2. Summary of the International Symposium

Development of Basic Technology for Sustainable Agriculture under Saline Conditions

The International Symposium on "Development of Basic Technology for Sustainable Agriculture under Saline Conditions" was held at the Tottori Prefectural Kenmin Bunka Kaikan in Tottori city, Japan by the Arid Land Research Center, Tottori University on December 12, 1996. Seven lectures were presented. Twenty two foreign researchers and 111 Japanese researchers were attended, and fruitful discussions were conducted in the panel discussions after the lectures.

Background and Objective

The vigorous expansion of human activities causes global environmental changes. It appears as if these changes may be destroying the fundamental conditions of human life. In arid and semi-arid areas, physical factors such as the excessive development of agricultural fields and the mismanagement of irrigation in addition to unstable water balance and climate conditions can result in decreasing fresh water resources, increasing salt concentrations of rivers and ground water and salt accumulation at the soil surface. These changes are accelerating the creation of saline environments and gradually depressing plant productivity. On the other hand, the world population is increasing rapidly, therefore, it is necessary to have sustainable agriculture, which by definition promises a long term sufficient food supply.

This international symposium focuses on development of fundamental knowledge, which is necessary for establishment of the sustainable agriculture in arid and semiarid areas. We will discuss technologies for preventing the salinization of soil and water resources, improving saline environments, and creating new salt-tolerant plants. This symposium will provide opportunities for the exchange of scientific information and opinions on a better understanding of the salinization processes and the above mentioned technologies.

* Extract from the Foreword of the Proceedings written by Dr. Inanaga,S., Director of the Arid Land Research Center

Abstract of the Lectures

New Assessment Technology for the Diagnosis & Control of Salinity in Irrigated Lands

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A practical methodology for appraising soil salinity and assessing the adequacy and appropriateness of irrigation, drainage and salinity-control systems and practices is described. This methodology is based upon the use of geophysical-instrument systems for intensively measuring bulk soil electrical conductivity within irrigated fields/root zones and associated spatial coordinates, algorithms for multi-linear regression data analysis and sensor calibration, and methods for selecting measurement-sites and obtaining salinity ground-truth. The technology package is unique and represents a breakthrough in our ability to rapidly and accurately assess soil salinity in irrigated lands. Results are presented to demonstrate the utility of the technology along with evidence supporting the conclusion that much of the apparent chaos observed in the spatial pattern of soil salinity in irrigated fields is man-induced and explainable in terms of deterministic processes caused by such management practices as irrigation, drainage, cultivation and tillage.

Modeling Saline Drainwater Reuse in a Eucalyptus Plantation

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One of the recommended management options for irrigation drainage in the Westside of San Joaquin Valley in California is the reuse of saline subsurface irrigation drainage as irrigation water for salt tolerant trees and halophytes. A 9.43 ha *Eucalyptus camendulensis* plantation from 1985 to 1990 successfully used water containing an EC of 10 dS/m and 12 mg/l of boron. The plantation was extensively monitored for water and salt flows. There was additional need for numerical simulations of interactive processes that are difficult to measure in the field. A previously formulated 2-DI Galerkin FEM for irrigation and drainage was monitored and extended for application to the tree plantation resulting in D-HYSAM, Version 2.0. New considerations, among others, included effects of salinity on root water uptake as well as the presence of gypsum that acts as both a salt sink and salt sources in the soil. The governing equation for water flow consisted of a non-linear, variably saturated model with sink term for root water uptake. The governing equation for salt flow consisted of an advection-dispersion model with sink/source terms for salinity. These equations with appropriate initial and boundary conditions were solved by the Galerkin FEM. The water and salt flow domain was discretized into 96 finite elements and 120 nodal points. The initial and boundary conditions were measured. The model was validated with data from the 1989 irrigation season, and verified with data from the 1990 irrigation season. The daily and seasonal simulation on volumetric soil water contents, soil water pressure, and soil salinity compared favorably with the observed data. Other simulation on soil water flux, salt flux and salt balance provided valuable additional evaluations.

Surface Accumulation and Leaching of Salts during Unsaturated Steady-State Flow in Soils

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The convective dispersion (CDE) is often used as a functional description of solute transport in soils. The analysis of salt accumulation near the soil surface during upward evaporative flux conditions where the water table is shallow and the initial salt distribution with depth is known (either constant or a function of depth) has been examined by Elrick et al. (1994, 1997). The rate at which salts either accumulate at the surface (net upward flux) or leach downwards (net downward flux) under steady-state flow conditions is examined here for both laboratory and field experiments. The effect of a depth-dependent water content (obtained by use of the Gardner solution for steady-state evaporation from a shallow water table) that is invariant with time is included in the analysis where appropriate. These relatively simple equations give good predictions of the salt movement although many of the basic assumptions in the model, such as

stead-state flow, are not met.

Opportunities and Alternatives for Sustainable Desert Agriculture in a Saline Environment

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For desert communities, agriculturists will need to focus on the development of advanced technological systems for food production and landscaping, that will preserve the environment in combination with energy and water conservation. It is vital for the desert dweller to adopt new concepts in irrigation that will dramatically increase water use efficiency along with lessening the amount of salt build up in desert soils. Rapid urbanization and resulting population centers in deserts throughout the world are exerting an increasing demand on limited water resources. The reuse of domestic wastewater is playing an increasing role to meet current and future water needs in the desert regions of the United States. Reclaimed water is today used to irrigate crops and parks with great success. Coinciding with new irrigation technologies, agriculturists are using space age technology with hand held infrared thermometers to determine irrigation need. This tied into weather information networks has helped to improve water use efficiencies. With an increasing awareness of biodiversity, research on alternative crops, such as halophytes, medicinal plants and desert ornamentals will receive increasing attention. Establishing new agricultural crop alternatives along with new advanced technological systems will provide new opportunity in greening the desert, replacing those technologies that demand greater water resources and production input, which often times are detrimental to the fragile desert environment.

Molecular Genetic Approaches to Improving Salt Stress Tolerance in Plants

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Recently, transgenic plants, engineered to accumulate mannitol, proline and HVA1 protein, which have an increased ability to tolerate high salinity were produced. These evidences showed clearly possibilities of molecular breeding of salt-tolerant plants and also that the genetic improvement of salt tolerance may be a useful strategy for the future of agriculture in salinity areas. However, the salt tolerance levels of these transgenic plants were not enough. In this paper, successful experiments which produced salt-tolerant plants, using genetical engineering and targets for further improvement of salt tolerance in plants, are described.

Fertilizer Management under Saline Conditions

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Salinity either naturally occurring or developed from runoff, shallow water tables, irrigation, and other human activities, is today hindering the productivity of nearly 60% of the cultivated lands of the world and its magnitude being manifested in the regions of low rainfall. Salinity inhibits plant growth as a result of (i) reduction of the free energy of the water in the root zone, which is an osmotic factor and (ii) uptake of one or more specific ions, their influence being essentially a physiological factor. Maximizing agricultural output in salt-affected soil is a vital issue in order to cope with the increasing food demand in many countries. Various methods have been proposed for managing the salinity problem. These included plant, soil, fertilizer and other cultural practices. Fertilizer management has proved very effective in boosting crop yields under saline conditions.

In this presentation we intend to highlight the role of different forms of fertilizers in alleviating salinity hazards or increasing productivity under saline conditions.

Availability of Nutrients under Saline Conditions

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The availability of essential elements under saline conditions depends on the pH and the concentration ratio between the elements in the soil. The pH affects the availability by changing the solubility of the elements. Phosphorus (P) availability depends strongly on the pH and the change in the solubility of P with pH is complex. Iron(Fe), manganese(Mn), zinc(Zn) and copper(Cu) are less available alkaline conditions because of low solubility. On the other hand, boron(B) is available at a high pH and toxicity occurs. The decrease in nitrogen(N) availability at a high pH is due to a low activity of nitrifying bacteria in the soil.

The concentration ratio of elements in the soil can affect the availability by competitive inhibition of ion absorption by the roots and its transport into the shoots by another ion(antagonism). The antagonism which occurs under saline conditions is that between potassium(K), calcium(Ca), magnesium(Mg) and sodium(Na). The antagonism found for K, Ca and Mg seems to depend on the activity ratio between them. A high concentration of soil solution tends to induce a high activity ratio of K to Ca and Mg and reduces the uptake of Ca and Mg by crops.

Na competitively inhibits the uptake and transport of K, Ca and Mg by crops. In turn, the Na hazard can be ameliorated by supplying K or Ca to the Na salinized medium.