U. of K. J. Agric. Sci. 19(1), 1-14, 2011

Effect of Cane Sugar By-products on Ratoon Production at Assalaya Sugar Scheme, Sudan

Mohammad A. Abouna, Muawia E. Hamad[1], Eltayeb M. Abdelmalik[1], Lubna M. Musa[1] and Hassan S. Ibrahim[2]

Sugarcane Research Center – Guneid, Sudanese Sugar Co. P.O box 511, Khartoum, Sudan

Abstract: An experiment was carried out to investigate the effect of 15 t ha^{-1} of each of green cane top (GCT), filter mud (FM) and bagasse (BA) and their combinations, on ratoon cane, sugar yield and ratoon yield recovery at Assalaya Sugar Scheme. The amendments were vertically mulched, in furrows, in a salt-affected clay soil. Plant cane crop was harvested in Dec. 2004/05 and Dec. 2005/06 and ratooned in seasons 2005/06 and 2006/07, respectively. The treatments were arranged in a randomized complete block design, replicated four times. The treated soil gave significantly higher cane, sugar yield and ratoon yield recovery than the control. The different combinations of any two of the three amendments had a significantly higher cane and sugar yields than that of any single one. GCT + BA resulted in the highest cane yield (117.5), followed by FM + BA (116.7) and then GCT + FM (115.9 t ha^{-1}); but with no significant differences between them. The ratoon yield recovery of the treated soil was significantly higher than the control. BA showed ratoon yield recovery of 94.0 % in 2004/05 and 97.0 % in 2005/06. Whenever there was BA in a treatment, the ratoon yield recovery was higher. Although GCT had lower ratoon recovery percentage, it produced the highest sugar tonnage. For high cane, sugar yield and ratoon yield recovery, 15 t ha^{-1} of each of GCT and BA are recommended.

Key words: By-products; ratoon production; Assalaya Sugar Scheme; Sudan

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[1]Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan
[2]Formerly, Agricultural Research Corporation, Wad Medani, Sudan

INTRODUCTION

Generally, in sugarcane, ratoons tend to yield less than the plant crop (Keerthipala and Dharma-Wardene 1996). Keerthipala (1997) found that in the rainfed areas of SriLanka, decline in yield occurred only from the second ratoon, whilst the first ratoon always gave either comparable yield to plant cane or sometimes higher yield. In contrast, irrigated areas always showed a yield decline from the first ratoon onwards.

The ratoon yield data collected from the Agricultural Division of Assalaya Sugar Scheme showed that, for a series of seasons, the yield by ratoon was considerably lower than its plant cane crop. Data taken for three seasons in the salt – affected area of the Scheme showed that in 1998/99 a plant cane yield of 101 t ha^{-1} declined to 71 t ha^{-1} in the first ratoon, while in the normal soil of the same Scheme, the plant cane yield of 135 t ha^{-1} gave about 125 t ha^{-1} in the first ratoon during that season. In 1999/2000, the plant cane yield of 112 t ha^{-1} in the salt-affected soil declined to 60 t ha^{-1} in the first ratoon, while in the same season the plant cane in the normal soil gave 160 t ha^{-1} and its first ratoon gave 140 t ha^{-1}. In 2000/2001 season, a plant cane yield of 105 t ha^{-1} was reduced to about 60 t ha^{-1} as a first ratoon, and in the non – problematic soil the plant cane gave 125 t ha^{-1} and its first ratoon yielded about 110 t ha^{-1} (Assalaya Agricultural Division, unpublished reports).

In normal soils, decline in yield of ratoon crops has been attributed to a number of factors, mainly formation of hard pan in top soil due to soil compaction by natural causes as well as by field machinery. Srinivasan (1985) found that as bulk density of the compacted soil increased to 1.7 g cm^{-3}, vertical root penetration became limited to the top 25 cm, while the root system penetrated deeper as the bulk density dropped to lower than 1.3 g cm^{-3}. Moreover, decline in soil nutrients, poor soil moisture, build up of pests and diseases are also responsible for yield decline (Robertson 2003).

Salinity when accompanied by other soil problems, results in ratoon yield decline. These problems could be solved by soil amendment which improves the different soil physical and chemical properties (Abouna *et al*. 2010).

Cane sugar industry by–products were widely used all over the world for soil amendment and reclamation purposes. Green cane top (GCT), filter mud (FM), bagasse (BA) and boiler ash (AS) are all used in many countries. Chapman (1996) and Abouna *et al*. (2010) argued that mill by – products contribute towards better yield, productivity and profitability by affecting the physical and chemical conditions of the soil.

Although, under most conditions the by – products are surface – applied, vertical mulching application of these materials, in the furrow, was proven effective (Abouna *et al.* 2010), giving significantly higher plant cane yields. Agrawal and Singh (1986) reported that in Srilanka vertical mulching of sugarcane soil, using cane sugar by – products immediately after harvest, brought about a decrease in soil temperature as well as improvement in bud germination. Consequently, the ratoon crop was well sprouted, and there was increase in number of ratoon cycles. The objective of this study was to investigate the effect of green cane trash (GCT), filter mud (FM), bagasse (BA) and their combinations on the yield of first ratoon in a salt – affected soil at Assalaya Sugar Scheme.

MATERIALS AND METHODS

The experimental area lies in the western strip of Assalaya Sugar Scheme. The soil belongs to Hosh series. It is slightly saline and moderate to strongly sodic (Abouna *et al.* 2010). Soil bulk density was determined by the methods of Blake and Hartage (1965). Soil moisture content was also determined. Leaf phosphorus and nitrogen were obtained according to Olsens' method (Olsen *et al.* 1954) and micro Kjeldahl method (Bremner and Mulvani 1982), respectively. Fifteen tons per hectare of each of green cane top (GCT), fitre mud (FM), bagasse (BA) and their combinations was used as vertical mulch, in furrow (Abouna *et al* 2010). All cultural practices were done according to Assalaya Sugar Scheme ratoon management. Cane sugar yields and quality were assessed by ICUMSA-system (Schneider 1979). The experiment was laid out in a randomized complete block design (RCBD) with four replicates. Analyses of variance and tests of significance were done according to the standard RCBD procedure. Duncan's multiple range test was used to separate the means.

RESULTS AND DISCUSSION

Bulk density of the treated soil was significantly (P=0.05) lower than the control. The different combinations of the soil amendment materials resulted in significant decrease in bulk density compared to the single materials but with no significant difference between treatments (Table 1). The treated soil had significantly (P=0.05) higher soil moisture content than the control, except for the treatment GCT+FM. Combination of filter mud and bagasse (FM+BA) improved soil moisture content than the other treatments, and all combinations resulted in higher soil moisture content than the single materials (GCT, FM and BA) (Table 1). Leaf analysis at 3-4 months of ratoon age showed that the combination of GCT+FM+BA was the best in nitrogen supply (Table 2). The data also show that the treated soil gave better phosphate supply to the ratoon crop. This means that cane sugar by-products are good sources of plant nutrients (Jadhav 1990).

For the two consecutive seasons 2005/06 and 2006/07, the soil amendments increased the first ratoon cane yield significantly (Table 3). In the first season, the different combinations of any two of the three soil amendments had a significantly higher cane yield than any single one. GCT+FM, GCT+BA and FM+BA gave the highest yield with no significant difference between them. That was followed by the combination of the three materials GCT+FM+BA and BA alone. In season 2006/07, the combinations GCT+FM, GCT+BA and FM+BA gave significantly higher cane yield than any single one, except GCT which showed the highest cane yield. The combination of the three materials GCT+FM+BA gave lower yield than the combination of any two of the tested soil amending materials. The combined analysis of the two seasons data showed that GCT alone, GCT+FM, GCT+BA and FM+BA produced significantly (P=0.001) higher cane yield than the control. Comparing the three soil amendments singly, BA gave significantly (P=0.01) higher cane yield than FM, while GCT showed significantly (P=0.001) higher cane yield than BA and FM. In fact, BA coupled with GCT or FM seemed to boost the ratoon yield to higher a level. This was not clear in the triple combination GCT+FM+BA, probably due to the lower amount of BA in the triple combination compared with the double combinations. However, the higher residual effect of BA or its slow decomposition during the plant cane might be one of the factors contributing to the high ratoon cane yield in the BA treated soil during first ratoon (Robertson 2003).

Data in Table 4 show the quality of first ratoon cane expressed as pol and brix percentage cane crushed. Generally, the treatments did not have any negative effects on the quality parameters and there was significant difference (P=0.05) between treatments. In the first season, BA gave the highest pol percentage cane followed by the combination of the three soil amendments, GCT+FM+BA. In season 2006/07, FM which was the third in pol percentage in the first season (2005/06) was the first in Pol percentage, followed by the combination of the three materials GCT+FM+BA. As a mean of the two seasons, FM and BA gave the highest pol percentage cane followed by GCT+FM. As far as brix percentage cane is concerned, in season 2005/05 the combination of GCT+FM+BA gave the highest brix percentage cane followed by FM, BA and GCT+FM with no significant difference between treatments. In 2006/07, the situation didn't change. Even as a mean of the two seasons the brix percentage cane of the ratoon was almost the same. Taking both pol and brix percentages as a combined quality measure, the best result was obtained by FM and BA followed by GCT+FM and GCT+FM+BA.

In the ratooning season 2005/06, BA alone gave the highest ratoon yield recovered from the plant cane (Table 5). The yield recovery percentage (94%) of BA was followed by GCT+FM+BA, GCT+BA and FM+BA which gave similar ratoon yield recovery of 88%. In season 2006/07, BA alone also gave the highest yield recovery of 97%, followed by GCT+BA which gave 91% and both GCT+FM+BA and FM+BA gave (89%). Whenever BA was present in a combination, the ratoon yield recovered from the plant cane was higher. This may probably be attributed to the slow decomposition of BA during plant cane season and its completion at later stages. Thus, probably improving the soil physical properties and releasing nutrient elements for the ratoon cane (Solomon *et al*. 2005).

The data in Table 6 show that the soil amendments improved the total sugar yield of the first ratoon. The treated soil gave significantly ($P \leq 0.05$) higher sugar tonnage per hectare than the control. GCT + FM + BA gave significantly ($P \leq 0.05$) higher sugar recovery percentage than all other treatments. However, this has not been reflected in their corresponding sugar tonnage ha^{-1}. Although GCT alone gave the lowest ratoon cane yield recovery percentage (Table 5) and significantly ($P \leq 0.05$) the lowest sugar recovery percentage (11.3 %), it gave significantly ($P \leq 0.05$) the highest ratoon cane sugar yield per hectare (14.2 t ha^{-1}). FM alone and BA alone gave significantly ($P \leq 0.05$) the lowest sugar tonnage (12.2 and 12.3 t ha^{-1}, respectively) but with no significant difference between them, and both were significantly ($P \leq 0.05$) higher than the control.

CONCLUSION

The results of the present study indicated that the use of 15 t ha^{-1} of GCT, FM, BA or their combinations when vertically mulched, in furrow, in a salt-affected Assalaya clay soil, gives high cane, sugar yields and ratoon yield recovery; in a soil that usually gave ratoon yield 40% - 50 % less than the respective plant cane yield. The study recommends vertical mulching of GCT alone, followed closely by GCT+ FM, GCT + BA and FM + BA.

Table 1. Effects of tested manures on soil bulk density (at 0 – 25 cm) and moisture content

Treatment	Soil property	
	Bulk density (g cm $^{-3}$)	Moisture content (%)
C	1.40[a]	23.38[e]
GCT	1.02[c]	27.67[c]
FM	1.01[c]	25.55[d]
BA	1.10[b]	25.79[d]
GCT + FM	0.90[d]	23.89[e]
GCT + BA	0.91[d]	29.61[b]
FM + BA	0.90[d]	30.95[a]
GCT + FM + BA	0.91[d]	29.99[b]
C.V. (%)	1.20	1.94

C = control; GCT= green cane top; FM= filter mud; BA= bagasse
Means followed by the same letter in the same column are not significantly different at P = 0.05, according to Duncan's multiple range test.

Table 2. N and P concentration in ratoon tissue at 3 – 4 months of its age

Treatment	Nutrient concentration in tissues	
	N (%)	P (%)
C	1.10[h]	0.40[d]
GCT	1.57[f]	0.61[c]
FM	1.47[g]	0.77[a]
BA	1.77[e]	0.68[b]
GCT + FM	1.83[d]	0.79[a]
GCT + BA	2.10[b]	0.75[a]
FM + BA	1.90[c]	0.79[a]
GCT + FM + BA	2.27[a]	0.80[a]
Mean	1.75	0.70
C.V. (%)	7.73	4.83

C = control; GCT= green cane top; FM= filter mud; BA= bagasse
Means followed by the same letter in the same column are not significantly different at P=0.05, according to Duncan's multiple range test.

Table 3. Influence of soil amendments on the yield of the first ratoon in the salt – affected soil at Assalaya sugar scheme

Treatment	Yield (t ha^{-1})		Mean	SL
	2005/06	2006/07		
C	92.18e	87.30e	89.74e	
GCT	104.56c	125.60a	115.08b	***
FM	100.46d	101.00d	100.73d	NS
BA	108.20b	104.90c	106.55c	**
GCT + FM	114.70a	117.10b	115.90ab	***
GCT + BA	117.20a	117.70b	117.45a	***
FM + BA	116.60a	116.80b	116.70a	***
GCT + FM + BA	108.90b	106.20c	107.55c	*
Mean	107.80	109.60	108.70	
C.V %	1.27	1.11	1.16	

C = control; GCT= green cane top; FM= filter mud; BA= bagasse
Means followed by the same letter (s) in the same column are not significantly different at P = 0.05;
SL= significance level; *= P<0.05; **= P< 0.01; ***= P<0.001; NS= not significant

Table 4. Quality of the first ratoon as affected by soil amendment

Treatment	* Pol (%)			** Brix (%)		
	2005/06	2006/07	Mean	2005/06	2006/07	Mean
C	13.2g	13.5d	13.4d	17.2d	17.3e	17.2d
GCT	13.1gh	13.2e	13.1e	17.5c	17.6c	17.6c
FM	14.1c	14.2a	14.2a	17.8b	17.7b	17.8b
BA	14.8a	13.7c	14.3a	17.8b	17.7b	17.8b
GCT + FM	13.9d	13.8b	13.9b	17.8b	17.7b	17.8b
GCT + BA	13.7e	13.7c	13.7c	17.1e	17.2f	17.1d
FM + BA	13.6f	13.7c	13.7c	17.2d	17.3d	17.2d
GCT + FM + BA	14.6b	13.7c	13.7c	18.2a	18.2a	18.2a
Mean	13.8	13.6	13.8	17.5	17.4	17.6
C.V. (%)	1.2	1.8	1.5	3.4	1.01	2.20

C = control; GCT= green cane top; FM= filter mud; BA= bagasse

*Total soluble sugars (mono, di, polysaccharides) in cane juice

**Total soluble solids in cane juice.

Means followed by the same letter in the same column are not significantly different at P = 0.05.

Table 5. Effect of soil amendment on ratoon yield recovered from the plant cane

Treatment	Yield t ha-1				Ratoon (%) plant cane	
	Plant cane	Ratoon	Plant cane	Ratoon		
	2004/05	2005/06	2005/06	2006/07	2005/06	2006/07
GCT	146.8a	104.5c	137.4b	102.6c	71	75
FM	122.9d	100.4d	119.7d	101.0d	82	84
BA	114.8a	108.2b	108.2e	104.9b	94	97
GCT + FM	147.7b	114.7a	140.4a	117.1a	78	83
GCT + BA	133.3b	117.2a	129.7c	117.7a	88	91
FM + BA	134.3c	116.6a	131.8c	116.8a	87	89
GCT + FM + BA	121.7c	108.9b	119.0d	106.2b	89	89
C.V. (%)	1.8	1.3	1.2	2.4	-	-

C = control; GCT= green cane top; FM= filter mud; BA= bagasse

Means followed by the same letter in the same column are not significantly different at P = 0.05.

Table 6. Effect of soil amendment on first ratoon sugar recovery and yield

Treatment	Sugar recovery (%)	Sugar yield (t ha^{-1})
C	11.5^{d}	10.1^{e}
GCT	11.3^{e}	14.2^{a}
FM	12.2^{b}	12.2^{b}
BA	11.7^{e}	12.3^{b}
GCT + FM	11.8^{c}	13.8^{b}
GCT + BA	11.7^{c}	13.8^{b}
FM + BA	11.6^{d}	13.7^{bc}
GCT + FM + BA	12.5^{a}	13.2^{d}
Mean	11.8	12.9
C.V. (%)	2.2	2.9

C = control; GCT= green cane top; FM= filter mud; BA= bagasse
Means followed by the same letter(s) in the same column are not significantly different at P = 0.05.

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تأثير مخلفات سكر القصب على إنتاجية الخلفة بسكر عسلاية – السودان

محمد أبوبكر أبونا ومعاوية بدوى حمدو والطيب محمد عبد الملك
ولبنى محمد موسي[1] وحسن سليمان إبراهيم[2]

مركز بحوث قصب السكر – الجنيد، شركة السكر السودانية، ص.ب. 511 الخرطوم - السودان.

المستخلص: أجريت تجربة لدراسة تأثير إضافة 15 طن/هكتار لكل من مخلفات رؤوس القصب الخضراء، وطينة المرشحات، والبقاس وخلطاتها، التى غطي بها بطن السراب (المروز) فى تربة طينية متأثرة بالملوحة في مشروع سكر عسلاية، على إنتاجية قصب الخلفة والسكر ونسبة إستخلاص الخلفة من الغرس. تم حصاد قصب الغرس خلال مواسم 05/2004 و06/2005 وتأسيس الخلفة فى مواسم 06/2005 و07/2006 على التوالى. وزعت المعاملات فى قطاعات كاملة العشوائية بأربعة مكررات. أعطت التربة المعاملة زيادة معنوية فى إنتاجية القصب والسكر ونسبة إستخلاص الخلفة من الغرس مقارنة بالشاهد. أوضحت الخلائط الثنائية لأى من المخلفات الثلاثة إنتاجية قصب وسكر أعلى معنوياً من أى من المخلفات منفرداً؛ وكشفت خلطة رؤوس القصب + البقاس عن أعلى إنتاجية قصب (117.5 طن للهكتار) تليها خلطة طينة المرشحات + البقاس 116.7 طن للهكتار) ثم رؤوس القصب + طينة المرشحات (115.9 طن للهكتار) مع عدم وجود فروقات معنوية بين المعاملات. كانت نسبة إستخلاص الخلفة من الغرس فى التربة المعاملة اعلى معنوياً من الشاهد. أظهر البقاس النسب الأعلى من الإستخلاص 94% فى موسم 05/2004 و 97% فى موسم 06/2005. كانت نسبة إستخلاص الخلفة أعلى كلما وجد البقاس فى معاملة من المعاملات. مع أن التربة المعاملة برؤوس القصب الأخضر أعطت أقل نسبة إستخلاص خلفة من الغرس، لكن إنتاجية السكر كانت الأعلى بين المعاملات. للحصول على إنتاجية أعلى من القصب والسكر ونسبة إستخلاص خلفة من الغرس يوصي بإضافة 15 طن /هكتار لكل من مخلف رؤوس القصب الأخضر والبقاس.

[1] كلية العلوم الزراعية، جامعة الجزيرة.، واد مدنى - السودان.
[2] هيئة البحوث الزراعية سابقاً، واد مدنى - السودان.