

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, Makio KAMICHIKA and Reiji KIMURA*

Study on the Meteorological Conditions in Tottori Sand Dune Using the Local Model

Tetsuya KAWAMURA, 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*

Soil Moisture Detection by the Remote Sensing

Soichi NISHIYAMA and Tomohisa YANO*

The Prediction of Crop Water Requirement in Arid Regions (I)

Shinichi TAKEUCHI and Tomohisa YANO*

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

Analysis of Cell Wall Components and Physical Properties Affected by Plant Hormones, Humidity and Salts

Eiichi TANIMOTO, Shinobu INANAGA and Yukihiro SUGIMOTO*

Effects of Soil Physical Properties on the Development of Root System and the Shoot Growth in Cereal Crops

*Jun ABE**, *Ping AN*, *Shinobu INANAGA* and *Yukihiro SUGIMOTO*

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

Responses of Halophytes and Glycophytes to Saline, Sodic and High Sodic Soils

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

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

*Katsuyoshi SHIMIZU** and *Kunio HAMAMURA*

Relation between Water Saving Rate and Crop Growth

*Yukuo ABE** and *Masao TOYAMA*

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

Physiological Responses of Cuttings of Salicaceae Species to Short-term Drought Stress

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

Fundamental Studies on the Creation of the Sustainable Greens

*Katsuhiko YABE**, *Kaoru MAEKAWA* and *Shigenobu TAMAI*

Studies on Salt Tolerance of Tree Species

*Tsuneo NAKASUGA** and *Shigenobu TAMAI*

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

Effect of Gypsum and Polyacrylamide Application on Erodibility of an Acid Kunigami Mahji Soil

*Taku NISHIMURA** and *Tahei YAMAMOTO*

Soil Moisture Environmental Management under the Water Saving Irrigation Application

*Torahiko TANIGAWA** and *Tahei YAMAMOTO*

Effect of Organic Matter on Rill Formation and Soil Loss

Kingshuk ROY and Tahei YAMAMOTO*

A-7) Comprehensive Studies on Planning to Combat Desertification

Evaluation of Indicators for the Monitoring of Desertification

Hideyuki SHIMIZU, Yong GAO, Yuanrun ZHENG and Shinobu INANAGA*

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

Fundamental Study for Construction of Crop Growing Model Using Satellite Data

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

Thermal Environment Monitoring from Space

Masao MORIYAMA, Makio KAMICHIKA and Reiji KIMURA*

Evaluation of Meteorological Environments of the Loess Plateau by Satellite Data

Nobuhiro MATSUOKA, Makio KAMICHIKA and Reiji KIMURA*

Application of Remote Sensing & GIS Technology for Water Management / Landuse Change in large Scale Irrigation Project in Aridland

Seiji TORII and Tahei YAMAMOTO*

Analysis of Temperature Properties of Land Surface by Using Remote Sensing Data

Hisashi FUJIMURA and Mitsuhiro INOUE*

B-2) Studies on Salt Accumulation and Leaching

Water and Temperature Dependence of Thermal Conductivity of Tottori Dune Sand

Tatsuaki KASUBUCHI, Toshihiko MOMOSE and Mitsuhiro INOUE*

Fractal Analysis on Recrystallization of Salts in Soil

Katsutoshi TAKUMA, Koji INOSAKO, Junichi SUZUKA and Tomohisa YANO*

Reduction of Bare Soil Evaporation under Heterogeneous Conditions

*Tsutomu YAMANAKA**, *Ichiro KAIHATSU* and *Mitsuhiro INOUE*

Mechanism of Simultaneous Transfer of Water, Solute and Heat

*Yasutaka KIHARA** and *Mitsuhiro INOUE*

C) Free Subject on Arid Land Studies

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

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

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

*Hiroshi TSUJII** and *Tomohisa YANO*

Study on the Types of Pastoralism in Dry Land

*Yoshihito SHIMADA**, *Yoshinobu KITAMURA* and *Tomohisa YANO*

Strategic Study on Assessment of Impacts of Global Warming on Irrigated Agriculture in Arid Lands

*Tsugihiko WATANABE** and *Tomohisa YANO*

Measurement of Mass Transfer from an Agricultural Land Using the Energy Balance Flux Ratio Method

*Hiromichi ODANI** and *Tomohisa YANO*

Fundamental Studies on the Relationship between Salinization and Evapotranspiration of Agricultural Lands in Arid Area (4)

*Tadao AODA** and *Tomohisa YANO*

Matter Production of Crop Plants under Dry Soil by Change of Water Use Efficiency

*Tohru KOBATA**, *Fumihiko ADACHI* and *Shinobu INANAGA*

Investigation for Physiology of Crop in the Arid Area of China

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

Comparative Study on Soil Factor Affected to Biological Production at Desert

*Kazuhisa HASEGAWA** and *Masao TOYAMA*

Studies on Chlorophyll Fluorescent Response and Water Use Efficiency of Xerophytes under Some Environmental Stresses

*Ken YOSHIKAWA**, *Shigenobu TAMAI* and *Norikazu YAMANAKA*

Ecophysiological Studies on the Pine Wilt Disease Occurring in Coastal Dune

*Kazuyoshi FUTAI**, *Yuko TAKEUCHI*, *Fukuju YAMAMOTO* and *Shigenobu TAMAI*

A Study on the Analysis of Desertification Status on Loess Plateau

*Tatsuaki KOBAYASHI** and *Shigenobu TAMAI*

Studies on the Dynamics of Water and Energy in a False Acacia Forest

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

Plant Nitrogen Use under Dry Condition, Light Effects on Plant NO₃ Use

*Naoko TOKUCHI** and *Norikazu YAMANAKA*

The Utilization of Water Resources and Rural Socio-Economic Development in Desert Fringe Regions in Iran

*Ryuichi HARA** and *Tahei YAMAMOTO*

On the Characteristics of Rill Patterns Generated on the Salinity Soil

- On the Effect of the Saline of the Soil on Soil Erosion and Soil Physical Properties -

*Mitsuo FUKADA** and *Tahei YAMAMOTO*

Importance of Surface Soil in Arid Area on Fertility Conservation – Germination Characteristics of Pioneer Plants

*Yuichi ISHIKAWA** and *Tahei YAMAMOTO*

Preferential Flows and Solutes Transport in Sandy Soils

*Hiroyuki CHO**, *Tahei YAMAMOTO* and *Mitsuhiro INOUE*

Measurement of Solute Transport by a Soil Water Flux Meter

*Koji INOSAKO** and *Mitsuhiro INOUE*

Research on in-situ Permeability Tests in Unsaturated Soils

*Yuji TAKESHITA** and *Mitsuhiro INOUE*

Measurement of Subsoil Permeability Using Well Permeameter Method

*Toshihiro MORII** and *Mitsuhiro INOUE*

Determination of Parameters in Root Water Extraction Models under Saline Irrigation

Haruyuki FUJIMAKI and Mitsuhiro INOUE*

Scheduling System of Water and Nutrients Application for the High Qualities of Vegetables

Satoshi YAMADA and Mitsuhiro INOUE*

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

Ken'ichirou KOSUGI and Mitsuhiro INOUE*

A Study on the Behavior of Pore Air in Unsaturated Soil

Koji KAMIYA and Mitsuhiro INOUE*

(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**, *Makio KAMICHIKA*** and *Reiji KIMURA***

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**Arid Land Research Center, Tottori University

Soil CO₂ concentration and micrometeorological elements were measured at a sand dune field, Arid Land Research Center, Tottori University and at a volcanic ash soil field, National Agricultural Center for Kyushu Okinawa Region. Soil CO₂ concentration was measured directly by small IRGA buried in a soil. The increase of soil CO₂ concentration was observed at rainfall events and it would be influenced by soil temperature and precipitation intensity. It concluded that the air flow from the soil to the atmosphere would be intercepted by the satiated layer which was formed within the surface soil layer, and this interception would increase concentration of CO₂ in the soil. Soil CO₂ concentration at 50cm layer was 5 times smaller in sand dune soil than that of volcanic ash soil because of the low content of total organic carbon (TOC) in sand dune soil. Soil CO₂ concentration in sand dune field decreased during the daytime and it increased at night similar to diurnal change of atmospheric CO₂, while in the cultivated volcanic ash soil field, soil CO₂ concentration decreased between night and morning, and increased between afternoon and early evening, suggesting the microbial activity in the soil. It concluded that difference of CO₂ concentration between sand dune soil and volcanic ash soil would be caused by TOC, microbial activity, gas permeability and diffusivity in soil and atmospheric CO₂ concentration.

Study on the Meteorological Conditions in Tottori Sand Dune Using the Local Model

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

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**Showa High School

***Arid Land Research Center, Tottori University

Three dimensional flow fields over the complex surface of the Tottori sand dunes are numerically simulated. Incompressible Navier-Stokes is solved to compute the flow fields. In order to estimate the effect of the temperature distribution near the ground, the density equation is also solved with Navier-Stokes equation. Boundary fitted coordinate system is employed so that high resolution is

obtained near the ground. Geographic data are obtained from the topographic map of the Tottori sand dune in 1981. By using the computer program developed in this study, three dimensional flow fields up to 300m above the sea level is computed under the various conditions of stratification. As a result, detailed structure of flow field is obtained and the effect of the wind direction, that of the shape of the sand dune and that of the stratification on the flow field are estimated.

Study on the Behaviors of NO₃-N in Sand Dune

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

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Measurements of CO₂, vapor, and sensible heat fluxes above upland rice canopy at sand dune are important to know indirectly the growth of crop and nitrogen cycle. The observation campaign was carried out at experimental field of Arid Land Research Center (ALRC), Tottori University, Japan, from Sep. 22 to Sep. 28, 2001. It is found that only the soil water above 50cm can contribute to evapotranspiration in the study site, where the upland rice is in senescent stage ($LAI=0.2$) during the campaign period. The maximum LE and H are only 184.96 and 230.73 W m⁻², while, the Rn can reach a value of more than 600 W m⁻². Daily evapotranspiration based on the EC measurements is about 1.6mm in this period. The peak of CO₂ flux in daytime is about -0.7 mgCO₂ m⁻² s⁻¹, while, nighttime CO₂ flux is about 0.10 mgCO₂ m⁻² s⁻¹. Net CO₂ absorption by rice canopy is around 0.143 kgCO₂ m⁻² d⁻¹ during the observation period. The CO₂ concentration near canopy daily varies in a range of around 2 mmol m⁻³, and its shows a clockwise loop as response to the net radiation.

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***

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Electric circuit board probes were created for making small TDR probe and were investigated in terms of the effectiveness for measuring the salt concentration in soil water. Dried sand was stuffed into an acrylic column for the laboratory experiments, where steady and unsteady water flow conditions were established. The probes were installed in the column and connected to a computer through the cable tester. Software WinTDR98 was used to determine volumetric water content and bulk electric conductivity of the sand. Electric conductivity in soil water also measured for the samples collected using a soil water sampler. The dispersivities as a parameter were estimated by using the simulation software of HYDRUS-1D from the break through curves obtained from the experiments. The results showed the differences in the dispersivity values between TDR measurement and soil water sampling were scarcely found under either water flow condition. This fact suggests the usefulness of the probe utilization for measuring water content and salt concentration in sand soil.

Soil Moisture Detection by the Remote Sensing

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The main purpose of study in this year is the application of actual field of irrigation reservoir in Yamaguchi Prefecture and detecting the application of problems of irrigation reservoir. If soil contents the water, by the sunshine, the evaporation will be increase, accordingly, the temperature of soil surface should be decreased. Under the last year results, in this year, the emphasized was on actual application in the field irrigation reservoir. By the use of result of basic experiment, the detection of water leakage in 11 irrigation reservoirs in Yamaguchi Prefecture were carryout. The leakage of water was detected in some reservoir.

In some irrigation reservoir, there are many grass and height of grass is very remarkable, the soil moisture of embankment were not be detected. In this case, cutting the grass and tree in embankment in irrigation reservoir are requested. After cutting and cleaning the embankment the leakage of water will be detected.

The Prediction of Crop Water Requirement in Arid Regions (I)

Shinichi TAKEUCHI and Tomohisa YANO***

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The prediction of crop water requirement in Turkey regions was investigated using GCM-Model data which is available at specific web site. Four model (CCCma,HADCM3,NCARPCM,CSIRO) were selected for analysis and checked the accuracy of prediction using air temperature in 2001. The NCARPCM model has best accuracy with B2 scenario.

The distribution of aridity index in Turkey was obtained with GIS. There are not significant changes from 2025 to 2099, while it has clear distinction between 2001 and 2025 in north part of Turkey.

The CROPWAT General purpose program was taken up for estimate crop water requirements. Three location, Tekirdag, Kayseri, Van were selected for analysis with maize plant. It has same tendency among three location that water requirement will increase gradually till 2099. In Tekirdag, rainfall in summer will decrease drastically and irrigation water should be prepared double as many as present value.

Improve the accuracy of predicted rainfall is essential for this kind of work.

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

Analysis of Cell Wall Components and Physical Properties Affected by Plant Hormones, Humidity and Salts

Eiichi TANIMOTO, Shinobu INANAGA** and Yukihiro SUGIMOTO***

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We found previously that the extensibility of root cell wall is expressed by some physical parameters such as viscoelasticity of creep-extension and that low-pH treatment most remarkably decreases viscosity coefficient (η_0). Since the decrease of viscosity is suggested to be conducted by hydrogen-bonding among cell-wall polysaccharides, degree of hydration of cell walls may regulate the viscosity. Thus, the dehydration and re-hydration of cell walls were tested to affect the viscoelastic properties of cell walls.

Dehydration of cell walls by ethanol and re-hydration of dry cell walls by humid air directly changed the viscoelastic properties *in vitro*. Pectin molecules are expected to hold water molecule strongly. Thus the effect of re-hydration on the decrease of viscoelastic parameters was examined using the dry cell walls from which the majority of pectins had been removed. Pectin-less cell walls showed more decrease in viscosity coefficient than normal cell walls, suggesting that pectin controls water-molecule-induced decrease in viscosity in dry root cell walls of *Pisum sativum* L.

**Effects of Soil Physical Properties on the Development of Root System
and the Shoot Growth in Cereal Crops**

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

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The establishment of adequate cultivation techniques is important for the improvement of drought resistance of crops. In particular, treatments that may suppress the loss of soil water by evaporation and/or enlarge the rooting zone may increase the available water to be used by crop plants and prevent from the decline of yield under drought conditions. In this study, the effects of (1) deep tillage, (2) wheat-straw mulching and (3) high planting density at early stage of the growth (hereafter "high density") on the growth, yield and rooting properties of upland rice, which is often affected by drought in Japanese climates, were investigated. The soil water content was kept relatively high by mulching, while got low by high density. The shoot dry weight at harvest was increased by mulching and decreased by high density. Mulching increase the number of grains per panicle, whereas the high density declined the yield due to the decrease in the number of grain per panicle, percentage of filled grains and harvest index. The effect of deep tillage on the shoot growth and yield was not clear. Deep tillage promoted the root distribution in deep soil layer and the high density resulted in shallow root distribution. The root mass, however, was rather decreased by deep tillage. The ratio of leaf area to root mass was enlarged by mulching, reflecting the good holding of soil water by this treatment.

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

Responses of Halophytes and Glycophytes to Saline, Sodic and High Sodic Soils

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

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**Arid Land Research Center, Tottori University

Salicornia, beets, maize and kidney bean were cultivated in saline, sodic and high sodic soils prepared from the dune soil. The mechanism of salt tolerance of the species was discussed from the nutrio-physiological responses. The largest dry weight of salicornia, beet, maize and kidney bean was obtained in sodic soil, saline soil and control soil, respectively. The osmotic potential (OP) of beets decreased with an increasing Na concentration in the soil, whereas other species did not respond to Na. The OP of salicornia was twice lower than that of other species, except for beets. Rubisco activity of all the species was lower in the sodic soils. Salicornia accumulated Na in the middle and upper parts of the shoots and the Na concentration in the shoots was equal between treatments. In other species, the Na concentration increased with an increasing Na concentration in the soil. In salicornia, the K concentration in the shoots was not influenced by the Na concentration in the soil, whereas that in other species decreased with an increasing Na concentration in the soil. Decreased growth by Na in glycophytes was due to a decrease in K/Na, lack of ability to osmotic regulation and decrease in Rubisco activity. It was suggested that salicornia controlled Na absorption and Na stimulated the growth of salicornia.

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

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In the arid area, salty water from river or under ground water is used for irrigation. Halophytes are important plants in the arid area because they can grow with saline water and adsorb salts. Therefore halophytes can inhibit the accumulation of salt in the soil and greenarize the surface of the saline soil.

Salicornia herbacea is a one of the halophytes in Japan, and is able to be used as an oil crop or a forage crop.

In this research, we tried to clear the salt-tolerant system of *Salicornia*, the store and translocation of Na in *Salicornia* shoot tissue by SEM with X ray microanalyzer.

Relation between Water Saving Rate and Crop Growth

*Yukuo ABE** and *Masao TOYAMA***

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In order to discuss the relationship between crops growth and water-saving irrigation, we tried to reform the water-saving irrigation method in the first stage. The control technique of water supply was developed in the laboratory experiment. The results showed that more accurate and higher-level water-saving irrigation effect, and easier control could be got by vertical subsurface drip irrigation method. Furthermore we have been collecting the crops production under water-saving irrigation.

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

Physiological Responses of cuttings of Salicaceae Species to Short-term Drought Stress

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

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**Arid Land Research Center, Tottori University

To determine the drought tolerance of *Salix psammophila* C.Wang et Ch. Y. Yang and *S. matsudana* Koidz., which are commonly used for controlling the movement of sand dunes and the protection of meadows and crop fields in Mo-usu, Inner Mongolia, China, various responses of their cuttings to drought stress including growth and development, leaf area, transpiration and ABA contents in leaves were studied in comparison with that of a Japanese willow species, *S.sieboldiana* Blume. The drought tolerance of *S. psammophila* and *S. matsudana* cuttings were greater than that of *S.sieboldiana* cuttings. However, *S. psammophila* cuttings were more tolerable to drought environment than that of *S. matsudana* cuttings.

Fundamental Studies on the Creation of the Sustainable Greens

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** Arid Land Research Center, Tottori University

This study was carried out to create sustainable soil condition which the much trees and crops could be easy to grow. Namely, Gramineae plants or Leguminosae plants were cultivated in the dressed soil or the reclaimed land and grown their plans to some extend were plowed into in order to improve the soil conditions. And after about three weeks passed when the biomass plowed into their soil were guessed to resolve, the soil samplings were conducted to grasp the physical properties and chemical properties whether their properties were improved or not.

Judging from the obtained results, the great effects of the improvement could not be gotten by plowing the green manure crops only one year. Because the original soil properties were too bad physical and chemical properties and so on. In addition to their properties, the meteorological condition was bad in experiment year. Therefore, if the soil improvement will be not obtained only by plowing the green manure crops, the organic matters and the organic fertilizer should be replenished to soil or the engineering works such as the deep tillage, drainage, and other should be conducted so that the green manure crops easily grow under the bad meteorological condition.

Studies on Salt Tolerance of Tree Species

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**Arid Land Research Center, Tottori University

The care of dug up natural seedlings of three Okinawan mangrove species, *Bruguiera gymnorrhiza*, *Kandelia candel* and *Rhizophora stylosa*, were described. The natural seedling were dug up using cylinders, then cared for in the greenhouse. The resulting survival rate was 70% to 100%, which shows that the technique is sufficiently applicable.

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

Effect of Gypsum and Polyacrylamide Application on Erodibility of an Acid Kunigami Mahji Soil

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**Arid Land Research Center, Tottori University

Calcium carbonates and gypsum (CaSO_4) are used to improve chemical status of the acid soil. However, application of Ca cation may sometimes enhance dispersion and deteriorate soil physical properties. Presenting study discusses effect of non-ionic polyacrylamide (PAM) application on erodibility of a gypsum amended Japanese acid soil.

Acid Kunigami mahji soil (Hapludult), $\text{pH}(\text{H}_2\text{O}):4.4$, from Okinawa, Japan was used in this study. The soil was sieved through 3 mm mesh screen and packed into an acrylic plastic box of 30cmx50cmx10cm in depth with bulk density of 1.15 Mg/m^3 . Prior to the simulated rainfall, a 2.5t/ha of gypsum and/or 15 Kg/ha of non-ionic PAM were applied onto soil surface. Intensity of the simulated rainfall were 40 mm/hr. During a rainfall, surface runoff was collected periodically.

Gypsum application enhanced runoff significantly. It caused quick and more surface runoff than without the amendment. During rainfall, electrolyte concentration of the runoff was greater than the critical coagulation concentration of the clay fraction of the soil material, however the soil became dispersive with gypsum application. When only PAM was applied prior to the rainfall, it could reinforce soil structure. The PAM application could improve infiltration of gypsum amended Kunigami mahji soil. Gypsum application caused greater sediment concentration (10 g/L) than without the gypsum amendment (5g/L). In presenting study, non-ionic PAM was effective for reducing runoff while non anionic PAM was more effective to reduce sediment concentration.

Soil Moisture Environmental Management under the Water Saving Irrigation Application

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On the application of water saving irrigation as drip irrigation and continuous sub-irrigation, the fouling in the irrigation tube by the water quality becomes a cause of water supply performance deterioration.

In this study, the effectiveness of various countermeasures was examined by cultivation experiment of the sub-irrigation application. As the result, it was clarified that regulation of the setting pressure and periodic cleaning inside of tube could maintain the water saving ability of the sub-irrigation.

In addition, the water saving irrigation method was able to create the suitable soil moisture environment, and it was possible to eliminate the infiltration loss.

Effect of Organic Matter on Rill Formation and Soil Loss

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Water erosion is a major factor that causes soil degradation, in other words, desertification throughout the world. The mechanism of water erosion manifests complicated phenomena in practical agricultural farmlands. Especially, the formation and development of rills on soil surface greatly influence the amount of soil loss. In this research, the author carried out a series of indoor experiments to investigate the formation and development status of rills with respect to the variation of organic matter contents of soil. The rills observed during each experiment could be classified into two types, namely, expanding type and stable type. From the results, it was found that the more the organic matter content (%) was, the less the amount of soil eroded.

A-7) Comprehensive Studies on Planning to Combat Desertification

Evaluation of Indicators for the Monitoring of Desertification

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

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Desertification monitoring and assessment is fundamentally necessary for its control. Vegetations might be applied as useful indicators of desertification, because they sensitively change with desertification intensifying. Present study was, therefore, carried out aiming at developing a vegetation indicator system for the assessment of desertification in Mu Us sandy land, a typical desertified area in semi-arid region of China. Based on literature review and field investigations, three vegetation parameters, coverage, above ground biomass and dominant species, were suggested to be associated with the indicator system. Categorization of desertification states to five degrees showed high practicability. The tendency that some certain species only presented at the areas with certain desertification stages (Table 1), implies that those species have high potential as desertification indicators to evaluate the desertification degree.

Stages of Desertification	Plant Species
Non	<i>Sabina vulgaris</i> ; <i>Artemisia ordosica</i> ; <i>Salix psammophila</i>
Light	<i>Artemisia ordosica</i> ; <i>Salix psammophila</i> ; <i>Hedysarum fruticosum</i> subsp. <i>Leave</i>
Middle	<i>Hedysarum fruticosum</i> subspe. <i>Leave</i> ; <i>Artemisia spheroccephala</i> ; <i>Caragana intermedia</i>
High	<i>Psammochloa villosa</i> ; <i>Phragmites communis</i> ; <i>Agriopyllum squarrosum</i>
Severe	<i>Agriopyllum squarrosum</i> ; <i>Cynanchum komarovii</i> ; <i>Inula salsoloides</i>

Table1. Plant species presented at the certain desertification stages in Mu Us sandy land in China.

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

Fundamental Study for Construction of Crop Growing Model Using Satellite Data

Etsuji ISHIGURO*, Muneharu SATO*, Koichi IWASAKI*, Hiroyuki KIKUKAWA**,
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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 paddy rice with the lengthening growing days, the spectral reflectance of rice leaves from 400 to 1,100nm wavelength range was acquired with a hand held 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.

Thermal Environment Monitoring from Space

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To estimate the thermal environment from the earth observation satellite, the attempt is made to make the simplified heat balance model and the retrieval scheme for the area averaged heat capacity. In the nighttime, surface wind is weaker than in the daytime, so that the latent/ sensible heat transfer can be negligible and the heat balance can be simplified as the IR radiation balance equals to the ground heat transfer. From the meteorological observation data, the downward IR radiation is formulated with the surface temperature. Thus the heat balance equation is simplified as the function of surface temperature and surface heat capacity. By using the GMS IR1 data during 2000, the heat capacity is estimated as the function of the nighttime mean surface temperature gradient over 7 hours. From the comparison between the estimated heat capacity and the land cover data, the heat capacity is regarded as functional.

Evaluation of Meteorological Environments of the Loess Plateau by Satellite Data

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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 5C 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.

Application of Remote Sensing & GIS Technology for Water Management / Landuse Change in Large Scale Irrigation Project in Aridland

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EOS project is executing under multi-national cooperation, USA, Japan, etc. ASTER sensor, carrying by Terra satellite, supplies precise image data of land surface. We try to apply these image data to Irrigation Project in Khuzestan Province, Iran. Comparing with former Satellite images, clearer and higher resolution images are given more often. ASTER sensor observes in the angle of both direct rights down direction and nearly 30-degree back sight simultaneously, and we can get 3 dimensional image data.

It would be possible to develop land use/cover in series in 3 dimensional space, information for grasp the situation, control, management of large scale irrigation project becomes easier to be caught, and combing USGS GTOPO30, big prospect become true to make geostatistical processing.

Analysis of Temperature Properties of Land Surface by Using Remote Sensing Data

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Rapid urbanization of our environment to accommodate the ever-increasing human needs has necessitated the replacement of vegetated land surfaces with man-made ones. Concrete and asphalt surfaces are two of the features of major concern, especially in relation to the resulting influence on urban heat environment. Asphalt surfaces on roads and parking lots, besides concrete pavements, buildings etc., primarily affect solar reflectivity thus disturbing the natural radiation balance of the city. They absorb and radiate more heat than a natural surface, thus causing warming in cities. Thermal response of natural and artificial surfaces is increasingly drawing attention of researchers.

Because of the significant influence of asphalt surfaces on an urban environment, it is important to know how they respond to solar illumination. In this study, daytime temperature variation of a portion of asphalt-paved road surface is measured and analyzed.

B-2) Studies on Salt Accumulation and Leaching

Water and Temperature Dependence of Thermal Conductivity of Tottori Sand Dune

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In general, thermal conductivity increased with temperature by the increase in the latent heat transfer. But the thermal conductivity of Toyoura sand at low water content decreased with temperature. This means that there would be other factor to decrease the heat transfer in soils.

Thermal conductivity of Tottori dune sand increased with temperature except the sample with 0.02% of water. Thermal conductivity of the sample with 0.02% increased with temperature from 5 to 35 but decreased from 35 to 75 . Thermal conductivity of Tottori dune sand had the same thermal property as Toyoura sand but the effect was rather small than Toyoura sand. We expected that this cause was due to the clay content of the Tottori dune sand.

Fractal Analysis on Recrystallization of Salts in Soil

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There are many studies about salt accumulation in arid and semi-arid regions. However, salt accumulation is considered as increase of salt concentration near the soil surface in most of them. In this study, this phenomenon was considered as recrystallization of salts in soil and fractal analysis was conducted for the modeling of this phenomenon.

Small size column experiments were conducted to obtain the digital pictures of recrystallization of salts on the soil surface. Soil was Tottori dune sand. The concentration of salt water in this column was 200,000 ppm. These digital pictures were assessed by two dimensional Euler's correlation. Moreover it was simulated the patterns of recrystallization of salts by using 3D diffusion limited aggregation (DLA). As a result, it cleared that the pattern could be reproduced by DLA.

At last, recrystallization of salts in large scale was tried at a large size column of the Arid land research center and we succeeded to obtain the digital pictures.

Reduction of Bare Soil Evaporation under Heterogeneous Conditions

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Laboratory experiments were carried out to investigate the effects of gravel mulch on evaporation with emphasis on resistance to water vapor transfer in a soil-mulch-atmosphere continuum. Comparison of experimental result for bare soil surface with that for mulched surface provides us a new finding that gravel mulch increases the resistance not only above the soil surface but also below the surface. The increase in the resistance below the soil surface, which is conventionally called as "soil surface resistance", is caused by local development of the dry surface layer. Partial covering of the soil surface with gravel induces concentrated evaporation flux and deepens locally the drying front, even if the soil is relatively wet on spatial average. The inhomogeneity in soil moisture movement may be reinforced when gravels are embedded in part into the soil.

Mechanism of Simultaneous Transfer of Water, Solute and Heat

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We measured water and salt behavior during leaching in soil columns which have produced salt accumulation artificially. Experiments were conducted using in large columns with 80cm in diameter that were installed at the ALRC. The following result was obtained. It has been found that salt concentration is decreased at surface layer. Electric Conductivity (EC) in soil solution is increased 10dS/m or more without leaching, whereas it is about 6dS/m at 5cm depth with leaching and it is downward trend in deeper layer. While the water for leaching is 3dS/m in EC which is not very high quality irrigation water, we can obtain this effect. In this experiment, we noticed at surface layer. Hereafter, we consider water and salt behavior during leaching with much deeper layer.

C) Free Subject on Arid Land Studies

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

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An apparatus for condensation of water vapor was constructed with a Peltier device (40mmx40mm), which was sandwiched between two heat dissipation fin modules and had a cooling fan on the heat radiation side and a ventilation fan on the condensation side. Performance tests of the apparatus have been conducted in a growth chamber in which temperature and humidity were controlled and set to the values of 25degrees C and 85% assuming the state of a humid desert in continent West Coast. Time variation of the weight of the apparatus by waterdrop adhesion was measured by making Peltier device voltage and the amount of ventilation into parameters. When there was no ventilation on the condensation side and when the input voltage to the Peltier device was 10V (electric power = about 18W) , the amount of production of water for an hour was about 3g. When the input voltage was the same and the amount of ventilation was 0.4 l/s, the water production became from 4g/h to 5g/h. Furthermore, when the amount of ventilation was large, water production decreased. When the input voltage was set other than 10V, although the increase in water production by a small amount of

ventilation was observed, the relation between the amounts of ventilation and water production was not clear. Some contrivances will be added to the apparatus to increase the efficiency of water production.

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

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This paper analyzes agricultural sustainability regarding soil fertility of a village in West Java by econometric methods using farm household and plot-wise agro-economic and agro-ecological data collected by our farm survey in the village in 2002. The results of the multinomial logit estimation of the agroforesters' perception function of plot wise soil fertility supported our hypothesis that the agroforesters' soil fertility mining behavior was stronger than soil conserving behavior in the surveyed banana Leaf (BL) plots. Weeding was the popular BL plot soil conservation activity by Kemang agroforesters. The estimated marginal effects of weeding frequency (WF) by the multinomial logit method indicated that our hypothesis that the negative effect from soil fertility perception to weeding frequency more than offset the positive effect of weeding to soil fertility. This indicates that if BL monoculture expanded its area rapidly, as it has been during past five years would increase agroforesters' income in the short run, but it may deplete soil fertility faster in the long run since this BL monoculture system was a heaviest soil mining one.

Study on the Use of Water Resources in Sahel Africa

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The *desertification* is an inappropriately posed question. It is why the problems of *desertification* have not been well resolved. First, the problems of *desertification* are in fact ones of drought, which are therefore considered in a narrow concept of botanical ecology without being looked at under more numerous aspects. Second, the desert region was considered as infertile, whereas men and others lives

existed there, even prosperously for example along the big rivers or in the oasis: the desert has produced important human civilizations. The fundamental question is in the confusion repeated between the climatic concept of the desert and the ecological one. The climatic desert is not necessary ecological one; therefore even under the climatic desert men and organisms can live. This paradox of the desert is well presented by the existence of camels and dromedary, the biggest domesticated animals; why so big animal can live in the desert, only in the desert?. But most of pastoralism has been plasticized in driers regions. It becomes a good chance of reconsidering the human life in the desert to study them in a comparative way as to get an overview of the pastoralisms.

Strategic Study on Assessment of Impacts of Global Warming on the Irrigated Agriculture in Arid Lands

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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 production system, a new evaluation method is to be established, including adaptation mechanism evaluation and module for launching mitigation measures. In this process, socio-economic adaptation of farm household, regional land and water management system, agricultural policies, and international food trade should be included in the analysis to give many concrete materials for considerations. In this research, the requirements for the framework have been studied and clarified, some of which are summarized as below.

- 1) Scenarios of the future changes in regional climate should be linked with the global climate change and customized to be used for prediction of the changes in agricultural production parameters.
- 2) On-farm bio-physical model should be included to assess the relation between soil and water conditions and crop and plant production, including effects of sea-level rise and soil salinity and changes in irrigation water requirements.
- 3) Analysis of response of the basin hydrology to the climate change should be included and linked with land and water use management.
- 4) Water balance of each sub-basin, from farm plot level to the whole basin level, should be analyzed quantitatively.

- 5) Land and water management should represent and integrate the whole system change of behavior of agricultural production.
- 6) Socio-economical evaluation of climate change impacts on the regional agricultural production system and identification of important elements and critical points for agricultural production and irrigation management in arid areas should be included.

Measurement of Mass Transfer from an Agricultural Land Using the Energy Balance Flux Ratio Method

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The CO₂ and CH₄ fluxes from a rice canopy were estimated with the energy balance flux ratio method from June 15 to July 31, 2002. Main results obtained were as follows:

1. The relationship between the CO₂ flux and the photosynthetic photon flux density (PPFD) was examined. The various values of the CO₂ flux were obtained even for any small range of the PPFD due to fluctuations of air temperature.
2. The CH₄ fluxes measured with the energy balance flux ratio method were overestimated in comparison with those published previously with the chamber method.

Fundamental Studies on the Relationship between Salinization and Evapotranspiration of Agricultural Lands in Arid Area (4)

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In the process of drying soils, vapor phase diffusivity overwhelms hydraulic conductivity. Under the condition of decreasing water level, liquid water forms isolated pendular ring at soil contact by capillarity, and semi-solid water covers soil as thin film by adsorption. In this film stage, water moves with phase transition. Because adsorbed film water behaves like a solid, it is not able to transmit pressure. In our experimental results show that pressure head in film stage

- 1) is independent from the fluctuation of water table,

- 2) is influenced by vapor phase water movement,
- 3) decrease gradually by vapor diffusion,
- 4) increase quickly by trickle down of liquid water.

Therefore, we conclude that mechanism of absorption and capillarity should be separated in the analysis of water movement in unsaturated soils.

Matter Production of Crop Plants under Dry Soil by Change of Water Use Efficiency

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It was investigated the effects of soil drying on relative transpiration rate (Td/0) as a ratio of transpiration rate suffered soil desiccation to that under irrigated conditions during vegetative stage in several rice cultivars. When irrigation to pots was stopped at middle vegetative stage, the Td/0 of all cultivars was maintained during higher soil water content and then linearly decreased. However, there was a difference in the slope of Td/0 between cultivars or soil types. The differences were almost deleted when soil water content was indicated by soil water potential. It was suggested that Td/0 was estimated by soil water potential regardless of cultivars or soil types.

Investigation for physiology of crop in the Arid Area of China

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We kept studying the physiological ecology and conducting cultivation experiment for cotton, sugar beet, soybean and tomato in the arid condition of Xingjiang China. These studies were done at the Experimental Farm of Shihezi Dry Land Agricultural Institute, Shihezi, Xingjiang China.

Soybean showed 8 t ha⁻¹ of high seed yield last year. While it is on the way to analyze the mechanisms for high yielding, there must be such a high potential productivity on soybean production in Xingjiang.

Tomato is under the practical experiment on organic farming. It is produced for export, so it needs

higher commercial value than abroad. The experiment was conducted in experimental fields with concrete levee. Manure from pig production was applied to compare the chemical fertilizing cultivation. Organic tomato was more delicious than conventional one.

Comparative Study on Soil Factor Affected to Biological Production in Arid Land

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In point of view for reasonable application of organic matter, manure made of all vegetable residue producing on ISHIKAWA sand dune for sweetpotato, radish and tomato cultivation field was applied to banded field oneself.

Nitrogen content of these manure was 1.0% ~ 1.6%, and when these manure were applied to field, nitrogen for fertilizer was recycled 12kg-sweetpotato 21kg-radish 35kg-tomato per 1000m².

Studies on Chlorophyll Fluorescent Response and Water Use Efficiency of Xerophytes under Some Environmental Stresses

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Plant species living in arid and degraded conditions must have effective properties against severe water stress and strong solar radiation. Shading and drought treatments were carried out with seedlings of *S. vulgaris*, evergreen coniferous tree species, growing in the Mu-U desert, China, to detect the photo-protection mechanism of xerophytes.

Under chronic water stress, *S. vulgaris* could control the water loss by prompt stomatal response. When the photo-energy became abruptly excessive by a change of solar radiation, *S. vulgaris* could avoid the damage on photosynthetic organ by the effective quenching response of photo energy to heat energy under high de-epoxidation condition. The de-epoxidation ratio, the chlorophyll a/b ratio and the xanthophylls pool size of photosynthetic organs of seedling growing under chronic strong photo condition became larger than these under the normal condition. These results indicated the induction of photo-protection response by the excessive photo-energy arisen from strong solar radiation.

Ecophysiological Studies on the Pine Wilt Disease Occurring in Coastal Dune

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As regards Pine Wilt Disease, which is the most serious forest disease in Japan, we evaluated the quantitative and qualitative properties of volatiles emitted from pine trees suffering from this disease at a sand dune stand, and found a latent carrier showing a characteristic emission pattern. We conclude that the evaluation of volatiles can be a sensitive and nondestructive diagnosis.

A Study on the Analysis of Desertification Status on Loess Plateau

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Vegetation-soil survey and the measurement to spectral reflectance were done on August 2002 in Shen-mu contry in the northern Loess Plateau. Land coverage recognized by spectral reflectance was categorized into the following three types as bare ground, vegetation coverage, and water-body or coal-mine. Bare ground was more divided into loessal or sandy bare ground and sparsely vegetated or microorganism-covered ground.

Multi-band radiometry of LANDSAT/TM data was analyzed with the result of ground truth survey in Shen-mu country. Radiometric pattern was classified into the following four types as bare ground, gully, irrigated cropland and rain-fed cropland or grassland.

Study on the Dynamics of Water and Energy in a False Acacia Forest

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Objective of this study is to investigate the dynamics of water and energy in the forest ecosystem of false acacia which is widely introduced in Loess Plateau in China for afforestation.

We set an observation plot of 10mx10m in the false acacia forest located in the north side of the experimental field of the Arid Land Research Center. In the plot, 16 storage-type throughfall gauges, three tipping bucket-type throughfall gauges, three tipping-type stem flow gauges and one tipping-type gross rainfall were installed to measure the input of water to the forest canopy and forest floor. We also measured the moisture contents of soil and trees using dielectric type soil moisture sensors, and sap flow of a tree using the heat pulse method.

In general, tree water content shows its maximum value several hours after sunrise. It decreases till several hours before sunset, then gradually increase throughout the night. On the other hand, we found that the water content of false acacia increased in the morning till several hours before sunset, and then decreased throughout the night.

In order to find the mechanism of this unique behavior of water transport of false acacia, we started measurement of the cross-sectional distribution of tree water content by means of weighing method and soft X-ray photograph method in February 2003.

Plant Nitrogen Use under Dry Condition Light Effects on Plant NO₃ Use

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It has shown that nitrate reductase activity (NRA) is controlled by light directly. However, it is not well known how NRA of tree species and the allocation of NR are influenced by short-term difference under different light condition. Gross chamber was used in order to make clear the influences of light to NRA. Light condition was set two different condition; Light condition, 11h (dark)/ 13h (light) / 11h (dark)/ 5h (light) and Dark condition, 11h (dark) /13h (light)/ 11h (dark)/ 5h (dark). The clear difference in NRA was shown in root of two broad leaf species of six species. These two species used

nitrate when light condition was enough. These things suggest that two species can adapt the short-term light condition change.

The Utilization of Water Resources and Rural Socio-Economic Development in Desert Fringe Regions in Iran

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- (1) The field surveys conducted in 2000 and 2001 in the Xinjiang Uygur autonomous regions, the People's Republic of China for the research project "the Traditional Production Practices and Living Necessaries in the Kashgar region; A Historical Process of Transfer, Acceptance and Development through the Silk Road" sponsored by the research center for silk Roadology. Main objective of this research to identify the relationships existing between natural ecological environment of as an object, local techniques as means, and social group as actors, and to trace the process of emergence and transformation of these relations.

The "water network" that unites nature and people and constitute the infrastructure for productive activities. On this basis the "periodical markets' network" covers all the oasis villages and relates their inhabitants each to others.

In the year of 2002, the final research report "The traditional Ways of Production and Life in the Kashgar and Hotan Region" has published [Ref. (3)].

- (2) In October of 2002, we made a field trip to Gorgan Plain where is located the north region of the Iran. It is surrounded by the Elbourz Mountains and Caspian Sea. This is a JICA's research project area.

I was involved in this research project for the JICA Steering Committee of the study (Rural development). "The study on improvement of irrigation, drainage and agricultural development for Gorgan Plain in the Islamic Republic of Iran". The study area has salinization and alkalization problems of soil, being necessary to be careful elaborating a development plan that is sustainable with adequate development technique, and being in constant harmony with the environment.

**On the Characteristics of Rill Patterns Generated on the Salinity Soil
- On the Effect of the Saline of the Soil on Soil Erosion and Soil Physical Properties -**

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This research aims at investigating the effect of saline content on the soil erosion and the dynamic strength of soil.

The outflow volume of saline soil was measured at 2 minutes interval in laboratory experiments under the fixed condition of experimental soil with 14 % water content and 10 ° slope-gradient of erosion box, constant surface flow.

The liquid test and plastic limit test by using the same saline soil was conducted. From these experiments, the following results were obtained:

- 1) It was appeared that the amount of soil loss, or erosion of saline soil was higher than that of the non-saline soil.
- 2) The difference of the aspect of generation and development of the erosion pattern on the surface of saline is small in comparison with the non-saline soil.
- 3) Liquid limit and shear strength of saline soil was lower in comparison with the soil, which did not do the saline soil.

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

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In order to protect desertification and to maintain sustainable plant production, it is important and urgent subject to conserve and recover soil fertilities. The objectives of the research are to quantify the impact of soil disturbance in degraded lands and to suggest some technologies to conserve and recover soil fertilities.

In 2001, it was shown that surface soil conservation worked as 'seed bank' to store the number of seeds of native vegetation that are annual or short-lived perennial, called pioneer plants. However because germinating properties of pioneer plants are not clear, we tested the reaction of some species of halophytes germinating on salt concentration.

We carried out the germination tests of 4 species of *Atriplex*; *A. codonocarpa* and *A. holocarpa* as annual, and *A. vesicaria* and *A. nummularia* as short-lived perennial with saline solution of 0 to 1.5%

NaCl. The results showed the germination rate of *A. vesicaria* is as less as 35%, whereas the other three species germinated by more than 90% and the germination rate decreased gently as the salt content in cultivating solution increased. The difference of the germination between annual plants and short-lived plants were not significant.

The germination of *A. vesicaria* was much lower than the previous work. It is suggested that the effect of individuals within a species are strong.

Preferential Flows and Solutes Transport in Sandy Soils

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Wetting front instability creates a shallow induction zone from which fingers emerge that rapidly transport water and solutes downward. How the induction zone affects finger location and spacing is unknown. In the moist subsoil, fingers may well dissipate because the finger tips no longer have to overcome the water entry value. Both flow regions were investigated in a two-dimensional chamber with a fine-over-coarse glass bead porous medium.

As a result of experiment, the induction zone did not affect finger properties. The pressure head in the induction zone was determined by the depth of the finger tips. The water requirement of the fingers dictated the lateral pressure head gradients. The pressure heads in the capillary fringe supported the hypothesis that the flow stabilized and dissipated there.

Measurement of Solute Transport by a Soil Water Flux Meter

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It is essential for quantity of solute transport in soil to establish the measurement method of percolated water from a root zone to lower layers. A soil water flux meter is considered as one of the rational methods following an unsaturated percolation theory. However, there are many problems which must be solved for the practice, for example, selection of filter and pressure control method of it.

When this facility is applied to Tottori sand dune fields, these problems will be remarkable. It is easy

for the sand to plug the filter, because it has a lot of infinitesimal suspended materials. Moreover, the method of pressure control has not been established for the soil which has high hydraulic conductivity, yet.

These problems for Tottori sand dune fields were discussed in this study. Unsaturated steady percolation experiments in small and big columns were conducted in this study. The results were summarized as follows;

- 1) A 3 μm Versapor filter was selected as a best one according to small column experiments. It cleared that this filter had tolerance of plugging and ensured stable percolation.
- 2) The experiment by using a big column showed that the correction rate of percolated water of it was 2.5 times of the designed one. This caused to correct water by great suction at the filter. This suggested that more study should be conducted to solve this problem.

Research on In-situ Permeability Tests in Unsaturated Soils

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In situ measurements of field-saturated hydraulic conductivity, K_{fs} and unsaturated hydraulic conductivity $K(\theta)$ are essential for accurate prediction of water movement in unsaturated soils. In this research, the practical applicability of the constant head permeability tests which have been developed to these hydraulic conductivities of unsaturated soils are examined using field tests, the tension infiltrometer (TI) method and the pressure infiltrometer (PI) method are explained. PI method and TI method can be an excellent practical in situ permeability test. It is shown that the K_{fs} measured by TI method is smaller than measured one by PI method.

Measurement of Subsoil Permeability using Well Permeameter Method

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An applicability of the Guelph well permeameter (GP) method was examined by in-situ tests in sand field. The GP method, which was developed by the researchers of Guelph University, Canada, around

1985, is an in-situ permeability test to determine a field-saturated hydraulic conductivity of soil, K_{fs} , by measuring steady-state infiltration rate from a bored well into the soil to maintain constant head of water within the well. The in-situ tests in the sand field showed that an apparatus of the GP method as well as a procedure to measure the steady-state infiltration rate is quite simple. Accuracy of K_{fs} was successfully evaluated by comparing with saturated hydraulic conductivity of soil cores sampled from the test sites without disturbance. K_{fs} along the vertical line from the soil surface to 140 cm in depth were measured by the GP method and plotted together with the soil profile along the vertical section of a trench in the soil. Comparison between K_{fs} along the soil profile and the saturated hydraulic conductivity of the soil cores sampled from the soil layers revealed that, in the case of layered soil, the GP method provides a weighted average value of K_{fs} of layered soils included within some region around the well. It was also shown that the vertical component of hydraulic conductivity is preferably measured by the GP method in sand soil.

Determination of Parameters in Root Water Extraction Models under Saline Irrigation

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To present an inverse parameter estimation method for determining parameters in Feddes's root water uptake model, we conducted a lysimeter experiment in a green house using soybean. The thermocouples and TDR probes were set at 5, 15 and 30 cm depth, respectively. The weight of the lysimeter was measured at sunrise and sundown to measure daily transpiration. The water stress was introduced for two of the six lysimeters by cutting any water supply in the duration. The other non-stressed lysimeters were used to provide potential transpiration.

The parameter values were determined such that the sum of square errors between calculated and measured daily transpiration were minimized. The root mean square errors for the two lysimeters were 0.15 and 0.13 mm/d, respectively, indicating the validity of the model and optimized parameters.

Early cold wave in late October disabled us to continue the experiment and introduction of salinity stress that is originally planned. We are thus conducting the experiment.

Scheduling System of Water and Nutrients Application for the High Qualities of Vegetables

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Komatsuna (*Brasica Rapa* L.) was pot cultured with varied levels of water and nitrogen fertilizer. Results obtained were as follows: Fresh weight of shoot increased with the increase of the water and nitrogen levels, indicating the synergy effect of water and nitrogen for the increase of fresh weight. Concentration of chlorophyll increased only with the increase of the nitrogen level. Protein concentration increased with the increase of nitrogen level and trended to be increased with the decrease of water level. The concentration of calcium was highest in W3N3 (soil moisture tension; 15-20 cmH₂O, amount of applied nitrogen; 0.3gN pot⁻¹), though the response among treatments was ambiguous. Total vitamin C concentration increased with the increase of the water level only in low N.

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

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Conventional methods to determine unsaturated soil hydraulic properties are laborious and time consuming. Although the inverse method can be an effective alternative, it occasionally exhibits a problem of solution non-uniqueness. The problem becomes more difficult to solve when the inverse method is applied to heterogeneous soil profiles. This study evaluated the method proposed by Kosugi and Nakayama which estimates retention and hydraulic conductivity functions simultaneously for each horizontal layer of a vertically heterogeneous soil by using transient matric pressure profiles. The effects of the model selection on the estimation results were analyzed by comparing six combined water retention-hydraulic conductivity models. Over all, most of the models produced similar retention and hydraulic conductivity curves. On average, the LN-M (the lognormal distribution model combined with Mualem's model) and VG-B (van Genuchten model combined with Burdine's model) models performed slightly better than other models did. Moreover, the value of the soil pore tortuosity parameter, l , in the LN-M model was discussed. A large l value ($l = 1.0$ to 2.0) produced good results for the shallower layers, while a small l value ($l = 0.0$ or 0.5) was preferable for the deeper layers. On average, the l value

of 0.5 introduced by Mualem was suitable for the forest soil sample studied. The sensitivity of parameter estimation to experimental errors in separately predetermined parameters was examined. When a 5 % error term was assumed for the measured water content values of the retention curves, and the measured saturated hydraulic conductivity values were doubled or halved, the estimated retention curves generally succeeded in reproducing the characteristics of the observed retention curves, and the uncertainty ranges for the conductivity estimation were narrow.

A Study on the Behavior of Pore Air in Unsaturated Soil

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The knowledge of the hydraulic properties of unsaturated soil is necessary to evaluate the seepage behavior of rainfall into the ground. Especially, it is important to understand the influence from the behavior of pore air to the seepage of rainfall into the ground. In this study, the method to measure the air permeability, the moisture characteristic curve and void diameter distribution was proposed. And then, the relationship between the air permeability and the hydraulic conductivity is examined.

(3) Open Seminar

Topic of Open Seminar

Name of Speaker

Occupation of Speaker

1) Research program and project related to the arid land in Research Institute for Humanity and Nature(RIHN) (Jun. 17, 2002)

Tsugihiko WATANABE

Research Institute for Humanity and Nature

2) Useful plant in arid or salt injury lands (Sep. 27, 2002)

(A) Silk road in new century

Environmental development in arid region of Central Asia – Joint research of TARC/JIRCAS

Shinya TSURU

College of Bioresource Sciences, Nihon University

(B) Meadow vegetation in west Asia

Shigeru TAKAHATA

Tohoku National Agricultural Experiment Station

3) Observation for soil water and electric conductivity by the TDR method (Oct. 18, 2002)

Kohsuke NOBORIO

Faculty of Agriculture, Iwate University

4) Global warming and agriculture and forestry industries (Oct. 21, 2002)

(A) Forecast in the future of global warming using the climate model

Akio KITOH

Climate Research Department, Meteorological Research Institute

(B) Spatial distribution and economics approach of water resource

Chieko UMETSU

Research Institute for Humanity and Nature

- 5) Estimation methods for heat fluxes based on thermal-infrared remote sensing combined with heat budget method (Nov. 26, 2002)**

Dai MATSUSHIMA

Graduate School of Science, Tohoku University

- 6) Genetic structure of the island populations of *Kandelia candel* in Nansei-shoto in Japan (Dec. 5, 2002)**

Ko HARADA

Faculty of Agriculture, Ehime University

- 7) To young students aiming at the arid land study (Jan. 22, 2003)**

Iwao KOBORI

The United Nations University

- 8) Precipitation processes in the Sahara Desert region based on TRMM PR data (Feb. 25, 2003)**

Chikako HARADA

Center for Climate System Research, University of Tokyo

- 9) Ununiformity of evaporative environment and variation of consumptive use in field soil surface (Mar. 3, 2003)**

Kozue YUGE and Yoshisuke NAKANO***

*Department of Regional Environment Engineering, Kyushu-kyouritsu University

**Faculty of Agriculture, Graduate School of Kyushu University

- 10) Estimation of surface water content using ERS SAR Satellite (Mar. 26, 2003)**

Jiftah BEN-ASHER

Blaustein Institute for Desert Research, Ben-Gurion University of the Negev