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Residual and Cumulative Eeffects of Filter Mud Applications on Sugarcane Production and on Soil Chemical Properties

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Abstract

To investigate the residual and cumulative effects of filter mud applications on sugarcane yield and quality and on soil chemical properties, a field experiment was established in the year 2005 at the Kenana Research Farm for three consecutive seasons. Five treatments i.e. 0, 10, 30, 100 dry tons FM ha^{-1} and the standard chemical fertilization dose were included in a Randomized Complete Block Design (RCBD) with three replications. Sugarcane variety CO6806 was used. Results showed that, in the first season the addition of 30 and 100 tons $FMha^{-1}$ resulted in cane yields comparable to those obtained from plots receiving the standard chemical fertilization dose (165 kg N ha^{-1}+ 55 kg P ha^{-1}). In the second season, the highest yield was obtained from treatment residual 100 tons $FMha^{-1}$. In the third season despite there were no significant differences in cane yield between the filter mud treatments, but there was an increase in the cane yield with the increase of FM dose. In all seasons high sugar quality was obtained and chemical analysis of soil showed a concurrent increase in organic carbon, total N, total and available P with the increase of FM concentrations.

Key words: Filter mud, sugarcane, organic carbon, Nitrogen, Phosphorus

Introduction

Sugarcane is a perennial grass cultivated in tropical and subtropical regions of the world between latitudes 35° north and south of the equator and altitudes ranging from sea-level to several thousand metres, (Halliday, 1956; Barnes, 1974). It is one of the most efficient photo-synthesizers in the plant kingdom and is cultivated for its ability of storing high concentrations of sucrose in the internodes of the stem. Filter mud (FM), a thick mud-like finely pulverized organic material, (Senthil and Das, 2004); that consists of the precipitated impurities contained in the juice cane and is removed by filtration during the sugarcane processing, (Barnes, 1974; Asquieri *et al*., 2003). It varies in composition, quantity and moisture content depending upon the variety and quality of sugarcane, harvesting method, soil type and the process followed for clarification of cane juice in a sugar factory (Barnes, 1974;

Prasad, 1976; Chapman, 1996; Poel *et al.*, 1998; Qureshi *et al*., 2000; Ghulam *et al*., 2006). It is a rich source of plant nutrients thus is used as a fertilizer in several countries like Argentina, Brazil, India, Pakistan, Taiwan, South Africa, Swaziland and Australia, (Barnes, 1974; Blackburn, 1984; Hunsigi, 1993; and Poel *et.al*, 1998; Barry *et al*., 2001). Investigations in Mauritius (Ne Kee Kwong, and Deville, 1988) and in Cuba (Arzola and Carrandi, 1982) confirmed an increase in organic matter content of soils with an enhanced nitrogen uptake by sugarcane with the application of filter mud. Halliday, (1956) reported an increase in cane yield in the plant canes as well as a residual effect reflected in the yields of first and second ratoons with the application of FM. Aloma, *et al*., (1974); Maclean, (1976); Smith, (1979) Chapman, (1996); Poel *et al.*, (1998); Kingston, (1999) reported that sugarcane yield increased significantly with the application of FM. Improvement in soil organic C, total N, P, and K status was obtained, (Piedra *et al*., 1992; Kaur *et al*., 2005). Moreover, Meade and Chen, (1977); Blackburn, (1984); Hunsigi, (1993); Arzola *et al*., (1995); Chapman, (1996); Kingston, (1999), reported that FM is an important source of P fertilizer.

Materials and Methods

A field experiment was established in the year 2005 at the Kenana Sugarcane Research Farm in Sudan for three consecutive seasons to investigate the residual and cumulative impact of FM on sugarcane yield and quality and on soil chemical properties. Kenana Research Farm is the research farm of Kenana Sugarcane Company that is located on the eastern bank of the White Nile at the intersection of latitude 13° 10‘ N and longitude 32° 40’ E, and altitude 410m above sea level in the central clay plain of Sudan. It has a semi-arid tropical climate with high temperatures during summer and relatively low temperatures during winter. Relative humidity varies with maximum of 87% in July and August and minimum of 15% in February and March. The soil is heavy black deeply cracking Vertisols. Clay content is 60 to 65% mainly montmorillonite, characterized by low infiltration rate. The soil is non-saline, non-sodic with pH ranging from 7.5 to 8.5 and organic carbon content of about 0.84%.

Chemical properties of soil and FM were determined prior to the establishment of the experiment, (Table 1 and 2), soil bulk density was carried out 4 months after cane planting. In the first season, five treatments, viz. 0, 10, 30 and 100 tons air dry FMha^{-1} and 165 kg Nha^{-1} + 55kgP2O5 ha^{-1} (recommended chemical fertilization dose) were used in a Randomized Complete Block Design (RCBD) with three replications. Each plot consisted of 9 rows at 1.55m spacing and 23m length. The main commercial sugarcane variety CO 6806 was used. For all treatments where FM was used, 55kgNha^{-1} were supplied. Other cultural practices for sugarcane growing had been adopted as usually done in the commercial field.

In the second season, each plot was vertically divided into two sub-plots, (4 rows x 1.55m spacing x 23m length). Same treatments used in the first season were used in the second season but for each treatment one sub-plot was not treated with FM to explore the residual effect of the treatment while the other sub-plot was treated to investigate for the cumulative impact of the treatment.

In the third season, each sub-plot was horizontally divided into two, (4 rows x 1.55m spacing x 10m length). The same treatments described above were used in such a way that the following effects were explored:

- Residual effect of the treatment applied in the 1st season.
- Cumulative effect of two successive applications, (In 1st and 2nd seasons).
- Cumulative effect of three successive applications, (In the 1st, 2nd and 3rd seasons).
- Effect of the treatment when applied in the first season and the third season without its application in the second season.

Data collected at harvest at the end of each season included yield of cane, plant population, plant height and determination of quality parameters viz. Pol%, fibre% and ERSC%. Data collected were subjected to analysis of variance using the MSTATC, (computer statistical software). Soil samples were chemically analyzed at the laboratories of CIRAD in France.

Table1: Chemical composition of a sugarcane cultivated soil at Kenana Sugarcane Estate

Organic contents %		Exch. cations $me100g^{-1}$		Others $g\ kg^{-1}$		$mg\ kg^{-1}$		$me100g^{-1}$	
O.C.	0.84	Ca	55.34	Total P	448.0	Avail P	3.82	CEC	45.14
Total N	0.50	Mg	13.95						
C/N	16.89	K	0.55						
		Na	0.78						

Table 2: Composition of FM produced by Kenana Sugar Factory (2004/05)

Organic contents (%)		Total elements ($g\ kg^{-1}$)		Total elements ($mg\ kg^{-1}$)	
Org-C	30.59	Ca	26.01	Cu	35.4
Total-N	0.486	Mg	8.07	Zn	84.15
C/N	62.9	K	8.51	S	352
		Na	0.96	Pb	3.88
		P	10.97	Ni	21.59
		Fe	18.59	Cr	39.5
		Al	25.63	Cd	0.12
				Hg	0.032
				Mn	475

Results and Discussion:

First season:

For cane yield, results showed a significant difference between the control and the other four treatments. However, no significant differences had been observed among the filter mud treatments. On the other hand, for millable cane stalks and quality parameters, there were no significant differences among the five treatments. The control treatment gave the lowest millable cane number, (Table 3). Furthermore, soil chemical analysis showed that with the addition of FM an increase in organic C, total N, total and available P was obtained, (Table 4). However, pH of the soil was not affected by the application of FM and all of the five treatments gave more or less similar pH readings. This is presumably so because Kenana soil has a high buffering capacity. However, there was a significant difference in pH between each of the four treatments and the treatment 100 tons FMha^{-1}. This is probably because the addition of 100 tons FMha^{-1} over-ruled the buffering capacity of this soil. Thus, those results suggested that when FM was added in amounts of 30 and 100 tons ha^{-1}, it could satisfy crop needs of chemical fertilization in the first season and resulted in cane yields comparable to those obtained from plots receiving the recommended chemical fertilization dose used in the commercial sugarcane fields of Kenana (i.e. 165 kgNha^{-1}+ 55kgP ha^{-1}). Hence, savings in chemical fertilizers could be achieved. These results supported the findings of Aloma *et al*., (1974); Poel *et al*. (1998); Kingston (1999) who had reported significant increase in sugarcane yields with the application of filter mud.

Table 3: Sugarcane Yield and Quality as influenced by FM applications in the 1st season

Treatments	*Pop/ha. (1000 stalks)	TC ha^{-1}	Pol	Brix	ERSC	Fibre	MC	Purity
				(%)				
Control	68	103	14.2	15.9	12.7	16.6	67.4	89.5
10 tons FM ha^{-1}	80	116	13.9	15.6	11.9	16.4	67.9	89.1
30 tons FM ha^{-1}	81	121	14.0	15.6	12.0	17.4	66.9	90.0
100 tons FM ha^{-1}	85	120	14.5	16.1	12.6	16.1	67.7	90.0
165 kgN ha^{-1}	89	125	14.7	16.4	12.7	16.4	67.1	89.8
CV%	12.69	5.22	3.5	3.16	4.31	6.64	1.27	1.58
$S_{E\pm}$	4.85	2.49	0.28	0.29	0.30	0.63	0.49	0.81
LSD $_{0.05}$	15.82	8.12	0.94	0.94	1.00	2.07	1.61	2.65

Table 4: Soil chemical properties as influenced by FM applications in the first season

Treatments	pH	O.C.	Total N	C/N	Total P	Available P
		(%)			(mg kg^{-1})	
Control	8.8	0.8	0.60	14.7	358	5.6
10 tons FM ha^{-1}	8.7	1.0	0.70	14.5	470	12.0
30 tons FM ha^{-1}	8.7	1.1	0.76	15.1	637	28.0
100 tons FM ha^{-1}	8.5	1.6	1.13	13.9	1342	108
165 kg N ha^{-1}	8.7	0.9	0.66	14.7	401	6.0
CV%	0.7	10.9	12.8	6.5	4.5	18.2
$S_{E\pm}$	0.03	0.06	0.05	0.54	16.74	3.37
LSD $_{0.05}$	0.11	0.22	0.18	1.78	54.62	11.0

Second season:

Significant differences in cane yield among treatments had been obtained. The highest yield was obtained from treatment residual 100 tons FMha^{-1} and the lowest was from the control. For quality parameters, there were no significant differences between the five treatments and high sugar quality was obtained, (Table 5). Moreover, soil chemical analysis showed concurrent increases in the amounts of organic C, total N, total and available P, with the increase in the amounts of filter mud applied into the soil. With respect to pH of the soil, despite the fact that there was no significant difference among treatments, but a clear decrease in pH values had been observed, (Table 6).

Table 5: Sugarcane yield and Quality as affected by Residual and Cumulative Applications of Filter Mud in the second season

Treatments	TC ha^{-1}	Pol	Brix	ERSC	Fibre	MC	Purity
		(%)					
Control	79	20.1	22.9	17.5	14.7	62.3	87.7
Residual 10 tons $FMha^{-1}$	84	19.6	22.6	17.0	15.4	61.9	86.7
Cumulative 10 tons $FMha^{-1}$	92	19.5	22.3	17.0	14.9	62.6	87.3
Residual 30 tons $FMha^{-1}$	100	20.0	23.2	17.3	14.5	62.2	86.1
Cumulative 30 tons $FMha^{-1}$	95	19.0	22.1	16.3	15.5	62.3	86.2
Residual 100 tons $FMha^{-1}$	119	19.0	22.4	16.9	14.3	63.2	86.6
Cumulative 100 tons $FMha^{-1}$	102	17.5	20.5	14.8	16.4	62.9	85.2
Chemical fertilization	100	21.1	24.1	18.5	12.8	62.9	87.4
CV%	11.69	9.21	9.13	10.51	12.97	1.44	2.23
$S_{E\pm}$	6.52	1.03	1.18	1.02	1.11	0.52	1.11
$LSD_{0.05}$	19.79	3.15	3.60	3.12	3.37	1.58	3.38

Table 6: Soil chemical properties as affected by Residual and Cumulative Applications of Filter Mud in the second season

Treatments	pH	OC	T-N	C/N	Total P	Available P
		(%)			($mgkg^{-1}$)	
Control	7.2	0.96	0.56	18.6	314	3.8
Residual 10 tons $FMha^{-1}$	7.1	1.20	0.56	16.8	379	5.9
Cumulative 10 tons $FMha^{-1}$	7.1	1.26	0.63	18.8	434	9.0
Residual 30 tons $FMha^{-1}$	7.2	1.30	0.80	16.6	591	18
Cumulative 30 tons $FMha^{-1}$	7.1	1.93	0.76	16.5	651	21
Residual 100 tons $FMha^{-1}$	7.2	1.60	1.2	15.9	1855	176
Cumulative 100 tons $FMha^{-1}$	7.2	1.03	1.13	14.4	1500	136
Chemical fertilization	7.1	1.03	0.53	19.5	311	3.4
CV%	1.21	7.74	13.3	11.5	21	109
$S_{E\pm}$	0.05	0.05	0.05	1.14	93	29
$LSD_{0.05}$	0.13	0.15	0.16	3.05	251	79

Third season:

Results showed significant differences in cane yield and stalk numbers among the treatments, (Table 7). In general, cane yields obtained are a little bit lower than the normal data of cane yield in Kenana. This may be due to the negative effect of the heavy flowering that dominated all plots during the third season. For cane yield and stalk number, there were significant differences between the control and most of the rest of treatments. However, the highest cane stalk numbers and sugar cane yields were obtained from chemical fertilization treatment.

Table (7): Sugarcane yield and quality as affected by residual and cumulative applications of filter mud in the third season

Treatments	*Pop ha^{-1} (1000 stalks)	TCha^{-1}	MC	Fibre	Brix	Pol	Purity	ERSC
			(%)					
Control	92	61	63.5	15.4	21.2	18.5	87.2	16.0
Chemical fertilization	120	106	63.2	15.1	21.3	18.3	85.7	15.6
Residual (10 tons)	112	79	63.2	15.6	21.4	18.3	85.5	15.6
Residual (10 tons+10 tons)	93	71	62.2	15.2	21.9	18.9	86.4	16.4
Cumulative (10 tons)	102	62	62.7	16.5	20.5	18.4	89.9	16.2
Cumulative (10 tons+10 tons)	111	77	63.6	15.0	21.3	18.5	86.9	16.1
Residual (30 tons)	108	84	63.6	15.2	22.2	19.5	88.1	17.1
Residual (30 tons+ 30 tons)	115	90	63.1	14.7	21.7	18.9	86.9	16.4
Cumulative (30 tons)	114	81	64.8	14.9	21.3	18.5	86.7	16.0
Cumulative (30 tons+30 tons)	119	93	63.7	14.4	21.8	18.7	85.7	16.0
Residual (100 tons)	119	87	63.4	15.6	21.4	18.8	88.1	16.4
Residual (100 tons+100 tons)	119	97	64.0	13.8	21.4	18.5	86.3	16.0
Cumulative (100 tons)	110	90	65.1	14.3	20.6	17.6	85.8	15.1
Cumulative (100 tons+100 tons)	116	90	64.4	14.1	20.5	17.3	84.4	14.7
CV%	11.5	13.0	1.7	7.8	3.8	4.4	2.2	5.7
$S_{E\pm}$	7.4	6.3	0.6	0.7	0.5	0.5	1.1	0.5
LSD $_{0.05}$	18.5	15.8	1.5	1.7	1.2	1.2	2.7	1.3

Table 8: Bulk density (gm.cm-3) as affected by application of different rates of FM, after 4 months of growth of sugarcane

Treatments	Bulk density, (gm.cm^{-3})
0% FM, (loose soil)	0.947 a
25% FM	0.790 b
50% FM	0.577 c
75% FM	0.413 d
100% FM	0.267 e
Mean	0.599
CV%	8.19
$S_{E\pm}$	0.02

Means of similar letter(s) are not significantly different

Conclusion

- The concurrent increase in organic carbon, total N, total P and available P accompanied by reduction in bulk density, (Table 8) that resulted from the different additions of filter mud into Kenana vertisols, were expected to improve soil fertility, reduce the penetration resistance to plant roots and increase porosity; thereby improvements in sugarcane productivity had been obtained.
- Such cultural practice presumably reduces cost of production of sugar, via reduction in the amounts of urea and TSP fertilizers used and at same time maintains a friendly and an environmentally sound agriculture by getting rid and benefiting from such an important sugar industry by-product.

Recommendations

- Filter mud, therefore, can be recommended to be used as an organic fertilizer to compensate for amounts of inorganic fertilizers needed for sugarcane production.

- Studies proved that filter mud can be composted with the vinasse (A by-product of sugarcane alcohol distillation) for production of organic fertilizers.

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الأثر المتبقي والتراكمي لطين المرشح على إنتاج محصول قصب السكر وعلى الخصائص الكيميائية للتربة

ثابت محمد أحمد السيد[1] و هاشم محمود بابكر[2] و الطيب محمد عبد الملك[2] و نوري عثمان مختار[3] و دينز مونتانج[4]

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المستخلص

طين المرشح هو أحد مخلفات صناعة سكر القصب الناتج من عملية تنقية عصير القصب والمعلوم باحتوائه على مجموعة من العناصر الغذائية الكبرى والصغرى. أجريت هذه الدارسة لغرض التعرف علي الأثر المتبقي والتراكمي الناجمين من اضافة طين المرشح للتربة على إنتاج محصول قصب السكر وعلي خصائص التربة الكيميائية والطبيعية وعلى إنبات وإنتاج محصول قصب السكر كماً ونوعاً وذلك لغرض النظر في إمكانية استخدامه في حقول القصب كمخصب طبيعي. لهذه الدراسة تم تاسيس تجربة في حقول بحوث قصب السكر بشركة سكر كنانة في العام 2005 ولمدة ثلاثة اعوام متتالية. تم اختبار ثلاثة جرعات من طين المرشح: 10، 30 و 100 طن للهكتار. أثبتت الدراسة أن إضافة طين المرشح لم توثر معنوياً على النسبة المئوية للإنبات لعقل قصب السكر وعلى إنتاج محصول قصب السكر الغرس بين المعاملتين 30 و 100 طن طين المرشح الجاف للهكتار والمعاملة 165كجم نيتروجين للهكتار وبين كل المعاملات في عدد سيقان القصب.أما بالنسبة لمحصول الخلفة الأولى لقد كان أعلى إنتاج للقصب في المعاملة (100 طن طين المرشح للهكتار) لمحصول الغرس. كذلك لم تحدث فروقات معنوية في معايير جودة المحصول التي تم اختبارها بين كل المعاملات في محصول الغرس والخلفة الأولى. أوضحت الدراسة أن إضافة طين المرشح أدت إلى زيادة طردية في محتوى التربة من الكربون العضوي و النتروجين الكلى والفسفور الكلى والفسفور المتاح. كذلك أكدت الدراسة أن الكثافة الظاهرية للتربة تناسبت تناسباً عكسياً مع كمية طين المرشح المضاف.تشير هذه النتائج الى تحسن في خصائص التربة الطبيعية بإضافة طين المرشح. مما سبق أتضح أن إضافة طين المرشح لحقول قصب السكر بشركة سكر كنانة نتج عنها تحسين فى خصائص التربة اللطبيعية والكيميائية مما يشير إلى تحسن في خصوبة التربة الشئ الذي أدى إلى تحسن نمو وإنتاجية المحصول. وعليه يمكن استخدام هذا المخلف الصناعي في حقول قصب السكر للحفاظ على بيئة صناعية خالية من التلوث وتقليل تكلفة الإنتاج بتقليل كمية السماد الكيميائي المستخدم.