STRUCTURAL STABILITY AND Na-Ca EXCHANGE SELECTIVITY OF SOILS UNDER SUGARCANE TRASH MANAGEMENT

by

AHMAD SURIADI

Thesis submitted for degree of Master of Agricultural Science

Department of Soil and Water
The Waite Agricultural Research Institute
Adelaide University

December, 2001

Contents

List of Figures

List of Tables

Abstract

Good structure is an important property for sustaining crop production on agricultural soils because it influences water status, workability, resistance to erosion, nutrient availability and crop growth and development. The influence of calcium sources (gypsum and lime) and molasses on the structure and structural stability of soils used for sugarcane production has received little attention. Information about the influence of cane trash management practices (in which crop residues are burned before harvest (burnt) or retained as a 'trash blanket' (green)) on sodification of soil under irrigation with saline and sodic water is scarce. The aims of this thesis were to determine 1) the influence of calcium sources (gypsum and lime) and molasses on the structural stability of soils, and 2) the influence of trash management practices on the resistance to sodification of irrigated soils used for cane production.

The first experiment was conducted to determine whether molasses, a by-product of sugar manufacture, alone or combined with gypsum, could improve the structural stability of sodic soils used for sugarcane production. Burdekin sandy clay loam and Proserpine loamy sand soils (both from Queensland) were incubated with molasses (0 and 10 t/ha) and gypsum (0 and 10 t/ha) for 12 weeks, during which time they were leached 5 times with water (0.5 pore volumes each time). In the Burdekin soil, molasses and gypsum, either alone or combined, decreased spontaneous and mechanical clay dispersion and exchangeable sodium percentage (ESP). Molasses and gypsum both increased electrical conductivity and wet aggregate stability, with the combined effect being greater. In the Proserpine soil, the amounts of dispersible clay were much less than in the Burdekin soil. The effects of molasses and gypsum in decreasing spontaneous and mechanical clay

dispersion were similar to those in the Burdekin soil, but less pronounced. There appeared to be an additive effect of molasses+gypsum in improving structural stability of soils. Molasses and gypsum, either alone or combined, improved the structural stability of both soils by decreasing dispersion and/or slaking.

A second, similar experiment was carried out using lime instead of gypsum, since gypsum is more expensive than lime in the sugarcane growing districts of Queensland. The aim of this experiment was to determine whether a combination of molasses and lime would increase the solubility of the applied lime and thus more effectively achieve a synergistic effect to reduce sodification of irrigated soils used for sugarcane production. Using materials and methods similar to those of the molasses and gypsum experiment, molasses and lime either alone or combined improved the structural stability of the Burdekin and Proserpine soils. However, there did not appear to be a synergistic effect of molasses+lime in improving structural stability. Furthermore, the rate of 10 t/ha molasses did not lower the pH of the soil sufficiently to dissolve the lime substantially in this experiment. Further experiments are needed to determine the best combination rate of molasses and lime to overcome problems associated with sodicity.

In the final experiment, sodium-calcium exchange selectivity of soils under different trash management practices and with different organic matter contents were examined. Three soil types were selected from different locations in Queensland (Ayr, Mackay and Tully) in which two long-term, sugarcane trash retention management regimes have been practiced (i.e. leaving cane harvest residues as a blanket (green) and burning cane residue prior to harvest (burnt)). Soil samples from the Waite Agricultural Research Institute, Urrbrae, South Australia from long-term permanent pasture and wheat-fallow plots were also included to extend the experiment to a red-brown earth from a Mediterranean zone. The reasons for including the Urrbrae soil in part of the study were it

represents an important, structurally vulnerable soil type in Southern Australia and that there were significantly different organic matter contents in both Urrbrae soil samples. One hundred grams of soil aggregates (0.5-2 mm) were placed on a sintered glass funnel, saturated slowly with $CaCl_2$, freed of excess electrolyte then equilibrated with solutions of different total cation concentration (TCC; 2 and 10 mmol(+)/L) and sodium adsorption ratio (SAR; 3 and 10). When equilibrium was attained, the solutions were analysed to calculate the Gapon selectivity coefficient (k_G). The value of k_G was influenced by soil type, trash management practices or organic matter, and by the combination of SAR and TCC. The green trash treatment had generally lower k_G values than the burnt trash treatment; suggesting that soil under the burnt trash management appeared to be more susceptible to sodification than under the green trash management. Total soil organic matter contents in the burnt and green trash management practices were not significantly different from each other, and this suggested that the nature of soil organic matter may influence the value of k_G. Further experiments are needed to investigate how the nature of organic matter influences the value of k_G. A method used for measuring Na-Ca exchange selectivity while maintaining the natural aggregate structure was developed. The method appeared to be successful in measuring the Na-Ca exchange selectivity of soils without disturbing soil aggregates. The method can also be used for inducing known levels of sodicity in natural soil aggregates. Further experiments are needed to validate and refine this method at high SAR and low TCC where the soil becomes more dispersive.

In conclusion, molasses, lime and gypsum improved the structural stability of sodic soil although there was no synergistic effect in their combination. Sodium leached during experiments was enhanced by these amendments, with the gypsum effect most pronounced. In the molasses+lime treatment, the rate of 10 t/ha molasses did not lower the pH of the soil sufficiently to dissolve the lime substantially in this experiment. Soil under

green trash management was more resistant to sodification than under burnt trash management. An implication of this work is that molasses may be a useful ameliorant for sodic soils, either alone or combined with gypsum and lime but with increased rates of application. The green trash management practice will increase the resistance of the soils to sodification.

Statement

This work contains no material, which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material published or written by another person, except where due reference is made in the text.

I give consent to this copy of my thesis, when deposited in the University Library, being available for loan and photocopying.

Signed..

Date.....28-03-2001

AHMAD SURIADI

Acknowledgements

This thesis could not be completed without the support I received from many people. Firstly, I am deeply indebted to my supervisors, Dr. R.S. Murray, Dr. C.D. Grant and Dr. P.N. Nelson for their constant encouragement, advise, guidance and generosity throughout my project. All their support and help during my candidature was invaluable.

I am grateful to Dr. G.J. Churchman from CSIRO land and water, who helped in determining clay mineralogy, and members of Soil Physics and Chemists Lab Group for valuable discussion and advice about my work.

Special thanks to Mr. C. Rivers, Mrs. A. Baklan and Mrs. T. Fowler for their assistance in the laboratory when required. I would like to thank other members of the Department of Soil and Water particularly Prof. S.E. Smith, Dr. D.J. Chittleborough (Head of Department), Dr. R.J. Smernik, Mr. J.F. Davey (Departmental Manager) and Mrs. T. Parish (Departmental Secretary) for their help.

This work was fully funded by the Australian Agency for International Development (AusAID).

Finally, my deep gratitude is extended to my wife, my children, and my parents for their continuous support, patience and encouragement.