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Response of Sugarcane (*Saccharum* spp.) to Urea and Methods of Application in some Soils in the Central Clay Plain of Sudan*

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Abstract: The present experiments were conducted in the seasons 2005/06 and 2006/07 at Guneid, Assalaya and New Halfa Sugar Estates in the central clay plain. The objectives were to investigate the response of sugarcane (plant cane) to different doses of urea (46% N), to splitting the dose and to covering urea by a thin layer of soil. Urea doses were 150 and 225 kg/feddan (one fed. = 0.42 ha). The fertilizer doses were applied either at 45-60 days after planting (full dose) or split into two doses: two thirds at 45-60 days after planting and the other third at the age of five to six months. Covering was also compared with uncovering the fertilizer with a thin layer of soil. This factorial arrangement of treatments was laid out in a randomized complete block design in Guneid and Assalaya for October planting and in Guneid and New Halfa for June planting. The results revealed that there were no significant differences in cane yield, yield components and quality of the crop of the plant cane between the rates of urea for the October and June plantings. Splitting the dose outyielded the full dose for June planting at New Halfa only which had a long season that exceeded 17 months. Covering urea insignificantly outyielded the uncovered treatments. The dose 150 kg urea/fed. proved to be satisfactory for both cane and sugar yields for the crop of the plant cane. Therefore, a dose of 150 kg urea/fed. is recommended for the plant cane crop, and a similar study should be done for ratoon cane.

Key words: Sugarcane; urea fertilizer; dose; split; covering; Sudan

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INTRODUCTION

Sudan possesses suitable conditions for the cultivation of sugarcane, which include extensive land, good quality irrigation water and optimal weather conditions. Sugarcane is a C_4 plant, a heavy feeder and a producer of huge biomass and is consequently very exhaustive to the soil nutrients. All the sugarcane estates in Sudan are located in the central clay plain. The soils are Vertisols with moderate fertility, due to high contents of smectitic clays, high pH, low N and organic matter.

In Sudan, urea is the only nitrogen fertilizer for sugarcane and is also predominantly used for other crops. As a result of the increased prices of fertilizers, the high cost of transport, storage and application, it is deemed necessary to determine the optimum requirements of fertilizers. In this regard, the cane growers supported by field inspectors claim that addition of extra dose of urea over the officially recommended dose (150 to 200 kg/ fed.) increases cane yield. However, local and worldwide research reports do not support this contention.

It is well known that increase in N fertilizer increases the number of millable stalks, plant height, and cane and sugar yields until an optimum is reached beyond which all these parameters will be negatively affected (Dillewijn 1952). However, it is reported that not more than 30% of the applied N is used by the sugarcane crop (Dharmawardene and Keerthipala 2005). Lack or poor response of plant cane to N fertilizer was also reported by several workers (Elfadil 1966; Abuzeid 1971; Ibrahim 1979; Wood 1989; Wiedenfeld 1997; Kennedy *et al*. 2004). Moreover, Ali (2003) did not find any significant difference in cane yield and yield components between doses of 0, 23, 46, 69, 92, and 115 kg N /fed. (as urea) for the plant cane crop and, therefore, he recommended a dose of 69 kg /fed. This rate was also confirmed by Elhag *et al*. (2007). In contrast, Mohamed (1982) reported significant increases of cane and sugar yields in response to increased rates of urea.

Splitting the dose of N fertilizer to sugarcane has little advantage over a single dose. This is because sugarcane absorbs nitrogen during the first few months of age in amounts more than needed (luxury consumption).

This excess is presumed to be stored and used lately during the "boom stage of growth" (Humbert 1968). In spite of the little advantage of split application, it becomes less acceptable due to the increased cost and the ill effects of additional movements of machines in the fields (Barnes 1974; Rao *et al*. 1975). On the other hand, split application is practiced in parts of the world where sugarcane is grown for longer than 18 months (Humbert 1968). It is worth mentioning that the cane of June planting in the sugar estates of the Sudanese Sugar Company is usually harvested after the age of 17 months. Therefore, splitting the dose in this case may prove to be beneficial.

It is also known that covering the urea by a thin layer of soil reduces N losses by volatilization (Havlin *et al*. 1999). The usual practice of urea application in the sugar estates of the Sudanese Sugar Company is 45 to 60 days after planting without covering the urea, leading to possible losses by volatilization.

The objectives of this study were (1) to study the response of sugarcane (plant cane) to different doses of nitrogen (urea) and (2) to test the effect of splitting the urea dose and covering and uncovering by a thin layer of soil after application.

MATERIALS AND METHODS

Soils of the experimental sites

The soils of the three experimental sites are more or less similar in their physical and chemical characteristics since they fall within the same order of Vertisols, having similar soil moisture conditions (ustic) and soil temperature regime (isohyperthermic). Therefore, they were reported as Haplusterts, fine to very fine, smectitic, isohyperthermic (Soil Survey Staff 1999). The land suitability subclass of each of the studied soils is S2v, i.e., moderately suitable with vertisolic limitation. Table 1 shows some of the relevant physical and chemical properties of the site of Guneid as an example for the three sites.

Table 1. Physical and chemical soil properties of the site of Guneid (0-30 cm depth composite sample)

Mechanical analysis				Soil moisture (%)			Bulk density ($g\ cm^{-3}$)
Sand (%)	Silt (%)	Clay (%)	Saturation (%)	33 kPa	1500 kPa	AWC	
28	17	55	61.5	43.7	22.4	21.3	1.75

pH 1:5 soil :H_2O Ratio	EC_e (dSm^{-1})	$CaCO_3$ (%)	N (%)	O.C. (%)	Soluble cations ($me\ l^{-1}$)		
					Na	Ca	Mg
8.7	0.84	4.4	0.03	0.50	0.48	4.8	1.0

Exch. K {cmol (+) kg^{-1} soil}	CEC {cmol(+) kg^{-1}soil	SAR	ESP	Avail. P (mg P kg^{-1} soil)
0.4	60	2.0	3.0	4.3

The treatments were as follows:

1) Urea was applied at two rates: 150 and 225 kg urea/fed.
2) Each rate was split into two thirds applied when the cane was 45-60 days old and the remainder was applied when the cane was five to six months old. The full dose (150 or 225 kg urea/fed.) was applied once when the cane was 45-60 days old.
3) For each of the two treatments, half was covered manually with a thin layer of soil and the other half was left uncovered.

The factorial experiment was laid out in a randomized complete block design with four replications in the three locations. The experimental unit (plot) was four rows, 1.5 m apart and the row was 10 m long. The sugarcane variety was Co 6806 which is dominating the sugar estates in Sudan (> 90% of the cultivated area). The experiments were planted in the farm of Guneid Sugarcane Research Centre in the last week of

October 2005, in Assalaya Sugar Scheme farm in the first week of November 2005 (October planting season), and again in Guneid Research Centre and New Halfa Sugar Scheme farms in June 2006 (June planting season).

Land preparation included deep ploughing, harrowing, leveling and ridging. Triple super phosphate (TSP) at the rate of 100 kg/fed. was applied as a basal dose in all treatments. Then healthy 3-eyed cane setts were planted as continuous double sett. The standard husbandry practices were followed; namely, application of herbicides, insecticides (to combat termites), irrigation and weeding.

Urea was applied on both sides of the row of cane plants, similar to machine application. Urea covering was achieved by hand hoes in the plots assigned for this treatment.

The number of millable stalks, stalk height and yield of cane were recorded at harvest. Brix (%) cane (total soluble solids), pol (%) cane (sucrose content), fibre (%) cane, ERS (estimated recoverable sugar) (%); were determined for cane quality according to the International Commission for Uniform Methods of Sugar Analysis (ICUMSA) (1979). Sugar yield in ton/fed (TS/fed.) was calculated as follows: ERS (%) x yield of cane (ton /fed.). Leaf sampling for N was done according to Clements (1980). The data was analyzed according to MSTAT-C.

RESULTS AND DISCUSSION

Statistical analysis showed that the effects of urea dose, splitting the dose and covering and uncovering the urea by soil after application and their interactions for all measured parameters were not significant for the cane of October planting at Guneid and Assalaya sites (Table 2). The number of millable stalks, stalk height and yield of cane did not show any specific trend in response to the dose of 150 or 225 kg urea /fed., and also to splitting the dose, compared to full application. However, there were slight increases in cane yield when urea was covered than when it

was uncovered at the sites of Guneid and Assalaya, though the increases were statistically insignificant.

The cane crop of June planting showed more or less similar results to those of October planting (Table 3). There was inconsistent behaviour of quantitative yield components in response to the dose of urea. Moreover, the results showed that there were slight increases in cane yield in case of covering the urea over that of uncovered urea for both Guneid and New Halfa sites. However, splitting the dose of urea gave significantly more millable stalks and cane yield than from the full dose at New Halfa only (Table 3).

Several workers reported that the response of yield of plant cane to increased rates of N is generally poor (Elfadil 1966; Abuzeid 1971; Ibrahim 1979; Wiedenfeld 1997; Ali 2003 and Elhag *et al.* 2007). It is presumed that the vigorous root system of the plant cane and the improved soil physical conditions preceding the plant cane results in better uptake of fertilizers (Humbert 1968). These improvements were envisaged to enable the plant cane to utilize the meager soil N more efficiently and hence the low response to the applied nitrogenous fertilizers

Since covering urea in these calcareous clay soils was reported to decrease losses of N by volatilization (Havlin *et al*. 1999), the slight increases in cane yield in case of covering urea compared to the uncovered fertilizer is understood. The irresponsiveness of sugarcane to split application of urea was documented (Barnes 1974 and Rao *et al*. 1975). However, the significant increase in cane yield due to split rate of urea of June planting at New Halfa was presumably related to fulfilling the higher needs of the older cane of the June planting compared to those of the relatively younger cane of October planting. In contrast, the results obtained in June planting at Guneid site showed a different trend to those obtained at New Halfa.

The cane quality parameters have exhibited more or less similar results to those of cane yield components, i.e., no significant difference was obtained in response to any treatment. This was explained by the fact that the two levels of the applied urea were somewhat comparable and relatively moderate (150 and 225 kg urea/fed.) and were applied early in the growing season and, therefore, did not cause any reduction in the cane quality. However, this study showed that pol (%) cane, ERS (%), and TS/fed. were slightly higher with the lower level of applied urea in two of the three sites, (Tables 2 and 3). In a similar way, fibre(%) cane showed no trend in response to any treatment, but there was relatively very slight decrease in fibre(%) cane with increasing dose of urea (Tables 2 and 3). It is known that high rate of N decreases fibre (%) cane (Dillewijn 1952). It is noteworthy that no trend was identified as a response to interaction between the two doses of urea whether split or not and covered or uncovered.

The data in Table 4 show that all concentrations of leaf nitrogen fell within the sufficiency levels for sugarcane (level of N at which sugarcane does not show deficiency symptoms) as described by Humbert (1968) and Gascho (2004). Furthermore, there were slight increases of the concentrations of N of the cane leaves when urea was covered compared to uncovered urea; and also higher for splitting the dose than the full dose at the different sampling ages. Therefore, these slight increases in leaf nitrogen are in conformity with the corresponding cane yields shown in Tables 2 and 3.

It can be concluded that the rate of 150 kg urea /fed. is satisfactory for the plant cane crop in Assalaya, Guneid and New Halfa, for both planting dates of October and June and, therefore, no extra dose is needed. Covering of urea after application is beneficial, and split application of N is advantageous for the plant cane of the longe=r season (June planting at New Halfa only). Based on the present results and those of Ali (2003) and Elhag *et al.* (2007) it is justifiable to recommend 150 kg urea/fed. to be adopted instead of the currently applied dose of 200 kg urea/fed. in the estates of the of the Sudanese Sugar Company. A similar study should be done for ratoon cane.

Table 2. Effect of urea dose, (split or full when covered or uncovered) on yield, yield components and quality of sugarcane at Guneid and Assalaya (October 2005 planting)

Parameter	Urea (kg/fed.)		Split	Full	Covered	Uncovered	S.E.(±)	C.V. (%)
	150	225						
				Guneid				
No.of millable stalks /fed.	57263	56680	56898	57044	57162	56780	1037	7.3
Stalk height (cm)	278.0	275.2	280.3	273.0	274.9	278.4	3.78	5.5
Yield of cane (ton /fed.)	72.09	71.36	71.55	71.89	72.51	70.93	1.35	7.5
Brix (%) cane	15.22	15.10	15.27	15.05	15.20	15.12	0.166	4.4
Pol (%) cane	12.09	11.98	12.21	11.86	12.16	11.92	0.153	5.1
Fibre (%) cane	15.43	15.38	15.43	15.37	15.56	15.24	0.290	7.5
ERS (%)	9.09	8.98	9.21	8.86	9.16	8.92	0.153	6.8
TS (ton/fed.)	6.58	6.59	6.62	6.55	6.82	6.35	0.217	13.2

Table 2. Cont.

Parameter	Urea (kg/fed.)		Split	Full	Covered	Uncovered	S.E. (±)	C.V. (%)
	150	225						
				Assalaya				
No. of millable stalks/fed.	48808	46568	48825	46550	49289	46068	1322	11.09
Stalk height (cm)	336.0	333.1	329.8	339.2	335	334.1	5.39	6.44
Yield of cane (ton /fed.)	60.79	59.08	61.66	58.22	61.43	58.44	1.88	12.52
Brix (%) cane	17.26	17.59	17.40	17.45	17.47	17.39	0.107	2.46
Pol (%) cane	14.17	14.49	14.30	14.36	14.32	14.34	0.147	4.09
Fibre (%) cane	14.70	14.63	14.75	14.58	14.34	14.99	0.347	9.45
ERS (%)	11.17	11.49	11.34	11.32	11.28	11.38	0.146	5.17
TS (ton /fed.)	6.78	6.80	6.99	6.59	6.94	6.65	0.245	14.44

One feddan (fed.) = 0.42 ha

Table 3. Effect of urea rates, split or full and covered or uncovered on yield, components of yield and quality of sugarcane, at: Guneid and New Halfa (June 2006 planting)

Parameter	Urea (kg/fed.)		Split	Full	Covered	Uncovered	S.E.(±)	C.V.(%)
	150	225						
				Guneid				
No. of millable stalks /fed.	66658	66588	66281	66964	66255	66990	1116	6.7
Stalk height (cm)	255.8	250.8	242.3	264.3	255.2	251.4	8.36	13.2
Yield of cane (ton /fed.)	68.65	68.5	67.27	69.89	69.03	68.13	2.48	14.5
Brix (%) cane	14.79	14.55	14.66	14.68	14.65	14.70	0.17	4.5
Pol (%) cane	10.38	9.76	10.09	10.06	10.05	10.10	0.22	8.5
Fibre (%) cane	15.43	15.38	15.43	15.37	15.56	15.24	0.29	7.5
ERS (%)	8.13	7.46	7.81	7.78	7.76	7.82	0.23	11.8
TS (ton /fed.)	5.57	5.13	5.29	5.41	5.36	5.34	0.24	17.8

Table 3. Cont.

Parameter	Urea (kg/fed.)		Split	Full	Covered	Uncovered	S.E.(±)	C.V. (%)
	150	225						
				New Halfa				
No. of millable stalks /fed.	73407	70434	74879	68962	72509	71332	1973	10.97
Stalk height (cm)	250.50	257.70	251.3	256.9	249.9	258.3	5.27	8.29
Yield of cane (ton /fed.)	82.08	78.50	85.16	75.41	80.96	79.62	3.10	15.38
Brix (%) cane	15.29	14.99	14.86	15.42	15.15	15.13	0.19	5.09
Pol (%) cane	12.33	12.13	12.02	12.44	12.16	12.3	0.15	5.03
Fibre (%) cane	20.39	20.49	20.63	20.25	20.38	20.5	0.15	2.9
ERS (%)	10.63	10.35	10.24	10.74	10.42	10.55	0.18	6.85
TS (ton /fed.)	8.72	8.04	8.70	8.06	8.31	8.45	0.35	16.85

One feddan (fed.) = 0.42 ha

Table 4. Nitrogen concentration percentage of leaf blades 3, 4, 5 and 6 at different ages of plant cane, for October and June 2006 planting

Site (and date of planting)	Sampling age (month)	Treatment					
		Urea (kg /fed.)		Split	Full	Covered	Uncovered
		150	225				
Guneid (October)	3.5	2.48	2.40	2.48	2.41	2.48	2.40
	6.5	2.33	2.43	2.34	1.81	2.44	2.31
	14.0 (Harvest)	2.03	1.88	2.00	1.88	2.26	1.62
Assalaya (October)	7.5	1.94	1.93	1.97	1.90	1.98	1.90
	14.0 (Harvest)	1.48	1.35	1.43	1.40	1.35	1.48
Guneid (June)	6.0	2.34	2.29	2.31	2.32	2.33	2.29
	16.5 (Harvest)	1.49	1.26	1.43	1.33	1.50	1.25
New Halfa (June)	6.0	2.08	1.99	2.11	1.96	2.15	1.92
	16.5 (Harvest)	1.38	1.25	1.33	1.30	1.28	1.35

One feddan (fed.) = 0.42 ha

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مجلة جامعة الخرطوم للعلوم الزراعية: المجلد السابع عشر-العدد الثاني، 2009م

إ ستجابة محصول قصب السكر لليوريا و طرق الإ ضافة في بعض أراضي سهل السودان الطيني الأوسط

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موجز البحث: أجريت تجارب فى المواسم 06/2005 و 07/2006 بمشاريع شركة السكر السودانية فى كل من الجنيد و عسلاية و حلفا الجديدة فى سهل السودان الطينى الأوسط . هدفت هذه التجارب لدراسة إستجابة محصول قصب السكر الغرس لمعدلات مختلفة من اليوريا، و مقارنة تقسيم الجرعة مع إضافتها كاملة، و تأثير تغطية اليوريا بطبقة خفيفة من التربة بعد إضا فة السماد. استعملت جرعتان من سماد اليوريا هما 150 و 225 كجم/فدان، فى حالة الإضافة الكاملة للسماد، بعد شهر و نصف إلى شهرين مقارنة بتقسيم الجرعة الي ثلثين عند عمر شهر و نصف إلى شهرين والثلث الآخر من الجرعة عند عمر خمسة الى ستة شهور. تمت تغطية سماد اليوريا فى نصف المعاملات بطبقة خفيفة من التربة و ترك النصف الآ خر بدون تغطية. وضع هذا الترتيب العاملى (factorial) فى تصميم القطاع العشوائى الكامل وعلى محصول غرس فى شهر أكتوبر فى كل من الجنيد وعسلاية وغرس فى شهر يونيو فى كل من الجنيد و حلفا الجديدة . دلت النتائج على عدم وجود فروق معنوية فى الإنتـا جية

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و مكوناتها ونوعية قصب السكر الغرس بين جرعات اليوريا التى استخد مت في الدراسة لكل من محصولى غرس أكتوبر و يونيو. كان تقسيم اليوريا الي جرعات أفضل من إضا فة الجرعة الكا ملة لغرس يونيو بمزرعة مصنع سكر حلفا فقط حيث يزيد عمر المحصول عن السبعة عشر شهرا. وفا قت إنتا جية معاملات تغطية سماد اليوريا إنتاجية معاملات اليوريا بدون تغطية ولكن دون فروقات معنوية. كما أوضحت الدراسة أن الجرعة 150 كجم للفدان هى الجرعة المنا سبة من حيث الانتاجية من القصب ومن السكر فى محصول الغرس . وعليه يمكن التوصية بالاتى:

1) إضافة 150 كجم من سماد اليوريا للفدان لمحصول الغرس (Plant cane) بدلا عن الممارسة الحا لية (200 كجم للفدان).
2) إجراء دراسة مماثلة لمعرفة متطلبات محصول الخلفة.