NOTE ON SALINITY LIMITS FOR SUGARCANE IN NATAL

By E. A. von der MEDEN

Soil samples from areas in the Natal Sugarbelt are frequently received by the Experiment Station for salinity appraisal. The effect of saline soils on plant growth has been studied extensively[7], but comparatively little work with regard to their effect on sugarcane has been reported, especially in South Africa.

Maud[4] described two alkali soils in Zululand where the cane had died and the conductivity* was over 10.0 millimhos/cm. throughout the profile. An adjacent profile on a field growing good cane had a conductivity less than 0.5 mmhos/cm. Preliminary studies in Iran[6] suggested a conductivity of 4 mmhos/cm. as the threshold value above which cane growth will be drastically reduced. It was concluded from a salinity survey in Swaziland[2] that cane will always be severely restricted or killed above 5 mmhos/cm., whereas fair to good growth will normally be recorded below 2 or 3 mmhos/cm.

From the above it would appear that sugarcane growth is seriously restricted above a value of 4-5 mmhos/cm., but accurate limits for good cane growth in Natal were uncertain. An area showing numerous outbreaks of brackish conditions is the Nkwaleni Valley in Zululand, where a preliminary examination of salinity was therefore undertaken.

Soil samples were taken at depths of 0-9 in. and 9-18 in. in transects across areas in which the cane showed varying degrees of impaired growth due to saline conditions. Conductivity, pH, and exchangeable sodium determinations were carried out on all samples. For comparison with the tentative limits suggested by Richards[5], the exchangeable sodium percentage (ESP) was also determined on the 0-9 in. samples.

Results

Cane growth at each sampling point was designated good, fair, very poor, or dead. The means of results from several quite widely separated sites are given in Table I. In all cases the soils were fairly heavy and derived from either Ecca shale or river terrace.

Of the 18 samples in the good category, 15 had conductivities less than 2.0 mmhos/cm., and all were below 3.0 mmhos/cm. All samples in the very poor and dead groups had conductivities above 5.0 mmhos/cm. Figure 1 illustrates the relationship between cane growth and average conductivity within the surface 18 in. of soil.

* The term "conductivity" refers throughout to the conductivity of a saturation soil extract at 25° C.

Discussion and Conclusions

Sugarcane growth is drastically reduced on soils with conductivities above 4.0 mmhos/cm., this being in agreement with the findings of Lea, Murdoch and Dicks[2] and Shoji and Sund[6]. It is also clear that cane grows well on soils with conductivities below 2.0 mmhos/cm. Between 2.0 and 4.0 mmhos/cm., cane growth would appear to be adversely affected, but to a variable degree and this trend is similar to that found by the above workers. Although data for only two sets of samples are quoted in the fair group because the transition from good to very poor cane was usually rapid, the marked effect on cane growth of an increase in conductivity much above 2.0 mmhos/cm. is apparent from Figure 1. The following tentative conductivity limits are therefore suggested for sugarcane growth in Natal:

Conductivity (mmhos/cm.) (average for top 18 in. of soil)	*Cane Growth*
<2.0	Not affected
2.0-4.0	Growth significantly reduced
>4.0	Yields seriously affected

On the basis of the U.S.D.A. scale of salinity[5], sugarcane would thus be classified as a sensitive crop. In the same publication, an ESP of 15 is tentatively suggested as the boundary between alkali and non-alkali soils. This compares as follows with the figures in Table I: For good cane, ESP was never higher than 10 and this could be taken as the limit for normal growth. Above an ESP of 10, growth seems likely to be impaired and above 15 seriously reduced.

A highly significant correlation coefficient of −0.699 between cane tonnage and salinity as measured by conductivity was recorded in Iran[6], and a "good correlation" was also found in Swaziland[2]. From the

TABLE I

Chemical characteristics of soil samples taken in transects across areas of salt damage

Cane growth	No. of Samples	Depth (in.)	pH	Na (ppm.)	Conductivity (millimhos/cm.)	ESP
Good	9	0– 9	6.64	198	1.52	9.31
	9	9–18	6.84	334	1.66	
Fair	2	0– 9	6.70	315	1.70	11.58
	2	9–18	7.07	665	5.20	
Very poor	4	0– 9	7.05	805	6.20	32.42
	4	9–18	7.67	1270	6.90	
Dead	7	0– 9	7.57	1723	12.10	44.48
	7	9–18	7.96	1694	8.80	

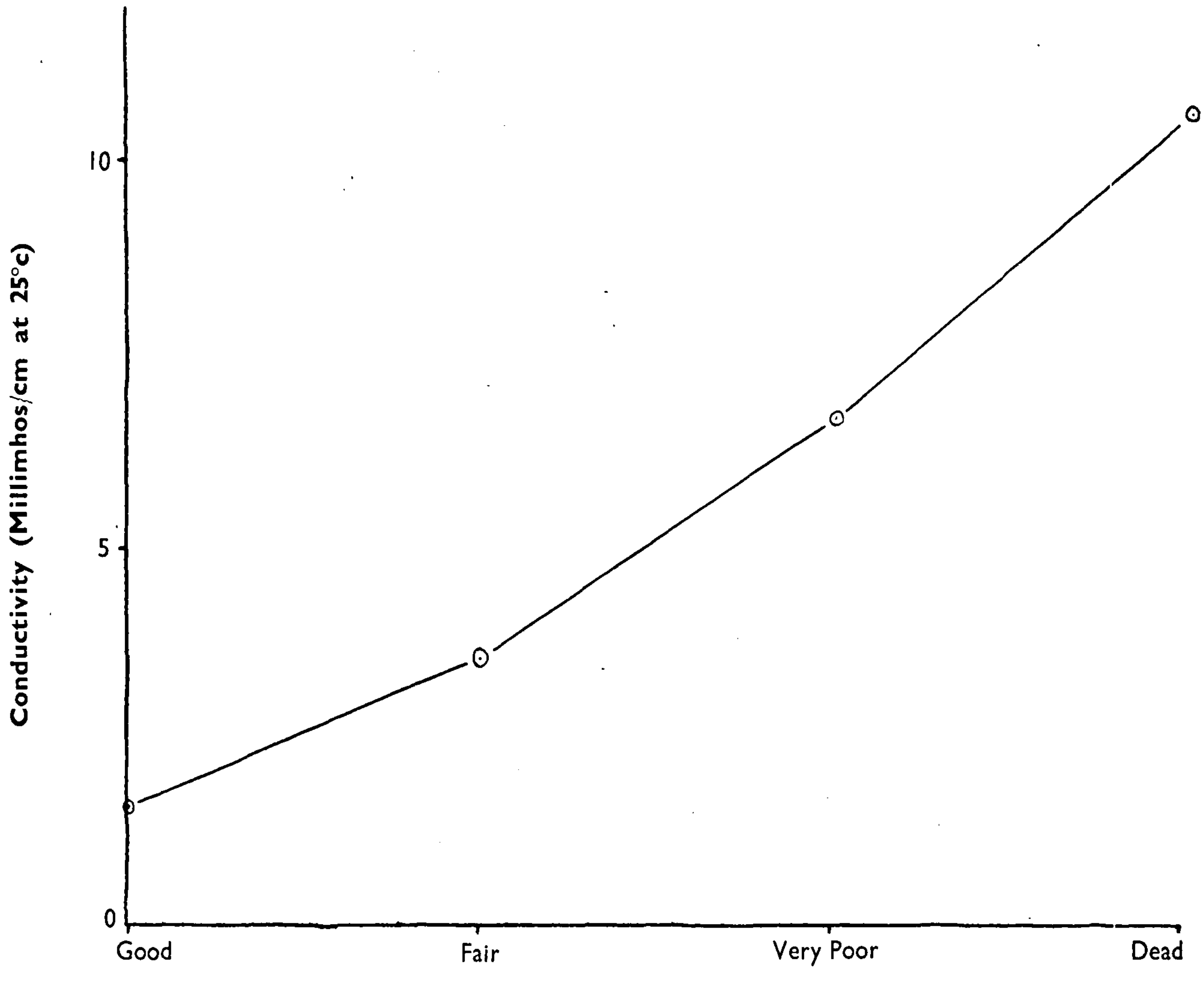

FIGURE 1. Relationship between cane growth and salinity (Nkwaleni Valley, Zululand)

results of the present survey it is concluded that conductivity measurements provide a sensitive and rapid estimate of soil salinity status which correlates well with the observed sugarcane growth. With reference to Table I, however, it is clear that such measurements representing only the top 6 or 9 in. of soil may be misleading, and for an accurate picture, samples should be taken to a depth of 18 in. where possible.

At all sites salinity appears to have developed either from injudicious irrigation or, perhaps more commonly, as a result of seepage from unlined canals. Whatever the cause, the percolating water accumulates dissolved salts, and where the water table is close to the surface, these rise and concentrate in the upper layers of soil, creating a high osmotic pressure against which the cane must withdraw water. As Marshall[3] points out, the control of salt is mainly a matter of controlling water movement. The work of Gardner and Fireman[1] suggests that the movement of salt near the surface is likely to be serious if the water table is less than 39 in. and this was clearly demonstrated in the present survey where the water table was invariably above this height under poor growth conditions.

A high water table (which is integrally related to aeration and the availability of 0_2 in the soil profile) and salt accumulation are obviously closely linked. The removal of the cause of waterlogging therefore, or the provision of suitable drainage systems, would solve both problems in many cases.

References

1. Gardner, W. R. and Fireman, M. (1958). Laboratory studies of evaporation from soil columns in the presence of a water table. Soil Sci. **85**: 244-249.
2. Lea, J. D., Murdoch, G., and Dicks, A. V. R. (1963). Report on a salinity survey, Swaziland Lowveld, 1962-1963.
3. Marshall, T. J. (1959). Relations between water and soil. Commonwealth Bureau of Soils, Harpenden, Tech. Comm. No. 50.
4. Maud, R. R. (1959). The occurrence of two alkali soils in Zululand. Proc. Annual Cong. S. Afr. Sugar Tech. Ass. **33**: 138-144.
5. Richards, L. A. *ed.* (1954). Diagnosis and improvement of saline and alkali soils. U.S.D.A. Handbook No. 60.
6. Shoji, K. and Sund, K. A. (1965). Drainage and salinity investigations at the Halft Tapeh sugar cane project, Iran. Proc. 12th Int. Sug. Tech. Cong., Puerto Rico. (In press).
7. Wilkins, R. A. and Athesian, K. H. (1965). Relationship between ground water, salinity, and sugar cane at Rose Hall Estate. Proc. 12th Int. Sug. Tech. Cong., Puerto Rico. (In press).

Dr. Sumner: I wish to sound a word of warning. Mr. von der Meden proposes these new conductivity limits for grading soil salinity based on one soil type. Presumably he is now going to extend these to the whole of Natal although it has only been worked out for one soil.

Mr. von der Meden: The area included several soils, such as Middle Ecca, Lower Ecca, and boulder bed derived types. Although these covered a range of textures, they tended to be mostly on the heavier side, but it is normally only on such soils that salinity becomes a problem.

Mr. Hill: Good cane growth should also be related to the amount of sodium present and not just conductivity as some high conductivities may be due to calcium and magnesium.

Mr. von der Meden: From our table you can see that the conductivity reflects the amount of sodium very closely. A high calcium could be very misleading, but one would not be looking for salinity on such soils.

Mr. Armstrong: Did you use the soil cup or the saturation extract method when measuring conductivity?

Mr. von der Meden: We used the soil cup method. Then, knowing the saturation percentage, we used standard graphs to transform the readings to conductivity of saturation extracts. We subsequently determined conductivity of saturation extracts directly on several of these samples covering a range of salinity. Agreement between these results and those obtained using the soil cup reading transformed by means of graphs was very satisfactory.