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Effects of Pre Cutting Nitrogen Application Rate and Time on Seed Cane Quality of Sugarcane (*Saccharum officinarum* L.) Crop at Finchaa Sugar Estate

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Abstract

Field experiment was conducted at Finchaa Sugar Estate during the 2010/11 cropping period to assess the effect of rate and time of pre-cutting nitrogen fertilization on seed cane quality of sugar cane (*Saccharum officinarum* L.) crop. The treatments consisted of four levels of N (0, 23, 46, 69 kg N ha^{-1}) and four times of N application (8, 6, 4 and 2 Weeks before Cutting (WBC). The field experiment was laid out as a RCBD in a factorial arrangement and replicated three times. A sugarcane cultivar named N-14 was used as a planting material. The experiment was conducted on a sandy clay luvisol. Analysis of variance of the data revealed that the pre-cutting N application rate had no significant main effect on seed cane sett quality at the time of harvest. In contrast, pre-cutting N application time had significant main effect on seed cane stalk height, girth, reducing sugar, moisture and total N content. Thus, treating seed cane with N 8WBC for commercial planting resulted in improvement of seed cane stalk height, girth, reducing sugar and moisture content. However, significant improvement in total N content occurred in response to treating the crop with N 2WBC. The two main factors interacted to significantly influence only seed cane stalk height, reducing sugar and total N content. Pre-cutting N treatment with the rate of 23 kg ha^{-1} 8WBC resulted in higher seed cane height. However, pre-cutting N treatment with the rate of 69 kg ha^{-1} 8WBC resulted in higher reducing sugar and total N content. On the other hand, treating the seed cane with N at the rate of 23 kg ha^{-1} 2WBC resulted in significantly higher total N content, but this value was in statistical parity with the nitrogen content of the seed cane that was obtained from the treatment of 69 kg N ha^{-1} applied 8 WBC. it was generally observed that early application (8WBC) of N at higher dose (69 kg ha^{-1}) or also late application (2WBC) of N at lower dose (23 kg ha^{-1}) improved seed cane quality through significantly enhancing reducing sugar and total N contents, respectively. Therefore, As the precutting N application rate had no significant main effect, it could be concluded that, treating the seed cane with N at the lower rate of 23 kg ha^{-1} 8WBC had a dual advantage of improving quality (in terms of height, reducing sugar and total N content) of the seed cane crop.

Keywords: Weeks Before Cutting (WBC); Pre-cutting N application; Seed cane; Seed cane quality (Sugar cane)

Introduction

Intensification of sugarcane cultural treatments (fertilization, irrigation, weeding, etc.) and agronomic related production factors play an important role for producing high cane and sugar yield per unit area. However, lack of proper cultural practices specific to fertilizer treatments on seed cane fields are among the major constraints of sugarcane production in Ethiopia in general and at Finchaa Sugar Estate in particular. Usually, fields of light red chromic luvisol have been allocated for the seed cane production and fertilized with Di-ammonium phosphate (DAP) with the rate of 250 kg ha^{-1} at planting and 150 kg urea ha^{-1} at about two and half months after planting in the same way as the commercial cane. However, the purpose of production and quality required to obtain is too different [1].

Seed cane production, which is an integral component of sugar production, often receives less priority than the commercial crop plants in many sugar cane plantations [2,3]. Most of the research works on seed cane has focused also on the mechanics of cutting and fungicidal treatments of setts. Therefore, little effort has been made to improve cultivation of seed cane [3,4]. On the other hand, it is emphasized that improving seed cane production is the basis for satisfactory crop stand establishment. Hebert [5] pointed out that planting sound pieces with high germination capacity is very essential in order to maintain a uniform stand of sugar cane that ultimately produces high cane and sugar yield. Thus, it is unquestionable that seed cane plants should receive special cultural treatments such as fertilization, irrigation, crop protection measures, and etc.

Apart from other cultural practices, fertilization is one essential input for seed cane production. In general, the importance of balanced fertilizer application to sugar cane has often been emphasized [6-8], since sugar cane by its nature requires nutrients such as nitrogen, phosphorous and potassium in large quantities. According to Russell [9] nitrogen occupies the highest position in the nutrition of sugar cane. Nitrogen fertilization enhances the growth of sugar cane and enables the plants to take up other nutrients [10].

Hebert [5] asserted that increasing the level of nitrogen to the optimum requirements of seed cane plants correspondingly increases

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the quality of seed sett. In the establishment of satisfactory crop stand, attaining good germination or emergence is very important, since germination constitutes a critical stage in the life of the plant [11]. In the physiological process of germination, it is a well-established fact that seed cane is largely dependent upon its own food reserve. Well treated and nourished seed canes have been found to have good germination capacity and vigour of the subsequent crop. According to King [12], plants with high nitrogen content germinate better than setts obtained from a poorly fertilized crop. Kakde [6] Suggested that application of nitrogen on seed cane at 50% greater than the recommended dose applied to the commercial crop leads to higher quality of seed cane sett for the subsequent commercial crop planting.

The intrinsic stalk characteristics are important factors on sprouting and tillering because of the fact that sugarcane is propagated by stalk cuttings and hence sprouting and the early stage of growth depend largely on the reserve food in the sett [13]. The findings of other researchers revealed that the condition of buds, nutrient reserves in setts, size and age of the stalk used affect sprouting and shoot development [6,14]. According to Kakde [6] fresh succulent condition of a bud enhances rapid multiplication of cells and quicker sprouting of buds. Soluble nitrogenous compounds and starch in sett are essential for cell division and elongation while glucose is used for formation of cell walls [15]. Adequate moisture content in setts is important for quicker sprouting as buds remain fresh, plump and healthy [6]. Dellewijin [11] reported that sprouting ability of the buds seems to be positively correlated with the moisture, nitrogen and glucose content of the bud tissue.

Nevertheless, in the Ethiopian Sugar Estates except allotting fertile and good fields for seed cane production, the seed cane plants are fertilized in the same way as the commercial cane fields, despite the difference in the purpose of production. In addition, information on optimum level and time of pre-cutting nitrogen application on seed cane of sugarcane and its effect on sett quality is inadequate. Therefore, the ultimate yield and quality of sugar may still be limited by low quality and poor performance of seed cane production in the country in general and at Finchaa Sugar Estate in particular. This is particularly true with regard to investigating the influence of pre-cutting nitrogen fertilization of sugarcane seed crop on its sett quality. Therefore, this study was initiated with the following objective: To study the effect of pre-cutting nitrogen application rate and time on the quality of seed cane setts.

Material and Method

The study was conducted on sandy clay luvisol soil type of the Estate and the variety Natal 14 (N-14) was used for the study propose. The treatments consisted of four rates of pre-cutting N application (0, 23, 46, and 69 kg N ha^{-1}) and four timings of N application (8, 6, 4, and 2 weeks) prior to cutting for seed cane (i.e. at nine months' crop age) for the subsequent commercial crop planting. At the time of N treatment application (at seven, seven and a half, eight, and eight and a half months crop age after planting of the seed cane nursery), the availability of soil moisture was checked for nutrient dissolution and absorption.

Totally, there were 16 treatment combinations. The experiment was laid out as Randomized Complete Block Design (RCBD) in a factorial arrangement and replicated three times per treatment. The total area of each experimental plot was 4 rows x 5 m x 1.45 m between each rows (29 m^2). The spaces between plots and replications/blocks were kept at 1.5 m and 2.9 m apart, respectively.

Ten months old, healthy and two budded seed cane setts were prepared from initial seed cane field of the Estate. The setts were prepared a day before planting. To protect the sett from various diseases, a Lysol solution (120 ml Lysol in one litre of water) was used for disinfecting cane knives after each cutting of stool and chopping of one stalk. Also to protect the chopped sett from soil borne diseases and pests after planting, the chopped seed material was completely dipped/immersed in a fungicide called Ben-late/Benomyl solution (180 g in 200 litres of water) for 1-2 minutes using a steel wire basket which is made for the free flow of chemical solution in the drum and the solution is drained off into the drum while removing the chopped sett in the steel wire basket after treatment [4].

The treated setts were planted in the furrow with 5 cm overlapping of sett arrangement on the pre-irrigated experimental field on 7th April 2010. Number of sett planted per five meter furrow length were determined based on the average length of the prepared setts before planting by carrying out a simple trial on the spot, i.e. thirty five two bud setts. At planting, the conventional recommended rate of 250 kg DAP (Di-ammonium phosphate, 46% P_2O_5 and 18% N) ha^{-1} (45 kg N + 115 kg P_2O_5) was equally applied for all experimental plots manually in the furrows and immediately covered with a 2-5cm layer of soil. Similarly, Urea (46% N) at the rate of 150 kg ha^{-1} (69 kg N) was equally applied to all experimental plots manually in both side of the furrow after two and a half months of planting the seed cane crop. Other cultural practices like weeding and irrigation were done according to the standard norms of the Estate.

After five months' growth of the crop, the cane fields were dense and had closed canopies that made movement of humans inconvenient for manual operation (fertilizer application). Therefore, to make manual pre-cutting nitrogen treatment application accessible at seven, seven and half, eight and eight and half months after planting of the seed cane nursery, detrashing of dry and lower leaves of all experimental plots was done one day before application of the first treatment (i.e. at seven months' crop age).

Pre-cutting nitrogen treatment in the form of urea (46% N) at the rate of 0, 23, 46, and 69 kg ha^{-1} was applied in both sides of the furrow through band application at 8, 6, 4 and 2 weeks before cutting the seed cane for the subsequent commercial planting, i.e. at seven, seven and a half, eight and eight and a half months after planting of the seed cane nursery, respectively.

Data collection and measurements

Seed canes propagated on experimental field were harvested at nine months crop age for the subsequent commercial crop planting. The following under mentioned seed cane quality parameters were measured, counted and analyzed during the harvest of seed cane:

Stalk length/height: Mean Seed cane stalk length (from zero ground level to the top visible dewlap) was measured from 20 randomly selected representative primary stalk samples of seed cane per plot at harvest by using a tape meter.

Seed cane stalk diameter/girth: Mean seed cane stalk diameter/girth was measured after removal of sheath from three seed cane stalk positions; top, middle and bottom parts by using a standard calliper meter from the above 20 randomly selected representative primary stalk samples of seed cane per plot at harvest.

Number of internodes per seed cane stalk: The number of internodes per seed cane stalk (after removal of sheath and top succulent parts) was counted from the above 20 randomly selected representative primary stalk samples of seed cane per plot at harvest.

Seed cane stalk weight per stalk: The weight of seed cane stalk was taken from the above 20 randomly selected representative primary stalk samples of seed cane per plot at harvest and expressed as weight per stalk. The above samples per specified treatment/plot were subjected to a laboratory analysis. The sample seed cane stalks were crushed with Jeffco cutter grinder having 10HP Model 265BX to disintegrate cane stalk tissue into the required grade. Fiberized cane was sampled for the analysis of different parameters like nitrogen, fibre and moisture content of seed cane stalk sample. To extract the juice, the crushed/fiberized cane samples were pressed with a 110 bar hydraulic press machine to collect the required quantity of juice for analysis of different parameter like reducing sugar, Brix% cane, Pol% cane and total non-sugar content of seed cane stalk sample following the methods and procedures developed for each parameters of cane juice analysis and fiberized cane tissue quality assessment (ICUMSA, 1994).

Total nitrogen content: Fiberized seed cane stalk by Jeffco cutter grinder was sampled and oven-dried at 65°C for 24 hrs and then at 60°C to a constant weight and the dried sample was grind by the standard leaf tissue sample grinding machine. Total nitrogen content of the fiberized seed cane stalk tissue sample was determined by the Micro-Kjeldahl digestion, distillation, and titration method (FAO, 2008).

Reducing sugar content: Reducing sugar content (percentage of other sugars like fructose and glucose) in the planting material/seed cane stalk sample was determined by using the Lane and Eynon's volumetric method outlined by (ICUMSA, 1994).

Cane moisture content (%): Moisture content of seed cane stalk sample was determined from samples taken from crushed/fiberized cane. A test portion of prepared cane was dried under standard conditions using a forced draught drying oven (moisture teller) and the moisture content was determined from the mass loss following the procedure outlined by (ICUMSA, 1994).

Cane moisture content (%) = (M2 - M3)/(M2 - M1)

Where: M1 - weight of empty container; M2 - weight of empty container plus the fresh sample; M3 - weight of empty container plus the dried sample

Fiber content of seed cane stalk (%): The fibre percent of the seed cane stalk sample was calculated using the analytical data of dry substance percent cane and Brix percent extract following the procedure outlined by (ICUMSA, 1994).

Fiber % cane = $(D - 4b_e)/(1 - 0.0125b_e)$

Where: D - Dry substance percent, be - Brix percent extract

Pol% cane, Brix % cane and Total non-sugar content: Pol% cane, Brix % cane and total non-sugar content of the juice were determined according to the methods out lined by ICUMSA (1994).

Brix % cane (Bc) = b_e (4 – 0.0125 F) Where: b_e = Brix extract

Pol % cane (Pc) = P_e (4 – 0.0125 F) p_e = Pol extract

Total non-sugar = 100 – sugar yield F = Fiber % cane

Statistical analysis

Data collected from the experiments was subjected to analysis of variance (ANOVA) with the GLM procedure of the SAS for windows software version 9.0 [16]. Differences between treatment means were separated using the Least Significant Difference Test (LSD) at 5% level of significance following the methods described by [17].

Results and Discussion

Effect of pre-cutting nitrogen application rate and time on the quality of seed cane stalk/sett

In the study, nitrogen levels had no significant main effect on all seed cane stalk/sett quality parameters. In contrast to this, pre-cutting nitrogen application time had significant (P ≤ 0.05) main effect only on seed cane stalk height, girth, reducing sugar, total nitrogen and moisture content. The two main factors interacted to significantly (P ≤ 0.05) influence only seed cane stalk height, reducing sugar and total nitrogen content of seed cane at harvest (Appendix Tables 1 and 2).

Effect of pre-cutting nitrogen application rate and time on seed cane stalk height and girth

The different levels of pre-cutting nitrogen application on seed cane of sugarcane did not significantly (P ≤ 0.05) affect the stalk height and girth of seed cane at the time of harvest. However, time of pre-cutting nitrogen application on seed cane of sugarcane showed significance main effect (P ≤ 0.05) on seed cane stalk height and girth/diameter (Appendix Table 1). In addition, the interaction effect of N levels and times of application showed significant differences (P ≤ 0.05) on seed cane stalk height during the time of harvest for planting (Table 2 and Appendix Table 1).

When the time of pre-cutting nitrogen application was reduced from 8 weeks to 6 weeks before cutting for seed cane, there was no significant change in stem girth (Table 2). However, when the pre-cutting time was shortened to 4 and 2 weeks before harvesting for seed cane, the girth of the plants decreased significantly (P ≤ 0.05). Thus, plants treated with nitrogen at 6 weeks before cutting for seed cane had about 1.3 and 2.4% wider stem girth than those supplied with nitrogen 4 and 2 weeks before cutting for seed cane, respectively. However, stem girth of plants treated with nitrogen 6 weeks before cutting the seed cane for planting and stem girth of those plants treated with nitrogen 8 weeks before cutting were in statistical parity. Therefore, the highest mean seed cane stalk girth was recorded by treating the seed cane with N at 6 weeks prior to cutting for seed cane but this was statistically the same with that treated 8 WBC (Table 2). Therefore, pre-cutting N treatment 8 and 6 WBC produced stalk girth that was higher by about 2.44% than that produced at 2 WBC. The significant reduction in stem girth with the reduction in the pre-harvest duration of nitrogen application before cutting the seed cane for planting could

Treatment No.	Rate and time of N application prior to cutting for seed cane	Treatment No.	Rate and time of N application prior to cutting for seed cane
T1	0 kg N ha^{-1}@ 8 WBC	T9	0 kg N ha^{-1}@ 4 WBC
T2	23 kg N ha^{-1}@ 8 WBC	T10	23 kg N ha^{-1}@ 4 WBC
T3	46 kg N ha^{-1}@ 8 WBC	T11	46 kg N ha^{-1}@ 4 WBC
T4	69 kg N ha^{-1}@ 8 WBC	T12	69 kg N ha^{-1}@ 4 WBC
T5	0 kg N ha^{-1}@ 6 WBC	T13	0 kg N ha^{-1}@ 2 WBC
T6	23 kg N ha^{-1}@ 6 WBC	T14	23 kg N ha^{-1}@ 2 WBC
T7	46 kg N ha^{-1}@ 6 WBC	T15	46 kg N ha^{-1}@ 2 WBC
T8	69 kg N ha^{-1}@ 6 WBC	T16	69 kg N ha^{-1}@ 2 WBC

Where, WBC = Weeks before cutting for seed cane; N = Nitrogen.

Table 1: Treatment number and the respective amounts of additional nitrogen applied to the seed cane plants at different rates and times prior to cutting for seed cane at Finchaa, 2011.

Treatment	Seed cane stalk girth (mm)
N rate (NR) (kg ha^{-1})	
0	28.39
23	28.43
46	28.68
69	28.73
SE±	0.17
LSD	NS
Time of N application (NT) (WBC)	
8	28.67^{ab}
6	28.94^{a}
4	28.56^{b}
2	28.25^{b}
SE±	0.17
LSD	0.50
Mean	28.55
CV (%)	2.12

Where, NS = Non-significant; WBC =Weeks before cutting for seed cane; means followed by the same letters are not significantly different at 5% level of significance according to the LSD test.

Table 2: Seed cane stalk girth as influenced by pre-cutting N application rate and time, at Finchaa, 2011.

be attributed to the short time left for the plant to effectively utilize the nitrogen for growth and development. This result is in agreement with that of Lakshimi et al. [18] who also reported that seed cane yield in terms of girth varied significantly with time of nitrogen application.

As a result of the interaction effect of the two factors, significantly tallest seed cane stalk resulted in response to applying nitrogen at the rate of 23 kg N ha^{-1} to the standing seed cane crop at 8 weeks before cutting for seed cane (Table 3). However, the seed cane stalk height attained at the rate of 23 kg N ha^{-1} supplied at 8 weeks before cutting for seed cane was in statistical parity with the seed cane stalk height obtained at the treatment combinations of 0 kg N ha^{-1} + 8 weeks before cutting, 46 kg N ha^{-1} + 2 weeks before cutting, 69 kg N ha^{-1} + 6 weeks before cutting, 69 kg N ha^{-1} + 4 weeks before cutting, and 69 kg N ha^{-1} + 2 weeks before cutting. The probable reason why higher seed cane stalk height resulted by untreated plot might be due to higher variance in measurement. Pre-cutting N application on standing seed cane crop prior to cutting for planting with a rate of 23 kg N ha^{-1} 8 WBC resulted in significantly ($P \leq 0.05$) higher stalk height than the treatment with 23 kg N ha^{-1} 2 WBC. In this study, it was observed that pre-cutting application of N with lower dose 8 WBC or early application favored good crop growth/elongation and this helped to increase the seed cane yield in terms of height (Table 3). This result is consistent with that obtained in a previous study by Lakshimi et al. [18]. In line with this, TNAU [19] also reported that applying 23 kg N ha^{-1} as a top dressing additionally before one month of cutting the seed cane to the nursery crop improved seed cane sett yield.

Bakker [20] illustrates that, growth develops from above to downwards and that it proceeds in the order of leaf blade to sheath and internodes. With respect to the phases of growth, cell elongation is preceded by cell division and cell differentiation. Cell division takes place in the meristem of the growing point, resulting in a continuous formation of new cells. These cells gradually form different kinds of tissues. As a result, stalk elongation and increase in girth comes at a later stage. Therefore, the shorter time gap between fertilizer treatment and cutting of the seed cane stalk for planting may be considered to be one the of the most important factors as the plants need sufficient time to take up the applied nutrient and convert to its stalk elongation and girth. Therefore, taller and thicker seed cane stalks were obtained from the seed cane plants that were treated with N at the rate of 23 kg ha^{-1} 8 weeks prior to cutting the seed cane for planting.

Gilbert et al. [21] also illustrates that, the growth of cane plant (increase in size/height or dry weight) is governed by a complex of internal and external factors. The more important external factors affecting growth are soil moisture, temperature, light, soil condition and its nutrient content, of which temperature plays an important role in limiting stalk elongation and girth of sugarcane and the internal factors affecting early establishment and growth of cane are set moisture and nutrient content mainly nitrogen.

Effect of pre-cutting nitrogen application rate and time on seed cane stalk internodes number and weight per stalk

Both the main factor and interaction effects of pre-cutting nitrogen application rate and time did not affect the internodes number and weight per stalk of the seed cane at nine months growth stage (Table 4 and Appendix Table 1).

However, the non-significant main as well as interaction effects of nitrogen level and pre-cutting nitrogen application time on seed cane

Nitrogen rate (NR) kg ha^{-1}	Seed cane stalk height (cm)				
	Time of N application (NT) (WBC)				
	8	6	4	2	Mean
0	189.23^{ab}	177.03^{cd}	181.37^{bcd}	181.50^{bcd}	182.28
23	191.70^{a}	175.03^{d}	182.03^{bcd}	181.77^{bcd}	182.63
46	181.67^{bcd}	182.40^{bcd}	175.90^{d}	187.10^{ab}	181.77
69	178.20^{cd}	186.63^{ab}	185.17^{abc}	187.83^{ab}	184.46
Mean	185.20	180.28	181.12	184.55	182.79
SE±	2.86				
LSD	4.13				
CV (%)	2.70				

Where, WBC = Weeks before cutting for seed cane; Means followed by the same letters are not significantly different at 5% level of significance according to the LSD test.

Table 3: Interaction effect of pre-cutting N application rate and time on seed cane stalk height at Finchaa, 2011.

Treatment	Seed cane stalk internodes (No)	Seed cane stalk weight (kg)
Nitrogen rate (NR) (kg ha^{-1})		
0	13.42	1.18
23	13.58	1.20
46	13.58	1.23
69	13.83	1.25
SE±	0.16	0.02
LSD	NS	NS
Time of N application (NT) (WBC)		
8	13.58	1.19
6	13.58	1.20
4	13.67	1.23
2	13.58	1.23
SE±	0.16	0.02
LSD	NS	NS
Mean	13.60	1.21
CV (%)	3.99	6.67

Where, NS= Non-significant at 5% level of significance, WBC= Weeks before cutting for seed cane

Table 4: Seed cane stalk internodes number and weight per stalk as influenced by pre-cutting N application rate and time, at Finchaa, 2011.

stalk growth parameters (internodes number and weight per stalk) might be attributed to the shorter time gap that occurred between nitrogen application and cutting of the seed cane for planting the subsequent commercial crop. This suggestion may be substantiated by the fact that, sugarcane has low nitrogen use efficiency, particularly so is variety N-14 [22]. Schumann, et al. [23] also reported that N-14 was less efficient in N use. Supporting this proposition, another experiments also proved that, most of the efficient N uptake takes place within the first six active growth months by the sugarcane crop [20].

Sundara [7] also described that, nitrogen is the key nutrient element influencing sugarcane yield and quality. It is required more for vegetative growth, i.e. tillering, foliage formation, stalk formation, stalk growth (internodes formation, internodes elongation, increase in stalk girth and weight) and root growth. But the author further revealed that to derive maximum benefits from the applied nutrients, it is highly important to apply the fertilizer at optimum time and required dose. In the case of seed cane nurseries, a faster rate of growth is essential in the early stage for maximizing sett yields. Therefore, optimum dosage of nutrients, particularly nitrogen, and their early application would be advantageous since nitrogen requirement of sugarcane is the greatest during the tillering and the early grand growth phase.

Effect of pre-cutting nitrogen application rate and time on seed cane stalk reducing sugar and total nitrogen content

The main effect of time of nitrogen application was significant ($P<0.05$) on reducing sugar and nitrogen contents of seed cane stalk/sett. However, the main effect of N rate had no influence on reducing sugar and nitrogen contents of the seed cane plant at the time of harvest for planting (Appendix Table 1). The interaction effect of N rate and time of pre-cutting nitrogen application was significant on both reducing sugar and nitrogen contents of seed cane stalk/sett at the time of harvest for commercial planting (Tables 5 and 6, Appendix Table 1).

The interaction effect revealed that treating the standing cane with nitrogen prior to cutting for planting of the subsequent commercial crop at the rate of 69 kg N ha^{-1} 8 weeks before cutting significantly enhanced the reducing sugar (glucose and fructose) content of the seed cane (Table 5). However, the reducing sugar content obtained at the combination of 69 kg N ha^{-1} and applying the N at 8 weeks before cutting the seed cane for planting was in statistical parity with reducing sugar contents obtained at the combination of untreated check plots at 6 as well as 2 weeks before planting (Table 5). Therefore, the result indicated that pre-cutting nitrogen application at the rate of 69 kg N ha^{-1} 8 WBC as well as plots untreated by pre-cutting nitrogen application at 6 and 2 WBC led to the production of stalk/sett having significantly higher contents of reducing sugar. Hence, effect of N applied before treatment application at planting (45 kg N ha^{-1}) and at two and half months after planting (69 kg N ha^{-1}) and/or biological N fixation might be benefited the untreated check plots at 6 as well as at 2 WBC for their significant increase in reducing sugar content of seed cane sett [5].

In line with the result, the overall means of N treated plots reducing sugar content of seed cane stalk/sett in the study was higher than that of matured sugarcane stalk reducing sugar content, which is on average less than 0.1% (35). In addition, Sundara [7] also suggested that pre-fertilizing the nursery crop at about 6 to 8 weeks prior to harvest for planting helps to obtain healthy setts with more moisture, more reducing sugar and with higher nutrient content. Richard and Irvine [24] also reported that young and immature canes have high amount of reducing sugar content.

The results of the interaction effect also showed that treating standing seed cane crop with 23 kg N ha^{-1} at 2 weeks prior to cutting was highest in total nitrogen content of the seed cane stalk, which was in statistical parity with the mean value produced by untreated/check plots at 2 WBC and plots treated with 46 kg N ha^{-1} 8 WBC, 69 kg N ha^{-1} at 8 WBC, 69 kg N ha^{-1} 4 WBC, 69 kg N ha^{-1} 2 WBC. Hence, effect of N applied before treatment application at planting (45 kg N ha^{-1}) and at two and half months after planting (69 kg N ha^{-1}) and/or biological N fixation might be benefited the untreated check plots at 2 WBC for their significant increase in total nitrogen content of seed cane sett (Table 6).

However, pre-cutting nitrogen application on seed cane of sugarcane with the rate of 23 kg N ha^{-1} 2 WBC had significantly higher nitrogen content in stalk/sett (Table 6). The average means of total nitrogen content of seed cane stalk/sett treated with N prior to cutting for seed cane for all treatment in the study was also higher than that of the untreated conventional nine month crop age stalk of total N content, i.e. 0.16% [20]. In line with this result, Singh et al. [25] reported that pre-cutting nitrogen treatment of seed cane crop during the normal course of growth has a profound effect on the nutritional status of cane stalk/sett which had marked influence on germination of sett for the subsequent commercial crop. Sreewarome et al. [26] also reported that nitrogen is vital for most plant metabolic processes and plays an important role in early growth, tillering and stalk elongation of sugar cane plant.

Kakde [6] reported that the nutritional status of cane stalk/sett had marked influence on germination of sett for the subsequent commercial crop as it is afforded the energy required for sprouting of bud and young shoot till it was established on its own. Therefore, high nitrogen,

Nitrogen rate (NR) kg ha-1	Reducing sugar content (%)				
	Time of N application(NT) (WBC)				
	8	6	4	2	Mean
0	1.83^{bcde}	1.97^{abc}	1.67^{e}	1.99^{ab}	1.87
23	1.95^{bcd}	1.92^{bcd}	1.93^{bcd}	1.82^{bcde}	1.91
46	1.91^{bcd}	1.86^{bcd}	1.79^{de}	1.80^{cde}	1.84
69	2.14^{a}	1.85^{bcd}	1.83^{bcde}	1.93^{bcd}	1.94
Mean	1.96	1.9	1.81	1.89	1.89
SE±	0.06				
LSD	0.09				
CV (%)	5.7				

Where, WBC = Weeks before cutting for seed cane; followed by the same letters are not significantly different at 5% level of significance according to the LSD test.

Table 5: Interaction effect of pre-cutting N applications rate and time on seed cane stalk reducing sugar content at Finchaa, 2011.

Nitrogen rate (NR) kg ha-1	Total nitrogen content (%)				
	Time of N application(NT) (WBC)				
	8	6	4	2	Mean
0	0.21^{d}	0.23^{bcd}	0.21^{cd}	0.24^{abc}	0.22
23	0.22^{bcd}	0.22^{bcd}	0.22^{bcd}	0.26^{a}	0.23
46	0.24^{ab}	0.23^{bcd}	0.23^{bcd}	0.23^{bcd}	0.23
69	0.24^{ab}	0.22^{bcd}	0.24^{ab}	0.24^{abc}	0.24
Mean	0.23	0.22	0.23	0.24	0.23
SE±	0.01				
LSD	0.01				
CV (%)	6.61				

Where, WBC = Weeks before cutting for seed cane; Variable means followed by the same letters are not significantly different at 5% level of significance according to the LSD test.

Table 6: Interaction effect of pre-cutting N application rate and time on seed cane stalk total nitrogen content at Finchaa, 2011.

starch and glucose contents were essential for good seed though their content varied with different varieties. There was also a high positive correlation with amide-N but variable with glucose. However, glucose content of setts was considered as a reliable index of planting material for germination. Thus, the causes of increased germination were attributed to the greater availability of food, water or nutrients from the substrate to the growing bud or an internal metabolic change in the sown sett culminating to a favorable influence on the emergence and after growth of the sugarcane buds [25].

Effect of pre-cutting nitrogen application rate and time on seed cane stalk/sett moisture and fibre content

The main effect of time of pre-cutting nitrogen application significantly ($P \leq 0.05$) influenced the moisture content of the seed cane. However, neither the main effect of rate of nitrogen application nor the interaction effect of the rate and time of nitrogen application had significant ($P \leq 0.05$) influence on moisture content of the seed cane. Fibre content of the seed cane was not affected by the main effect of the rate of nitrogen as well as the time of pre-cutting nitrogen application. It was not also affected by the interaction effects of the two factors (Table 7 and Appendix Table 1).

Sett moisture content increased significantly by about 1% when the time of nitrogen application before cutting was lengthened from 2 to 8 weeks before cutting. However, this increase in moisture content was in statistical parity with the moisture content of the seed cane that occurred when the application of nitrogen was done 4 weeks before cutting the cane for commercial planting. Consistent with this result, Sundara [7] reported that additional fertilizers given to sugarcane crop planted exclusively for seed purpose at about 6 weeks prior to harvest improved seed quality by enhancing sett nutrient status and sett moisture content. Verma [27] also reported that setts with higher moisture content give quicker and higher germination and the seedlings emerging from such setts establish quickly and grow vigorously. Singh et al. [25] also reported that optimum level of sett moisture content for rapid germination was 72 to74%. In addition, Srivastava [28] also described standards of seed cane moisture content and suggested that it should not be less than 65% on weight basis. In general, the average stalk/sett moisture content of all treatments in the study was greater than that of the critical sett moisture content (50.3%) for germination of buds on seed cane sett by 55.35%.

Pre-cutting nitrogen treatment levels and time of application on seed cane had not significantly change the fiber content of the seed cane stalk/sett (Table 7). Corroborating the results of this study, Koochekzadeh et al. [29] revealed that the N application rate had no influence on enhancing the fiber content and trash amounts of sugarcane. This might be more of varietal character. According to SASRI [22] variety N-14 is moderate in fiber content for matured cane (approx. 12.7%). However, the mean result in the study was lower than that of the approximate fiber content of matured cane by 22.71% which is well below the average value for the variety fiber content. This might be due to the fact that the crop supplied with N was harvested earlier for seed cane than the usual time for cane harvesting intended for sugar production. High rate of N application and early harvesting are known to reduce the degree of lignifications of tissues by reducing fiber content of plant organs.

Effect of pre-cutting nitrogen application rate and time on seed cane stalk pol% cane, brix% cane and total non-sugar content

The results of the study indicated that, both the main factors (N level and time of pre- cutting nitrogen application) and also the interaction effect between them did not significantly ($P \leq 0.05$) affect the Pol% cane, brix% cane and total non-sugar content of the seed cane stalk/sett at the time of harvest for seed cane (Table 8 and Appendix Table 2).

Pol% cane (the apparent sucrose in a juice) is important qualitative parameters used for maturity judgment in sugar cane production [30]. However, the lowest value was recorded for N treated plots and the highest was recorded for untreated check plots. These results are identical with the results obtained by Mohammed [31] who described an inverse relationship between the increasing rate of late fertilizer application and decreasing value of Pol% in juice of seed cane plants.

Treatment	Moisture content (%)	Fiber content (%)
N rate (NR) (kg ha-1)		
0	78.23	10.05
23	78.12	10.49
46	77.80	10.70
69	78.41	10.16
SE±	0.17	0.30
LSD	NS	NS
Time of N application (NT) (WBC)		
8	78.55[a]	9.98
6	78.02[b]	10.62
4	78.22[ab]	10.01
2	77.77[b]	10.80
SE±	0.17	0.30
LSD	0.50	NS
Mean	78.14	10.35
CV (%)	0.77	0.86

Where, NS = Non-significant; WBC; Weeks before cutting for seed cane; means followed by the same letters with in column are not significantly different at 5% level of significance according to the LSD test.

Table 7: Seed cane stalk/sett moisture content and fibre content as influenced by pre-cutting N application rate and time on seed cane of sugarcane at Finchaa, 2011.

Treatment	Pol % cane	Brix% cane	Total non sugar (%)
Nitrogen rate (NR) (kg ha^{-1})			
0	8.42	11.72	93.77
23	8.20	11.39	93.97
46	8.22	11.50	93.95
69	8.23	11.41	93.86
SE±	0.18	0.17	0.21
LSD	NS	NS	NS
Time of N application (NT) (WBC)			
8	8.09	11.47	94.09
6	8.16	11.36	94.02
4	8.40	11.56	93.79
2	8.43	11.43	93.64
SE±	0.18	0.17	0.21
LSD	NS	NS	NS
Mean	8.27	11.51	93.88
CV (%)	7.38	0.49	0.77

Where, NS = Non-significant at 5% level of significance; WBC = Weeks before cutting for seed cane.

Table 8: Pol, brix and total non-sugar content of seed cane stalk/sett as influenced by pre -cutting N application rate and time on seed cane of sugarcane at Finchaa, 2011.

Brix% cane (apparent/total soluble solids in a juice) is the second qualitative parameters used for maturity judgment in sugar cane production [30]. However, the lowest reading result of brix and pol were recorded for N treated plots and the highest was observed for untreated check plots. These results are in accord with those of Wiedenfeld [32] and who reported that late application of N resulted in poor juice quality (low brix and pol value) in matured cane but in contrary to this, it is a good quality for seed cane plants in maintaining food reserve for the germinating buds [20,33].

Total non-sugar content of seed cane stalk/sett is a constituents of the seed cane stalk/sett other than sucrose, glucose and fructose, i.e. fibre, water and dissolved non sugars (both organic and inorganic). The result obtained in this study is high as compared to the matured cane total non-sugar content. However, the low result of Pol% and Brix% cane and high result of total non-sugar content of the immature seed cane stalk/sett than matured sugarcane stalk might be due to low/minimum rate of reversion of glucose and fructose to sucrose at active growth stage of the plant [20].

Conclusions

Based on the results of this study, it is generally concluded that, early (8 WBC) application of N at higher dose (69 kg ha^{-1}) or also late (2 WBC) application of N at lower dose (23 kg ha^{-1}) improved seed cane quality through significantly enhancing in reducing sugar and total nitrogen contents of the seed cane stalk/sett, respectively. Therefore, As the precutting N application rate had no significant main effect, treating the seed cane with N at 23 kg ha^{-1} 8WBC the seed cane for commercial planting had evidently the dual advantage of improving seed cane quality (in terms of seed cane height, reducing sugar, and total N content. Moreover, similar studies should be conducted by including more N rates with different times of pre-cutting N application on seed cane for this and other popular varieties under production in the Estate.

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