

2.7 Activities of Foreign Researchers

(1) Associate Professor Mohamed Elfatih K. Ali

Visiting Associate Professor (April 2001-March 2002)

El-Obeid Research Station, Agricultural Research Corporation, Sudan

Title: *Growth and Physiological responses of three sorghum cultivars under drought stress*

My activities have been performed in the Plant Ecophysiology Subdivision in collaboration with Prof. Shinobu Inanaga, the Head of the Subdivision.

Research activities

My research activities have been focused on characterizing the drought tolerance of three Sudanese sorghum cultivars and quantifying the physiological bases for the differences in their drought tolerance. This work has been conducted in collaboration with W. Tsuji, the M. Sc. student of Prof. Shinobu Inanaga. In addition to my research work, I also edited three doctoral theses and several manuscripts written in English of graduate students and staff, as well as conferences and symposia presentations. Furthermore, a seminar titled "Crop production in arid and semi-arid areas of North Kordofan State, Sudan: current status, constraints and prospects for improvement" was presented on December 6, 2001 as a special lecture at the Annual Joint Research Symposium, Arid Land Research Center, Tottori University, Tottori.

Publication

1. Ali, M. E. K., Inanaga, S. and Sugimoto, Y. (2001). Physiological Races of *Fusarium oxysporum* f. sp. *ciceris* in Sudan. Submitted to Sudan Journal of Agricultural Research.
2. Ali, M. E. K., Inanaga, S. and Sugimoto, Y. (2002). Sources of resistance to Fusarium wilt of chickpea in Sudan. Submitted to Phytopathologia Mediterranea .
3. An, P., Inanaga, S., Lux, A., Li, X. J. Ali, M. E. K., Matsui, T. and Sugimoto, Y. (2002). Effects of salinity and relative humidity on two melon cultivars differing in salt tolerance. *Biologia Plantarum* 45: (3): 409-415.
4. Deng, Xi-ping, Shan, L., Inanaga, S. and Ali, M. E. K. (2002). Perspectives on wheat yield improvement in the semiarid environments. Submitted to Australian Journal of Agricultural Research.
5. Gamaan, R. S., Egrinya Eneji, E., Ahmed, O. S., Al-Rawahi, M., Al-Raisi, F., Ali, M. E. K., Hamamura, K. and Inanaga, S. (2001). Influence of mulching and salt content of irrigation water on the performance of fruit vegetables in the arid sandy soils of Oman; II: Tomato growth and yield. Sand Dune Research (in press).
6. Gamaan, R. S., Egrinya Eneji, E., Al-Rawahi, M., Al-Raisi, F., Ahmed, O. S., Ali, M. E. K., Hamamura, K. and Inanaga, S. (2001). Influence of mulching and salt content of irrigation water on the performance of fruit vegetables in the arid sandy soils of Oman; II: Watermelon growth and yield. Sand Dune Research (in press).
7. Inanaga, S., Ali, A. M. and Ali, M. E. K. (2001). Reducing water stress through ecological approaches and crop characteristics. 8th JIRCAS International Symposium on Water for Sustainable Agriculture in

Developing Regions. 27-28. November 2001, Tsukuba, Japan.

8. Tsuji, W., Inanaga, S., Sugimoto, Y., Morita, S. and Ali, M. E. K. (2001). Morphological and physiological responses of root system to water stress in two sorghum cultivars. Pages 316-317 in Proceedings of the 6th Symposium of the International Society of Root Research. November 11-15, 2001; Nagoya, Japan. 600 pp.
9. Tsuji, W., Ali, M. E. K., Inanaga, S. and Sugimoto, Y. (2002). Growth and physiological responses of three sorghum cultivars under drought stress. Submitted to *Biologia Plantarum*.

Abstract

A field study was conducted to evaluate the drought tolerance of three sorghum [*Sorghum bicolor* (L.) Moench] cultivars, Gadambalia, Arous elRimal and Tabat, and quantify the physiological bases for differences in their drought tolerance. Two irrigation treatments (wet and dry) were applied. All treatments received water at a rate of $0.01\text{m}^3 \text{m}^{-2}$ every two days up to 32 days after sowing. After that, the wet treatment continued to receive the same amount of water, while the dry treatment was not watered up to the termination of the experiment. Water stress reduced shoot dry weight of Gadambalia, Arous elRimal and Tabat by 43, 46 and 58%, respectively. The respective reduction in leaf area of the three cultivars was 28, 54 and 63%. The reduction in photosynthesis, stomatal conductance and transpiration rate due to water stress was lowest in Gadambalia and highest in Tabat. The leaf water potentials and relative water contents of Gadambalia under wet and dry treatments were similar, while those of Tabat were significantly reduced by water stress. The lowest and highest resistance to water flow was displayed by Gadambalia and Tabat, respectively. Drought tolerance in Gadambalia is associated with its smaller leaf area, lower resistance to water flow, and ability to maintain high leaf water potential, relative water content, stomatal conductance, transpiration rate and photosynthetic rate under drought stress.

(2) Associate Professor Guang Wen

COE Visiting Associate Professor (April 2001 –March 2002)

University of Saskatchewan, Canada

Title: *Soil improvement by using recycling materials for sustainable agriculture production in arid region*

Research activities

During my time of staying at ALRC, with help from students and professors in Land Conservation Division, I have conducted two field experiments, testing effects of coated fertilizers on production of soybean and peanuts in the University Experimental Farm and in the ALRC. These experiments are expected to be completed next year with help from students. I hope we can summarize good results from these experiments.

Along with the students and professors, I contributed 5 conference presentations. The titles of the conferences are listed below. Three refereed papers have been published during the time above

mentioned. In addition, two papers related to application of organic wastes such as sludges, irradiated sludges, sludge and manure composts have been revised and waiting for the final decision from the editor.

A book chapter has been completed and expected to be published next year. Three manuscripts have been submitted. I expect to have editor's and reviewer's comments next year.

I also edited a number of manuscripts for English as well as academical improvements. It is my great pleasure to contribute to the research activities in the ALRC.

Experiments conducted

- A. Field evaluation of coated fertilizers on soybean production in a fertile soil in Tottori, Japan
- B. Field evaluation of coated fertilizers on peanut production in a sand soil in Tottori, Japan

Conference Proceedings and Presentations

1. G. Wen (2001). Agricultural production in arid and semiarid Saskatchewan, Canada. Annual meeting of co-operated research on arid lands. Organized and sponsored by Arid Land Research Center, Tottori University, Japan. Special Lecture: p.1-10
2. C Nakashima, G Wen, T Yamamoto and M. Inoue (2001). Application of coated fertilizers and an artificial zeolite to a sand soil for corn production. Proceedings of the 56th Meeting of Branch of Chugoku-shikoku, Japanese Society of Irrigation, Drainage and Reclamation Engineering (JSIDRE). Yamagushi Prefecture. p.150-152
3. T Yamamoto, G Wen, V Rasiah and M Yamada (2001). Sustainable irrigation in arid land and the use of artificial zeolite. Proceedings of the 56th Meeting of Branch of Chugoku-shikoku, Japanese Society of Irrigation, Drainage and Reclamation Engineering (JSIDRE). Yamaguchi Prefecture. p.153-154 (in Japanese)

Refereed paper publications

1. G Wen, JJ Schoenau, T Yamamoto and M Inoue (2001). A model of oxidation of an elemental sulfur fertilizer in soils. *Soil Science* 166: 607-613
2. G Wen, T Mori, T Yamamoto, J Chikushi and M. Inoue (2001) Nitrogen recovery of coated fertilizers and influence on peanut seed quality for peanut plants grown in a sandy soil. *Communications in Soil Science and Plant Analysis*. 32: 3121-3140
3. G Wen, PR Voroney, JJ Schoenau, T Yamamoto and J Chikushi (2001) Assessment of ionic quenching on soil ATP bioluminescence reaction. *Soil Biology & Biochemistry* 33: 1-7

Book Chapters

G Wen (2002). Sulfur. In: *The Macmillan Encyclopedia of Chemistry*. Ed: J. Lagowski et al. (in press). Macmillan Reference USA, New York. Elly Dickason Publisher.

Revised refereed papers

1. Guang Wen, TE Bates, PR Voroney, T Yamamoto, J Chikushi and D Curtin. A yield control approach to assess phytoavailability of Zn and Cu in irradiated, composted sewage sludges and composted manure in field experiments: I. Zinc
2. Guang Wen, TE Bates, S Inanaga, PR Voroney and K Hamamura. A yield control approach to assess phytoavailability of Zn and Cu in irradiated, composted sewage sludges and composted manure in

field experiments: II. Copper

Papers submitted for publication

1. T. Yamamoto, M. Yamada, Guang Wen and A. Yuya. Soil improvement by using recycling materials for degraded soil in arid land agriculture (in Japanese).
2. Guang Wen, Jeff J. Schoenau, Shinobu Inanaga, Tahei Yamamoto, Kunio Hamamura, S. Patrick Mooleki, Mitsuhiro Inoue and Ping An. Effectiveness of an elemental sulfur fertilizer in an oilseed-cereal-legume pulse rotation
3. Guang Wen, S Inanaga, JJ Schoenau, T Yamamoto, K Hamamura, SP Mooleki and JL Charles. A role of sulfur in regulating carbon and nitrogen concentration interaction in seeds of upland crops
4. SP Mooleki, JJ Schoenau, Guang Wen, JL Charles and G Hultgreen. Effect of rate, frequency and method of liquid swine manure application on soil nitrogen availability, crop performance and N use efficiency in east-central Saskatchewan

(3) Associate Professor Abdelbagi Mukhtar Ali

COE Visiting Associate Professor (June 2001 - March 2002)

Agricultural Research Corporation, Wad Medani, Sudan

Title: *Basic study on improving plant production under semi-arid conditions*

Summary of research activities during 10 months

I was invited to the Ecophysiology subdivision, headed by Prof. Inanaga, and collaborated with Dr. Sugimoto, Y., Associate Professor. My research activities have been performed mainly in the application of molecular technology for better understanding of gene expression during condition and germination of *Striga hermonthica* seeds. In addition, I initiated a work for molecular cloning of low-stimulant producing gene from a resistant sorghum line.

1. Expression of ACC synthase and oxidase during seed conditioning and germination

Understanding of conditioning and germination strategy of *Striga* seed is vital in designing a sound control measure. A research theme has been going on to clone and investigate the expression of two ACC synthase (1 and 2) and oxidase genes which are involved in the biosynthesis of ethylene, an inducer inducer of *Striga* seed germination. A full length of ACC Synthase 1 and oxidase, and partial length of synthase 2 were cloned and sequenced. Expression of synthase 1 and 2 during seed germination showed a temporal change with a peak at 10 h after GR24 treatment, which was in accord with ethylene evolution from the seeds. The level of ACC oxidase was maximum immediately after GR24 treatment and then started decreasing with time. To investigate the expression of oxidase gene during seed conditioning, total RNA was extracted during seed condition at an interval of 5 days for a period of 30 days. Twenty micrograms of the total RNA from each sample were fractioned through 1.0% agarose gels and transfer by capillary onto Hybond N⁺ Nylon membrane. Northern hybridization of the membrane was performed using purified fragment from the cloned gene as a probe. The probe was labeled with ³²P. Hybridization

signals were captured on X-ray film and analyzed. Northern hybridization revealed that ACC oxidase exhibited a temporal expression with a peak at 15 days. The expression of the gene was in association with the peak of germination in response to GR24. The result suggests that ACC oxidase and ACC synthases are responsive to conditioning and germination stimulant, respectively. Both of the enzymes act concertedly to biosynthesize ethylene, which induces seed germination.

2. Genomic analysis of ACC synthase and oxidase

In a separate experiment, total DNA was extracted from germinating *Striga* seeds, digested by three different restriction enzymes, fractionated through 1.0% agarose and transferred to Nylon membrane. Southern hybridization was performed using labeled probes of purified fragment from each of ACC synthase 1 and 2, and ACC oxidase. A single hybridization signal was observed in two of the enzymes digests, while the third enzyme gave smear hybridization. This suggests that each of the three genes has a single copy in the genome of *Striga*. Genomic PCR amplification using primers specific to the full length of the three genes revealed intron length of 0.2, 0.9 and 0.4 kbp in ACC oxidase and ACC synthase 1 and 2 genes, respectively.

3. Cloning of low-stimulant producing gene from sorghum

Breeding of resistant sorghum varieties to *Striga hermonthica* is urgently needed to reduce the heavy losses in sorghum yield due to *Striga* infestation, particularly in sub-sahara Africa. I initiated a molecular work to clone and develop molecular markers for low-stimulant producing gene. The work is expected to provide an in-depth knowledge of stimulant production and contribute to genetic engineering of resistant variety. Molecular markers linked to the resistance are also expected to be useful in selection for the gene in breeding programs. Differential gene expression display was conducted between low and high stimulant producing sorghum lines. Total RNA was extracted and reverse transcribed to cDNA. Single stranded cDNA was used as a template for PCR amplification with 26 different 10-mer random primers. About 25 differentially expressed fragments were identified. So far, six of these fragments were purified and cloned. The work supposed to proceed to sequencing, data base search and identification of fragments expressing the gene. On completion, the work is expected to contribute significantly to development of resistant sorghum variety.

4. Beside the above experiments in which I was directly involved, I provided material and follow-up for an experiment designed to screen for drought tolerance in advanced breeding lines of cotton. Sixteen lines were evaluated for seedling drought tolerance. Based on preliminary results, the genotypes were grouped into three groups; tolerant, intermediate and sensitive to seedling water stress. The work is continuing to identify differential mechanisms associated with drought tolerance in these genotypes.

5. Student assistance and editorial activities

I have been assisting students in various research activities, particularly, those who are working in molecular technology. I helped in English edition of papers and PhD thesis.

Seminars

Collaborative research activities between the International Center for Agricultural Research in the Dry Areas (ICARDA) and Sudan. This seminar was presented during the Joint Research Symposium, Arid

Land Research Center, December 6, 2001.

Publications submitted during my visit

1. Abdelbagi M. Ali, Osama M. Ahmed, Beatrice Masaka, Takehiko Matsui and Shinobu Inanaga (2002). Utilization of cotton germplasm in breeding for biotic and abiotic stresses in Sudan. International Symposium on Bioresources and Environmental Stress, Okayama, Japan 17-20.
2. Shinobu Inanaga, Abdelbagi M. Ali and Mohamed E. K. Ali (2001). Reducing Water Stress through Ecological Approaches and Crop Characteristics. JIRCAS 8th International Conference on Water for Sustainable Agriculture in Developing Regions-More crop for every scarce drop, Tsukuba, Japan (in press).
3. Yukihiro Sugimoto, Abdelbagi M. ali, Sumiyo Yabuta, Hiromi Kinoshita, Shinobu Inanaga and Akihiro Itai. Germination Strategy of *Striga hermonthica* through Regulation of Ethylene Biosynthesis (submitted to Plant Physiology).

(4) Professor Berliner, Pedro Reuven

Visiting Professor (October 2001-September 2002)

Ben Gurion University, Israel

Title: *Effect of water quality, irrigation frequency and alternating water sources on the productivity and water efficiency of halophytes*

Seminars presented

1. "Use of marginal water resources for the production of firewood and fodder in arid area". Special lecture at the Joint Research Symposium, ALRC, Tottori University. December 6, 2001
2. " A simplified approach for modeling agricultural production for climate change impact assessment" Workshop on Impacts of Climate Change on Agricultural Production in Arid Areas ", hosted by the Research Institute for Humanity and Nature, Kyoto February 10-11, 2002
3. "Runoff Agroforestry for arid regions". Biotron Institute, Kyushu University, 19 February 2002

Scientific meetings

Japan-China Joint Open Seminar on Combating Desertification and Development in Inland China, November 14, 2001

Scientific visits

1. Kyushu University, Prof. Chikushi, Biotron Institute
2. Kyushu University, Dr. Otsuki, Res. Institute Kyushu University Forests
3. Saga University, Prof. Cho, Department of Agricultural Engineering
4. Kyushu-Kyoritsu University, Prof. Kuroda and Dr. Takeuchi, Faculty of Engineering

Title of articles submitted or in preparation

1. Validation in an arid area of an algorithm for the estimation of daily solar radiation.
2. Runoff Harvesting System as Part of Desertification Prevention and Sustainable Development of

Desert Ecosystems

3. Effect of water quality and irrigation frequency on the biomass production of a leguminous shrub.

Results

- a) Validation in an arid area of an algorithm for the estimation of daily solar radiation. The Thornton-Running algorithm to estimate daily global radiation was tested at a site located in a coastal desert. A good correlation was obtained between predicted and measured values. The predictions of transmissivity for clear days were very good but a systematic underprediction was observed for the whole data set when measured global radiation exceeded 20 MJ m⁻². A regression analysis showed that errors in the estimated global radiation were linearly related to errors in one of the factors used in the algorithm. This factor is computed using the diurnal amplitude of air temperature and our results showed that the correlation between the measured factor and diurnal temperature amplitude was very poor. The Thornton-Running algorithm includes a correction for atmospheric water vapor content, which is usually unavailable. We evaluated the possibility of using the saturated vapour pressure at minimum temperature in lieu of the actual measured daily average and our results indicate that this approximation works well and does not noticeably affect the estimated fluxes. A serious underestimation of daily PET was observed when the estimated values of global radiation were used in the computation instead of the measured values. An evaluation of decade values indicated that differences during the rainy period were relatively minor but a serious underestimation is evident during the dry period.
- b) Runoff Harvesting System as Part of Desertification Prevention and Sustainable Development of Desert Ecosystems. The lack of readily available water resources, in particular those of good quality, is the main factor in hindering the sustainable development of desert ecosystems. In arid zones runoff can be used as a supplementary source of water for agricultural purposes. In these areas runoff is frequently generated as a result of the development of a crust on the surface of the soil. The purpose of this work is to study in the field and under natural rainfall conditions soil crust generation and evaluate the effect the changes in crust permeability and roughness have on runoff production. Runoff generated on 100 m² plots was measured on six plots by a tipping bucket system. Rainfall intensity was recorded on site with a rainfall gauge (resolution 0.25 mm). On three of the six plots rainfall induced crusts had been formed during the preceding three years (CP) and on three plots the crust had been completely destroyed by cultivation with a rotary tiller (RP). Surface roughness was characterized by the surface rms height obtained from laser micro-relief measurements before and during the season. Prior to the onset of rain, the roughness for the RP plots was similar. After five rainfall events totaling 30 mm. Their surface roughness had decreased significantly. Additional rainfall events did not affect the roughness of these plots. The final roughness of the RP plots was significantly different from that of the CP plots (whose roughness had not changed throughout the season). No clear correlation between roughness and runoff could be established and the latter was therefore governed by crust permeability. Runoff generated on CP and RP plots during rainfall events that occurred after 40mm of cumulative rainfall had been registered, was not significantly different. The initially cultivated plots were always rougher than the long-term crusted plots suggesting that the newly developed crusted areas in the RP plots had a lower

conductivity. The results from this study indicate that roughness appears to be of limited importance in determining total runoff from micro-catchments. An additional observation is that the length of the rain-less gaps occurring during rainfall events appear to be extremely important in determining runoff efficiency.

- c) Effect of water quality and irrigation frequency on the biomass production of a leguminous shrub. Systems based on the collection of runoff water are a viable approach for afforestation in arid and semi arid zones. Arid zones are characterized by low rainfall with rare runoff pulses. The time interval between runoff events is of the order of one year with extremely hot and dry periods in between and it is therefore advantageous to store the largest volumes of water possible during a runoff event. It is however a common feature in arid zones that no runoff may be collected during one rainy season and without supplementary irrigation shrubs or trees may die. In arid zones, aquifers with good quality water are rare, and if they exist they are used for conventional agricultural production. On the other hand brackish water aquifers are common. This source of water could be used to supplement the runoff water and thereby stabilize tree/shrub production. We studied the behavior of a mixed irrigated forestry system by monitoring the above and below-ground response of *Acacia saligana* shrubs in a field trial in which the following treatments were imposed:
- a. Quality of irrigation water: good quality (1 dS/m) and brackish (6 dS/m)
 - b. Irrigation frequency (once every two weeks, once a week and twice per week) and
 - c. flooding the plots with good quality water once a year or not.

We monitored to the effects of water quality and water stress. The results showed that the effect of salinity was to reduce transpiration and a linear relationship between above ground yield and water consumption (irrespective of quality) was found. No significant difference between yield as a result of water quality could be found when low frequency irrigation was employed.

(5) Professor Rami Keren

Visiting Professor (October 2001 - August 2002)

The Volcani Center, Israel

Title: *Soil structure and soil hydraulic properties*

My stay at the Arid Land Research Center of Tottori University has been a pleasure both professionally and socially. It was an honor to be a Visiting Professor in the ALRC and to collaborate with Prof. S. Inanaga the Director of the ALRC and with Professor T. Yamamoto, Head of the division Land Conservation. I was pleased to work closely with Professor T. Yamamoto to instruct students for their dissertations, to help undergraduate and graduate students and to conduct series of lectures on physical chemistry of soils. Thanks to Miss Kyoko Takahashi and those who have worked hard helping us to communicate and to make our stay here so enjoyable.

Summary of research

My activities in the Arid Land Research Center, Tottori University, during Oct. 16, 2001 and August 31, 2002 were as follows:

a. Symposiums and workshops

1. Key note lecture on response of saline-sodic soil to water quality: Processes and managements. Proceedings of the 40th Annual Meeting of Soil Physics Section, Japanese Society of Irrigation, Drainage and Reclamation Engineering (JSIDRE). ALR Center, Tottori University, 2001.
2. Water conservation practices assessments and wheat adaptation to semiarid regions with eroded environment. The 12 International Soil Conservation Organization Conference, Beijing, China, May 26-31, 2002
3. Effect of ESP and clay content on soil aggregate stability. The annual meetings of the Japanese Society of Irrigation, Drainage and Reclamation Engineering. Tsu - shi Mie – Ken, Japan, August 2002.

Seminars and lectures

1. Plant uptake of Boron as affected by Boron distribution between the liquid and the solid phases in soil. Kyushu University, Fukuoka, Japan. February 2002.
2. Soil properties and Combat Desertification - the agricultural approach. Arid Land Research Center, Tottori University, Tottori Japan. April, 2002.
3. The properties of clay minerals and their behavior in aqueous media. Arid Land Research Center, Tottori University, Tottori Japan. June 2002.

A. Series of lectures on the topic “Soil Physical and Chemical Properties Relations”

4. Clay swelling and dispersion processes and their roles in soils hydraulic properties. Arid Land Research Center, Tottori University, Tottori Japan. June 2002.
5. Hydraulic properties of soils and their relation to water quality. Arid Land Research Center, Tottori University, Tottori Japan. June 2002.
6. Water quality assessment for irrigation in arid land regions. Arid Land Research Center, Tottori University, Tottori Japan. June 2002.
7. Kinetics of gypsum dissolution and its solubility in aqueous media. Arid Land Research Center, Tottori University, Tottori Japan. June 2002.
8. Sodic soil reclamation under semi arid and arid conditions. Arid Land Research Center, Tottori University, Tottori Japan. June 2002.

B. Research

Instructing a Ph.D. candidate on the subject: “Soil aggregate stability and hydraulic conductivity of soils with 2:1 and 1:1 clay minerals as affected by water quality”.

Titles of articles

1. Keren, R. 2001. Response of saline-sodic soil to water quality: Processes and managements. Proceedings of the 40th Annual Meeting of Soil Physics Section, Japanese Society of Irrigation, Drainage and Reclamation Engineering (JSIDRE). ALR Center, Tottori University, 2001.
2. Masae ARAI , R. Keren, T. Yamamoto and M. Inoue. 2002. Effect of Water Quality on Saturated Hydraulic Conductivity of Soils with 2:1 and 1:1 Clay Minerals. Transactions of the Japanese Society of Irrigation, Drainage and Reclamation Engineering (Submitted).
3. Masae ARAI , R. Keren, T. Yamamoto and M. Inoue. 2002. Aggregate Stability Evaluation of Sodic Soils Using Water-Ethanol Mixtures Transactions of the Japanese Society of Irrigation, Drainage and Reclamation Engineering. (Submitted).
4. Masae ARAI, R. Keren, T. Yamamoto and M. Inoue. 2003. Aggregate stability and hydraulic conductivity of Sodic Soils Using Water-Ethanol Mixtures. Soil Science, (In preparation).
5. Deng Xi-ping, L. Shan, S. Inanaga and R. Keren. 2002. Water Conservation Practices Assessments and Wheat Adaptation to Semiarid Regions with Eroded Environment. A review paper presented in the 12 International Soil Conservation Organization Conference, Beijing, China, May 26-31, 2002, China.

6. Communar, G., and R. Keren. Convection-dispersion transport of non-linearly adsorbed desorbed solutes in saturated soils. *Soil Sci. Soc. Am. J.* (Submitted).

Research Results

1. Response of saline-sodic soil to water quality: Processes and managements.

R. Keren

Many soils in arid to humid regions have unstable structure which makes them difficult to manage owing to their tendency to swell and disperse. Since soil permeability decreases with the square of the pore radius, a small reduction in size of the large pores due to swelling and clay movement has a large effect on soil permeability for water and gases. The favorable effect of exchangeable Ca and the deleterious effect of exchangeable Na on soil swelling and dispersion is well known. The soils responded differently to the same combination of electrolyte concentration and ESP.

The extent of swelling and dispersion of clays depends on the clay mineralogy, the composition of the adsorbed ions and the salt concentration in solution. It was concluded that the electrolyte concentration - SAR threshold values for HC and clay dispersion of arid soils are closely related. However, whether clay will leave the system or move and seal the soil depends on the extent of swelling. At any particular percentage of exchangeable Na, the influence of exchangeable Na is greater with exchangeable Mg as the complementary ion than it is with Ca.

Water infiltration is more susceptible to ESP than the HC of the soil profile for the following three reasons (1) the mechanical impact of the water drops, (2) the absence of the soil matrix which slows clay movement, and (3) concentration of electrolytes in the surface soil solution is determined solely by the composition of the applied water, because dissolution of CaCO_3 and primary minerals is too slow to affect the surface solution concentration. Thus, when water with low electrolyte concentration is applied (rain water or snow water) salt concentration in the soil surface solution remains low even for calcareous soils, and clay dispersion is possible only if the salt concentration is below the FV of the clay. Studies imply that also Mg is a deleterious ion in some circumstances. Adsorbed Mg has a specific effect on soil erosion and infiltration for montmorillonitic noncalcareous and calcareous soils and the erosion rate for Na/Mg soil is greater than the rate for Na/Ca soil. Sodic soil reclamation management was discussed.

2. Effect of Water Quality on Saturated Hydraulic Conductivity of Soils with 2:1 and 1:1 Clay Minerals.

Masae ARAI, R. Keren, T. Yamamoto and M. Inoue

The pHs of the Niigata and Tottori soil were 6.5 and 6.2, respectively, showing slight acidity; the EC were 0.23 and 0.29 dS/m, respectively. Both soils were classified as light clay according to the International Society of Soil Science. The liquid limit of the Niigata and Tottori soil was 48.3, 44.3 %; the plastic limit 29.1, 28.2 %; and the plastic index 19.2, 16.1, respectively. The liquid limit of the Niigata soil was slightly higher than that of the Tottori soil, but the difference was not significant. The X-ray diffraction patterns of the $< 2 \mu\text{m}$ clay fractions revealed that smectite was the dominant clay mineral for the Niigata soil, and kaolinite and vermiculite were in Tottori soil. The final HC values when leached with the 500 me/L solution at SAR 0 and 30 were 4.99 and 2.99 mm/h for the Niigata soil, 3.63 and 7.71 mm/h for the Tottori soil, respectively. These values were taken as reference value in the calculation of the RHC.

The drastic drops in the RHC of both soils occurred when the concentration of the applied solutions were reduced to less than 10 and 5 me/L at SAR 30, respectively. The RHC of the Niigata soil and the Tottori soil dropped 69 and 71 %, respectively. The amount of the cumulative effluent volume approaching to a nearly steady RHC of the Niigata soil with 10 me/L solution at SAR 30 was about 2200 mL. Conversely, in the Tottori soil with 5 me/L solution at SAR 30, it was about 4300 mL. At SAR 0, however, the RHC of the both soils dropped drastically only when leached with DW. The amount of the cumulative effluent volume approaching to a nearly steady RHC of the Niigata soil was about 1000 and 250 mL for SAR 0 and 30 for DW. In the Tottori soil, they were about 7000 and 500 mL for SAR 0 and

30 for DW. No clay was detected in the effluent of both soils at all SAR and the all solution concentrations.

3. Aggregate Stability Evaluation of Sodic Soils Using Water-Ethanol Mixtures

Masae ARAI, R. Keren, T. Yamamoto and M. Inoue

The aggregates of most arid regions soils are not stable while testing their stability by the current wet-sieving method when using water and nearly complete aggregate breakdown occur. A modified wet sieving method that based on ethanol-distilled water mixtures was suggested for relative aggregate stability assessment for these soils. The objectives of this study were (1) to modify the wet-sieving method by using ethanol-water mixtures for assessing aggregate stability of arid region soils and (2) to evaluate aggregate size distribution resulting of initial aggregates breakdown as affected by clay content and adsorbed cation composition.

Aggregate stability was conducted for sandy clay loam and clay soils using ethanol-distilled water solution at ethanol concentration of 0, 25, 40, 50, 65, 75, 85 or 96 % (to obtain various dielectric constants in the range between 81.7 and 25.6) or by using NaCl and CaCl₂ solutions at total electrolyte concentration of 0.1 and 1 mol_c L⁻¹ at SAR appropriate to the soils' ESP. Aggregate stability decreased significantly with the decreasing of ethanol concentration in the aqueous solution. High fraction of unstable aggregates was observed after sieving in ethanol for 1 min when the wetting rate was 100 mm h⁻¹. On the contrary, 4-6 mm aggregates of both soils were stable after sieving in ethanol for 1 min, when the wetting rate was reduced to 4 mm h⁻¹. These results indicate that wetting rate is an important factor in aggregate stability determination even when the wetting liquid is ethanol. The fraction of the stable 4-6 mm aggregates decreased substantially in a relatively small ethanol concentration range, having an inflection point at a stable aggregate fraction of 50 %. The ethanol concentration in solution at the inflection point for the sandy clay loam soil was higher than that for the clay soil and increased with the ESP.

The higher aggregate stability in the presence of ethanol can be attributed to the reduction in the dielectric constant of the medium between aggregates or due to bridging of two adjacent clay particles through ethanol molecule interaction. The fact that all (most for the soil at ESP 9.3) of the 4-6 mm aggregates disintegrated at this high electrolyte concentration may indicate that the dominant mechanism involves in stabilizing the larger aggregates of the soil is the bridging of two adjacent small aggregates through a clay particle-ethanol molecule interaction.

4. Aggregate stability and hydraulic conductivity of Sodic Soils Using Water-Ethanol Mixtures

Masae ARAI, R. Keren, T. Yamamoto and M. Inoue

5. Water Conservation Practices Assessments and Wheat Adaptation to Semiarid Regions with Eroded Environment

Deng Xi-ping, L. Shan, S. Inanaga and R. Keren.

About 40% of the land in the world is under arid and semiarid climatic conditions. Moreover, semiarid regions are currently under a treat of desertification due to deficiently in water for irrigation. Water is the principal constraint that limited agricultural development in these regions.

The soils in these regions are characterized by relatively high runoff / rainfall ratio and much of the rainwater evaporates through the soil surface between rainstorms. The drying process may deplete as much as 50% of the total precipitation. Therefore, soil managements to minimize both water runoff and evaporation is the primary objective to achieve in rain-fed farming under regions where rainfall is the limited factor. The following subjects were discussed: (1) Soil and water managements, increase water availability (technologies, water harvesting), water infiltration technologies, water holding capacity of soils, and minimizing water evaporation through soil surface; (2) Water use efficiency, tolerant crops to drought and cropping management; and (3) Breeding of tolerant plants for drought conditions.

6. Convection-dispersion transport of non-linearly adsorbed desorbed solutes in saturated soils.

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Analytical solutions of the classical convection-dispersion equation (CDE) have been derived for non-linear adsorption-desorption of solute in soil systems. It is assumed that water flow is steady and that the chemical equilibrium is established instantaneously. An analytical solution for a non-linear CDE was suggested by dividing an adsorption isotherm into several linear segments. The advantage of the solutions presented is that they incorporate real parameters of non-linear isotherms. The calculated data demonstrate the effects of dispersion and non-linear adsorption and desorption of a solute on the solute transport process in soil, under saturation condition.