

Effect of Spacing on Performance of Sugarcane Seedcane Raised Using Single Eye Bud Technology in Western Kenya

Anne Omututi ^{1,✉}, Harun O. Ogindo ¹, George K'Otuto ¹, George Omoto ², Victor O. Otieno ³

1. Crops and Soil Science, Maseno University, Kisumu, KEN

2. Crop Improvement and Management, Kenya Sugar Research and Training Institute, Kisumu, KEN

3. Socio Economics and Biometrics, Kenya Sugar Research and Training Institute, Kisumu, KEN

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Abstract

Sugarcane (*Saccharum officinarum* L.) production in Kenya faces increasing pressure to improve planting efficiency, crop establishment, and seedcane supply. To address this, a 12-month field experiment (2024-2025) was conducted at Kibos (Kisumu County) and Opapo (Migori County) to evaluate the effects of inter-row (1.2 m and 1.5 m) and intra-row (0.45 m, 0.60 m, and 0.75 m) spacing on survival, growth, and yield of variety KEN 83-737 using single-eye bud settlings. A split-plot design with three replications was employed, assessing survival, tillering, plant height, cane weight, stalk population, girth, internodes, and brix. Tillers peaked at 180 days after treatment (DAT) in Kibos and 210 DAT in Opapo before declining. Narrow intra-row spacing (0.45 m) reduced survival in Opapo but enhanced early tillering in Kibos. Closer inter-row spacing (1.2 m) produced significantly more stalks in Kibos and taller plants in Opapo compared to 1.5 m. These outcomes reflect the benefits of higher plant density and faster canopy closure under closer spacing. Yield was highest under 1.2 m × 0.45 m spacing, reaching 101.46 t ha⁻¹ in Kibos and 124.63 t ha⁻¹ in Opapo, although differences were not statistically significant ($P > 0.05$). This spacing combination appears most optimal for the tested sites and similar agro-ecological conditions.

Categories: Organic agriculture, Seed technology, Sustainable climate smart agriculture

Keywords: sugarcane, spacing, single eye bud, technology, productivity

Introduction

Sugarcane (*Saccharum officinarum* L.) is an important perennial cash crop cultivated in nearly 120 countries around the globe on an estimated area of 27 million hectares. It contributes to about 64.6% of the total world sugar production due to its ability to store high concentrations of sucrose in its stalks [1,2]. In Kenya, the local sugar industry spread across 14 counties is solely dependent on sugarcane crop for its operations. The crop is cultivated on 289,041 hectares with a cane yield of 61 tons per hectare against a potential of over 100 tons per hectare using improved sugarcane varieties [3]. Good sugarcane development and productivity is highly dependent on new agrotechnologies, including varieties to address the various environmental limitations and appropriate agronomy of the crop.

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The potential of agrotechnologies including varieties to enhance sugarcane productivity has been underscored [4]. However, the introduction of new agrotechnologies, including varieties, require refining of the relevant agronomic practices to optimize the benefits from such investments [5,6].

Recent developments in the Kenyan sugar industry are the development and recommendation of elite sugarcane varieties including the KEN 83-737 variety and the single eye bud (SEB) technology for seedcane production. The KEN 83-737, which has been reported by the Kenya Sugar Board in their 2024 cane availability survey report to be the leading elite sugarcane variety is early maturing, has high tonnage and brix. Its resilience to adverse environmental stresses including Smut and Sugarcane Mosaic Virus Disease has been documented. It has an erect to semi-erect leaf orientation which forms a moderately open canopy that allows adequate incident radiation to its lower leaves and soil surface.

Under the conventional seedcane production, sugarcane stalks, setts, and even cane tops are laid in the furrows and the intra spacing depended on the internode lengths on the original stalks and on eye buds that successfully grow. On the contrary, when using SEB technology, the eye buds are scooped out and started off in nurseries resulting into seedlings which are then transplanted in the field at specific placements [7] making spacing a very important consideration when establishing sugarcane crop from SEB technology. This transplant-based establishment method allows precise control of plant population, thereby making spacing a critical management factor in sugarcane production using SEB technology. The spacing recommendation derived from three eye bud setts are likely inapplicable to SEB-derived plants due to differences in early-stage vigor and tillering dynamics.

One of the most important components of sugarcane agronomy is crop geometry which refers to the space available for individual plants and is primarily determined by the inter-row and intra-row spacing of the crop. Crop geometry determines the plant population and efficient utilization of space-based resources including solar radiation, soil water, and soil nutrients among others [8,9]. In terms of sugarcane crop productivity, spacing has a direct effect on light interception, tillering ability, and canopy development, which ultimately affect weed growth, photosynthetic capacity, biomass production, and yield of the crop [10,11]. Excessively wide spacing results in inefficient utilization of the resources which then become available to weeds increasing the risk of weed infestation [12]. On the other hand, too close spacing increases competition for the resources which leads to the more competitive plants or shoots dominating over the less competitive ones.

In order to achieve higher sugarcane productivity, disease control and cost effectiveness in a sustainable manner, the potential of elite variety and the SEB technology needs to be optimized through studies and capacity building to industry stakeholders. SEB technology is already being piloted and promoted in Kenya as an alternative to the traditional method of propagation and is considered a promising innovation for sugarcane production in East Africa. The objective of this study was to determine the optimal spacing and yield optimization of seedcane raised from SEB seedlings of KEN 83-737 sugarcane variety under two agroecological conditions in Western Kenya.

Materials And Methods

Characteristics of study sites

The experiment was conducted in two experimental sites namely, Kenya Sugar Research and Training Institute in Kibos, Kisumu County and at the Institute's sub center in Opapo, Migori County (Figure 1).

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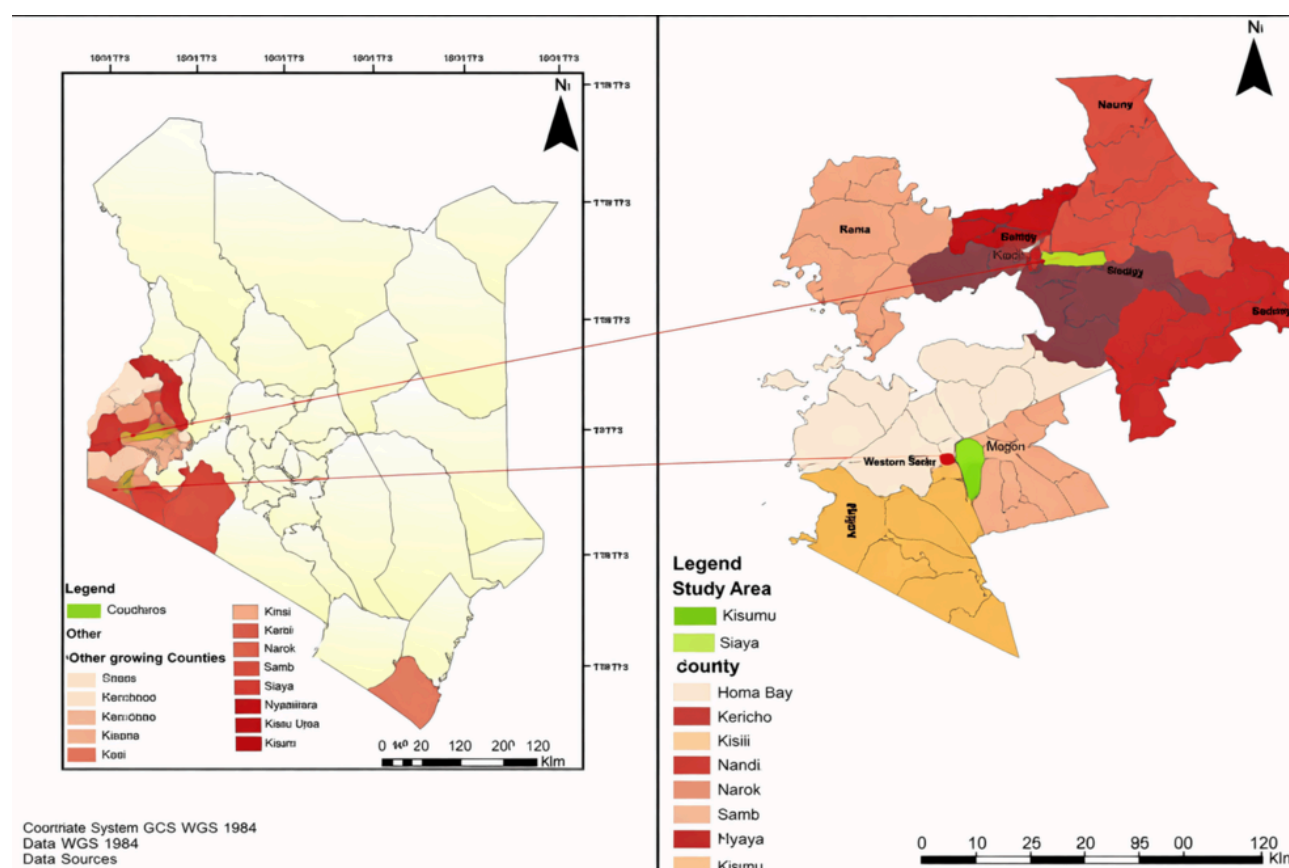


FIGURE 1: Map of Kibos and Opapo experimental study sites.

Source: Created in ArcMap 10.8.2.

Kibos site is categorized as agro ecological zone lower midland 2 (LM2), which has a sub-humid climate. It lies at an altitude of 1200-1500 m above sea level, latitude 0°04'S and longitude 34°48' E. The area receives mean annual rainfall of 1200-1400 mm with mean annual temperature of 20.9°C to 22.3°C. Soils are cambisols [13], with Soil pH of 4.6 and a bulk density of 1.87g/cm³. The second site, Opapo falls under agro ecological zone lower midland 1 (LM1) which has humid climate. It receives a mean annual rainfall of 1600-1800 mm, and mean annual temperature of 20.4°C-21.7°C. It is at an altitude of 1300-1550m above sea level and lies between latitude 0° 54'S and longitude 34° 32'E. Soils in Opapo site are planosols, with pH of 4.3 and a bulk density of 1.3g/cm³ [13,14]. All weather and climatic variables during the investigation period as well as long-term characteristics of both study sites are summarized in Table 1.

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Parameter	Kibos		Opapo	
	Long term	Experimental period	Long term	Experimental period
Agro-ecological zone	Lower Midland 2	Lower Midland 2	Lower Midland 1	Lower Midland 1
Climate type	Sub-humid	Sub-humid	Humid	Humid
Altitude	1,200–1,500	1,200–1,500	1,300–1,550	1,300–1,550
Latitude	0° 04' S	0° 04' S	0° 54' S	0° 54' S
Longitude	34° 48' E	34° 48' E	34° 32' E	34° 32' E
Mean annual rainfall (mm)	1,200–1,400	1,500–1,750	1,600–1,800	1,500–1,900
Mean annual temp (°C)	20.9–22.3	23.3	20.4–21.7	20.7
Soil type	Cambisols	Cambisols	Planosols	Planosols
Soil pH	4.60	4.80	4.30	4.60
Bulk density (g cm ⁻³)	1.87	1.87	1.30	1.30

TABLE 1: Long-term and seasonal weather and climatic variables of Kibos and Opapo study sites

The primary source of materials for preparation of eye bud chips was sugarcane plant crops, 10 months old. Whole stalks of healthy cane with robust, undamaged eye buds were harvested and used for seedcane. A sterilized hand operated bud scooping device was used to extract bud chips. For controlling pathogens and maintaining bud viability, the chips were not hot water treated but immersed in systemic insecticide Malathion 50 EC at 2 ml/l for 15 minutes. Pre-germination of the materials was done by placing them in airtight gunny bags covered with a black polythene sheet to increase temperatures and induce germination. The gunny bags were opened 5 days later; healthy sprouted buds were selected for raising settlings.

Prior to field establishment, SEBs were excised from elite sugarcane variety KEN 83-737, pre-treated with fungicide and nurtured in a nursery for 35 days. The settlings were transplanted into the main field following a randomized experimental layout based on the designated inter- and intra-row spacing treatments. Kibos site was planted on November 5, 2023 and harvested on November 7, 2024 while Opapo was planted on March 4, 2024 and harvested March 6, 2025. Phosphate fertilizer as Di-Ammonium Phosphate (46% P₂O₅ and 18%N) at 100 kg P₂O₅ was applied during planting. Nitrogen as Urea (46%N) at 80 kg N was applied as top dress 3 months after transplanting. Fertilizers and manual weed control were applied based on recommendations in the sugarcane growers guide.

Land preparation involved initial ploughing to a depth of 0.30 m using a disc plough, followed 21 days later by harrowing to the same depth to break soil clods, level the field, and achieve a uniform and desirable tilth. Demarcation of the experimental area was done using a tape measure, sisal twine, and wooden pegs. Eighteen experimental units measuring

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48 m² and 38.4 m² were established following a statistically randomized and replicated field layout, with 1.5 m paths between plots and 2.0 m spacing between replicates. Sugarcane seedlings were transplanted at the designated intra row spacings of 0.45 m, 0.60 m, and 0.75 m, and subsequently covered with soil, leaving approximately 0.05 m of the shoot exposed above the soil surface. The crop was raised under rainfed conditions for the entire growth cycle.

Experimental design and treatments

The experiment comprised a total of six spacing treatments of which two were inter-row spacings at 1.2m and 1.5m (main plot factor) as recommended for the Kenyan sugar industry and three intra-row spacings at 0.45 m, 0.60 m, and 0.75 m (sub-plot factor) under evaluation for the SEB technology. The treatments were replicated three times. The spacing was tested using one elite variety KEN 83-737 in a gross plot of 4 rows × 8 m long × 1.5 m (48 m²) and 4 rows × 8 m long × 1.2 m (38.4 m²). The net plot had 2 rows × 8 m × 1.5m for the main plot factor (24 m²) and 2 rows × 8m × 1.2m for the sub-plot factor (19.2 m²). KEN 83-737 was selected because it is an early maturing, high yielding (tonnage and sucrose content) and resilient to adverse environmental stresses [15]. The variety was also reported by AFA-Sugar directorate to be the leading in adopted by farmers across all sugarcane growing zones in Kenya [16].

Initial soil analysis

Soil testing was conducted on experimental sites before land preparation. Soil was sampled in each of the experimental plots referred to as the sampling unit. The zig-zag pattern was used to mark the sampling points where soil auger was used to collect soil sample at a depth of 0-15 cm for topsoil and 15-30 cm for subsoil. The samples were then composited per depth and per unit. About ½ kg of soil was then packed, well labeled and transported to laboratory in KALRO-SRI Kibos, Kisumu. The sampled soils were then prepared for soil pH (1: 2.5 soil/water - Potentiometrically), organic carbon (Dichromate Wet Oxidation 89570-Wakley Black method), organic matter (Converted using factor 1.72 × Org, C), total nitrogen (Kjeldahl method), available phosphorus (Bray-1), available potassium and calcium were extracted by Percolation with 1M NH₄OAc followed by determination in Atomic Adsorption Spectrophotometer (AAS). The micronutrients zinc and copper were extracted by 1% EDTA followed by determination in AAS.

Calibration details, sampling time, and temperature correction

Field measurements were conducted using calibrated instruments to ensure accuracy and reproducibility during the growth cycle. The hand-held refractometer used for Brix determination was calibrated daily against distilled water (0° Brix) and verified with a standard solution prior to sampling. Data collection on brix was performed at mid-morning (09:00-11:00 hours) to minimize diurnal variation in stalk physiology, with four representative stalks selected per plot for each spacing treatment. To account for field variability in ambient conditions, temperature correction was applied to refractometer readings according to manufacturer specifications, normalizing values to 20°C. At harvest [360 (days after treatment (DAT))], all cane stalks from the net plot were weighed immediately after cutting to minimize moisture loss. This was done using a digital weighing balance with a capacity of 50 kg and an accuracy of ±0.01 kg. The balance was calibrated daily using standardized weights prior to field measurements to ensure precision. Stalk girth was measured at harvest using a digital vernier caliper (Mitutoyo) with an accuracy of ±0.01 cm.

Data collection

All parameters were measured from the net plot. Survival rates were determined at 30 days after transplanting by manually counting surviving shoots within net plots, calculated as percentage survival (Equation 1) [17]. Tiller numbers were recorded from 60 to 330 days after transplanting at 30-day intervals. Four stalks per net plot were randomly tagged for repeated measurement of stalk height using a tape measure from plant base to leaf dewlap, with wooden pegs marking stalk bases for consistency.

At harvest (360 days), eight tagged millable stalks per net plot were collected for yield component analysis. Stalk height was measured from base to top visible dewlap, stalk girth at mid-section using a vernier caliper, and internode number by manual node counting. Stalk counts per plot and cane weight were recorded; cane weight was converted to tonnes per hectare. Brix (%) was measured using a handheld refractometer on juice extracted from stalk mid-sections.

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Determination of cane survival rates

All settlings in the net plot were manually counted at 30 days after transplanting to ascertain the survival percentage. Survival was determined using percentages as described in equation 1.

$$\text{Survival\%} = [(\text{Number of surviving shoots})/(\text{Total number of settlings transplanted}) \times 100] \text{ Equation 1}$$

Determination of cane growth performance

The total tiller numbers from each net plot were counted manually from 60 to 330 days after crop establishment at 30-day interval. Four stalks were randomly selected from the net plot and tagged with a ribbon for ease of identification during the growth cycle. A tape measure was used to measure stalk height from the base of the plant to the leaf dewlap. For precision and consistency, a wooded peg was placed at the base of each tagged sample stalk to indicate the original base of the plant for the entire duration. The tagged plants were used consistently during the growth time to assess progression of the plant height.

Determination of cane yield components and yield

At harvest (360 days), the tagged eight millable cane stalks from each net plot were collected and analyzed for yield components and yield. Cane stalks were cut and their height (cm) measured using a tape measure from base of the stalk to the Top Visible Dewlap (TVD)/leaf with distinct collar. Stalk girth/diameter (cm) measurements were taken using a Vanier caliper (Mitutoyo) at the mid-section of the cane stalk and a mean of the scores calculated. Number of internodes were determined manually by counting nodes from the base of the cane stalk to the last visible node of each stalk and a mean obtained. Cane stalk population were manually counted within each plot while cane weight (kg) was determined by weighing stalks tied in bundles of 20 stalks of harvested cane using a weighing balance. Brix (%) was determined using a handheld refractometer machine on juice extracted from the tagged stalks just before harvesting. A pricker was used to extract juice from the mid-section of the stalk, the juice was placed on the prism of a hand-held refractometer brixing machine and a reading collected for measurement of cane brix percent. Later, cane weight per plot was converted to tons per hectare (t ha^{-1}) while tillers and stalk population were converted to number of millable stalks per hectare (ha^{-1}).

Data analysis

The obtained data were subjected to statistical analysis using GenStat 22nd Edition (VSN International Ltd., Hemel Hempstead, UK). Prior to analysis, data were checked for normality and homogeneity of variances using Shapiro-Wilk and Levene's tests, respectively. Analysis of variance (ANOVA) was performed to determine the significance of treatment effects. Fisher's Least Significant Difference (LSD) post hoc test at alpha 0.05 were applied to detect the differences in spacings [18]. Interactions between (i) within intra-row spacing and (ii) within inter-row spacing were tested.

Results And Discussion

Soil properties

Both Opapo and Kibos soils are acidic (pH 4.3-4.6), but they differ in fertility and structure. Opapo had higher organic carbon (1.22%), organic matter (2.10%), and total nitrogen (0.035%), reflecting stronger organic fertility. However, it contained lower available phosphorus (13.11 ppm) and potassium (70.71 ppm). In contrast, Kibos soils were richer in available phosphorus (55.09 ppm), potassium (239.88 ppm), and calcium (243.03 ppm), but had reduced organic carbon (0.65%) and nitrogen (0.012%).

Structurally, Kibos soils were more compacted (bulk density 1.87 g/cm^3 , porosity 30%), while Opapo soils had a looser structure (bulk density 1.3 g/cm^3 , porosity 49.5%). Despite the relatively high bulk density observed at Kibos, no visible symptoms of root restriction or compaction stress were detected, signifying that soil physical property remained within a tolerable range for sugarcane growth or that the crop's root system was able to adapt to these conditions (Table 2).

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Soil property	Opapo	Kibos
Soil pH _{water}	4.3	4.6
Organic Carbon, %	1.22	0.65
Organic matter, %	2.10	1.12
Total Nitrogen (N), %	0.035	0.012
Phosphorus (P), ppm	13.11	55.09
Potassium (K), ppm	70.71	239.88
Calcium (Ca), ppm	BLDL	243.03
Zinc (Zn), ppm	2.43	1.17
Iron (Fe), ppm	199.68	147.13
Copper (Cu), ppm	0.08	0.59
Bulk density	1.3g/cm ³	1.87g/cm ³
Porosity	49.5%	30%

TABLE 2: Soil physicochemical properties of study sites.

BLDL, Below Detection Level

Sugarcane seedlings survival was generally higher at Kibos (>90%) across all spacing treatments than at Opapo, where survival was slightly lower and generally remained below 90% (Table 3). At Kibos, survival tended to be greater under the 1.2 m inter-row spacing (98.3%) than under the 1.5 m spacing (95.4%), although the difference was not statistically significant. In contrast, intra-row spacing significantly affected survival at Kibos, with the 0.45 m spacing recording lower survival (93.5%) than the 0.60 m (98.7%) and 0.75 m (98.4%) spacings. No significant differences among intra-row spacings were observed at Opapo. Across inter- and intra-row spacing combinations, survival at Opapo ranged from 79.6% under the 1.5 m × 0.45 m treatment to 92.4% under the 1.2 m × 0.75 m treatment, indicating greater variability than at Kibos. Although the interaction between inter- and intra-row spacing was not significant at either site ($P > 0.05$), the 1.2 m × 0.45 m treatment achieved 100% survival at Kibos (Table 3).

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Treatments	Survival%	
	Kibos	Opapo
Inter-row spacing		
1.2M	98.30a	86.67a
1.5M	95.40a	84.23a
Intra-row spacing		
0.45M	93.50b	81.94a
0.60M	98.70a	86.53a
0.75M	98.40a	87.87a
Inter × Intra interaction		
1.2M × 0.45M	100.00a	84.25a
1.2M × 0.60M	98.70a	83.33a
1.2M × 0.75M	98.70a	92.42a
1.5M × 0.45M	96.90a	79.62a
1.5M × 0.60M	96.20a	89.74a
1.5M × 0.75M	90.70a	83.33a

TABLE 3: Effect of inter and intra row spacing on seed cane settling survival% in Kibos and Opapo.

Means within each column followed by different letters are significantly different according to analysis of variance and Fisher's least significant difference test at $\alpha = 0.05$.

Survival rates (85.5-96.9%) confirm that SEB technology provides satisfactory establishment under the tested spacing regimes, consistent with prior studies [17,19,20]. Lower survival at 0.45 m intra-row spacing in Kibos likely reflects increased competition from higher plant density, though overall survival was not significantly affected by spacing ($P > 0.05$) [10].

Tiller production peaked at 180 DAT in Kibos and 210 DAT in Opapo. Narrower inter-row spacing (1.2 m) consistently produced more tillers than 1.5 m, while natural thinning after peak growth reflected resource competition. Kibos soils, with higher bulk density (1.87 g/cm³), suggested compaction effects, yet closer spacing enhanced tiller production and

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resource use efficiency. Narrow intra-row spacing (0.45 m) stimulated higher tiller numbers, particularly in Kibos, though differences diminished at later stages due to compensatory growth. At Opapo, intra-row spacing effects were minimal, with significant differences only at 120 and 150 DAT (1.2 m × 0.45 m vs. 1.5 m × 0.75 m).

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Treatment	Yield and yield components					
	Cane weight (t ha ⁻¹)	Stalks (No. ha ⁻¹)	Height (cm)	Girth (cm)	Internodes	HR Brix (%)
Kibos site						
Inter-row spacing						
1.2M	94.67a	126,909.72a	218.10a	2.29a	20.11a	20.63a
1.5M	88.74a	111,562.49b	201.50a	2.33a	20.00a	21.46a
Intra -row spacing						
0.45M	96.14a	124,982.63a	208.60a	2.34a	19.81a	20.7a
0.60M	90.83a	119,444.44a	204.91a	2.26a	19.66a	21.04a
0.75M	88.15a	113,281.25a	215.81a	2.34a	20.66a	21.39a
Inter x Intra Interaction						
1.2M × 0.45M	101.46a	136,284.72a	222.63a	2.39ab	20.00a	20.35b
1.2M × 0.60M	100.29a	128,298.61a	212.11a	2.23b	20.00a	20.8ab
1.2M × 0.75M	82.27a	116,145.83a	219.62a	2.25ab	20.33a	20.75ab
1.5M × 0.45M	90.82a	113,680.55a	194.63a	2.29ab	19.66a	21.06ab
1.5M × 0.60M	81.37a	110,590.27a	197.82a	2.29ab	19.33a	21.28ab
1.5M × 0.75M	94.02a	110,416.66a	212.06a	2.42a	21.00a	22.03a
Opapo site						
Inter-row spacing						
1.2M	108.02a	98,495.37a	247.75a	2.41a	22.55a	19.87a
1.5M	71.84a	78,472.22a	210.08b	2.14a	21.22a	19.53a
Intra -row spacing						
0.45M	96.09a	94,930.55a	235.79a	2.12a	22.51a	20.13a
0.60M	93.63a	85,555.55a	227.71a	2.29a	21.66a	19.45a

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0.75M	80.07a	84,965.27a	223.25a	2.41a	21.50a	19.47a
Inter x Intra Interaction						
1.2M × 0.45M	124.63a	107,638.88a	255.5a	2.22a	24.00a	19.76a
1.2M × 0.60M	100.28a	85,416.66ab	231.41a	2.48a	21.00a	19.94a
1.2M × 0.75M	99.15a	102,430.55ab	256.33a	2.55a	22.60a	19.96a
1.5M × 0.45M	67.55a	82222.22ab	216.08a	2.03a	21.00a	20.51a
1.5M × 0.60M	86.98a	85,694.44ab	224.01a	2.10a	22.33a	19.01a
1.5M × 0.75M	61.00a	67,500.01b	190.16a	2.28a	20.33a	18.98a

TABLE 4: Effect of spacing on yield components and yield of sugarcane in Kibos and Opapo.

Means within each column followed by different letters are significantly different according to analysis of variance and Fisher's least significant difference test at $\alpha = 0.05$.

Significant interaction effects ($P < 0.05$) indicated that the 1.2 m × 0.45 m spacing optimized tiller production, especially during early to mid-growth stages at Kibos and at 120-150 DAT in Opapo (Table 4). These findings align with previous reports [21] showing increased tiller populations under narrower row arrangements in sugarcane.

Yield trends mirrored tiller production. Closer intra-row spacing (0.45 m) increased stalk numbers and biomass, while wider spacing (0.75 m) favored thicker stalks and higher brix, reflecting a trade-off between yield quantity and quality [22]. At Opapo, spacing effects were generally minor, with the only significant difference ($P < 0.05$) observed in stalk height, where 1.2 m inter-row spacing produced taller stalks than 1.5 m [23,24]. Closer spacing increased stalk population and overall cane yield, but this came at the expense of stalk girth and brix. Conversely, wider spacing reduced stalk numbers and tonnage but favored thicker stalks with higher juice quality. This balance underscores the agronomic challenge of optimizing both factory recovery efficiency and field productivity, particularly in rainfed Kenyan sugarcane production where resource competition is amplified.

Interaction effects highlighted that 1.2 m × 0.45 m spacing produced the highest cane weight, stalk numbers, and height, particularly at Kibos, while 1.5 m × 0.75 m spacing yielded greater stalk girth and brix ($P < 0.05$). Overall, 1.2 m inter-row spacing consistently outperformed 1.5 m in yield components, with intra-row spacing differences less pronounced, though 0.45 m often recorded higher values across parameters (Table 4).

Although the study establishes important biological trade-offs, it does not incorporate an economic assessment of profitability across spacing regimes. In the sugar value chain, yield quantity and quality affect both farmer income and mill recovery, future research should include cost benefit analyses to identify the most viable strategies. Moreover, the findings of this study are restricted to the plant crop cycle (12 months, as recommended for seedcane). Evaluation of performance of mature sugarcane (14-18 months) and subsequent ratoon crops is essential for long-term productivity and sustainability of the industry. These gaps represent key limitations that should be addressed to build a more comprehensive agronomic and economic framework.

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Conclusions

Spacing influences growth and yield of seedcane raised via SEB technology. Trade-offs between yield quantity and stalk quality were well displayed where intra row spacing of 0.45 m had high stalk population but lower brix and girth while intra row spacing of 0.75 m had low stalk population but high brix and girth. Considering land fragmentation, input costs, and management practices, a spacing of 1.2 m × 0.45 m may be considered a practical option for sugarcane production, as it generally produced comparable or numerically higher yields while maintaining efficient land use and management. Although yield advantages were not consistently statistically significant, this spacing showed potential to support productivity and sustainability under the conditions of the study.

The study underscores the potential of SEB technology to transform sugarcane production in Western Kenya. Further research is recommended to assess economic viability, varietal responses, ratoon crop evaluations across diverse agroecological zones and soil types as these were the limitations of the study. Long-term trials extending to milling maturity age and multiple growth cycles are advised to validate consistency and applicability of spacing treatments.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Anne Omututi, Harun O. Ogindo, George K'Otuto, Victor O. Otieno

Acquisition, analysis, or interpretation of data: Anne Omututi, George Omoto, Victor O. Otieno

Drafting of the manuscript: Anne Omututi

Critical review of the manuscript for important intellectual content: Anne Omututi, Harun O. Ogindo, George K'Otuto, George Omoto, Victor O. Otieno

Supervision: Harun O. Ogindo, George K'Otuto, George Omoto, Victor O. Otieno

Disclosures

Plant subjects: All authors have confirmed that this study did not involve any herbarium specimen. **Human subjects:** All authors have confirmed that this study did not involve human participants or tissue. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

Data Availability Statements

The datasets (and/or code) supporting this study are available from the corresponding author upon reasonable request.

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