

2.3 Joint Research

(1) List of Joint Research

Title of Joint Research Project

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

Effect of Mulching on Thermal and CO₂ Environments in Soil

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

Effects of Micro Meteorology to Plant Stem Flow

Kengo ITO and Makio KAMICHIKA*

Numerical Study of the Flow above the Tottori Sand Dune and the Effect of the Vegetation on the Flow

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

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

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Silicon Accumulation and Its Possible Contribution to Stress Tolerance in Crop Plants

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Thermal Environment Monitoring from the Satellite

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Yasushi MORI and Mitsuhiro INOUE*

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*Kiyoshi TANAKA**, *Naoyoshi KAWANO*, *Yanhua QI* and *Shinobu INANAGA*

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*Tsugihiko WATANABE**, *Takanori NAGANO* and *Shigenobu TAMAI*

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

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*Ken YOSHIKAWA**, *Yoshiro ISHII* and *Shigenobu TAMAI*

Water and Nutrient Use Efficiency under Water Stress

*Naoko TOKUCHI** and *Norikazu YAMANAKA*

Effect of Soil Structure on Soil Erosion

*Kingshuk ROY** and *Tahei YAMAMOTO*

(2) Summary of Joint Research

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

Effect of Mulching on Thermal and CO₂ Environments in Soil

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

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The purpose of this research obtained CO₂ environment in soil under mulching-covering as part of CO₂ transport mechanism of the soil-air system in a sand dune field, Arid Land Research Center, Tottori University. The experiment performed continuation measurement of CO₂ concentration of the soil under mulching-covering, soil moisture, and soil temperature using two or more mulching-materials. After covering, also in which the depth, concentration increased gently and CO₂ concentration in soil before mulching-covering showed about 1000 ppm value higher than a bare soil and a paper mulching in the black mulching and the silver mulching, although the difference arising from the section and the depth was very small at about 1000 ppmV. The water vapor permeability of each processing division was the paper mulching 0.48, the black mulching 0.015, and the silver mulching 0.02, respectively. The paper mulching with high water vapor permeability was the behavior same under dryness conditions as bare soil, and since, as for the mulching where permeability was low, exchange of the air between the soil-atmospheres was controlled, CO₂ concentration was considered to become high. After rain, CO₂ concentration in soil increases also in which division, this increase is rapid and the change tendency is similar in the bare soil and the paper mulching. In the black mulching and the silver mulching, while other concentration of the second division decreases and approaching regularly by the loose increase, it is the maximum. While adding to analysis further from now on, the experiment in consideration of the influence of vegetation is required.

Effects of Micro Meteorology to Plant Stem Flow

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Plant water consumption can be estimated using meteorology and soil water contents. Especially with the meteorological data, the measurement of evapotranspiration rate of wide area is common, but plant resistance to climate change is poorly discussed in literature. The influence of climate change on stem flow of tomato directly measured using flow sensor. The results showed that there was a rhythm in plants, and stem flow is not affected by climate sudden changes. Furthermore, it was showed that the water movement in leaf and root was rather consistence, but the water movement direction in fruits was

absolutely contrary. During daytime, the water absorption from root and inflow to leaf could be seen, but outflow occurred from fruit. In nighttime, inflow to fruit occurred, but water movement from leaf to stem and from stem to root can be recognized. More than that, it was also seen that the response of water absorption by root on climate change tended to slow at plants with big water storage capacity.

Numerical Study of the Flow above the Tottori Sand Dune and the Effect of the Vegetation on the Flow

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The objective of the present study is to simulate flow field above Tottori sand dune numerically in order to estimate the effect of the windbreak forest on the flow. The governing equation is three dimensional incompressible Navier-Stokes equation. The standard MAC method is chosen for solving it numerically. Since the shape of the sand dune is complex, the generalized coordinate system is used so that the accurate solution is obtained. For simplicity, eddy viscosity turbulence model is employed in this simulation. The effect of the vegetation is included by changing the drag coefficient in the flow field. The movement of the sand is computed by our previous method (J. Physical Society of Japan, Vol. 74 No.2,2005). Using the present method, the flow field and the change of the shape of the dune are computed and the results are compared with the observation. Reasonable agreement is obtained. If the part of the windbreak forest is cut off, the mass transfer of the sand would be changed. The effect is also estimated in this study.

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

The Effect of Soil Evaporation Beneath the Canopy on Crop Water Requirement

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The objective of this study is separate estimation of transpiration and evaporation from various surfaces with different irrigation systems. In this year, long-stem type of field maize (Pioneer G98) was investigated for 1) tube irrigation in a greenhouse condition and 2) practical furrow irrigated commercial

field in south Turkey. 1) Weighing lysimeters and micro-lysimeters were used to measure crop ET and soil evaporation respectively. Under the conditions of this experiment, the Penman-Monteith model accurately predicted ET rate of maize under high plant densities (6, and 8 plants/m²). However, large discrepancies were observed between measured and estimated values under sparse crop (4 plants/m²) for most of the growing period where plant transpiration was over-estimated. 2) Soil evaporation rate was obtained from 23 to 30 % of ET after the irrigation, and then reduced 20% of ET. Before and after irrigation, the value of T/ET₀ was 0.906 and 0.978, respectively. The K_{cbmid} for sweet corn is 1.10 and for field corn is 1.15. Our value was smaller than k_{cbmid} although our plants were larger than normal plants.

Studies on the Flow Meter Using Bend Pipe

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The development of curved pipe bend flow meter using a float meter in bypass route was shown. Recently, the mulch is introduced to prevent the infiltration of rainfall in order to control the soil moisture in the orange orchard.

Under the mulch, drip irrigation systems were carried out in orange orchard. By the introducing the flow meter, control of the irrigation system is easy. Especially if the float meter is installed at the beginning of drip irrigation system, controlling of the irrigation system is very easy.

The result is as follows.

- 1) The flow meter with float in bypass route is recommended to control the irrigation system and is low cost system.
- 2) The hydraulic design method of flow meter with bypass is proposed.
- 3) As curved pipe bend with bypass is used, the cost of flow meter is low and easy to set up in irrigation system.

Although main flow direction is horizontal, using the bypass flow system, float meter is easy introduced.

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

Silicon Accumulation and Its Possible Contribution to Stress Tolerance in Crop Plants

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The accumulation and alleviative effects of silicon against environmental stresses had been mostly studied in cereal crops (e.g., rice, sorghum, wheat). In the present study, we detected the accumulation of silicon in forage grass species and dicot horticultural plants, and examined the effect of silica application to dicot plants. The results clearly showed the silicon accumulation at the base of leaf trichomes in cucumber, while no clear accumulation of silicon was found in strawberry or common bean. Four C3 and C4 grass species showed different amount of silicon accumulation in root endodermis, where Sudan grass deposited largest amount of silicon. Application of silica fertilizer had positive effect to maintain the number of fruit under draught condition in cucumber, whereas it did not affected the yield of tomato in the same condition.

Adaptive Responses in Hydraulic Properties of Crops to Dry Conditions

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Water absorption in plants is determined by not only root mass but also by water uptake efficiency such as water uptake rate per unit root length. So far, genetic variations of water uptake efficiency between cultivars or varieties in crops have not been studied. In the present study, the difference for water uptake efficiency from lower soil layers between the two sorghum cultivars from Sudan differing in drought tolerance, Gadambalia (drought tolerant) and Tabat (drought susceptible), was examined. The condition of drying in the upper soil layer and wetting in the lower soil layer were simulated using two cylindrical containers combined vertically, water uptake properties of roots elongating to the lower layer were investigated. The relationships between root length per unit leaf area (RL/LA) and water uptake rate were calculated using regression analysis, and the root length required to supply the same amount of water to the shoot were compared between two cultivars. There were positive significant relationships between the two parameters in both cultivars. Comparing the regression curves of the two cultivars, Gadambalia had higher water uptake rates than Tabat for the same RL/LA. The relationships between RL/LAs and leaf water potentials showed similar trend. Calculating the hydraulic resistance from the relationship between water uptake rate and leaf water potential, gives an estimate of the ability to transport water. Gadambalia had lower hydraulic resistance than Tabat. This tendency was remarkable at smaller RL/LAs. These results suggested that higher water uptake efficiency from roots in the lower layer (i.e. higher ability to supply larger amount water to shoot by the small root) in Gadambalia compared with Tabat contributed to the alleviation of reduction of leaf water potential in top soil drying conditions.

Viscoelastic Analysis of Cell Wall Extensibility in Adventitious Roots of Tea under Acidic Condition

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Mechanical properties of cell walls are important factors to control morphology and growth of plant roots. The root cell walls of herbaceous plants such as maize and pea are known to become more extensible under acidic pH lower than pH5. In contrast, tea trees grow well in acidic soil and roots are resistant to considerably high concentration of aluminum.

When one year-old tea tree cuttings are cultured in a hydroponics-culture box (Nihon-ikakikai Co.), their roots grow well in the standard hydroponics for tea (Konishi's medium, with Al 0.21 mM) and also well even in twice concentration, 0.42 mM. At the same time, the pH value of the medium declined down to pH 3 after a few week of culture but the roots normally grew without any notable injury. In the herbaceous roots like pea and maize, the viscoelastic parameters of cell walls decrease at pH 4-5, and extensibility increase. The localized decrease in cell wall pH at elongation zone is conceived to play a role in keeping cell wall extensibility and elongation growth of roots. However, the relationship between the acidification of cell walls and elongation growth are not well known. Thus, viscoelastic properties and biochemical properties of tea cell walls were analyzed in this study.

Since the gradient of ageing from root tip to the base of tea roots is found very steep as compared with herbaceous roots in our previous studies on adventitious roots, we analyzed gradient of cell wall polysaccharide components along root axis and the gradient of viscoelastic parameters of cell wall from tip to the base. We also compared such gradients of hydroponics-grown roots with those of soil-grown white roots in the same age.

The gradients from tip to the base, in the break load (obtained by extending every part of roots at 0.05 mm/s), in the extensibility, and in reciprocal figures of viscoelastic parameters were all steeper in soil grown roots compared with hydroponics-grown roots. Cellular ageing of soil-grown roots takes place more quickly than the hydroponics roots. However, at the apical 1-2 mm zone, these cell wall properties are kept soft in both roots, suggesting that the hardening or ageing of cell walls takes place quickly behind 2 mm towards base, and it proceeds more steeply by the stress in soil. The composition of cell wall polysaccharides also changed along root axis from tip to the base of the root in parallel with the mechanical properties.

Tea roots showed more apical localization of extensible cell walls and more apical development of suberin layer and Casparian strip than maize and pea which we have previously examined. Such early ageing properties may have relationship to the stress-resistant properties of tea roots under acidic conditions.

A-4) Studies on Production and Utilization of Plants in Arid Lands and Salts Accumulation Places

Studies on Nitrogen Nutrition of Salicornia Plants

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The response of *Salicornia bigelovii* to nitrogen nutrition under high salt conditions was investigated.

In order to elucidate nitrogen preference of *Salicornia bigelovii*, plants were grown in hydroponics with NO₃-N dominant or NH₄-N condition. In order to decide the optimum nitrogen concentration, they were grown under nine N (NH₄NO₃) levels. In both experiments, the NaCl concentration was fixed at 200 mmol L⁻¹.

Under low N levels, NH₄-N brought about a better growth and high N concentration of plants than NO₃-N. An antagonism between NO₃⁻ and Cl⁻ was found under low N levels. It is likely that *Salicornia bigelovii* prefers NH₄-N.

The optimum N level for the growth of *Salicornia bigelovii* was 9 mmol L⁻¹, which was nearly equal to those of glycophytes.

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

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Suaeda japonica M. could grow under sea-water NaCl concentration, 3%NaCl, and under 6% salt treatment condition, growth of *S. japonica* was inhibited heavily. It is clear that *S. japonica* is a kind of halophyte and has a salt-tolerant mechanism. In the leaf tissue, some salt-stored parenchyma cells were observed. It was estimated that salt was stored in parenchyma cells to keep low Na concentration in the palisade cells for stable photosynthesis level.

Crude protein concentration of leaves were about 15 to 20 % DW. Therefore *S. japonica* would be a good forage in salt-affected land.

Production of Beach Grass Chromosome Addition Lines of Wheat, and Evaluation of the Lines for Salt Stress

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Leymus racemosus (2n=28), *L. mollis* (2n=28) are beach grass species in Poaceae. We crossed the

plants with wheat and obtained the hybrids by embryo culture. From the backcrossed offspring of the hybrids, we obtained 11 wheat lines carrying a pair of *L. racemosus* chromosomes and 8 of *L. mollis*. Some of these lines are expected to show tolerance to salinity and drought stresses. We investigated the proper method to evaluate the characteristics of the lines to the stresses.

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

Studies on Salt Tolerance of Tree Species

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In usual, mangrove community is distributed in swamp area where is filled with water, therefore studies on drought resistance of the mangrove tree species are rare. It was observed that mangrove seedlings were died by low soil moisture contents in the nursery and field condition. We examined the effects of low soil moisture contents to response of survival of *Bruguiera gymnorhiza* seedlings. Viviparous seedlings were collected at the Awase mangrove forest, Okinawa Island on May 2004. A seedling was planted in a Wagner pot (1/5000a), and 90 seedlings were grown under fresh water condition in the greenhouse from June to November 2004. At the beginning of December, watering was stopped, and monitoring of soil moisture contents was continued until soil pF value 4.4. At the beginning of experiment and on the points of soil pF value 2.8 (moisture equivalent), 3.8 (temporary wilting point), 4.2 (permanent wilting point) and 4.4, every five seedlings were dug up and shape and weight were measured in each part, leaf, stem, viviparous part, bud and root. On the soil pF value 3.8, seedlings were continued to be good condition and mean water moisture contents was 77% in root, 68% in viviparous parts, 70% in stem and 79% in leaves. On the soil pF 4.2 value, leaves wilted slightly, water moisture contents were 60%, 61%, 64% and 73%, respectively. On the soil pF 4.4 value, leaves were wilted downward. After two days of this soil water condition, watering started again to these seedlings. About 75% of the seedlings survived and were recovering normal leaf condition. It was observed that one year old *Bruguiera gymnorhiza* seedlings have strong drought resistance as same as that of Okinawan pine (*Pinus luchuensis*) that is high drought resistance tree species in Okinawa.

Studies on the Salt Tolerant Mechanism of Plant and the Improvement of Saline Soil

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The experiments were carried out in order to clarify the evapotranspiration, the tree growth and the

salinity integration by planting Tamarix under the four kinds of saline concentration. Their saline solutions were supplied to each experiment pot by applying the subsurface irrigation. The soils used are the sandy soil. The experimental containers are the cylindrical pots of 38cm diameter and 48cm depth. The ground water level applied is 32.0 to 37.0cm under earth surface. Measurement items were the tree growth, evapotranspiration, and the saline distribution. Their measurements were carried out June to December 26th.

Firstly, the evapotranspiration rapidly increased with over 4.0mm/d at July. But it rapidly decreased after September 16th with 2mm/d or less. Secondly, the growth was increased from the June beginning throughout the end August, but the growth could not be almost observed after September. In addition, the salt accumulation was not observed from the saline distribution in the testing condition set at salinity (0.03%) which corresponded to the groundwater in the actual field.

The more rightful consideration and conclusion could not be probably proposed from the results obtained, because the above results are obtained from the experiment of only one time. Therefore, by repeating more experiments, the results of experiment are need to be examined. After then, it should be lead to the conclusion.

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

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

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The objectives of the study are to quantify the impact of soil disturbance through monitoring cleared land after mining and pot experiments, and to establish sustainable maintain soil fertility and rehabilitation technology. In this year, germination tests of some species of the plants which were conserved in a refrigerator for a year were carried out with different saline solution. Four species of *Atriplex* spp.; *A. codonocarpa*, and *A. holocarpa* that were annual plants, and *A. vesicaria* and *A. nummularia* that were perennial plants, were specimen. Seeds were sown in Petri dish filled with 4 concentration level of NaCl solution from 0 to 1.5 %w/v and left in a growing cabinet for 3 weeks. *A. vesicaria* had low germination rate i.e. less than 35% all through saline condition, on the other hand the rest of 4 species had greater than 90 % of germination rate in 0% NaCl solution and the germination rate decreased gently as the solution became saline. The results showed the similar trend as the results obtained in the last year. The results mean *A. vesicaria* seeds lost germination capability in the first year, whereas the rest *Atriplexes* kept the capability even after 1 year. There was not a significant difference on germination between annual and perennial plants. Taking the former study into consideration, the genus plants hold the high germination rate for the considerable long time. Once the environment becomes good for germination and growth, most of the seeds in soil germinate and occupy the community even on the bare soil. The high germination made the plants as pioneer plants and rapid cycle

of germination-fruited. The results may contradict the first hypothesis that plants reserve the seeds in 'seed bank'. Further study is needed to find other factors to control germination of pioneer plants.

Effects of Chemical Amendment on Soil Loss

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**Arid Land Research Center, Tottori University

Calcium carbonates and gypsum are often used to improve the chemical status of acid soils. This study discusses the effects of gypsum and polyacrylamide (PAM) application on infiltration and erodibility of a Japanese acid soil. Acid Kunigami mahji soil (sedimentary rock derived, Typic Hapludult) from Okinawa was packed into an acrylic plastic box, and simulated rainfall of 40 mm/hr was applied. Prior to the rainfall, 2.5 t/ha of gypsum and/or 15 kg/ha of non ionic or anionic PAM were applied onto soil surface. During a rainfall, surface runoff was collected periodically, and sediment concentration, pH, and electric conductivity of the runoff were measured. Gypsum application enhanced surface runoff. During the rainfall, EC of the runoff was greater than the critical coagulation concentration of the clays of the mahji soil, however the soil became dispersive with gypsum application. PAM application could improve infiltration of gypsum amended mahji soil and reduce sediment loss.

The Experimental Research on the Replanting Basis Creation

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The continuous sub-irrigation method seems to be beneficial on the creation of the soil-water environmental basis for vegetation. The drastic water saving is possible by the application of sub-irrigation, and then, the zero-emission has also been achieved on the infiltration loss. On the practical application of this method, the following must be improved : simple structure, simple operation, low cost and low energy consumption performance.

In this fiscal year, applying the combination of the tube material with the treatment of the hydrophilicity and the repellency, the bubble elimination of tube and antifouling property was established fundamentally. The water infiltration to the soil is stabilized by the hydrophilic treatment, and the bubble in the tube can be easily discharged by the water repellency treatment. By these treatments, the optimum design of the sub-irrigation tube became possible for each irrigation of negative pressure type and low positive pressure type.

In addition, the examination of the new control theory on the regional afforestation was tried. As the result, the approach of the predictive control and the static stability relaxation on the environmental

management hard-system itself can be judged most useful to the afforestation.

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

Sustainable Land Management in Dry Areas

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Integrated Research on Desertification Assessment and Rehabilitation by Vegetation

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The Ordos Plateau including Mu Us sandy land is situated in the southern part of Inner Mongolia, northern China. Formerly, the Plateau was known for its fine pastures with ample water, abundance of grass and huge potential productivity. In the past 1,000 years, overgrazing has resulted in serious desertification. The loss of productive land and the disastrous effects in downstream area make it imperative to combat desertification and to restore these degraded ecosystems. We focused on wind erosion in Ordos Plateau due to its significant effect on land degradation. Annual precipitation varies from 300-400mm in the east to only 100-150mm in the west. Annual mean temperature is 6.2 . The hours of sunlight range from 2900 to 3200h per year. And there are between 130 and 165 frost-free days per year. Since economic and population pressures are usually the main causes of desertification in developing countries, vegetation rehabilitation should also consider socio-economic demands to ensure a sustainable development of both environment and socio-economy. However, in the past decades, because synthetic technology was ignored, although great progress has been made in combating desertification in Mu Us sandy land, success has only been partial, and overall desertification is worsening.

Firstly, we summarized traditional knowledge and technologies used for vegetation restoration in the Ordos plateau. We also analyzed their merits and demerits. Then we try to improve and integrate these knowledge and technologies to develop a synthetic technology. Among them, air seeding was more important direct technologies for vegetation rehabilitation. This technology is successfully used in the Ordos plateau, while indigenous species are emphasized in such ecological restoration processes. Behavior of germination of nine species related to air seeding was analyzed in the environment controlled laboratory. Based on our germination experiment results, light is an inhibitory factor for

successful germination of *Agriophyllum squarrosum*, *Artemisia sphaerocephala* and *Artemisia ordosica*. It is recommended that the seeds are dispersed in mid or late May instead of early June to enable them to become buried by sand under prevailing wind. This may lead to a higher germination rate and a longer seedling growth period.

Secondly, to ensure sustainability of vegetation restoration, trend of climate and socio-economy was analyzed. At last, we proposed a socio-economic developing pattern in this region. The interaction of decreasing precipitation and increasing temperature in winter and spring may be the main climatic factors for desertification. However, socio-economic development should be responsible for rapid desertification, and thus we proposed four type socio-economic zones to keep harmony-developing pattern. In Stella model environment, an eco-physiological process based plant community model was built to simulate the seasonal growth of plant community. Then suitable coverage (less than 50%) and reasonable livestock husbandry density ($0.8-2.0 \text{ ha}^{-1}$) was derived based on simulation results.

Finally, based on the above results and landscape classification result, we proposed a “3-circle” pattern for vegetation restoration in Mu Us sandy land. It means the first circle, high efficient agricultural and pastoral area, the second circle, runoff garden, and the third circle, natural and artificial vegetation restoration area (fenced). Through the agricultural products in first circle and some shrub species, which have high economic value in the second circle, we can provide a high quality living conditions for local people. At last, the seriously desertified land in the third circle can be restored due to lack of over disturbance by human activities.

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

Studies on the Estimation of Soil Moisture Content Using Spectral Reflectance and Landsat Data

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This study presents a reflectance-based method to quantify the characteristics of vegetation cover from TM and ETM+ data more accurately. The study was conducted on the vegetation cover of a Kake-cho area, which is situated on the northern side of Hiroshima City in Hiroshima Prefecture. The normalized difference vegetation index (NDVI), one of the most popular vegetation indices, was used to assess and evaluate the vegetation indices of four species.

The vegetation indices appear different because the image acquisition times were different in every year and the different stages of green leaf density of the plants had different heights. The lower values of vegetation indices showed in the years 1985, 1987 and 1996 for the acquisitions of vegetation images at the early stage of green leaf density and the lowest values came into view in 2003. The lowest vegetation indices appeared for the image acquisition time (April), which was at the end of the winter season or beginning of the spring season when all matured leaves of some plant species already dropped.

The vegetation indices are relatively less in case of “Ca” species in the years 1985 and 2003 for its deciduous character and the yearly changes were nearly uniform in both R and C species. It was

discovered that the values of vegetation indices are higher for taller plants in the cases of R species. It was revealed from the study that vegetation index is highly correlated with green leaf density and being used as a representative for the status of ground surface biomass.

Development of Methods of Crop Growing Condition Using Satellite Data

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This study was conducted to investigate tea plant growing condition, using spectral characteristics. The experimental plots were designed with five degree of nitrogen. The spectral characteristics of tea canopy on each plot were measured by a handheld spectroradiometer during new leaves growing season. Those canopies were taken with video camera with several band pass filters. On the same time, nitrogen contents in the leaves were measured with SPAD meter. And the picked leaves were analyzed for several ingredients in these leaves.

The first- and second-differential curves of these spectral reflectances were analyzed, and several characterized narrow wavebands were found. Several indices, which consisted by those wavebands, were contrived and compared with ground truth data. It was demonstrated that the index, $NDVI_{77,66} = (R_{770} - R_{660}) / (R_{770} + R_{660})$, strongly coincided with the results of SPAD meter. It was shown that $NDVI_{77,71} = (R_{770} - R_{710}) / (R_{770} + R_{710})$ agreed with the nitrogen content, and amino acid content in the leaves. $NDVI_{71,52} = (R_{710} - R_{520}) / (R_{710} + R_{520})$ highly correlated to the theanine, caffeine and tannin contents in the leaves.

The result suggested that the spectral reflectance with non-destructive and non-contact measurement was effective to evaluate the leaf growth condition and to estimate the leaf quality, instead of conventional methods such as SPAD. Moreover, the spectral images taken with video camera mounted by band pass filters will be able to analyze differences of growing stage.

Evaluation of Meteorological Environments of the Northern Loess Plateau by Satellite Data

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Thermal Environment Monitoring from the Satellite

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To estimate the surface heat capacity, an attempt is made to solve the heat balance equation from the satellite observed brightness temperature time series. From the solution of the equation, the heat capacity is expressed as the ratio of the brightness temperature at the sunset and the maximum cooling time. this method has an advantage that no meteorological data such as wind speed is needed.

Possibility of R/S &GIS Applications to Promotion of Participatory Water Management in Gezira Scheme in Sudan

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The Gezira Scheme is the largest irrigation system in Sudan. At present, it covers an area of 800,000 ha, which is irrigated by gravity from Sennar Dam. The whole project area is divided into 18 areas: each area is called a Group. Each group is divided into 4 to 8 smaller areas, called Blocks, making a total of 113 Blocks.

Throughout its history, the management has been in Top-Down structure, concerning mainly with instructions relayed down wards to tenants with very little, if any, feedback from tenants.

One Block, comprising 12 minor canals, was chosen as the pilot project. Operation and maintenance of this 12 minor canals for water management are carried on by one committee consisting of local tenants. This has led to very active participation of tenants in the maintenance works. Here, we will find some possibility of R/S & GIS application to the promotion of participatory water management in some blocks.

B-2) Studies on Salt Accumulation and Leaching

Preferential Flow Effect on Solute Leaching

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Fingered flow rapidly moves water and pollutants from the root zone to the groundwater through a limited fraction of the unsaturated zone, limiting the possibilities for decay and adsorption. We aim to theoretically and experimentally advance our understanding of pre-fingered flow, and contrast fingered flow under ponding and non-ponding conditions. We developed a Green-Ampt based expression for the pressure head in a developing induction zone (from which fingers protrude) for the time before fingers developed. A uniform, non-ponding water flux was applied to the surface of two-dimensional glass bead porous media with a dry region above a capillary fringe. The pressure head data confirmed both the theoretical early-time pre-finger model, and a model developed earlier for late-time lateral flow towards fully developed fingers.

Mechanism of Simultaneous Transfer of Water, Solute and Heat

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To do effective leaching, it needs that correct understanding of salt accumulation phenomena. To understand phenomena of salt accumulation, computer program was developed to simulate simultaneous transfer of water, solute and heat including evaporation. Evaporation rate was predicted by water potential at soil surface. Calculated values were compared with experimental values obtained by the experiments using the large column installed in ALRC. When concentration of soil solution was low, program was well simulated changes of evaporation rate, water, solute and heat. On the other hand, concentration of soil solution is high; this program couldn't simulate the salt behavior. This is the reason why "density flow" was occurred in the high concentration column.

Digital Analyses of Salt Crust Casused by Salt Accumulation

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There are two types of salt accumulation, salt crystallization on the soil surface and that in pore of soil from the view point of the mechanism. To evaluate those two types of salt accumulation, laboratory experiments were carried out. Laboratory experiments showed the following results.

1. Formation of salt crust was heterogeneous while the experimental condition was uniform.
2. The degree of salt accumulation was proportional to the temperature.
3. While formation of salt crust on the soil surface was superior at higher temperature, salt accumulation in the pore was superior at lower temperature.

The experiments were carried out in the same condition except the temperature. A difference on the salt crystallization was caused by the temperature. At high temperature drives salt flux in the upward direction and crystallization on the surface was formed. On the other hand salt crystallization in the pores below the surface was caused by lower temperature.

C) Free Subject on Arid Land Studies

Physico-chemical Analysis on Solid Surfaces for Solute Transport

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Though pendular saturation has more liquid water than residual water content, one has to investigate the application of Darcy's law in this water condition. At the pendular saturation, liquid water remains at the neck of pore against gravitational force, and forms catenoid shaped pendular ring. The pendular rings are isolated and do not form continuous water phase, except for the film of adsorbed water on the solid surface. The adsorbed water is governed by surface force, and does not behave as ordinary liquid water. Therefore, in the microscopic point of view, no water pressure can be transmitted from one ring to the next through the liquid phase water.

In this study we measured water pressure of the test column by using micro-tensiometer. The test column contains glass beads with diameter of 0.1mm. We controlled water pressure of the test column by lowering water level. The experimental results showed as follows;

- 1) In the funicular saturation (condition of hydraulic continuity), water pressure obeyed hydrostatic pressure gradient until threshold pressure. This threshold pressure is the function of effective porosity and is represented by Laplace formula.
- 2) Lowering water level further, the test column became pendular saturation (condition of hydraulic discontinuity). At this water saturation, water pressure became independent from the fluctuation of free water table, and showed almost constant value.
- 3) The macroscopic trend of water pressure change synchronized each other. Those phenomena might explain by the Kelvin's Law for vapor movement.

We conclude that water moves not in liquid phase but in vapor phase in the pendular saturation.

Changes in Gas Behaviors through Sandy Soil by Application of Organic Matters

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Soil conditions for plant growth would be improved by applying organic matter because the organic matter content of soil increase and because the characteristic of soil water retention improved. On the other hand, organic matter could change the soil gas behavior because the activity of soil microorganisms and because the characteristic of soil water retention and water permeability change. The objective of this study is to clarify the effect of organic matter on the soil physical properties from the viewpoint of the gas permeability and air-filled porosity.

When the amount of organic matter (waste compost) was relatively small, the soil water retention changed little and the saturated hydraulic conductivity increased by applying organic matter. It indicates that air-filled porosity could quickly increase after irrigation because of high drainage ability. The hydraulic conductivity of organic matter applied soil decreased after 20 days. When the amount of organic matter was relatively large, the saturated hydraulic conductivity decreased. Both the drainage from the soil and the air permeability would decrease after applying organic matter. But some cracks appeared after 20days and the saturated hydraulic conductivity increased. These cracks were expected to increase the air permeability of soil.

Monitoring and Numerical Prediction of Salinization due to Root Water Uptake and Transpiration

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Accurate prediction of root water uptake under salinity stress contributes to efficient water management in arid and semi-arid land. Several water uptake-transpiration models have been proposed. Most of them assume that when a plant is released from salinity stress, transpiration rate recover instantaneously even after heavy stress. To investigate hysteretic behavior of response to salinity stress, we carried out a column experiment using Tottori dune sand in a greenhouse. Eight columns, each had one soybean, were used and after enough growth under non-stress condition, saline irrigation with NaCl was started. Concentration of the irrigation water was 4000, 3000, and 2000ppm for two plants (columns) respectively, and the other two provided potential transpiration. When tranpiration ratio became less than that before stress period, leaching with sufficient amount of tap water was applied. As a result, even after release from salinity stress, it took about three days to recover their original tranpiration ratio. Also, we found that time required to recover depends on stress level and tranpilation rate of two plants under heavy stress did not recover even four days after. This may be due to death of some leaves. We will develop a model with simple mathematical expression of these response and present a method to detemine parameters used in the model.

Research on Fracture Control of the Desert Base Rock for the Replanting Using the Explosives

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Recently, the phenomenon in which the woodland is desertified from the change of the environment by the global warming becomes large problem. It becomes large problem of the mankind that it prevents this desert expansion and plants desertifying ground with trees. The many deserts which exist on the earth are the rock desert. Therefore, it is difficult to transplant the direct plant in the rock desert, and it is important that the optimum soil environment is improved. In this study, model test experiments were carried out in order to create optimum soil environment in the rock desert. In the experiment, blasting experiments using model test-piece (30 × 30 × 30cm) of the granite were carried out with ANFO explosives. In the explosion experiments, the following were measured : crush grain size of granite rock and material ion concentration done the residual quantity in the debris of rock. It was shown that crush grain size and ion concentration of rock could be controlled from these experimental result.

Mycorrhizal Symbiosis as a Control Factor of Pine Wilt Disease Occurring in Semiarid Sand Dune

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Coastal forests of Japanese black pine have been forested to protect public lives from strong sandy and salty winds from sea. These forests, however, have been devastated by Pine Wilt disease, and cohabiting locust seem to overwhelm the pine trees. Thus regeneration of pine seedlings seem to be disturbed. There are several possibilities, but our studies have revealed that soils in locust-dominated forest became eutrophicated, the forest floor is more shaded, and the roots of pine seedlings reduce the ratio of mycorrhization. These may explain partly the decline of pine regeneration.

The Utilization of Indigenous Technology for Water Resources and Agri-rural Socio- economic Development in Desert Fringe Region, Iran

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We conducted intensive field survey in Summer of 2004 and Spring of 2005 for 3 months at

Kheirabad and Polnow villages, Marvdasht region of the southern Iran for the research project "The Socio-Economic Rural Changes for 40 years at Kor River Basin in Southern Iran" sponsored by the Scientific Research Grant by the Minister of Education, Culture, Sports, Science and Technology.

The main results are as follows.

- (1) We conducted to draw maps on ownership, utilization and changes of water and land resources at village level.
- (2) We conducted to collect precedence datas (handwriting texts, maps, photographs) of this region from 1960's to 1990's done by late Prof. Ono and We are tring to do digital for making database at village level.
- (3) We also started to do research over a wide area of Marvdasht river basin by using G.I.S. sources.

Comparative Study on Soil Factor Affected to Biological Production at Desert

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Plant growth of minirose and hydrangea (cutling) in planter box 1 frame field was examined comparatively on alkanin soil (sand dune, shell phossil), alluvial soil, humus rich soil. Chlorosis phenomenon of ferrocleficiency in leaf and stem was observed on alkanin soil clearly. It was indicated that growth of minirose was affected by difficulty on solubility of iron in alkanin soil.

It was better that side point placement by stube of fertilizer confained iron was taken in these soil.

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

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Objective of this study is development of a water making system that condenses vapor in air by using electric power generated from renewable energy, especially wind and/or solar energy, in order to produce good quality water useful in arid region for drinking, medical treatment and irrigation.

A simple and tough water maker (170W) was built by using eight Peltier devices, a copper heat exchanger and fans. Experiments were carried out in a constant-temperature and constant-humidity chamber to investigate the best driving environment and the operating condition of the system. One of the results is that temperature at the outlet of the heat exchanger is lower than the dew point by some

degree (between 2.5 and 4.8), whenever the water production becomes the largest at some environmental condition.

We are planning to conduct the outdoor experiments with the water making system at Tottori Sand Dune. A meteorological observation system has already been installed at the site and has been collecting the meteorological data.

In this research, assuming the use of a 340W wind turbine and a 200Ah battery, the water production was simulated based on the wind speed measured at the site. Operation of the water maker was assumed to be controlled based on conditions of both the dew point and the battery level. The simulation using the meteorological data of November, 2004, shows that the system obtains the highest efficiency when it is controlled based on the dew point of 10°C. The water production of the month was expected to be 9.7kg when ignoring the battery level. However, if considering the battery level, the water production reduces to 3.4kg.

Measurement of Solute Transport on a Sand Dune Field

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In this study, apparatuses for collecting percolation water with simple structure were assessed the performances for using multi-points sampling in a sand dune field.

A tension free sampler (TS) and a wick sampler (WS) were selected as the apparatuses. Both of them were PVC cylinders and have 0.13 m in diameters and 0.105 m in height. Stainless filter is used as a water collection face for TS. In WS, wick filter made from glass fiber, is radially spread on the bottom of WS for collecting soil water. Collected water is conveyed to tanks in observation pits. Matric potential at six points were measured by micro-tensiometers. Three points were located in the apparatus and three points were outside. Precipitation was observed near the field by a rainfall gauge. All measurement tools were set on December 17, 2004.

In the TS plot, percolating water flowed downward to lower soil layer, avoiding the sampler. Therefore, amount of collected water was 0 mm. Material and structure of the filter should be re-considered because it was succeeded to collect percolating water by a similar apparatus with gauze filters.

In the WS plot, a time-percolation flux curve showed sharp peaks but the curve of sampling flux showed gradually peaks. It means that collection of water by WS was continued for a long time. Maximum sampling flux was 0.7 mm/d.

As a result, it cleared to need various modifications of these apparatuses for practical utilization.

The Effects of Soil Drying on Transpiration under Elevated Temperature and CO₂ Conditions in Cereal Crops

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The effect of soil water deficit on transpiration in spring wheat subject to elevated temperature and CO₂ concentration was investigated. A spring wheat cultivar, Adana99 from Mediterranean area, during the late vegetative stage was grown in pots under glass house condition, and suffered elevated temperature and CO₂ condition in growth cabinet after one week naturalization. Transpiration rate decreased with decrease in soil water contents and there was a curve liner relationship between relative transpiration rate (soil desiccated/irrigated control) and fraction transpirable soil water. The relationship under ambient and elevated conditions was similar. The relationship will be compared with our past results and used to make a submodel for estimation of soil water deficit on biomass suppression under elevated temperature and CO₂ condition.

Relationship between Beach Width and Size of Coastal Sand Dunes

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The relationship between beach width and size of coastal sand dunes were surveyed along the Enshu-nada coast, Shizuoka Pref. and the Jouetsu-Takada coast in Niigata Pref. Both fields show a contrast between width and size of the beach and the sand dune along the coast, that is, the size of the sand dune becomes larger further from the main river mouth in spite of a decrease in beach width. In the Enshu-nada area, sand transport processes from beach surfaces could explain the observed phenomena. However in contrast, in the Jouetsu-Takada area, the historical development processes are more important to explain the observed phenomena.

Soil Environmental Monitoring Using Multi-Functional Heat Pulse Probe

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A small multi-functional heat pulse probe (MFHPP) was applied to further develop measurement methodologies to improve on water flux estimations for unsaturated soils. The temperature responses of four thermistors surrounding a central heater in a 2.7 cm diameter probe were analyzed by the heat transport equation to estimate thermal properties and convective heat flow. Volumetric heat capacity,

water content, and thermal diffusivity were estimated from the horizontally-placed thermistors, neglecting the convective flow effects in the transverse direction, whereas the water flux density was estimated from the temperature responses to the vertically-placed thermistors. A parameter optimization technique was employed to fit the most likely parameters to the relevant analytical solutions. Falling head and multi-step outflow experiments yielded independently-obtained water flux measurements. Results showed that the estimated volumetric water content corresponded well with independent gravimetric measurements with a RMSE of 0.0056 m³ m⁻³, across a wide range of water fluxes smaller than 0.5 m d⁻¹. Thermal diffusivity values as obtained with the MFHHP also agreed well with independently measured thermal diffusivity values, for water flux density values smaller than 2 m d⁻¹. For saturated conditions, the estimated water fluxes from the MFHPP measurements were accurate in the range between 0.056 and 27.0 m d⁻¹, with a R of 0.995 and RSME of 0.0952 log(m d⁻¹) (0.52 m d⁻¹). For unsaturated flow, MFHHP estimations significantly overestimated water flux density for flux values smaller than 0.10 m d⁻¹. Within these limitations, we conclude that MFHPP methodologies are now available, making possible simultaneous estimation of thermal diffusivity and water flux density in unsaturated soils.

Field Investigation Procedures to Design Rainwater Catchment Facility in Semi-arid Area

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An integrated procedure to determine hydraulic conductivity of sand sediment soil that is characterized by an inclusion of gravel particles and cobbles in sand soil is proposed. Firstly the Guelph pressure infiltrometer (GPI) method to measure the soil permeability of the sand is introduced and extended so that it can estimate unsaturated moisture properties of the soil. Secondly a descriptive cylindrical soil model representing sand, gravel and cobbles, and voids within soil is assumed to determine the hydraulic conductivity of the sand sediment soil. A continuity law of flow discharge through the cylindrical soil model is introduced to derive theoretically a functional relationship of the hydraulic conductivity of the sand sediment soil with both the hydraulic conductivity of the sand measured by the GPI method and the gravel content of the soil. An accuracy of the functional relationship of the hydraulic conductivity is examined by laboratory permeability tests. Finally the GPI method and the functional relationship of the hydraulic conductivity are integrated to determine the soil permeability of the sand sediment soil. A numerical example is given to show an effect of the gravel content of soil on a prediction of storm runoff over the sand sediment soil.

Agriculture in the Arid Land

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Dwarfism is a very important biological phenomenon in agriculture because it prevents crops from lodging on the ground and produces a better harvest. Recently we found that the metabolites produced by a plant pathogen showed plant growth detergent activity toward rice seedlings. This fungus had been isolated from the diseased strawberry in Tottori Prefecture, identified as *Botrytis cinerea*, and maintained in my laboratory as a strain TUAEM-211. The fungus was grown without shaking on malt medium and bioassay-guided fractionations of the metabolites in the culture filtrate afforded two active compounds. One was identified to be abscisic acid (ABA) and the other was a new compound having the molecular formulae, C₂₂H₃₄O₆, and botocinolide-like structure. Application of ABA (0.1 mg/plant) and the new compound (30 mg/plant) produced 25 and 61% of the control, respectively, in second leaf sheath length of rice seedlings.

Dynamics of Water and Energy in a False Accacia Forest

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

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Byyobusan sand dune area at Aomori prefecture had high groundwater Level and also had underdrain. But sub-lateral drain was closed by iron deposit and then groundwater level rose. Therefore cultivation of root crops was damaged and forming were disturbed. Consequently, farmers gave up cultivation and that area became more than 100 ha. Such as background, water quality and the factor of closed sub-lateral drain were investigated.

The deeper the groundwater level is, the higher the iron concentration in groundwater became up to 1.5m. The iron concentration at 3.0m depth under the surface of the earth became 60 mg/kg. We investigated where the iron occurred by using incubated basket with saturated sand with distilled water. Consequently, we realized the iron caused from the sand and those water flow in the drain and caused iron deposit by contacting the air. We took the countermeasure that those sub-lateral drains set at the depth of 3m under the surface of the earth. And then those were not closed by iron deposit and became less risk for closing the sub-lateral drains.

Physiological Responses of Plants to Salinity Stress

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

Suppression subtraction hybridization, a method that selectively amplifies target cDNA fragments and simultaneously suppresses non-target DNA amplification, was employed to isolate down-regulated genes in the salt-adapted *Petunia* cell line. Searches in the GenBank database revealed that either of the seven isolated genes did not exhibit sequence identity to previously reported genes. These results suggest that down-regulated genes under salt-stress have received less attention than up-regulated genes.

Investigation for Physiology of Crop in the Arid Area of China

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Shihezi is a city in arid area of XingZhang China. It has less than 200 mm of the annual precipitation. Isoda and Wang (2004) showed that more than 8 t/ha of soybean seed yields were recorded in 2002 and 2003 at the experimental field of the Shihezi Agricultural and Environmental Institute for Arid Area in Central Asia. In this study we analyzed the effects of their nodule and the soil on those high yieldings. So that it was thought that the nodule would not take effect to the high yieldings. We should think the other factors, for example, high radiation or long seed filling period. The number of nodule was much in sandy soil condition but less in clay soil condition. It was closely related to nitrogen content in the soil.

Research on Non-destructive Testing for Developments of Water Resources in Arid Land

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Measuring soil water content profiles is the most common form of vadose zone monitoring. For

developments of water resources in arid land, it is important to monitor soil water content profiles or groundwater tables over time. This necessitates a nondestructive measurement that can be made repeatedly. In the past decade, there has been a considerable amount of research on the use of ground penetrating radar (GPR) to detect buried objects and geological structures and to measure soil water content.

In this research, the potential of GPR for the soil water content profiles determination is evaluated. It is shown from field experiments that the GPR measurements performed satisfactorily. The utility of our proposed method is demonstrated by using the experimental data for Tottori dune sand.

Amelioration of the Environment of the Plantation Cultivation by the Artificial Zeolite

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The example of the cultivation environment was investigated using an artificial zeolite. Improvement of soil improvement by artificial zeolite mixing each cultivation article A fact in the effect, a progressive further application method, and the improvement of an artificial zeolite in the future were examined. It will be examined that basic data acquires it to apply it to a cultivation technique where the effect goes up in addition and a wide cultivation environment in the future.

Development of Draught-tolerant Plants by Gene Technology

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There have been accumulated evidences showing the intimate relationship between plant drought tolerance and active oxygen scavenging system. Four kinds of transgenic tobacco plants, which have high activity of dehydroascorbate reductase, monodehydroascorbate reductase, ascorbate peroxidase or superoxide dismutase, were generated by gene –recombination. All of those transgenic plants showed higher tolerance to high salt, drought and polyethylene glycol. And also interestingly, the recovering speed from drought injury in transgenic plants was higher than the control ones.

Water Flow and Solute Transport in Undisturbed Soils

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

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

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In this research project, water balance model for of middle to large-scale irrigation scheme, named IMPAM (Irrigation Management Performance Assessment Model) is developed. Water balance of middle to large-scale irrigation consists of not only irrigation, drainage, and evapo-transpiration in cropland but also seepage loss from irrigation canals, evapo-transpiration from land without crop, seasonal change of regional water table etc., which depend on both management and physical characteristics of the irrigation system. Combining four modules (Water Distribution Module, Drainage Reuse Module, Spatial Water Balance Module, and Farm Water Balance Module), IMPAM includes these components and simulates total water balance of middle to large-scale irrigation. Spatial analysis unit of IMPAM is a command area of a tertiary canal, and water balance of a command area of a main canal is calculated. A proto type of IMPAM was applied to the Yonji Irrigation Area, Hetao Irrigation District, in the Yellow River basin, China, which consists of a main canal (Yonji Main Canal), six secondary canals, more than 700 tertiary canals, and about 1,300 km² of command area. Results of this test run suggest that it is important for accurate simulation of crop growth and its water consumption to take components of water balance other than direct water supply to cropland into account especially in semi-arid regions including Hetao ID.

The Yellow River basin has considerable number of middle to large-scale irrigation districts, and they are now requested to decrease their water use because of serious water shortage. Water saving methods such as crop cultivation with less water, decrease of transmission loss through lining of irrigation canals, are studied and applied. However, an application of a water saving method causes another problem. IMPAM that can simulate results of changes in management and facility of irrigation systems should be

a useful decision support tool for irrigated areas.

Effect of Supplied Water on Yield and Qualities of Cucumber Grown in Vinyl House

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Cucumber plant was cultivated in a vinyl house varying soil moisture tension (W1; 10-35 cmH₂O, W2; 45-65cmH₂O, W3; 80-125cmH₂O), and growth and fruits qualities (Ca²⁺, total vitamin C, and NO₃⁻-N) were measured through growth. Results obtained were as follows; 1) For all Ws, crop growth rate (CGR), dry matter production, and harvest index (H. I.; proportion of fruits dry weight to total dry weight) were similar. 2) Calcium content of fruits was reduced slightly by dry treatment (W3), though total vitamin C content of fruits was not significantly affected by water treatments. 3) Nitrate N content of fruits was almost same among Ws, even though NO₃⁻-N concentration of soil was higher in W3 compared with other Ws. 4) Total amount of irrigated water was 23.0, 4.2, and 2.0 m³ in W1, W2, and W3, respectively.

These results indicated that growth and fruits qualities of cucumber plant were stable, even if the amount of irrigated water was half of standard amount. Trial with severer dry treatment is planed in order to determine critical value of soil moisture limiting growth and fruits qualities of cucumber plant in 2005.

Effects of Water Stress on Growth and Transpiration of *Artemisia Ordosica*

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Artemisia ordosica, a perennial herbaceous plant, can grow on shifting sand dune with dense community in Mu Us sand land, one of the famous dry land confronting desertification in China. *A. ordosica* has a peculiar feature of tolerance for barren environmental conditions to enable speedy invasion and establishment on drifting sand surface under low soil moisture and sterile nutrient conditions. Therefore, *A. ordosica* is one of key revegetation plant materials to fix drifting sand in degraded dry land of China. To investigate the effects of drought stress on the growth and physiological response of *A. ordosica*, seedlings were grown under three levels of soil moisture condition, such as pF1.8, pF3.0 and pF4.2, and their phenology and transpiration rate were measured.

Both height and basal diameter growth rate were significantly higher in the control condition than in other two drought stress conditions. Number and size of leaf were also higher in the control condition

which indicated the strong effect of drought stress on the leaf phenology. Just before irrigation, the transpiration rate in the strong drought stress condition was significantly suppressed by the severe water deficiency. However, it showed a remarkable increase in the transpiration rate after a release from drought stress by irrigation to reach almost the same level in control condition. On the other hand, seedlings growing under week drought stress condition did not show such change in the transpiration rate before and after irrigation.

Water and Nutrient Use Efficiency under Water Stress

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Litterfall amount and litter decomposition rate was studied in an artificial forest of Robinia, pseudoacacia (Acacia) and a native forest of Quercus liaotungensis (Quercus) near Yanan in the loess plateau, China. We established 20 m × 20 m plot in Acacia plantation and Quercus forest. Diameter at breast height (DBH) was measured and species identified for all trees larger than 1 cm DBH. Ten littertraps of area 0.25m² were located in both plots. Litterfall was collected monthly from 2001 to 2003. All collections were sorted into leaves, twigs and other organs and each fraction was weighed separately for each littertrap. Leaf litterfall were ground, and the total N and C content were determined. Litterfall amount was larger in Quercus forest than in Acacia plantation. But nitrogen in litterfall was larger in Acacia plantation in Quercus forest, because of the high nitrogen concentration of Acacia leaf litter. Litter decomposition rate of Acacia leaf was faster than Quercus leaf. These things make nitrogen cycling larger and faster in Acacia plantation. However, faster decomposition brought the disappearance of organic horizon on soil surface. Organic horizon mediates the surface soil temperature and moisture. It seems to be one of the reasons of no Acacia seedling re-growth. From these results, Acacia plantation has the advantage for nutrient cycling, while it seems the disadvantage for surface soil condition. We proposed Quercus plantation in Acacia plantation and lead to the sustainable mixed forest of Acacia and Quercus.

Effect of Soil Structure on Soil Erosion

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In practical farmlands, the structure of soil modifies slowly because of the difference in cultivation methods. Therefore, a series of new experiments were conducted using soils with different structures (aggregates) but the same type (grain size accumulation). The soil samples were collected from 3

neighboring fields namely, non-cultivated land, cultivated land and no-till (short-period) land. The basic properties such as three-phase of soil particles, grain size accumulation, organic matter content, consistency, etc. were investigated and indoor erosion experiments using surface flow were carried out with all these soils. Observations and analyses showed that the differences in the basic properties in all these soil types eventually affected the amount of soil erosion. In particular, the no-till soil showed the most minimum erodibility. Besides, even the dry density (as compacted into the experiment box) was the same, because of the difference in aggregates (from aggregate analysis result), the amounts of soil erosion were different. On the other hand, although the aggregates of the no-till and the cultivated soils were almost the same, no distinguished difference in soil erosion was found. The study result can be concluded as: no-till (short-period) condition could maintain the aggregate stability of soil particles essential to reduce the amount of soil erosion.