2.7 Activities of Foreign Researchers

(1) Professor. Mehmet Aydin

COE Visiting Professor (April 1, 2000-March 31, 2001)
University of Mustafa Kemal, Faculty of Agriculture, TR-31040, Antakya, Turkey.
Title: *Effect of soil salinity on crop evapotranspiration*

My activities have been performed in the Subdivision of Water Resources, headed by Prof. T. Yano. I was pleased to work closely with Dr. Y. Kitamura, Associate Professor and to help graduate students in their MS/Ph.D. studies. I have also been involved in experiment of Mr. Shengli Yang, Ph.D. student.

Research activities

My research activities have been focused on two major topics:1) Measurement of electrophoretic mobility of soil-clay fraction, 2) Evapotranspiration from citrus trees irrigated with saline water. These topics are related to the ongoing research program at the Arid Land Research Center (ALRC).

Seminars

1. Quantification of soil-water balance components in the root zone. Arid Land Research Center, Tottori University. June 8, 2000.
2. Challenges in sustainable rainfed agricultural development in Turkey. Arid Land Research Center, Tottori University. June 15, 2000.
3. An overview of arid land agriculture in Turkey. Institute of Agricultural and Forest Engineering, Arid Land Engineering, Tsukuba University. August 7, 2000.
4. Quantification of soil-water balance components under bare and cropped soil. Graduate School of Environmental Earth Science, Hokkaido University. September 8, 2000.
5. Efforts to boost crop production in dryland regions of Turkey (special lecture). Annual Meeting of Joint Researcher. Tottori Prefectural Kenmin Bunkakaikan. December 6, 2000.
6. Zeta potential of soil-clay particles (a short presentation on the ongoing research). Arid Land Research Center, Tottori University. January 17, 2001.

Lectures

A series of informal lectures were given to graduate students of the Water Resources Subdivision:

1. Volume and mass relationships of soil constituents
2. Soil-water content/potential
3. Saturated and unsaturated hydraulic conductivity
4. Determination of unsaturated hydraulic conductivity under field conditions
5. Quantification of soil-water balance components in plant rooting zone
   a) Capillary flux (upward flux, downward flux)
   b) Water uptake by roots
6. Determining the contribution of water table to the water consumption of plants.

Special lectures given to the students in the Water Resources Subdivision in March 2001:

1. Electrophoretic migration of clay fraction and its relation to salt concentration in aqueous media.
2. Combination of irrigation schedules and nitrogen rates for cotton in a semi-arid region.

Students assistance

1. Instruction of one student in his Ph. D. research
2. Discussions with MS students: Water balance on large areas; hydraulic properties of soils and their relation to soil salinity; water flux through roots.

Participation in national and international symposia

1. Annual Meeting of Japanese Society of Irrigation, Drainage and Reclamation Engineering (JSIDRE).Tottori Prefectural Kenmin Bunkakaikan. Tottori, Japan. 2-4 August 2000.

2. East Asia 2000 Regional Symposium on Rainwater Utilization. National Taiwan University,Taipei,Taiwan. 31 October-3 November 2000.
3. International Mini-symposium of the Arid Land Research Center on 'Role of Arid Land Agriculture for Overcoming Food Deficits in the 21st Century.' Tottori Prefectural Kenmin Bunkakaikan. Tottori, Japan. December 5, 2000.

Publications submitted during the sabbatical period in Tottori

1. Aydin, M., Yano, T., Kitamura, Y., 2000. The soil as a natural pool to store rainwater. East Asia 2000 Regional Symposium on Rainwater Utilization. National Taiwan University, Taipei, Taiwan. 31 October-3 November 2000. Proceedings Book: 93-98.
2. Aydin, M., Yano, T., 2000. Effects of adsorbed cation and aqueous phase properties on electrophoretic mobility of soil-clay particles. Soil Sci. Soc. Amer. J., submitted.
3. Yang, S., Yano, T., Aydin, M., Kitamura, Y., Takeuchi, S., 2001. A short-term experiment on evapotranspiration from lysimeter-grown citrus trees irrigated with saline water. Agric. Water Manage., submitted.

Participation in preparation of a proposal for an international project

A joint project proposal entitled 'Ammonia losses from irrigated Turkish soils under arable use' was prepared in close collaboration with German colleagues from Giessen University, and Prof. Yano for submitting to DFG, Germany.

Research results

1. *Effects of adsorbed cation and aqueous phase properties on electrophoretic mobility of soil-clay particles*

This study deals with the effects of aqueous phase properties (pH, electrolyte concentration, and ionic species) and exchangeable sodium percentage on electrophoretic mobility/zeta potential of clay particles. The soils taken from Japan (AS) and Kazakhstan (KS) were used for obtaining clay fraction. For electrophoretic mobility (EM) determinations, clay suspensions were prepared at a concentration of 4 g-clay/100 ml of distilled water or electrolyte solution. The EMs were measured using Burton apparatus of improved design and converted into zeta potential (.p). Results showed clearly that the mobility was very sensitive to the valency of ion adsorbed on the clay. The negative EM of homoionic Na-AS clay and Na-KS clay were 2.13 and 2.14 μm cm/volt sec, respectively, whereas Ca-clays flocculated. The .p values of AS-clay and KS-clay, as a function of the sodium percentage, varied between -12.83 and -26.84 mV, and -5.68 and -27.00 mV, respectively. The EM of KS-clay was strongly dependent on pH, and ranged from 0.37 μm cm/volt sec, (.p = -4.67 mV) at pH 4 to 2.22 μm cm/volt sec, (.p = -28.02 mV) at pHs 11-12. However, changes in the mobility of AS-clay were only observed at a pH range of 5-8. The negative EM of AS-clay varied between 1.85 μm cm/volt sec, (.p = -23.35 mV) at pH 5 and 2.22 μm cm/volt sec, (.p = -28.02 mV) at pHs 8-12. At pHs 2-3 or 4, the both clay suspensions flocculated. The EM of KS-clay reduced from 1.85 μm cm/volt sec, (.p = -23.35 mV) in 0.001 M NaCl-treated suspension to 1.11 μm cm/volt sec, (.p = -14.01 mV) in 0.1 M ionic strength. The EM of AS-clay did not fluctuate with changes in the concentration between 0.001 and 0.01 M. However, the negative EM of this clay decreased from 2.03 μm cm/volt sec, (.p = -25.68 mV) to a value of 1.11 μm cm/volt sec, (.p = -14.01 mV) when the salt concentration in the suspension were raised from 0.01 to 0.1 M. The EM curve of AS-clay vs ionic species (Na_2SO_4, NaCl, $NaHCO_3$, and Na_2CO_3) had a very small slope, except NaHMP. In contrast, the ionic species showed a greater influence on the EM and .p of KS-clay.

2. *Evapotranspiration from citrus trees irrigated with saline water*

Eight-years-old 'Murcott' orange trees grown in greenhouse lysimeters filled with sandy soil were subjected to investigate the influence of irrigation water salinity on daily evapotranspiration. The treatments were: L1 (control): non-saline water having an electrical conductivity (ECi) of 1.0 dS/m was applied when water at field capacity (FC) in 0-120 cm of soil depth was reduced to 70% of the total

content; L2: saline water having an ECi of 8.65 dS/m was applied at the same time with L1; and L3: irrigated with the same saline water at 85% of the FC. The trees were irrigated with excess of water require to reach the FC during the experimental period. The results will be reported in a Ph. D. thesis (S. Yang).

Summary of seminars and special lectures given at ALRC

1. *Quantification of soil-water balance components in the root zone*

It is necessary to predict the different components of the water balance to obtain a greater understanding of the effect of crop management on crop water use. Unfortunately it is almost impossible to measure the seepage rate and the rate of evapotranspiration directly. Therefore in many investigations, evapotranspiration is equated to the water depletion within the soil profile. But, the discrepancy between water depletion and evapotranspiration can be enormous.

One can also study the water budget of a field soil under natural condition by theoretical means. The experimental procedure to determine the evaporation rate, the drainage rate and the unsaturated hydraulic conductivity is based on numerical calculations with the unsaturated water flow equation. In a soil with a vegetation the vertical water flow is controlled by the continuity equation. Despite the difficulties of the field method in obtaining hydraulic functions and water fluxes in addition to water uptake rates by roots, many investigations show that the unsaturated soil water flow equation can provide data on soil water behavior that are sufficiently accurate to study soil-water flow processes in the field.

The experiments on soil-water-plant relationships show that the capillary fluxes towards the surface soil, and drainage rates below the root zone are less than the total water uptake by roots. However, the drainage is a component which should not be neglected when dealing with water use of crops even on deep clay soils. In addition, for the evaluation of water withdrawal by roots from individual soil layers in relation to root density, the water flux through soil must be considered.

2. *Challenges in sustainable rainfed agricultural development in Turkey*

About 40 % of Turkey's 780,000 km^2 landmass is semi-arid, which is mainly located on the country's Central Plateau. Arid areas exist near the Syrian and Iranian borders. Low and erratic precipitation is the single most important climatic factor that limits crop yield.

Wheat production represents the key agricultural challenge facing the nation's drier regions. Between 1923 and 1970, the nation focused its wheat yield to meet the food needs of an expanding population. Until 1970, increases in wheat production were caused mostly by increases in the area of land that was cleared and cultivated. After 1970, crop production in Turkey's wheat fields increased dramatically, largely because of the National Wheat Research and Extension Project launched in 1969. After the introduction of the project, researchers focused on techniques aimed at conserving water in the soil during the fallow period. Based on the National Wheat and Extension Project's findings, wheat farmers sought to improve production, not by tilling more land, but by increasing the productivity of soils already under cultivation. Farmers also replaced their old wheat seeds with high-yield varieties adapted to dry areas. For a time, these new farming practices appeared to resolve Turkey's agricultural production problems. In fact, between 1969 and 1990, while the area cultivated in wheat increased by only 9 percent, wheat production increased by 90 percent. Even if Turkish farmers do their utmost to ensure the fertility of the soils in arid regions, they will still find themselves at the mercy of the climate. By the early 1990s, it became clear that it was time to establish new guidelines for sustainable agriculture, particularly in the nation’s dry regions.

To address the pressing need for water, the Turkish government launched the Southeastern Anatolian Development Project, with an acronym of GAP (Guneydogu Anadolu Projesi) in 1987. GAP is a multipurpose integrated- and the largest irrigation and hydroelectric power-project to be undertaken in Turkey. In fact, the introduction of irrigation will allow farmers to produce as many as three succeeding crops in the same field annually, creating an estimated 10 percent overall increase in productivity. All the past research was focused on this issue. However, the integrity of the environment has almost become an overriding factor. The environmental component still baffles the agricultural scientists.

3. *Electrophoretic migration of clay fraction and its relation to salt concentration in aqueous media*

The interaction of clay surface with ions has great influence on soil properties. The types and concentration of ions in soil solution govern the dominance of attracting and repelling forces and the resulting flocculation or deflocculation of clays. For example, saline soils in arid regions are normally flocculated because of the large amount of electrolyte present. In contrast, other soils in the same region low in salt and high in exchangeable sodium are deflocculated and dispersed. Divalent exchangeable cations result in flocculated clay systems while monovalent exchangeable cations produce dispersed systems.

In many practical situations the value of the zeta potential, obtained from electrophoresis experiments, is used to characterize the potential at the surface of particles and the thickness of the electrical double layer and hence is valuable in discussing double layer interactions between the surfaces, and tendency for the soil colloids to disperse. However, the determination of the zeta potential is indirect and is done via the measurements of electrophoretic mobility.

Apart from charge density, the electrophoretic mobility of a particle depends on a number of other factors, such as electrolyte concentration (ionic strength), ionic species, pH, dielectric permittivity of the medium, viscosity, temperature, particle size and density, and the shape of the suspended particles.

4. *Combination of irrigation schedules and nitrogen rates for cotton in a semi-arid region*

Cotton is one of the most responsive crops to irrigation as well as to nitrogen applications. Therefore, the most appropriate combination of nitrogen rate and water level should be experimentally determined and practiced. For this purpose, a multifactorial experiment was carried out in three different locations of Cukurova region, Turkey. Combinations of five different rates of nitrogen and three different levels of soil water content were used as the treatments.

1) The effects of nitrogen rates and nitrogen-water combinations on the yield of seedcotton were significant. Irrigation was favourable when the available water in 0-120 cm of the soil profile was reduced to 20%, and application of 120 kg N/ha was optimum. In general, nitrate concentration in soil water extracted from different depths of soil profiles did not differ significantly between treatments. However, concentrations of nitrate-N at 120 cm depth of soils indicated possible environmental and economical

(2) Professor Nafisa E. Ahmed

Visiting Professor

Agricultural Research Corporation, Crop protection Center, Sudan**.**

Title: *Basic Studies on control of root parasitic weeds in semiarid regions*

My activities have been performed in the Ecophysiology subdivision, headed by Prof. Inanaga, S. in collaboration with Dr Sugimoto, Y., Associate Professor.

Research activities

My research activities have been focused on development of biological control strategies to *Striga hermonthica* being devastating to cereal cultivation in Africa and responsible for most of the losses encountered in these crops and a shift towards desertification and hunger. During my stay, I was able to identify fungal toxins that can inhibit *Striga* seed germination an deplete the seed reserves in the soil. In addition these toxins could be utilized to synthesize new herbicides for *Striga* OR otherwise their mode of action could be efficiently used to invent new herbicide molecules. My research activities opened new avenues for research in *Striga* program on going in the ecophysiology subdivision at ALRC.

Editorial activities

I edited quite a number of English manuscripts of Staff and students as well as conferences and symposia presentations and reports. I am happy to be able to help in this essential part of research.

Publications submitted during the sabbatical period at ALRC

1. Nafisa E. Ahmed, Yukihiro Sugimoto, Abdel Garbar T. Babiker, Omayma E. Mohamed, Yongqing. Ma,Shinobu Inanaga, Hiromitsu Nakajima (2000) : Effects of some isolates of *Fusarium solani* on germination of *Striga hermonthica* (Del.) Benth. (submitted to Weed Science).
2. N. E. Ahmed, H. O. Kanan, Y. Sugimoto, Y. Q. Ma, S. Inanaga (2000) : Effect of Imidacloprid on Incidence of Tomato Yellow Leaf Curl Virus. (Accepted for publication in Plant Disease)
3. N. E. Ahmed, H. O. Kanan, S. Inanaga, Y. Q. Ma and Y. Sugimoto (2000) : Effects of Pesticide Seed Treatment on Aphids Control and Wheat Yield Improvement (Accepted for Publication in Crop Protection)
4. Yukihiro Sugimoto, Nafisa E. Ahmed, Norifumi Yasuda and Shinobu Inanaga (2000) : *Striga hermonthica* seed germination inhibitors produced by *Fusarium* solani (To be submitted to Weed Science)
5. S. A. Gamiel, N. E. Ahmed, Y. Ma, S. Inanaga and Y. Sugimoto (2000) : More important weed species as host plants of powdery mildew. Accepted for publication in Journal of Agric. Sciences, Sudan.
6. Yukihiro Sugimoto, Masayuki Miyamoto, Shinobu Inanaga and Nafisa E. Ahmed (2000) : Non-host tissue cultures produce haustorium inducing substance for root prasitic weed Striga hermonthica. Invited chapter in Recent Research Development in Phytochemistry, Publisher Research Signpost, India.
7. O. E. Mohamed, N. E. Ahmed, Eneji, Y. Ma, E. Ali, S. Inanaga and Y. Sugimoto (2000) : Effect of sowing dates on incidence of bacterial blight and yield of cotton.
   Submitted to J. Field Crops Research.

International Symposium

- Nafisa E. Ahmed, Yukihiro Sugimoto, Norifumi Yasuda and Shinobu Inanaga : Effect of *Fusarium solani* on germination of *Striga hermonthica*. 27th Annual Meeting of the Plant Growth Regulating Society of America, Hawaii July 30 – August 3, 2000.
- Nafisa E. Ahmed, Yukihiro Sugimoto, Yongqing Ma and Shinobu Inanaga : Toxins of Fusarium solani and their effects on *Striga hermonthica* seed germination. Seventh Arab Congress of Plant Protection, Amman, Jordan, 22 - 26 October 2000.
- Ma, Y. ; Inanaga, S. ; Sugimoto, Y. ; Han, Q. ; Feng, X. ; Tian, K. ; Li, H. ; Liu, G. ; Babiker, AGT. ; Ahmed, N. : Inducing of *Striga hemonthica* (Del.) Benth seeds germination by Chinese traditional medical herbs. Weed Science Society of America, Greensboro, North Carolina, Feb. 11 – 14, 2001.

National symposium

Sugimoto, Y. ; Ahmed, N. E. ; Yasuda, F. and Inanaga, S. (2000) : Germination inhibitors against the root parasitic weed *Striga hermonthica* produced by *Fusarium solani*. Annual Meeting of Japanese Growth Regulation Society, Tokyo, October

Students Assistance

1. Co-supervising the MSc. Study of Norifumi Yasuda, Arid Land Research Center, Tottori University.

Seminars and Lectures

1. Crop Protection in Sudan, an Overview of the state of research and development work on Integrated Pest Management (IPM). Utsunomiya University, Center for Research on Wild Plants, May 31, 2000.
2. The above mentioned seminar was given with some modifications, Arid Land Research Center, Tottori University, Tottori, June 19, 2000.
3. Farmers Field School Approach, Arid Land Research Center, Tottori University, Tottori, June 26, 2000.

Summary of the Seminars

1. Crop Protection in Sudan, an Overview of the state of research and development work on Integrated Pest Management (IPM).

In Sudan, there is a wide range of basic knowledge gained in the different aspects of crop protection. Implementation of this knowledge has up to now succeed in very few cases. Integrated pest management had become an acceptable strategy to control pests and diseases. The deficit in IPM relates to biological pest control and establishment of the bases for process development such as mass breeding and culturing of natural enemies. The current requirement to complement the existing chemical control system is to design IPM strategy suitable for the existing cultivation system. Biological crop protection strategy created by adoption of IPM in field crops should be extended to vegetable crops. It become very clear that promotion of naturally occurring beneficial could be introduced very quickly and at no cost. However, economic relations between these natural enemies and the ecosystem should be evaluated and accurately determined to attract farmers to adopt IPM.

2. Farmer Field school :

The farmer field school (FFS) approach requires a change of attitude of both farmers and extension staff involved. In contrast to the traditional top-down approach, in which the extensionists or researchers (top) introduce a new technology to the farmers (base) to be implemented according to their instructions. FFS approach is based on participatory approach in which extentionists and farmers are considered equal partners. This approach aims at changing farmers skills of crop management for a safe environment and human health. It focuses on the agro-ecosystem of the crop, relation and interactions of the crop with the environment. This is achieved by non-formal system of adult education using long season group meetings in the field. Learning is based on learning by doing and to make use of farmers traditional knowledge. New technologies are introduced and adapted to farmers local conditions and farmers existing ideas are transferred to research topics. Group meeting and participatory approach, stimulate discussion and create farmer - to – farmer extension service. It also increases self – reliance of the farmers and reduces their dependence on outside services. Simple problems may be easily solved through knowledge and experience from a fellow farmer, and more complicated problems can be well formulated and addressed to specialized services.

Research

Basic studies on control of root parasitic weeds in semi – arid regions

Striga hermonthica is a root parasitic weed, which seriously affect sorghum cultivation in Africa. The damage inflicted by this parasite on cereals may account to > 70%. The parasite is characterized by their high efficiency to produce seeds, which will remain viable for up to 20 years in the soil. The seeds remain dormant in the soil until triggered by adequate rains and an external germination stimulant naturally produced by host plants. Once germinated, the parasite is attached to the host plant within 3 – 5 days or the seedling dies. Several methods of stimulating *Striga* germination had been identified and suggested for control of the parasite in agricultural system. However, the instability and high cost of synthetic stimulants precluded their usefulness an use of stimulant producing non – host plants in a crop rotation with host plant cereals appear to be unacceptable to traditional farmers in the region. The method needs a long time to deplete the seed reservoir in the soil and become economically and socially acceptable. Several methods of control have been recommended, but because of high cost and other logistic reasons, none of them has been adopted to any appreciable extent in farmers' fields.

Recently, interests in exploiting microbes and their toxins to control weeds, including *Striga* have been developed. Many fungi including *Fusarium* spp. were reported to have a potential as bioherbicides for *Striga* and a number of other weeds.

Fusarium solani isolated from infected *Striga* plant growing parasitically on sorghum was found very effective in inhibiting *Striga* seed germination. Our study was directed to investigate the production of

toxins by this isolate as inhibitors to *Striga* seed germination and their impact on *Striga* control within the existing agricultural system. Suitable culture medium for the fungus growth and production of inhibitory toxins was elected. Effective application time of these toxins was studied to verify the mechanism of action, which remains a question. Our results indicated the presence of at least four toxins with the potential to inhibit *Striga* seed germination. Identification of these toxins was performed using NMR, Mass spectra, UV detector, and other analytical methods. Effective concentration of each toxin on *Striga* seed germination was detected and their effects on growth parameters of some important cultivated crops in sub – Saharan region were reported.

(3) Professor Xin LI

Visiting Professor (Oct. 2000-Mar. 31, 2001)
Xinjiang Institute of Ecology and Geography, People's Republic of China
Title : *Evapotranspiration from orange tree inside greenhouse*

Summary of research activity for half year

My activity in ALRC is in the subdivision of Water Resources Research, headed by Prof. T.Yano. I have been involved in the experiment of evapotranspiration of orange trees in the lysimeter and soil moisture movement.

1) Based on the data of evapotranspiration and salt content after irrigation with fresh water and saline water in lysimeter, I observed evapotranspiration, air temperature, and air humidity in winter together with the students in ALRC and Prof.Ading, who is a COE research in ALRC from Turkey. And I finally finished a research paper "hourly variation of evapotranspiration from orange tree inside greenhouse" together with Prof.Yano *etc*.
2) Attended the international Symposium of the Arid Land Research Center on: Role of Arid Land Agriculture for Overcoming Food Deficits in the 21st Century, and presented a lecture of "the pressure of water shortage to agriculture in the arid region of china".
3) Joined the seminar of "Natural resources and agriculture in Xinjiang Uigur Autonomous Region, the People's Republic of China" in ALRC hold by Prof. K.Hamamura, and gave a lecture of "Characteristics of water transformation and its effects to environment in Xinjiang, China
4) Visit the Meteorological Research Institute of Japan in Tsukuba and Graduate School of Human Informatics, Nagoya University. In the joined meeting in Meteorological Research Institute of Japan, we discussed the research plan about the "Lang distance transportation of dust from the Northwestern of China" which starts from 2001 as a cooperative research project between the Chinese Academy of Science and the Ministry of Education, Science, Sports and Culture, Government of Japan.

Result and articles related to my research in ALRC

The following are the abstracts of the research results:

1) A prelection in the seminar on 14,Nov.2000, ALRC (4,Nov.2000)

CHARACTERISTICS OF WATER TRANSFORMATION AND ITS EFFECTS TO ENVIRONMENT IN XINJIANG, CHINA

Abstract

The regularity of water transform in stream form area and disappear area is very different. In stream form area, water transform is mainly that groundwater flows out to form surface water. And in stream loss area, water transform is mainly that surface water seeps into ground. At the plain in front of mountains, when water resources finished the transform of surface water-groundwater-surface water, it may begin the second transform if there is structural basin in the lower reaches of river. However, water is less and less

after the process of transform. Effect of water to environment can be divided into two types, natural affect and human effect. The changes of natural condition need a long time of geological period. The influences of human activities toke place in a short time and regionally.

Natural environment, inland water distribution and water circulation has been changed greatly affected by human activities in Xinjiang, China. Population there has increased from 4.3 million in 1949 to 17.9 million in 1999. Human activities developed quickly in the inland watersheds in Xinjiang after 1950. More than 50% of river water is drawn into irrigation area, and all water in parts of little river is drawn to canal or reservoirs. However, there is evident hydrological effect caused by human activities.

Water distribution in arid land has changed. A lot of river water is drawn into oasis and water table inside of oasis has risen but declined out of oasis. However, water table has declined in some cities because of over pumping for groundwater. Stream process has changed after water drawing and drainage for irrigation. Runoff in the lower reaches of river has generally decreased, and the lower reaches of some rivers are even disappeared for stream. Large watersheds have been divided into several small watersheds. In some tributaries, most of the river water has drawn to irrigation area so that stream in the lower reaches has disappeared for years. There were 150 lakes in Xinjiang in 1950's; the area of lake was 9 000km^2. Some of them are contract and some are dried up. Tens of lakes in Xinjiang were dried up in last 40 years, and the area of lakes reduced for 4395km^2. Continuously dry up and contract of plain lakes are caused by human activities those changed the regional distribution of surface water. Water quality of inland rivers and lakes has generally deteriorated because it accepts drainage water from farmland and factories.

Such conditions pose challenges for adequate water distribution based on monitoring, planning and management of water resources.

2) In the Proceedings of the international Symposium of the Arid Land Research Center on: Role of Arid Land Agriculture for Overcoming Food Deficits in the 21st Century (5,Dec.2000)

THE PRESSURE OF WATER SHORTAGE TO AGRICULTURE IN THE ARID REGION OF CHINA

Abstract

The arid land in China is mainly in the North and Northwest. The Northern China is the main region for food produce, farmland there is 31.19% of the total farmland in China, and population is 26.01% of the Total in China, but water resources there is only 6.14% of the total in China. Groundwater is over pumped for 6.53 billion m^3 every year in the area of Beijing, Tianjin, and Hebei Province, water supply could not be meet demand there. The distribution of water in the Northwestern China is uneven and some inland rivers and lakes are dried up, and desert has expanded since river water in the up reaches is diverted for irrigation. Up to 2050, population will increase to 1.6 billion, and industry will develop fast, 50% of the supplied water will used by industry and resident, water for agriculture will decrease year by year. Water demand for agriculture in Yellow River Watershed will be increase of 5.6 billion m^3 in the future of 50 years, and in Northwestern China will increase for 1.7 billion m3. It will be impossible for Yellow River, it always drying up in the cold half year since 1984, to supply water to meet the demand.

To avoid water shortage on agriculture in the arid regions, it is necessary to divert water from the Yangtze River in the south of China, and to use water efficiently. It is the best way that to drip irrigation in agriculture, to recycle water in industry and resident, and control water pollution. Otherwise water shortage in the arid regions will restrict the development of agriculture in China.

3) Research paper about the experiment on the evapotranspiration from orange trees in greenhouse.

HOURLY VARIATION OF EVAPOTRANSPIRATION FROM ORANGE TREE INSIDE GREENHOUSE

Abstract

The experiment of evapotranspiration from orange tree was done inside the greenhouse at the Arid Land research Center of Tottori University. Tree lysimeters were set in the greenhouse and full of silver sand, one 4 year-growth orange tree grows in each lysimeter. The experiment for evapotranspiration from orange tree in the summer of 2000 and the winter of early 2001 were done in with enough soil moisture in the

lysimeter. In the greenhouse, main climate factors to effect evapotranspiration is air temperature and relative humidity; air temperature in greenhouse is 4°C higher the outside both in summer and in winter, but air humidity inside in summer is almost the same to outside. In August when monthly average air temperature is the highest in a year, daily evapotranspiration, which was unstable, was from lysimeter was about 8mm; and it was only around 0.8mm in winter. Maximum evapotranspiration rate in the noon in summer was about 1mm/h, and there was almost no evapotranspiration in the night and also no coagulation in summer. In winter, evapotranspiration was quite less and which was mainly evaporation of soil moisture. Most of the air holes of the leaves were closed in winter that water in the leaves evaporated hardly. Evaporation from soil moisture in winter increased in the morning and decreased quickly from the maximum about 0.15mm/h in the noon just in the afternoon everyday. The result showed that evapotranspiration inside of greenhouse is more that that outside in summer if soil moisture was enough, and water demand for evaporation in greenhouse will be more. And in winter, evapotranspiration from tree is quite limited; water demand for evaporation in winter is not so much.

(4) Professor Alexander Lux

COE Visiting Professor (Aug. 1, 2000-Mar. 31, 2001)
Comenius University, Slovakia
Title: *Analysis of morphological characteristics of drought tolerant crops*

My research activities have been performed in the Subdivision of Plant Ecophysiology, headed by Prof. S. Inanaga in close cooperation with him. I have also been involved in experiments of a number of graduate and Ph.D. students.

Research activities

Majority of my research activities has been focused on the elucidation of the role of silica deposition in plant organs and interaction of silica with drought tolerance. During my previous stay in ALRC in 1997 we have found higher silica deposition in roots of upland rice compared with lowland varieties. This indicated a possibility of relationship between silica deposition and drought tolerance in some plant species. This time I have selected sorghum, another silica accumulating crop, known for its high drought tolerance. Si content was determined by chemical quantitative analysis and simultaneously by environmental scanning electron microscope (ESEM) coupled with X-ray microanalysis equipment (EDAX). X-ray microanalysis is particularly suitable method for precise determination of Si deposition on tissue and cell level.

Field experiment: Study of silica content in sorghum varieties differing in drought tolerance

Two sorghum cultivars with different tolerance to drought were selected: Gadambalia - drought tolerant and Tabat - non-tolerant. Plants were grown in field conditions; the area was covered with transparent plastic, which permitted transmission of more than 95% of incident solar radiation. Plants were grown to flowering stage in well-watered conditions. Samples of leaves and roots were taken for determination of silica content. To eliminate the possible contamination of root samples by Si from the soil peeled roots were used. This technique is based on the possibility to remove epidermal and outer cortical layers of roots and separate them from stele surrounded by endodermis. Silica in sorghum roots is almost exclusively accumulated in endodermal cell walls. The Si content determined by quantitative chemical method in drought tolerant Gadambalia in root and leaf samples is 34 mg Si g^{-1} dw and 41 mg Si g^{-1} dw, respectively. The values for non-tolerant Tabat are 22 mg Si g^{-1} dw and 33 mg Si g^{-1} dw, respectively

For X-ray microanalysis specifically the tissues of maximum silica deposition were used: leaf epidermis and root endodermis. That is why the values are higher, than the values from chemical analysis of bulk samples of organs. Nevertheless the data of X-ray analysis are in good agreement with chemical analysis.

The data (expressed as weight per cent) for root endodermis and leaf epidermis of cv. Gadambalia are 36.8 and 23.7, respectively and for Tabat 20.5 and 21.2, respectively.

The higher values of root endodermal silicification found in drought tolerant sorghum cultivar indicated the importance of silica deposition for drought tolerance. Therefore in the next experiment the silica treatment in combination with drought stress was investigated.

Pot experiments: Study of silica treatment on drought tolerance of sorghum

Three pot experiments were conducted to study the effect of silica treatment on the drought tolerance.

In the first experiment the plants were grown in greenhouse conditions (Arid Dome) under partially controlled conditions: day/night temperature 30/20^{o}C, relative air humidity 65% and natural day light. Two cultivars used previously were grown in well-watered and dry conditions. Plants were cultivated in vermiculite and peat moss (low silica content mixtures). Four silica treatments were used: 0, 0.5, 1 and 5 g Si per pot. The results showed almost no difference in growth and physiological parameters between the treatments in well watered conditions. However, in dry conditions, the growth in Si treatments was significantly improved. In the treatment 5 g Si per pot the total leaf area and shoot dry weight were approximately two times higher when compared with 0 g Si per pot. A great difference was also found in relative water content of leaves, with higher values after silica application.

In the second experiment the plants of both varieties were grown in growth chamber under fully controlled conditions. Day/night temperature was set to 35/25^{o}C, relative air humidity at 30% and the light intensity at 80.000 lux. In this experiment only peat moss was used for cultivation and Si+ and Si- treatment was applied as silicic acid prepared by the Okuda and Takahashi (1961) method. This method eliminates a possible influence of soil pH, changed by potassium silicate application. The results of this experiment were similar to the first one. Apart of the higher biomass of shoots after Si application a higher biomass of roots was also observed. In high temperature and low air humidity, under severe drought stress conditions in this experiment, significantly reduced leaf senescence was found in Si+ treatment.

The third experiment repeated the treatment of the first experiment in fully controlled environmental conditions of growth chamber (same as in experiment 2). Precise evaluation of growth and physiological parameters confirmed positive influence of silica application for sorghum in drought conditions.

The new findings of this research might be of particular interest for sorghum production in arid and semiarid conditions. Soils in these regions are often poor in silica content. However, the importance of silica for sorghum, particularly in drought conditions, opens new possibilities for improved growth of this important crop of dry regions.

Okuda, A., Takahashi, E. 1961: J. Sci. Soil Manure, Japan 32, 475-480.

Teaching activities

A lecture of plant cells structure and anatomy of roots was given to the graduate class of prof. Inanaga. Various methods of sample preparation for anatomical analysis of plant material were demonstrated and explained to the students of Subdivision of Plant Ecophysiology. Operation of environmental electron microscope and EDAX microanalyser was also taught to one of the students (Mr.Hatttori) who was interested to learn it.

Editorial activities

I edited several English manuscripts of staff and students and often also helped with organization of manuscripts and interpretation of the results. In collaboration with Ph.D. student Miss An Ping a paper was finalized and accepted for publication during my stay in ALRC [AN, P., INANAGA, S., KAFKAFI, U., LUX, A., SUGIMOTO, Y.: Different effect of humidity on growth and salt tolerance of two soybean cultivars. Biologia Plantarum 44 (in press)].

Presentations and visits

Presentation on research results obtained during my stay at ALRC was given at a seminar held in the Arid Land Research Center (January 17, 2001).

A special invited seminar was given at the Annual meeting of cooperative research projects of ALRC Tottori University, held on December 6, 2000, entitled "Phytoremediation - the use of plants to remove toxic substances from the environment".

As an invited speaker I attended an International Conference "Ecosystem Service and Sustainable Watershed Management towards Flood Prevention, Pollution Control, and Socio-Economic Development in North China" held on August 23-25, 2000 in Beijing, PR China, (lecture entitled: Renaturation of degraded forests and natural wetlands and construction of semi-natural wetlands designed from native woody plants).

I attended the Annual meeting of Japanese Society for Root Research (JSRR) held in Nagoya (November 25. -26, 2000)

I stayed several days in Laboratory of Prof. Tanimoto (Nagoya City University) and used transmission electron microscope for some detail structural studies, with the kind allowance of this institution. (December 2000).

I have also visited laboratory of Dr. Morita and Dr. Abe, (Department of Agricult. & Environment. Biology, Graduate School of Agric. and Life Sci., The Tokyo University), basing of their kind invitation. (February 10. -14, 2001).

I discussed various research subjects of mutual interest with many researchers and professors at visited institutions and with numerous Japanese colleagues and friends at the annual meeting of JSRR. This society is organizing the 6th ISRR (International Society of Root Research) Symposium, which will be held in Nagoya in November 2001. As a member of Organizing Committee of this international symposium and one of invited speakers I discussed the program and organization of this meeting and help with the preparation.

(5) Professor V. Rasiah

Visiting Professor (October 1st /2000 to September 30th/2001)
Government Department of Natural Resources, Australia.
Title : *Sustainable Irrigation Schedules for Degraded Arid Lands*

Research Activity

My research was conducted in the Land Conservation subdivision laboratory headed by Professor Yamamoto, who is also my host professor at ALRC. The research was conducted in collaboration with Dr. T. Yamamoto, Dr. M. Inoue, and Mr. M. Imai. I took the initiative to critically identify and prioritise the issues associated with the use of poor quality water (saline water) for irrigation in Arid/Semi-arid environment and the outcome is reported as a review paper in Japanese Journal of Rural Engineering (see publication list). The issues identified in the aforementioned review paper were used in formulating my research undertaken in ALRC. It was agreed that for better continuity of the research issues identified, graduate students should be involved in the program and selected research objectives could be used for their theses. In this regard, Dr. Yamamoto was grateful to engage a M. Sc. student, Mr. Makato Imai, in the research program so that he could continue to work on the identified issues after my departure. For the research program, Dr. Yamamoto agreed to purchase the costly mini-TDR sensors and related accessories. Preliminary studies were conducted in a temperature-controlled room and the results are summarised submitted as a journal paper to Jap. J. Arid Land Research (see publication list). Mr. Imai also used the data from the same experiment and gave a presentation at the national meeting of the Japanese Society of Irrigation, Drainage, and Reclamation held in Morioka, Japan (see meetings). Mr. Imai is continuing his research now in growth chambers and I hope to collaborate with him, from Australia, in his thesis preparation. I strongly believe that I my research activities in ALRC enabled the Land Conservation

subdivision to better focus their attention in resolving and addressing priority issues in salinity-irrigation-mulch interrelation as it relates to arid/semi-arid environment.

During my sabbatical period here, I was able to complete and submit two papers, from my previous studies, to refereed journals with Dr. Yamamoto as co-author (see publication list). The subject matters reported in these two papers are relevant to Arid/Semi-arid land management and water quality.

Manuscript Reviewing and Editorial Activities

I served as reviewer for two manuscripts submitted to Sand Dune Research. I re-reviewed these manuscripts on editorial committee's request. I served as an internal reviewer for a paper prepared by a Ph. D. student and the paper was submitted to the Japanese Journal of irrigation, Drainage and Reclamation Engineering. I was able to help students and staff in editorial activities related to summary of Ph. D. thesis, oral presentations, and annual report preparation.

Publications submitted and revised during the sabbatical

1. Rasiah, V. and T. Yamamoto. (2001). Mulching, evaporation, and salinity interrelation in arid/semi-arid environment – a review. *Revised after the first review and submitted to the Jap. J. Rural and Environmental Engineering.*
2. Rasiah, V. and T. Yamamoto. (2001). Maximum potentially dispersible and stabilizable clay under cropping in soils with inherent textural differences. *Revised after the first review and submitted to the J.Jap. Society of Soil Physics.*
3. Rasiah, V., M. Imai, T. Yamamoto, and M. Inoue. (2001). Evaporation losses from dune sand: Influence of column and gravel size. *In review by the J.Arid Land Research.*
4. Rasiah, V., J. Armour, and T. Yamamoto. (2001). Nitrate-N in shallow groundwater under sugarcane in the wet tropics of Australia. *In review by the Water Air and Soil Pollution J.*

Presentations/Participation at National Meetings

1. Rasiah, V. (2000). In search of sustainable soil management practices under cropping. National Joint Research Meeting held in Tottori on Dec. 4th, 5th, and 6th / 2000 (Oral presentation).
2. Imai, M. Rasiah, V., T. Yamamoto, and M. Inoue. (2001). Evaporation losses from dune sand: Influence of column and gravel size. National Meeting of the Japanese Society of Irrigation, Drainage, and Reclamation Engineering held in Morioka July 27th and 28th / 2001 (Oral presentation).
3. Participated and contributed, through questioning, in the National Meeting of the Japanese Society of Irrigation, Drainage, and Reclamation Engineering held in Tokushima November 14th and 15th / 2000.

Professional contacts/meetings with scientists from other universities

1. Faculty of Environmental Sciences, Okayama University. Met with Dr. Takeo Akae and exchanged concepts and views in current environmental issues in Japan and Australia. Visited the Bioreosurces Institute and had similar exchange with Dr. Shigemi and Dr. Kimura.
2. University of Kyoto, Kyoto. Met with Prof. Toru Mitsuno and Dr. Kimihito Nakamura and exchanged concepts and views in research activities of mutual interest, particularly solutes in fluctuating groundwater in terraced paddy fields and denitrification in paddy fields.
3. Iwate University, Moirioka, met with Dr. Noborio, Soil Physicist who has been to University of Guelph in Canada where I worked for seven years. Exchanged concepts and views in N-pollution and estimation of hydraulic parameters.
4. Tokyo University of Agricultural Technology, met with Dr. Koki Toyota (soil microbiologist) and exchanged concepts and views in soil microbial processes, aggregation, and C and N-mineralization.

Introductory talks to students in the Land Conservation group

1. My research background and discussion with students in their research programs.
2. An informal talk on 'Evaporation Losses in Arid Environment'.

Special Open lectures at the Center

1. Inverse method for the estimation of hydraulic parameters in soil-water flow models.

2. Application of fractal mathematics in Soil Science to characterise number-size distributions, particularly aggregate- and pore-size.
3. Integrating the influence of soil physical, chemical, biological properties to characterise microbial activities in soils.
4. Pedotransfer functions and its applicability in Soil Science.

Assistance to students

1. Advising the M. Sc. thesis research work of Mr. Makato Imai
2. Assisting in manuscript preparation, for Ph. D. requirement of Mr. Hossein Dehghani Sanij.

Summaries of the manuscripts submitted and in review.

1. Velu Rasiah and Tahei Yamamoto : Mulching, evaporation, and salinity interrelation in arid/semi-arid environment - a review. (*In second review: Journal of Rural and Environmental Engineering*).

Summary

Mulching to reduce evaporation losses (EL) from small farms, which is the predominant agricultural production system in the arid and semi-arid regions of Africa and Asia, is a common practice. To increase crop yield in these farms irrigation seems to be a necessity. However, the water resources available for irrigation in arid and semi-arid environment are limited and saline or capable of inducing salinity through shallow groundwater table development. In this context, we reviewed the information available in literature on mulching, evaporation, and salinity (MES) interrelation in-order to assess the sustainability of agricultural production systems in small farms using saline water resources and mulches. It is surprising to find the information on MES interrelation is practically non-existent even from drying column studies. However, results from a 4～6 year in-situ legume green-manure cover crop, as a mulch, study from California indicate potential exists for salt accumulation in the rooting-zone under saline drainage water irrigation. Without exception, almost all the reviewed studies indicated substantial reduction in EL under mulching. Three new issues, however, emerged from the review. First, though gravel mulching reduced EL, the savings could be counterbalanced by gravel induced reduction water vapor adsorption during night. Second, the influence of gravel mulch on EL and rainfall infiltration was determined by gravel size. Third, the depth and rate of straw mulch incorporation had significant influence on EL. The review indicated the need for information on EL and water vapor adsorption under different mulches, mulch rates, mulch incorporation depth, and the MES interrelation under these different scenarios. In the absence of sufficient information in the above complex interrelation, it is suggested that for immediate need, surveys of saline water irrigated field histories be supplemented with drying column experiment results to seek answers for this complex interrelation.

2. Velu Rasiah, Makato Imai, Tahei Yamamoto, and Mitsuhiro Inoue : Evaporation losses from dune sand: Influence of column and gravel mulch size. *(In review: Journal of Arid Land Reseacrh)*

Abstract

To clarify the issue of evaporation losses (EL) from different size columns and the effectiveness of mulches in reducing EL from sandy soils, we conducted column experiments in a temperature-controlled room. The major emphasis was on EL during the first stage of drying, which is not controlled by soil-water availability. The EL and diffusivity (D) from larger columns were higher than smaller, whereas the evaporation rates (ER), computed using EL and column size, showed an opposite trend. Though sandy soils may be self-mulching during drying, our results show that gravel mulching reduced EL, ER, and D even during the first stage of drying. Smaller gravel was more effective than larger in reducing EL, ER, and D. The D was found to be a more sensitive evaporation index than EL or ER in discriminating treatment influence on evaporation mechanism. Because, the values of the evaporation indices obtained from column experiments depended on column size, it is suggested that due consideration be given when such results are used as guide for adopting soil-water management practices in the field.

3. Velu Rasiah and Tahei Yamamoto : Maximum potentially dispersible and stabilizable clays under cropping in soils with inherent textural differences. *(In second review second: Journal Japanese Society of Soil Physics)*

Abstract

Physical and mechanical stresses induced changes in clay dispersion is a major sustainability and environmental issue, particularly in large-scale intensive agricultural production systems. However, the dispersed clay may re-stabilize when the stresses are reduced or minimized/removed. The objectives of this study are to (i) quantify the maximum potentially dispersible (DC_{max}) and stabilizable clay (SC_{max}) in soils with textural differences when the stresses were introduced and reduced, respectively, and (ii) identify the role of inherent soil variable(s) on DC_{max} and SC_{max}. Dispersible clay measurements were conducted at monthly intervals for 3 years on seven soil types under different cropping treatments. The cropping treatments used in this study were conventionally tilled continuous corn (CTCC) and forages, which were established in 1989 on plot that were previously under CTCC for more than 10 years. The CTCC represents stress imposed and the forages the stress reduced system. The DC_{max} in the stress imposed system across soils ranged from 3.2 to 16.6% compared to 6.4 to 33.8%, the total clay (TC) content. The DC_{max} increased with increasing TC and decreasing soil organic matter (SOM) content. The SC_{max} in the stress reduced system across soils ranged from 1.2 to 4.5% and it increased with increasing TC and SOM. Eleven to 37% of the DC_{max} was re-stabilized during the 3-year period under forages, i.e. stress reduced system. The amount of SOM in the soil at the time of switchover from CTCC played a significant role in the re-stabilization of dispersed clay, particularly in soils with similar TC. The results show the stabilization of dispersed clay under reduced stresses depended on DC_{max} and SOM.

4. V. Rasiah, J. D. Armour, and T. Yamamoto : Nitrate-N in shallow groundwater under sugarcane in the wet tropics of Australia. (In review: Water Air and Soil Pollution)

Abstract

Thirty to 130 kg of NO_3-N ha^{-1} yr^{-1} that leaches below crop root-zone, particularly during the wet season, in the wet tropical Far North Queensland (FNQ) of Australia, may be entering the water resources in the catchment. The objectives of this study were to (i) provide quantitative information on the amounts of NO_3-N in the shallow fluctuating groundwater (GW) that develops during the wet rainy season (January through May) in the Johnstone River Catchment (JRC) of FNQ and (ii) determine whether this NO_3-N is potentially transportable to creeks and streams. The NO_3-N concentration and GW table heights were monitored, at least at weekly intervals, in 6 piezometers, installed to 12.5 m depth in 6 different soil types under fertilized sugarcane (*Saccharum Officinarum*-S) in JRC during the 1999 wet season. Depending on the location of piezometers in JRC and on the landscape and time of water sampling, the GW table in the piezometers fluctuated between 1.5 to 11.5 m (spatio-temporal dynamics), from the bottom, during the wet season. The NO_3-N concentration in fluctuating GW also showed spatio-temporal dynamics and it ranged from 0.60 to 3.70 mg L^{-1}. The NO_3-N adsorbed at the anion exchanges sites, up to 10 m depth, under sugarcane ranged from 154 to 3965 kg ha^{-1} compared with 20 kg ha^{-1} under rainforest. In the fluctuating GW, the NO_3-N concentration increased with increasing GW table height and the NO_3-N adsorbed at anion exchange sites ($R^2 = 0.96$). The NO_3-N load in the GW ranged from 40 to 110 kg ha^{-1} and it increased with increasing GW table height and the NO_3-N concentration in GW. The estimated N-load in the GW water that discharged into creeks/streams when the GW table receded ranged from 21 to 81 kg ha^{-1}. The results provide evidence for that a (i) major proportion of the NO_3-N that was leaching below sugarcane root-zone entering the shallow GW that developed during the wet season, and (ii) significant proportion of the NO_3-N in the GW was transported to creeks/streams when the GW table receded.