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SUMMARY OF DOCTORAL THESIS

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Title: Effect of Seawater Irrigation Management on Physicochemical Properties of Soil – Water – Plant System
土壌の理化学的特性に及ぼす海水灌漑管理の影響

Increasing food production to meet the needs of the increasing population on a sustainable basis remains the primary goal in the developing world. Many countries are looking to the irrigated agriculture as the reliable source to achieve this increased production. The utilization of the groundwater with the poor recharging system is an emerging threat to the arid and semiarid areas of the world. Due to several environmental reasons the groundwater is being degraded and negatively impacting food production. Therefore, the researchers have to look at ways to use effectively marginal-quality waters as an alternative source for irrigation. The problems associated with the use of low quality waters for agriculture need to be searched and addressed in such a way that it could produce technically sound, economically viable and environmentally safe system. Therefore our research studies were mainly focused on the utilization of saline-waters for crop production. Several experiments were conducted at the Subdivision of Land Conservation of the Arid Land Research Center, Tottori University, Japan during 2004 - 06.

The 1st experiment was conducted to determine the efficiency of seawater to leach salt from a simulated profile of a coastal sandy soil. Soil salinity level was highly dependent on soil depth and virtually reduced by the range of 17.8 to 90.4% through a leaching process with seawater. A lower level of salinity occurred in the surface soil as compared to the underlying soil layers. An efficient leaching happened when the application of seawater became equal to the depth of soil to be leached. The leaching trial undertaken in the field confirmed the findings of the laboratory study.

The 2nd experiment was carried out to evaluate the effects of different meteorological conditions on growth of barley and salt accumulations in sand dune soil irrigated with diluted seawater under three experimental environments– glasshouse during winter 2005, controlled growth-chamber conditions (20 ^{o}C, 60% RH) and greenhouse during summer 2005. Plants were irrigated with diluted seawater adjusted to the electrical conductivity levels of 3, 8 and 13 dS m^{-1}. The results showed that saline waters and experimental conditions remarkably affected the evapo-transpiration rate, soil moisture, salts accumulation and plant biomass production. Low

temperature conditions exhibited highest plant growth and soil moisture, and lowest salt deposition. Plants showed no symptoms of salt stress in the glasshouse. Growth-chamber and greenhouse conditions profoundly reduced plant biomass and accumulated higher salts in the soil. Higher stress of salinity was noticed in plants irrigated with high saline water. The increasing level of salinity in irrigation water impaired the dry shoot yield by an average of 60 %. The higher temperature conditions of greenhouse and growth-chamber caused substantial water loss and induced water deficit in plants.

In the 3rd experiment, the investigation was aimed to evaluate the effects of saline irrigation on barley and salts accumulation in a greenhouse under different leaching fractions. The saline water significantly interfered with the growth of barley. Both the quantity and quality of water regulated salts distribution within the soil. Higher leaching fraction lowered soil salinity and increased soil water content. The salts were found higher near or immediately below the soil surface. An enhanced leaching fraction carried more salts down the soil horizon. Higher saline irrigation retarded evaporation. Infiltration rate and hydraulic conductivity of soil remained similar across the treatments. Conjunctive use of marginal water at relative leaching fraction could effectively enhance the yield of crop in water scarce areas.

In the 4th experiment, calcium-type artificial zeolite was used as an amendment to mitigate the plant grown under saline irrigation. The study primarily investigated the joint influence of zeolite (1 & 5 %) and diluted seawater (3 &16 $dS.m^{-1}$) on the composition of soil and performance of barley. Saline irrigation significantly suppressed plant growth in terms of plant height, leaf area, dry weight and grain yield. Plant biomass yield was improved in salt stressed barley due to zeolite amendment. The application of zeolite apparently enhanced water and salt holding capacity of soil as compared to control soil. The soil analysis exhibited high concentrations of Ca^{2+}, Mg^{2+}, Na^{+} and K^{+} under saline water especially in upper soil surface and deceased with soil depth. The salts were directly related to the intensive applications of saline water. A low composition of salts in soil amended with zeolite was noticed. The cations concentrations in plants also varied due to saline water and zeolite applications. Higher zeolite dose increased Ca^{2+} concentration of plants under high saline treatment. Application of zeolite in the soil may adsorb heavy metals and produce a favorable environment for plants. The study indicates that zeolite amendment could effectively ameliorate crop stress and improve the physicochemical properties of sandy soil.