2.3 Joint Research

(1) List of Joint Research

A-1. Analysis of Surface Conditions in Arid Land by Remote Sensing

(a) Estimating Volcanic Ash Deposits and Their Effects on Leaf Optical Properties using Satellite Data

Etsuji ISHIGURO, Muneharu SATO*, Koichi IWASAKI*, Kazuo MORITA* and Koichi MIWA*,*
with Makio KAMICHIKA and Kyoichi OTSUKI
*Faculty of Agriculture, Kagoshima University

(b) Estimation of Plant growth Using Remote Sensing Techniques
- Discrimination of Water in Near Infrared Region Spectra -

Takayuki KOJIMA and Masahiro SEGUCHI**
with Makio KAMICHIKA and Kyoichi OTSUKI
*Faculty of Agriculture, Saga University

(c) Analysis of Night Time Temperature by Using LANDSAT TM Data

*Tomoyuki ISHIDA**
with Makio KAMICHIKA and Kyoichi OTSUKI
*Faculty of Agriculture, Kagawa University,

A-2. Hydraulic Design and Water Management of Microirrigation

(a) Hydraulic Studies on Micro-irrigation System

*Souichi NISIYAMA**
with Tomohisa YANO
*Faculty of Agriculture, Kagawa University

(b) Analysis of Soil Water Behavior Following Irrigation from Line Sources with the Finite Element Method

*Syouhei WATANABE**
with Tomohisa YANO
*Faculty of Agriculture, Tottori University

(c) The Estimation of Crop Water Requirement under Drip Irrigation

Reijiro KAWAHARADA and Shinichi TAKEUCHI**
with Tomohisa YANO
*Faculty of Engineering, Kyushu Kyoritsu University.

A-3. Analysis of the Eco-Physiological Characteristics of the Root System under Arid Land Condition

(a) Studies on the Effect of pH on the Formation of Root-hairs

*Yasunori INOUE**
with Shinobu INANAGA
*Faculty of Science and Technology, Science University of Tokyo

(b) Root System Structure in Relation to Water Collection and Conductance in Crop Plants

*Akira YAMAUCHI**
with Shinobu INANAGA

*School of Agriculture, Nagoya University

(c) Analysis on Root Characteristics of Upland Rice for Sustainable High Yields

Jun ABE and Junko YAMAGISHI**
with Shinobu INANAGA and Yukihiro SUGIMOTO
*Faculty of Agriculture, The University of Tokyo

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

(a) Effects of Salt Stress on the Growth, Fruit Crops and Yield of 'Sun Cherry' Tomato under Arid Conditions

*Shin'ichi SHIRAISHI**
with Yoshichika TAKEUCHI
*Faculty of Agriculture, Khushu University

(b) Bulb Formation of Tropical Geophytes - Relationship between Bulb Formation and Drought Stress -

*Hiroshi OKUBO**
with Masao TOYAMA
*Faculty of Agriculture, Kyushu University

A-5. Eco-Physiological Studies on Tree Tolerance to Water Deficiency and Salinity

(a)Photosynthesis and Transpiration of *Avicennia marina* under different Salinity Conditions

*Yoshitaka KAKUBARI**
with Shigenobu TAMAI.
*Faculty of Agriculture, Shizuoka University

(b) Studies on Salt Tolerance of Tree Species

*Tsuneo NAKASUGA**
with Shigenobu TAMAI
*College of Agriculture, University of the Ryukyus

(c) Effects of Salinity and Anaerobic Stresses on Growth and Physiology of Water-cultured *Avicennia Marina* Seedlings

*Fukuju YAMAMOTO**
with Shigenobu TAMAI
*Faculty of Agriculture, Tottori University

A-6. Studies on Farm Land Conservation in Arid Areas

(a) Moisture and salt movement under drip irrigation.

*Akira TANAKA**
with Tahei YAMAMOTO
*Marine and highland Bioscience Research Center, Saga University

(b) Soil Erosion and Vegetation at Slopes Covered by Non-woven Fabric in Shirasu Test Plot

*Kenzo HOSOYAMADA**
with Tahei YAMAMOTO
*Faculty of Agriculture, Miyazaki University

(c)Water balances and Observations of Cracks in Saline Soils

*Shizuo HAYASHI**
with Tahei YAMAMOTO
*Institute of Tropical Agriculture, Kyushu University

B-1. Studies on Water and Salt Management on Woody Plants in Arid Areas

(a) Effects of Water Stress on Transpiration Rate and Leaf Temperature in Rice and Soybean Plants

Hiroshi TANI, Seiji HAYAKAWA and Haruhiko YAMAMOTO**

with Makio KAMICHIKA and Kyoichi OTSUKI

*Faculty of Agriculture, Yamaguchi University,

(b) Studies on the Salt Stress of the Citrus Trees

Masaya SHIRAISHI

with Tomohisa YANO

*Faculty of Agriculture, Ehime University

(c) Application of a Plant Infusion Method for the Control of the Pine Wilt Disease.

*Hidetoshi OKAMOTO**

with Yoshichika TAKEUCHI

*United Graduate School (Doctoral Course) of Agricultural Sciences, Ehime University.

(d) Analysis of Water Uptake of a Tree Using a Root System Model

*Tatsuaki KOBAYASHI**

with Shigenobu TAMAI

*Faculty of Horticulture, Chiba University

(e) Ecophysiological Study on Drought Resistance of Tree Species

Ken YOSHIKAWA

with Shigenobu TAMAI

*Faculty of Agriculture, Okayama University

B-2. Measurement of Evapotranspiration and Photosynthesis on the Crop Canopy

(a) Numerical Simulation of Vegetation Structure Effect on the Photosynthesis using Soil-Plant-Air System Model (NEO-SPAM)

*Tetuya KAWAMURA**

with Makio KAMICHIKA

*Department of Computer and Information Sciences, Chiba University

(b) Measurement of Water Vapor Flux Using the Eddy Correlation Method

*Hiromichi ODANI**

with Tomohisa YANO

*Faculty of Agriculture, Shiga Prefectural Junior College

(c) A Relationship between Soil Moisture Deficit of Root Zone and Evapotranspiration on an Upland Field

*Koji INOSAKO**

with Tomohisa YANO

*Faculty of Agriculture, Tottori University

(d) Studies on Estimation of Evapotranspiration

*Kazuro MOMII**

with Tomohisa YANO

*Faculty of Agriculture, Kagoshima University

(e) Water Use Efficiency of Rice in Humid Area

*Tohru KOBATA**

with Sinobu INANAGA

*Faculty of Life and Environmental Science, Shimane University

C. Free Subjects on Arid Land Studies

(a) Study on Irrigation Development and Environmental Conservation in Arid Area

Hikaru TSUTSUI and Nobumasa HATCHO**
with Kyoichi OTSUKI
*Faculty of Agriculture, Kinki University

(b) Irrigation and Drainage Management and Salinization Problems in Hetao Irrigation Districts of China

*Takao AMAYA**
with Tomohisa YANO
*Faculty of Agriculture, Gifu University

(c) Desertification and agricultural development in Africa : A social-scientist view on theSahelien case

*Makoto KATSUMATA**
with Tomohisa YANO
*Faculty of International Studies, Meiji-Gakuin University

(d) Non-Destructive Simultaneous Measurement of Salt and Water in Situ

Toshimasa HONNA and Sadahiro YAMAMOTO**
with Mitsuhiro INOUE and Tahei YAMAMOTO
*Faculty of Agriculture, Tottori university

(2) Summary of Joint Research

A-1 Analysis of Surface Conditions in Arid Land by Remote Sensing

Estimation of Plant growth Using Remote Sensing Techniques - Discrimination of Water in Near Infrared Region Spectra -

Takayuki KOJIMA, Masahiro SEGUCHI*, Makio KAMICHIKA** and Kyoichi OTSUKI***

*Faculty of Agriculture, Saga University
**Arid Land Research Center, Tottori University

Near-infrared(NIR) absorption occurs as overtones and is combined with fundamental vibration frequencies in the infrared region. It is very weak but includes much information on bio-materials. Water is the basic component bio-material and contains much information on living bodies and mineral resources. NIR spectra have been measured for three kinds of commercial mineral waters, ultra pure water and deionized water.
Discrimination analysis of these spectra enable one to distinguish the kind of water at 90 to 96% of probability among 20 samples of each. These spectra revealed that minerals affect the O-H stretch first overtone band. The selected wavelengths are concerned with the hydration of the cations, Na, Ca, Li and Mg.

Analysis of Night Time Temperature by Using LANDSAT TM Data

Tomoyuki ISHIDA, Mitsuo MINOMURA*, Makio KAMICHIKA** and Kyoichi OTSUKI***

*Faculty of Agriculture, Kagawa University,
**Arid Land Research Center, Tottori University

Surface air temperature in central Japan was analyzed using Landsat TM data, the temperature recordings from sensors in the Automated Meteorological Data Acquisition System(AMeDAS) and the digital elevation data. As pre-processing for Landsat TM image data, registration and atmospheric correction were done. An affin transformation was performed as the registration. The Lowtran 7 was utilized as the atmospheric correction. Landsat surface air temperature decreased with increasing elevation. Landsat surface air temperature was highly correlated with AMeDAS air temperature.

Estimating Volcanic Ash Deposits and Their Effects on Leaf Optical Properties using Satellite Data

Etsuji ISHIGURO, Muneharu SATO*, Koichi IWASAKI*, Kazuo MORITA*, Koichi MIWA*, Makio KAMICHIKA** and Kyoichi OTSUKI***

*Faculty of Agriculture, Kagoshima University
**Arid Land Research Center, Tottori University

In Kagoshima where an active volcano, Mt. Sakurajima, is located, many rice paddies are contaminated with deposits of volcanic origin. Therefore, in this research most of our efforts were focused on how to estimate the amount of volcanic ash deposits and then to assess their effects on leaf optical properties. The images processed by multi-sensor models well depicted the ash contaminated areas. Although the exact amount of deposits could not be estimated, the darkness of a pixel indicated fair association with the amount of ash deposit at the corresponding location of the ground, suggesting the potential usefulness of these models. Several yield prediction models were proposed and evaluated. Models with correction factor for the year effect proved to be practical if adjusted for sunshine hours. The correlation between actual yield and the prediction based on satellite data of August was high. Our models that make use of multi-sensor data make satellite remote sensing a powerful tool to monitor growth levels and yields of plants in large areas without having to carry out direct measurements of plants in the fields.

A-2 Hydraulic Design and Water Management of Microirrigation

Hydraulic Studies on Micro-irrigation System

Souichi NISIYAMA and Tomohisa YANO***

*Faculty of Agriculture, Kagawa University
**Arid Land Research Center, Tottori University

The uniform application of water in irrigation system is very important. A simple method was developed to determine the total friction drop at the end of the lateral by assuming that all emitter flows along the lateral are constant and are determined by the assumed pressure at the end of the lateral line. It was found that the error caused by using this simple calculating method is insignificant, when it was checked by using the step-by-step calculation method, as the length is short.

Analysis of Soil Water Behavior Following Irrigation from Line Sources with the Finite Element Method

Syouhei WATANABE, Tomohisa YANO** and Masayuki YAMADA***

*Faculty of Agriculture, Tottori University
**Arid Land Research Center, Tottori University

The objectives of this study are to analyze the soil water behavior following irrigation from line sources with the finite element method (FEM) and to compare the results with theoretical solutions to the one dimensional linearized moisture flow. Calculations were done by setting the conditions necessary for both methods as close as possible. The results obtained are as follows :

(1) The non-dimensional matric flux potential, matric potential and volumetric soil moisture content at the initial moisture of 0.1% with FEM agreed well with those with the theoretical solutions near the line sources where the soil moisture content was relatively high.

(2) It showed the tendency that the contour lines of the above mentioned parameters did not agree well. However, the difference of the soil moisture was not so much although the difference of the contour lines was considerable. There was a relatively large difference of soil moisture content near the bottom border.

(3) It was considered that the analysis with FEM showed high reliability if the element partition and the time increment are properly done and the soil physical data are properly used. There is no problem to compare both methods from the practical point of view. However, the accuracy of the analysis in the presence of evapotranspiration with FEM is still unknown.

The Estimation of Crop Water Requirement under Drip Irrigation

Reijiro KAWAHARADA, Shinichi TAKEUCHI* and Tomohisa YANO***

*Faculty of Engineering, Kyushu Kyoritsu University.
**Arid Land Research Center, Tottori University.

Irrigation scheduling has been made using criteria based on soil moisture, crop response and meteorological data. Recently, a theory has been established that irrigation scheduling should be determined by crop water status and characteristics of crop water stress. When the soil volume wetted is limited due to the use of the drip irrigation, the transpiration rate data is much more important than that of evapotranspiration rate.

The heat pulse method on sap flow measurements was applied to obtain transpiration rate under drip irrigation. The transpiration data on soybeans were examined for irrigation scheduling relating to potential transpiration measured by unstressed plots of soybean plants.

Investigating the relationship between irrigation and transpiration, measured transpiration was sensitive to irrigation under dune sand conditions. The concept of Relative Transpiration and Relative Transpiration Ratio introduced in this study based on the measurement of transpiration with control and water stress treatments can be used as a criteria for determining the timing of irrigation, even in Japan if allowable range of water stress for the object plants is known previously. Yields obtained by applying irrigation using the above method and measured transpiration are linearly related and are discussed as Water Use Efficiency. Bringing irrigation amounts close to the transpiration rate enable to operate highly efficient irrigation.

A-3 Analysis of the Eco-Physiological Characteristics of the Root System under Arid Land Condition

Studies on the Effect of pH on the Formation of Root-hairs

Yasunori INOUE and Shinobu INANAGA***

*Faculty of Science and Technology, Science University of Tokyo
**Arid Land Research Center, Tottori University

Low pH induced enormous amounts of root hairs on young lettuce roots. Mediation of plant hormones in this phenomenon were determined.

Application of auxin (IAA) could induce root-hairs at neutral pH. Application of anti-auxins (PCIB and TIBA) clearly suppressed low pH induced root-hair formation. This effects were recovered by the application of IAA. These results suggested that, IAA mediated in the course of low pH induced root-hair formation. Application of ACC(precursor of ethylene) could induce root-hair formation instead of low pH. Inhibitor of ACC-synthetase (AVG) suppressed the inductive effects of low pH and IAA. This effect could be recovered by the addition of ACC. Anti-auxins could not suppress the inductive effect of ACC. These results suggested that ethylene should mediate on the low pH induced root-hair formation.

Low pH probably induced the increment of IAA, then IAA induced formation of ethylene. Finally, ethylene induced the root-hair formation on the young epidermal cells of lettuce root.

Root System Structure in Relation to Water Collection and Conductance in Crop Plants

Akira YAMAUCHI, Md. Wahiduzzaman MIA*, Shinobu INANAGA** and Yukihiro SUGIMOTO***

*School of Agriculture, Nagoya University
**Arid Land Research Center, Tottori University

We previously showed that a large variation exists in the 10-day-old seedling root system of six food legume species; cowpea, mung bean, black gram, chickpea, grasspea and lentil, as well as among genotypes within each species. In this study, root system development of those species was investigated up to 44 days after planting and it was found that characteristics observed at seedling stages almost remained the same. Further, these species were grown in two different seasons (spring and summer) and under irrigated and non-irrigated conditions to evaluate plasticity in root growth triggered by those environmental factors. Results revealed that the taproot elongation rate significantly responded to the environment, especially growing seasons. The significant species (genotypes) environment interactions indicated that the plasticity in taproot growth differed among species; warm-season species (cowpea, mung bean, black gram) were more plastic than cool-season species (chickpea, grasspea, lentil). Evaluation on plasticity in lateral root development and its significance in water collection are now in progress.

We also found that cowpea and soybean roots show osmotic adjustment and can maintain turgor pressure under water stress conditions. The degree of osmotic adjustment differed among various component and roots of different ages.

Analysis on Root Characteristics of Upland Rice for Sustainable High Yields

Jun ABE, Junko YAMAGISHI*, Shinobu INANAGA** and Yukihiro SUGIMOTO***

*Faculty of Agriculture, The University of Tokyo
**Arid Land Research Center, Tottori University

Upland rice cultivars and a lowland rice cultivar were grown in upland field. The distribution of their root systems was investigated by the wall-profile method after harvest season. The rooting depth was different among the cultivars examined. The lowland rice cultivar formed the shallowest root system and had very few roots in the sub-soil layer, which was at 50cm. Moreover, varietal differences in rooting depth was observed among upland rice cultivars. Newly bred cultivars and a foreign cultivar, that are drought resistant cultivars, had much more roots in the subsoil than a Japanese popular cultivar that is rather sensitive to drought stress. The mean diameter of stems was also investigated. Positive correlation was shown between the mean diameter of stems and root amount in deep soil layer among the examined cultivars, suggesting the possible availability of stem diameter as an easy index of rooting of upland rice.

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

Effects of Salt Stress on the Growth, Fruit Crops and Yield of 'Sun Cherry' Tomato under Arid Condition

Shin'ichi SHIRAISHI and Yoshichika TAKEUCHI***

*Faculty of Agriculture, Khushu University
**Arid Land Research Center, Tottori University

Both water and salt stress are known to have adverse effects on the fruit-set physiology of plants. The efficiency of soil microbes and organic fertilizer to minimize the stresses was tested. 'Sun cherry' tomato was subjected to two factorials of manuring, and without manuring treatments.

The effect of microbial culture and amino acid solution on sugar content was the best, followed by that of manure, and chemical fertilizer. Salt stress increased sugar content by 6-10%. Fruit weight was affected differently as salt stress decreased it about 17%. Salt stress also adversely affected root growth. Furthermore, fungi did not grow at all under salt stress conditions. Compared to plants receiving organic fertilizer, the root growth of those receiving chemical fertilizer was worse. Moreover, compared to plants without salt stress, organic manuring increased the percent dry matter of salt-stressed plants by about 20%. The number of rhizospherical microbes on plants receiving organic fertilizer increased considerably. Salt stress, however, did not affect the percent dry matter of those receiving only chemical fertilizer.

Bulb Formation of Tropical Geophytes
- Relationship between Bulb Formation and Drought Stress -

Hiroshi OKUBO and Masao TOYAMA***

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**Arid Land Research Center, Tottori University

Similar experiments to those done in the previous year were conducted to clarify the major factor inducing bulb formation in Allium (Allium wakegi). Low soil moisture promoted bulb formation in this plant under long daylength, but only slightly under short daylength. Low temperature also affected bulb formation either in normal or low soil moisture conditions, but the long day was most effective in inducing bulb formation. These results were similar to those obtained in the previous year. One of the other geophytes of tropical origin, maryllis (Hippeastrum hybridum), was not tolerant to salt treatment, and no data was unfortunately obtained in this experimet.

A-5 Eco-Physiological Studies on Tree Tolerance to Water Deficiency and Salinity

Photosynthesis and Transpiration of *Avicennia marina* under different Salinity Conditions.

Yoshitaka KAKUBARI, Kiyoshi MITUI*, Fukujyu YAMAMOTO** and Shigenobu TAMAI***.*

*Faculty of Agriculture, Shizuoka University
**Faculty of Agriculture, Tottori University
***Arid Land Research Center, Tottori University

We measured photosynthesis and transpiration of *Avicennia marina* by using the Compact Minicuvette System (H.Walz, Germany) at different salinity levels of 0, 0.8, 1.6, 2.4 and 3.2% , Reroot stock of seedlings was treated under the different salinity levels during 12 hours every days from 15.10. 1994 to 30. 10. 1995. The measurement conditions were performed at 30 centigrade, a dew point temperature of 22. 6(RH 65 %) and eight different light conditions of 0, 10, 30, 100, 400, 800, 1200, 1800 micromol m-2.s-1..
1) Tree height growth of *Avicennia marina* decreased with increasing concentrations of salinity, and dry weight of biomass and amounts of leaves at the levels of 0.8 and 1.6% treatements were larger than other treatements. On the other hand, the rate of tree growth on treatement of 0% was the worst. It seems that *Avicennia marina* needs NaCl contents. 2)The light photosynthetic curve depends on the concentration of salinity, and shows a high inclination at the low light conditions using the Tamiya's equation.

Studies on Salt Tolerance of Tree Species

Tsuneo NAKASUGA and Shigenobu TAMAI***

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**Arid Land Research Center, Tottori University

Salinity and salt-hardening effects of mangrove trees were studied using an Okinawan mangrove tree, *Kandelia candel* Druce, in a greenhouse at the University of the Ryukyus, Okinawa. The soil salinity was adjusted to 1.8% and 3.6% levels by the addition of sodium chloride to the nutrient solution. The comparative condition was non-salt nutrient solution. After 110 days, more than 5% salt solution was added to all treatments. Photosynthetic rate was measured before and after the addition of the high salt solution, and from these results, the salt-hardening effect on *K. candel* seedlings was examined.

Among the three salinity conditions, shoot length, total weight, and chlorophyll content showed the highest value at 1.8% salinity, and the lowest value at 3.6% salinity. Change of photosynthetic rate by the addition of a high salt solution was low in the non-salt condition, and high in the 1.8%, 3.6% salt conditions. However, mortality in the non-salt treatment was higher than that in the salt treatment. These results showed that hardening effect for salt tolerance of *K. candel* seedling increased by pretreatment of a salt solution.

Effects of Salinity and Anaerobic Stresses on Growth and Physiology of Water-cultured *Avicennia Marina* Seedlings

Fukuju YAMAMOTO, Tokihiko NANJO*, Hiroaki HOSHINO*, and Shigenobu TAMAI***

*Faculty of Agriculture, Tottori University
**Arid Land Research Center, Tottori University

The effects of salinity and anaerobic stresses on growth and physiology of *Avicennia marina* seedlings native to the Arabian Gulf were studied using a water-culture method. Various concentrations of NaCl greatly affected growth and the rate of dry weight increment of plant parts. Not only height and diameter growth but also biomass increment was significantly increased by 0.85% NaCl and reduced by high concentrations of NaCl at 4.25, 5.10, and 5.95%. Culture medium without NaCl significantly reduced growth and biomass increment of seedlings. Periodic aeration of the culture media was more effective in growth and dry weight increment of seedlings than successive aeration. Anaerobic stress caused by N_2 gas aeration slightly increased diameter growth and biomass increment of seedlings. In general, lack of oxygen in rhizosphere causes ACC and ethylene production in roots and stems of waterlogged plants. However, the anaerobic stress did not enhance ethylene production in stem segments of seedlings throughout the 28-day experiment.

A-6 Studies on Farm Land Conservation in Arid Areas

Moisture and salt movement under drip irrigation.

Akira TANAKA and Tahei YAMAMOTO***

*Marine and highland Bioscience Research Center, Saga University
**Arid Land Research Center, Tottori University

The influence of water retentivity and hydraulic conductivity of unsaturated soils on crops under drip irrigation was analyzed theoretically. In this study, a nonlinear partial differential equation of moisture flow in soils was linearized with the water retentivity and hydraulic conductivity indices.

A two-dimensional seepage region is infinite in the horizontal direction and semi-infinite in the vertical direction. It is supposed that crop roots are concentrated at 10 cm depth and daily transpiration rate is 30 cc per unit length. We obtained a relation of these indices and the number of days when available moisture was consumed.

The role of capillary supply to roots from outside of the roots'region is large for soils whose hydraulic conductivity index ,average conductivity between pF2 and pF3, is larger than 0.02cm/day ,and the role of water rententivity is larger than that of capillary supply for the soils whose hydraulic conductivity index is lower than 0.005cm/day

Soil Erosion and Vegetation at Slope Covered by Non-woven Fabric in Shirasu Test Plot

Kenzo HOSOYAMADA and Tahei YAMAMOTO***

*Faculty of Agriculture, Miyazaki University
**Arid Land Research Center, Tottori University

Soil erosion and promotion of vegetation using the non-woven fabric on Shirasu soil were studied.
In 1995, the annual precipitation was 2170 mm (less than average) and the temperature in summer was very high. The result was lush vegetation. Soil loss from bare slopes was 93.43 t/ha/year and zero from the non-woven fabric slope.

Features of test results in this year were that the growth of bush clover was remarkable and an invasion of Pencross family plant to the non-woven fabric (no seeds)plot was also remarkable.

It is clear that Biomass C, N, total C and N obtained from soil samples of the root zone covered by non-woven fabric at MIYAZAKI UNIV. test plot increase in quantity, especially biomass C and total C.

Water balances and Observations of Cracks in Saline Soils

Shizuo HAYASHI and Tahei YAMAMOTO***

*Institute of Tropical Agriculture, Kyushu University
**Arid Land Research Center Tottori University

Cohesive soils in arid lands involve many unsettled problems relating to irrigation and drainage. Most important are moisture content and water quality. Cohesive soils give rise to changes in structure. In this study, the authors carried out some experiments on soil cracks.

The growth process of soil cracks developes essentially a straight line as the soil layer depth increases. If the soil layer depth is thin, in a relatively fast stage the first borne cracks ressemble curves and after they combine with several other cracks the first large crack block is born. From some experiments it is estimated that the tensile stress at the time when soils are dried and shrinkage are the determining factors of different crack block areas and types. It will be necessary to consider some influences of both the supply of water and the rate of drying.

B-1 Studies on Water and Salt Management on Woody Plants in Arid Areas

Effects of Water Stress on Transpiration Rate and Leaf Temperature in Rice and Soybean Plants

Haruhiko YAMAMOTO, Seiji HAYAKAWA*, Hiroshi TANI*, Makio KAMICHIKA** and Kyoichi OTSUKI***

*Faculty of Agriculture, Yamaguchi University,
**Arid Land Research Center, Tottori University

Remote sensing of leaf temperatures of water stress in rice (c.v. Nipponbare) and soybean (c.v. Fukuyutaka) plants was made using an infrared radiative thermometer. The transpiration rate of leaves was measured using a porometer. The soil water content and relative transpiration rate were proportional. The difference of leaf temperature (non-water stress plot - water stress plot) and relative transpiration rate were also proportional. The relative transpiration rate = 100 + 26.4 X, where X was the difference of leaf temperature (℃).

Application of a Plant Infusion Method for the Control of the Pine Wilt Disease.

Hidetoshi OKAMOTO and Yoshichika TAKEUCHI***

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**Arid Land Research Center, Tottori University

Pine wilt disease is the most serious problem of the pine forests in Japan. In the present study, the plant infusion method was examined and evaluated as a new method to control pine wilt disease, without any drift of pesticides.

In a period from early May to early June of 1995, three different nematocides were infused into the inner parts of trees using a special infusion system for plants. The nematocide treated pine trees were inoculated with the pathogen of pine wilt disease in the middle of August and were inspected for survivorship there offer.

The rate of death of pine trees applied with nematocides by infusion system was low in comparing with the non treated pine trees.

In conclusion the plant infusion method seemed to be an useful method to control pine wilt disease.

Analysis of Water Uptake of a Tree Using a Root System Model

Tatsuaki KOBAYASHI and Shigenobu TAMAI***

*Faculty of Horticulture, Chiba University
**Arid Land Research Center, Tottori University

The vertical distribution of water uptake resistance from soil to plant of saplings of *Poplus alba* L. was analyzed using a root system model. Though the root surface area decreased with the depth of soil, the water uptake rate was large at the bottom part of the root system. It depended both on the high water uptake conductance and the high soil moisture content. At the wet phase (more than -25 kPa of soil matric potential), the water uptake resistance was dominated by root hydraulic resistance. As the soil dried, the ratio of soil hydraulic resistance increased, and it dominated water uptake resistance at low soil water contents.

Ecophysiological Study on Drought Resistance of Tree Species

Ken YOSHIKAWA and Shigenobu TAMAI***

*Faculty of Agriculture, Okayama University
**Arid Land Research Center, Tottori University

Water stress has some effects on tree phenology, namely, a reduction in leaf area, an increased chlorophyll destruction, a slow development of new leaves and a rapid defoliation. Plants for revegetation of arid areas must have drought tolerance. They must possess two kinds of drought tolerance, one for acute drought which happens suddenly, and another for chronic drought which continues over a long term. The latter is important especially for tree species, because they have longer longevity than herbs. In this study, we aimed at the effect of chronic water stress on seedlings of several tree species.

Following defoliation of old leaves produced before water stress, new leaves of *Quercus glauca* started developing in spring. The growth rate of new leaves was not reduced by water stress. The highest rate of growth occurred in May in highest stressed treatment. The constant growth under a water stress may account for the same leaf size in each treatments. The rapidity of emergency also seemed to contribute to the fast compensation for lost old leaves. The chlorophyll content of new leaves in the stress treatments was slightly lower than in the control, but higher than lost old leaves.

B-2 Measurement of Evapotranspiration and Photosynthesis on the Crop Canopy

Numerical Simulation of Vegetation Structure Effect on the Photosynthesis Using Soil-Plant-Air System Model (NEO-SPAM)

Tetsuya KAWAMURA and Makio KAMICHIKA***

*Department of Computer and Information Sciences, Chiba University
**Arid Land Research Center, Tottori University

The effects of canopy structure on mass transfer between the atmosphere and vegetation were examined by numerical computations with a Soil-Plant-Air system Model(NEO-SPAM) for two different vegetation types (i.e. young vegetation and matured one) of a soy bean canopy. The differences between the two vegetations is distinguished by the leaf area index(LAI) which indicates the density of the leaves. A cyclic boundary condition is assumed in the direction of the flow because of simplicity.

Air flow above and inside the vegetation is simulated reasonably. The wind speed of young vegetation is higher at the bottom part of canopy because of its sparse density of leaves. This gives rise to a higher value of the eddy viscosity coefficient K in the canopy compared to that of matured vegetation. Also the penetrated solar radiation Rs is higher. The photosynthetic rate per leaf area of vegetation is several times higher for the young vegetation than for the maturevegetation, which is caused by the effect of both higher values of K and Rs.

Measurement of Water Vapor Flux Using the Eddy Correlation Method

Hiromichi ODANI and Tomohisa YANO***

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Two eddy correlation systems have been developed to measure water vapor fluxes from a field. Water vapor fluxes measured over a sorghum field at the Arid Land Research Center of Tottori University were compared with those measured using the energy balance Bowen ratio method.

Fair agreement was found between the fluctuations in the absolute humidity. Water vapor fluxes measured with the eddy correlation method were about 30 percent of those measured with the energy balance Bowen ratio method. Causes for the difference between fluxes measured with the two methods will need to be clarified in the future.

A Relationship between Soil Moisture Deficit of the Root Zone and Evapotranspiration on an Upland Field

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In order to plan for rational irrigation scheduling it is important to understand the relationship between soil moisture deficit of the root zone and evapotranspiration on an upland filed.

In this study, a field experiment using Tanukimame as a cultivated crop was conducted at the Arid Land Research Center. Using measured data, actual evapotranspiration rate (ETa) , potential evapotranspiration rate (ETp) and equilibrium evaporation rate (Eeq) were evaluated and relationships between the soil moisture conditions of the root zone (SMC) and these values were discussed.

The SMC were kept wet in this experiment. Therefore ETa > ETp > Eeq was maintained throughout the experiment. The following equations, ETa = 0.77 ETp and ETa = 1.22 Eeq, were obtained using a regression analysis. Thus the ETa predicted by Eeq agreed well with the measured ETa.

The subsurface layers of soil, less than 10cm, often dried up to pF2.9. However the significant decrease of ETa/Eeq and ETa/ETp was not obtained. The average volumetric water content of the root zone (AVWC) was 0.056 (about pF1.9). This fact suggested that the relationship between AVWC and ETa is important under relatively wet conditions.

We plan to investigate these relationship under the more drier conditions.

Studies on Estimation of Evapotranspiration

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The objectives of this study are to experimentally investigate the soil water dynamics in sprinkler-irrigated sandy fields, the response of the crop-surface temperature to changes in soil water and atmospheric conditions, and the validity of the estimation method of evapotranspiration based on the micro-meteorological data. Evapotranspiration was measured with the weighing lysimeter. The temperature of the crop surface, which was covered by leaves of Sorghum, was monitored with an infrared thermometer.

The experimental results show that the temperature difference between air and crop surfaces is sensitive to the soil water condition. The daily evapotranspiration estimated from the crop-air temperature difference is roughly consistent with that measured with the lysimeter. The daily evapotranspiration estimated by the Penman-Monteith method is in good agreement with the measured one when the appropriate canopy resistance is used. The canopy resistance is estimated so as to minimize the difference between the measured and the calculated evapotranspiration under given values of the canopy resistance. The estimation of the canopy resistance is still controversial under actual field conditions.

Thus, it can be said that temperature measurements of crop surface and air will give useful information on evapotranspiration and soil water status in irrigation planning.

Water Use Efficiency of Rice in Humid Area

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Water use efficiency (WUE) is an important factor for estimating amounts of irrigation water for crop production. Stability of WUE has been known regardless of dates or places, when the effect of humidity in transpiration rate is corrected by vapor deficit. The stability , however, is not known in humid areas such as Japan. WUE of paddy rice under irrigated conditions at several locations in Shimane prefecture was compared with that at hot and low humid glasshouse conditions. The WUE under humid paddy fields was much higher than under the low humid glasshouse, but there were small differences in WUE between humid conditions if the transpiration rate corrected by the vapor water deficit was used. We suggested that the corrected WUE of rice also is very stable under humid conditions.

C Free Subjects on Arid Land Studies

Study on Irrigation Development and Environmental Conservation in Arid Area

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Due to the excessive withdrawal of water for irrigation purposes, the environment and the related eco-system of the Aral Sea and its surrounding areas have been adversely affected. The sustainable development of agriculture and conservation of the environment of the region became the focus of our concern.

The present conditions of irrigation and its management have been analyzed. For the improvement of irrigation management and its performance, not only the rehabilitation and improvement of related infrastructures but also the improvement in management practices and institutional setup/capacity will be important.

In the region, it is necessary to transform and diversify the production structure from that of the former-Soviet supported cotton and paddy to that which corresponds to actual food demands. In establishing a proper cropping pattern, the functions of paddy cultivation in terms of salt leaching should not be overlooked. Economy and benefits of water use for irrigation should also be fully analyzed.

With regard to the conservation of the environment in the region, local initiatives of constructing artificial shallow water bodies in the dried lower delta areas needs to be fully investigated. To support the stable supply of water to these water bodies, further efficient use and water savings in the upper irrigated areas are required.

Irrigation and Drainage Managements and Salinization Problems in Hetao Irrigation Districts of China

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The Hetao irrigation districts are formed from two areas, namely Front-Tao and Back-tao. Though these areas have only 200mm of annual precipitation, the long-term irrigation using Yellow-river water has resulted in plentiful agricultural production as well as extensive salinity problems. Historical considerations have made this a natural consequence. The aims of this study are to develop procedures for solving the salinity problems caused by unsuitable irrigation and drainage management and to assess the practical possibility of such procedures.

Roughly speaking, the effects of irrigation by Yellow-river water for increasing agricultural production has been proved. The future tasks are to maintain these effects for a long time in accordance with the following programs. Firstly the prevention of the occurrence of salt injury by the rise of groundwater level should be observed strictly, and next the acquisition and support of improved soil structure is equally important.

Desertification and agricultural development in Africa : A social-scientist view on the Sahelien case

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In analyzing social dynamism, the chief interest of social scientists, focusing on relational aspects is particularly important, and it invariably leads us to the question of who gets what, how, when and why. This focus on the issue of power relations is in its every way crucial when thinking about the issue of development.

For instance, in the context of the semi-arid Sahelien region, water resource development can not be separated from the question of who gets the water, how, when and why. From this aspect, the means for livelihood is directly political.

On the following two points social science is starkly different from natural science. First, as mentioned above, attention to the domain of politics is crucial for explaining social dynamism, and even so for constructing social structural alternatives to the present one. Second, since the object of social science is to study the livelihood of people, it deals with the issue of values. While natural science studies "relations", social science studies "relations" and "relationalities". It is very important to keep in mind that such social relationships are hard to quantify and explain through linear cause-and-effect relationships.

But the need for contribution from both social and natural sciences becomes evident not "despite the differences" but precisely "because of the differences" between them. The issue of development is complex in nature, and it is useful, if not necessary, to exchange the different views coming from different disciplines. The case of desertification in the Sahelien region would benefit from such a cross-disciplinary approach.

Non-Destructive Simultaneous Measurement of Salt and Water in Situ

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In order to establish the proper management of saline soil and to evaluate the effectiveness of implemented farm management practices, the salinity status of the soil, the concentration and distribution of soluble salts in the root zones of soils over time must be monitored periodically.

In this research, the simultaneous movement of salt and water was non-destructively measured in a subsurface soil column in a sand dune field. The soil water electrical conductivity(ECw) is obtained as the function of the bulk soil electrical conductivity(ECa) and the volumetric soil water content(θ) as follows: $ECw = \{(ECa / \theta) - b\}/(a \cdot \theta)$, where ECa is directly measured by the four-electrode sensor, θ is estimated from the matric suction head (h) by a set of tensiometer with a pressure transducer using the soil water characteristic curve (including soil water hysteresis), a and b are experimental values due to the calibration of four-electrode technique. The results of the estimation of ECw from ECa and $\theta(h)$ measured using the four-electrode sensor and tensiometer respectively gave good agreement with the electrical conductivity(ECws) of soil extract solutions by soil sampling in the field.