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Effect of Soil Amendments, Variety and Irrigation Interval on Soil Properties and Yield of Sugarcane of a Salt-Affected Soil At Assalaya Sugar Scheme, Sudan

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ABSTRACT

An experiment was conducted during February 1993 at Assalaya Sugar Scheme (Sudan), to study the effects of soil amendments, irrigation intervals and cane varieties on some physical and chemical properties of a salt-affected soil as well as yield of sugarcane. The experimental design was a split-split plot with three replications. Application of four tonnes/ha of a combination of filtermud and bagasse significantly increased soil moisture content compared to that of other amendments. Soil amendments decreased ESP and increased saturation percentage which in turn decreased ECe and SAR especially under 10 day irrigation interval. The highest cane yield (158.8 t ha^{-1}) was obtained by the addition of filtermud and bagasse. Variety C06806 with a mean cane yield of 146.6 t ha^{-1} outyielded C0527 by about 27%, and the 10 day irrigation interval produced about 25% more cane than that of the 15 day irrigation interval. C06806 is suggested to be grown under the amendment of four tonnes/ha of filtermud and bagasse and irrigation interval of 10 days to give the highest cane yield in the salt-affected soil at Assalaya Sugar Scheme.

INTRODUCTION

Salt-affected soils are rife under arid and semi-arid climates because of insufficient leaching which results in accumulation of soluble salts in the solum in amounts harmful to plants. In Sudan salt-affected soils comprise about 5% of the total arable land (Nachtergaele, 1976). These soils are mostly scattered in central and northern parts of Sudan.

Sugarcane is considered as moderately sensitive to salinity (Maas (1990). Valdivia (1980) stated that reduction in yield of cane started EC_e of 1.6 dS me^{-1}, and that about 50% reduction in yield of cane occurred when the EC_e reached 3.6 dS m^{-1}. This finding was confirmed by Nour *et al*. (1989) who found about 10% reduction in cane yield at an EC_e of 1.4 dsm^{-1} in a poorly drained clay soil Sodicity was also found to adversely affect growth and yield of cane In this respect, Valdivia (1977) stated that exchangeable sodium percentage (ESP) of 15 reduced cane yield by about 15% and that an ESP of 26 reduced the yield of cane by about 50% and that no cane production at an ESP of 45. Valdivia (1980) documented that cane yield was significantly affected at an EC_e of 1.2 dsm^{-1} when the ESP was 11.4. In this regard, Nour et al. (1989) reported that cane yield under saline-sodic conditions was far worse than under salinity alone.

Purnell (1974) reported that reclamation of salt-affected soils in the central clay plain of Sudan, where sugar industry is now centred, was uneconomical. However, Ibrahim (1980a) reported that addition of gypsum with ripping, significantly improved yield of cane. Cooper and Abuidris (1980) obtained an increase in cane yield by applying 125 tonnes of filtermud per hectare. Humbert (1968) stated that addition of bagasse improved many soil properties and cane yield. It was generally observed that the yield of cane crop and that of the ratoon in the salt-affected sites in Assalaya Sugar Scheme were noticeably very low. The cane yield of the western part of this scheme was as low as three tonnes per hectare per year compared to 50 to 80 tonnes per hectare per year for the non-problematic soils of the same cane field (Ibrahim, 1989). It is worth mentioning that ratooning of cane in these problematic sites was very poor and never—extended beyond the second ratoon, whereas cane under non-problematic sites extended up to fifth ratoon or more.

The present study was undertaken to evaluate the effect of seven soil amendments, suagrcane varieties and two irrigation frequencies on some chemical and physical properties and sugarcane yield of a salt-affected soil at Assalaya Sugar Scheme.

MATERIALS AND METHODS

a) The study area

The Assalaya Sugar Scheme lies few kilometres north of Rabak town (latitudes 13^0 12' N and 13^0 19' N and longitudes 32^0 40' E and 32˚ 50'E) on the eastern bank of the White Nile. The salt – affected soils cover about 17% of the cultivable area of the scheme, (Fadl, (1973). The site of the present experiment was field No. 9 DA XX NO. l.

b) The soil

The soil is Rabak series with the following general properties:

pH	Sand	Silt	Clay	$CaCO_3$	CEC	EC_e	ESP	SAR
2:5 soil :water	←----------%--------→				$Me100^{-1}$ gsoil	dSm^{-1}		
8.2	52	14	34	4.5	30	6.5	42	14

This soil was classified as Sodic Haplocambids, fine loamy، smectitic, isohyperthermic (Soil Survey Staff, 1999) and as Calcaric Cambisols (FAO, 1988). The land suitability for general irrigated agriculture was S3a, i.e., marginally suitable land for irrigated agric-ulture with sodicity limitation (Fadl, 1973).

c) Treatments

The design of the experiment was a split-split plot factorial arrangement in three randomized complete blocks with soil amendments: control (C); gypsum (G); filtermud (FM); bagasse(B); G+FM; G+B, FM+B, and G+FM+B in the sub-subplot; the two sugarcane varieties (C06806 and C0527) were grown in the subplot and the two irrigation intervals (10 day and 15 day) were confined to the main plots. Each of the seven soil amendments was broadcast before sowing at a rate of four tonnes per hectare. The area of each experimental unit was 8X6m (four ridges). It is noteworthy to mention that the chemical composition of the FM as reported by Cooper and Abuidris (1980) was 1.3%N; 1.04% P; 0.47% K; 2.1% Ca, 0.3%Mg, 1800μg Mn g^{-1} 50μg Cu g^{-1} ; 3500 μg Fe g^{-1}; and 350 μg Zn g^{-1}

d) Cultural Practices

The experimental area was ploughed and the seedbed for sugarcane was prepared in the same way as that of the commercial sugarcane field in the scheme. The cane was planted on the first of February 1993and 219 kg N ha^{-1} as urea and 48 kg P ha^{-1} as triple super-combat termites and control weeds. Earthing up was done when the cane was four and half months old, then 110 kg N ha^{-l} as urea added to compensate for the nitrogen loss from February 1993 application. The two irrigation intervals were scheduled and carefully observed. Thereafter, weeds were hand removed whenever required.

e) Soil moisture profile

Sixteen experimental units were randomly chosen to represent the two irrigation intervals(eight units for each interval). From each experimental unit, soil samples were collected by auger every 15 down to 105 cm. The soil samples were kept separate in polyethylene bags for determination of gravimetric moisture. The generated data were presented in graphical forms.

f) Soil analysis

Soil analysis included the following

Particle size distribution, saturation percentage (SP), cation exchange capacity (CEC), electrical conductivity of the extract of a saturated soil paste (EC_e), sodium adsorption ratio (SAR), exchangeable sodium percentage (ESP), pH (2:5 soil: water ratio) and % $CaC0_3$. The laboratory methods for these measurements were those of Richards (1954).

g) Yield of sugarcane

An area of 2x1.5m from the centre of each experimental unit was harvested and weighed. The weight was then expressed as tonnes cane per hectare.

RESULTS

a) Soil moisture profile

The results generally showed that the moisture content of the studied soil was low near soil surface and gradually increased until it reached a certain depth below which the-soil moisture was virtually constant irrespective of the treatments. This depth ranged from 45 to 70 cm and from 45 to 60 cm in the 10 day and 15 day irrigation intervals، respectively (Figs. 1 and 2). It was observed that treatments in which G was included registered relatively lower moisture content for the two irrigation intervals. Treatment of FM+B showed the highest moisture content throughout the soil profile. The soil moisture content of the control was intermediate.

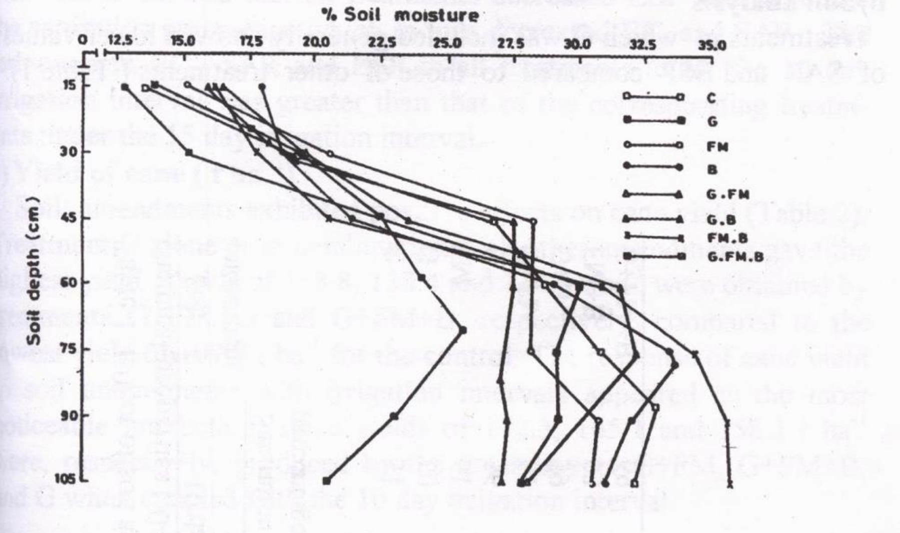

Fig.1. The effect of irrigation(10 day) and soil amendment on soil moisture profile.

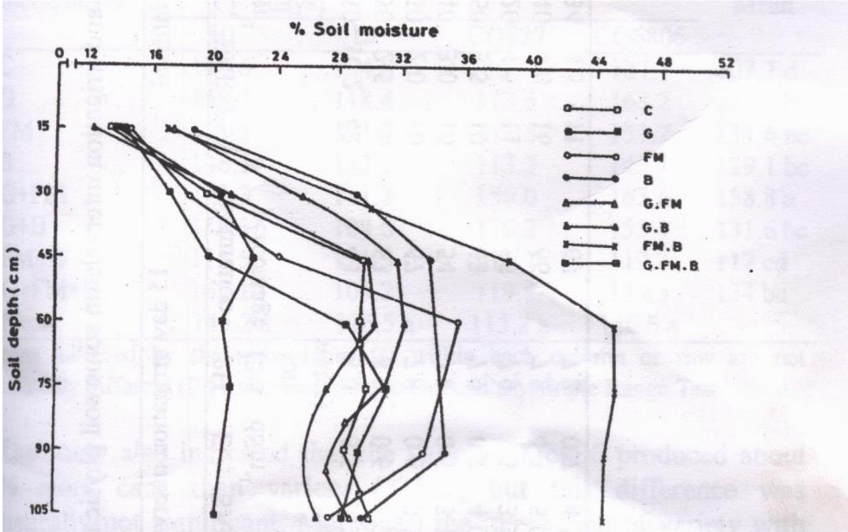

Fig.2. The effect of irrigation(15 day) and soil amendment on soil moisture profile.

b) Soil analysis

Treatments in which G was included generally showed lower values of SAR and ESP compared to those of other treatments (Table 1).

Table 1. Effect of soil amendments and irrigation intervals on some soil physical and chemical properties (0-30cm).

Soil amendment	10 day irrigation interval					15 day irrigation interval				
	Saturation percentage	pH (2:5 soil: water)	EC_e dSm^{-1}	SAR	ESP	Saturation percentage	PH (2:5 soil: water)	EC_e dSm^{-1}	SAR	ESP
C	51	8.0	6.50	10.2	42	43	8.0	6.5	10.2	42
G	60	7.9	0.50	2.5	8	63	8.0	0.6	3.2	12
FM	61	7.8	0.50	2.0	10	67	7.8	0.6	3.5	14
B	56	7.8	0.40	3.0	10	54	7.8	0.5	3.7	17
G+FM	61	7.8	0.60	3.5	10	63	7.9	0.7	4.0	15
G+B	59	7.8	1.20	4.5	11	55	7.9	1.3	3.5	15
FM+B	93	7.9	0.40	4.0	16	66	7.8	4.3	5.0	18
G+FM+B	69	7.7	1.34	4.5	11	67	7.8	0.7	4.5	15

The results showed that all treatments decreased ESP and increased he saturation percentage which in turn decreased EC_e and SAR . The reduction in EC_e, SAR and ESP in all treatments under the 10 day irrigation interval was greater than that of the corresponding treatments under the 15 day irrigation interval.

c)Yield of cane (t ha $^{-1}$)

Soil amendments exhibited positive effects on cane yield (Table 2). Treatment G alone or in combination with other amendments gave the highest yield. Yields of 158.8, 138.4 and 134.6 t ha^{-1} were obtained by treatments G+FM, G and G+FM+B, respectively, compared to the lowest yield of 107.7 t ha^{-1} for the control. The response of cane yield to soil amendments with irrigation intervals appeared as the most noticeable interaction, since yields of 172.3, 165.1 and 158.3 t ha^{-1} were, respectively, produced by the amendments G+FM, G+FM+B، and G when coupled with the 10 day irrigation interval.

Table 2. Influence of soil amendments, irrigation interval and variety on cane yield (t ha^{-1})

Soil amendments	Irrigation interval (days)		Variety		Mean
	10	15	C0527	C06806	
C	110.6	104.8	88.4	127.1	107.7d
G	158.3	118.4	113.5	163.2	138.4b
FM	141.5	121.7	111.5	151.7	131.6bc
B	146.1	112.2	113.2	145.1	129.1bc
G+FM	172.3	141.3	150.0	163.6	158.8a
G+B	155.3	108.0	110.2	153.1	131.6 bc
FM+B	112.5	121.5	114.7	119.3	117 cd
G+FM+B	165.1	104.2	119.8	149.5	134 bc
Mean	145.2a	116.5a	115.2a	146.6a	

*Means followed by the same letter (s) within each column or row are not significantly different (P≤ 0.01) according to Duncan's Multiple Range Test.

The study also indicated that the variety C06806 produced about %27more cane than variety C0527, but this difference was statistically not significant. Moreover, the interaction of variety with irrigation intervals did not produce statistically significant increase in cane yield.

The obtained results revealed that treatments G+FM, G+FM+B, G and G+B when coupled with the 10 day irrigation interval excelled all other treatments in cane yield. The present data also showed that the 10day irrigation interval produced about 25% more cane than that of the 15 day irrigation interval, but this difference was statistically not significant.

DISCUSSION

The results showed that G alone or in combination with the other tested amendments increased cane yield. This finding is in conformity with that of Ibrahim (1980a and b) who reported that G increased yield of sugarcane. This is understandable because addition of G to a saline-sodic soil improves soil chemical and physical properties. It is generally accepted that application of G encourages soil aggregation and hence soil permeability and aeration in addition to replacement of Na ions from the exchange complex by Ca ions. In the present study، low values of EC_e, SAR and ESP were obtained where G was applied especially under the 10 day irrigation interval. These lower values of soil properties presumeably have created better soil environment for root development. The positive effect of FM, B and FM+B on yield was substantiated by relatively high soil moisture content and low values of $EC_{e,}$ SAR and ESP, respectively, under the 10 day irrigation interval.

The positive effect of FM on cane yield is envisaged as a probable response to the addition of nutrient elements especially micronutrients contained in the composition of the FM. In this regard, Cooper and Abuidris (1980) have found out that application of 125 t of FM ha^{-l} increased yield of sugarcane and the yield of successive ratoons. They have stated that the FM supplies phosphorus most of which was probably in readily available form.

The relatively moderate effect of B on cane yield is probably related to the low rate of application (4 t ha^{-l}), as compared to 250 t of B ha^{-I} by Humbert (1968) and 23.8 t of B ha^{-1} by Ibrahim (1989). The low yield of cane in the control might be attributed to the relatively high EC_e, SAR and ESP(Table l). Maas(1990) described the Ec_e of 1.7 dSm^{-l} as the threshold for sugarcane after which a decrease in yield by %5.9 for every dSm^{-l} increase in EC_e will be highly probable. Also, sodicity exerts an adverse effect on growing cane since it accentuates the damaging effect of salinity. Valdivia (1980) reported that yield of cane was noticeably affected even at an EC_e of 1.2 dSm^{-l} when the ESP was 11.4. Brenstein *et al.* (1966) and Valdivia (1980) stated that the negative effect of salinity and sodicity on sugarcane were more pronounced in the ratoons.

The relatively high yield of variety C06806 over that of variety C0527 was probably related to its salt tolerance. In this respect, variety C06806 is considered as salinity resistant in India (Copersucar Technology Centre, Brazil, 1994).

This study showed that the 10 day irrigation interval surpassed the 15day irrigation interval in yield of cane. This result is in conformity with that of Elfadil(1969). Yousif (1987) and Abdulgabbar (1988) reported that an irrigation interval of seven days was much better in improving quantitative yield components of sugarcane than did the 14 day irrigation interval. This is understandable especially under soil salinity because frequent watering results in diluting the soil solution and thus provides better conditions for roots to absorb water and nutrients for the various processes of growth.

Humbert (1968, 1971) documented that cane approaching maturity requires an extended period of drought as well as low temperature to suppress vegetative growth and promote the conversion of reducing sugars to sucrose. Based on this information, it is predicted that for cane growing in Vertisols of Sudan, the short irrigation intervals may enhance the growth of cane and the extended periods of drought towards maturity of cane will, in part, accommodate the view that Venisols require a dry period to crack in order to improve exchange of gases in the solum.

In conclusion, the present study suggested the probable adequacy of variety C06806 for the salt-affected soil at Assalya Sugar Scheme under G+FM at four tonnes per hectare and a 10 day irrigation interval.

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