

2.3 Joint Research

(1) List of Joint Research

Title of Joint Research Project

** A representative of joint research to carry out each project*

A-1) Micrometeorological Improvement of Agricultural Fields in Arid Lands

CO₂ and Water Exchange in Soil-vegetation-atmosphere System at Sand Dune Field

*Kazuhiko OBA**, *Kyoko NAKAMOTO*, *Atsushi MARUYAMA* and *Makio KAMICHIKA*

Numerical Simulation of the Formation of the Various Sand Dunes

*Tetsuya KAWAMURA**, *Hiroshi SUITO*, *Makiko KAN*, *Yuko SATO*, *Makio KAMICHIKA*
and *Reiji KIMURA*

Study on the Behaviors of NO₃-N in Sand Dune

*Changyuan TANG**, *Yasuo SAKURA* and *Makio KAMICHIKA*

A-2) Irrigation Management for Water and Salinity Control in Soil

Measurements of Water and Salt Behavior in Soils Using TDR Method

*Jiro CHIKUSHI** and *Tomohisa YANO*

Studies on the Development of Low Cost Irrigation Facility

*Soichi NISHIYAMA**, *Yuya TAKEDA* and *Tomohisa YANO*

Relationship between the CO₂ Flux and the PPFD in a Rice Field

*Hiromichi ODANI** and *Tomohisa YANO*

A-3) Physiological and Morphological Responses of the Plants Arid and Saline Conditions

Analysis of Mechanical Properties of Growing Cell Walls in Adventitious Roots of Tea Plants Modified by Plant Hormones and Water Environment

*Eiichi TANIMOTO** and *Shinobu INANAGA*

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Effect of Drought on Water Transport in Crop Roots

Hideki ARAKI and Shinobu INANAGA*

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Hideyasu FUJIYAMA, Mariko OKA and Kunio HAMAMURA*

Morphological, Physiological and Utilization Studies on a Halophyte Expected to be Cultivated on Saline Water Irrigated Fields

Katsuyoshi SHIMIZU and Kunio HAMAMURA*

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Studies on Salt Tolerance of Tree Species

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Fundamental Studies on the Creation of the Sustainable Greens

Katsuhiko YABE and Shigenobu TAMAI*

A-6) Studies on Farm Land Conservation in Arid Lands

Effects of Chemical Amendment and Surface Coverage on Soil Loss

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Evaluation of Meteorological Condition in Loess Plateau by Satellite Data

Nobuhiro MATSUOKA and Makio KAMICHIKA*

Thermal Environment Monitoring from Space

Masao MORIYAMA and Makio KAMICHIKA*

Analysis of Landuse Change on Large Scale Irrigation Project Area in Arid Land by Geostatistical Procedure

Kiyoshi TORII and Tahei YAMAMOTO*

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Studies on Chemical Properties of Undisturbed Soil -Cation Exchange Capacity-

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Preferential Flow Effect on Solute Leaching

Hiroyuki CHO and Makio KAMICHIKA*

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Ken YOSHIKAWA and Shigenobu TAMAI*

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Tsutomu HAYASHI, Yutaka HARA and Makio KAMICHIKA*

The Effect of Soil Desiccation on Transpiration Rate in Semiarid Plants under Warming Climate Condition

Tohru KOBATA, Fumihiko ADACHI and Shigenobu TAMAI*

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Water Flow and Solute Transport in Undisturbed Soils

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Soil Water and Temperature Dependence of Thermal Conductivity of Tottori Dune Sand

Tatsuaki KASUBUCHI, Toshihiko MOMOSE and Mitsuhiro INOUE*

Plant N Use under the Water Stress Condition

Naoko TOKUCHI and Norikazu YAMANAKA*

Mycorrhizal Symbiosis as a Resistant Factor of Japanese Black Pine, *Pinus Thunbergii*, to Pine Wilt Disease Occurring at Coastal Sand Dune

Kazuyoshi FUTAI, Fukuju YAMAMOTO, Shigenobu TAMAI and Norikazu YAMANAKA*

Measurement of Solute Transport by a Soil Water Flux Meter

Koji INOSAKO and Mitsuhiro INOUE*

Influence from the Behavior of Pore Air to the Seepage of Rainfall into the Ground

Koji KAMIYA and Mitsuhiro INOUE*

Determination of Saturated and Unsaturated Moisture properties of Soil and Subsoil

Toshihiro MORII and Mitsuhiro INOUE*

Dynamics of Water and Energy in a False Acacia Forest

Kyoichi OTSUKI, Yasuhiro UTSUMI, Norikazu YAMANAKA and Reiji KIMURA*

Investigation for Physiology of Crop in the Arid Area of China

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Research on Improvement of the Accuracy for in-situ Constant Head Permeability Tests in Unsaturated Soil

Yuji TAKESHITA, Masahiro YAMASHITA and Mitsuhiro INOUE*

Research on Zero Emission of the Percolating Water by Advanced Water Saving Irrigation System

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Tsugihiko WATANABE, Takanori NAGANO and Tomohisa YANO*

Determination of Parameters in Root Water Extraction Models under Saline Irrigation

Haruyuki FUJIMAKI and Mitsuhiro INOUE*

Studies on Fluid Transport Considering with Phase Transition

Tadao AODA and Tomohisa YANO*

Studies on Improvements of Water Qualities and Soil Properties by Porous Grass Materials

Tomonori FUJIKAWA and Shinobu INANAGA*

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Ken'ichirou KOSUGI and Mitsuhiro INOUE*

Simultaneous Measurement of Water Flow, Solute and Heat Transport Properties Using a Multi-Functional Sensor

Yasushi MORI and Mitsuhiro INOUE*

Modeling of Phenological Development in Wheat Grown under Drought Environments

Hiroshi NAKAGAWA and Tomohisa YANO*

Cultivation of Vegetables under Controlled Soil Moisture Content

Satoshi YAMADA, Koji INOSAKO and Mitsuhiro INOUE*

Physiological Responses of Plants to Salinity Stress

Yukihiro SUGIMOTO and Shinobu INANAGA*

(2) Summary of Joint Research

A-1) Micrometeorological Improvement of Agricultural Fields in Arid Lands

CO₂ and Water Exchange in Soil-vegetation-atmosphere System at Sand Dune Field

*Kazuhiko OBA**, *Kyoko NAKAMOTO**, *Atsushi MARUYAMA** and *Makio KAMICHIKA***

*National Agricultural Research Center for Kyushu Okinawa Region

**Arid Land Research Center, Tottori University

In-situ measurement of soil CO₂ concentration was conducted in a bare sand dune field and a bare Andisol field to find out the behavior of gaseous CO₂ in soil. For the further investigation, the soil gas diffusion coefficient in core samples of each soil was also measured. The soil CO₂ concentration of the sand dune field was five times smaller than that of the Andisol field because of quite small amount of organic matter in the sand dune soil. The soil CO₂ profile of the sand dune field was not well developed, comparing with that of the Andisol field. The rise and fall in soil CO₂ concentration during rainfall events were very quick, compared to those of the Andisol field. The soil CO₂ concentration of the Andisol field remained high for a few days after a rainfall event. The gas diffusion coefficient of the sand dune soil was smaller than that of the Andisol soil within the high soil moisture beyond the field capacity. However, for the low soil moisture, the gas diffusion coefficient of the sand dune soil was greater than that of the Andisol soil. It was concluded that the simple structure and the coarse porosity of the sand dune soil promoted gas diffusion in the soil with low soil moisture while those properties greatly prevented gas diffusion as soil moisture increased.

Numerical Simulation of the Formation of the Various Sand Dunes

*Tetsuya KAWAMURA**, *Hiroshi SUITO***, *Makiko KAN****, *Yuko SATO*****,
*Makio KAMICHIKA****** and *Reiji KIMURA******

*Graduate School of Humanities and Sciences, Ochanomizu University

**Faculty of Environmental Sciences and Technology, Okayama University

***Showa High School

****Computer Center, Gakushuin University

*****Arid Land Research Center, Tottori University

Various sand dunes are found in a desert which have typical configurations, e.g. the barchan dunes, the transvers dunes, the linear dunes and the star dunes. Most observers recognize them as four elemental types of sand dunes. In this study, transvers dunes and linear dunes are simulated in order to make clear

the mechanism of the formations of them and the flow above the sand dunes are also investigated.

The numerical employed in this study consist of the following three parts.

- (1) Calculation of air flow above the sand dunes.
- (2) Estimation of the sand transfer caused by the flow.
- (3) Determination of the shape of the sand dune.

Since the shape of the sand surface is changed due to step (3), Steps (1)-(3) are repeated until prescribed times.

In the simulation of transvers dunes, three hills are put on the sand surface as the initial conditions. When the wind blows from one direction, the arms of three hills are connect each other firstly, when a steady state is arriving, it becomes essentially parallel straight rigdes at right angle to the wind direction with only one slip-face on lee side.

In the simulation of linear dunes, when the winds changes periodically in two directions, the simulated dunes extends in the converging directions firstly, then, when the steady state is arriving, it becomes essentially parallel straight ridges in converging direction with two slip-faces on both sides.

Study on the Behaviors of NO₃-N in Sand Dune

*Changyuan TANG**, *Yasuo SAKURA*** and *Makio KAMICHIKA****

*Graduate School of Science and Technology, Chiba University

**Faculty of Sciences, Chiba University

***Arid Land Research Center, Tottori University

In order to make clear how and where natural attenuation processes happen in wetland which is an important part of the headwater, a typical headwater in Chiba, Japan was chosen to investigate nitrate behaviors in groundwater. Major ions and $\delta^{15}\text{N}$ of groundwater from piezometers, wells and spring were analyzed. When the groundwater from the upland moved up across the wetland, nitrate concentration in groundwater decreased rapidly in the place several meters from the upstream boundary of the seepage zone because of denitrification. However, chemistry and $\delta^{15}\text{N}$ data provide strong evidences that the behavior of nitrate in the spring water was different from that in the seepage zone, since both dilution and denitrification processes were involved in the decrease of nitrate concentration in groundwater.

A-2) Irrigation Management for Water and Salinity Control in Soil

Measurements of Water and Salt Behavior in Soils Using TDR Method

Jiro CHIKUSHI and Tomohisa YANO***

*Biotron Institute, Kyushu University

**Arid Land Research Center, Tottori University

A soil water control system based on the TDR measurements was constructed for controlling soil water content more precisely, and further the effect of reference depth (RD) on the control was investigated. A soil column filling with sandy soil was used for the experiment. TDR probes were installed at three depths of 5, 15, 25 cm. TDR-measured data were saved in a data logger and used for the control of water application. For the RD of shallow depth, in initial stage the water contents at deeper locations indicated delayed responses due to the travel time of water to the locations, and afterward were kept at almost constant values. Irrigation, in this case, was performed with high frequency and higher amount of water. On the other hand, for the RD of deeper location, water content profile varied with a time period and the width of the period reduced with depth. An intermittent irrigation was performed in this case. From these results, it was suggested that the RD greatly affects the controlled soil water profile and the amount of irrigation water.

Studies on the Development of Low Cost Irrigation Facility

Soichi NISHIYAMA, Yuya TAKEDA* and Tomohisa YANO***

*Faculty of Agriculture, Yamaguchi University

**Arid Land Research Center, Tottori University

The hydraulic characteristic of flow meter using the pipe bend was clarified. The outside and inside parts of the pipe bend were connected by the small pipe. In this route, the bypass water flow is generated by the centrifugal force of flowing water in the curved main pipe. The hydraulics of water flow in bypass route of the curved pipe is characterized by the centrifugal force line. The relationship between main pipe flow and bypass flow rate is discussed, and the hydraulic design procedure of flow meter using the curved pipe with bypass flow is also described.

The adjustment of flow resistance in bypass route was also proposed.

Relationship between the CO₂ Flux and the PPFD in a Rice Field

Hiromichi ODANI and Tomohisa YANO***

*School of Environmental Science, University of Shiga Prefecture

**Arid Land Research Center, Tottori University

The CO₂ fluxes from a rice canopy were estimated with the energy balance flux ratio method. The relationships between the CO₂ flux and micrometeorological factors, such as the photosynthetic photon flux density (PPFD), air temperature, the friction velocity, and the water deficit in the air, were examined. Results obtained were as follows:

1. The various values of the CO₂ flux were obtained even for any small range of the PPFD, air temperature, the friction velocity, or the water deficit in the air.
2. The index of Iwssd was defined as the ratio of the friction velocity to the water deficit in the air. At almost constant air temperatures, the CO₂ flux increased gradually with the Iwssd, and decreased gradually after that. The maximum value of CO₂ flux was obtained at a value of Iwssd. The maximum value was the greatest for air temperatures ranging from 29.5 to 31 .
3. The maximum value of CO₂ flux was obtained at a value of temperature for the constant value of Iwssd, but the CO₂ flux decreased markedly at both higher and lower temperatures.

A-3) Physiological and Morphological Responses of the Plants Arid and Saline Conditions

Analysis of Mechanical Properties of Growing Cell Walls in Adventitious Roots of Tea Plants Modified by Plant Hormones and Water Environment

Eiichi TANIMOTO and Shinobu INANAGA***

*Graduate School of Natural Sciences, Nagoya City University

**Arid Land Research Center, Tottori University

Mechanical properties of cell walls control the growth and morphology of roots. Plant hormone, gibberellin(GA), is known to regulate the growth and morphology of roots. Role of GA for growth regulation of roots and the mechanism of low-pH induced cell-wall extension have been elucidated in herbaceous roots. However, little information is available for woody roots. Tea (*Camellia sinensis* L.), a woody plant, is well known to grow well in acidic soil. Shoot cuttings of tea actively develop adventitious roots and they produce white roots in hydroponics. Tea roots provide a good experimental material of woody plants for physiological and morphological studies on root cell-walls. This study aimed to obtain cytological and physiological information of tea roots and characterize the acid-tolerant growth of tea roots by measuring viscoelastic properties of root cell walls under acidic conditions by comparing with the previous evidences accumulated in herbaceous roots such as pea, maize, and sorghum.

We observed morphological characteristics of tea roots at the apical part of soil-grown and hydroponics-grown roots, focusing on the development of endodermis and exodermis. Mechanical properties of cell walls were also analyzed for every one-mm distance from the root tip. A cytological characteristic of tea root was the early development of endodermis and exodermis in the tip of roots. Well-developed stele and Casparian strips were observed at the extremely apical zone of secondary roots, even at the 1-mm distance from the root tip. The gradient of cell wall extensibility from the tip to the base was compared between soil-grown roots and hydroponics-grown roots. Soil-grown roots showed more rapid decline of extensibility at the apical 1-5 mm zone than that of hydroponics-grown roots. By comparing cytological observation and the gradient of cell-wall extensibility, the elongation zone of tea roots was found to be shorter than that of herbaceous roots such as pea and maize. The correlation between hardening of cell walls and development of Casparian strips suggested that the early ageing both in biochemical and in mechanical properties of cell walls is taking place at the apical part of roots. The low-pH response of cell walls was tested in vitro but little increase in extensibility was detected in tea roots in contrast to the case of pea roots. Relation of low-pH tolerance of tea roots to a lack of acid-response remains to be investigated. The chemical analyses of cell walls are under investigation to obtain the chemical basis of these observations.

Analysis of Crop Root System and Rhizosphere Soil Using New Research Methods

Jun ABE and Shinobu INANAGA***

*Graduate School of Agricultural and Life Sciences, The University of Tokyo

**Arid Land Research Center, Tottori University

Establishment of root system with high functional ability and suitable structure is necessary to promote plant cultivation in arid lands. However, most of traditional methods to evaluate root system of field grown plants are destructive and time-consuming. Moreover, knowledge on microorganisms in rhizosphere soil is also limited despite of their importance to plant nutrition and soil ecology because of insufficient research methods. In this study, we tried a non destructive method, "mini-rhizotron" to observe root system development in upland rice grown under rain-shelter as a model plant to study drought stress in plants. In addition, molecular biological techniques were applied to investigate bacterial biota in rhizosphere soil. Namely, DNA was collected from rhizosphere soils and a fragment of 16SrDNA was amplified by polymerase chain reaction (PCR). The amplified 16SrDNA was separated by denaturing gradient gel electrophoresis (DGGE) to evaluate the diversity of bacterial species according to the DGGE banding patterns. The data of mini-rhizotron well exhibited the features in root distribution of rice cultivars with different drought resistance. The result of DGGE analysis suggested the effects of soil-water conditions on the diversity of rhizosphere bacteria, although there needs some improvement in method to collect DNA from soil.

Effect of Drought on Water Transport in Crop Roots

Hideki ARAKI and Shinobu INANAGA***

*Faculty of Agriculture, Yamaguchi University

**Arid Land Research Center, Tottori University

Roles of hydraulic resistance of root system in SPAC (Soil-Plant-Atmosphere Continuum) have not been adequately understood. The subjective of this work was to elucidate effects of aging and water demand of atmosphere on the hydraulic resistance of root system where have the largest resistance in plants. High pressure flow meter was used for measurements of the hydraulic resistance for soybean and cowpea seedling. The axial resistance along base of a tap root became lower two weeks after sowing in soybean. The resistance of root system decreased as the water demand from atmosphere increased in cowpea seedlings.

A-4) Studies on Water-Saving Cultivation of Crops in Arid Lands

Nutrio-physiological Studies of Salicornia Species

*Hideyasu FUJIYAMA**, *Mariko OKA** and *Kunio HAMAMURA***

*Faculty of Agriculture, Tottori University

**Arid Land Research Center, Tottori University

In order to investigate the antagonism between nitrate and chloride absorption and to characterize nitrogen nutrition in Salicornia plants, a highly salinized water (EC:18.1dS/m) with three concentrations of nitrogen (NH₄NO₃) were irrigated to soil-grown plants in 4 L plastic pots. Three hundred milli litres of the water with 100, 300 and 500 mg/L N was daily irrigated.

There was no significant difference in fresh and dry weight of shoots and roots between nitrogen treatments. The nitrogen concentration of shoots and roots increased with an increasing nitrogen concentration of the irrigation water. The chloride concentration of shoots and roots also increased with increasing nitrogen concentration of the irrigation water. The N 300 treatment brought about the highest nitrate-N (NO₃-N) concentration in shoots and roots.

It was concluded from these results that there was no antagonism between nitrate and chloride absorption in Salicornia plants. It was suggested that Salicornia plants would not highly respond to nitrogen concentration in the media.

Morphological, Physiological and Utilization Studies on a Halophyte Expected to be Cultivated on Saline Water Irrigated Fields

*Katsuyoshi SHIMIZU** and *Kunio HAMAMURA***

*Institute of Agriculture and Forestry, University of Tsukuba

**Arid Land Research Center, Tottori University

It is important to cultivate halophytes with the irrigation water which is high in salinity concentration for preventing desertification / land degradation. Typical halophyte, Suaeda spp., especially *S. japonica* Makino is a kind of halophytes about which there are few reports. Therefore we tried to clear the response of *S. japonica* plants to saline environment (0.3(cont.), 3 or 6% NaCl treatment cultivation), morphological and physiological features, and utilization of the plants as forage, with comparing with the features another kind of halophytes, *Salicornia herbacea* L. which we have already reported. As a result, plant heights and dry weights of *S. japonica* were higher than those of *Salicornia* at harvest under 0.3 and 3% NaCl treatment cultivation. It was obvious that Na was accumulated more in leaves than in shoots or roots of *S. japonica*, and Na content of *S. japonica* plant increased with the increase of

salt treatment concentration. On the other hand, K, Ca and Mg content decreased with the increase of salt treatment concentration. Crude protein contents of leaves were increased with the increase of salt treatment concentration.

Both halophytes, *S. herbacea* and *S. japonica* showed very high salt tolerance. Therefore they are very useful to make the salt affected land turn green or as forage because of high content of crude protein. *S. japonica* is more promising than *S. herbacea* as forage because Na content of *S. japonica* was lower than that of *Salicornia*.

A-5) Eco-physiological Studies on Tree Tolerance to Water deficiency and Salinity

Studies on Salt Tolerance of Tree Species

*Tsuneo NAKASUGA**, *Shigenobu TAMAI*** and *Norikazu YAMANAKA***

*Faculty of Agriculture, Ryukyu University

**Arid Land Research Center, Tottori University

In this report, we examined the effects of light intensity and salt concentration of soil water to growth of mangrove seedlings. Two years old seedlings of three Okinawan mangrove tree species, *Bruguiera gymnorhiza*, *Kandelia candel* and *Rhizophora stylosa* were used.

In *Bruguiera gymnorhiza* seedling, degree of weakness(top weight/shoot length) and TR(top/root in weight)ratio were suppressed by low light intensity, the other way, specific leaf area(SLA)was accelerated by it. Under the 2% salt soil water condotion, shoot length and SLA were accelerated under the same light condition. In *Kandelia candel* seedling, shoot length,relative seedling height(shoot length/diameter), degree of weakness and TR ratio were suppressed by shade condition(35% relative light intensity), the other way, SLA was accelerated under the same condotion. Under the 2% salt soil water condition, shoot length of seedlings was accelerated. Under the 10% relative light intensity,SLA was accelerated, especially. In *Rhizophora stylosa* seedling, light intensity controlled shoot length, degree of weakness and TR ratio, but SLA was accelerated slightly. Under the 2% salt soil water condition, 70% relative light intensity accelerated the seedling growth, especially, SLA and TR ratio.

In three Okinawan mangrove tree species, the order of tolerance to low light intensity was *Bruguiera*>*Rhizophora*>*Kandelia*, and that to salinity was *Rhizophora*>*Kandelia*>*Bruguiera*, respectively. It was observed that the effects of low light intensity to the seedling growth were negated by salt soil water condition.

Fundamental Studies on the Creation of the Sustainable Greens

*Katsuhiko YABE** and *Shigenobu TAMAI***

*School of Environmental Science, the University of Shiga Prefecture

** Arid Land Research Center, Tottori University

It is the important problem how to develop and maintain the sustainable farmland. In the meantime, to develop the new farmland, recent years generally the construction is carried out by using the big equipment to the poor and insufficient soil without casting the sufficient nutrients and is tightly compacted. Therefore, the physical and chemical conditions are not always satisfied to the growth or the

production of crops.

So in this study, the experiments were repeatedly tried to improve the physical and the chemical properties of the soil by planting the green manure crop, and then plowing them into the soil. The green manure crops which were cultivated were seeded at early summer or later autumn, and then they were plowed into soil at early autumn or later spring respectively. However soil conditions of the physical and the chemical properties were not almost improved.

So in the next experiment, after the ripened cattle compost was spread on the soil surface and plowed into the soil, the green manure crops were seeded, and then plowed into soil after growing to some extent. Consequently, the dry weight of the biomass increased one and half times in comparison with the case without casting livestock manure, and the increase of the chemical components was observed only in the upper soil layer. And also the improvements of the physical conditions were hardly observed to the deeper soil layer from the upper.

Therefore, the most useful means are guessed that the green manure crops should be introduced in order to improve the soil conditions after the civil engineering technique is applied to the deeper soil layer and then the much organic compost is casted into the deeper soil layer.

A-6) Studies on Farm Land Conservation in Arid Lands

Effects of Chemical Amendment and Surface Coverage on Soil Loss

Taku NISHIMURA and Tahei YAMAMOTO***

*Graduate School of Agriculture, Tokyo University of Agriculture and Technology

**Arid Land Research Center, Tottori University

Presenting study discusses effect of gypsum and polyacrylamide (PAM) application on infiltration and erodibility of a Japanese acid soil. Acid Kunigami mahji soil from Okinawa was packed into an acrylic plastic box, and simulated rainfall of 40 mm/hr was applied. Prior to the rainfall, a 2.5t/ha of gypsum and/or 15 Kg/ha of non-ionic or anionic PAM were applied onto soil surface. During a rainfall, surface runoff was collected periodically, and sediment concentration, pH, and electric conductivity (EC) of the runoff was measured. Gypsum application enhanced surface runoff. During the rainfall, EC of the runoff was greater than the critical coagulation concentration of the clays of the mahji soil, however the soil became dispersive with gypsum application. PAM application could improve infiltration of gypsum amended mahji soil and reduce sediment loss.

Effects of Ca-Mg cations on dispersion and erodibility of variable charged soil was also studied under simulated rainfall. It was concluded that when electrolyte concentration is high enough, Ca and Mg had similar contribution on soil erodibility.

Outflow of Soil Nutrients due to Surface Runoff

Kingshuk ROY and Tahei YAMAMOTO***

*College of Bioresource Sciences, Nihon University

**Arid Land Research Center, Tottori University

Soil erosion always decreases the crop production and causes potential environmental hazards as well as human suffering. Erosion of soils by water reduces crop fields principally through the loss of nutrients and available water. In this research, the analysis about the mechanism of soil erosion was tried paying attention to the loss of three major essential plant nutrients (N, P and K) due to surface outflow. As the experiment method, three kinds of fertilizers (main ingredients are N, P₂O₅ and K₂O) were mixed in same type of soil and filled in erosion boxes (length: 70cm, width: 40cm, height: 9cm). Surface flows

with different intensities were generated on the soil in erosion boxes. From the result, the amount of nutrients flowed out in order of K, P, and N with the same amount of surface outflows was observed. Further experiments and analyses going concern target to investigate the correlation of the intensity of soil erosion and the outflow of nutrients in soil.

Importance of Surface Soil in Arid Area on Fertility Conservation
-Germination Characteristics of Pioneer Plant-

Yuichi ISHIKAWA and Tahei YAMAMOTO***

*Faculty of Bioresource Sciences, Akita Prefectural University

**Arid Land Research Center, Tottori University

The objectives of the study are to quantify the impact of soil disturbance through monitoring cleared land after mining and pot experiments, and to establish sustainable maintain soil fertility and rehabilitation technology. In order to clarify germination characteristics of selected species of pioneer plants by monitoring cleared land in a mine, germination tests of some species of the plants were carried out with different saline solution. Four species of *Atriplex* spp.; *A. codonocarpa*, and *A. holocarpa* that were annual plants, and *A. vesicaria* and *A. nummularia* that were perennial plants, were specimen. Seeds were sown in Petri dish filled with 4 concentration level of NaCl solution from 0 to 1.5 %w/v and left in a growing cabinet for 3 weeks. *A. vesicaria* had low germination rate i.e. less than 35% all through saline condition, on the other hand the rest of 4 species had greater than 90 % of germination rate in 0% NaCl solution and the germination rate decreased gently as the solution became saline. However there was not a significant difference on germination between annual and perennial plants. Comparing the former study, the germination rate of *A. vesicaria* was very low. The big difference of germination rate came from individual difference within a species. From the results, the pioneer plants had high germination rate under saline condition, though there were individual differences. The high germination made the plants as pioneer plants. On the other hand, if the plants can germinate easily, the plants were not able to reserve the seeds as 'seed bank', which might lead to unprofitable strategy for long period. Further study is needed to find other factors to control germination of pioneer plants.

A-7) Comprehensive Studies on Desertification Indicators and Traditional Knowledge

Study on Traditional System of Knowledge and Technology against Desertification

Yoshihito SHIMADA and Shinobu INANAGA*

Criticizing a popularly accepted vision of dry land as poor land, this paper remarked the richness particular to dry land. First, to understand this new idea, we must refuse the notion of "desertification"; the proper denomination is "drought". Even in the desert, men have lived and built their civilization.

As richness of dry land, three elements can be cited.

1. richness of agro-pastoral production. Grains crops can be cultivated only in dryland, exception for rice. Animal husbandary is also a speciality for dry land, exception for pig.

2. richness of rivers and oasis in dry land.

3. richness of transport culture because of the existence of big animals and no obstacle land without forest and rivers. Dry land has developed wide range communications and transport system covering thus many kind of peoples and regions. This lead to a "civilisation".

So called poorness of dry land is rather a result of recent modern rather political history which has largely destroyed wide range networks system; therefore each region became isolated.

Selection of Plant Indicators for Indicating Desertification Degrees

Ping AN, Hideyuki SHIMIZU**, Yong GAO**, Yuan Run ZHENG**
and Shinobu INANAGA****

*Global Environmental Forum

**National Institute for Environmental Studies

***Arid Land Research Center, Tottori University

The study was carried out to identify plant species as indicators of degree of desertification with the aim of providing a simple and practical complimentary measure for desertification assessment. Based on the objectives stated above, the distribution of plants in sandy rangelands with different degrees of desertification in Horqin and Mu Us sandy lands in north of China, Darfur district in northwest Sudan, and southern Tunisia were studied. Severity of desertification in these areas was divided into four levels: light, moderate, severe, and extreme. The following characteristics of vegetation changes with increasing severity of desertification were observed: a decrease in number of plant species, an increase in the proportion of drought tolerant plant species, a decrease in the proportion of palatable grass species, an availability of some plant species in areas with certain degrees of desertification, and an availability of

some plant species in several areas with different degrees of desertification. Plant species that were present only in areas with certain degrees of desertification were identified and recommended as indicator plants for the degree of desertification in a given area. For an extreme degree of desertification in the two sandy lands in China, Darfur district in Sudan, and southern Tunisia, one species, *Agriophyllum squarrosum*, three species, *Cissus quadrangularis*, *Ipomea carnea* and *Ricinus communis*, and four species, *Cleome Arabica*, *Hammada scoparia*, *Peganum harmala* and *Thapsia garganica* were recommended as indicator plants, respectively, because of their presence in only extremely desertified areas with species characteristics corresponding to their growing environments.

Key words: China, Degree of desertification, Plant indicator, Sudan, Tunisia.

B-1) Integrated Researches on Soil-Water-Plant Monitoring by Remote Sensing

Fundamental Study for Construction of Crop Growth Model Using Satellite Data

*Etsuji ISHIGURO**, *Muneharu SATO**, *Koichi IWASAKI**, *Sumitaka KASHIWAGI**,
*Hiroyuki KIKUKAWA***, *Keisuke YOSHINAGA***, *Akira HIGASHI*** and
*Makio KAMICHIKA****

*Faculty of Agriculture, Kagoshima University

**Faculty of Fisheries, Kagoshima University

***Arid Land Research Center, Tottori University

In recent years, many studies have been reported on remote sensing techniques in agricultural production to utilize the advantage of simultaneous and wider monitoring capability of satellite data. Several studies have been conducted to develop links between spectral reflectance and temperature for traditional paddy rice cultivation. In our study to characterize the spectral reflectance of rice leaves from 400 nm to 1,100 nm wavelength range was acquired with a handheld spectroradiometer. A wide range of nitrogen (N) was applied in experimentally field-grown paddy rice. To develop a growth model for paddy rice we analyzed physical parameters, spectral reflectance and fractional photosynthetically active radiation (fPAR). The following conclusions were drawn: (1) Different spectral characteristics were observed during the growth stage for different N-treatments: (2) Detection of significant differences between N-treatments was realized with the ratio vegetation index (RVI) at full heading stage: (3) Red edge points poorly correlated with leaf area index (LAI), dry weight (DW) and fPAR; (4) The R830/R550 ratio highly correlated with LAI and DW during the entire growing season. The prediction accuracy of fPAR was also very high using the R830/R550 ratio. Though our study accounts for only limited factors, it was concluded that growth models for monitoring paddy rice could be based on RVI and the R830/R550 ratio.

Evaluation of Meteorological Condition in Loess Plateau by Satellite Data

*Nobuhiro MATSUOKA** and *Makio KAMICHIKA***

*Faculty of Horticulture, Chiba University

** Arid Land Research Center, Tottori University

A sub-model for estimating soil moisture with Satellite data of GMS was examined for Ansai in

Shanxi province. The model was developed by Nakayama et al.(1989) and based on the water balance of soil column. It needs air temperature, solar radiation and precipitation. These meteorological factors were estimated by data from thermal and visible band of GMS.

We defined growth period was the period which air temperature exceeded 5 and during the period, the number of days with soil water content below first wilting point were 151 for Ansai. To keep its growth, irrigation of 239mm was needed during growth period. Water shortage in April, June and September was remarkable. There were no days with soil water content below the permanent wilting point and theoretically they can manage their plants without irrigation at Ansai.

A model for estimating soil moisture was developed and can predict the amount of irrigation. It will be applied to the prediction of the amount of irrigation for Yellow river basin.

Thermal Environment Monitoring from Space

Masao MORIYAMA and Makio KAMICHIKA***

*Faculty of Engineering, Nagasaki University

**Arid Land Research Center, Tottori University

To estimate the areal heat capacity from the satellite, an attempt is made to establish the simplified solution of the heat balance equation from the GMS based sequential brightness temperature observation. In the night time, for the contentious clear sky case, the surface temperature will be going down along with the heat capacity. The temporal heat balance equation is simplified into the linear differential equation which can be analytically solved. From the brightness temperature and the formal solution, the heat capacity can be estimated as the coefficient in the formal solution. The result shows the good correspondence with the land cover dataset.

Analysis of Landuse Change on Large Scale Irrigation Project Area in Arid Land by Geostatistical Procedure

Kiyoshi TORII and Tahei YAMAMOTO***

*Graduate School of Agriculture, Kyoto University

**Arid Land Research Center, Tottori University

Space Information data of earth surface, which was observed by space shuttle launched at January 2001, began to be open for public use. It was called SRTM(Shuttle Radar Topography Mission), 3 dimensional data, which cover 80 % of earth surface, the resolution is 30 m in horizontal, and 18 m in vertical direction. We can describe 3 dimensional landscape using both SRTM data and satellite images

by overlapping operatio. Any scale from global size to local size such as village can be drawn out in the shape of the topography. It becomes possible to discuss in the many view points, hydrological environment, landuse/cover, urban environment, meteorology, distribution of forest, ground water distribution on the common base of 3 dimensional landscape.

Author was in focus on landuse/cover change of large scale irrigation projects in the semi arid area of world and analysed how they make their landuse upgrade from new standing point.

B-2) Studies on Salt Accumulation and Leaching

Fractal Analysis on Recrystallization of Salts in Soil

Katsutoshi TAKUMA, Koji INOSAKO* and Hiroshi YASUDA***

*Faculty of Agriculture, Tottori University

**Arid Land Research Center, Tottori University

To evaluate formation of salt crust on the ground surface caused by the salt accumulation in arid environment, column tests were carried out. Dune sand in the columns were saturated by salt water and kept in the evaporation process to develop salt crust. Photos of the surface of sand were taken and transferred to 256 colored BMP type files. The BMP files were digitized and salt crust development was evaluated quantitatively. While the columns were in same condition during the evaporation process, the patterns of salt crust development indicated heterogeneity in addition to variation due to the columns. Coverage ratio of salt crust of some columns indicated almost whole of the surface, however that of others indicated only partially. Development of salt crust converged to equilibrium condition even for low crust coverage ratio.

Studies on Chemical Properties of Undisturbed Soil -Cation Exchange Capacity-

Sadahiro YAMAMOTO and Mitsuhiro INOUE***

*Faculty of Agriculture, Tottori University

**Arid Land Research Center, Tottori University

Cation exchange capacity (CEC) is one of the important soil chemical properties that greatly influences nutrients retention and solute movement in soil system, but CEC observed under field condition might be greatly different from CEC obtained in laboratory, as field condition is greatly different from the conditions of CEC analysis. As a first step to evaluate soil CEC under field conditions, CEC and exchangeable cations (ExC) of undisturbed soil (UDS) were determined under various concentration of ammonium acetate (AA) solution to saturate cation exchange site with NH_4^+ . It was clarified that ion exchange process was greatly different between UDS and uniformly repacked soil (disturbed soil; DS). CEC of UDS was lower than DS, and decreased remarkably with the decrease in concentration of AA. The amount of ExC decreased with decrease in CEC. ExC composition of UDS showed high rate of divalent cations such as Ca and Mg, especially in high AA concentration. Decrease in the amount of ExC of UDS caused by AA concentration decline was explained by decrease in the

amount of Ca and Mg.

As mentioned above, the decrease in CEC of UDS could be caused by the limitation of the effective area of AA, as solution flow was spatially limited in undisturbed soil. AA solution, however, is able to affect intensively on a specific site, it might be possible to exchange higher amount of cations by higher concentration of NH_4 in the solution, and the CEC value may be enhanced.

Mechanism of Simultaneous Transfer of Water, Solute and Heat

Yasutaka KIHARA and Mitsuhiro INOUE***

*Faculty of Life and Environmental Sciences, Shimane University

** Arid Land Research Center, Tottori University

Salt was accumulated heterogeneously even if soil was homogeneously. We conducted evaporation experiments by using a large column packed Tottori dune sand as homogeneously as possible. The purpose of this study was to clarify the degree of non-uniformity for water contents and salt concentrations according to depth. The degree of non-uniformity was evaluated by coefficient of variance(CV). The values of CV for both water contents and salt concentrations were largest at surface. Below 10cm depth CV for water contents was not changed. On the other hand, the value of CV for salt concentration distribution was decreasing.

Preferential Flow Effect on Solute Leaching

Hiroyuki CHO and Mitsuhiro INOUE***

*Faculty of Agriculture, Saga University

** Arid Land Research Center, Tottori University

Fingered flow caused by wetting front instability enhances solute leaching to the groundwater and reduces the amount of water available to crops. In the past decades, many aspects of fingered flow have been revealed, but the early stages of finger formation are still poorly understood. We tried to grasp the onset of finger formation through laboratory experiments and mathematical analysis. A narrow, vertical chamber with transparent walls was filled with air-dry glass beads and placed in a shallow water reservoir, which created a capillary fringe by wetting the porous medium from below. We then applied non-ponding artificial rainfall and observed the evolution of the pressure head pattern in the induction

zone (a uniformly wetted surface layer from which fingers protrude) with a large number of rapid-response microtensiometers. Through a modification of the Green-Ampt model, we developed an analytical expression for the pressure head at a given location in the induction zone as a function of time for uniform (non-fingered) flow.

C) Free Subject on Arid Land Studies

Study on Heat and Drought Tolerance in Common Wheat

Noboru NAKATA and Shinobu INANAGA***

*Faculty of Agriculture, Tottori University

**Arid Land Research Center, Tottori University

Two separate experiments were conducted using three wheat genotypes and three shoot/root temperature treatments. The first experiment was carried out during the vegetative growth, while the second one was executed during the grain filling period. In the first experiment, high root temperature effect was similar to high shoot/root temperature indicating the importance of the root temperature during the early stage of the growth. Similar reduction in xylem exudates and specific leaf area were found under high root temperature alone or in combination with high shoot temperature. In the second experiment, high root and root/shoot temperature significantly reduced the duration of the grain filling and accelerated the senescence of leaf. As a result, reduction in grain yield and biomass were found under both high temperature regimes and differential responses were observed among genotypes.

Effects of Light and Temperature on Chlorophyll Fluorescent Response of *Artemisia Ordosica*

Ken YOSHIKAWA and Shigenobu TAMAI***

*Faculty of Agriculture, Okayama University

**Arid Land Research Center, Tottori University

Plant species living in arid and degraded conditions must have effective properties against severe water stress and strong solar radiation. Drought treatments were carried out with seedlings of *Artemisia ordosica*, deciduous shrub species, growing in the Mu-U desert, China, to elucidate the water relations.

Seedlings growing under severe water stress tended to reduce their stomatal conductance in response to the soil drying and avoided losing water. While, seedlings growing under moderate water stress maintained the high activity of transpiration on acute water stress. The values of the bulk modulus of elasticity of seedlings growing on pF 4.2 treatment were higher than those values of seedlings on pF 3.0 soil moisture. It was suggested that *A. ordosica* growing on severe and moderate water stress controlled the stomatal openness in response to soil drought, respectively, because of the acquirement the bulk modulus of elasticity in leaf depend on the growing soil moisture conditions.

Comparative Study on Soil Factor Affected to Biological Production at Desert

*Kazuhisa HASEGAWA**, *Masao TOYAMA*** and *Kunio HAMAMURA***

*Ishikawa Agricultural College

**Arid Land Research Center, Tottori University

Relation with fertilizer placement of organic matter fermented residue of raw foods and plant growth in sandy soil was studied in the view of greening of desert by use of waste biological residue. Plant growth and root extension of flower and vegetable was observed on sandy soil and rootbox. The results of experiment are as follows. Mix application placement with all soil layer mixing placement of cover dressing and side point placement by stubble were concretely better placement method of fertilizer. Especially in case using 30×60×5cm rootbox better growth was observed by cover dressing and mixing placement of fertilizer of 200g contained total nitrogen 2%.

A Study on Condensation of Water Vapor for Use in Arid Land Agriculture

*Tsutomu HAYASHI**, *Yutaka HARA** and *Makio KAMICHIKA***

*Faculty of Engineering, Tottori University

**Arid Land Research Center, Tottori University

A water maker equipment using eight Peltier devices was made as an experiment. The power consumption is about 170W. The cooling fin arrangement, which condenses steam into water, was composed of copper plates. The cooling fin arrangement was sandwiched between two sets of four Peltier device arrangements. The size of the fins (length: 80,120,160mm) and amount of wind sent into them were changed, and the relation between the ventilation and the quantity of water produced was investigated.

In the case of middle size of fin arrangement (length: 120mm), the quantity of the produced water was more than the smallest fin case (80mm), although the temperature of the fins of the middle size became higher. However, in the case of the largest fin size (160mm), the quantity of the water decreased. This is because the temperature of the cooling fin becomes high too much due to the insufficiency of the refrigeration capacity of the Peltier devices against the enlargement of cooling fin area.

As the temperature of the cooling fins becomes the lower under the condition of no ventilation, the more water is produced. On the other hand, when there is ventilation between the cooling fins, the amount of the produced water increases as the ventilation gets stronger, as long as the fin temperature is less than the dew point. The efficiency of water production became high when the input electric power to the Peltier devices was small.

**The Effect of Soil Desiccation on Transpiration Rate
in Semiarid Plants Under Warming Climate Condition**

*Tohru KOBATA**, *Fumihiko ADACHI** and *Shigenobu TAMAI***

* Faculty of Life and Environmental Sciences, Shimane University

** Arid Land Research Center, Tottori University

The effects of soil desiccation on the response of transpiration rate to soil desiccation under elevated temperature and carbon dioxide concentrations in seedlings of Mediterranean two wheat cultivars were observed. Soil water content (% of field capacity) decreased by stopping of irrigation from 100 to 50 or 60 % in both cultivars under the ambient and the elevated temperature and CO₂ concentration conditions. In spring wheat Seri M82 ratio of transpiration rate slightly decreased although in winter wheat Bezostaya1 it was maintained till 60 % of field capacity regardless of the elevated treatments. There was not a clear difference in the response of the ratio of transpiration to soil water contents between the ambient and elevated treatment plots. During the soil desiccated treatment water use efficiency (WUE) increased in both cultivars under the elevated treatments although soil desiccation did not clear affected the WUE. Because vapor water deficit in the elevated treatment chamber was similar to that in ambient chamber, the increase of WUE did not seem to be cause by differences of air humidity.

Fundamental Study on Natural Plant Growth Regulators with the Aim of their Application

*Hikomitsu NAKAJIMA** and *Shinobu INANAGA***

*Faculty of Agriculture, Tottori University

**Arid Land Research Center, Tottori University

Dwarfism is a very important biological phenomenon in agriculture because it prevents crops from lodging on the ground and produces a better harvest. Recently we found the chlamydocin analogues 1, 2, and 3 as natural plant growth retardants. In the course of our research on the structure-retardation relationship, compound 8 that was derived chemically from compound 1 was found to have the growth retardant activity. Compound 1 reduces the level of endogenous GA1 and at the same time raises the level of endogenous ABA, while compound 8 reduces only the level of endogenous GA1. Compound 1 inhibited histone deacetylase like a chlamydocin, while compound 8 did not. Trichostatin A, which is a famous histone deacetylase inhibitor, did not retard the plant growth.

Influence of the Water Quality of the Groundwater on the Irrigation and Drainage Apparatus at the Sand Dune

Choichi SASAKI and Tahei YAMAMOTO***

*Faculty of Agriculture and Life Science, Hirosaki University

**Arid Land Research Center, Tottori University

The cause of functional decline of drainage was investigated at Byoubusann sand dune area beside the Japan sea in Aomori prefecture. We realized that this phenomenon was caused by iron deposit. we investigated that the vertical change of groundwater quality and these seasonal change. Also, we studied the origin of the supplied iron element and we tried incubation test using sands from Byoubusann sand dune area and Tottori sand dune area. 10 degree and 20 degree were used at this test.

As a result of this study, iron concentration in the groundwater became more higher at vertical direction. The increase limit depth of the groundwater was about 150cm under groundwater table. The supply of the iron element to the surrounding the water with the sand was recognized when it elapsed 60 days. The more higher this solution rate became, the more higher the incubation temperatures were. Also, we tried same incubation test using sand that sampled from Tottori sand dune area(Arid Land Research Center, Tottori Univ.). But the iron concentration didn't increase in the same period.

In this study, we clarified both characteristics of the iron concentration and origin of the iron in the groundwater.

Water Flow and Solute Transport in Undisturbed Soils

Nobuo TORIDE and Mitsuhiro INOUE***

*Faculty of Agriculture, Saga University

**Arid Land Research Center, Tottori University

Water flow and solute transport are heterogeneous due to the inherent nature of undisturbed soils. Hydrodynamic dispersion coefficients for undisturbed and disturbed Japanese volcanic ash soils, Andisols (Kurobokudo), were determined. The dispersivity for the saturated undisturbed soil was more than ten times greater than for the disturbed soil, and increased with the observation depth, reaching up to tens of centimeters. Furthermore, the convection dispersion equation (CDE) did not fit well for the undisturbed soils. On the other hand, the dispersivity for the unsaturated undisturbed soil became close to that for the disturbed soil. Flow and transport in the saturated undisturbed soils become heterogeneous because of macropores such as root channels, while these macropores become empty as the water content decreases.

**An Economic Analysis of Farm Behavior and National Policy
Concerning Agricultural Sustainability in Arid Area**

Hiroshi TSUJII and Tomohisa YANO*

*Graduate School of Agriculture, Kyoto University

**Arid Land Research Center, Tottori University

In the savannas of northern Nigeria, increased land-use intensity due to population pressure on land has depressed the use of fallow periods in restoring soil fertility. Crop yields have fallen and food security is under threat. Farmers' access to inorganic fertilizers is limited by poverty and high cost. Reliance on crop-livestock interaction is a plausible option because animals provide manure for soil fertility maintenance in the intensive system. This research project evaluates the nature of crop-livestock interactions occurring in the savannas of northern Nigeria, assesses the capability of existing crop-livestock interactions to maintain crop and livestock productivity, and uses the logit model to estimate the determinants of a farmer's decision whether to adopt or not to adopt animal manure for soil fertility maintenance. Result shows that 86% of farmers indicated some interaction between crops and livestock in their farming activities with manure being the most important provision from livestock to crops. Although animal manure is critical in soil fertility maintenance, given the limited access of farmers to inorganic fertilizers, only 56% of the farmers applied it to their largest upland plot in 2001 and the average quantity applied is only 40 to 67% of the amount required to maintain cereal grain yields. The results of a logit model on factors that influence a farmer's decision to adopt animal manure indicate that farmer characteristics (and perceptions), followed by conditional variables are the most crucial. The important farmer characteristics include household size, educational level of household head, perceptions on availability of animal manure, market opportunity for manure, and on restrictions on access to pasture resources. Farmer's past experience in ruminant livestock keeping, livestock disease outbreak, and his rating of the importance of animal manure for soil fertility maintenance are the important conditional factors. Our project recommends policies that can promote crop-livestock integration and the adoption of animal manure for soil fertility maintenance in the savannas of northern Nigeria and similar ecologies elsewhere.

Soil Water and Temperature Dependence of Thermal Conductivity of Tottori Dune Sand

*Tatsuaki KASUBUCHI**, *Toshihiko MOMOSE*** and *Mitsuhiro INOUE****

*Faculty of Agriculture, Yamagata University

**The United Graduate School of Agricultural Sciences, Iwate University

***Arid Land Research Center, Tottori University

In general, soil thermal conductivity increased with temperature by the increase in the latent heat transfer. However, at low water content the thermal conductivity of Toyoura sand decreased with temperature. This means that there would be a factor to decrease the heat transfer in soils. We considered that the clay might be related to this phenomenon. The effect of clay content on the temperature dependence of the thermal conductivity should be clarified. We measured the thermal conductivity of Tottori dune sand over three kinds of clay contents (0, 1, 3%) and a wide range of temperature (5-75 °C) at 0.02 of volumetric water content. Thermal conductivity of Tottori dune sand without clay decreased as temperature increased. The thermal conductivity of the sample with 1% and 3% of clay contents remained almost constant and increased with temperature, respectively. It was found that the clay content had relation to the decrease in the thermal conductivity as temperature increase. The clay in soils has an influence on the increase in the latent heat transfer with temperature.

Plant N Use under the Water Stress Condition

*Naoko Tokuchi** and *Norikazu YAMANAKA***

*Graduate School of Agriculture, Kyoto University

**Arid Land Research Center, Tottori University

The purpose of this study is to clarify the plant N use under dry condition. Especially in this study, we focused nitrate reductase activity (NRA), is useful index for plant nitrate use. There were significant relationships among photosynthesis rates, leaf NRA and root NRA of all species. It suggests that energy for N use was supplied by photosynthesis even in root. While there were the critical differences of N use between in root and in leaf in *Swida controversa* and *Acer sieboldianum*, there was no difference in other four species. These results indicate that the response of NRA to light was different among tree species.

Mycorrhizal Symbiosis as a Resistant Factor of Japanese Black Pine, *Pinus, Thunbergii*, to Pine Wilt Disease Occurring at Coastal Sand Dune

*Kazuyoshi FUTAI**, *Fukuju YAMAMOTO***, *Shigenobu TAMAI****
*and Norikazu YAMANAKA****

*Graduate School of Agriculture, Kyoto University

**Faculty of Agriculture, Tottori University

***Arid Land Research Center, Tottori University

The coastal stands of Japanese black pine, *Pinus thunbergii*, which has been playing a very important role in protecting agricultural fields and residential area from sandy winds are declining due to the pine wilt disease. To reforest the devastated area Japanese black pine trees seem to be suitable plants for reasons of landscape conservation. However, natural regeneration by pine seedlings seems to be inhibited by co-planted false acacia which had been planted to supply nitrogen. To elucidate the influence of false acacia on the regeneration of pine stands, the following aspects were compared between Japanese black pine-dominated and false acacia-dominated stands.

- (1) Environmental conditions such as canopy density, nitrogen contents in soil, soil water content, and so on.
- (2) Survival ratios of current-year, and one-year old seedlings of Japanese black pine with the lapse of time.
- (3) Mycorrhizal types and mycorrhizal ratio on Japanese black pine seedlings.

From these comparisons, we obtained the following results that current-year seedlings of Japanese black pine seem to be inhibited to grow in false acacia-dominated stand. Light and soil conditions seem to be determinative factors for the survival rate of pine seedlings. The effects of mycorrhizal symbiosis on the survival rate of pine seedlings remains to be solved in future.

Measurement of Solute Transport by a Soil Water Flux Meter

*Koji INOSAKO** and *Mitsuhiro INOUE***

* Faculty of Agriculture, Tottori University

**Arid Land Research Center, Tottori University

A soil water flux meter is one of sampling devices of percolating water from a root zone to lower soil layers. It cleared that a 0.003 mm Versapor filter is adequate for this device and it collects excess amount

of percolating water according to our studies.

In this year, experiments of steady state percolation were conducted for comparison of the collection performance of a soil water flux meter with ordinary methods. A tension free lysimeter and a wick lysimeter were selected as ordinary devices. These experiments were conducted using the salt movement monitoring system at the arid land research center.

Tension free lysimeter can collect percolating water only under the condition that soil closed to the collection part of this device is saturated. The collection ratio of tension free lysimeter was only 20 % because the condition that it can collect soil water, merely occurred. On the other hand, wick lysimeter continued to collect soil water for a long time because the collection part is kept under the condition of negative pressure. However the collection ratio was only 35 %. This fact shows that wick lysimeter is not available for soil with high percolation rate, as Tottori sand dune. These results indicated that soil water flux meter is adequate for collection of percolating water on farms with high hydraulic conductivity.

Influence from the Behavior of Pore Air to the Seepage of Rainfall into the Ground

Kohji KAMIYA and Mitsuhiro INOUE***

* Collaborative Center for Academy/Industry/Government, Gifu University

**Arid Land Research Center, Tottori University

The knowledge of the hydraulic properties of unsaturated soil is necessary to evaluate the seepage behavior of river water and rainfall into the river levee. Especially, it is important to understand the behavior of pore-air in unsaturated soil, due to the possibility of pore-air trapped and compressed in the soil. The purpose of this research is to study the influence of the pore-air behavior to the water seepage into unsaturated soil. In this study, the following two points were experimentally examined:

- (1)The method of air permeability test on unsaturated soil
- (2)Influence of air permeability coefficient to degree of saturation and suction

As the results, the apparatus of air permeability test method which able to repetitively controlling the suction to adjust the degree of saturation of the unsaturated soil sample was developed. This method gave an appropriate result data to the relationship between the air permeability coefficient with the degree of saturation and also with suction. The factors of water characteristic curve and void size distribution can be also measured by this method. It was confirmed that the relationship between the air permeability coefficient and the degree of saturation can be expressed by equations which proposed by Brooks et al., etc. In the other hand, the relationship between the air permeability coefficient and suction by considering the hysteresis in drying and wetting process was proposed.

Determination of Saturated and Unsaturated Moisture Properties of Soil and Subsoil

Toshihiro MORII and Mitsuhiro INOUE***

* Faculty of Agriculture, Niigata University

**Arid Land Research Center, Tottori University

It is well noticed that field or in-situ determination of soil permeability is essential for accurate prediction of water movement in soil such as natural slope, embankment, landfill and agricultural field. As the soil permeability is characterized by hydraulic conductivity, an accurate and effective in-situ measurement of the hydraulic conductivity of soil is critically important in design and monitoring of water movement in soil. The Guelph well permeameter (GWP) method, which is classified into a borehole permeameter employed in the field tests, is thought to be one of such test methods that promise useful and effective in-situ measurement of the hydraulic conductivity of soil. It provides a field-saturated hydraulic conductivity of soil, K_{fs} , based on measurement of a constant-head infiltration from a borehole or a well into soil. K_{fs} is a value which represents the permeability of soil saturated by downward infiltrating water with entrapped air in it.

In the study the GWP method is effectively introduced into the in-situ permeability test, and its accuracy and effectiveness are examined by the field test and by a numerical experiment in a sand soil. The values of K_{fs} are measured along the soil depth by the in-situ permeability test using the GWP method and compared with those of soil cores collected from the test field. The hydraulic conductivity measured by the in-situ permeability test is also compared with that computed by the numerical experiment which is designed to simulate the sand soil and the infiltration from the well into the soil. From these comparisons it was concluded that the in-situ permeability test is now available to measure easily and effectively the soil permeability along the soil depth about one to two meters deep below the soil surface.

Dynamics of Water and Energy in a False Acacia Forest

Kyoichi OTSUKI, Yasuhiro UTSUMI*, Norikazu YAMANAKA ** and Reiji KIMURA***

*Graduate School of Agriculture, Kyushu University

**Arid Land Research Center, Tottori University

We set a test plot of 20x20m in the forest of *Robinia pseudoacacia* L. located north of the experimental farm field of ALRC, and investigated water dynamics in the forest as well as within the stem. We also analyzed the water distribution in the stem by using soft X-ray and Cryo-SEM photos.

The results showed that 1) sap flow changed depending on the climate and soil moisture condition, and 2) the stem shrunk when sap flow increased and expanded when sap flow decreased, and the range of the stem movement increased with the increase of sap flow. Water content of the sapwood increased in daytime while that of the heartwood decreased in daytime. The soft X-ray and Cryo-SEM photos showed that many vessels in the sapwood were not filled with water while most of the vessels in the heartwood were filled with water.

Investigation for Physiology of Crop in the Arid Area of China

*Tadashi TAKAHASHI**, *Akihiro ISODA*** and *Shinobu INANAGA***

* Faculty of Agriculture, Yamaguchi University

**Faculty of Agriculture, Chiba University

***Arid Land Research Center, Tottori University

Seed yield and dry matter production were grown at high density and under irrigation for two years on three Chinese and two Japanese soybean cultivars in arid area of China. In the result, Chinese cultivars showed smaller leaf area of upper leaves, more nodes and pods, more seeds per pod and lighter 100 seeds weight than Japanese cultivars. LAI on each layer was smaller for Chinese cultivars than for Japanese cultivars. Chinese cultivar, Shi-dadou 1, and Japanese cultivar, Toyokomachi, showed heavier total dry weight for both 2002 and 2003, while they did not show different harvest index with the other cultivars. Seeds yield were extremely high, 8t/ha and 7t/ha in Toyokomachi and Shi-dadou 1, respectively.

Research on Improvement of the Accuracy for in-situ Constant Head Permeability Tests in Unsaturated Soil

*Yuji TAKESHITA**, *Masahiro YAMASHITA*** and *Mitsuhiro INOUE****

* Faculty of Environmental Science and Technology, Okayama University

**The Graduate School of Natural Science and Technology

**Arid Land Research Center, Tottori University

In situ measurements of field-saturated hydraulic conductivity, K_f s and unsaturated hydraulic

conductivity $K(\theta)$ are essential for accurate prediction of water movement in arid lands.

In this research, a ponded single-ring infiltrometer technique, such as the Guelph Pressure Infiltrometer with the soil moisture sensor is performed. The change of soil water content data at different depth with time was measured. These data were used to determine $K(\theta)$ by Instantaneous profile method theory. The advantage of the proposed method is that it allows estimation of $K(\theta)$ by quite simple in-situ permeability test data.

Research on Zero Emission of the Percolating Water by Advanced Water Saving Irrigation System

Torahiko TANIGAWA and Tomohisa YANO***

* Graduate School of Agriculture and Biological Sciences, Osaka Prefecture University

**Arid Land Research Center, Tottori University

Especially, the examination considering the application to urban area replanting was carried out in this fiscal year. Still, it is the planter cultivation experiment, and this result is regarded as being applicable for the general potted plant–vegetable cultivation. When the replanting in the urban area was considered, water saving, lightening, cost reduction of the system including running cost, simple operability, continuance of the suitable soil moisture environment, low or zero emission to the external environment are necessary. This study aimed at the zero emission on infiltration loss of water supply, but the soil volume is little in the planter cultivation. Therefore water supply control performance of the high accuracy was required. In the experimental result, the zero emission was able to be achieved, while soil wet situation of the gravitational water was maintained. The gravitational water consists for the infiltration loss of the definition. Of course, detailed examination will be necessary in future. But, in the experimental result, it was balanced in the condition of which water supply and water absorption of the plant were near optimum, and the less infiltration loss was stabilized, and become the zero.

Development of Water Balance Model for Assessing Impact of Climate Change on Irrigated Agriculture in Arid Region

Tsugihiko WATANABE, Takanori NAGANO* and Tahei YAMAMOTO***

*Research Institute for Humanity and Nature

**Arid Land Research Center, Tottori University

This research aims at developing an innovative framework for predicting and evaluating the climate change impacts and adaptations on agricultural production. Future global climate change is likely to

affect the agriculture in arid and semi-arid zones, with changes in temperature, rainfall, evaporation, and so on. Especially, irrigated agriculture, which depends on unstable and limited land and water conditions, even now may have difficulties to adapt to changes. For estimation of the impact of the climate change and integrated evaluation of the vulnerability of the irrigated agriculture, a new water balance model of irrigation scheme is to be established. The research is going to be implemented in the following procedures.

- 1) History of irrigated agriculture are examined in the case study areas; the Lower Seyhan Irrigation Project in Turkey and the Hetao Irrigation District in China.
- 2) The basic structure of irrigation system and water balance is to be clarified, including relationship between on-farm dynamics and regional hydrological regime.
- 3) The connectional water balance model is to be developed, which can simulate water demand and supply, distribution in the region, and their relation with land use and cropping system.
- 4) With generated scenarios on future climate changes and changes in water resources availability, future water management and balance is to be predicted by the developed model.

Determination of Parameters in Root Water Extraction Models under Saline Irrigation

*Haruyuki FUJIMAKI and Mitsuhiro INOUE***

*Institute of Agricultural and Forest Engineering, University of Tsukuba

** Arid Land Research Center, Tottori University

We proposed a low-cost and accurate method to determine parameter values in Feddes(1978)'s root water uptake model. From a small lysimeter experiment in a greenhouse using soybean, we showed that transpiration amount can be accurately calculated using the optimized parameter values. Moreover, deviation of the optimized stress response function was small, indicating the reliability of the method.

Studies on Fluid Transport Considering with Phase Transition

Tadao AODA and Tomohisa YANO***

*Faculty of Agriculture, Niigata University

** Arid Land Research Center, Tottori University

During drying process, soil water in liquid phase remains in the form of independent pendular ring at the contact point of soil particles. At this water content (film stage), water is in vapor, liquid and semi-solid phase. Semi-solid phased water adsorbs on the soil surface as film, and not able to move by pressure change. As far as continuous body, liquid phase water transmits pressure, and moves conform

to Darcy's law. The other side, it is still not clear that the pressure transition and liquid water movement of pendular ring. Because most studies, which focused on unsaturated soil water movement, have been discussed energy state of water without proper physical analysis of the water phase. In this study, we measured the time series of water pressure and the diameter of pendular ring under the condition of various water levels in glass beads (diameter=24mm) media. Consequently, pendular ring in the film stage, 1) could not transmit pressure each other, 2) could not move by the change of water level, 3) decreased by the vapor diffusion, 4) could not represent the pressure value at the inspection plane, 5) does move with phase transition.

Studies on Improvements of Water Qualities and Soil Properties by Porous Glass Materials

Tomonori FUJIKAWA and Shinobu INANAGA***

*Graduate School of Agricultural and Life Sciences, The University of Tokyo

** Arid Land Research Center, Tottori University

Soil improvement techniques by waste glass fragments or porous glass materials have been developing. The soil physical and chemical properties are observed to be improved by applying these materials to the soil but the mechanisms of these improvements have been vague. For volcanic soil, the hydraulic conductivity increased with the mixing ratio of the glass fragments, on the other hand, it decreased with the ratio of the porous glass materials in relatively low ratio range. For alluvial soil, the effects of mixing these materials on hydraulic conductivity are small because the particle size of alluvial soil is smaller than that of volcanic soil.

Analysis of Unsaturated Soil Water Movement by Using the Generalized Model for Hydraulic Properties

Ken'ichirou KOSUGI and Mitsuhiro INOUE***

*Graduate School of Agriculture, Kyoto University

**Arid Land Research Center, Tottori University

The soil moisture characteristics are represented by the relationship between the volumetric soil water content and the soil capillary pressure head, which is called the soil water retention curve. The water retention curve is usually measured in a laboratory by using a soil sample, which might be different from the retention characteristic observed in a field under natural rainfall condition. In this study, we conducted simultaneous measurements of the volumetric water content and the soil capillary pressure

head at a forested hillslope, which produced field-measured water retention curves. The field-measured retention curves were similar to the laboratory-measured curves when the soil capillary pressure head was smaller than -100cm. In the region where the soil capillary pressure head was greater than -100cm, the field-measured retention curves had less increases in the volumetric water content than the laboratory-measured curves. This trend was more clear in the surface layers than in the subsurface layers. It was presumed that the soil water repellency is the one of the main reason of this contradiction between the field- and laboratory-measured retention curves.

Simultaneous Measurement of Water Flow, Solute and Heat Transport properties Using a Multi-Functional Sensor

Yasushi MORI and Mitsuhiro INOUE***

*Faculty of Life and Environmental Sciences, Shimane University

** Arid Land Research Center, Tottori University

A small multi-functional heat pulse probe (MFHPP) with 6 stainless tube that includes a heater, two vertically and two horizontally installed thermistors was developed for water flux density measurement. A heat pulse generated from heater tube was measured at thermistor tubes 6mm away from the heater. Vertically installed thermistor measurement was affected by water flow and the flux was estimated by analytical solution for heat conduction including convection. Volumetric heat capacity and thermal diffusivity were estimated at horizontally installed thermistor assuming effect of water flow was small. Parameter optimization was employed because parameters could be examined using many data points and are not affected by outlier or noise. Falling head hydraulic conductivity experiment and multi-step outflow experiment were conducted for saturated and unsaturated water flux estimation respectively. Results showed that volumetric water content calculated from volumetric heat capacity corresponded very well with gravitationally calculated water content for both static condition and transient flow ranging from 10^{-5} to 10^{-8} ms⁻¹. Also thermal diffusivity corresponded well with the known thermal diffusivity. Saturated water flow was successfully estimated in the range from 6.5×10^{-7} to 1.7×10^{-4} ms⁻¹. However, for unsaturated flow, estimation diverged systematically at lower than 10^{-6} ms⁻¹. This may be attribute to the resolution limit of thermistor measurement or uncertainty in thermal diffusivity measurement. As a whole, unlike traditional methods, this method does not require water potential and hydraulic conductivity measurements, but directly measures water flux at a single point. Moreover, water content and thermal diffusivity were substituted from horizontal measurement, thus required data were also obtained within the same volume. It is an advantage for field condition where water content or thermal properties are not always available.

Modeling of Phonological Development in Wheat Grown under Drought Environments

Hiroshi NAKAGAWA and Tomohisa YANO***

*Ishikawa Agricultural College

**Arid Land Research Center, Tottori University

Crop simulation models are indispensable for the impact assessment of climate change on crop production. A phenology sub-model was created for winter cereal crops and was parameterized for a barley cultivar grown under well-watered conditions.

Crop development stage is quantified by a continuous variable termed DVS (DeVelopment Stage). DVS is defined to be 0, 1, 2 at emergence, heading and maturity, respectively. The value of DVS at any moment is given by integrating the development rate (DVR) with respect to time. Parameters of the phenology model were estimated from heading dates of 'Amagi-Nijo' with meteorological data. The present model could well explain the heading dates of 'Amagi-Nijo' grown under a wide range of environmental conditions with high accuracy (se = 1.43 days, $r = 0.999$). The response of DVR to temperature and daylength was given with parameters and shows the curvilinearity of the temperature response and that long day conditions promote phenological development towards heading in 'Amagi-Nijo'. The model with parameters was tested by using independent data sets of 'Amagi-Nijo' grown in 13 prefectures in Japan, which were documented in annual reports of agricultural research institutes in those prefectures. The present model could well explain the site-to-site difference and yearly variations of heading date without any adjustment of parameters.

These results suggest that the present model can be applied for simulating the phenological development of winter cereal crops including wheat grown under a wide range of temperature and daylength conditions, if the vernalization effect can be omitted as in the case of 'Amagi-Nijo'. Experiments are being conducted in Turkey and Japan to obtain the data required for parameterizing the phenology model for wheat cultivars.

Cultivation of Vegetables under Controlled Soil Moisture Content

Satoshi YAMADA and Mitsuhiro INOUE***

*Faculty of Agriculture, Tottori University

**Arid Land Research Center, Tottori University

Komatsuna (*Brasica rapa* L. cv. Saori) was pot-cultured with varied amount of supplied nitrogen and water, and yield and qualities; dry weight ratio, Ca, total V.C. and nitrate concentrations were measured. The amount of supplied nitrogen per pot were 0.4gN (N1), 0.6gN (N2), 0.9gN (N3), and 1.1gN (N4) with ammonium nitrate. Water was supplied so as to make soil moisture 100 ~ 200cmH₂O (W1), 35 ~ 40 cmH₂O (W2), and 10 ~ 15 cmH₂O (W3). Results obtained were as follows; 1) Komatsuna grown in N3W2 showed higher yield and improved qualities than those of commercial products. Dry weight ratio accounting for post-harvesting long-life was approximate 3 times and nitrate concentration was less than one tenth than those of commercial products. 2) Exceeded water content of Komatsuna decreased significantly the concentration of soluble protein, Ca, and total V.C.

These results suggested that the combination between the amount of supplied nitrogen and water was important and exceeded supplied water deteriorated qualities for leaf vegetable cultivation.

Physiological Responses of Plants to Salinity Stress

Yukihiro SUGIMOTO and Shinobu INANAGA***

*Faculty of Agriculture, Kobe University

**Arid Land Research Center, Tottori University

We have established photoautotrophic chlorophyllous suspension cell culture of *Petunia hybrida* and generated a salt-adapted line through a step-wise selection in NaCl-containing medium.

Suppression subtraction hybridization, a method that selectively amplifies target cDNA fragments and simultaneously suppresses non-target DNA amplification, was employed to isolate the differentially over-expressed genes in the salt-adapted *Petunia* cell line. Ten clones were obtained and their 3'- and 5'-regions were determined by RACE. Searches in the GenBank database revealed that three genes exhibited high degrees of sequence identity to previously reported genes encoding chlorophyll a/b binding protein, elongation factor 1-alpha, and cyclophilin.

Employing the same method, isolation of under-expressed genes is going on.

(3) Summary of Open Seminar

Topic of Open Seminar (Date)

Name of Speaker

Occupation of Speaker

Summary of Open Seminar

1) Introduction of Cele Desert Research Station, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, and A New Method to Improve Lint Yield of Cotton in Xinjiang, China (Apr. 9, 2003)

Yuanjie ZAO

Xinjiang Institute of Ecology and Geography, C.A.S.

Cele Desert Research Station locates 90 km east of Hotien city at the southern periphery of Taklimakan Desert, Xinjiang Uygul Autonomous region. It is one of the 7 branch stations of XIGE (Xinjiang Institute of Ecology and Geography). Major mandates of the station are to study on; sand stream fixation, yield improvement of cotton, and efficient use of seasonal water from Kunlon mountains.

Cotton yield in dry regions of china has been improved basing on updated cultivating methods in recent decades. With the new method of “Double plants and double layers”, the key measures of which mainly include: (1) Adopt the structure of two plants per seeding den to increase cotton plant population on a large scale, and (2) Use the technique of cotton multiple layer management by means of controlling plant heights in different plant layers to utilize the light and heat resources fully, the lint yield per capita could reach to more than $3750 \text{ kg} \cdot \text{hm}^{-2}$ in the experiments conducted during the period from 1998 to 2000 in Cele County of Xinjiang, China even under traditional row spacing. The matched measures include: Selection of superior cotton varieties, Timely care, Growth control by DPC, Fertilization with reason, Proper irrigation, Prevention and cure of plant diseases and insect pests, and so on. The new cultivating method is an effective way to bring cotton production potential, to improve lint yield per capita, and to improve utilization efficiencies of agricultural resources.

2) ICARDA and natural environment in Syria –An approach to dryland science- (Nov. 5, 2003)

Takahiro SATO

Facility / Graduate School of Agriculture, Kyoto University

The international center for agricultural research in the dry area (ICARDA), the one of the centers in CGIAR, is based in Aleppo, Syria. ICARDA works for the dryland agriculture mainly in Central and West Asia and North Africa, and diffuses the knowledge for the national research centers in these countries. The research activities in ICARDA cover many agricultural topics: variety improvement of cereals and legumes, on-farm water-use efficiency, rangeland, small-ruminant production, farming systems etc.

More than 85% of Syrian land, where many works in ICARDA has been conducted, has a few rainfall that amount is less than 350mm. One may relate the simple vegetation and a few rain, however, vegetation in Syria varies considerably because of the difference in microclimate. The site-specific problems in agriculture are appearing on this characteristic, and scientists in ICARDA began to respect for them. Participatory breeding and farmer's participatory in interdisciplinary research project are the examples of ICARDA's new challenge. They are expected to meet the complex problems in the dryland agriculture. Such approaches may increase in future of ICARDA.

3) Genesis of alkali soils and their eco-engineering amelioration (Jan. 15, 2004)

Satoshi MATSUMOTO

Faculty of Bioresources Science, Akita Prefectural University

Alkali soils distribution in China are found in the arid and semi-arid regions of Inner-Mongolia, Jilinan, Heilongjiang, Liaoning, Xinjiang-Uygur Autonomous, Heibei, Gansu, Shaanxi and Qinhai provinces and especially the distribution in the northeast and north China of latitude 40 degree north is intensified. And its acreage is estimated more than 100,000 km². The most characteristic difference between non-alkali and alkali soil is found in the content of calcium, magnesium, carbonate and bicarbonate ions in the solution extracted from soil by distilled water. In the northeast China, the formation of alkali or alkali-saline soil is also related to the topographical characteristics of the lands; they usually are found in the areas with high groundwater tables, or in low lying ground. These areas are favorable for forming sodium carbonate and bicarbonate, because the sodium ion is more mobile than other cations, and because carbonate and bicarbonate originate from microbial decomposition of the organic matter which predominates in the wet location. Calcium sulfate has the most excellent amelioration effects for the alkali soils. However, the cost of calcium sulfate in China is quite expensive. Therefore, the possibility of using the byproduct from desulfurization processes for amelioration of alkali soil is examined, to provide incentives for the construction of desulfurization processing facilities in China. It was shown that applying mixture of 0.5 wt% of the byproduct from semi-dry process, which tends to be adopted owing to its low construction and running costs, to alkali soil have the same amelioration effects on such soils as the byproduct from the wet lime slurry used in developed countries. However, application to alkali soils of more byproduct than 0.5 wt% from the semi-dry process a deterioration effect on amelioration, due to the persistent increase pH of the soil.

4) Measurement and simulation of soil moisture in a rain-fed field in northeastern Thailand

(Jan. 23, 2004)

Toshitsugu MOROIZUMI

Faculty of Environmental Science and Technology, Okayama University

Measurement and simulations of soil moisture at a rain-fed in northeastern Thailand were introduced.

The study area was located at a rain-fed paddy and upland fields in Khon Kaen prefecture in northeastern Thailand. Soil moistures were measured from a sloping upland in higher location to a rain-fed paddy field in lower. The soil moistures were measured at eleven points from July 18 to August 8, 2003. A profile probe sensor (PR1) which was a kind of ADR method was used to measure the soil moisture. The relationship between output volts of PR1 and measured soil moisture contents was obtained. A Boltzman function curve for sandy loam and a regression line for sandy clay loam were good fitting. As examples of measurement of soil moistures, the daily changes and profiles of soil moistures were shown. Soil moisture contents at SW1 were larger than those at SW6 before and after rainfall. After rainfall, soil moisture storage of SW1 increased by 43.5mm and that of SW6 by 41.0mm. From this fact, it was proven that the soil moisture tended to increase approaching the rain-fed paddy field in lower location from the sloping upland field in higher location.

Soil moisture movements in this study field were simulated using HYDRUS-2D. The simulations were conducted for five patterns; a sloping upland with no hysteresis and hysteresis, a sloping upland with hypothetical runoff, and a rain-fed paddy and sloping upland field with no-runoff and hypothetical runoff. Each simulation showed the tendency that soil moisture moved from a higher location in the sloping field to a lower location in the rain-fed paddy field. These simulations were still at primary stage. The HYDRUS-2D was, however, shown to be a useful and powerful tool for the analysis, prediction, and management of soil moisture.

5) Scientific Exchange Seminars for Japan – France Integrated Action Program (SAKURA)

(Mar. 10, 2004)

(A) Mechanism of Solute Transport in French Subsurface Drained Soil

Julian TOURNEBIZE

Drainage and Barrier Engineering Research Unit Cemagref, French

The presentation starts with brief overview of Cemagref, the institute which Dr. Tournebize comes from. The main topic will be the subsurface drainage and solute transport influenced by tile pipe. The typical French waterlogged soil problems and their engineering applications for agronomical and environmental problems will be discussed. France – Japan research exchange SAKURA Project will be

also introduced.

(B) Rice Pesticide Fate and Transport in Agricultural Surface Water

Son Hong VU

Vietnam Institute for Water Resources Research

Objectives of this study are to identify the key mechanisms to develop a simulation model for the pesticide fate and transport in paddy field watershed for reducing pesticide runoff from the paddy field watershed, the pesticide fate and transport monitoring in 100 ha watershed consist of paddy fields was conducted in 2002 – 2003. The monitoring results and recommended best management practice will be discussed in the presentation.

(C) Pesticide fate and transport monitoring and modeling for paddy fields

Hirozumi WATANABE

Graduate School of Agriculture, Tokyo University of Agriculture and Technology

Pesticide used in rice paddy fields is probably main non-point source pollution of surface water in Japan and it is important to develop and extend the best management practice to reduce pesticide runoff from rice paddy. Introducing the research activity of the laboratory, monitoring and modeling pesticide fate and transport in paddy field will be presented.

(4) Summary of Open Seminar for 21st Century COE Program

Topic of Open Seminar (Date)

Name of Speaker

Occupation of Speaker

Summary of Open Seminar

1) Desertification and Agriculture in the Dry Areas. The Examples of Research and Practical Use (Aug. 26, 2003)

(A) Desertification and Agriculture in Sudan. The Examples of Research and Practical Use about Breeding and Cultivation Techniques.

Salih Hussein SALIH

Agricultural Research Corporation (ARC), Sudan

The lecture outlined the topography and agriculture in Sudan. The problem of water for irrigation (Sudan depends almost entirely on the Nile), climatic features and recent desertification were discussed. Also discussed were measures taken by the Sudanese government (e.g., afforestation with acacia, stabilization of sand dune, prevention of blown sand by bush planting shrubs) to contain desertification and land degradation. Research projects by ARC were introduced such as management of soil and irrigation, crop breeding, studies on gum arabic and the forest, and combined projects (policy investigation, co-operation with private sectors) were highlighted.

(B) Desertification and Agriculture in Israel, and the Examples of Research and Practical Use about Salt Accumulation and Reclamation of Salt Affected Soils.

Rami KEREN

Institute of Soil, Water and Environmental Sciences, Volcani Center, Israel

During the lecture, I summarized the potential risk to water resources from the viewpoints of population increase and irrigation. The climate and type of agriculture based on the relation between the dry level index and precipitation were discussed, in addition to the spatial distribution of the desert climate in Israel, status of desertification, precipitation, urbanization, population and agricultural activities.

Some problems related to soil such acidification alkalinity due to NaHCO_3 or Na_2CO_3 and salinity due to NaCl or Na_2SO_4 were presented. Past and current research into water movement, soil erosion, and drip irrigation under saline soil were discussed. From the research on the leaching technique to restore saline soil, the comparison between traditional method of using water stream and that of making pond was discussed. As a result, it is possible to efficiently reclaim saline soil by using the pond method and sprinkler irrigation. The lecture was concluded by introducing the academic activities of the Israel Volcani Center using VTR.

2) Introduction of the Dry Areas in China and Research Activities (Dec. 8, 2003)

Rui Li, YongQuing MA, BiCheng LI and YongSheng XIE

Institute of Soil and Water Conservation, C.A.S., China

3) Introduction of ICARDA (Feb. 5, 2004)

William ERSKINE

International Center for Agricultural Research in Dry Areas (ICARDA)

In the lecture, the outline of target area and activities of ICARDA (International Center for Agricultural Research in the Dry Areas) were introduced. In our target area called CIWANA, high rate of population growth causes imbalance in water demand and supply. Salt accumulation and long term weather changes are also serious problems in this area. For these problems, ICARDA's mission is to

improve the welfare of poor people and alleviate poverty through agricultural research and training in the dry areas. There are also partnerships between ICARDA and UN agencies or other CGIAR centers. The achievements of each section of ICARDA were presented with pictures and data. New tools of science, such as GIS, biotechnology and participatory research approach are being utilized to advance our research works at ICARDA.

4) Crop Improvement in the Dry Areas (Feb. 6, 2004)

William ERSKINE

International Center for Agricultural Research in Dry Areas (ICARDA)

The general information of ICARDA as an international agricultural research organization, and various research projects of ICARDA on plant breeding in arid region, especially about drought and salt tolerance of plant, and insecticide plant breeding were introduced to show the cutting edge of Arid Land Science, especially plant breeding.

In the CWANA region where is the main research target of ICARDA, loss of the crop-diversity is one of the serious problems. ICARDA is now taking measures by utilizing our gene bank resources to meet it. During the measures, cooperation with rural farmers is the most important aspect. ICARDA developed a plant breeding system and evaluates the effect of proper crop selection with them. ICARDA is also conducting a research project about the application of the molecular biological techniques into plant breeding, clarifying the gene information about the various plant tolerances, and breeding some new varieties which have great tolerance to the hazardous growing environment.