EFFECT OF SOIL SALINITY ON SUGARCANE YIELD

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ABSTRACT

A field study was conducted to determine the effect of soil characteristics and salinity on sugarcane yield. Seventeen fields were selected, the soils described and characterized and classified according to their salinity and alkalinity. Salinity (ECe) levels ranged from 0.99 to 17.32 mmho/cm with the higher values associated with fine textured soils. Eight fields were classified as non-saline non-alkaline with an average ECe of 1.62 mmho/cm, seven fields were classified as saline with an average ECe of 6.9 mmho/cm, ranging from 4.46 to 10.46 mmho/cm, and two fields were classified as saline alkaline with an average ECe of 15.6 mmho/cm, ranging from 13.88 to 17.32 mmho/cm. Salinity (ECe) was associated with lower cane yields of the order of 5.45 tons per hectare for each one mmho/cm, ($r = -0.88$). On average sugarcane yields were 94 tc/ha on non-saline non-alkaline soils; 51 tc/ha on saline soils and 22 tc/ha on saline alkaline soils. The variety Giza 54-C9 gave higher yields on all soil textures than did NCo310.

INTRODUCTION

In semi-arid and arid areas such as Egypt, provision of irrigation water is one of the most important factors for the expansion of agricultural production in terms of intensification as well as expansion of the area to be cultivated. However irrigation may induce new problems that need special consideration such as salination of soils, water table development, water logging, and shortage of irrigation water. Apart from low rainfall, changing topography, hydrological factors, physiochemical considerations, the correct management of soil and water are the most important factors affecting salinization and waterlogging.

Sugarcane has been reported to be sensitive to salts. Robinson and Worker[6] indicated that a conductivity slightly higher than 4.2 mmho/cm would reduce the yield by 50%. Shoji and Sund[8] concluded that a soil conductivity of 4 mmho/cm was the threshold above which the growth of sugarcane was drastically reduced. Sehgal *et al*[7] showed that an ECe of 2.6 seemed to be the critical level at which cane yields declined by 25%. Mehrad[4] reported that at a conductivity below 2 mmho/cm cane growth was not affected; between 2 and 4 mmho/cm growth was reduced, while at conductivities above 4 mmho/cm yields were seriously affected. Bernstein *et al*[1] reported yield reductions of 10 and 25% at 3 and 5 mmho/cm respectively and concluded that NCo varieties should be considered salt sensitive.

In Egypt there is a lack of any kind of data on salt tolerance of sugarcane. Results are presented of a field study on the effects of salinity on sugarcane in Upper Egypt following a survey during two consecutive growing seasons, 1982 - 1984 and 1983 - 1985.

MATERIALS AND METHODS

Seventeen locations were chosen to represent the soils of three states in the sugarcane belt, namely El-Minia, Qena and Aswan Governorates.

Soil samples were collected at depths of 0-30, 30-60, 60-90, 90-120, 120-200 cm from the surface. Samples were analyzed for total soluble salts, and soluble cations and an-

ions in soil paste extracts (US Salinity Laboratory Staff[9]). Organic matter was determined by the Walkley and Black method (Jackson[3]), soil pH was measured in 1: 2.5 soil-water suspension, $CaCO_3$ (Bower *et al*[2]) was determined with Collin's calcimeter and the pipette method was used for soil mechanical analysis (Piper[5]).
The cane yields from the selected fields which were planted to varieties NCo310 and Giza-54C9 were recorded. The relationships between soil characteristics, eg salinity and cane yield were studied.

RESULTS AND DISCUSSION

Soil description

The measured characteristics are given in Table 1. The data show that the yearly mean water table ranged from 50 to 167 cm. Three categories of drainage were described: imperfectly drained soil where the water table level was at a depth less than 80 cm (sites 5, 6, 11, 12, and 16), moderately drained soils where the water table was at a depth from 80 to 120 cm (sites 3, 4, 10, 14, and 15), and perfect or well drained soils where the water table was at a depth greater than 120 cm (sites 1, 2, 7, 8, 9, 13 and 17).

Table 1 - Description of the soils at the selected sites (analyses are agenerally the means of 10 samples per site)

Site No	Govern-orate	GWL* cm	Soil text-ure**	pH	ECe*** mmho/cm	ESP	Salinity & alkalinity	Drainage conditions****
1	Menia	167	CL	7.74	1.28	2.0	Non S. Non-A	Perfect
2	Menia	132	CL	7.70	2.60	3.6	Non S. Non-A	Perfect
3	Menia	114	CL	7.70	5.18	7.7	Saline	Moderate
4	Menia	93	CL	7.62	6.10	8.5	Saline	Moderate
5	Menia	74	CL	7.90	7.76	8.4	Saline	Imperfect
6	Menia	52	CL	8.50	13.88	18.0	Saline Alk	Imperfect
7	Menia	165	CL	7.70	0.99	1.7	Non S. Non-A	Perfect
8	Menia	163	S	7.60	1.11	2.4	Non S. Non-A	Perfect
9	Qena	162	CL	7.70	1.28	1.9	Non S. Non-A	Perfect
10	Qena	112	CL	7.70	4.77	5.1	Saline	Perfect
11	Qena	76	CL	7.86	10.46	11.0	Saline	Imperfect
12	Qena	50	CL	8.12	17.32	18.6	Saline Alk	Imperfect
13	Qena	162	Lo	7.72	1.33	2.0	Non S. Non-A	Perfect
14	Qena	130	Lo	7.64	1.47	2.7	Non S. Non-A	Perfect
15	Qena	92	Lo	7.70	4.46	5.8	Saline	Moderate
16	Aswan	52	Lo	7.58	9.59	11.3	Saline	Imperfect
17	Aswan	165	S	7.50	1.87	3.9	Non S. Non-A	Perfect

*** GWL: Ground water level**
**** CL: Clay; S: Sandy, Lo: Loamy**
***** mean of 5 depths per profile (0-200 cm)**
******Imperfect: Water table level is <80 cm; Moderate: water table is between 80 - 120 cm; perfect: Water table level is >120 cm.**

From Table 1 it can be seen that the high electrical conductivity values (EC mmho/cm) of the saturation extract were all associated with imperfectly drained soils which had EC values close to 8 mmho/cm or greater. The moderately drained soils show that they were less affected with salts, the average EC values exceeding 4 mmho/cm. The well drained soils generally had lower ECe values with the exception of site 10.
Generally the amounts of accumulated soluble salts were higher in fine textured soils than in coarse soils. In fine textured soils the height of the capillary fringe above the water table may be a crop controlling factor. This is particularly true where harmful soluble salts are moved up the soil profile by capillarity. In coarse-textured soils capillary movement is slight and the capillary fringe may extend only a very little way above the water table. When studying the critical depth of a water table it is important to consider the position of the capillary fringe.

The effect of soil salinity on sugarcane yield

The harvest data (Table 2) show that the non-saline non-alkali soil gave a mean yield of 94 tc/ha (100%) with a range from 120 to 73 tc/ha, the saline soil wielded 51 tc/ha (55%) with a range from 32 to 75 tc/ha. The saline alkali soil yielded only 22 tc/ha (23.2%) on average with a range from 18 to 25 tc/ha. The regression equation showed a highly significant yield decrease of 5.5 tc/ha for each one mmho/cm (ECe) increase in soil salinity. This yield decrease was highly significant and negatively correlated ($r = -0.88^{**}$) with salinity. The degree of salinity approved to be more pronounced in clay soils with imperfect drainage where yields decreased by 10% at 1.4 mmho/cm (ECe) and by 25% at 3.9 mmho/cm.

Table 2 - Effect of salinity (ECe) mmho/cm on sugarcane yield (tc/ha)

Site No	Salinity mmho/cm	Category of salinity/alkalinity	Yield tc/ha	Soil texture
7	0.99	Non S - Non A	85.7	Lo
1	1.28	Non S - Non A	76.2	C1
9	1.28	Non S - Non A	109.9	C1
13	1.33	Non S - Non A	120.4	Lo
14	1.47	Non S - Non A	98.3	Lo
2	2.60	Non S - Non A	72.6	C1
Mean	1.62		93.8 (100%)	
15	4.96	Saline	68.3	Lo
10	4.77	Saline	73.7	C1
3	5.18	Saline	59.5	C1
4	6.10	Saline	46.6	C1
5	7.76	Saline	34.0	C1
16	9.59	Saline	31.7	Lo
11	10.46	Saline	44.3	C1
Mean	6.98		51.3 (54.7%)	
6	13.88	Saline - Alk	25.2	C1
12	17.32	Saline - Alk	18.3	C1
Mean	15.6		21.7 (23.2%)	

These results agree with those of Bernstein *et al*[1] who found that yields of NCo varieties of sugarcane were decreased by 10% at 3 mmho/cm (ECe) and by 25% at about 5 mmho/cm. Similar results were reported by Sehgal *et al*[7] in Iraq. The wide range in cane yields appears to be associated in some cases with soil texture, cane yields being higher in loamy soils than in clay soils, as was reported by Sehgal *et al*[7].

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LES EFFETS DE LA SALINITÉ SUR LE RENDEMENT EN CANNE

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EXTRAIT

Un essai fut entrepris afin de déterminer les effets des caractéristiques du sol et la salinité sur le rendement en canne. Dix sept champs on été choisis et les sols ont été décrits et classifiés selon la salinité et l'alcalinité. Le degré de salinité (ECe) varie de 0.99 à 17.32 mmhos/cm, les plus fortes valeurs étant associées aux sols de texture fine. Huit champs furent classifiés comme non salin et non alcalin avec des valeurs moyennes de ECe de 1.62 mmhos/cm; sept champs furent classifiés comme salin avec une moyenne de 6.9 mmhos/cm et une variation de 4.46 à 10.46 mmhos/cm et deux autres champs furent classifiés comme saline et alcalin avec une moyenne de 15.6 mmhos/cm et une variation de 13.88 à 17.32 mmhos/cm.

La salinité (ECe) était associée à une baisse de rendement en canne de 5.45 t/ha pour chaque mmhos/cm d'augmentation en salinité.

Le rendement en canne était en moyenne de 94 t/ha pour les sols non salins et non alcalins, 51 t/ha pour les sols salins et 22 t/ha pour les sols salins et alcalins.

La variété Giza 54-C9 donnait des rendements supérieurs à ceux de la NCo 310 sur tous les types de sols.

EFECTOS DE LA SALINIDAD DEL SUELO EN LOS RENDIMIENTOS DE CAÑA DE AZUCAR.

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RESUMEN

Se hizo un estudio de campo para determinar los efectos de las características de suelos y la salinidad en los rendimientos de la caña de azúcar. Se seleccionaron 17 campos clasificados de acuerdo a su salinidad y alcalinidad. Para la salinidad (ECe) se tomó un rango entre 0.99 y 17.32 mmhos/cm con valores más elevados de ECe en los suelos de textura fina. Ocho campos fueron clasificados como no-salinos/no-alcalinos con ECe promedio de 1.62 mmhos/cm. Siete campos resultaron salinos con ECe promedio de 6.9 mmhos/cm, y un rango entre 4.46 y 10.46 mmhos/cm. Dos campos fueron clasificados como salinos/alcalinos con ECe promedio de 15.6 mmhos/cm, y un rango entre 13.88 y 17.32 mmhos/cm.

La salinidad (ECe) redujo significativamente el rendimiento en 2.29 tons por Feddan por cada mmhos/cm, y hubo una correlación negativa entre la salinidad y el rendimiento ($r = -0.88$). Los rendimientos disminuyeron en un 10% a 1.4 mmhos/cm, y en un 25% a 3.9 mmhos/cm.

El rendimiento promedio en caña fué significativamente reducido de 39.43 toneladas por Feddan en los suelos no salinos/no alcalinos, a 21.56 en los salinos, y a 9.15 en los salinos/alcalinos. La variedad Giza 54-C9 produjo más altos rendimientos que la N:Co. 310 en todas las texturas de suelos.