

(2) Summary of Joint Research

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

Early Detection of Water Stress by Analysis of Chlorophyll Fluorescence Distribution

*Yasuomi IBARAKI**, *Seiji HAYAKAWA** and *Makio KAMICHIKA***

*Faculty of Agriculture, Yamaguchi University

**Arid Land Research Center, Tottori University

The chlorophyll fluorescence parameter $\Delta F/F'm$, which expresses the quantum yield of photosynthetic photosystem II (PS II), was measured in water-stressed coffee plants and the distribution pattern of the chlorophyll fluorescence parameter in an individual plant was analyzed. Although the average value of $\Delta F/F'm$ in water-stressed plants was inclined to be lower than that in control plants (well-watered plants), the significant difference was found only under severe water stress condition. The different distribution pattern of $\Delta F/F'm$ in an individual plant was observed between water-stressed and control plants. This difference could be detected at the early stage of water stress. These results suggest that the distribution pattern of the chlorophyll fluorescence parameter has the potential to be used for early detection of water stress.

Study on the Behaviors of NO₃-N in Sand Dune

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

*Graduate School of Science and Technology, Chiba University

**Faculty of Sciences, Chiba University

***Arid Land Research Center, Tottori University

In a global context, five main causes of groundwater nitrate accumulation are known: (1) naturally occurring nitrogen fixation in desert areas such as the arid regions of Australia (Barnes et al. 1992); (2) the decomposition of soil organic matter in the absence of a nitrate sink, for example in the case of deforestation (Faillat and Rambaud 1991); (3) the use of nitrogen fertilizers in intensive agriculture (Dudley 1990); (4) the concentration and decomposition of human and animal waste (Smith et al. 1999); and (5) land treatment of urban wastewater, the nature of which, in the context of crop production regions near urban in arid and semi-arid countries, is the subject of this paper. This paper addresses broad issues related to fertilizer on croplands systems. The long-term efficacy of irrigation with marginal quality waters is dependent on several factors, such as unique limiting water quality characteristics and site-specific crop, soil and climatic conditions.

It is important to understand the behaviors of water soil and infiltration processes in sand dune in order to understand the nitrate movement. In this study, we paid our attentions on both water and nitrate movements in sand dune. A typical experimental site in sand dune has been chosen in Tottori, Japan where the water table is 650cm in depth. TDRs and tensiometers have been set in the depths of 5cm, 10cm, 20cm, 50cm, 100cm, 150cm, 200cm, 300cm and 380cm, respectively. Observations started from May 2001. Variations of water contents and water table have been recorded at the loggers for every 20 minutes.

The following conclusions can be expressed:

- (1) Hydraulic conductivities range from $5.9 \times 10^{-4} \sim 1.0 \times 10^{-2}$ cm/s. Variations of hydraulic conductivity were found large from surface to 200cm in depth.
- (2) During 40mm above events, both water table and soil water in 200cm in depth responded rainfall very well, which means that recharge to groundwater can be expected with the rainfall over than 40mm in the study site.
- (1) There are some daily changes for soil water from surface to 50cm in depth. Comparing with soil water in 10cm depth, variation of soil water in 50cm depth has 2 hours delay. The maximum of soil water in top layer was 9-10%.

The Control of the High Temperature Environment Using Latent Heat of Vaporization of the Water-retentive Ceramics

*Haruhiko YAMAMOTO**, *Makio KAMICHIKA*** and *Reiji KIMURA***

*Faculty of Agriculture, Yamaguchi University

**Arid Land Research Center, Tottori University

From a thermal power plant, a lot of coal fly ashes are discharged by power generation. Although some fly ashes are used as materials, such as cement, most is disposed of as industrial waste. In this research, the porosity ceramic tile which contains a fly ash 80% or more was used. The tile was installed to the roof side of a house, and the tile side was watered and it absorbed water. The rise control effect of the temperature in the house by the tile was compared with tin. The heat on the surface of a tile was taken by evaporation latent heat under strong solar energy, and it became clear that an effect is in rise control of the temperature under a board.

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

Measurement of Soil Moisture Contents by the Remote Sensing and its Application to Irrigation System

Soichi NISHIYAMA and Tomohisa YANO***

*Faculty of Agriculture, Yamaguchi University

**Arid Land Research Center, Tottori University

The main purpose of this study in this year is the development of low cost detection method of leakage water in embankment in irrigation reservoir. If soil content the water, by the sunshine, the evaporation will be increase, accordingly, the temperature of soil surface should be decreased.

Under above principle, the experiments were carried out in the field.

By the use of radiation type thermometer, firstly, the relation of soil surface temperature and soil moisture contents were examine in university farm in Yamaguchi University.

The results indicate that soil surface temperature is function of soil moisture content. By the use of result of basic experiment, the detection of water leakage in irrigation reservoir was tried in Yamaguchi Prefecture. The leakage of water was detected in this reservoir.

Measurements of Water and Salt Behavior in Soils Using TDR Method

Jiro CHIKUSHI and Tomohisa YANO***

*Biotron Institute, Kyushu University

**Arid Land Research Center, Tottori University

A small type of probe for TDR measurements was produced, and the dielectric properties, sampling volume, and calibrations were examined. The probe was made of bakelite of about 5cm length, 1cm width and 1mm thickness. The wave guide length of the probe was 15.8cm. The estimate of dielectric constant based on a mixing model was compared to the real dielectric constants that were defined by media of water-ethanol mixture. Good correlation was found between them. Using HYDRUS-2D, we investigated the sampling volume of the probe. From the calculated results, it was fount that the sampling volume is limited only the range of a few mm above the probe surface. Furthermore, the calibration results showed that calibrated curve were quite different among soils of sand, sandy loam and volcanic ash.

Prediction of Fluctuation in Irrigation Demand in Arid Regions (I)

Shinichi TAKEUCHI and Tomohisa YANO***

*Faculty of Engineering, Kyushu Kyoritsu University

**Arid Land Research Center, Tottori University

Automatic drip irrigation system based on soil moisture measurement has widely used in arid regions. It is essential to select proper sensor placement for achieving successful irrigation management.

Experiment was conducted in green house with planting sweet peppers. The soil moisture sensors were installed at the locations where distance from emitter was 0cm, 5cm and 10cm.(0,5,10cm Plot) Each sensor was used for irrigation scheduling with keeping soil water content at 8%. Sap flow and PTR and plant water conditions were investigated.

Accumulated irrigation amount was highest at 0cm Plot, while soil water content among root zone indicates driest and wetted width shows 16.9, 12.0 and 10.2 cm at 10,5,0cm Plot respectively. There were quick responses between root water uptake and irrigation interval at 0 and 5cm Plot. In 10cm Plot, water stress condition was observed due to lack of water applied from emitter which is caused by small reduction of water at soil moisture sensor. There was no significant difference in root distribution among plots. Water requirement at 10cm Plot was 20% lower than other plots during experiment. The leaf water potential indicated same tendency.

Results show that it is important to get knowledge with both soil water distribution and spatial root uptake pattern for selecting proper sensor placement.

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

Responses and Varietal Differences of Crop Roots in their Cell and Tissue Structures

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

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

**Arid Land Research Center, Tottori University

The dynamics of cell length along the root axis was investigated for several rice cultivars (*Oryza sativa* L.) that differ in drought resistance. The rice seedlings were grown in vermiculite. The apical 5cm of the seminal root was divided into 2 or 5mm segments along the axis. The longitudinal sections of the root segments were observed by fluorescent microscope to measure the cell length of mid-cortex. The cell length showed oscillatory basipetal increase along the axis in all the cultivars. The varietal difference was obvious in the increase of cell length in elongation zone. Namely, the cell length reached the maximum nearer to the apex in upland rice cultivars than in lowland rice cultivars. Moreover, the cell elongation was suppressed in drought-sensitive cultivars under low moisture conditions, whereas the cell elongation in drought-tolerant cultivars was rather promoted in such conditions. The expansibility of the cell wall may be different among those cultivars.

Viscoelastic Analysis of Root Cell Walls under Humid and Dry Conditions

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

*Graduate School of Natural Sciences, Nagoya City University

**Arid Land Research Center, Tottori University

Since the root surface has no cuticles nor barrier against water transport, the physical and chemical properties of root cell walls may directly be affected by outer environment. We tested if the extensibility of root cell walls are affected by dehydration and humidity change *in vitro* in the lateral root of Alaska peas.

Viscoelastic properties of cell walls were measured by a creep meter (Yamaden, Tokyo) and analyzed by a Voigt-Kelvin-Burgers' six-element model to obtain elastic moduli (E0, E1, E2) and plastic coefficients (η_0 , η_1 , η_2).

Effect of dehydration by ethanol: Methanol-killed root segments were equilibrated with a series of

ethanol concentration and extensibility of cell walls was measured. Increasing the ethanol concentration increased all parameters; E_0 was 8-times and η_0 was 11 times greater than those of fully hydrated control cell walls.

Effect of humidity: Root segments were dried at a CO_2 critical point to keep intact root morphology. The Viscoelastic properties were measured in different humidity. All parameters decreased by increasing humidity. Viscosity coefficients decreased more quickly than the elastic moduli by increasing the humidity.

Analysis of Crop Root Formation Using Acoustic Emission (AE) Method

Tomohide SHIMOTASHIRO and Shinobu INANAGA***

*Faculty of Agriculture, Kagoshima University

**Arid Land Research Center, Tottori University

The non-destructive measurement method is required for measurement and evaluation of the morphology of crop root system that changes by responding to environmental stress. However, there are few methods for using by the field level, which are not little on the effect on the root system. Then, non-destructive method to measure root system using acoustic emission (AE), of which the effect on root system is less than the conventional method, has been developed. The demonstration as an object of the corn was carried out in this fiscal year. Consequently the fundamental measurement principle was established in the current. It has the restriction of limiting to the crop that puts the great number of node root with the diameter that detects by AE sensors. On this point, in order to expand the crop as a measurement object, the improvement that enables the perception of the fine roots including the secondary root is necessary.

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

Effects of Salt on Growth and Bulb Formation in Bulbous Plants

Hiroshi OKUBO and Masao TOYAMA***

*Faculty of Agriculture, Kyushu University

**Arid Land Research Center, Tottori University

Salt tolerance of 45 species/cultivars of 29 genera of geophytes was investigated in the last year. An additional experiment on three genera, dahlia, tulip and amaryllis, was conducted in this year. These three genera had no salt tolerance, leading the conclusion that among the investigated geophytes muscari has the strongest tolerance to salt.

Relation between Water Saving Rate and Crop Growth

Yukuo ABE and Masao TOYAMA***

*Agricultural and Forest Engineering, University of Tsukuba

** Arid Land Research Center, Tottori University

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.

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

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

*Institute of Agriculture and Forestry, University of Tsukuba

**Arid Land Research Center, Tottori University

Irrigated water in arid-land is usually shows high salt concentration. Therefore we are trying to cultivate halophyte to inhibit the soil salinization and desertification. A kind of halophyte, *Salicornia herbacea* L can grow under sea water irrigation , and is able to provide oil from their seeds, and be as a forage crop. In this experiment, we tried to clear the necessity of Na for *Salicornia* and the reason why *Salicornia* need Na morphologically , and physiologically.

We cultivated rice (var. Koshihikari) and *Salicornia*. Rice and *Salicornia* were sown in the each 3 and 6 seeds on the 1/5000 wagner pots with sand. After germination, rice was started the cultivation with the solution for rice (3pots). *Salicornia* was started the cultivation under same solution with tap water (3pots) or distilled water (3 pots) at that time. 120 days after sowing, all plants were harvested.

Plant height of *Salicornia* under the tap water treatment was higher than that of *Salicornia* under distilled water treatment at harvest. Na content of above ground part of rice was lower than that of *Salicornia*. *Salicornia* showed it took and accumulated Na positively. Under low Na environment *Salicornia* accumulated Na around the palisade tissue, although under high saline condition Na was shown around parenchyma by X-ray microanalysis.

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

Fundamental Studies on Technical Improvement of Afforestation

Katsuhiko YABE and Shigenobu TAMAI***

*School of Environmental Science, the University of Shiga Prefecture

** Arid Land Research Center, Tottori University

In order to promote afforestation in semi-arid and arid zone, the main work issue is not only develop drought resistance plants, but also to conduct soil and water management in effective and sustainable style. Taking into account of water management, we have attempted developing innovative technologies to prevent soil degradation and to use scarce water for afforestation on degraded soil. As the results of this two years research work, we understood the possibility of “the continuous automatic subsurface irrigation system”, which enables to use water sparingly with the management style based on based simple and labor-saving devices. Using all-in-one hose for water distribution and emitter, the continuous automatic subsurface irrigation system can response to soil suction surrounding each emitter. Therefore, we confirm that the system can prevent excessive water supply, and moreover, maintain adequate soil moisture in plant root-zone mainly.

Comparative Studies on Drought and Waterlogging Tolerances in Salicaceae Species

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

*Faculty of Agriculture, Tottori University

**Arid Land Research Center, Tottori University

Physiological responses to short-term drought stress were compared among three different *Salix* species including *S. psammophila* C. Wang et Ch.Y. Yang and *S. matsudana* Koidz., Chinese species for afforestation in semi-arid areas, and *S. sieboldiana* Blume, a Japanese species. Sufficiently watered (control) and water-withheld (stressed) cuttings of them were prepared in pots and volumetric soil water contents and transpiration rate of them were measured. The pre-dawn and midday contents of abscisic acid in leaves also were analyzed. The *S. psammophila* and *S. matsudana* cuttings were adaptable to water-deficient environments in comparison with the *S. sieboldiana* cuttings. The *S. psammophila* was the most tolerant to short-term drought stress among three species.

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

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

Taku NISHIMURA and Tahei YAMAMOTO***

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

**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 that without the gypsum amendment (5g/L).

The Relationship between Crop Root Zone and Salinization under Water Saving Irrigation Application

Torahiko TANIGAWA and Tahei YAMAMOTO***

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

**Arid Land Research Center, Tottori University

This study was carried out to clarify the plant soil moisture environment under the application of water saving irrigation. The result is shown in the following.

Statistical analysis of upland soil properties was conducted for the cultivation experiment. In the cultivation experiment in the next fiscal year, it's necessary to investigate root zone and salt accumulation under application of water saving irrigation. Furthermore, the problem of the plugging inside of the drip tube by the organic and inorganic substance in the irrigation water was clarified, so, it's necessary to examine prevention of the plugging.

Effect of Organic Matter and Soil Gas on Rill Formation and Erosion

Kingshuk ROY and Tahei YAMAMOTO***

*College of Bioresource Sciences, Nihon University

**Arid Land Research Center, Tottori University

Water erosion due to rainfall manifests complicated phenomena. As to the results of experiments carried out by the author previously, the rill characteristics (formation and development) greatly influences the amount of soil erosion. The author also classified the behavior of rills into two types, and termed them as "stable type" and "developing type". Such experiments and observations were carried out in different bare and vegetated plots for a couple of years. However, only the physical factors (soil type, field dimension, precipitation, surface cover, dry density of soil, particle size distribution of soil, etc.) responsible for causing the soil outflow were analyzed to clarify the erosion mechanism. The chemical interaction of the soil materials was not taken into consideration. On the other hand, although the soil chemists indicate that when farmland soil comes in touch with water (rain), it usually exhausts CO₂ and other gases from the surface. However, no study was reported on relating the nature of soil gas to the rill development characteristics. All these backgrounds led the author to carry out the present research that aimed at to investigating a possible relation between the soil chemical properties (mainly based on the soil organic matter content and the soil gas) and the soil erosion (based on the formation and development of rills). Kuroboku soil was used in the experiments of the study. Two erosion boxes with identical dimension was filled up with the soil under the same physical characteristics (dry density, soil moisture), and different pairs of rainfalls and surface flows were passed over the soil surfaces of each box. Standard CO₂ gas was injected at several points into the soil layer of one box while passing the water flow over its surface. Soon after the injection, CO₂ gas was exhausted to the air through the surface making some small cracks and holes on the soil surface. A series of experiments with different intensities of rainfall and surface flow were carried out. However, no sharp distinction was found to relate the effect of gas to the rill development because of the lack of CO₂ gas saturation/intimation with the soil. Therefore, the method of experiments was changed and experiments were carried out using the same Kuroboku soil, but after drying (with an oven) under different temperature and period. Since the difference in drying made change in the chemical properties (as well as physical properties), the soil

surfaces reacted in different ways even under the same amount of flow. These latter experiments are still going on and data are getting collected for the analyses. It is expected that the author will be able to find a relative effect of organic matter content and CO₂ gas in the experiment soil on rill development and thus soil erosion.

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

Basic Study on Saline Water Resources Assessment in the Middle East Based on Integrated GIS Database

Masahiro MURAKAMI, Tomohisa YANO** and Yoshinobu KITAMURA***

* Kochi University of Technology

** Arid Land Research Center, Tottori University

This study was performed to delineate the status of degradation of water resources owing to the increasing salinity. Jordan Valley region, which has been suffered from the severe drought in late 1990s, was selected for the case study to review the outcome of GIS data base in the digital national water master plan study by GTZ (German Government Technical Cooperation). It is noted that the salinization of existing water resources as well as potential use of brackish groundwater are to be integrated in the relational data base to facilitate the digital balancing model for water resources management. Based on this concept, the system composition of the suitable integrated GIS database was designed. Basic studies on the assessment and analysis methods of saline water resources were also conducted from the viewpoint of water strategies in the region.

Potential of Estimation of Underground Water Position Using Satellite Data

Etsuji ISHIGURO, Muneharu SATO*, Koichi IWASAKI*, Yukio TERAOKA*,
Hiroyuki KIKUKAWA**, Sumitaka KASHIWAGI* and Makio KAMICHIKA****

*Faculty of Agriculture, Kagoshima University

**Faculty of Fisheries, Kagoshima University

***Arid Land Research Center, Tottori University

Underground water depths at the large agricultural crop production regions on the Earth, i.e., America and India, have recently become deeper. Moreover, the arid- and semiarid- areas are extending owing to the greenhouse effects and the population increment. Thus the food problem in the earth must be the most important subject in the near future. We conducted to establish the estimating method of underground water depth using satellite data. The relationship among spectral reflectance, water content in soil and underground water depth is first examined in the laboratory, and the results were adapted for the use of satellite data to the field application.

Evaluation of Meteorological Environments of the Loess Plateau by Satellite Data

Nobuhiro MATSUOKA, Makio KAMICHIKA** and Reiji KIMURA***

*Faculty of Horticulture, Chiba University

** Arid Land Research Center, Tottori University

In the agricultural area of the Yellow River basin, the drought has occurred frequently in 1972 and afterwards, and the fundamental measure for this problem must be considered. For that purpose, it is necessary to grasp the hydro-environment and the agricultural form of the Yellow River basin, and to fix them as GIS data. In this research, it was shown clearly that the existence of rain can be presumed by calculating the threshold whether rain will be observed for a Loess Plateau if the radiance of the thermal-infrared data (IR data) of a Geostationary Meteorological Satellite-5 (GMS-5) is how much small.

In the circumference of a Loess Plateau, time series change was compared with the DCC value (digital count value) of IR data of GMS for a period from July 1, 1997 to August 31 at the time of the daily precipitation data of each weather survey point of Xian, Yanan, and Yulin.

Consequently, it turns out that about 60 order is appropriate to the threshold whether there is any rain if the DCC value of IR data becomes how much small.

However, the case when there is rain or not regardless of the conditions of a threshold by the difference in the thickness of clouds was seen.

In order to conquer this problem, it is possible to use visible data (albedo data) as another parameter, and this is a future subject.

Analysis of Spectral Properties of Land Surfaces by Using Remote Sensing Data

Hisashi FUJIMURA and Mitsuhiro INOUE***

*Faculty of Agriculture, Tottori University

** Arid Land Research Center, Tottori University

For the maintenance of shotcrete-covered cut slopes, finding out the weak locations, cracked zones, is very important. In this study, thermal infrared imaging technique was used as a new method for this purpose. The study was conducted in a portion of a big shotcrete cut slope for which detailed geological investigation report was already available. Several thermal infrared images of the test sites were taken, and variation in thermal emission over time was analyzed to detect field observation. It was found that the technique has a potential to be an efficient method for this purpose.

B-2) Studies on Salt Accumulation and Leaching

Studies on Evaporation under Advective Conditions Using the Wind Tunnel

*Seiji HAYAKAWA**, *Mitsuo FUKADA**, *Yasuomi IBARAKI**,
*Makio KAMICHIKA*** and *Tahei YAMAMOTO***

*Faculty of Agriculture, Tottori University

** Arid Land Research Center, Tottori University

Experiments are carried out with numerical simulation and observation using the wind tunnel. The observed vertical temperature is very much like the theoretical profiles obtained from the evaluation in consideration of the stability of each layer and the evaluation using a logarithmic profile does not provide a very good fit.

Study on the Measurement of Subsoil Permeability

*Toshihiro MORII** and *Mitsuhiro INOUE***

*Faculty of Agriculture, Niigata University

**Arid Land Research Center, Tottori University

In-situ measurements of field-saturated hydraulic conductivity are essential for accurate prediction of water movement in soil. Practical applicability of the Guelph well permeameter (GWP) method was investigated by in-situ tests in sand field. The GWP method 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 well inserted into the soil to maintain constant head of water within the well. K_{fs} were measured along soil depth into 140 cm in deep by the GWP method. The GWP method was effectively applied to determine quickly and easily the soil permeability. Then a trench was excavated into about 160 cm in depth, the soil profile was sketched and the 100cc-in-volume cores were sampled from the soil. Some practical features of the GWP method were concluded from the comparison of the soil permeability between the GWP and the soil core. It was shown that, in the case of layered soil, the GWP 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 GWP method in sand soil.

Mechanism of Simultaneous Transfer of Water, Solute and Heat

Yasutaka KIHARA and Mitsuhiro INOUE***

*Faculty of Life and Environmental Sciences, Shimane University

** Arid Land Research Center, Tottori University

Soil surface conditions affect the behavior of evaporation. Gravel mulch was often used to prevent evaporation from bare soil surface in the arid land agriculture. This study was carried out to investigate the decline of evaporation by gravel mulch and the transfer of water, solute and heat below the gravel mulch. Experiments were conducted using in large columns with 80cm in diameter that were installed at the ALRC. The following result was obtained. The amount of cumulative evaporation from mulch condition was half or less than that from bare soil. Especially, the effect was outstanding at the early stage of evaporation.

Reduction of Bare Soil Evaporation under Heterogeneous Conditions

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

*Terrestrial Environment Research Center, University of Tsukuba

** Faculty of Integrated Arts and Sciences, Hiroshima University

*** Arid Land Research Center, Tottori University

To reduce or avoid salt accumulation in arid lands, it is effective to reduce evaporation from soil surface by mulching. However, evaporation from soil covered by mulch has not yet been revealed very well because it is a complicated process under heterogeneous conditions. In this study, evaporation and water movement in liquid and vapor phases in a heterogeneous system are investigated using wind tunnel and weighing lysimeter with emphasis on the effect of mulch. As a result of evaporation experiment for mulch covered soil, vertical distribution of water vapor diffusion coefficient inside a gravel mulch layer. The depression rate of the evaporating surface into deeper soil layer is smaller in mulch covered soil than in no mulch soil due to reduction of vapor diffusivity in mulch layer.

C) Free Subject on Arid Land Studies

Numerical Study of the Sand Movement in Arid Lands

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

*Graduate School of Humanities and Sciences, Ochanomizu University

**Showa High School

***Arid Land Research Center, Tottori University

In this study, the previous study on the sand movement has been extended and flows around various cylindrical bodies have been applied. The results are compared with each other and the following conclusions are obtained: (1) The ground is scooped by the flow strongly when the cylindrical body has a flat plate perpendicular to the flow. This is because that the horseshoe vortex is easily formed for this kind of cylinder. On the other hand, the scour is small when the cylindrical body has a curved plane such as lenticular or elliptical shape. (2) For the cylindrical body with conical base, the flow is curved upward and the formation of the horseshoe vortex is suppressed. Therefore, this kind of shape prevents scour formation and is more suitable for the pier of a bridge.

Although the effect of the turbulence is only incorporated into the computation through the simplest eddy viscosity model, we can obtain the qualitative difference among various shapes of the cylindrical body.

A Study on Photovoltaic (PV) Power System for World Deserts using the Arid Land Dome

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

*Faculty of Engineering, Tottori University

**Arid Land Research Center, Tottori University

We have carried out research for three years for the purposes of (a) realizing data transmission of weather condition and solar irradiation from a remote place to Japan by use of INMARSAT satellite telephone and (b) investigating the conditions that are needed for simulation of the remote place inside the Arid Land Dome in ALRC. The results are the following: [1] Feasibility of data transmission via satellite for long time period was verified by two year's consecutive system operation. [2] Solar irradiation in Inner Mongolia was 1.2 times as much as that in Tottori and it was three times as much as that in Arid Land Dome. The transmittance of the Arid Land Dome is about 40% and this fact requires

large amount of supplementary irradiation for the simulation. [3] Efficiency of amorphous Si solar photovoltaic (PV) power system was almost the same in 2000 and 2001. On the other hand, efficiency of crystal Si PV decreased by 20% in a year. [4] In Inner Mongolia, the maximum temperature and the minimum humidity in a day appear between 16 and 18 o'clock. [5] At the observation site, wind gets stronger from March to May (2.5m/s on average at height of 3 m). However, the mean wind speed through the year is about 1.5m/s.

Development of Ecotechnology in the Sahel zone of West Africa

*Toshiyuki WAKATSUKI**, *Keiichi HAYASHI*** and *Tomohisa YANO****

*Faculty of Life and Environmental Sciences, Shimane University

** International Crops Research Institute for the Semi-Arid Tropics

***Arid Land Research Center, Tottori University

The effect of crop residue as mulch for the deposition of Harmattan dust was examined at the field condition. The experiment revealed that crop residue seemed not only as a soil fixing agent, but as a trap for nutrient-rich dust thereby improving the fertility level of the soil. In addition, the changes in physical and chemical properties of the soil were due to the deposition of Harmattan dust as proven by the results of the mineralogical analysis. Crop residue in the Sahel zone has been utilized in various important ways. These include forage for domestic animals, substitution of wood as a fuel, and as construction materials, among others. This explains why mulching has not been a widespread practice even though it was considered as a traditional way for soil management. Even if it can be still applied, there are few ways to protect the residue from animal grazing. However, restoration of crop residue can be available if it is applied to suitable places where animal grazing is not severe, The upper area of watershed, which soil is classified as Phara-kassa in traditional way, is an example area for mulch application because there is not enough water available for the animal during the dry season. Nomad people need enough water for their animals. Wherever they can find enough water, they come and stay throughout the dry season. Therefore, the soil fertility in the lower area of the watershed can be improved by the incorporation of animal dung while soil in upper area of the watershed can be improved by the incorporation of Harmattan dust. Therefore, the combination of two methods, mulch application and animal grazing, can contribute to the improvement of the fertility level of the soil in the benchmark watershed, Matankari, Dosso, Niger. Furthermore, this will be a useful ecotechnology not only for the regeneration of the degraded watershed but for the coexistence of different tribes in an ecosystem.

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

Tsugihiko WATANABE and Tomohisa YANO***

*Research Institute for Humanity and Nature

** Arid Land Research Center, Tottori University

This research aims at predicting and evaluating the climate change impacts and adaptations of agriculture to them, based on the global warming and climate change predicted by the climate model. However, the structure of relation between soil and water management in the agricultural production system and regional environment is not yet clear, and there remains a large room of uncertainty in prediction of the climate change. The research in this year has proved that it was inadequate to concentrate on assessing or evaluating the impact and adaptation based on these uncertain factors. For this reason, this research has shifted its focus firstly to examine and analyze the present problem structure of land and water management, and then to assess and clarify further the structure and issues through prediction and evaluation of impact and adaptation in the arid-zone agriculture.

In this year, the research framework has been developed, where, firstly, the present agricultural production system (APS) would be assessed with an emphasis on soil and water management to clarify its baseline vulnerability. The assessments include following elements: a) regional climate and meteorology, b) hydrology and water resources including irrigation and drainage, c) soil-water regime and plant growth, and d) socio-economics with land use management and cropping pattern. Secondly, regional climate change in accord with the global climate change is estimated through simulations and its impacts and adaptations to it are evaluated. For the time being, precise and quantitative prediction of regional climate change seems difficult to be realized, therefore variance and characteristic of the change will be generated as some scenarios. In this process, the basic structure of APS and interactions among the elements will be made clear and integrated analysis will lead to an overall comprehensive understanding of the relation between natural system fluctuation and human activity.

In estimation and evaluation of the impact of the climate change and adaptation, it is structurally analyzed to identify dominating factors and critical values, which in turn will be used to clarify direction and extent of the possible change. From these results, important factors for adaptation will be revealed for the specific elements of the studied APS. In this process, socio-economic adaptation of farm household, regional land and water management system, agricultural policies, and international food trade will be included in the analysis to give much concrete materials for considerations.

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

Hiromichi ODANI and Tomohisa YANO***

*School of Environmental Science, University of Shiga Prefecture

**Arid Land Research Center, Tottori University

To measure accurately CO₂, CH₄ and N₂O fluxes from an agricultural land using the energy balance flux ratio method, the temperature difference, which is a variable in the method, between two heights was corrected with the law of propagation of error. The CO₂ fluxes from a paddy field were estimated for 6 days from planting to harvesting. Main results obtained were as follows:

1. The CO₂ fluxes were corrected satisfactorily using the energy balance flux ratio method in which the corrected temperature difference was applied.
2. The values of the estimated CO₂ flux were compatible with those published formerly.

In conclusion, CH₄ and N₂O fluxes from an agricultural land could be also estimated satisfactorily using the energy balance flux ratio method if the gas concentration of CH₄ and N₂O could be measured accurately.

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

Tadao AODA and Tomohisa YANO***

*Faculty of Agriculture, Niigata University

**Arid Land Research Center, Tottori University

We measured the pressure head of liquid phase water in the test column filled with glass beads (diameter is 24mm) in zigzag state (bulk density is 1.29 g/cm³). The experimental result showed as follows;

- 1) Liquid phase water became independent from free water surface and made pendular ring at the critical water level.
- 2) Pendular ring do not move under the closed unsaturated condition.
- 3) However under the open air unsaturated condition water moved with phase transition, hence pendular ring decrease the volume.

Pendular ring and absorbed water has different density and viscosity, and does not transmit any pressure.

Study on the Use of Water Resources in Sahel Africa

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

* Graduate School of Letters, Nagoya University

** Arid Land Research Center, Tottori University

African Sahel is the most seriously affected region by “desertification”. Most of the politics taken against “desertification” look however unsuccessful: its main cause is the insufficient knowledge about the real desertification; especially want of the particular ways of use of the water resources in Sahel. Therefore taking the case of the Inner Delta Region of the Niger with strong seasonal floods lands, we have done a micro analysis of the multiple and mutual complementary ways of the use of the Niger Delta between fishing, pastoral, rice cultivating, dry land cultivating peoples and even boat transporting merchants people. In this region however situated in strong dry zone, the desertification in the most strict meaning of the word doesn’t exist, the reduction of the flood lands severely affected not only each of the production, but also delicately associated balance established for a long time between multi types of production, between multiples ethnic groups of different way of livelihood.

The Effect of Cultivar Difference in Water Use Efficiency on Rice Dry Matter Production in Desiccated Soils

*Tohru KOBATA**, *Sigeto FUJISAKA** and *Shinobu INANAGA***

* Faculty of Life and Environmental Science, Shimane University

** Arid Land Research Center, Tottori University

It is unknown whether cultivar difference of water use efficiency (WUE) is a key factor of the dry-matter production (DMP) in rice under water limited conditions. Six cultivars indicating different WUE under irrigated condition were sown in 1 m plastic pot and low levels of water depth (-0.95 m) in the pot were set to give long-term water deficit to the plants. The DMP differed between cultivars and correlated with transpiration rate (T) and WUE although the T highly contributed to the DMP. It was concluded that under soil desiccated condition the WUE increased from under wet condition but was not an important factor for the higher DMP.

Investigation for physiology of crop in the Arid Area of China

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

*Faculty of Agriculture, Yamaguchi University

**Faculty of Horticulture, Chiba University

***Arid Land Research Center, Tottori University

Six tomato cultivars were planted to be selected for making paste at the Experimental Farm of Shihezi Dry Land Agricultural Institute, Shihezi, Xingjiang China. They were evaluated on fruit yield and quality for two harvesting styles, machine harvesting and hand harvesting, analyzing fruit ripening physiology. H8892, a cultivar introduced from USA, had the highest yield for machine harvesting, on which farmers harvest fruits by big harvester at a time. H3044 of USA and UC82-B of China yielded higher than others on hand harvesting, even though they did lower on machine harvesting. H8892 did not go bad but kept its fruits harvesting mature for four days, while UC82-B make them change from pre-mature to ripeness in excess for four days. H8892 is thought to be a good cultivar for machine harvest because of its high yielding at a one-time harvesting and its fruit's character hard to go bad. UC82-B is thought to be a good cultivar for hand machine harvest because of its large size fruit and compact canopy which make harvesting efficient.

The Relationship between Desaturation of the Fatty Acid and Salt Tolerance in Plants

Kenichi MUROTA* and Shinobu INANAGA**

*School of Humanities and Culture, Tokai University

**Arid Land Research Center, Tottori University

The cloning of the gene (*sad*) coding stearyl ACP (Acyl Carrier Protein) desaturase from sugar beet (*Beta Vulgaris* L.) was done, in order to clarify the relationship between desaturation of the fatty acid and salt tolerance in plants by using transgenic plants. 1,566 bp full length cDNA of *sad* was obtained. The cDNA has open reading frame from 104 to 1,201 bp encodes a protein of 399 amino acid, putative molecular weight and isoelectric point, 45.6 kDa and 5.57 respectively.

The vector that has CaMV35S promoter and NOS terminator, at upstream and downstream of the cDNA respectively, was assembled, for the purpose of overexpression of the cDNA in plants.

**Fundamental Study on Natural Plant Growth Regulators for
Enhancement of Crop Productivity in the Arid Land**

Hiromitsu NAKAJIMA and Yukihiro SUGIMOTO***

*Faculty of Agriculture, Tottori University

**Arid Land Research Center, Tottori University

Dwarfism is very important biological phenomenon in agriculture because it prevents crops from lodging on the ground and produces a better harvest. Recently we found a soil fungus, *Peniophora nuda* C-133, which produced three new plant growth retardants. They (compound 1, 2 and 3) were determined to be the chlamydocin analogues. In the course of our research on the structure-activity relationship, compound 8, derived chemically from compound 1, was found to have the growth retardant activity which was apparently different from that of compound 1. Compound 8 reduces only the level of endogenous GA₁ while compound 1 reduces the level of endogenous GA₁ and at the same time raises the level of endogenous ABA.

Study on Seed Germination Mechanism of Parasitic Weeds

Koichi YONEYAMA, Yasutomo TAKEUCHI* and Yukihiro SUGIMOTO***

To clarify seed germination mechanism of root parasitic weeds, *Striga* and *Orobanche* spp., a rapid and simple analytical method for germination stimulants was developed with HPLC-tandem mass spectrometry (LC/MS/MS), since the stimulants produced by and released from host and some nonhost plants have been recognized to play an important role in the host recognition in these root parasites. By using the LC/MS/MS method, the known germination stimulants including orobanchol, strigol, and sorgolacone in crude ethyl acetate extracts of root exudates could be quantified without any purification. This is the first direct qualification and quantification method for the germination stimulants. This analytical method is expected to explore the qualitative and quantitative differences of germination stimulants produced by various host plants.

**Studies on Chlorophyll Fluorescent Response and Pigment Structure of Xerophytes
under Some Environmental Stresses**

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

Shading treatments were carried out with seedlings of *S. vulgaris*, evergreen coniferous tree species, growing in the Mu-Uts desert to detect the photo-protection mechanism of xerophytes. Two levels of shading treatments (75% and 90%) were started in April and exposed to full solar radiation in July. Y_o value of predawn in the control treatment remained at about 0.8 for all experimental period, indicating the normal function under stress less condition. Seedlings in all stress treatments showed remarkable decrease in Y_o value immediately after the induction of light stress and the gradual recovery after that. The proportion of epoxidated pigments, which could quench excitation energy as heard from the LHC, became high immediately after the induction of light stress. After these response, the increase of the xanthophyll pool size consisted with violaxanthin, antheraxanthin and zeaxanthin was observed. The initial decrease of Y_o value suggested the quenching reaction to dissipate excessive excitation energy as heat to adjust the photosynthetic activity to the suddenly increased solar radiation. The gradual recovery of Y_o value after the initial decrease indicated the adaptation of photosynthetic organ to the light stress by the modification of the composition of photochemical pigments.

Ecophysiological Studies on the Pine Wilt Disease Occurring in Coastal Dune

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

*Graduate School of Agriculture, Kyoto University

**Faculty of Agriculture, Tottori University

***Arid Land Research Center, Tottori University

The pine trees infected with pine wilt then weakened are known to diffuse volatiles into the air. The present study was planned to examine whether or not these volatiles influence on the surrounding healthy trees, and thereby determine the progress of epidemic development. Ten pine trees, five healthy and five wilting trees, served this experiment. Tenax tube (GL Science Co.) was attached on the trunk surface of these trees. Volatiles were trapped in the tube for two hours by pumping, then analyzed by GC-MS. Sampling was repeated monthly from May to November. Seasonal fluctuation patterns of volatile chemicals detected could be divided into two types. One is a seasonal fluctuation common to all trees irrespective of their symptoms as shown in benzaldehyde, phenol, 1-phenyl ethanone. The other is a seasonal pattern characteristic to special trees. The substances such as sativene, carvacrol methyl ether and mono terpenes were only from pine trees showing wilting symptoms. Tricyclene,

P-cymene, fenchone, camphor, and 2,4-bis (1,1-dimethylethyl) -5-methyl phenol were from such trees killed early in the season or in previous year.

A Study on the Production of Local Desertification Map

Tatsuaki KOBAYASHI and Shigenobu TAMAI***

*Faculty of Horticulture, Chiba University

**Arid Land Research Center, Tottori University

Desertification map of the Mu-Uss Sands was made on the comparison of LANDSAT/MSS image 1978 and LANDSAT/TM image 1996. Land-cover was classified into bare-area and vegetation-area by unsupervised ISODATA method from the multi-spectral data. Excluding the semi-vegetated area, the change from vegetation-area to bare area was categorized as denuded area. The adverse change from bare-area to vegetation-area was categorized as revegetated area. Revegetated area was mainly distributed in Yu-Lin City and denuded area was mainly located in Wu-shen Banner.

The analysis of the denuded area suggests that the main factor of desertification is desertification and the critical value is approximately 2 heads per 1 ha. Particularly, in the case that the proportion of goat density is high, heavy desertification was caused.

The Utilization of Water Resources and Agri-rural Sustainable Development in Arid Zone of West Asia and North Africa

Ryuichi HARA and Tahei YAMAMOTO***

*Faculty of International Relations, Daito Bunka University

**Arid Land Research Center, Tottori University

In September of 2001, we made a field research to Kashgar and Hotan region at Uygur, China where is located between the foothills of the Kunlun mountains and western fringe of the great Taklamakan Desert. We did a survey on the utilization of irrigation network system and oasis agriculture and rural economy. We also did survey on the traditional indigenous technology of agriculture and foods.

In July of 2001, we made a field research to Shahr-e Kord Region in Iran where is located at the upstream basin of Karoon River in the highly elevated Zagros Mountain ranges. This is a JICA's research project area "The study on Watershed Management Plan for Karoon River in Iran."

This area is suffering from a vicious cycles of natural-social environment: "Increase of population →

Increase of demand for natural resources → Decrease of forest resources → Degradation of environment and decrease of productivity of land poverty.” Natural disaster such as flood and debris flows accelerate the vicious cycles and the regional society is facing the danger of collapse.

It is necessary to break the above mentioned vicious cycle of natural and social environment and to formulate comprehensive natural-social sustainable regional development plan. This is our main research object and we did a field survey focus on socio-economic impact on the above mentioned study.

Study about Fertility Conservation of Surface Soil in Arid Area

Yuichi ISHIKAWA and Tahei YAMAMOTO***

*Faculty of Bioresource Sciences, Akita Prefectural University

**Arid Land Research Center, Tottori University

In the study, soil analyses and plant growth under soil-disturbed condition were carried out. A mine site in Western Australia was selected as model field. Chemical properties of the surface and subsurface soil in Western Australia were determined. Two species of *Atriplex* were grown in nutrient deficiency condition in order to clarify the effect of soil chemical properties on plant growth.

Field survey in Western Australia showed significant invasion and germination of *Atriplex* sp. on surface soil conservation plot comparing with subsurface soil. However, there were not significant differences between surface and subsurface soil. Both of the soil were low fertile.

The pot experiment showed that the growth of both *Atriplex* declined especially under nitrogen deficiency condition and that adaptability of the plants to low nutrient was low. The results suggest that a significant cause of emergence of the plants is not inorganic contents in surface soil but the number of the seeds in soil.

**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**, *Tahei YAMAMOTO*** and *Mitsuhiro INOUE***

* Faculty of Agriculture, Yamaguchi University

**Arid Land Research Center, Tottori University

This research aims at investigating the effect of clay and saline content on soil erosion in laboratory experiments. Under the fixed condition of experimental soil with 14 % water content and 10 ° slope-gradient in an erosion box, constant surface flow was applied over the surface of the soil content with a clay ratio of 2.5, 5.0 and 7.5 % respectively. The outflow soil volume was measured at 2 minutes interval. The other experiments were liquid limit test and plastic limit test by using the saline soil. From these experiments, the following results were obtained: 1) Under the same surface flow volume, the surface soil loss, or erosion of saline soil was higher than that of the non-saline soil. 2) Liquid limit of saline soil was any lower in comparison with the soil, which did not do the saline soil.

Preferential Flows and Solutes Transport in Sandy Soils

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

*Faculty of Agriculture, Saga University

** Arid Land Research Center, Tottori University

In the laboratory, fingered flow is usually established by ponding infiltration into a fine-over-coarse textured profile. In nature, non-ponding infiltration is much more likely. In case of ponding, water flux is supplied through the interface between fine and coarse layer, so that cross sectional supplied flux beneath the interface is changeable depending on the pressure distribution in the coarse layer. In case of non-ponding infiltration, supplied water flux is constant if the water supplied in a steady state. This difference can produce unexpected effects when the physics of finger development is investigated. We therefore used a low-flux rainfall simulator to create fingers in a mono-layer glass bead porous medium. High-accuracy microtensiometers recorded pressure heads in the distribution zone above the fingers during finger formation and subsequent finger growth. The behavior of the pressure heads is compared for ponding and non-ponding infiltration. The detailed measurements shed light on the different stages in the development of the fingered flow pattern.

**Research on Measurement of the Unsaturated Soil Hydraulic Properties
by In-situ Permeability Tests**

Yuji TAKESHITA and Mitsuhiro INOUE***

*Faculty of Environmental Science and Technology, Okayama University

**Arid Land Research Center, Tottori University

A new field experimental method of determining unsaturated soil hydraulic properties is proposed. In this method these properties are assumed to be represented by van Genuchten's closed-form expressions. Unknown parameters of this model are identified by Genetic algorithms (GA) incorporating finite element analysis of transient axisymmetric seepage flow. GA is search algorithms based on the mechanics of natural selection and natural genetics. They have become a popular global optimization method. A ponded single-ring infiltrometer technique, such as the Guelph Pressure Infiltrometer is performed. Simultaneously the measured change of soil water content with time and cumulative inflow data are used to identify unsaturated soil hydraulic function parameters. The advantage of the proposed method is that it allows estimation of the unsaturated soil hydraulic parameters by quite simple in-situ permeability test data. The utility of our proposed method is demonstrated by using a numerical model and experimental data for Tottori dune sand.

Effect of Salty Crust on Evaporation from Soil Surfaces

Haruyuki FUJIMAKI and Mitsuhiro INOUE***

*Institute of Agricultural and Forest Engineering, University of Tsukuba

**Arid Land Research Center, Tottori University

The relationships among soil salt content, soil water content, and soil albedo were investigated for two soils, Masa sandy loam and Kanto loam. Albedos of each soil were measured for various combinations of surface water content and mass of accumulated salt near or on the soil surface. Apparent albedos from soil slab samples were first normalized to apparent albedos at a reference solar zenith angle of 50° , and then corrected to real albedos expected for large-area surfaces by using predetermined linear calibration equations. Under our experimental conditions, we found that the increase of albedo from nonsaline condition reached a value as high as 0.3 with increasing mass of accumulated salt. We developed an empirical equation that describes the dependence of albedo on both surface water content and mass of accumulated salt (Γ) above a certain depth. Despite the scatter of the data, a practical result of our experiment is that a unit mass of accumulated salt (mg/cm^2) above the depth of 20mm would increase the albedo approximately by 0.002.

Evaluation of Hydraulic Properties of Unsaturated Soils

*Koji KAMIYA**, *Takayuki SASOU*** and *Mitsuhiro INOUE****

*Faculty of Engineering, Gifu University

**Graduate School of Engineering, Gifu University

*** Arid Land Research Center, Tottori University

Knowledge of the hydraulic properties is necessary to evaluate the mechanism of groundwater cultivation by the rainfall. The factors of hydraulic property are the moisture characteristic curve, the coefficient of permeability and the air permeability. To obtain the factors of hydraulic property easily, it is necessary to produce the database model for predicting the unsaturated hydraulic properties from the soil properties.

In this study, the relationship between the moisture characteristic curve and the grain size distribution is examined. As a result, the moisture characteristic curve can be evaluated from 85 % diameter of particle, the uniformity coefficient and the void ratio.

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

*Ken'ichirou KOSUGI** and *Mitsuhiro INOUE***

*Graduate School of Agriculture, Kyoto University

**Arid Land Research Center, Tottori University

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. Artificial rainfall experiments were conducted on an undisturbed forest soil sample, and 14 unknown parameters for 7 layers were estimated. The result showed that the estimated hydraulic properties corresponded well with those measured by the conventional methods. Various initial parameter guesses converged at very similar final parameters, indicating the unique and stable solution. In addition, effects of model selection and the soil pore tortuosity parameter on the estimation results were discussed.

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

*Satoshi YAMADA**, *Koji INOSAKO** and *Mitsuhiro INOUE***

*Faculty of Agriculture, Tottori University

**Arid Land Research Center, Tottori University

Tomato (*Lycopersicon esculentum* Mill.) was pot-cultured with sand dune soil. The amount of applied nitrogen was varied as low-N; 0.6, middle-N; 1.0, and high-N; 1.2 g N pot⁻¹, and the amount of applied water was varied as low-W; 80-100cmH₂O, Middle-W; 45-60cmH₂O, and High-W; 25-40cmH₂O. These nitrogen and water treatments were combined with each other and dry matter and fruits production, chlorophyll content, and sugar content were determined. Results obtained were as follows: 1) Highest dry matter production was obtained in middle-N/Middle-W treatment. 2) Sugar contents trended to decrease with the increase of fruits production.

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

*Kazuhisa HASEGAWA** and *Masao TOYAMA***

*Ishikawa Agricultural College

**Arid Land Research Center, Tottori University

It is desirable for plant or crop growth in arid or desert areas and on sandy soils that water and nutrients are kept by the soil and released slowly and continuously. In our experiments, organic materials such as farm manure, fibers obtained after chopping the plant (bamboo), water holding substances made by the microorganisms, synthesized water absorbing substances and wasted papers (old newspaper) were compared of their water holding capacities and effects on plant growth. A new iron fertilizer containing EDTA-Fe specially designed for use in the sodic soils was examined for its effects under different ways of application.