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Research Article

Effects of Bioactivators on Yield and Yield Components of Sugarcane at Wonji-Shoa Sugar Estate

Netsanet Ayele, Alemayehu Dengia, Abiy Getaneh, Leul Mengistu and Zinaw Dilnesaw

Ethiopian Sugar Corporation, and Training Section Sugarcane Research Directorate, Wonji,
*Corresponding author: *netsanet77@gmail.com*

Abstract

Study on the effect of three fertilizer rates (0, 100 and 200 kg ha^{-1}) and two types of bioactivators (Agrostemin and Crops®), and untreated treatments were tested to determine the effect on early growth, yield and quality of sugarcane variety NCo334. The experiment was carried out at Wonji/Shoa on clay loam textured soil in a factorial RCBD design using four replications. Analysis of variance revealed that number of tillers, stalk thickness, stalk weight, stalk height, number of millable canes, percent sucrose, cane and sugar yield were affected significantly ($p<0.01$) by treatments. Sole application of Agrostemin and Crops® resulted in a 13.56 and 12.86 % increase in sucrose percent cane against the check (200 kg ha^{-1} urea). Similarly, estimated sugar yield increased by 45.00 and 44.00 % against the check (200 kg ha^{-1} urea). Therefore, it is concluded that use of bioactivators Agrostemin and Crops® improve sucrose and sugar yields with a concomitant reduction of urea fertilizer requirements.

Keywords: bioactivators, Agrostemin, Crops®, fertilizer, sugarcane, sucrose.

Introduction

Sugarcane (*Saccharum officinarum* L.) is an important industrial crop of the World. Yield of sugarcane is constrained by many environmental and management factors (Verma, 2004) and its production entails an integration of various factors such as weather, water, biotic, soil and economic factors (Chaudhry, 1983). Over the last 50 years, the sugarcane yield in Ethiopian Sugar Estates has showed a declining trend. Especially at Wonji/Shoa the yield declined from 204 t ha^{-1} m^{-1} (in 1958/59) to 130 t ha^{-1} m^{-1} (in 2012/13) which is a 36 % reduction. Consequently, various efforts have been made to enhance the yield. Sugarcane cultivation consumes various agrochemicals which are integrated in the production system and new technologies are also emerging due to the continuous research and advances in technology. Among these, bio-activators are getting focus due to their broad physiological role and yield increments observed in different studies (Plissey, 2003; Bower, 2004).

Plant growth regulators have recently become the most rapidly growing part of the agro-chemical industry (Knot *et al*, ND). Compared to other inputs, bio-activators are required in minor quantities and the cost benefit ratio is much higher as compared to all other inputs (Knot *et al*, ND). The awareness created from the research and developments of many soil and nutrient related factors that are affecting the production of optimum crop yields, agro-chemical industries are focused to produce products to tackle these challenges. Stress factors having a negative effect on the normal growth and development of crops such as inadequate or inactive soil microbial population and/or poor soil structure had been assumed to be the cause of the inefficient utilization of soil and fertilizer nutrients by crops. Therefore the purpose of this study was to evaluate the effect of the two bio-activators Agrostemin and Crops®, on the yield and quality of sugarcane at Wonji/Shoa Sugar Estate.

Materials and Methods

Site Description

Wonji-Shoa is located in the Rift Valley of Ethiopia at an altitude and longitude of 8º31'N and 39º12'E, respectively, with an elevation of 1550 masl. The area has a mean maximum and minimum temperature of 26.9^{0}C and 15.3^{0}C, respectively with annual rainfall of 800 mm.

Treatments and Design

The experiment was laid out in a randomized complete block design in factorial combination of rate of fertilizer and type of bio-activators using four replications. The treatments consisted of three rates of fertilizers (0, 100 and 200 kg ha^{-1}) and two types of bioactivators (Agrostemin applied in furrows at 30 gm ha^{-1} and Crops® foliar applied at 30 ml ha^{-1}) as well as untreated (No bioactivator) plot. The control rate of nitrogen fertilizer at Wonji/Shoa is 200 kg ha^{-1}. The sugarcane variety was NCo334 which was selected based on its yielding potential and area coverage. The study was carried out on clay loam textured soil on plant cane in a factorial RCBD design using four replications.

The size of each experimental plot was 43.5 m^2 (six furrows of 5 m length and 1.45 m width). The net plot area used for data collection was 29 m^2 (four furrows of 5 m length and 1.45 m width). The distance between adjacent plots and replications were 1.50 and 2.90 meters, respectively. Healthy stalks of 10 months of age were used as seed cane source.

Two budded setts which were prepared from the same portion of seed cane, i.e., the middle of the stalk of 10 months of age were used for planting. In each row, 25 two budded setts were planted with ear-to-ear alignment. All cultural managements were conducted as per the norm of the estate except fertilization. Agrostemin was applied during planting into furrows on the setts (at a rate of 30 g ha^{-1} in 1000 liter) prior to covering. Crops® application was performed by spraying (using knapsack sprayer) the solution on the leaf of the cane at 20, 35, 50 and 65 days after planting at a rate of 30 ml ha^{-1}.

Data Collections

Sprouting count was recorded at 45th day after planting. Tiller per hectare was calculated from the counting data that was recorded at four and half month before moulding (earthing-up). The number of millable canes in each plot was counted and average cane weight of 50 stalks was taken per plot at harvest. However, for cane height, girth and juice quality parameters (Brix, Pol and Purity) 12 cane samples were taken randomly from each plot.

Harvesting was made at 14th months of age after drying the cane as per recommended for the Estate. Cane yield per hectare basis was calculated from the yield obtained per plot. 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 (James and Chung, 1993). Then, commercial sugar yield per hectare was calculated as follows;

$$ESY \ (t/ha) = CYH \ (t/ha) \ x \ ERS \ (\%)$$

Where;

ESY = estimated sugar yield
CYH = cane yield per hectare
ERS = estimated recoverable sucrose (%)

The cane and sugar yields were described as suggested by Sweet & Patel (1985) according to COTCHM method (Corrected Tones Cane per Hectare per Month).

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 done based on the Duncan Multiple Range Test (DMRT).

Results and Discussion

Anova for the effect of fertilizer and bioactivators on yield and yield components of sugarcane

Analysis of variance showed that there was no significant difference among the treatments in sprouting; however number of tillers, stalk thickness, height and weight were significantly ($p<0.01$) affected by treatments (Table 1 and 2). Application of urea at 200 kg ha^{-1} combined with Agrostemin resulted in a significantly highest ($p<0.01$) number of tillers (2.72×10^5) while the treatment that didn't receive either urea or bioactivator resulted in a significantly lowest ($p<0.01$) number of tillers (2.05×10^5) followed by sole application of 100 kg ha^{-1} urea (2.32×10^5).

In terms of height, the treatment that didn't receive either urea or bioactivator resulted in a significantly lowest ($p<0.01$) cane height (2.15 m) though it was not differed statistically from the sole application of 100 kg ha^{-1} urea (Table 2). Stalk weight was significantly ($p<0.05$) affected by the treatments (Table 2). Sole application of bioactivators resulted a significantly ($p<0.05$) higher stalk weight than the sole application of urea (100 and 200 kg ha^{-1}) and the treatment that didn't receive either urea or bioactivator (Table 2). Sole application of Agrostemin and Crops® increased cane weight by 7.37 and 9.50 %, respectively over the check.

Similar studies conducted on sugarcane indicated that growth regulators have a positive effect with an improvement in cane quality, yield and yield components. According to Bhale (1993), amino acid caused a considerable stimulation of sprouting and growth of sugarcane at later stages resulting in increased production of both cane and sugar yields. Kamlesh Kanawar (1991) also reported the beneficial effect of kinetin treated plants in sugarcane due to low mortality percentage of tillers resulting into high number of canes per pit and significant increase in ratoon cane yield.

Combined application treatment of 200 kg ha^{-1} Urea + Agrostemin (30 gm ha^{-1}) gave a significantly ($p<0.05$) higher number of millable canes than the sole application treatments 100 kg ha^{-1} urea and the treatment that didn't receive either urea or bioactivator (Table 2). However, it didn't show significant difference from the remaining treatments (Table 2).

Sole application of Agrostemin gave statistically the same yield with other treatments except the sole application treatment of 100 kg ha^{-1} urea and the treatment that didn't receive both urea or bioactivator (Table 3). All the treatments that received both the bioactivator and urea were superior to the sole application treatments 100 kg ha^{-1} urea, 200 kg ha^{-1} urea and the treatment that didn't receive either urea or bioactivator (Table 3). In terms of yield, sole application of Agrostemin and crop increased cane yield by 9.95 and 9.88 % against the check.

Similarly, in sucrose percent cane, the sole application treatments 100 kg ha^{-1} urea, 200 kg ha^{-1} urea and the treatment that didn't receive either urea or bioactivator gave significantly ($p<0.05$) the lowest percent sucrose cane. Sole application of Agrostemin and Crops® resulted in a 13.56 and 12.86 % increase in sucrose percent cane against the check (200 kg ha^{-1} urea). In agreement with this, Anon (1996) and Agentra (ND), reported the increase in sucrose content and hastening maturity of cane by growth regulators Agrostemin and Crops®, respectively.

In terms of estimated sugar yield, the sole applications of Agrostemin and Crops® gave a significantly ($p<0.01$) higher estimated sugar yields than all the treatments, and followed by the combination treatments 200 kg ha^{-1} urea + Agrostemin, 100 kg ha^{-1} urea + Agrostemin, 200 kg ha^{-1} urea + Crops® and 100 kg ha^{-1} urea + Crops® treatments, which were not significantly ($p<0.01$) different from each other and were at par with the check (Table 3). The increase in sugar yield in the sole application treatments was due to the increase in sucrose percent cane due to the hastening of maturity (Table 3).

As compared to the check, sole application of Agrostemin and Crops® resulted in a 45.00 and 44.0 % increase in sugar yield, respectively. Similarly, the combination treatments *viz*. 200 kg ha^{-1} urea + Agrostemin, 100 kg ha^{-1} urea + Agrostemin, 200 kg ha^{-1} urea + Crops® and 100 kg ha^{-1} urea + Crops® increased estimated sugar yields by 19, 12, 15 and 10 %, respectively.

Conclusion

The study result indicated that bioactivators have affected early growth and yields of sugarcane in all the parameters considered except sprouting. Sole application of Agrostemin and Crops® resulted in a 13.56 and 12.86 % increase in sucrose percent cane against the check (200 kg ha^{-1} urea), which resulted in increased sugar yield. Thus, the result indicates the possibility of improvement in cane juice qualities. Therefore, it can be concluded that Agrostemin and Crops® improve growth, yields and quality of sugarcane.

Table 1. Anova for the effect of rates of urea nitrogen fertilizer and bioactivators Agrostemin and Crop® on sprouting, tillering and stalk girth of sugarcane on plant crop at Wonji/Shoa from 2013-2014

Treatments	**Sprouting (%)**	**Tillers 000'ha^{-1})**	**Stalk Girth (mm)**
NF + NB (Untreated)	62.3	205 c	2.16 c
Agrostemin (30 gm ha^{-1}) alone	58.1	261 ab	2.40 a
Crops (30 ml ha^{-1}) alone	59.4	257 ab	2.38 a
200 kg ha^{-1} Urea alone (Check)	63.7	237 b	2.15 c
200 kg ha^{-1} Urea + Agrostemin (30 gm ha^{-1})	61.3	272 a	2.40 a
200 kg ha^{-1} Urea + Crops (30 ml ha^{-1})	63.8	246 ab	2.43 a
100 kg ha^{-1} Urea alone	68.8	232 bc	2.20 bc
100 kg ha^{-1} Urea + Agrostemin (30 gm ha^{-1})	66.0	249 ab	2.40 a
100 kg ha^{-1} Urea + Crops (30 ml ha^{-1})	65.8	247 ab	2.35 ab
SE ($\pm$)	2.65	9.54	0.054
LSD (5%)	NS	**	**
CV	**8.40**	**7.78**	**4.64**

Means followed by the same letter in a column are not significantly different from each other; NF = without fertilizer application; NB= without bioactivator application; mm= millimeter; CV = Coefficient of Variation, LSD = Least significant Difference; ha = hectare.

Table 2. Anova for the effect of rates of urea nitrogen fertilizer and bioactivators Agrostemin and Crops® on stalk height, weight and population of sugarcane on plant crop at Wonji/Shoa from 2013-2014

Treatments	**Stalk height (m)**	**Stalk Weight (Kg)**	**Millable Canes (000' ha^{-1})**
NF + NB (Untreated)	2.15 c	1.24 c	137 c
Agrostemin (30 gm ha^{-1}) alone	2.47 a	1.48 a	153 a
Crops (30 ml ha^{-1}) alone	2.45 a	1.51 a	150 ab
200 kg ha^{-1} Urea alone (Check)	2.30 abc	1.37 bc	149 ab
200 kg ha^{-1} Urea + Agrostemin (30 gm ha^{-1})	2.46 a	1.41 abc	156 a
200 kg ha^{-1} Urea + Crops (30 ml ha^{-1})	2.40 ab	1.45 ab	146 abc
100 kg ha^{-1} Urea alone	2.24 bc	1.29 bc	141 bc
100 kg ha^{-1} Urea + Agrostemin (30 gm ha^{-1})	2.47 a	1.40 abc	150 ab
100 kg ha^{-1} Urea + Crops (30 ml ha^{-1})	2.46 a	1.38 abc	149 abc
SE ($\pm$)	0.065	0.054	3.57
LSD (5%)	**	*	*
CV	5.45	7.81	4.83

Means followed by the same letter in a column are not significantly different from each other; NF = without fertilizer application; NB= without bioactivator application; CV = Coefficient of Variation, LSD = Least significant Difference; Kg = Killogram; m = meter; ha = hectare.

Table 3. Anova for the effect of rates of urea nitrogen fertilizer and bioactivators Agrostemin and Crops® on cane yield, sucrose (%) and sugar yields of sugarcane on plant crop at Wonji/Shoa from 2013-2014

Treatments	**Cane Yield ($t\ ha^{-1}m^{-1}$)**	**Sucrose (%)**	**Sugar Yield ($t\ ha^{-1}m^{-1}$)**
NF + NB (Untreated)	12.21 c	11.50 b	1.41 d
Agrostemin (30 gm ha^{-1}) alone	16.19 a	13.15 a	2.13 a
Crops (30 ml ha^{-1}) alone	16.18 a	13.07 a	2.12 a
200 kg ha^{-1} Urea alone (Check)	14.58 ab	11.58 b	1.68 bc
200 kg ha^{-1} Urea + Agrostemin (30 gm ha^{-1})	15.60 a	12.04 ab	1.87 b
200 kg ha^{-1} Urea + Crops (30 ml ha^{-1})	15.09 a	12.18 ab	1.83 b
100 kg ha^{-1} Urea alone	12.97 bc	11.70 b	1.52 cd
100 kg ha^{-1} Urea + Agrostemin (30 gm ha^{-1})	14.95 a	12.05 ab	1.80 b
100 kg ha^{-1} Urea + Crops (30 ml ha^{-1})	14.65 a	12.15 ab	1.78 b
SE ($\pm$)	8.09	0.374	1.10
LSD (5%)	**	*	**
CV	7.85	6.16	8.81

Means followed by the same letter in a column are not significantly different from each other; NF = without fertilizer application; NB= without bioactivator application; m = month; CV = Coefficient of Variation, LSD = Least significant Difference; t = tone; ha = hectare.

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