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BARD

FINAL REPORT

PROJECT NO. US-971-85

Effect of Irrigation with Brackish and Sewage Effluent Waters on Potassium Reactions in Soils

D.L. Sparks, S. Feigenbaum

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EFFECT OF IRRIGATION WITH BRACKISH AND SEWAGE EFFLUENT WATERS
ON POTASSIUM REACTIONS IN SOILS

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A. ABSTRACT

We studied the effect of salinity and ion composition on: potassium (K) reactions in soils and separates and clay minerals; and, the availability of K to corn (*Zea mays* L.) plants. A stirred-flow reaction chamber was employed to study K-Ca exchange kinetics on montmorillonite, vermiculite, and Israeli soils. Perfect mixing was effected in the chamber and tests were developed and analyzed so that reactions that were kinetically controlled and those that were characterized by instantaneous equilibrium could be differentiated. Reactions on montmorillonite were too rapid to be measured using the stirred-flow technique while those on vermiculite could be measured. Binary and ternary exchange equilibrium involving K were studied on the soils and separates using different approaches for predicting selectivity coefficients. A simple mathematical solution of the Gapon "binary" equations in combination with an assumption of constant CEC, was used to predict the amount of exchangeable K as a function of solution composition. In screenhouse and laboratory studies, plant response to K and K dynamics in the soils as effected by irrigation with saline water were evaluated. In both soils, increased salinity significantly decreased corn yield and enhanced K release from the soils when low amounts of K were applied. Under high K fertilization, K fixation was reduced when salinity was increased.

B. Objectives of the Research

The aim of this research was to improve our understanding of potassium (K) availability indices in soils irrigated with brackish and sewage effluent waters. This was achieved by better understanding binary and ternary exchange reactions and fixation and release phenomena involving K in different soils under irrigated conditions.

The specific objectives of this study were:

- 1) To study the ternary exchange reactions between K, NH_4 , Ca, Na, and Mg in soils, soil fractions, and clay minerals from both kinetic and thermodynamic points of view.
- 2) To study the release of soil K and fixation of applied K by different soil types under irrigation with brackish waters.
- 3) To improve and develop K availability indexes in soils irrigated with sewage effluents and saline waters.

All of the above objectives were studied and the results are presented in the next section. The only deviation from them is that NH_4 exchange was not studied since its reactions in soil are similar to K and we wanted to avoid duplicity. Additionally, the study of kinetics of binary exchange reactions proved quite complex and time consuming. We therefore did not have time to study ternary exchange kinetics on the soils and separates.

D. Description of Cooperation

There has been excellent cooperation between Drs. Sparks and Feigenbaum throughout this research project. Dr. Feigenbaum visited Dr. Sparks twice at the University of Delaware to discuss progress on the research and to work on manuscripts. Dr. Sparks visited Dr. Feigenbaum in Israel in 1989 to talk about the cooperative research and review plans for the third year of the project. Dr. Asher Bar-Tal of Israel, spent one year in Delaware as a postdoctoral fellow. He conducted research on binary exchange kinetics. He has worked on the project during the entire three year period and has communicated his findings to Dr. Sparks on an almost weekly basis through BITNET. Dr. Sparks and Feigenbaum have been in contact with each other by BITNET and by letters throughout the project. Eight manuscripts have been published or are in review on their cooperative research. Additionally, five papers, based on their cooperative research, have been presented at national and international meetings and congresses. In short, the cooperation between the investigators has been outstanding and productive.

E. Evaluation of Research Achievements and Their Benefit to Agriculture

Many achievements have resulted from this research. We have successfully modeled binary and ternary exchange equilibria and binary exchange kinetics on soils, soil separates, and reference clay minerals. Such studies involving K are novel, and they will make significant contributions to the scientific literature. At least eight publications in first-rate refereed journals and symposia proceedings will result. Additionally, the work has been presented at a number of national and international meetings and symposia.

In the studies mentioned above and in screenhouse and laboratory leaching studies, we have shown how salinity affects K dynamics in soils and in turn how crop yield and K uptake in plants is affected. Such findings have immense benefit to agriculture, particularly in areas like Israel where there is increasing use of brackish water to grow crops. Our research results will assist professionals and growers in making proper K fertilizer recommendations for saline soils that will be irrigated with brackish waters. Such recommendations will maximize crop yields and enhance fertilizer efficiency.

F. LIST OF PUBLICATIONS

- Bar-Tal, A., D.L. Sparks, J.D. Pesek, and S. Feigenbaum. 1991. Analyses of adsorption kinetics using a stirred-flow chamber: I. Theory and critical tests. *Soil Sci. Soc. Am. J.* 54:In review.
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