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Effect of Different Nitrogen Rates and Time of Application in Improving Yield and Quality of Seed Cane of Sugarcane (Saccharum spp. L.) Variety B41/227

Mengistu Sime

Department of Plant Sciences, School of Agriculture, Adama Science and Technology University, P.O.Box 1888, Adama, Ethiopia
E-mail: simemengistu@gmail.com; msimeb@yahoo.com

Abstract- A two-phase field experiment on the effect of N application was studied on growth, yield and quality of seed cane of sugarcane variety, B41/227 at Finchaa Sugarcane Plantation during 2000/2001 and 2002/2003 cropping years. Thirty two treatments comprised of four N levels – 0, 46, 92 and 138kg/ha, and applied at $2^1/_2$, 5 and $7^1/_2$ months after planting in whole and split applications were used in RCBD with three replications. The source of fertilizer is urea (46%N), which is the commonly used fertilizer in the plantation. The results of the experiment showed that application of high N rate resulted in better plant height, stalk population, stalk length as well as higher sett yield and improved sprouting of buds. In phase-1 experiment, significantly higher sett yield was obtained for the highest rate of 138kgN/ha applied in single, double and triple doses over the control. Apart from other treatments, application of 138kgN/ha in two doses at two and half and five months significantly increased stalk population and sett yield by 39.1 and 51.7%, respectively, over the control. In the second phase, seed setts obtained from seed cane plants treated with the same rate gave sprouting performance of average quality. Significantly higher sprouting performance was recorded for seed setts from seed cane plants treated with N rates applied at mid and late crop ages. Therefore, to get higher sett yield of average quality it is advisable that urea be applied to seed cane plants of sugarcane variety B41/227 at the rate of 300kgN/ha in two splits of 200 and 100kgN/ha at two and half and five months of crop ages, respectively. Besides, as this study is the first by its kind under Finchaa condition, it paves an opportunity for further investigation including major sugarcane varieties under cultivation in the study site and other sugarcane plantations in the country.

Index Terms- Fertilization, nitrogen, seed cane/sett, sett yield, sugarcane

I. Introduction

Sugarcane is propagated commercially by vegetative method, which involves the planting of the stem cuttings of immature cane about 8 to 12 months old, grown with special care are recommended for seed cane (Fauconnier, 1993). Herbert (1956) asserted that planting sound seed pieces with high germination capacity is very essential in order to maintain a uniform stand of sugarcane that ultimately produces high cane and sugar yield. Thus it is a point of due consideration that seed cane plants should receive high nitrogen (N) fertilization with balanced phosphorus (P) and potassium (K). According to Russell (1988) N occupies the highest place in the nutrition of sugarcane. N fertilization enhances and increases the growth of sugarcane and enables the plants to take up other nutrients (Barnes, 1974). Increasing the level of nitrogen to the optimum requirements of the seed cane plants correspondingly increases sett yield and quality (Herbert, 1956). Kakde (1985) also reported application of N as high dose 50% greater than that applied to the commercial cane. Various review reports (Humber, 1963; Clements, 1980) indicated that N fertilizer applications at two to six weeks before the cane is cut for seed is useful to improve germination, tillering and induce early vigour.

The foregoing reviews at the formerly established sugarcane plantations of Wonji-Shoa and Metahara suggest that N fertilization of seed cane plants has a potential to improve yield and quality of setts, which in turn gives a foundation for good crop stand (Tadesse, 1993, 2004) whereas no research results are available on seed cane fertilization under Finchaa condition, which may differ from Wonji-Shoa and Metahara in fertility status and climatic conditions.

At Finchaa Sugarcane Plantation the practices of seed cane fertilization is the same to the commercial cane fields despite the difference in the purpose of production. Usually, fields of light red chromic Luvisols have been allocated for seed cane production. Therefore, this study was initiated to investigate the influence of different N rates on growth, yield and quality of seed cane of sugarcane variety understudy.

II. Materials and Methods

The study was carried out at Finchaa, which is located at about 330km west of Addis Ababa. Its elevation is about 1350-1600m.a.s.l. with long years' annual mean maximum and minimum temperatures of 30.6 and 14.5^{0}C, respectively. Long years annual mean rainfall of the area is about 1310mm and mean maximum and minimum relative humidity is 83.8% and 38%, respectively.

The experiment was conducted during 2000/2001 and 2002/20003 cropping years on sugarcane variety, B41/27. The study was classified into two experimental phases and repeated over two years on red chromic Luvisols. In phase-1, seed cane plants were fertilized with different N levels at three application times. In phase 2, quality of the setts obtained from the treated seed cane plants was tested.

Phase-1

The experiment was laid in randomized complete block design (RCBD) with three replications. Thirty two treatments comprised of four N levels: 0, 46, 92, and 138kgN/ha and applied at $2^1/_2$, 5 and $7^1/_2$ months after planting in single and split doses were used. The source of N is urea (46%N), which is the commonly used fertilizer in the plantation. Each plot consists of four furrows of each five meters long and a spacing of 1.45m. In each furrow 35 two-budded setts were planted at five centimeters overlap. Data were collected from the middle two furrows. Other cultural practices were executed according to the standard norms of the plantation.

To determine soil physico-chemical properties of the study site, composite soil samples were collected from the two soil depths (0-30 and 30-60cm) before planting. The samples were analysed for texture, pH, organic C, total N, available P and K, CEC and EC following the procedures outlined in FAO (Cottenie, 1980) and IITA (1979) laboratory manuals.

Growth and yield parameters were recorded at nine months of crop age to measure treatment effects. Plant height measurement of randomly selected 10 plants and stalk population count were done. Plant heights were measured from the ground level to the top visible dewlap (TVD).

At cutting the plants for seed cane, final stalk population count was done. Ten randomly selected sample stalks per the middle two rows were collected and average stalk weight, stalk length and girth, number of internodes per stalk were recorded. Finally, estimated sett yield per hectare and juice quality parameters for reducing sugar were computed.

Sett yield per hectare was calculated using the formula:
Y = N-1)/2*P, where Y = number of two-budded setts/ha, N = number of internodes/stalk and P = stalk population/ha

Phase-2

The influence of different N levels and time of application on the quality of seed material as measured by germination/sprouting was studied. Planting materials prepared from seed cane plants of phase-1 were planted in this phase. The samples were thoroughly mixed and then planting of the composite sample was executed. Field layout as well as arrangement and size of experimental plots were the same as in phase-1. At about 45 days after planting final sprouting count was conducted.

In both cases, the collected data were subjected to combine analysis of variance (ANOVA) over years using the Mstat computer package. Treatment means that showed significant differences were separated by Duncan's Multiple Range Test (DMRT).

III. Results and Discussion

Soil physico-chemical characteristics of the study site

Results of soil analysis of the study site shows that low level of total N was observed at both top and sub-soil layers.

Phase-1

Plant height/stalk elongation

The results in Table 1 below indicated that plant height at nine months of crop age was not significantly affected by different N levels and time of application. Though, the lowest plant height was observed for the control.

Table 1. Average plant height as affected by different N rates

Trt. No.	N Rate (kgN/ha)	Time of Application	Plant height at nine month of crop age (cm)
T1	0	-	150.2
T2	46	$2^1/_2$	199.8
T3	46 (23, 23)	$2^1/_2$, 5	201.9
T4	46	5	186.6
T5	46 (23, 23)	5, $7^1/_2$	176.5
T6	46 (23, 23)	$2^1/_2$, $7^1/_2$	186.6
T7	46	$7^1/_2$	188.4
T8	46	$2^1/_2$	206.8
T9	92 (46, 46)	$2^1/_2$, 5	195.9
T10	92	5	204.6
T11	92 (46, 46)	5, $7^1/_2$	160.6
T12	92 (46, 46)	$2^1/_2$, $7^1/_2$	174.2
T13	92	$7^1/_2$	149.5
T14	138	$2^1/_2$	212.5
T15	138 (69, 69)	$2^1/_2$, 5	202.7
T16	138	5	219.9
T17	138 (69, 69)	5, $7^1/_2$	176.5
T18	138 (69, 69)	$2^1/_2$, $7^1/_2$	205.0
T19	138	$7^1/_2$	170.1
T20	138 (46, 46, 46)	$2^1/_2$, 5, $7^1/_2$	199.1
T21	138 (46, 92)	5, $7^1/_2$	198.9
T22	138 (46, 92)	$2^1/_2$, $7^1/_2$	199.8
T23	138 (92, 46)	$2^1/_2$, $7^1/_2$	205.6
T24	138 (92, 46)	5, $7^1/_2$	197.9
T25	138 (46, 92)	$2^1/_2$, 5	203.1
T26	138 (92, 46)	$2^1/_2$, 5	202.3
T27	138 (69, 46, 23)	$2^1/_2$, 5, $7^1/_2$	209.4
T28	138 (69, 23, 46)	$2^1/_2$, 5, $7^1/_2$	213.4
T29	138 (46, 69, 23)	$2^1/_2$, 5, $7^1/_2$	211.1
T30	138 (46, 69, 23)	$2^1/_2$, 5, $7^1/_2$	217.5
T31	138 (23, 69, 46)	$2^1/_2$, 5, $7^1/_2$	202.5
T32	138 (23, 69, 46)	$2^1/_2$, 5, $7^1/_2$	185.9
	CV (%)		**11.7**

Stalk characteristics at harvest

Average stalk population, length and girth, and number of internodes per stalk are presented in Table 2. Statistically significant differences between treatments were observed for stalk population and length ($P<0.01$). Significantly higher stalk population (144 793) was recorded for high N rate, i.e., 138kg N\ha (T26) and increased stalk population by 39.1% over the control (104 096) but with no significant differences from most the treatments. Regarding stalk length, significantly higher stalk lengths of 161.4 to 168.7cm were recorded for T_{14}, T_{18}, T_{20}, T_{26}, T_{27} and T_{28} against control (125.cm). On the other hand, variations among stalk girth and number of internodes per stalk were not significant for different N rates studied. From the quantitative aspect of seed cane production, except stalk population and number of internodes, other parameters such as stalk length and girth do not affect sett yield but may have influence on setts quality. Research findings conducted in Egypt also revealed that increasing nitrogen level increased stalk height, stalk diameter and quality of setts/seed cane as compared with the lowest rate (Azzay *et al*, 2008).

Table 2. Stalk population, stalk length, stalk girth and number of internodes/stalk as affected by different N rates at harvest (at nine months of crop age)

Trt. No.	N Rate (kgN/ha)	Time of Application	Stalk population per ha*	Stalk length (cm)*	Stalk girth (mm)	Average no. of internodes/stalk
T1	0	-	104 096 fg	125.5 e	25.0	12.7
T2	46	$2^1/_2$	128 830 abcdefg	153.8 abcde	25.2	13.0
T3	46 (23, 23)	$2^1/_2$, 5	116 689 abcdefg	140.2 abcde	26.3	13.3
T4	46	5	120 736 abcdefg	146.0 abcde	25.9	13.3
T5	46 (23, 23)	5, $7^1/_2$	107 246 defg	132.4 cde	27.0	12.3
T6	46 (23, 23)	$2^1/_2$, $7^1/_2$	105 222 efg	134.5 bcde	26.1	13.0
T7	46	$7^1/_2$	101 175 g	134.9 bcde	27.4	14.0
T8	46	$2^1/_2$	126 354 abcdefg	152.1 abcde	27.6	13.3
T9	92 (46, 46)	$2^1/_2$, 5	118 936 abcdefg	155.3 abcde	27.0	13.0
T10	92	5	126 354 abcdefg	151.0 abcde	26.9	13.3
T11	92 (46, 46)	5, $7^1/_2$	114 665 bcdefg	146.6 abcde	27.6	13.7
T12	92 (46, 46)	$2^1/_2$, $7^1/_2$	110 168 bcdefg	151.8 abcde	25.2	13.7
T13	92	$7^1/_2$	110 841 bcdefg	139.6 abcde	27.1	13.0
T14	138	$2^1/_2$	132 877 abcde	161.4 abcd	25.8	12.7
T15	138 (69, 69)	$2^1/_2$, 5	117 588 abcdefg	156.7 abcde	26.7	14.0
T16	138	5	108 819 defg	137.0 abcde	26.9	13.0
T17	138 (69, 69)	5, $7^1/_2$	109 044 defg	129.3 de	25.9	13.3
T18	138 (69, 69)	$2^1/_2$, $7^1/_2$	131 304 abcdefg	164.4 abc	26.2	14.0
T19	138	$7^1/_2$	106 571 defg	136.4 abcde	26.3	13.0
T20	138 (46, 46, 46)	$2^1/_2$, 5, $7^1/_2$	133 326 abcde	164.1 abc	26.7	14.0
T21	138 (46, 92)	5, $7^1/_2$	133 776 abcde	147.2 abcde	27.2	13.0
T22	138 (46, 92)	$2^1/_2$, $7^1/_2$	121 410 abcdefg	156.9 abcde	26.4	13.0
T23	138 (92, 46)	$2^1/_2$, $7^1/_2$	120 736 abcdefg	154.8 abcde	26.3	13.0
T24	138 (92, 46)	5, $7^1/_2$	115 115 abcdefg	137.7 abcde	25.6	13.0
T25	138 (46, 92)	$2^1/_2$, 5	140 070 ab	154.7 abcde	26.0	13.0
T26	138 (92, 46)	$2^1/_2$, 5	144 793 a	166.7 ab	26.1	12.7
T27	138 (69, 46, 23)	$2^1/_2$, 5, $7^1/_2$	127 930 abcdefg	163.2 abc	26.3	13.3
T28	138 (69, 23, 46)	$2^1/_2$, 5, $7^1/_2$	134 450 abcd	168.7 a	26.2	13.3
T29	138 (46, 69, 23)	$2^1/_2$, 5, $7^1/_2$	138 947 abc	142.9 abcde	26.4	12.7
T30	138 (46, 69, 23)	$2^1/_2$, 5, $7^1/_2$	119 387 abcdefg	153.3 abcde	25.9	12.7
T31	138 (23, 69, 46)	$2^1/_2$, 5, $7^1/_2$	111 068 cdefg	150.2 abcde	27.6	13.7
T32	138 (23, 69, 46)	$2^1/_2$, 5, $7^1/_2$	110 393 defg	146.5 abcde	26.4	13.0
CV(%)			**8.97**	**8.43**	**4.05**	**7.0**

* - Means followed by different letters within the same column are significantly different at 1% probability level.

Sett yield

Data in Table 3 shows significant differences between treatments ($P<0.01$) for sett yield. Significantly higher sett yield was obtained for T_{14}, T_{18}, T_{25}, T_{26} and $T_{28,}$ i.e., for the higher rate of 138kg N/ha in whole and split doses as compared to other treatments but with no difference among them. However, the highest and lowest sett yield 868 758 and 572 528 were recorded for T26 and the control respectively. N rate of 138kg N/ha in two doses (92 and 46) applied at $2^1/_2$ and 5 months, respectively, had shown sett yield advantage and increased sett yield by 51.7% over the control as compared with the rest treatments. Moreover, the result of this study also supports earlier observations (Tadesse, 1993, 2004) that N fertilization of seed cane plants has a potential to improve yield and quality of setts, which in turn gives a foundation for good crop stand.

Table 3. Sett yield as affected by different N rates

Treatment No.	N Rate (kgN/ha)	Time of Application	Estimated number of two-budded setts per ha*
T1	0	-	572 528 c
T2	46	$2^1/_2$	772 980 bc
T3	46 (23, 23)	$2^1/_2$, 5	700 134 bc
T4	46	5	724 416 bc
T5	46 (23, 23)	5, $7^1/_2$	589 853 c
T6	46 (23, 23)	$2^1/_2$, $7^1/_2$	631 332 bc
T7	46	$7^1/_2$	657 637 bc
T8	46	$2^1/_2$	758 638 bc
T9	92 (46, 46)	$2^1/_2$, 5	713 616 bc
T10	92	5	758 124 bc
T11	92 (46, 46)	5, $7^1/_2$	745 323 bc
T12	92 (46, 46)	$2^1/_2$, $7^1/_2$	716 092 bc
T13	92	$7^1/_2$	665 046 bc
T14	138	$2^1/_2$	797 262 ab
T15	138 (69, 69)	$2^1/_2$, 5	764 322 bc
T16	138	5	652 914 bc
T17	138 (69, 69)	5, $7^1/_2$	654 264 bc
T18	138 (69, 69)	$2^1/_2$, $7^1/_2$	853 470 ab
T19	138	$7^1/_2$	639 426 bc
T20	138 (46, 46, 46)	$2^1/_2$, 5, $7^1/_2$	733 293 bc
T21	138 (46, 92)	5, $7^1/_2$	735 768 bc
T22	138 (46, 92)	$2^1/_2$, $7^1/_2$	728 460 bc
T23	138 (92, 46)	$2^1/_2$, $7^1/_2$	724 416 bc
T24	138 (92, 46)	5, $7^1/_2$	690 690 bc
T25	138 (46, 92)	$2^1/_2$, 5	840 420 ab
T26	138 (92, 46)	$2^1/_2$, 5	868 758 a
T27	138 (69, 46, 23)	$2^1/_2$, 5, $7^1/_2$	767 580 bc
T28	138 (69, 23, 46)	$2^1/_2$, 5, $7^1/_2$	806 700 ab
T29	138 (46, 69, 23)	$2^1/_2$, 5, $7^1/_2$	833 682 bc
T30	138 (46, 69, 23)	$2^1/_2$, 5, $7^1/_2$	716 322 bc
T31	138 (23, 69, 46)	$2^1/_2$, 5, $7^1/_2$	721 942 bc
T32	138 (23, 69, 46)	$2^1/_2$, 5, $7^1/_2$	662 358 bc
CV (%)		**15.76**	

* - Means followed by different letters within the same column are significantly different at 1% probability level.

Phase-2

Sprouting/germination percentage

Sprouting percentages were remarkably different among treatment and varies between 47.1% and 80.7%. The highest sprouting percentages were recorded for T_{11} (80.7%) and T19 (80.0%), i.e., plants grown from seed cane plants treated with application of 92kg N/ha in two equal split doses at five, and seven and half months, and single application of 138kg N/ha applied at seven and half month, respectively. The lowest sprouting percentage was recorded for T14 – single application of 138kg N/ha at early crop age (two and half month); in view of the fact that N applied at early growing stage, regardless of the rate, it could be utilized for vegetative growth and may have not been enough to produce reserve nutrients for the sprouting buds as compared to late application. Figures presented in Table 5 revealed that significantly higher sprouting percentages (P<0.01) were recorded for T11 and T19 and improved shoot emergence by 39.5 and 38.3%, respectively, over the control. On the contrary, no significant difference between the rest treatments and the control was observed. Similarly, Tadesse (2004) reported high sprouting percentage with nitrogen level increased as compared with the lowest rate (the control). This is possibly due to the fact that single or double application of high rate of N fertilizer at middle and late ages have made the applied N available for the sprouting buds to be easily utilized for emergence.

Table 4. Average plant height as affected by different N rates

Trt. No.	**N Rate (kgN/ha)**	**Time of Application**	**Sprouting/germination %age***
T1	0	-	57.8 bcd
T2	46	$2^1/_2$	62.6 abcd
T3	46 (23, 23)	$2^1/_2$, 5	64.5 abcd
T4	46	5	59.8 bcd
T5	46 (23, 23)	5, $7^1/_2$	68.1 abc
T6	46 (23, 23)	$2^1/_2$, $7^1/_2$	69.1 abc
T7	46	$7^1/_2$	72.9 abc
TT8	46	$2^1/_2$	70.7 abc
T9	92 (46, 46)	$2^1/_2$, 5	64.5 abcd
T10	92	5	77.1 ab
T11	92 (46, 46)	5, $7^1/_2$	80.7 a
T12	92 (46, 46)	$2^1/_2$, $7^1/_2$	68.8 abc
T13	92	$7^1/_2$	73.8 abc
T14	138	$2^1/_2$	47.1 d
T15	138 (69, 69)	$2^1/_2$, 5	54.5 cd
T16	138	5	77.1 ab
T17	138 (69, 69)	5, $7^1/_2$	71.2 abc
T18	138 (69, 69)	$2^1/_2$, $7^1/_2$	58.1 bcd
T19	138	$7^1/_2$	80.0 a
T20	138 (46, 46, 46)	$2^1/_2$, 5, $7^1/_2$	61.4 abcd
T21	138 (46, 92)	5, $7^1/_2$	76.7 ab
T22	138 (46, 92)	$2^1/_2$, $7^1/_2$	65.2 abcd
T23	138 (92, 46)	$2^1/_2$, $7^1/_2$	59.3 bcd
T24	138 (92, 46)	5, $7^1/_2$	73.6 abc
T25	138 (46, 92)	$2^1/_2$, 5	68.3 abc
T26	138 (92, 46)	$2^1/_2$, 5	63.1 abcd
T27	138 (69, 46, 23)	$2^1/_2$, 5, $7^1/_2$	58.8 bcd
T28	138 (69, 23, 46)	$2^1/_2$, 5, $7^1/_2$	59.3 bcd
T29	138 (46, 69, 23)	$2^1/_2$, 5, $7^1/_2$	67.1 abc
T30	138 (46, 69, 23)	$2^1/_2$, 5, $7^1/_2$	64.5 abcd
T31	138 (23, 69, 46)	$2^1/_2$, 5, $7^1/_2$	72.8 abc
T32	138 (23, 69, 46)	$2^1/_2$, 5, $7^1/_2$	77.1 ab
	CV (%)		**10.9**

* - Means followed by different letters within the same column are significantly different at 1% probability level.

IV. Conclusion and Recommendations

In this study, it was found that effects of different N rates were noted to be reflected both on sett yield and quality parameter. Application of 138kg N/ha (300 kg urea/ha) in two doses of 92 and 46kg N/ha at two and half and five months, respectively, resulted in good growth, population, stalk length as well as higher sett yield in phase-1. In phase-2, however, per cent of shoot emergence of seed setts treated with this rate gave seed cane of average quality with no significant difference from that of zero N level and the rest treatments. This is possibly due to the fact that applications of adequate amount of N fertilizer at early and middle growth stages enhanced better vegetative growth as compared to late applications but may not have been enough to produce seed setts of higher quality. Therefore, adequate applications of N fertilizer at early and middle crop ages resulted in higher sett yield and ultimately seed cane of average quality.

Accordingly, based on the results obtained and out of it, the following recommendations are forwarded: Biological yield of sugarcane for seed production required more N than what is being applied to attain its maximum. Hence, to get higher sett yield and ultimately seed cane of average quality it is recommended that Urea be applied to seed cane plants of sugarcane variety under study at the rate of 300kh/ha in two doses of 200 and 100kg/ha at two and half and five months after planting, respectively. Hence, as this study is the first by its kind under Finchaa condition, it paves a way for further investigation including major sugarcane varieties under cultivation in the study site and other sugarcane plantations in the country.

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