

## 1.3 Joint Research

### (1) List of joint research

Title of Joint Research Project (\*A representative of joint research to carry out each project.)

#### Focused Research

Fukui, K.\*, Tsujimoto, H., Tsuji, W., Tomemori, H., Kohinata, T., Tanaka, J., Yuasa, S., Tsuchimoto, S., Sakai, H., Atefeh, A., Mandai, A., Sasai, T., Mohamed, I.A. and Tsunekawa, A.: Development and characterization of drought-stress tolerant plants using genetically engineering and arid-land simulator system

Otsuki, K. \*, Kitano, M., Tasauchi, O., Kashima, K., Yongqing, M., Tateno, R., Yasuhuku, N., Satoh, R. and Yamanaka, N.: Establishment of Japan-China-Korea collaborative research center for combatting desertification in Ningxia District in the Loess Plateau, China

Tagawa, K. \*, Kimura, R., Tsutsui, K., Tali, L., Hayashi, T. and Inoue, M.: Field test of seawater pumping and irrigation water making system using solar and wind power for greening the desert

#### General Research

Yamashita, H. \* and Shinoda, M.: Urban Developments and its Character in Arid Land of North America

Iijima, Y.\* and Shinoda, M.: Hydrological cycle in grassland ecocsystem in Mongolia and Kazakhstan

Tachiiri, K.\*, Purevjay, G. and Shinoda, M.: Future risk assessment of dzud in Mongolia using CMIP3 multi-model dataset

Kimura, K.\* and Shinoda, M.: Analysis of seasonal and interannual variation of rainfall in Mongolia in summer with its mechanism

Kurozawa, Y.\*, Mu, H., Onishi, K. and Shinoda, M.: The effect of Asian dust storm on human health

Morinaga, Y.\* and Shinoda, M.: Quality control and utilization of zoo-meteorological data of Mongolia for mitigating a disaster impact

Nakano, T.\* and Shinoda, M.: Estimation of plant biomass and soil moisture in Mongolian semiarid grassland

Kashima, K. \*, Orkhonselemge, A., Ganzorig, U., Fukumoto, Y. and Shinoda, M.: Long-term Monitoring of Water Resources in Mongolia

Mikami M.\*, Ishiduka, M., Yamada, Y. and Shinoda, M.: Observation of the atmosphere-ground surface interactive processes in arid region

- Tasumi, M.\*, Yoneda, S. and Kimura, R.: Estimation of soil moisture and evapotranspiration for yellow-dust monitoring
- Zhou, J.\* and Kimura, R.: The Results and the Problems of the Chinese Policy of Reverting Forests and Grasslands to Farmlands and grazing lands
- Matsushima, D.\*, Kurosaki, Y. and Kimura, R.: Decadal trends of spatial distribution of threshold wind speed of wind erosion in Mongolia
- Iwasaki, E.\*, Kato, H., Matsuoka, N., Fujimaki, H. and Kimura, R.: Water management in Southern Tunisian Oasis
- Kato H.\*, Hasegawa, S., Iwasaki, E., Matsuoka, N., Fujimaki, H. and Kimura, R.: Irrigation system in Lower Egypt: Multi-Disciplinary research of area study collaborated with archeology and natural sciences
- Matsuoka, N.\*, Nakano, S. and Kimura, R.: Prediction of surface soil moisture under Caragana stands by meteorological data
- Noborio, K.\* and Yasuda, H.: Effects of fertilizer distribution on greenhouse gas emissions with drip irrigation
- Ito, Y.\*, Nakagawa, K., Kawai, T. and Yasuda, H.: Conservation and management of fresh water resources in a sandy coastal aquifer
- Nishiyama, K.\* and Yasuda, H.: Relationships between global climate change and local hydrological features inherent in arid and semi-arid regions
- Aoda, T.\* and Yasuda, H.: Analysis on soil moisture and solute transport to improve agricultural products in arid area
- Yoda, K.\*, Mohamed Ahmed, M.A.E., Eldoma, A., Hoshino, B. and Yasuda, H.: Comparative study of the growth patterns of root system in Mesquite (*Prosopis juliflora* (Swart) DC) seedlings under different soil water conditions
- Nakagawa, K.\*, Kawai, T. and Yasuda, H.: Effect of phreatophyte on groundwater and soil in arid environment
- Tanaka, K.\*, Lina, Y. and Tsunekawa, A.: Molecular physiological researches on enhancement of drought tolerance in silicate-treated sorghum
- Murakami, K.\*, Kishida, S., Kinoshita, K. and Tsunekawa, A.: Development of remote sensing system in

- aridland farming (3) -Development of highly reliable ad hoc multihop communication technology in aridland-
- Kinoshita, K.\* , Kishida, S., Murakami, K. and Tsunekawa, A.: Development of remote sensing system in aridland farming (2) -Development of highly reliable and environmental monitor on aridland-
- Tamura, K.\* , Kanda, T., Isa, H. and Tsunekawa, A.: Evaluation on stability of soil organic matter fractions by stable carbon isotope analysis through soil profile
- Kishida, S.\* , Kinoshita, K., Murakami, K. and Tsunekawa, A.: Development of remote sensing system in aridland farming (1) -basic examination concerning improvement of performance and reliability of solar photovoltaic system in aridland-
- Sakamoto, A.\* , Watanabe, S. and Tsunekawa, A.: Revealing a hidden role of nucleobase metabolism in plant strategies coping with stress
- Sugimoto, Y.\* , Mizutani, M., Ueno, K., Yoshimoto, C., Nomura, S. and Ping, A.: Physiology and biochemistry of noxious plants in semi-arid regions
- Matsuura A.\* , Murata, K. and Ping, A.: Mechanisms of tolerance to environmental stress of millets and collection both of culture method and genetic resources in China
- Kashiwagi, J.\* , Morota, Y., Hamada, K. and Ping, A.: Improvements of drought tolerance in wheat via enhancement of water absorption capability in the root systems
- Shimizu, H.\* , Kobayashi, S., Sasagawa, H. and Ping, A.: Researches on water use and water stress resistance of shrub species grown in semiarid land
- Abe, J.\* , Tanimoto, E. and Ping, A.: Study on eco-physiological properties of infertile land crops
- Araki, H.\* , Kajita, K., Sakata, R. and Ping, A.: Establishment of a measurement system on carbon balance in crops under over-optimal temperature
- Okamoto, H.\* , Sasaki, M., Matsubara, T. and Ping, A.: Study on effect of soil moisture on root system development of temperate grasses
- Oka, M.\* and Ping, A.: Hormonal regulation of responses to low nitrogen stress in higher plants
- Nishihara, E.\* , Van der Watt, E. and Tsubo, M.: Bio-stimulators improving dryland crop production
- Shibata, S.\* and Tsubo, M.: Estimation of grassland production in Loess Plateau China
- Taniguchi, S.\* , Noguchi, Y., Nakasone, T. and Yamanaka, N.: Specific characteristics for salt tolerance

mechanism of halophilous plants

Futai, K.\*, Takeuchi, Y., Taniguchi, T., Yasuda, A. and Yamanaka, N.: Studies on mycorrhizal fungi that facilitate drought resistance of Japanese black pine

Yamamoto, F.\*, Okada, Y. and Yamanaka, N.: Experimental studies on relationships between drought and salt tolerances and the ability of osmotic adjustment in economically-important plants in semi-arid region of China

Tateno, R.\*, Sheng, D. and Yamanaka, N.: The effects of slope position on soil-plant interaction in a semi-arid forest ecosystems

Matsuo, N.\*, Koyama, L., Hara, N., Nishizawa, M. and Yamanaka, N.: Estimating salt tolerance from the oxygen and carbon isotope compositions in arid plants

Miki, N.\*, Yoshikawa, K., Yang, L., Ogasa, M., Murakami, Y., Sasaki, S. and Yamanaka, N.: Changes of xylem hydraulic conductivity and stomatal regulations of water loss in response to water stress in ring-porous and diffuse-porous species

Iwama, K.\*, Yano, H. and Yanamaka, N.: The development of remediation technology for the saline soil using Tamarix

Nawata, H.\*, Satoh, R., Muramatsu, K., Matsunaga, K. and Yamanaka, N.: Methodological studies on social development impact assessment at village level in the Loess Plateau

Iwase, K.\*, Kodama, M., Tharnrat, K. and Yamanaka, N.: Determination of mycorrhizal fungi in the soils to form mycorrhizas to the seedlings of *Dipterocarpus alatus* growing in the dry area in Thailand

Koyama, L.\*, Arai, N., Mitamura, H., Wada, A. and Yamanaka, N.: Vegetation survey technique using low altitude aerial photograph in dene ecosystems

Matsuzoe, N.\*, Zushi, K., Kondo, K., Wajima, T. and Inoue, M.: Study of sandponics bed system using capillary uptake method

Morii, T.\* and Inoue, M.: Experimental study on water saving irrigation by using capillary barrier of soil

Cho, H.\*, Miyamoto, H. and Inoue, M.: Two-dimensional measurement of water content and EC in surface area with TDR system

Higashi, T.\*, Orioku, T., Takizawa, S., Yageta, Y. and Inoue, M.: The evaluation on soil environment affected by irrigation at arid land

Kamiya, K.\*, Shirane, G. and Inoue, M.: Evaluation of pore-air behavior during rainfall infiltration in

unsaturated soil and its influence to water seepage

Takeshita, Y.\* , Oka, T., Komatsu, M., Kuroda, S., Takino, Y. and Inoue, M.: Research on Non-destructive measurements of soil hydraulic properties of unsaturated soils by using Ground-penetrating radar

Inosako, K.\* , Saito, T. and Inoue, M.: Salt and water movement after leaching in a salt accumulated soil with multi capillary barriers

Kuroda, S.\* and Inoue, M.: Applicability of ground penetrating radar for deep vadose zone survey in arid land

Hara, R.\* and Ando, T.: The utilization of indigenous technology for water and rural socio-economic development in West Asia

### **Incentive Research by Young Scientists**

Asanp, M.\* and Tsunekawa, A.: Stock and dynamics of pedogenic carbonate carbon under cold desert

Matsumoto, K.\* and Ping, A.: Physiological studies on drought and salt tolerance of apple and pear rootstock species

Kinugasa, T.\* and Yamanaka, N.: Contribution of buried seeds to natural revegetation after vehicle track formation in Mongolian steppe

Miyazawa, Y.\* and Yamanaka, N.: Analysis of geographical trend in transpiration by Robinia pseudoacacia plantation along precipitation gradient

Sato, H.\* and Inoue, M.: Controlling vapor transport in soils using thermal energy in arid region

Saito, T.\* and Inoue, M.: INOUE Development of method for accurate soil moisture measurement using dielectric probes in arid land environments

Kondo, K.\* and Inoue, M.: Utilization of saline water in closed soilless culture system for growing vegetables

Yoshihara, Y.\* and Ito, T.: Effect of dietary mineral imbalance due to overgrazing on Mongolian livestock health

### **Research Meeting**

Otsuki, K.\* , Kashima, K., Kitano, M., Kimura, R., Tsunekawa, A., Shinoda, M. and Yamanaka, N.:  
The open symposium on the drylands and desertification in East Asia

## **(2) Summary of Joint Research**

### **Focused Research**

#### **Development and characterization of drought-stress tolerant plants using genetically engineering and arid-land simulator system**

Kiichi Fukui<sup>1</sup>, Hisashi Tsujimoto<sup>2</sup>, Wataru Tsuji<sup>3</sup>, Hisashi Tomemori<sup>2</sup>, Tsutomu Kohinata<sup>1</sup>, Junko Tanaka<sup>1</sup>, Syota Yuasa<sup>1</sup>, Suguru Tsuchimoto<sup>1</sup>, Hiroe Sakai<sup>1</sup>, Alipour Atefeh<sup>1</sup>, Ayako Mandai<sup>1</sup>, Tomohiro Sasai<sup>4</sup>, Iamail Ahmed Mohammed<sup>1</sup> and Atsushi Tsunekawa<sup>2</sup>

1: Graduate School of Engineering, Osaka University, 2: Arid Land Research Center, Tottori University, 3: Faculty of Agriculture, Tottori University, 4: School of Engineering, Osaka University

We acclimatized GM jatropha plants, and tested under the drought condition. GM (ATPPAT, AtNF-YB, JcPPAT, and GUS) or non-GM plants from tissue culture as well as non-GM seedlings were brought to Arid Land Research Center from Osaka University in Jan. 19, 2012, were transplanted in 1/5000 Wagner pots with sand, and were placed in a cold desert simulator (30°C, RH: 40%, 12/12 h(day/night)). Light intensity was raised gradually until it reached 120,000 lux. Pots were watered to be 23% of water content in sand and sealed at Feb. 7. They were put on electric balance to start measuring transpiration. From Feb. 8, photosynthetic rate, stomatal conductance, and transpiration rate of the uppermost expanded leaves were measured for 5 days. Plants from tissue culture showed more transpiration than seedlings. Transpiration rate per leaf area denoted the same tendency. Especially in two transgenic plants (AtPPAT) showed significantly high transpiration rate, but it rapidly lowered after Feb. 11. It is probably because they depleted water. Photosynthetic rate, stomatal conductance and electron transfer rate denoted the same tendency. We plotted photosynthetic rate and water content ratio, and positive correlation between them were found. Seedlings showed lower photosynthetic speed than plants from tissue culture. It may be caused by bad growth or stresses other than water stress in seedlings. We found that it is necessary to repeat the experiments by using plants with the uniform condition. We also did phylogenetic analysis of Mexican jatropha lines by using SSR markers, and showed high genetic diversity of them.

#### **Establishment of Japan-China-Korea collaborative research center for combatting desertification in Ningxia District in the Loess Plateau, China**

Kyoichi Otsuki<sup>1</sup>, Masaharu Kitano<sup>1</sup>, Osamu Tadauchi<sup>1</sup>, Kaoru Kashima<sup>2</sup>, Ma Yongqing<sup>3</sup>, Ryunosuke Taten<sup>4</sup>, Noriyuki Yasuhuku<sup>5</sup>, Renya Satoh<sup>6</sup> and Norikazu Yamanaka<sup>7</sup>

1: Faculty of Agriculture, Kyushu University, 2: Faculty of Sciences, Kyushu University, 3: Institute of Soil and Water Conservation, Chinese Academy of Science, 4: Faculty of Agriculture, Kagoshima University, 5: Graduate School of Engineering, Kyushu University, 6: Graduate School of Social and Cultural Studies, Kyushu University, 7: Arid Land Research Center, Tottori University

(1) Establishment of the Research Network for Combating Desertification in Kyushu University: The Research Group for Combating Desertification of the Research Institute for East Asia Environment (RIEAE) of Kyushu University has been enlarged. The Group consists of six members from four Faculties: Agriculture, Science, Engineering and Social & Cultural Studies in 2011.

(2) Establishment of the Organizational Research Network for Combating Desertification in Japan:

- 1) RIEAE and Arid Land Research Center (ALRC) attended at the 10th. United Nations Convention to Combat Desertification (UNCCD) in Korea and jointly exhibited our activities for combating desertification.
- 2) RIEAE and Arid Land Research Center (ALRC) jointly held the event for combating desertification for the citizens in Fukuoka Prefecture at the JR Hakata City during 28-29 February, 2012 .
- 3) RIEAE and ALRC signed the Academic Exchange Agreement to combat desertification.

(3) Preparation for the Japan-China-Korea Joint Research for Combating Desertification in East Asia.

After searching the research site to study combating desertification in Ningxia District in the Loess Plateau, China, we decided to make the research base in Guyuan Station of the Institute of Soil and Water Conservation (ISWC), CAS & MWR of Cina and initiating the Japan-China-Korea Joint Research Project at the station by RIEAE, ALRC, ISWC and the College of Forestry & Environmental of Kangwon National University of Korea.

### **Field test of seawater pumping and irrigation water making system using solar and wind power for greening the desert**

Kotaro Tagawa<sup>1</sup>, Reiji Kimura<sup>2</sup>, Kazunobu Tsutsui<sup>1</sup>, Li Yali<sup>3</sup>, Tsutomu Hayashi<sup>4</sup> and Mitsuhiro Inoue<sup>2</sup>

1: Faculty of Regional Sciences, Tottori University, 2: Arid Land Research Center, Tottori University, 3: Graduate School of Regional Sciences, Tottori University, 4: Department of Research, Nagoya Industrial Science Research Institute

The purpose of this study is the development of sustainable food production system which is environmentally friendly and economical in arid land. In this study, the food production system has been developed by combing the crop cultivation using drip irrigation with photovoltaic and wind power system, pump system and meteorological measurement system at sand dune along seacoast and a greenhouse located in the Arid Land Research Center, Tottori University. The preliminary examination was carried out to investigate the basic performance of the pump system with photovoltaic power system. It was examined to be possible to pump up the seawater from a well at the seacoast to an inland greenhouse. The electric consumption needed to operate the pump system, the flow rate of seawater supplied by pump and the concentration of seawater were also measured in the experiment. The procedure was also designed for pumping the seawater in a day based on the results. The field experiment has been continued with the procedure.

Moreover, the field investigation was performed to obtain the information about key factors to install and manage the system combined by the crop cultivation using drip irrigation with photovoltaic and wind power system in Canary Island, Spain located in arid region. Large-scale system with 2.5 MW wind power system (0.65MW wind turbine ×4) has been installed to drive the reverse osmosis (RO) desalination plant for producing irrigation water from seawater in the farm. The whole irrigation water for vegetables cultivation was produced and supplied. It was found that the capacity of RO desalination plant per day was 5,000 m<sup>3</sup>/day and the cost of selling electricity to the national grid was 0.013 cent/kWh. The current situation of water resource and consumption in the remote island of arid region were also understood.

## **General Research**

### **Urban developments and its character in arid land of North America**

Hiroki Yamashita<sup>1</sup> and Masato Shinoda<sup>2</sup>

1: Faculty of Regional Sciences, Tottori University, 2: Arid Land Research Center, Tottori University

I analyzed about the sustainability of desert cities in the south-western part of USA. On the exhaustion of natural resources, not safe of peace and order, and the disaster, many small towns have declined and have been ghost towns.

But a few cities grow and build up its metropolitan area, like Las Vegas and Phoenix. Phoenix metropolitan area have several suburban cities. these have own industries and characters, like leisure, University, aged welfare, and IT. Some ghost towns had been restored to the sightseeing spot or the artists' village.

### **Hydrological cycle in grassland ecosystem in Mongolia and Kazakhstan**

Yoshihiro Iijima<sup>1</sup> and Masato Shinoda<sup>2</sup>

1: Japan Agency for Marine-Earth Science and Technology, 2: Arid Land Research Center, Tottori University

In the Kazakhstan steppe, field manipulation (spring snow removal and autumn rain interception plots) and hydro-meteorological observation were continued following the first year (2010FY). In this year, maximum snow depth was about 40 cm and summer precipitation was 241 mm. Thus, water resource was about 3 times larger than that of the previous year. The aboveground biomass in August showed 6.4 times (alive-part) larger than that in 2010 at the snow removal plot. In spite of wetter climate in this year, soil temperature and moisture showed the higher and drier soil condition at the snow removal plot. These anomalies have reached to the depth of 120 cm. Therefore, the influence of snow coverage removal on hydro-thermal conditions is likely prolonged in perennial time scale. Stable isotope analyses were performed using water sample from winter snowfall from November 2010 to March 2011. According to the d-excess value, the rain in the middle of November had the remarkably low value. The water might be strongly influenced by evaporation. In contrast, water was close to the meteoric line after the middle of November. The corresponding seasonal contrast of the oxygen isotopic ratio was also found during the winter along with seasonal variation in air temperature. The result indicates that possibility to identify source within soil and plant water using the stable isotope analyses.

### **Future risk assessment of dzud in Mongolia using CMIP3 multi-model dataset**

Kaoru Tachiiri<sup>1</sup>, Gomboluudev Purevjav<sup>2</sup> and Masato Shinoda<sup>3</sup>

1: Japan Agency for Marine-Earth Science and Technology, 2: Institute of Meteorology and Hydrology , Mongolia, 3: Arid Land Research Center, Tottori University

To examine the impact of future climate change on summer droughts in Mongolia, we investigated the

effect of climatic conditions during the growing season on vegetation. Outputs from an ensemble of climate models running the Special Report on Emissions Scenarios (SRES) A1B scenario were fed into a process-based vegetation model in the 2005 version of the Earth system model MIROC-ESM (MIROC-ESM05), modified for dryland conditions. To assess the effects of inter-model differences, we adjusted summer temperature and precipitation by coefficients representing each of the Phase 3 Coupled Model Intercomparison Project (CMIP3) datasets, and then assessed the changes in leaf area index (LAI) and the frequency of agricultural drought, defined as years with low LAI values, during the 21st century. The model results showed that LAI will increase and agricultural droughts will decrease in all cases. We also modeled the CMIP3 dataset for the SRES A2 scenario and found that LAI will increase in all cases. Using coefficients beyond the range of the CMIP3 data, we found that under warming twice as great as in MIROC, drought frequency will increase and LAI will decrease. Our results demonstrated a robust increase in LAI and a decrease in agricultural drought and risk of dzuds (livestock-killing snowfall events), showing that vegetation has the capability to adjust to warming climate in the rest of this century.

### **Analysis of seasonal and interannual variation of rainfall in Mongolia in summer with its mechanism**

Keiji Kimura<sup>1</sup> and Masato Shinoda<sup>2</sup>

1: Graduate School of Information Science and Technology, Hokkaido University, 2: Arid Land Research Center, Tottori University

Meteorological disasters such as floods and droughts often occur in middle to high latitudes in relation to extreme extra-tropical cyclone activities, thus causing serious socio-economic damage at a regional scale. Given this background, this study investigated the tracks of rain-producing cyclones and water vapour transport to the systems in Mongolia during the period from 1993 to 2002.

Daily synoptic analysis of objective reanalysis data identified two major types of tracks, which are located north (N-track type) and south (S-track type) of the mountainous area of western Mongolia. The N- and S-track types comprised 36% and 64% of all rain-producing cyclones in Mongolia, respectively. Moreover, the analysis of water vapour transportation also revealed two major directions (from the north and south) of transportation of water vapour to the cyclones. Water vapour was transported from the north and south for 52% and 46% of all rain-producing cyclones that passed over Mongolia, respectively. The dynamics of the rain-producing systems were associated with the migration of the upper tropospheric trough and the existence of a cut-off low.

The combination of the locations of the tracks (two types) and the directions of water vapour transport (two types) enabled us to classify the synoptic features of the cyclones into four types and discuss exceptional cases. The S-track type with the southward vapour source has been found to cause major heavy rainfall events in the area. The crucial role of the southward vapour source in exciting cyclone activity was, for the first time, pointed out by the present daily analysis although previous monthly analyses could not detect water vapour transportation from the south in Mongolia.

### **The effect of Asian dust storm on human health**

Youichi Kurozawa<sup>1</sup>, Haosheng Mu<sup>1</sup>, Kazunari Onishi<sup>1</sup> and Masato Shinoda<sup>2</sup>

1: Faculty of Medicine, Tottori University, 2: Arid Land Research Center, Tottori University

We investigated the possible causes for the diversity in symptoms produced by Asian dust events, as reported in a questionnaire survey, on the basis of the dust components and estimated trajectories. Nine dust events were recorded and classified into three types on the basis of light detection and ranging (lidar) data: Type 1 events with high counts of non- mineral dust (spherical) particles, Type 2 events with high counts of mineral dust particles in comparison to non-mineral dust particles, and Type 3 events with very low counts of non-mineral dust particles as compared with other Asian dust events during the surveillance period. Ensemble backward trajectory analysis showed that the atmospheric transport route indeed accounted for the differences. Subjective symptom scores showed the greatest increase after exposure to Type 1 events and a decrease after exposure to Type 3 events. A variety of aerosols were detected concurrent with Asian dust events, and the link between health effects in humans and changes in pollutant levels was explored. The results suggest that the components of Asian dust should be considered when investigating related health effects.

### **Quality control and utilization of zoo-meteorological data of Mongolia for mitigating a disaster impact**

Yuki Morinaga<sup>1</sup> and Masato Shinoda<sup>2</sup>

1: School of Commerce, Meiji University, 2: Arid Land Research Center, Tottori University

In order to examine the Mongolian herders' indigenous knowledge about seasonal campsite selection, the data of meteorological observations of winter and summer campsites carried out in the forest steppe of Bulgan province in northern Mongolia were analyzed along with the result of the zoo-meteorological study of Mongolia.

The threshold of effective temperature (factor of air temperature and wind speed) for livestock's grazing at pasture had been shown from the zoo-meteorological observation. Using the threshold and the meteorological data, feeding difficulty index (FDI) was developed.

Threshold value of wind speed for sheep grazing  $V_t$ (ms-1) is shown as

$$V_t = 0.4 \cdot T + 12.3 \quad \text{where } T \text{ is the air temperature.}$$

Here, we defined the distance between  $V$ ,  $T$  and the threshold line as FDI.

$$FDI = (V - V_t) \cdot \cos(\tan^{-1}(0.4))$$

The area for the severe condition is shown as positive while the mild condition as negative. If the amount of FDI is large, the weather condition is harsh for sheep. FDI for summer camp (FDI<sub>b</sub>) and winter camp (sFDI) were estimated and, the difference between the two (dFDI) and sum of the two (sFDI) were calculated.

$$dFDI = FDI_b - FDI_s$$

$$sFDI = FDI_b + FDI_s$$

It was shown that FDI were large in both amount and the duration during the dzud (cold and/or snow disaster) year of 2009/2010 compared to the normal year.

### **Estimation of plant biomass and soil moisture in Mongolian semiarid grassland**

Tomoko Nakano<sup>1</sup> and Masato Shinoda<sup>2</sup>

1: Faculty of Economics, Chuo University, 2: Arid Land Research Center, Tottori University

CO<sub>2</sub> exchanges between the atmosphere and terrestrial ecosystems are highly related to the amount of growing plant and the soil moisture. We aim at estimating temporal and spatial variations in aboveground plant biomass and soil water content in semiarid grassland ecosystems using satellite remote sensing images. In the present study, we focused on the soil moisture product of Advanced Microwave Scanning Radiometer for EOS (AMSR-E) onboard the Aqua satellite and examined the relationships between the AMSR-E products and values of volumetric soil water content which were measured in semiarid grasslands of Mongolia. The result indicated that the correlations between the remotely sensed data and the measured ones were different by location, probably depending on the soil texture at the sites. The AMSR-E soil moisture was characterized by rapid increase and decrease with rain events, because it reflects water condition near the surface of soil. In general, water retention ability of soil depends on soil texture, that is, the finer soil has the higher water retentivity. In our result, the correlation coefficient between the AMSR-E products and the measured value was high at the site which mainly contained coarse soil and vice versa.

#### **Long-term Monitoring of Water Resources in Mongolia**

Kaoru Kashima<sup>1</sup>, Aleksandr Orkhonselenge<sup>2</sup>, Ulgiichimeg Ganzorig<sup>3</sup>, Yu Fukimoto<sup>1</sup> and Masato Shinoda<sup>4</sup>

1: Faculty of Sciences, Kyushu University, 2: The Institute of Nature and Environmental Technology, Kanazawa University, 3: Institute of Geography, Mongolia Academy of Science, 4: Arid Land Research Center, Tottori University

The field survey at Mongolia was done since August 26 through September 3, 2011. The members of the survey were Prof. Kaoru Kashima (Kyushu University), Mr. Yu Fukimoto (Kyushu University) and Mr. U. Ganzorig (Institute of Geography, Mongolian Academy of Sciences). Ms. A. Orkhonselenge (Kanazawa University) went to Mongolia before the survey to arrange the preparing for it. The field area of it is the Khuder Peat Land, north-central Mongolia where peat has been deposited for more than 9,000 years without break. We took the peat sediment using the drilling machine, and presumed the environmental changes by C14 dating and micro-paleontological analyses. The drastic changes of climatic environment and water resources at 4000 years ago and 800 years ago at north Mongolia were clearly examined by the survey.

#### **Observation of the atmosphere-ground surface interactive processes in arid region**

Masao Mikami<sup>1</sup>, Masahide Ishiduka<sup>2</sup>, Yutaka Yamada<sup>3</sup>, and Masato Shinoda<sup>4</sup>

1: Meteorological Research Institute, Japan Meteorological Agency, 2: Faculty of Engineering, Kagawa University, 3: Rapid Engineering Team, The Institute of Physical and Chemical Research, 4: Arid Land Research Center, Tottori University

We have made a profile observation of dust concentration using 10m tower at a sparse grass land in Mongolia for monitoring of dust flux under various ground surface conditions. Observation was conducted from 3 May to 28 June 2011. On 10 May, a dust storm occurred with strong wind of over 22 m/s at 3.1 m in

height. The dust concentrations at two different heights, 1m and 10m, indicated clear gradient that implies dust emission outbreak from ground surface. This preliminary result showed that dust flux can be evaluated using this tower observation system when we apply the gradient method for dust flux calculation.

### **Estimation of soil moisture and evapotranspiration for yellow-dust monitoring**

Masahiro Tasumi<sup>1</sup>, Shun Yoneda<sup>2</sup>, and Reiji Kimura<sup>3</sup>

1: Faculty of Agriculture, Miyazaki University, 2: Graduate School of Agriculture, Miyazaki University,  
3: Arid Land Research Center, Tottori University

This research focuses on a large-scale soil moisture estimation using satellite remote-sensing as a tool of monitoring water environment for yellow-dust production areas in arid and semi-arid lands. In this year, we developed a simple algorithm which enables to estimate soil moisture via surface temperature image of satellite. The algorithm was applied and soil moisture was estimated in Zhangye region of China, using MODIS satellite imagery, DEM and the observed wind speed data for 6 days during 2010-2011. Also, we have conducted soil moisture, vegetation and land use observations in Zhangye in fall 2011, for evaluation of our estimation algorithm. The comparison between observed soil moisture and the estimated result indicated that the error of estimated volumetric soil water content was about 8% of the total volume of soil in desert area, which was greater than the result in preliminary study reported in last year (2.6-2.8%), probably due to error in calibration of soil parameters and/or weather parameters. The current algorithm estimated "relative" soil wetness very well - high soil moisture for irrigated agricultural area, low moisture for desert, and intermediate for other regions. Future improvement of the algorithm is possible by studying the parameters. Also, continued evaluation works using more satellite images will make the error assessment more rigid, which will make this algorithm as an effective monitoring tool of soil moisture in arid regions.

### **The results and the problems of the Chinese policy of reverting forests and grasslands to farmlands and grazing lands**

Jianzhong Zhou<sup>1</sup> and Reiji Kimura<sup>2</sup>

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The effect of implementation "to convert arable land to forest" policy in China, we investigated the neighboring district of Inner Mongolia from the northern part of Shaanxi province. Issues change in the frequency effect of suppressing the results of greening, the yellow sand, dust storms to occur, and the improvement of the economy and the lives of residents, collecting field work, data have been exchange of opinions.

Between 2001 to 2010, in these districts, the effects of greening are large, considerably more vegetation, such as frequency of occurrence of dust storms is reduced and the income of residents has increased. However, some farmers worry about is whether policy will continue indefinitely.

### **Decadal trends of spatial distribution of threshold wind speed of wind erosion in Mongolia**

Dai Matsushima<sup>1</sup>, Yasunori Kurosaki<sup>2</sup> and Reiji Kimura<sup>2</sup>

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Subsurface thermal inertia was estimated using a surface heat budget model incorporating surface meteorological data observed at Bayan Unjuul located in a typical steppe in Central Mongolia. Threshold wind speed of dust emission was also estimated using dust emission data observed at the same location, and a linear empirical formula in terms of threshold wind speed as a function of thermal inertia was developed. The estimation method of the threshold wind speed was developed in this study. The method was as follows: First, one-minute-averages of PM10 density and corresponding wind speed were prepared, and they were classified into ranks divided by every 1m/s of wind speed. In each rank, scatter of the logarithm of the PM10 density was almost approximated as t-distribution, and the 10-percentile values of individual ranks were almost located at the envelope of the scatters. Then, the threshold wind speed was defined as the curve connecting the 10-percentile values crossing the PM10 density level of 0.05 mg/m<sup>3</sup> which was typical value of the density when dust emission began. Values of threshold wind speed determined as above and thermal inertia values showed a positive correlation under the surface being almost non-vegetated, and a linear regression formula was obtained. Using this formula, threshold wind speeds at locations of routine meteorological observations were performed in the steppe in Central Mongolia were estimated, and the estimates were examined by actual wind speed and dust observation data. Values of thermal inertia were estimated using the routine meteorological data and the satellite data. As a result, at two third of all analysed data, relation between actual and threshold wind speed, and dust emission were determined correctly. The determination accuracy was worse as the locations were apart more from Bayan Unjuul where the data which the formula was based on were obtained. This may have been due to the difference of soil texture, that remains as a future issue.

### **Water management in Southern Tunisian Oasis**

Erina Iwasaki<sup>1</sup>, Hiroshi Kato<sup>2</sup>, Nobuhiro Matsuoka<sup>3</sup>, Haruyuki Fujimaki<sup>4</sup> and Reiji Kimura<sup>4</sup>

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Maghreb (North Africa) including Tunisia belongs to the Mediterranean world, and its economy is integrated within the Mediterranean region notably with France for historical reason. However, the majority of the geographic space in Maghreb is composed of oasis region.

This study focus on Southern Tunisia located on the fringe of Sahara desert. It is an agricultural area based on date production. Majority of palm date trees are found in this area. Focusing on this area, the study aims at examining the water use and irrigation system. To this end, information and statistics on the irrigation in Southern Tunisia were collected with the assistance of Tunisian researchers and office of Ministry of Agriculture.

The information and statistics collected include number of water associations (GIC), water sources, number of cultivators, etc. GIC is an association organized by the water right users who share the water source (wells). It is a communal association that administrates the use of water among the sharers with the assistance of Water Source Direction of Ministry of Agriculture in charge of primary and secondary canals.

Today, this association has an importation role of efficient and equal distribution of water among different actors (among farmers, irrigation districts, within oasis, region).

### **Irrigation system in Lower Egypt: Multi-Disciplinary research of area study collaborated with archeology and natural sciences**

Hiroshi Kato<sup>1</sup>, So Hasegawa<sup>2</sup>, Erina Iwasaki<sup>3</sup>, Nobuhiro Matsuoka<sup>4</sup>, Haruyuki Fujimaki<sup>5</sup> and Reiji Kimura<sup>5</sup>

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Egyptian agriculture has many vicissitudes, depending on the water situation. This study aims to examine the relationship between the unsustainability of water and the development of irrigation system in the Egyptian society, using such various source materials as the archeological data and information, the remote sensing, GIS, the geological information such as historical maps and irrigation maps, data and information collected from social survey, and historical information. The research area is the area around Sidi Oqba Village in Beheira Prefecture, located in the western part of Egyptian Delta. The area is abundant of water and prosperous in agriculture today. However, it is the most lately developed area in Egyptian Delta region since the end of 19th century. It is very strange and interesting that there remain a lot of archeological sites in such an area as arable land in the beginning of modern time. It means that this area was prosperous in ancient time, lost its prosperity in middle age, and was redeveloped in modern time. This research aims to examine the reasons of the vicissitudes of the survey area in the long terms, focusing on the development of irrigation. One of the most important facts that we can deduce from our research is that the reclamation of the survey area could be done by the combination of the traditional irrigation system and the modern irrigation system, using the mounts of the archeological sites.

### **Prediction of surface soil moisture under Caragana stands by meteorological data**

Nobuhiro Matsuoka<sup>1</sup>, Satoshi Nakano<sup>2</sup> and Reiji Kimura<sup>3</sup>

1: Graduate School of Horticulture, Chiba University, 2: National Agricultural Research Center Hokuriku Research Center, 3: Arid Land Research Center, Tottori University

Caragana chamlagu was grown in the wagner pots of 1/5000a. Measured by gravimetric method and stem flow in the transpiration rate of Karagana a lid on the soil surface after the water supply ①, the comparison test. Was calculated by subtracting the amount of land surface evaporation transpiration measured by the gravimetric method the evapotranspiration of the soil surface and remove the lid ②, sap flow was measured by. Compared the soil moisture and soil moisture was measured to estimate soil moisture input into the model the measured values of evaporation and transpiration rate ③ Karagana surface was estimated. As a result, the following became clear.

Corresponding amount of transpiration by the flow method was good in the stem ① but overestimated the gravimetric method. Average value of the ratio of the flow method in the stem / gravimetric method in measuring transpiration rate (25% excluding the top and bottom) was 0.40. By combining the flow method and gravimetric method in the stem, it has become possible to measure the

separation of transpiration and soil surface evaporation Karagana.

Prediction model was applied to the soil moisture content (1985), 0.065m and 0.03m depth change in moisture content is a reasonable change in moisture content was increased to 0.104m depth without decreasing ② Campbell. This is due to low moisture content of the initial value, the model is for the supply of moisture occurs from the top and bottom. In addition, the model has decreased rapidly moisture depth of 0.15m, was calculated to water flowing out there in this model there is a non-root group layer under the layer of 0.15m. Depending on the nature of the soil, changes in the amount of transpiration rate and soil surface evaporation is very different, causing transpiration to Karagana suppression in pot conditions. In this measurement, because they start from a value considerably less soil moisture condition was removed the lid that is the subject of calculation of soil moisture, the model soil moisture in the areas a little shorter a state with a lid, resulting in changes in soil moisture it is necessary to perform verification of.

### **Effects of fertilizer distribution on greenhouse gas emissions with drip irrigation**

Kosuke Noborio<sup>1</sup> and Hiroshi Yasuda<sup>2</sup>

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The purpose of this proposed study was to develop appropriate management practices of liquid fertilizer to mitigate greenhouse gas emissions with maintaining a crop yield. The proposed study enhance the knowledge of the effects of nitrification and denitrification on N<sub>2</sub>O production with various distribution of fertilizer concentration in soil by controlling fertilizer application rates under drip irrigation. It is useful to use a simulation model to explore an effective water and fertilizer management practice to mitigate greenhouse gas emissions and to maintain crop yield. A simulation model requires soil hydraulic properties. It is desirable to measure hydraulic properties of an undisturbed soil in situ for simulation under realistic situations. Kachanoski et al. (1994) proposed that a procedure to estimate hydraulic properties by measuring the propagation velocity of the wetting front using time domain reflectometry (TDR) after volumetric water content became a quasi-steady state condition. They applied water to the soil surface of the mid-place of two electrodes of TDR using a dripper. We evaluated that the procedure of Kachanoski et al. (1994) using Hydrus\_3D, a popular simulation model for soil water and solute transport.

### **Conservation and management of fresh water resources in a sandy coastal aquifer**

Yuji Ito<sup>1</sup>, Kei Nakagawa<sup>2</sup>, Takayuki Kawai<sup>3</sup> and Hiroshi Yasuda<sup>3</sup>

1: Institute of Lowland and Marine Research, Saga University, 2: Graduate School of Fisheries Science and Environmental Studies, Nagasaki University, 3: Arid Land Research Center, Tottori University

To establish monitoring techniques of a layer thickness of freshwater and displacement of saltwater in a sandy coastal aquifer, the conditions to be capable of applying a newly developed probe to the measurements of groundwater level and freshwater/saltwater interface level were examined. A technique of time domain reflectometry (TDR) was introduced to the probe that is of coaxial type having 67.5 cm in length and 3 cm in diameter. Laboratory column tests were carried out for two measurement conditions. To reproduce the actual aquifer situation, the groundwater level or the interface level were fluctuated by controlling the supplies and extractions of freshwater or saltwater at the bottom of the column. In first

condition, dune sand obtained in Tottori was packed in the column and the probe was vertically set under ground. At second, we tested under the condition without packing sand. Manometer and four electrode sensor (four electrode method) was installed to the column and those measurements were compared with TDR one. The groundwater levels measured by the probe were good agreement with one by manometer in both conditions. For the experiments of freshwater/saltwater interface level, the TDR measurements were good agreement with one based on the vertical profile of electrical conductivity measured by the four electrode method in first condition, although measurement error increased for second condition. The error, however, could be reduced by improving the configuration in the probe. The results demonstrate that the fluctuation of groundwater level can be measured with the probe vertically set under ground even if the observation borehole is not on site and that the fluctuation of freshwater/saltwater interface level can be measured with the probe into the borehole.

### **Relationships between global climate change and local hydrological features inherent in arid and semi-arid regions**

Koji Nishiyama<sup>1</sup> and Hiroshi Yasuda<sup>2</sup>

1: Faculty of Engineering, Kyushu University, 2: Arid Land Research Center, Tottori University

The Yellow River is an important water source for human life and economical development in China. Therefore, it is highly important to understand spatial and temporal (decadal) variation in rainfall in the Yellow River basin. The purpose of this study was to find significant relationships between spatial distribution of rainfall or moisture and ENSO (El Niño-Southern Oscillation) represented by sea surface temperature (SST) during warm season from June to September (1961-2000) in the Yellow River basin (E105-115, N32.5-42.5). In this study, moisture distribution in the target area is represented by precipitable water (PW), which means vertically-accumulated amount of water vapor.

The results show that there was a correlation between rainfall and SST. Especially for the term of El Niño and La Niña, there was a strong correlation between rainfall and SST or PW. During El Niño, rainfall and PW tends to be less than average under the influence of dry atmospheric condition. On the other hand, during La Niña, rainfall and PW tends to be more than average under the influence of wet atmospheric condition.

The analysis shows that moisture inflow is a direct key factor tele-connecting between ENSO and rainfall in the Yellow River basin. These results give significant information for considering future water resources affected by global warming.

### **Analysis on soil moisture and solute transport to improve agricultural products in arid area**

Tadao Aoda<sup>1</sup> and Hiroshi Yasuda<sup>2</sup>

1: Faculty of Agriculture, Niigata University, 2: Arid Land Research Center, Tottori University

The performance of Spreadsheet software, i.e., Microsoft Excel, improved significantly, in these days. Hence spreadsheet is able to solve technological matter comparable to C or FORTRAN. Therefore we studied and present a spreadsheet numerical model to simulate saturated-unsaturated subsurface steady state flow in rectangular porous media. The laboratory experiment was done with rectangular earth dam

model and with 1.0 mm diameter glass beads. We carried out laboratory experiment with three sets of water tables, and monitored pressure head, water content, and electric conductivity during steady state water flow. Consequently we clarified that water flows only in funicular zone where hydraulic conductivity is enough high in unsaturated area. Furthermore we succeed to represent the flow lines are perpendicular to equi-potential lines, rigorously. However vertical profile of potential is not able to represent the experimental result near the upper boundary under the condition of low water table.

### **Comparative study of the growth patterns of root system in Mesquite (*Prosopis juliflora* (Swart) DC) seedlings under different soil water conditions**

Kiyotsugu Yoda<sup>1</sup>, Mohamed Abd Elbasit Mohamed Ahmed<sup>2</sup>, Ahmed Eldoma<sup>3</sup>, Buho Hoshino<sup>4</sup> and Hiroshi Yasuda<sup>2</sup>

1: School of Science and Engineering, Ishinomaki Senshu University, 2: Arid Land Research Center, Tottori University, 3: College of Forestry and Range Science Sudan University of Science and Technology, 4: Faculty of Environment Systems, Rakuno Gakuen University

Mesquite (*Prosopis juliflora* (Swartz) DC, Leguminosae) expands rapidly into farm lands and canals in Eastern Sudan during last decades, and brings about many problems in human subsistence. To survey the mechanism of this rapid expansion, we have been investigating growth patterns of seedlings, and clarified that seedlings grow rapidly in younger stage. In the present study, we examined the response of seed germination and initial growth of seedling under different soil moisture conditions. Columns (diam. = 5.6cm, height = 10cm) packing loamy sand were prepared in growth chamber of Arid Land Research Center, and eight or ten steps of irrigation (2.5 to 80 ml per column) were prepared. Seeds were sowed in the columns to investigate germination response against different soil moisture conditions. As a next, germinated seeds were cultivated under the same condition to compare the response of initial seedling growth among different irrigation treatments. Seeds showed four types of response; seed (no response), imbibed, germinated and emerged. More humid soil promoted germination and/or emergence. Germinated seeds also responded differently along with dry-wet gradient with the different irrigations. Middle to higher wet conditions accelerated seedling growth, which were corresponded to single event of heavy rainfall in Sudan. These results suggest that mesquite seeds respond sensitively to sparsely occurred rain events, and heavy rain pulse promotes the response and facilitate this species to expand rapidly in Sudan.

### **Effect of phreatophyte on groundwater and soil in arid environment**

Kei Nakagawa<sup>1</sup>, Takayuki Kawai<sup>2</sup> and Hiroshi Yasuda<sup>2</sup>

1: Graduate School of Fisheries Science and Environmental Studies, Nagasaki University, 2: Arid Land Research Center, Tottori University

The laboratory experiment was carried out to investigate the effects of phreatophyte on groundwater and soil in arid environment. Mesquite was used as phreatophyte which was transplanted on the soil column surface. In the soil column, the fixed groundwater level was maintained by the Marriott pump. At the three depth of the column, the sensors were installed to measure water content, electric conductivity and temperatures. The mixed solution was used as a modeled groundwater supplied from the pump. After the

experiment, the column was divided into segments to measure distribution of the root dry weight and the adsorbed ion concentration profiles. From the experimental result, water movement based on the plant water use by transpiration was ascertained in the column. The relationship between the plant water use and groundwater level change was suggested. According to the profile of adsorbed concentrations, basic knowledge about ion transport with water movement and formation mechanism of the salt environment in the soil was obtained. It will be useful to develop future numerical simulation model to evaluate above phenomenon

### **Molecular physiological researches on enhancement of drought tolerance in silicate-treated sorghum**

Kiyoshi Tanaka<sup>1</sup>, Yin Lina<sup>1</sup> and Atsushi Tsunakawa<sup>2</sup>

1: Faculty of Agriculture, Tottori University, 2: Arid Land Research Center, Tottori University

Salinity is one of major factors in limiting crop production in the world, and improving plant salinity tolerance is very crucial and urgent. Silicon (Si) is the second most abundant element on the surface of the earth, and many studies have shown its beneficial effect for plant growth and development and as well as stress tolerance. To test the function of Si in salinity stress, we applied Si on sorghum under hydroponic condition. We found that Si could maintain both shoot and root growth under salinity stress significantly. The genome DNA sequence of sorghum was recently clarified. By analyzing gene expressions in Si-treated sorghum, we can know the physiological mechanism of Si alleviating effect on salinity stress in sorghum. We identified couples of Si-induced genes from sorghum. We focused on S-adenosylmethionine decarboxylase gene relating to the synthesis of polyamine, which plays a role as an environmental stress signal substance, and sucrose synthase and fructosebiphosphate aldolase, relating to the biosynthesis of sucrose, which participates in the metabolism of cell wall and compatible solute. We generated these gene modified potato and Arabidopsis overexpressing or suppressing these genes, and analyzed their functions in stress tolerance.

### **Development of remote sensing system in aridland farming (3) -Development of highly reliable adhoc multihop communication technology in aridland-**

Kensuke Murakami<sup>1</sup>, Satoru Kishida<sup>2</sup>, Kentaro Kinoshita<sup>2</sup> and Atsushi Tsunekawa<sup>3</sup>

1: Electronic Display Research Center, Tottori University, 2: Graduate School of Engineering, Tottori University, 3: Arid Land Research Center, Tottori University

We have developed two-dimensional remote sensing system which can be used as a stand-alone and long-term maintenance-free system in order to support sustainable agriculture in arid land making use of two-dimensional environment information. In this remote sensing system, sensor nodes and access point which are placed in the target area, are connected by wireless communication. The access point of this system is connected to the internet and sends measurement data from sensor nodes to the server. The server used in this system can process, accumulate and display measurement data. Therefore, we can see the data in the internet. Elemental technologies in this work is solar photovoltaic system, environment monitor and ad-hoc multi-hop communication.

In this study, we constructed two-dimensional remote sensing system and investigated stability of

ad-hoc multi-hop network in arid land. From the result, we found that the environment monitor and the power generated by solar photovoltaic system had worked stability in stand-alone. Therefore, the system is thought to be useful as a two-dimensional remote sensing system with maintenance-free in arid land.

### **Development of remote sensing system in aridland farming (2) - Development of highly reliable and environmental monitor on aridland -**

Kentaro Kinoshita<sup>1</sup>, Satoru Kishida<sup>1</sup>, Kensuke Murakami<sup>2</sup> and Atsushi Tsunekawa<sup>3</sup>

1: Graduate School of Engineering, Tottori University, 2: Electronic Display Research Center, Tottori University, 3: Arid Land Research Center, Tottori University

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In this study, we constructed two-dimensional remote sensing system and investigated performance of environment monitor in arid land. From the result, we found that the environment monitor and the power generated by solar photovoltaic system had worked stability in stand-alone. Therefore, the system is thought to be useful as a two-dimensional remote sensing system with maintenance-free in arid land.

### **Evaluation on stability of soil organic matter fractions by stable carbon isotope analysis through soil profile**

Kenji Tamura<sup>1</sup>, Takashi Kanda<sup>1</sup>, Humika Isa<sup>1</sup> and Atsushi Tsunekawa<sup>2</sup>

1: Graduate School of Life and Environmental Sciences, University of Tsukuba, 2: Arid Land Research Center, Tottori University

Soil organic matter (SOM) consists of various functional pools that are stabilized by specific mechanisms and different turnover time (Lutzow et al., 2007). The  $\delta^{13}\text{C}$  values of more decomposed SOM were larger than that of fresh plant materials (Lichtfouse et al., 1995). Therefore,  $\delta^{13}\text{C}$  values of soil organic matter may be a useful tool for indicating the stability of SOM. Our object was to evaluate the stability of soil organic matter using physical fractionation method and stable carbon isotopic technique.

The study sites were located at Hulunbeier grassland, Inner Mongolia, China. Soil survey was conducted at 7 sites in 2006 and 2009. Soil samples were obtained from each horizon of soil profile in each site. We used bulk samples of A1 horizon and particle size fractions for analysis of organic carbon, total nitrogen content and stable carbon isotope. In addition, light fractions ( $d < 1.6 \text{ g/ml}$ ) obtained from density fractionation (Golchin et al., 1997) were also measured.

The soil organic carbon (SOC) associated with clay and silt fraction accounted for 58-70% and

33-42% of the total SOC, respectively. Clay and silt fractions played a key role in retaining SOC in this study site. There were positive correlation between the proportion of either clay or clay + silt fractions and the SOC associated with these fractions ( $r=0.761, 0.852$ ). The amount of C associated with clay and silt particles is mainly affected by soil texture.

The  $\delta^{13}\text{C}$  values of light fractions were as same as that of sand fractions. Because SOM of light fractions were composed by plant roots or less decomposed plants (Golchin et al., 1997), sand fraction also mainly contained plant residues. On the other hand, the  $\delta^{13}\text{C}$  values of SOM increased with particle size decreased and C/N ratio of clay fractions was smallest in particle size fractions. Therefore, the  $\delta^{13}\text{C}$  value was good indicator for stability of soil organic matter in this study sites. However, we should try to measure the  $^{14}\text{C}$  values of particle size fractions of soil organic matter to clarify the absolute age.

### **Development of remote sensing system in aridland farming (1) - basic examination concerning improvement of performance and reliability of solar photovoltaic system in aridland -**

Satoru Kishida<sup>1</sup>, Kentaro Kinoshita<sup>1</sup>, Kensuke Murakami<sup>2</sup> and Atsushi Tsunekawa<sup>3</sup>

1: Graduate School of Engineering, Tottori University, 2: Electronic Display Research Center, Tottori University, 3: Arid Land Research Center, Tottori University

We have developed two-dimensional remote sensing system which can be used as a stand-alone and long-term maintenance-free system in order to support sustainable agriculture in arid land making use of two-dimensional environment information.

In this remote sensing system, sensor nodes and access point which are placed in the target area, are connected by wireless communication. The access point of this system is connected to the internet and sends measurement data from sensor nodes to the server. The server used in this system can process, accumulate and display measurement data. Therefore, we can see the data in the internet. Elemental technologies in this work is solar photovoltaic system, environment monitor and ad-hoc multi-hop communication.

In this study, we constructed two-dimensional remote sensing system and investigated characteristic of electric generation in solar photovoltaic system in arid land. From the result, we found that the environment monitor and the power generated by solar photovoltaic system had worked stability in stand-alone. Therefore, the system is thought to be useful as a two-dimensional remote sensing system with maintenance-free in arid land.

### **Revealing a hidden role of nucleobase metabolism in plant strategies coping with stress**

Atsushi Sakamoto<sup>1</sup>, Shunsuke Watanabe<sup>1</sup> and Atsushi Tsunekawa<sup>2</sup>

1: Graduate School of Science, Hiroshima University, 2: Arid Land Research Center, Tottori University

Nucleobase degradation, especially catabolism of nitrogen-rich purine bases, has long been regarded as a housekeeping metabolism that allows remobilization and recycling of nitrogen for sustainable growth and development of plants. Recently, however, we unveiled a novel role of purine catabolism in stress acclimatization of Arabidopsis plants under drought stress conditions. Various oxidizing and hydrolyzing enzymes participate in plant purine catabolism that consists of two fundamental processes, namely

oxidative dehydrogenation of the initial substrate xanthine to form ureide compounds and the subsequent step-wise hydrolysis of ureides to release ammonia. In this study, we undertook to identify which step(s) of the sequential enzyme reactions are critical for coping with drought stress, particularly focusing upon degradation steps of ureides, since these intermediates often accumulate as the major catabolites when plants are exposed to various environmental stress. The physiological evaluation of Arabidopsis metabolic mutants suggested the importance of ureide metabolism in drought stress protection on the basis of plant responses to both acute and chronic drought.

### **Physiology and biochemistry of noxious plants in semi-arid regions**

Yukihiro Sugimoto<sup>1</sup>, Masaharu Mizutani<sup>1</sup>, Kotomi Ueno<sup>1</sup>, Chizu Yoshimoto<sup>1</sup>, Saki Nomura<sup>1</sup> and An Ping<sup>2</sup>

1: Graduate School of Agricultural Science, Kobe University, 2: Arid Land Research Center, Tottori University

GR24 is a widely used synthetic strigolactone able to stimulate parasitic seed germination in the absence of a host plant to reduce soil seed levels. However, *S. gesnerioides* seeds do not respond to GR24 and only germinate by exposure to cowpea (*Vigna unguiculata*) root exudates or their active ingredient, the structure of which has not been established. Our present study provides substantial insight into the plant metabolism and structural requirements of strigolactones for host recognition by parasitic weeds.

First, we clarified the structural and stereochemical requirements of synthetic strigolactones for seed germination of *S. gesnerioides* through bioassays of 4-hydroxy-GR24 (HO-GR24) and 4-acetoxy-GR24 (AcO-GR24) and their stereoisomers. These results suggest that both an oxygenated substituent at C-4 and the configuration of the tricyclic lactone and the D-ring are essential structural requirements for induction of *S. gesnerioides* seed germination. Furthermore, GR24 exhibited inhibitory activity against seed germination of *S. gesnerioides* at concentrations that induce seed germination of *S. hermonthica* and *O. minor*. Second, we isolated the germination stimulants from hydroponic culture filtrate of cowpea, and their structures were unambiguously determined as (-)-(3aR,4R,8bR,2'R)-ent-2'-epi-orobanchol and (+)-(3aR,4R,8bR,2'R)-ent-2'-epi-orobanchyl acetate, on the basis of mass, CD, and <sup>1</sup>H NMR spectra; optical rotator power; and chromatographic behavior on HPLC.

### **Mechanisms of tolerance to environmental stress of millets and collection both of culture method and genetic resources in China**

Asana Matsuura<sup>1</sup>, Kohei Murata<sup>1</sup> and An Ping<sup>2</sup>

1: School of Agriculture, Tokai University, 2: Arid Land Research Center, Tottori University

#### **I . Collection of information of culture method and genetic resources of millets in China.**

I visited China from November 6 to November 10. I visited Loess Plateau to collect culture method of several millets. I visited Institute of Soil and Water Conservation, The Chinese Academy of Sciences and Northwest Agriculture and Forestry University in Yangling.

#### **II . Studies for interspecific differences of environmental stress in millets.**

Water limitation is a crucial factor affecting crop yield. Increasing crop yields in water-limited environments requires genotypes with strong tolerance to dehydration combined with management

practices that aim to maximize water availability. The objective of this study was to clear the dehydration tolerance of millets.

*Setaria italica*, *S. glauca*, *Panicum miliaceum*, *P. sumatrense* were used. Seeds of each species were sowed in Wagner pot (1/5000 a) filled 3 kg of soil at 40% soil water content. Water stress treatment was started at 13 days after sowing. Half of the pot was imposed to 20% of soil water content (dry treatment) and the other half pot was continuously irrigated as 40% soil water content.

Dry treatment delayed days to heading of *S.italica*, *S.glauca* and *P. sumatrense* but not changed in *P. miliaceum*. Plant growth rate at heading decreased to 45~62% in all millets compared to wet treatment. This reduction was attributed to net assimilation rate in *S. glauca* and mean leaf area in the other three species. Dry treatment also reduced water use to 38~59% except *S. glauca*. Transpiration rate of all millet also decreased to 35~62% compared to wet treatment. These results showed that water use was limited by transpiration rate in *S.italica*, *P.miliaceum* and *P. sumatrense* and days to heading in *S.glauca*.

Grain yield of dry treatment was *S.italica* > *P.miliaceum* > *P. sumatrense* > *S.glauca*. The reduction of grain yield was attributed to number of grain per panicle in all millets. Water use at harvest decreased 45~59% by the dry treatment and there is no significant difference. WUE was decreased in *S.italica* but not changed of the other three millets by the dry treatment. Yield WUE of *S.italica* and *P.miliaceum* did not change, however, those of *P. sumatrense* and *S.glauca* increased 2~5 times as compared to wet treatment. In conclusion, *S.italica* showed most dehydration tolerance because of use of water effectively and retention of number of grain per panicle and growth after heading rather than the other three millets.

### **Improvements of drought tolerance in wheat via enhancement of water absorption capability in the root systems**

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The highlight in this collaborative study in 2011, under the well watered conditions, the drought tolerant wheat genotypes had less amount of transpired water than the drought susceptible one. Under soil water stress conditions, there was a significant positive relationship between the total transpiration reduction ratio and the total dry matter production reduction ratio. In the drought tolerant genotypes, the dynamics of transpiration was similar between the well watered and soil water stress conditions. These mean that the drought tolerant wheat genotypes defined as less dry matter production reduction ratio would have less transpiration reduction ratio under soil water stress conditions.

Under water stress conditions, the drought tolerant genotypes with less transpiration reduction ratio had less water demand in the leaves as well as water absorption capability in the roots. This means that the water demand in the leaves and the water absorption capability in the roots would be important traits to control the transpiration under the soil water stress conditions. In the water absorption capability in the roots, a significant difference among the genotypes was observed under soil water stress condition, but not in the water demand in the leaves. These indicate that the water absorption capability in the roots would play an important role to regulate the transpiration under soil water stress conditions.

### **Researches on water use and water stress resistance of shrub species grown in semiarid land**

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Water use and water stress resistance of shrub species grown in semiarid grassland were analyzed, and a growth simulation model which reflects the response to soil water stress was developed using a shrub species, *Artemisia halodendron*. The structure of shoots and the distribution (angle/length) of root system were compared between plants treated with normal precipitation (90 mm/month) in summer of Horqin sandyland and those with drought condition (45 mm/month) under the controlled environment. Furthermore, the three-dimensional plant growth simulation model using L-system was developed. The shoot branching was restricted and the main shoot length and number of leaves were reduced by drought condition, which also reduced the development of root branching and main root length. As including the responses of plants experimented under the controlled environments, a simulation model using L-studio-4.2.13 was developed which showed good responses of *A. halodendron* to water stress in terms of structure/morphology and eco-physiology.

#### **Study on eco-physiological properties of infertile land crops**

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Although the phytin is a common material, it was thought that plants could not utilize it as a phosphorus source. Use of phytin as organic phosphorus source by maize and peanut seedlings was demonstrated in vermiculite culture. Application of calcium phytate to vermiculite medium improved the seedling growth of the two species as well as the application of calcium superphosphate. In addition, application of calcium phytate to the central layer of vermiculite as well as that of calcium superphosphate enhanced the root development at the layer. Staining by toluidine blue O suggested that phytin had been decomposed in rhizosphere before the roots absorbed the phosphorus. Although silica is not an essential element for plants in normal conditions, it plays important roles for some plants to improve their tolerance to environmental stresses. We showed that the bloom (white powder-like structures covering the fruit) is a compound of silicon and carbon hydrate and can contribute to avoid June fruit drop in our previous studies. In addition, we found that the root-stock cultivars of pumpkin for bloomless cucumber production lack the ability to uptake silica, which can be good materials to study on the role of silicon and the silicon transporter(s) in Cucurbitaceae plants.

#### **Establishment of a measurement system on carbon balance in crops under over-optimal temperature**

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In wheat, optimal temperature for dry matter production is around 25 degree Celsius. However, wheat

plants are sometimes exposed to high temperature higher than 30 degree Celsius. In this study, assimilation rate of wheat plants was examined at 25 and 31 degree Celsius. In the measurement, wheat plants at 5-6th leaf stage were grown in 17 containers (30 cm long, 40 cm wide and 30 cm deep) at a greenhouse, and transferred to a growth chamber that is almost air-proof when CO<sub>2</sub> balance measurement is carried out. Those plants were imposed to 4 days measurement; day/night temperature was 25/20 degree at first day, 31/25 degree at second and third days, and 25/20 degree at fourth day. Illumination intensity was consistently at 80000 Lux. Carbon assimilation rate was estimated by reduction rate of carbon dioxide in the enclosed chamber after concentration of carbon dioxide was temporally raised to 600 ppm. The carbon assimilation rate was linearly correlated with the CO<sub>2</sub> concentration in any measurement days. For instance, the regression line at fourth day was  $A = 0.009 \times [\text{CO}_2] - 0.0451$ , where A indicates carbon assimilation rate. The assimilation rate at 400 ppm was 8.28  $\mu\text{mol} [\text{CO}_2] \text{ kg}^{-1} [\text{DW}] \text{ min}^{-1}$ . The carbon assimilation rate per chamber increased from first day to fourth day, as 2.94, 3.16, 3.18, 3.56  $\mu \text{ mol} [\text{CO}_2] \text{ min}^{-1}$ . This indicates that room temperature at 31 degree did not significantly reduce carbon assimilation rate of wheat.

### **Study on effect of soil moisture on root system development of temperate grasses**

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The objective of this study is to clarify the relationship between drought tolerance and root development of four temperate grass species (*Bromus inermis* Leyss., *Dactylis glomerata* L., *Lolium perenne* L. and *Phleum pratense* L.), through some experiments on the influence of soil moisture on the root system development. To investigate the effects of soil moisture on root development, the following experiments were conducted.

1. Investigation of root box size and plant density for the analysis of root development.

To find an appropriate method for investigating root development using root box, experiments on different size of the boxes and plant densities were conducted. The result showed that one root box with one plant was mostly proper for the observation of horizontal root development. Besides, the boxes with 25 cm width, 30 cm depth and 5 cm thickness were mostly suitable for 3 month-period of experiment.

2. Experiments on the effect of soil moisture on root system development.

The experiment was conducted in the plant growth chamber set at 18°C and 14 hours day length. Root boxes were filled with gardening soils. Seeds of the four grasses were germinated in the root boxes. The cross section of root boxes were observed every one month. Three months after germination, root boxes were decomposed and the roots were collected. The results showed that the roots of *L. perenne* and *B. inermis* developed deeper than other grasses one month after germination. Besides, the rhizomes of *B. inermis* were observed three months later after germination. The distributions of roots (horizontal and vertical) were measured with WinRhizo in ALRC and the data are under preparation

### **Hormonal regulation of responses to low nitrogen stress in higher plants**

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We have already shown that chlorophyll biosynthesis in cucumber plants grown under low nitrogen conditions was promoted and suppressed by the application of abscisic acid (ABA) and cytokinin, respectively. Since reactive oxygen species (ROS) have been known to promote yellowing and bleaching of leaves, we investigated the accumulation of ROS in cotyledons and first leaves of cucumber plants applied ABA or kinetin using nitroblue tetrazolium staining and diaminobenzidine staining. The amount of O<sub>2</sub>- and H<sub>2</sub>O<sub>2</sub> increased in cotyledons and first leaves of cucumber plants treated with kinetin, whereas it decreased in the presence of ABA. The activities of ROS-degrading enzymes such as ascorbate peroxidases (APX), catalase (CAT), glutathione reductase (GR) and superoxide dismutase (SOD) were determined in cucumber plants grown under low nitrogen conditions in the presence of ABA or kinetin. The activity of APX and SOD in first leaves of cucumber plants increased remarkably but that of GR increased slightly in the presence of ABA, although almost no difference in activities of these enzymes in cotyledons was observed in both treatments. No significant difference in activities of these enzymes was found in first leaves treated with kinetin except the activity of SOD slightly increased in first leaves of cucumber plants treated with 10<sup>-5</sup> M kinetin. These results suggest that ABA increased activities of ROS-degrading enzymes and suppressed leaf yellowing in cucumber plants grown under low nitrogen conditions. Activities of these enzymes were not suppressed by kinetin, although ROS still accumulated. The total amounts of ROS production might be exceeded ones degraded by ROS-degrading enzymes.

### **Bio-stimulators improving dryland crop production**

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Recently, bio-stimulators which are extracted from plant leaves have become a widely used tool to improve crop production under climate changes such as both drought and cold condition in arid region. However, the mechanisms to crop response by applying the bio-stimulators are still unknown even though the application is very effectiveness to increase crop yield on site. The present study was designed to understand from a view point of photosynthesis to two different crops; maize and soybean while investigating the interacting effects of the application of two different bio-stimulators (CC and SS) and crop growth under both non-drought and drought condition.

The photosynthetic rate of both maize and soybean was improved more or less under non-drought and drought condition. Especially, the rate in maize leaves was gradually increased from day 2 to 5 after application of low concentration (0.5mg/L and 0.15ul/L, respectively) of both CC and SS when compared to that of control under drought condition. The maximum rate showed 19% increase by especially CC application. The same phenomenon, which showed 27% increase to that of control, occurred in the rate of soybean leaves by only CC application. However, the increase of photosynthetic rate were showed two times (day 2 and 7) for 14 days after applying CC to soybean leaves. In contrast, SS application to soybean leaves worked well in the increasing rate from day 7 after application without day 2 such as CC application. Although dry matter of both top and root was increased by bio-stimulator application, the influence of T/R ratio in two application was different. CC showed more effectiveness to improve top dry matter, while SS influenced the increase of root dry weight of two different crops.

Thus, CC and SS application showed improvement of photosynthetic rate and then increased dry matter of each crop in this study. Finally, crop yield may be improved under drought condition. However, the mechanism of crop response has still unknown.

### **Estimation of grassland production in Loess Plateau China**

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We conducted the numerical simulation to estimate the horizontal distribution of potential productivity of alfalfa (*Medicago sativa* L.) around Loess Plateau in the northwestern part of China, where desertification is in progress. We found that a large difference appears in the biomass distribution of alfalfa due to the differences in the distribution of solar radiation caused by microtopography.

The meteorological condition was calculated with Regional Atmospheric Modeling System (RAMS) during 2007 to 2008. In this simulation, the amounts of solar radiation were in good agreement with the values observed at the local observation point. However, the temperature variation was estimated to be about 10 degree centigrade higher than the observed value, despite the daily and long-term fluctuations were well reproduced. The reason of the difference in the air temperature despite the amount of solar radiation were in good agreement was seemed the heat balance at the ground surface was different from the actual value.

Then, we conducted the meteorological simulation in four type vegetation (crop/mixed farming, short grass, irrigated crop, evergreen shrub) to examine the effects of differences in albedo and transpiration. As a result, the differences in vegetation type, appeared as a difference of about 1 °C air temperature during the daytime and we could not explain the phenomenon of 10 degree centigrade divergence. This meteorological modeling system (TERC-RAMS) has been tuned up for the East Asia and the error may be larger in the inland of continent like Loess Plateau. Or it also be possible there were some problem with the data set of NCEP / NCAR reanalysis used as the boundary conditions.

### **Specific characteristics for salt tolerance mechanism of halophilous plants**

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Related to the salt gland, which is an organ that excretes salt intake. This research, using saplings of *Avicennia marina* (with salt gland) and *Kadelia candel* (no salt gland) as test specimen, we investigated the effect of salinity concentration level on growth of sapling and on content of ion in body of tree in hydroponic culture.

Health of the seedling, diameter, number of leaves and speed of photosynthesis dropped notably as the concentration level increased in *Kadelia candel* which does not have a salt gland. In addition, although the growth was 1 ~ 3% higher than the 0% salinity concentration area, it was notably smaller than the height of *Avicennia marina*. In terms of ion content of different organs, it was suggested that the sodium content was high in the root over any other organs if salinity concentration was high and that roots prevented from

sodium infiltration. It is considered that other ions were prevented from intake by sodium ion.

*Avicennia marina* which has salt glands tended to show no considerable difference in seed health, diameter, or number of leaves up to 3% salinity concentration area. The growth and speed of photosynthesis showed signs of more activity if salinity was increased. On the other hand, it was tended to decline in survival, diameter and growth at the 4% area compared to other areas. It was shown that the content of sodium ion in different organs was high as salinity concentration was increased. The drastic reduction in the content of sodium ion in the 2~4% area were observed after 1 month and 2 months of salt addition, presumably due to salt excretion from a salt gland. Therefore, the inhibition of water absorption can hardly be occurred, as *Avicennia marina* absorbs water and salt at the same time. In addition, *Avicennia marina* adjusts osmotic pressure by accumulating salt and thereby allowing easily to absorb. It is considered that *Avicennia marina* is adapted to salt by combining various mechanisms that excretes the excess salt which are accumulated from salt glands and controls internal salinity concentration in body of tree. Consequently, it was suggested that *Avicennia marina* were fairly unaffected by salinity concentration up to 3% and showed healthy growth without dropping leaves or wilting.

These results suggest that, it was found that *Avicennia marina* with a salt gland has high adaptability to high salinity concentration environment and the effect of salt concentration to growth is smaller than *Kadelia candel* which does not have a salt gland. Furthermore, it is considered that the reason that *Avicennia marina* survives in the front lines of intertidal zones of the mangrove is due to its high adaptability to salinity, compared to inland *Kadelia candel*.

### **Studies on mycorrhizal fungi that facilitate drought resistance of Japanese black pine**

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The Japanese black pine, *Pinus thunbergii*, is a highly tolerant species against salinity stress and drought stress, so that it has been planted as sand-preventive shelter belt at the coastal area across Japan. This property would be attributed to the close symbiont, ectomycorrhizal fungi. We isolated several species/isolates of ectomycorrhizal fungi to investigate their effect on the fixation and growth of the host pine seedlings, and to clarify the mechanisms.

We isolated *Pisolithus tinctorius*, *Amanita ibotengutake*, and two isolates of *Suillus granulatus* from the pine rhizosphere at the Arid Land Research Center, Tottori University. They were then inoculated into the axenic seedlings of Japanese black pine under different salinity stresses (0 mM, 100 mM, or 300 mM NaCl), and monitored for the effect on plant growth and mycorrhization process.

After 10 weeks all seedling samples were taken and observed under stereomicroscope. Although no ectomycorrhiza was formed under the highest salinity stress (300 mM NaCl), *A. ibotengutake* showed a high mycorrhization rate at both 0 mM and 100 mM NaCl. In *A. ibotengutake* inoculated seedlings, the water content of the root systems was higher than non-inoculated ones, suggesting that *A. ibotengutake* inoculation alleviated the drought stress. Also, the potassium content was greater in the mycorrhizal seedlings than non-mycorrhizal seedlings, while the sodium content was not.

Thus the ectomycorrhization under salinity stress may positively affect their host plant by (1) alleviating water stress and (2) regulating the osmotic balance by facilitating potassium uptake.

## **Experimental studies on relationships between drought and salt tolerances and the ability of osmotic adjustment in economically-important plants in semi-arid region of China**

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Effects of jasmonic acid application on salt stress tolerance and betaine accumulation in hydroponically-cultured *Salix psammophila* and *S. matsudana* cuttings. A 2/5 Hoagland medium was used as a basic culture medium. Totally 96 plants of each species were divided into three large groups as: 32 plants cultured in 0mM NaCl; 36 plants in 50mM NaCl; 32 plants in 100mM NaCl. Then, plants of each large group was divided into four small groups as: 8 plants sprayed with 0mM Methyl jasmonate(MJ); 8 plants with 1mM MJ; 8 plants with 5mM MJ; 8 plants with 100mM MJ. Treatments of MJ were once in two weeks. The culture experiment was started on July 14th and ended on August 25th, 2011. During the experiment, shoot and diameter growth, the rate of photosynthesis and water relations were determined. At the end of experiments, all plants were harvested and dry weights of leaves, stems and roots were determined. Contents of betaines including glycine betaine, alanine betaine and gamma butylo betaine were also determined. Salt stress strongly affected growth and photosynthesis of two *Salix* species. *S. psammophila* was relatively stronger than *S. matsudana*. In *S. psammophila*, 150mM NaCl stimulated accumulation of glycine betaine in leaves. However, salt stress did not affect betaine accumulation in *S. matsudana*. There was little or no effect of methyl jasmonate application on betaine accumulation in leaves of those *Salix* species.

## **The effects of slope position on soil-plant interaction in a semi-arid forest ecosystems**

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Topography affects soil nitrogen and water condition, and also affects forest structure, production and nutrient cycling and so on. In semi-arid region, it is expected soil nitrogen and water limit plant production more severe compared to other humid ecosystems. However there were only few studies investigated topographical changes in production and plant nitrogen and water use efficiency along a slope in semi-arid region. So we investigated the effects of slope position (upper, middle and lower slope position) on forest stand structure, litterfall production, nitrogen uptake, nitrogen use efficiency and water use efficiency in forested ecosystem on Loess Plateau, China. We established total 9 plots for three slope positions on three different slopes in natural deciduous oak forest. We measured DBH and height of trees in each plot and collected litterfall, fresh leaves and soils, and measured chemicals. As an index of nitrogen use efficiency, we used the inverse of nitrogen concentration of litterfall. As an index of water use efficiency, we measured carbon stable isotope ratio of fresh leaves. According to the results, we can categorize two types of forest, i.e. nitrogen and water limited forest on upper and middle slopes and relatively non-limited forest on lower slopes. In upper and middle slope, forest structure was not well developed and litterfall production and nitrogen cycling tended to be low. Plants grown on upper and middle slopes showed high nitrogen and

water use efficiency to mitigate limitation of soil nitrogen and water.

### **Estimating salt tolerance from the oxygen and carbon isotope compositions in arid plants**

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Carbon and oxygen isotope ratios of leaf organic matter are expected to be good indicators for salt tolerance of desert plants because these ratios reflect the long-term trends in the intrinsic water-use efficiency and transpiration rate, respectively. We, therefore, measured the carbon and oxygen isotope ratios of leaf organic matter in the saplings of *Tamarix ramosissima* grown under a variety of salinity conditions. The saplings grown at high-salinity conditions tended to have lower transpiration rate and higher carbon isotope ratio of leaf organic matter. However, there was no difference in the oxygen isotope ratio of leaf organic matter between salinity levels, which was inconsistent with the results of transpiration rate. This suggested that salt stress would vary the relationship between transpiration rate and oxygen isotope ratio of leaf organic matter. The distance between leaf vein and stoma, which might affect the relationship between transpiration rate and oxygen isotope ratio of leaf water, showed no difference between salinity conditions. The evaporation rate of the salt secretion through salt glands estimated from the dry mass and concentration of NaCl was much smaller than transpiration rate. These results suggested that neither the change in leaf structure nor the isotope discrimination during salt secretion accounted for the inconsistency.

### **Changes of xylem hydraulic conductivity and stomatal regulations of water loss in response to water stress in ring-porous and diffuse-porous species.**

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Species with a hydraulically small safety margin, which is defined as the difference between the xylem water potential at its minimum and that inducing 50% loss of hydraulic conductivity ( $\Psi_{50}$ ), appear to be threatened intrinsically by xylem cavitation. However, countermeasures against the small safety margin have been poorly addressed in the literature. This study, using saplings of seven temperate woody species, assessed the hypothesis that low cavitation resistance and the consequent small safety margin are compensated by the recovery performance from xylem cavitation and by other functional and structural traits. Cavitation resistance  $\Psi_{50}$  varied among species from  $-1.0$  to  $-3.9$  MPa. The extent of the recovery of hydraulic conductivity ( $K_h$ ) from 50%-decreased  $K_h$  was positively correlated with  $\Psi_{50}$  across species, indicating that species with low cavitation resistance showed high xylem recovery performance. The wood density was negatively correlated with  $\Psi_{50}$  and the extent of xylem recovery. Results show that  $\Psi_{50}$  was correlated positively with the photosynthetic capacity. A trade-off was found between cavitation resistance and xylem recovery performance via wood density, probably because of a compromise between the

structural function of the mechanical strength and physiological functions such as water storage capacitance. Therefore, wood density can be a central feature of a strategy for maintaining capacity in xylem water transport. The wood density might also interact with photosynthetic capacity through cavitation resistance in the context of growth performance, as reflected in carbon allocation patterns.

### **The development of remediation technology for the saline soil using Tamarix**

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It is expected to reduce the salt in halomorphic soil using the salt absorption of *Tamarix Austromongolica* N., which grows naturally in arid region, and it is important to evaluate the cultivating methods of *Tamarix* for maximizing the growth. For these purposes, a greenhouse cultivation experiment was conducted to measure the pruning and the fertilizer application. Soil, in 45L containers in four experimental sections of 4 containers each, was mixed with NaCl in concentration of 1% at the field capacity. After transplanting the seedlings of *Tamarix* in mid-July, 0.3% saline water was supplied from the bottom of the pot and pruning and fertilization were carried out in late September. No significant difference was found in height and stem diameter during the growth. After these experiments, all samples were dug up to determine the dry weights and Na contents of leaves, branches, trunks and roots. The effects of pruning and fertilizer were evaluated by measuring the dry weights, but these differences did not show the significant level of 5%, because of the delay in transplanting and the pruning and fertilization timing. On the other hand, EC of the surface soil (0 – 0.01m in depth) of the pot in which *Tamarix* was implanted was significantly lower than that of the pot without *Tamarix*, and we can estimate the mitigation effect of salt accumulation.

### **Methodological studies on social development impact assessment at village level in the Loess Plateau**

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The purpose of this study is to analyze the ‘Grain for Green’ project and social development in the Loess Plateau, by making cooperative research networks between the researchers of Arid Land Research Center, Tottori University, Research Institute for Humanity and Nature Initiative for Chinese Environmental Issues, and Research Institute for East Asia Environments, Kyushu University.

We published one reviewed article, two book chapters, and five oral presentations this year. We could start field researches together, by obtaining two funds: 1) Grants-in-Aid for Scientific Research, Scientific Research (B) “Studies on land cover change and its socio-economic factors in the Loess Plateau (China) under the ‘Grain for Green’ project”, 2) Research Institute for Humanity and Nature Feasibility Study “The History of Human-Water Interactions in East Asian Livelihood Complexes”.

## **Determination of mycorrhizal fungi in the soils to form mycorrhizas to the seedlings of *Dipterocarpus alatus* growing in the dry area in Thailand**

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In Thailand, 50 soil samples each were collected both in natural forest where *Dipterocarpus alatus* is growing and in the plantations of the same species. There exist mycorrhizal fungi in these soils. Part of those soils was autoclaved to prepare sterilized soils. Natural forest soil, plantation soil and each of the sterilized soils are put into the plastic pots, and the one each *D. alatus* seedling is planted in the pots. 50 seedlings each were prepared for each treatment. Those seedlings were irrigated by industrially produced drinking water at appropriate intervals. After about 3 months, diameter of the seedlings at the base and the seedling height were measured. No significant difference was found between the treatments at this time to be confirmed again after several months. Furthermore, one each seedling from each treatment was collected to check the mycorrhiza formation. No mycorrhiza formation was found in all of the seedlings with sterilized soils, whereas all seedlings with non-sterilized soils formed mycorrhizas. Seedlings growth is continuing, and the detailed results will be reported in the next year.

## **Vegetation survey technique using low altitude aerial photograph in dune ecosystems**

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The invasion of plants into the Tottori Sand Dune has been occurred recent decades, and now the dune is changing into the grassland or forest. In this study, we tried to establish the method to quantitatively estimate the vegetation cover in the dune, and to investigate the species composition and distribution of plants on the Tottori Sand Dune.

We obtained 180 bird's-eye images taken by about 2m high in 50 m × 60 m plot set in the Tottori Sand Dune (N35°32'23.2", E134°12'9.3"). A 1 m × 1 m area was extracted from each image, and the species and cover of the plants in the area was recorded.

The results showed totally 17 species were observed in the plot. *Artemisia capillaris* was found in almost all the images. *Carex kobomugi*, *Wedelia prostrata*, *Racomitrium japonicum* were dominant in the plot, too. *Pinus thunbergii* and *Robinia pseudoacacia* was not dominant, though they are plantation species surrounding the dune.

The vegetation survey using bird's eye images showed the advantage of objectivity and reproducibility. However, it is very likely that the automated image analysis is required for the mass analysis of image from wider area and/or larger number of image.

## **Study of sandponics bet system using capillary uptake method**

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In this study, our focus is on "Sandponics" (or sand-bed), which is one of the soilless culture. Sand-bed system has been recently recognized as a clean cultivation method. On the other hand, "Capillary wick irrigation system" has often been applied to cultivate potted plants, and there are several researches on its application to vegetables. Then, the main purpose of this study is to develop watering system for "Sandponics" using "Capillary wick irrigation system." We constructed automatic water supply systems, each of which consisted of a sand-bed, capillary wicks, and two tanks. As to these two tanks, the first tank was used to keep the water surface level constant, and the second tank was used to provide the first tank with necessary water. Each of our water supply systems had the different  $\Delta h$ , which is water head difference between the bed surface and the water surface in the tank.

Our aims are;

- ① to control the soil water content in the sand-bed by water head difference, and
- ② to recognize the relation between the amount of irrigation and weather conditions.

We performed the experiments in a vinyl house at Prefectural University of Kumamoto. Then we have the following results.

- ① The soil water content varied depending on water head differences.
- ② Weather conditions influenced the amount of irrigation per day from the tank.
- ③ We could acquire an accuracy fitting model for the amount of irrigation under different weather conditions.

### **Experimental study on water saving irrigation by using capillary barrier of soil**

Toshihiro Morii<sup>1</sup> and Mitsuhiro Inoue<sup>2</sup>

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A simple soil layer system which is composed of a finer soil layer underlain by a coarser soil layer provides a characteristic property of capillary barrier (CB). Water infiltrated into soil is suspended just above an interface between soil layers due to a physical difference in unsaturated hydraulic properties of soils. Because, in the case of tilted interface, the suspended water flows downward along the interface and a vertical movement of water into deeper soil below the interface will be prevented within some length along the interface, the CB can be well applied to a top cover of a waste disposal and a slope repair. In the case of a horizontal interface, as their roots can easily utilize the water stored in the upper soil layer, the CB can be well employed as a effective water harvesting and saving irrigation. Because the CB cuts the upward flow from the ground water, it may be expected that the capillary barrier will provide effective salinization prevention.

In the study, field experiments on a sand plot placed gravel layer in some depth were conducted to study a practical effectiveness of the CB for water harvesting in 2010 and salinization prevention in 2011. In the experiment for water harvesting, experiment plots of capillary barrier soil were constructed, green vegetables were planted, and soil moisture contents were measured in the soils to investigate the effect of

suspended water above the gravel layer on the plant growth. In the salinization prevention, the experimental plots constructed in container boxes were connected to the water supply tank to supply artificial ground water, 10,000ppm of NaCl. Water content and electric conductivity in the soils were measured after planting the green vegetable. It was observed that the gravel layer inserted in the sand soil in some depth can prevent the upward movement of water from the ground water, with the result that the plant well grew in the capillary barrier plots, and contrary died in the experiment plot without the gravel layer.

These two series of field experiment in 2010 and 2011 reveals that the capillary barrier can be well applicable to soil problems the water harvesting and salinization, leading to green technological aspect of soils.

### **Two dimensional measurement of water content and EC in surface area with TDR system**

Hiroyuki Cho<sup>1</sup>, Hideki Miyamoto<sup>1</sup> and Mitsuhiro Inoue<sup>2</sup>

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A multiple-rod TDR probe was developed with a view to measure water content and electrical conductivity (EC) of surface soil. The probe consisted of several three-rod probes in which the outer rods of each three-rod probe were the common electrical earth guides for the adjacent probes. There was thus no extra space between the adjacent three-rod probes. This probe configuration enabled the TDR measurement to extend over a large area in the field. The characteristics of the multiple-rod probe were examined in sand in a container of 1.1m ´ 0.81m ´ 0.20m. First, a one unit of probe consisting of three 1-m long steel rods of 0.5 cm diameter with a spacing of 10 cm between the rods was tested for its detective performance for water and EC in sand. Then, a multiple-rod probe consisting of seven rods and with the same probe specifications was inserted horizontally in the sand of the container at 10 cm below the surface. The dielectric constant and EC of the sand were measured with during an evaporation test. Since TDR measurement depended on the air volume in the sampling volume of a probe, the unit probe test revealed the dependency of dielectric constant on the insertion depth of the probe. A cubic expression, such as the Topp's one, provided a good relation between the average water content and dielectric constant of the surface soil. The insertion depth did not however affect the EC measurement. Moreover, the multiple-rod probe, through the evaporation test, accurately measured the change in water content and EC over 0.88 m<sup>2</sup> in the surface region. Our results thus showed the possibility of extending the multiple-rod TDR measurement system to a larger area to make the remote sensing data more accurate.

### **The evaluation on soil environment affected by irrigation at arid land**

Teruo Higashi<sup>1</sup>, Takuma Orioku<sup>1</sup>, Sachika Takizawa<sup>1</sup>, Yoshie Yageta<sup>1</sup> and Mitsuhiro Inoue<sup>2</sup>

1: Graduate School of Life and Environmental Sciences, University of Tsukuba, 2: Arid Land Research Center, Tottori University

This study aimed to evaluate the soil salinization in the middle of Nile Delta, to clarify the effect of the drainage water reuse on soil properties and to clarify the relationship between clay mineralogy and water permeability. The leaching effect of the irrigation was recognized. However, excessive use of irrigation water was less effective than expected. It was suggested that the quality of irrigation water

influenced the soil salinization. On the other hand, it was suggested that the calcium ion on cation-exchange group made the water permeability improve but the sodium ion made it deteriorate. The clay mineral in the middle of Nile Delta was composed of Smectite, Kaolinite and a small amount of Vermiculite and hydroxy interlayered mineral. The amount of hydroxyl interlayered mineral was different between upstream area and downstream area, therefore it was suggested that the kind of alluvium is different in each area.

In conclusion, it was hypothesized that the soil salinization has proceeded and come up to the level to prevent plant growth.

### **Evaluation of pore-air behavior during rainfall infiltration in unsaturated soil and its influence to water seepage**

Kohji Kamiya<sup>1</sup>, Gaku Shirane<sup>2</sup> and Mitsuhiro Inoue<sup>3</sup>

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For the evaluation of the rainfall seepage behavior into the ground, it is important to understand the pore-air behavior in the unsaturated soil. In this research, the pore-air behavior during wetting process in an unsaturated soil is examined by the artificial rainfall infiltration tests in one-dimension. In this test, the pore-air pressure, the pore-water pressure and the volumetric water content in the unsaturated soil column were measured during the wetting process at the constant rainfall intensity. As a result, it was recognized that the pore-air was trapped and the pressure was increased when the rainfall intensity was greater and that the water seepage behavior was influenced by the pore-air pressure in unsaturated soil.

### **Research on Non-destructive measurements of soil hydraulic properties of unsaturated soils by using Ground-penetrating radar**

Yuji Takeshita<sup>1</sup>, Tomohiro Oka<sup>1</sup>, Mitsuru Komatsu<sup>1</sup>, Seiichiro Kuroda<sup>2</sup>, Yasunori Takino<sup>1</sup> and Mitsuhiro Inoue<sup>3</sup>

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The potential of surface ground-penetrating radar (GPR) for measuring unsaturated seepage flow in sandy soils was evaluated. It is shown from field infiltration experiments performed in homogeneous unsaturated dune sands. Non-steady behavior of the wetting front caused by two-dimensional seepage flow from the infiltration tests was non-destructive measured by using GPR in profile survey modes with the antennas on the surface. The utility of our proposed GPR profile survey was demonstrated by using seepage flow analysis of field infiltration experiments. There was good agreement between computed and measured wetted zone movements in two-dimensional unsaturated seepage flow.

### **Salt and water movement after leaching in a salt accumulated soil with multi capillary barriers**

Koji Inosako<sup>1</sup>, Tadaomi Saito<sup>1</sup> and Mitsuhiro Inoue<sup>2</sup>

1: Faculty of Agriculture, Tottori University, 2: Arid Land Research Center, Tottori University

A capillary barrier cuts off capillary rise of water from a lower soil layer and percolation of water from an upper layer. It is effective to prevent the salt accumulation by capillary rise and increase of soil water in a plow layer. On the other hand, it makes difficult to remove salt accumulated after installing it and perform water-saving cultivation.

In this study, a charcoal layer was installed above a capillary barrier as a water storage layer. This system was named “Multi capillary barrier (MCB)”.

Soil column experiments were conducted in order to assess the performance of this system for desalinization and increase of the amount of soil water in a plow layer. Three types of columns were prepared in the experiments, 1) the column packed only soil (S column), 2) the column with a gravel layer as an ordinary capillary barrier below the plow layer (OCB column), and 3) the column with a charcoal layer for water retention and a gravel layer below the plow layer (MCB column). There were salt rich layers on the top of all columns. The soil was sandy soil. The leaching and evaporation experiments were conducted under the conditions with and without shallow underground saline water.

Regardless of the presence of underground water, salts of the top layers were discharged into lower soil layers below capillary barriers. Both of OCB and MCB columns could hold large amount of water with low salinity in the plow layers. Furthermore, both of them perfectly cut off capillary rise and prevented re-salinization. However, there was not remarkable difference of water content in the plow layers between OCB and MCB columns, because water did not move from the water storage layer to the plow layer in the MCB column. It means that this system should be improved.

### **Applicability of ground penetrating radar for deep vadose zone survey in arid land**

Seiichiro Kuroda<sup>1</sup> and Mitsuhiro Inoue<sup>2</sup>

1: National Institute for Rural Engineering, National Agriculture and Food Research Organization, 2: Arid Land Research Center, Tottori University

We evaluate the applicability of Ground Penetrating Radar (GPR) for characterization of subsurface structure and groundwater in arid land, which control the transport phenomena of water and solute transport in vadose zone.

We conducted the field test in the fields of Arid Land Research Center, Tottori University, using the GPR system with shielded antennas of dominant frequencies, 100,200,400,500,900,1.5GHz. Soil type in the field is almost uniform sand, and water content of soil is around or lower than 5%. Then soil is considered to be lossless media in electric magnetic sense. Penetration depth of each antenna is deeper than values usually reported. For example penetration depth of the system with 100MHz antennas is considered to be in the range from 20 to 30m.

We visualize 3D subsurface structure using the 100 MHz antennas. The obtained image shows the distribution of ground water table and thin layers of volcanic ash in sand and will control water recharge process in vadose zone.

### **The utilization of indigenous technology for water and rural socio-economic development in West**

## **Asia**

Ryuichi Hara<sup>1</sup> and Takayuki Ando<sup>2</sup>

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The field survey was conducted twice in 2011 fiscal year. The first survey was conducted from 9 September to 21 October, 2011 for 21 days in Jordan and Lebanon, at the arid region, Maan (Wadi Rum), Aqaba, Al Shoubak (Wadi Musa), Al Rabba (Wadi Mujib) which is located at the back of East Mediterranean Sea, by the guidance of Agriculture Extension Unit, The Ministry of Agriculture. At the North of Jordan, we could have a chance to observe the fertile Jordan Valley and improvements in agriculture.

The second survey was conducted from 5 March to 26 March, 2012 for 21 days in the southern part of Israel, at the arid region of Negev Desert, Beer Sheva, Sede Boker, Avdat, Mitzpe Ramon which is located at the back of East Mediterranean Sea. We could have a chance to visit Prof. Berliner, Pedro, Jacob Blaustein Institute for Desert Research, Ben-Gurion University of the Negev and also Prof. Kressel Gideon M. (Social Studies Unit), and had time to exchange of our research views on desert studies and a short field trip.

At the North of Israel, we could have a chance to observe the rich water resources of and upper stream of Jordan River and also Kibbutz.

A research presentation was conducted in 2011 fiscal year. "The Utilization of Water Resources and Rural Socio-Economic Development in Jordan" (At Daito Bunka University, Workshop for Toyo Kenkyujo in 2012, Feb 18).

## **Incentive Research by Young Scientists**

### **Stock and dynamics of pedogenic carbonate carbon under cold desert**

Maki Asano<sup>1</sup> and Atsushi Tsunekawa<sup>2</sup>

1: Graduate School of Life and Environmental Sciences, University of Tsukuba, 2: Arid Land Research Center, Tottori University

Stabilization of soil organic matter (SOM) is largely controlled by interaction of organic matter (OM) and soil minerals. Physical fractionation is an effective approach to distinguish different types of organo-mineral associate on behalf of chemical extraction of humic substances. We tried to apply particle size fractionation of organo-mineral associate in semi-arid grassland soils. At first, the most appropriate condition to particle size fractionation was examined. Plant residue (LF) was separated by sodium-poly-tungstate solution (density 1.6g cm<sup>3</sup>) with sonication at 20W, 750J mL<sup>-1</sup>, then organo-mineral associate was fractionated by precipitation method, <2, 2-53, 53-4000µm. The result of TOC and TN analyses suggested that organo-mineral associates were successfully separated with particle size, and 45% of total OC was distributed in <2µm fraction as microbially-processed OM.

### **Physiological studies on drought and salt tolerance of apple and pear rootstock species**

Kazuhiro Matsumoto<sup>1</sup> and An Ping<sup>2</sup>

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Salt tolerance was tested in 5 *Malus* rootstocks: *Malus prunifolia* ver. Ringo, JM1, JM2, JM7 and Aodai3. Two-year-old rooted cutting were subjected to each of 50 mM, 100 mM, and 150 mM NaCl solutions, and leaf injury, shoot growth, leaf water potential, and mineral uptake were evaluated. JM2 showed the highest salt tolerance with little visible symptoms of injury even in the 150 mM NaCl treatment. JM2 also showed a slight decrease of leaf water potential under the NaCl treatment. Moreover, Na and Cl accumulation in the leaves were lesser than the other rootstocks. In contrast, *M. prunifolia*, and JM1 exhibited lower salt tolerance with severe leaf injuries and more accumulation of Na and Cl in the leaves. However, leaf water potential was decreased differently between *M. prunifolia*, and JM1 and the decrease of the former was extremely slighter than the latter. JM7 and Aodai3 showed the middle range of salt tolerance. In conclusion, the salt tolerance of 5 *Malus* rootstocks was ranked as followings; JM2 > Aodai3 > JM7 > *M. prunifolia* > JM1.

### **Contribution of buried seeds to natural revegetation after vehicle track formation in Mongolian steppe**

Toshihiko Kinugasa<sup>1</sup> and Norikazu Yamanaka<sup>2</sup>

1: Faculty of Agriculture, Tottori University, 2: Arid Land Research Center, Tottori University

In Mongolia, most of roads are still unpaved, and the unpaved dirt road is one of causes of dust outbreak. Natural revegetation on dirt roads largely depends on germination of buried seeds in the soil. Last year, we investigated the distribution of buried seeds at the grassland dominated by annual plants, and found that buried seeds are mostly occupied by annual *Chenopodium* species. However, the species composition of buried seeds may differ between grasslands with different aboveground vegetation, and consequently the potential of natural revegetation may differ between grasslands. Thus we investigated species composition of buried seeds at two different grasslands, annual grassland and perennial grassland, and evaluated the difference in revegetation potential of grassland from buried seeds.

We investigated vegetation and buried seeds at two grasslands: annual grassland with relatively high grazing pressure near Bayan-Unnjuul city and perennial grassland with low grazing 15km away from Bayan-Unnjuul.

Most of buried seeds were found in topsoil both in annual and in perennial grasslands. Irrespective of the grassland vegetation, most of buried seeds were occupied by *Chenopodium* species. These results indicate that natural revegetation on dirt roads after abandonment depends on annual *Chenopodium* species, irrespective of aboveground vegetation. Seeds of annual *Chenopodium* species may be widely redistributed by wind after primary seed dispersal.

### **Analysis of geographical trend in transpiration by *Robinia pseudoacacia* plantation along precipitation gradient**

Yoshiyuki Miyazawa<sup>1</sup> and Norikazu Yamanaka<sup>2</sup>

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This study investigated the potential transpiration by plantation of *Robinia pseudoacacia* in Loess Plateau in China in order to achieve large scale and future prediction of transpiration. We focused on the potential for transpiration, which is the function of leaf ecophysiological traits and the microclimate of the leaf surface, and the actual transpiration rate, which equals the potential transpiration minus depression by environmental stresses. Because previous studies showed that trees in arid regions show ecophysiological traits adapted to the water shortage environments and that potential transpiration rates coincide with the actual ones, we calculated the potential transpiration rate.

Potential transpiration rate exceeded actual transpiration rate in midday, even under environments where previous studies did not regarded as evaporative conditions. This result was in contrast to the previous studies in which trees in arid regions have potential transpiration rate and avoid excessive water loss.

Further studies are required to

1. Models should include the processes for soil-root-leaf continuum that regulate the water flow to lower levels than the leaf transpiration.
2. Because leaves in Tottori site with higher precipitation had lower potential transpiration rates than those in YingShong with lower precipitation, this result would be attributed to the different soil type (sand for Tottori and clay for YingShonh). Modeling of transpiration should be, at least, separately carried out for sand and clay.

### **Controlling Vapor Transport in Soils using Thermal Energy in Arid Region**

Hiroataka Saito<sup>1</sup> and Mitsuhiro Inoue<sup>2</sup>

1: Institute of Symbiotic Science and Technology, Tokyo University of Agriculture and Technology, 2: Arid Land Research Center, Tottori University

Salt affected lands can be found in many arid and/or semi-arid areas because highly saline water is used. When shallow saline groundwater exists, salts often accumulate near the soil surface through capillary rise. During capillary rise, water moves upward to the soil surface against the gravity. When water evaporates at the surface, salts are left behind, resulting excess salt accumulation near the surface. To suppress capillary rise of saline groundwater, the concept of capillary barrier has been used by placing a layer with materials having larger pores such as gravel.

In this study, column experiments were conducted to investigate the effect of gravel layer thickness on capillary rise and salt accumulation at the surface. We also investigated the effect of enhanced water vapor flow in unsaturated soils to use the heat resource for irrigation purposes in arid or semi-arid regions. The basic idea is to use intercepted liquid water during capillary rise at the gravel layer by transforming it to water vapor and transporting water vapor by an artificially created temperature gradient to the surface soil. This approach allows us to avoid surface soils from salinization. The experimental results were also simulated using HYDRUS software. Despite slight overestimation near the soil surface, experimental results were, in general, well reproduced by simulated results in terms of volumetric water content

distributions within the soil column. The overestimation can be attributed to insufficient thermal insulation during the experiments. In the next step, soil temperatures need to be monitored during the experiment so that more accurate simulation results can be obtained.

### **Development of method for accurate soil moisture measurement using dielectric probes in arid land environments**

Tadaomi Saito<sup>1</sup> and Mitsuhiro Inoue<sup>2</sup>

1: Faculty of Agriculture, Tottori University, 2: Arid Land Research Center, Tottori University

The objective of this study was development of empirical calibration methods for temperature and salinity dependences of commercial dielectric probes to measure soil water content in arid environments. In fiscal year 2011, we proposed a new calibration method of temperature dependence of dielectric probes using time series of field data which requires no laboratory experiments. In general, empirical temperature calibration equations are derived from laboratory experiments using responses of probe outputs to temperature variations under constant water content conditions. In contrast, daily fluctuations of probe output with daily fluctuations of soil temperature from field observation data were used to derive calibration equations in this study.

Hourly outputs from the ECH2O EC-5 and EC-20 probes and temperature sensors at 5-cm depth were analyzed to derive calibration equations in Liudaogou Basin in Shaanxi Province in the Loess Plateau, China. Data taken on the days that meet the following conditions were previously removed from the analysis: i) rainy days, ii) minimum soil temperature below 0 °C and iii) daily temperature difference less than 10 °C. Under the assumption that actual daily water content was constant at a daily average value for each day, a slope value was obtained by dividing the difference in daily probe outputs by difference in daily minimum and maximum soil temperatures for each day. Temperature calibration equations were derived from the relationships between the daily average water contents and the slope values.

As a result, the derived calibration equations from field data were in good agreement with the calibration equations derived from the laboratory experiments for both EC-5 and EC-20 probes. The calibration equations were applied to the field data and they validly reduced the temperature effects in daily and seasonal time-scale data.

### **Utilization of saline water in closed soilless culture system for growing vegetables**

Kensuke Kondo<sup>1</sup> and Mitsuhiro Inoue<sup>2</sup>

1: Faculty of Agriculture, Tottori University, 2: Arid Land Research Center, Tottori University

Soilless culture is one of the cultivation methods, which is growing plants in vermiculite or other substances using a liquid solution of nutrients. It was investigated that effects of different concentration of salt in nutrients solution on the growth and quality of vegetable in a closed hydroponic system. Objective of this study is in order to get basic data for introducing the soilless culture at arid or semiarid land. Mizuna were grown in the closed hydroponic system at glasshouse. Nutrient solution was used a half strength of Otsuka A solution with an electric conductivity (EC) of 1.3 dS m<sup>-1</sup>. The experiment comprised four salt treatments with four different NaCl concentrate nutrient solutions, which was 0 mM (1.3 dS m<sup>-1</sup>), 20 mM

(3.3 dS m<sup>-1</sup>), 50 mM (6.5 dS m<sup>-1</sup>), and 100 mM (11.3 dS m<sup>-1</sup>) NaCl. The growth of mizuna was not inhibited 0 to 50 mM NaCl treatments. There was tendency that SPAD value (leaf chlorophyll content) was increased in higher concentration salt treatments. Total sugar contents, ascorbic acid contents, and nitrate concentration were affected by salt treatments. Usually, irrigation water in arid and semiarid land was not including Na, but also Mg and Ca. Therefore, it is needed to study with growing vegetables using different type of salt in the closed hydroponic system.

### **Effect of dietary mineral imbalance due to overgrazing on Mongolian livestock health**

Yu Yoshihara<sup>1</sup> and Takehiko Ito<sup>2</sup>

1: Graduate school of agricultural science, Tohoku University, 2: Arid Land Research Center, Tottori University

The purposes of this study are to clarify 1) the relationship between the predicted reduction in the number of accessible plant species for livestock due to settlement of nomads and the mineral status of livestock in Mongolia, and 2) the impact of the mineral balance degradation in plants by soil salinization on mineral status of livestock and productivity.

We found that the sheep accessible to many plant species had the higher concentration of major minerals but less toxic mineral elements (such as aluminum) with their hair compared to sheep accessible to less plant species. In the salt accumulated area, excess sodium in the sheep hair and the consequent lowest productivity through the plant was detected.

We thus concluded that 1) maintaining a grassland with high species diversity of plant could improve the health of grazing sheep, and 2) grazing sheep on soil salinization area would lead to deterioration of sheep mineral status and productivity.

### **Research Meeting**

#### **The Open Symposium on the Drylands and Desertification in East Asia**

Kyoichi Otsuki<sup>1</sup>, Kaoru Kashima<sup>2</sup>, Masaharu Kitano<sup>1</sup>, Reiji Kimura<sup>3</sup>, Atsushi Tsunekawa<sup>3</sup>, Masato Shinoda<sup>3</sup> and Norikazu Yamanaka<sup>3</sup>

1: Faculty of Agriculture, Kyushu University, 2: Faculty of Sciences, Kyushu University, 3: Arid Land Research Center, Tottori University

Memorial Joint Event between Research Institute for East Asia Environments of Kyushu University & Arid Land Research Center of Tottori University: “Dry Land the Desert –Home of Yellow Dust–”

The Research Institute for East Asia Environments (RIEAE) of Kyushu University and the Arid Land Research Center (ALRC) of Tottori University signed the academic exchange agreement on 28 February, 2012 to promote organizational coordination and joint research for integrated solution of the environmental problems related to the nature, history, culture and society of the arid lands in East Asia. The both organizations will promote the academic exchange such as joint symposium, joint research, human exchange, information exchange based on the agreement. To memorize the agreement, the measures for the desertification problem and the front line of the yellow dust researches were introduced to Fukuoka

residents as follows:

Date: February 28 (12:00~20:00) ~ February 29 (9:30~19:00), 2012

Venue: Tenth floor meeting room of JR Hakata City (Hakata, Fukuoka)

Special Lecture: Three lectures from each organization

Exhibition Corner: Yurt, posters, photographs, DVD pictures, etc.

Active Learning Corner: Observation of various sands, making sand art, trial fitting of ethnic costume, quiz, etc.