1983

Cane yield investigations on a sodic soil

Spalding, RD

91-0057

BUREAU OF SUGAR EXPERIMENT STATIONS
QUEENSLAND AUSTRALIA

CANE YIELD INVESTIGATIONS ON A SODIC SOIL

by

R.D. Spalding

Project 103.10.324

February, 1983
Mackay

SUMMARY

In the Marian mill area 15 plots were chosen in a block of caneland affected by sodium to represent high, medium and low yielding areas. At each plot cane yield and c.c.s. were measured, and soil samples, taken to a depth of 750 mm were analysed for specific electrical conductivity (SEC), pH, cation exchange capacity (CEC) and exchangeable cations, (Na, K, Ca, Mg). Cane yield was highly correlated with the exchangeable sodium percentage (ESP) of the 250 to 500 mm and 500 to 750 mm soil samples but not the 0 to 250 mm samples. Yield was depressed by 23 per cent where the soil sampled from 250 to 500 mm had an ESP of 15.

INTRODUCTION

In the canelands of the Mackay district there are many low yielding sodic areas (Ham and Chapman, 1982). There is little quantitative information about the effect of exchangeable sodium on cane yield in Queensland. In Peru, Valdivia (1977) found that yield was halved when the exchangeable sodium percentage was 25, but yield was also being affected by salt. The work reported here was done to provide information about the effect of exchangeable sodium levels on yield.

METHOD

Soil, cane yield and c.c.s. samples were taken in December 1981, from the first plant crop (NCo310) grown on a gently sloping block on the farm of Mr L. Harris, Marian, near Mackay. Fifteen plots, each four rows by 10 m were selected to represent low, medium and high yielding areas. There were five plots in each yield group. Cane yield was estimated before burning by the method of Hogarth and Skinner (1967). To measure c.c.s., six stalks were collected from each plot and crushed in a laboratory mill; each laboratory c.c.s. was reduced by 1.5 units to relate it to commercial c.c.s.

Soil samples were collected from each of the plots at three depths, 0 to 250 mm, 250 to 500 mm and 500 to 750 mm. Each sample from 0 to 250 mm and 250 to 500 mm comprised 10 cores and each sample from 500 to 750 mm, three cores. Standard BSES methods (Haysom, 1982) were used to determine SEC, water pH and exchangeable cations.

Before determining exchangeable cations those samples with an SEC > 0.2 mS/cm were leached with 80 per cent ethanol until the leachate was chloride free. The presence of free lime was detected by sprinkling soil into strong HCl. Where free lime was present Ca and Mg were not determined. The ratio of Ca to Mg (Ca/Mg) was calculated. Exchangeable magnesium was also expressed as a percentage of the CEC (Mg% of CEC). Exchangeable sodium was also expressed as ESP and as a fraction of the sum of cations (Na/cations).

For the determination of CEC, 2 g of soil, ground to pass a 0.5 mm sieve, was leached with 75 ml 1N NH_4OAc (pH 7.0) followed by 20 ml 80 per cent ethanol then 4 x 5 ml 95 per cent ethanol. The 'ammonium soil' was heated with 20 ml 2N KCl and 1 g Mg0, the distillate being collected in 10 ml of two per cent boric acid with bromo cresol green/methyl red as indicator. The distillate was then titrated to the red end point using 0.05 N HCl to estimate the CEC.

For each of Na, Mg and Ca, correlations were calculated between the levels from different sampling depths. Correlations between different soil assays at one sampling depth were also calculated. Regressions of yield on selected soil assays were performed.

RESULTS

The site comprised soils of the Allandale and Kinchant soil profile classes (Holz and Shields, 1982). A profile description of the Allandale is given in the Appendix. Table I shows the mean soil analysis values for the yield groups.

Free lime was detected below 250 mm in the soil samples from the four lower yielding plots, so Ca and Mg were not determined for these. Because of this, regressions were calculated over the 11 better-yielding plots.

Table II shows the correlation of soil cations between sampling depths while Table III shows the correlation between different soil assays. Table IV shows the correlation coefficients for linear regressions of soil assays on cane yield, and Table V illustrates linear regressions of selected soil assays on yield.

Figure 1 shows the regression of ESP from 250 to 500 mm on yield over 15 plots.

There was no advantage in using more than one sampling depth in regressions of Na or ESP on yield or in adding Mg to regressions of Na on yield, or in adding Mg% of CEC to regressions of ESP on yield and these data are not shown.

C.C.S. was not correlated with ESP.

TABLE 1

Mean soil analysis values at three sampling depths, 0 to 250 mm (A), 250 to 500 mm (B), 500 to 750 mm (C) for three cane yield groups, low (23.7 t/ha), medium (67.4 t/ha) and high (87.9 t/ha)

Yield group	CEC			SEC			pH			ESP			Na		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Low	5.10	7.42	10.07	0.032	0.226	0.486	7.37	8.00	8.69	37.30	49.03	68.16	1.870	3.532	6.485
Medium	1.94	3.30	6.44	0.022	0.053	0.088	6.14	6.37	6.30	6.45	19.91	38.23	0.129	0.700	2.550
High	1.98	2.03	4.13	0.091	0.030	0.054	6.49	6.72	6.37	8.88	11.77	19.32	0.180	0.243	0.780

Yield group	Na/cations			Ca			Mg			Ca/Mg			K		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Low	0.315	-	-	1.25	-	-	1.93	-	-	0.69	-	-	0.061	0.043	0.003
Medium	0.095	0.288	0.513	0.73	0.70	0.38	0.44	0.99	2.02	1.72	0.78	0.18	0.051	0.037	0.026
High	0.093	0.133	0.304	1.20	0.98	0.51	0.50	0.55	1.25	2.31	1.75	0.41	0.057	0.057	0.031

TABLE II

Correlation matrix for soil cations at three sampling depths, 0 to 250 mm (A), 250 to 500 mm (B), 500 to 750 mm (C) for the 11 better-yielding plots

Cations	A v/s B	A v/s C	B v/s C
Na	0.193	0.042	0.892**
Ca	0.607	0.448	0.279
Mg	-0.049	-0.198	0.834**

$*P < 0.05$ $**P < 0.01$

TABLE III

Correlation between soil assays at three sampling depths, 0 to 250 mm (A), 250 to 500 mm (B), 500 to 750 mm (C) for the 11 better-yielding plots

Sample depth	Na v/s Ca	Na v/s Mg	Na v/s CEC	pH v/s ESP	ESP v/s Na/cations
A	0.449	0.809*	0.621*	0.738*	0.607*
B	-0.192	0.818**	0.873**	-0.229	0.921**
C	0.101	0.894**	0.846**	0.276	0.946**

$*P < 0.05$ $**P < 0.01$

TABLE IV

Correlation coefficients for the regression of soil assays on cane yield at three sampling depths 0 to 250 mm (A), 250 to 500 mm (B), 500 to 750 mm (C)

No. of plots	Soil assay	A	B	C
15	Na	-0.905**	-0.918**	-0.902**
15	ESP	-0.821**	-0.961**	-0.909**
11	Na	-0.034	-0.841**	-0.743**
11	ESP	0.099	-0.837**	-0.844**
11	Na/cations	-0.533	-0.931**	-0.928**
11	Ca	0.685*	0.504	0.445
11	Ca% of CEC	0.682*	0.710*	0.855*
11	Ca/cations	0.793**	0.767**	0.952**
11	Ca/Mg	0.784**	0.842**	0.919**

*$P < 0.05$ **$P < 0.01$

In addition Mg, Mg% of CEC, K and pH were not significantly correlated with yield over 11 plots.

TABLE V

The regression coefficient (b), intercept (a), standard error of the regression coefficient (sb), standard error of the estimate (SE) and correlation co-efficient for linear regressions of soil assays (from 250 to 500 mm) on cane yield

No. of plots	Soil assays	b	a	sb	SE	r
15	ESP	-001.538	101.040	0.122	8.889	-0.961**
11	ESP	-001.300	98.213	0.283	8.584	-0.837**
11	Na/cations	-108.29	99.750	14.149	5.728	-0.931**

*$P < 0.05$ **$P < 0.01$

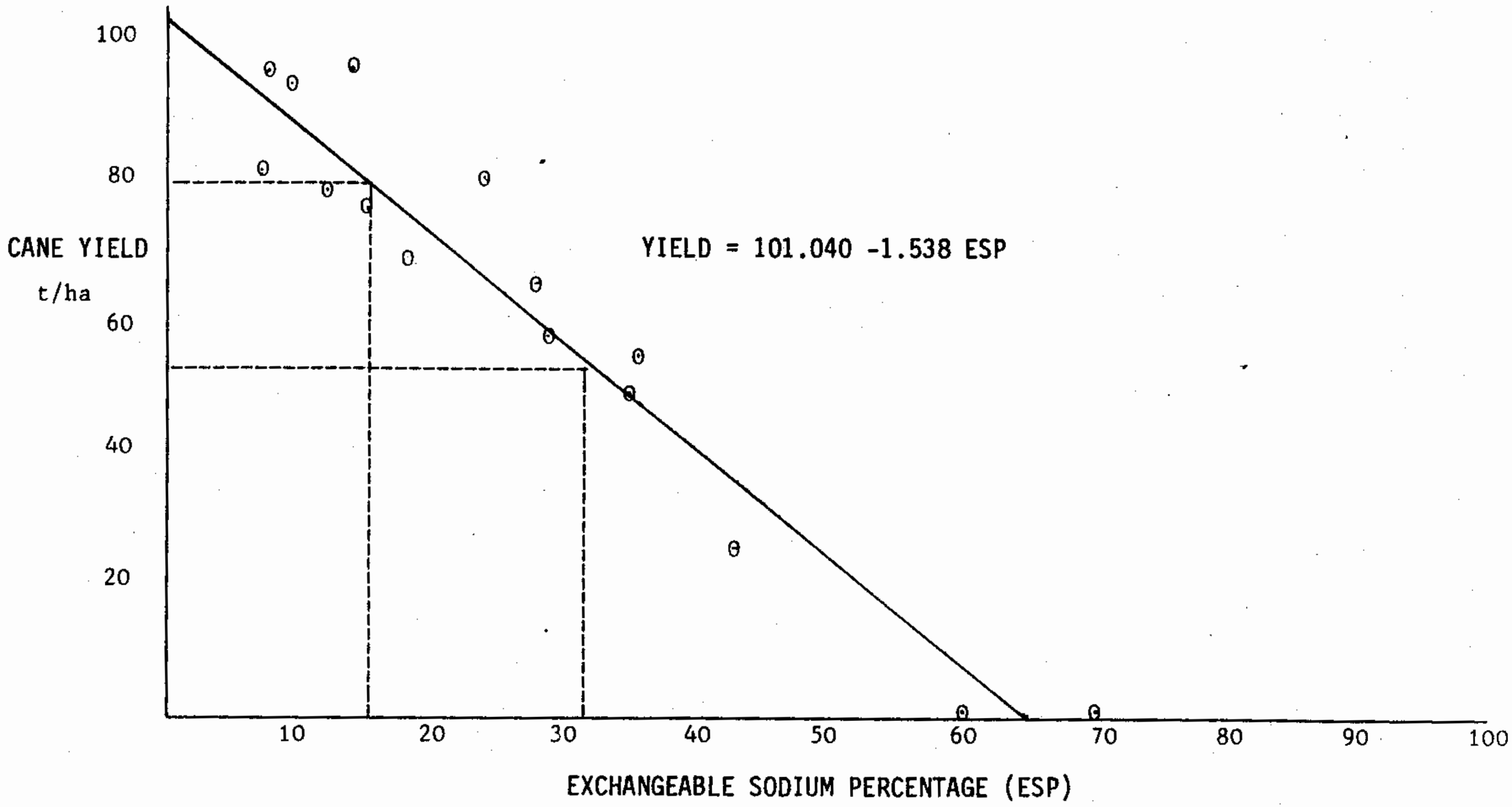

Figure 1: The relationship between cane yield and exchangeable sodium percentage at sampling depths 250 mm to 500 mm

DISCUSSION

The clay was closer to the surface in the low yielding plots than in the high yielding plots. This is reflected in the high CEC of the low yielding plots. Salinity levels were low except in the 250 to 500 mm and 500 to 750 mm samples of the low yield plots where they would indicate slight to moderate growth restrictions according to BSES standards (Ridge, 1980). These standards were calibrated on soil sampled from 0 to 250 mm so it is unlikely that salt is having a substantial effect on yield.

Ca was correlated with yield ($P < 0.05$) for the 0 to 250 mm sample but not at other sampling depths. Ca could be deficient as the Ca status ranged from 0.5 to 1.5 me/100 g for the 0 to 250 mm sampling depth. The supply to the crop could be further restricted in the sodic plots by the low solubility of calcium compounds at high pH and the excess of Na and Mg over Ca. Ca/Mg was highly correlated with yield.

High levels of exchangeable magnesium can impair soil structure and reduce yield but yield was not correlated with either Mg or Mg% of CEC. Although K levels were low they were not correlated with yield and it is unlikely that they are a major factor in the yield differences observed. Adequate fertilizer potassium was applied.

The Na and ESP levels of the 0 the 250 mm sample were correlated with yield over 15 plots but not over the 11 better-yielding plots. At greater sampling depths Na, ESP and Na/cations were highly correlated with yield and, as could be expected, there was also good correlation between ESP and Na/cations.

Correlations of soil assays with yield were generally better at the 250 to 500 mm sampling depth than at other sampling depths, and sampling at this depth is preferred as a means of predicting yield. The assays best correlated with yield were ESP ($r = 0.96$) and Na/cations ($r = 0.93$).

Na from 0 to 250 mm was not correlated with Na at greater sampling depths.

The regression presented in Figure 1 is linear and can not be used to determine a critical level of soil sodium. As even the highest yielding plots had ESP which may affect soil structure, the critical level for yield may not be within the sampled range. From Figure 1 an ESP of 15 corresponds to a 23 per cent (22 t/ha) yield reduction so it is speculated that losses could be occurring where the ESP is less than 15. Cane yield was halved when the ESP was 33, and at 66 per cent, zero yield was indicated. High soil sodicity greatly reduces yield. The high yielding plots produced crops averaging 97.4 t/ha, even though the soil appeared moderately sodic, with an ESP of 9 from 0 to 250 mm, 12 from 250 to 500 mm and 19 from 500 to 750 mm.

The cane on the highly sodic plots suffered severe moisture stress. On a flat, sodic part of the block, water stood for several days and penetrated less than 100 mm. It is likely that the major effect of sodium on yield was moisture stress since water could not penetrate because of poor hydraulic conductivity caused by the dispersed nature of the soil.

CONCLUSIONS

1. These result support the current practice of sampling from 250 to 500 mm in suspect sodic areas.

2. Both ESP and Na/cations were good indicators of sodicity problems.

3. Very high ESP levels greatly reduce yield but good crops can be grown on moderately sodic soils.

4. C.C.S. was not affected by soil sodium.

APPENDIX

SOIL PROFILE DATA

This profile was taken from the middle of the sodic area, with zero cane yield.

Depth of sample (mm)	Horizon	Colour		Texture	Inclusions
		Dry	Wet		
0 - 100	A_1	10YR6/2	10YR4/2	S.L.	Trace of
100 - 200	$A2_1$	10YR6/2-7/2	10YR4/2	S.L.	siliceous grit
200 - 300	$A2_2$	10YR7/1	7.5YR4/3	S.L.	grit
300 - 400	$A2_3$	10YR7/2	7.5YR4/3	L.S.C.L.	grit
400 - 500	A3	10YR7/3	10YR4/3	S.C.L.	
500 - 600	$B2_1$	N8/0 + 10YR6/6 (Dominant)		S.C.	10% Feldspathic grit
600 - 700	$B2_1$	N8/0 + 10YR6/6 (Dominant)		S.C.	Feldspathic grit
700 - 800	$B2_2$	N8/0 + 10YR6/6 (Dominant)		S.C.	grit, soft, manganous, inclusions

The soil had a hard setting surface

REFERENCES

HAM, G.J. & CHAPMAN, L.S. (1982). A review of salinity related drainage problems in cane in the central region. Proc. Aust. Soc. Sug. Cane Technol., 1982 Conf., 77-81

HAYSOM, M.B.C. (1982). Relationships between chemical methods used to analyse sugar cane soils in Queensland. Proc. Aust. Soc. Sug. Cane Technol., 1982 Conf., 139-145

HOGARTH, D.M. & SKINNER, J.C. (1967). A sampling method of measuring sugar cane yields in replicated trials. Bur. Sug. Exp. Stns Qd, Tech. Comm.

HOLZ, G. & SHIELDS, P. Mackay land use study (in preparation)

RIDGE, D.R. (1980). BSES recommendations for application of saline and sodic irrigation water. (Internal information sheet).

VALDIVIA, S.V. (1977). Effect of excess sodium on sugar cane yield. Proc. Int. Soc. Sug. Cane Technol. 861-866