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Effect of sett type and intra-row sett spacing on yield of Sugarcane varieties at Metahara Sugar Estate

Abiy Getaneh, Netsanet Ayele and Tadesse Negi
Ethiopian Sugar Corporation, Research Directorate, Wonji, P.O. Box 15
*Corresponding author: *abiygz@gmail.com*

Abstract

An experiment was conducted at Metahara Sugar Estate from 2008-2013 cropping period in plant cane and two ratoon crops in order to evaluate the effect of different number of buds per sett (2 buds(check), 3 buds, 4 buds and 5 buds setts) and two within row spacings (end-to-end and 5 cm overlapping (check)) using six sugarcane varieties in three setts of experiments viz., Set I (B52298, Co680), Set II (NCo334,Co678), Set III (Mex54/245,B41/227) on yield and yield components of sugarcane. The experiment was carried out in split plot design in three replications, where varieties were assigned as a main plot and combination of number of buds per sett and intra-row spacing were assigned as a sub-plot. Analysis of variance revealed that irrespective of the varieties, soils and crop types, sett type and placement didn't affect cane and sugar yields. Whereas, considering the cost benefit analysis using five budded setts as a planting material is mandatory with the benefit of reduce seed cane preparation and transportation cost, increasing of labour efficiency, increasing laborers income, and saving extra land for commercial cane production. Therefore, it is recommended that Metahara sugar estate can use five budded sett in end-to-end sett arrangements for all varieties under study.

Keywords: Sugarcane, buds, setts, cutting, plant crop, ratoon, intra-row spacing.

1. Introduction

Currently Ethiopia has planned to build more than 10 sugar factories, in order to meet the local demand and earn foreign currency through exporting surplus sugar abroad by the end of 2014 (MoFED, 2010). Exporting by itself requires competency in price, which makes cost minimization an inevitable issue. Thus, it is imperative to search alternative options of minimizing cost in the sugar production system of the country to be competent in the World market. Among these, optimization of the planting materials and adoption of efficient, fast and cost effective methods of planting are the important ones.

Commercially sugarcane is propagated vegetativelly. The planting materials used are the stem cuttings known as "sett", each having one or several eyes/buds (Sundara, 2000). Age of the seed cane, portion of the stalk, number of buds per sett, material status of seed cane, duration between cutting and planting are known to have considerable effect on sprouting and subsequent growth of sugarcane (Barnes, 1974).

The size of cane portion used for planting differs from place to places. According to Sundara (2000), in India three eye/bud setts are most common. In Tamil Nadu two eye/bud setts are recommended. On the other hand whole stalks or longer stalk pieces are planted in countries where sugarcane plantings are done through machineries. Dillewijin (1952) also indicated that, in regions with less favorable conditions the length of the cuttings has to be increased accordingly. A series of experiments conducted in Louisiana indicated that 5 buds cuttings gave the highest yield in autumn planting. In line with this, at Formosa, to deter the effect of severe growing conditions cuttings having 4 and 6 buds are used.

Furthermore, intra-row spacing of cuttings also affects growth and yield of cane and imparts its role to minimize the seed requirement for planting. According to Humbert (1968), planting of setts butt-to-butt (end-to-end) and in partial overlapping gave adequate stands and substantial saving of seed requirements. Maintaining optimal planting portion and density of planting is vital during planting for uniform stand establishment and ultimately yield (Netsanet, 2009).
Conventionally, at Metahara Sugar Estate overlapping of two budded setts planting is used commercially. The number of setts and cost incurred for the preparation of two-budded setts to cover one hectare can be minimized by optimizing the spacing used and shifting from the use of two-budded setts having more number of buds per cutting. It is common to use commercially overlapped planting of two budded setts which results in high plant population, which results in competition and death of tillers formed in the formative stage (Netsanet *et al*., 2014). Furthermore, the seed requirement in the case of ear-to-ear (overlapping of setts) planting is very high (Verma, 2004) and the associated cost of chopping and planting is high (SSI, 2009). Therefore, this experiment was initiated with the objective of evaluating the effect of different number of buds per sett on yield and yield components of sugarcane varieties using two different intra-row spacings.

2. Materials and Methods

2.1. Site Description

Metahara Sugar Estate is located in the Rift Valley region of Ethiopia at a latitude of $8^0 51'$N and longitude of $39^0 52'$E, respectively with elevation of 950 meters above sea level. The area has a mean maximum temperature of 32.6 ^{0}C and a mean minimum temperature of 17.5 ^{0}C. The area has a mean annual total rainfall of 554 mm. The experiment was conducted from 2008 - 2013 cropping seasons on plant cane and two successive ratoon crops.

2.2 Experimental Design and Treatments

The treatments consisted of four number of buds/setts (2 buds sett, 3 bud setts, 4 bud setts and 5 buds sett) and two intra-row placement of setts (butt-to-butt (end-to-end) and ear-to-ear (overlapping of setts). The sugarcane varieties used were six and grouped into three sets *viz*., Set I (B52298, Co680), Set II (NCo334, Co678), Set III (Mex54/245, B41/227). The sugarcane varieties were selected based on their high yielding potential and area coverage in the sugar estate. The study was carried out on Class II (light) and Class IV (heavy) soils (Booker Tate, 2009) and three crop types *viz-a-viz*, plant crop (PC), first ratoon (RI) and second ratoon (RII).

The experimental design was split-plot with three replications. The main plots were sugarcane varieties and sub plots were number of buds/setts and intra-row setts placements. Area of each experimental plot was 52.2 m^2 (six furrows of 6 m length and 1.45 m width) and data was collected from the middle rows of net area 34.8 m^2 (four rows of 6 m length and 1.45 m width). The distance between adjacent plots and replications were 1.50 and 2.90 meters, respectively. The plant cane crop was raised using healthy stalk planting materials were selected from 8-10 month old seed cane field for planting. Nitrogen fertilizer urea at 200 kg ha^{-1} was applied as a source of nitrogen . The fertilizer was applied at the rates of 400, 500, and 650 kg ha^{-1} for the plant cane, first ratoon crop, and second ratoon crops; respectively. Furthermore, a foliar application of ferrous sulphate (FeSO4) was done at the rate of 30 kg ha^{-1} with a spray volume of 300 L ha^{-1} for the ratoons as soon as the iron deficiency symptom was detected at the 2nd week after harvesting. Weeds were removed manually as required until full canopy coverage was attained. Irrigation was provided as per the norm of the Estate.

2.3. Data collection and measurements

Germination count was recorded at 7 days interval from the 7th day after planting until 45th day and the counting made at the 45th day was used for statistical analysis. Tillers counted after one month at 15 days interval. However, the counting that was made at four and half month before moulding (earthing-up) was considered for analysis. The number of millable canes in each plot was counted at the age of 10 months. Average cane weight of 20 stalks was taken per plot at harvest. Stalk height measurement was made from twenty randomly selected stalks from each plots by measuring the distance from the soil surface to the top visible dewlap (TVD).

Girth (stalk diameter) measurement was taken from 20 sample stalks taken randomly from the middle two rows. Measurement was made using a caliper on three points of the stalks (upper, middle and bottom part of the stalk) after removal of the sheath. Weight per stalk was determined by taking 20 samples randomly from the middle two rows and by measuring the weight of each sample using weighing spring balance. Then the average weight per stalk was taken.

For cane quality analysis, juice was extracted from 10 stalk samples using a sample mill. Percent recoverable sucrose (*rendiment*) was calculated using Winter Carp indirect method of cane juice analysis (Kassa, 2010). Cane yield was taken from the middle four rows and weighed using grab loader then per hectare basis calculated. Then, commercial sugar yield per hectare was calculated as the product of the sucrose percent and cane yield per hectare.

Finally, the data collected were subjected to analysis of variance using SAS software (SAS Institute, 2002). Comparisons among treatment means with significant differences for the measured and counted parameters were based on the Duncan Multiple Range Test (DMRT).

3. Results and Discussion

The combined analysis over crop types (plant cane and ratoons) and soils showed a non significant interaction for all the parameters considered (Annex Table 1). Number of millable canes was affected by the main effects of variety in the set I and II experiments (Table 1 and 2), and crop types in all sets of experiments (Tables 1, 2 and 3). However, in all sets of experiments, set type and intra-row spacing were not significant (Tables 1, 2 and 3).

Table 1: Effect of variety and number of bud per sett and placement on number of millable canes, stalk weight, cane yield, sucrose content and sugar yield.

Variety	Millable stalk count ('000/ha)	Stalk weight (kg)	Cane yield (t/ha/m)	Sucrose content (%)	Sugar yield (t/ha/m)
B52 298	115.11a	2.74b	10.27	13.0a	1.34a
Co 680	88.97b	3.33a	10.09	11.5b	1.17b
Sett type and placement					
2Bud*Overlaping	105.06	3.06	10.85	12.3	1.34
2Bud*End-to-end	102.47	2.99	10.64	12.2	1.29
3Bud*Overlaping	100.92	3.16	10.76	12.4	1.34
3Bud*End-to-end	103.64	3.02	10.60	12.2	1.31
4Bud*Overlaping	103.53	3.04	10.39	12.2	1.27
4Bud*End-to-end	102.53	2.99	10.60	12.3	1.30
5Bud*Overlaping	100.28	3.04	10.51	12.0	1.27
5Bud*End-to-end	97.89	2.98	9.92	12.0	1.19
Soil					
Light clay	100.65	2.89b	10.70	12.4a	1.33a
Heavy clay	103.43	3.18a	10.40	12.0b	1.25b
Cuttings					
Plant cane	103.69b	2.79b	10.87b	11.4c	1.24b
First ratoon	94.83c	2.27c	11.43a	13.4a	1.52a
Second ratoon	107.59a	4.04a	9.30c	11.8b	1.11c
CV (%)	12	21	24	9	15

Note: *Means followed by the same letter in a column are not significantly different from each other; ha = hectare; CV= coefficient of variation.*

B52298 and NCo334 gave a significantly higher number of millable canes in set I and II experiments; respectively, while in set III experiments there was no statistical difference among the varieties Mex54/245 and B41227. The presence of varietal differences in number of millable canes was reported by Sundara (2003). Similar to this result, Feyissa *et al.* (2008) also observed variation among varieties on number of millable canes. Besides, none of the sett type by placement combinations were significant (Table 1,2 and 3).

Stalk weight was affected by all the main effects except sett type and placement in all sets of experiments (Tables 1, 2 and 3). Muhammad *et al.* (2002) found significant difference among different sugarcane genotypes in weight per stalk. Similarly, cane yield was affected by all the main effects except sett type and placement treatment in set II and III experiments (Tables 2 and 3); however, set I was affected by the main effect of crop type (Table 1). The presence of variation of cane yield among varieties indicated the difference in their inherent yielding ability (Soomro *et al*. 2006).

Table 2: Effect of number of bud per sett and sett spacing on yield and yield components of sugarcane varieties (Set II)

Variety	Millable stalk count ('000/ha)	Stalk weight (kg)	Cane yield (t/ha/m)	Sucrose content (%)	Sugar yield (t/ha/m)
Nco 334	149.80a	2.15b	12.13a	12.8a	1.57a
Co 678	94.54b	2.84a	11.21b	11.4b	1.28b
Sett type and placement					
2Bud*Overlaping	121.83	2.49	11.51	12.2	1.38
2Bud*End-to-end	126.50	2.55	12.46	12.1	1.56
3Bud*Overlaping	120.69	2.43	11.45	12.3	1.41
3Bud*End-to-end	123.47	2.48	11.87	12.0	1.40
4Bud*Overlaping	123.14	2.47	11.98	12.3	1.44
4Bud*End-to-end	119.86	2.47	11.26	12.3	1.44
5Bud*Overlaping	122.06	2.51	11.33	11.9	1.38
5Bud*End-to-end	119.78	2.54	11.46	11.8	1.34
Soil					
Light clay	122.77	2.32b	10.97b	12.47a	1.40
Heavy clay	121.56	2.67a	12.36a	11.77b	1.44
Cuttings					
Plant cane	124.34a	3.09a	15.27a	11.2c	1.77a
First ratoon	119.32b	2.25b	11.24b	12.9a	1.45b
Second ratoon	122.83ab	2.14b	8.50c	12.2b	1.04c
CV (%)	13	18	22	9	16

Note: *Means followed by the same letter in a column are not significantly different from each other; ha = hectare; CV= coefficient of variation.*

Sucrose percent cane was affected by the main effects of variety, soil and crop types in the set I and II experiments (Table 1 and 2). However, in the 3rd set of experiment, it was affected only by variety (Table 3).

Sugar yield was affected only by the main effects variety and crop types in the Set I and II experiments (Tables 1 and 2); however, only by the main effects of soil and crop types (Table 3).

Table 3: Effect of number of bud per sett and sett spacing on yield and yield components of sugarcane varieties (Set III)

Variety	Millable stalk count ('000/ha)	Stalk weight (kg)	Cane yield (t/ha/m)	Sucrose content (%)	Sugar yield (t/ha/m)
Mex54/245	110.40	2.61a	12.78a	11.4b	1.46
B41 227	112.00	2.30b	11.94b	12.3a	1.46
Sett type and placement					
2Bud*Overlaping	110.94	2.46	11.97	11.8	1.42
2Bud*End-to-end	113.97	2.41	12.52	11.6	1.44
3Bud*Overlaping	110.08	2.42	12.51	11.8	1.48
3Bud*End-to-end	111.86	2.44	11.95	11.8	1.40
4Bud*Overlaping	110.97	2.47	12.96	12.0	1.55
4Bud*End-to-end	111.78	2.42	12.72	11.7	1.49
5Bud*Overlaping	109.67	2.52	12.18	12.1	1.46
5Bud*End-to-end	110.31	2.50	12.06	12.0	1.44
Soil					
Light clay	104.74b	2.38b	12.01b	11.8	1.41b
Heavy clay	117.66a	2.53a	12.70a	11.9	1.50a
Cuttings					
Plant cane	103.37c	3.01a	14.53a	11.7	1.69a
First ratoon	119.47a	2.10c	13.07b	12.0	1.57b
Second ratoon	110.76b	2.25b	9.47c	11.9	1.12c
CV (%)	12	16	18	13	11

Note: *Means followed by the same letter in a column are not significantly different from each other; ha = hectare; CV= coefficient of variation.*

In all the parameters the effect of sett type and placement combination didn't bring significant difference. The presence of apical dominance and lower density of planting could not bring significant effect on yield (Tables 1, 2 and 3). Apical dominance suppresses the lower buds on the stalk and delays emergence (Blackburn, 1984). The reduced density of planting i.e., end-to-end reduces the number of buds per unit area from the conventional overlapped planting (Netsanet, 2014). However, the low density of buds planting (5 buds and end to end) was in statistical parity with the check (Tables 1,2 and 3). This may be attributed to the phenomenon that where sunlight quality and intensity is limiting, yield reduction arises due to the diversion of photosynthate away from the primary stalks. It is for this reason that high density planting is practiced in some countries (Amolo and Abayo, ND; Nayamuth and Koonjah, 2003).

4. Cost benefit Analysis

It is known that different varieties have different planting rate depending on their inter node length. But the average quantity of planting materials used to plant a hectare of land is 120, 108, 95 and 85qt/ha for 2, 3, 4, and 5bud sett respectively. Planting of cane has been practiced by two-budded sets having an average propagation rate of 1:10, i.e. One hectare seed cane field is used to plant ten hectares of commercial cane. From the collected data the propagation ratio of 1:14, 1:16 and 1:18 was found for three, four and five bud sett in end to end arrangement. Therefore, it is customary to use five budded setts as a planting material so as to reduce seed cane preparation and transportation cost, increasing of labour efficiency, increasing laborers income, and saving extra land for commercial cane production.

5. Conclusion and Recommendations

The results of this study revealed that sett type and placement influenced neither cane yield nor sugar yield in all varieties under study. Using three, four or five bud sett in an overlapping or end-to-end arrangement didn't have a significant difference from the check (two bud sett in an overlapping arrangement). Whereas, considering the cost benefit analysis using five budded setts as a planting material is mandatory with the benefit of reduce seed cane preparation and transportation cost, increasing of labour efficiency, increasing laborers income, and saving extra land for commercial cane production. Therefore, it is recommended that Metahara sugar estate can use five budded sett in end-to-end sett arrangements for all varieties under study.

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