CO 421, CB 38-22 and CO 945 have thicker cane stalks compared to N14, KEN 82-808 and KEN 83-737, indicating stalk thickness reported could be associated with genetic make-up of the varieties and the environmental conditions in which they are grown. Findings concur with observations by [7] Geddawy et al. (2015) and [12] Mahareb et al (2016).

Response of varieties to millable cane was significantly different with N14 producing highest millable cane 92.8 (000 ha^{-1}), CO 421(check) yielded 80.3 (000 ha^{-1}) cane stalks which was statistically at par with CO 945, KEN 82-808 and KEN 83-737 and lowest was 56.7 (000 ha^{-1}) associated to D 8484 . The millable cane stalks produced by individual varieties could be associated with their tillering ability and number of tillers that mature to millable cane. The variation in stalk number among the test varieties could be probably be associated with genetic potential of individual varieties to generate tillers and their survival to millable cane at harvest, similar results were reported [5] Endris, 2018).

Cane yield is influenced by stalk length, diameter and stalk population (millable cane) per unit area, results revealed that CO 945 yielded highest 118.7 tch surpassing check CO 421 at 108.4 $tcha^{-1,}$ however yields were statistically at par with two other varieties D 8484 and KEN 82-808 while lowest yield was 84.5 tch on KEN83-737. Higher cane yield reported on CO 945 and CO421 was attributed to balanced influence of thick stalk diameters, stalk length balanced individual stalk weight and number millable cane. Variety D 8484 yielded at par to check despite having lower millable cane, this could be attributed to influence of individual longer, thicker and heavier stalks of cane of this cultivar. For variety KEN 82-808 although having medium cane stalk, its yield was influenced by an interplay between long cane stalks and comparatively higher number of milleable cane compensating for average individual stalk diameter and weight. KEN 83-737 which gave lowest cane yield 84.5 tch which could be attributed to low number of millable cane, long and less thick stalks with low average individual stalk weights. Results are similar to findings of [4] Arian et al. (2011) and [8] Getaneh et al. (2015), that cane yield in sugarcane is strongly influenced by stalk length, stalk diameter, stalk population (millable cane), and ability of variety to exploit available resources and its genetic makeup response in a given environment.

Conclusion

The results of this study revealed yield components; stalk length, stalk diameter and number of millable cane influenced yield of cultivars tested in the study area. Yield of CO945 was influenced by a balance of long stalk lengths, thick diameter and higher millable stalks of cane. Yield of D8484 was due to thick stalk dimeters and long stalk lengths that compensated for low millable cane stalks. Whereas for KEN82-808 yield was mainly controlled by long stalk length and higher number of millable cane. Low yield observed on KEN 83-737 could be due to thin stalk diameter and low number of millable cane.

Recommendations

Based on these findings it is recommended that area under new varieties KEN82-808, D8484 and CO945, should be increased while reducing area under check CO 421 in the region.

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Acknowledgement
Authors acknowledge support of Director General Kenya agricultural and livestock research organization (KALRO), Director sugar research institute, Agronomist -KISCOL, agronomy section staff and colleagues at sugarcane breeding Centre -Mtwapa**.**