

1.3 Joint Research

(1) List of joint research

Title of Joint Research Project

** A representative of joint research to carry out each project*

A-1) Land-atmosphere interaction in arid regions

Research on the atmosphere-ground surface interaction in arid region

Masao MIKAMI, Masahide ISHIDUKA and Masato SHINODA*

Producing a data base of vegetation changes in the dry steppe of Mongolia

Nachinshonhor URIANHAI and Masato SHINODA*

A development of the maps of wind erosion conditions using sub-surface thermal inertia retrieved from a surface heat budget model optimized by satellite data

Dai MATSUSHIMA and Reiji KIMURA*

A-2) Advanced utilization of water resources and water conservation for irrigation

Alternate watering with drip irrigation for mitigating greenhouse gas emissions and water use

Kosuke NOBORIO and Hisao ANYOJI*

Use of stable isotopes and micro-elements for tracing salt dynamics

Tsugihiko WATANABE, Takashi SHIBAI, Kume TAKASHI, Takanori NAGANO and Hisao ANYOJI*

Climate features linking to past draught in Central South America

Koji NISHIYAMA and Hiroshi YASUDA*

A-3) Physiological and morphological responses to dry and saline conditions in plants

Mechanisms of drought, salt and excess water tolerance among millets

Asana MATSUURA, Kouhei MURATA and Wataru TSUJI*

Silicon and phosphorus: uptake and accumulation by plants and effects on growth and yield under soil environmental-stress conditions

Jun ABE and Wataru TSUJI*

Responses to environmental stresses of some plant species grown in desertificated grassland in North-East Asia

Hideyuki SHIMIZU, ZOU Chunjing, XU Zhenzhu, Yuji SASAGAWA, Shoko KOBAYASHI and Wataru TSUJI*

A-4) Monitoring and modeling of plant production and ecosystem change in drylands

Cultivar differences in maintenance capacity of green leaves in crop plants under desiccated soils

-Application on crop model-

Tohru KOBATA and Atsushi TSUNEKAWA*

Interaction growth-inhibition of the other plant by volatile allelochemicals associated with *Artemisia adamsii* leaves

Eiji NISHIHARA and Mitsuru TSUBO*

A-5) Eco-physiology of tree tolerance to water deficiency and salinity

Specific characteristics for salt tolerance mechanism of halophilous plants

Shingo TANIGUCHI and Norikazu YAMANAKA*

Drought, salinity and anaerobic stress tolerances of Salicaceae species widely planted in China

Fukuju YAMAMOTO, Fumiko IWANAGA and Norikazu YAMANAKA*

A-6) Soil degradation in arid areas

Dynamics of matter in irrigated agricultural field in semi-arid regions

Taku NISHIMURA, Chihiro KATO and Mitsuhiro INOUE*

Characterizing land degradation processes as affected by changes in soil surface environment

Yasushi MORI, Atsushi FUJIWARA, Tahei MORISAWA, Junichiro IDE, Norikazu YAMANAKA and Mitsuhiro INOUE*

Prediction and control of salt accumulation in the upper root zone under sub-surface drip irrigation

Haruyuki FUJIMAKI and Mitsuhiro INOUE*

B-1) Joint research on the prevention of desertification and the development and application of drylands through network of research institutes

An Interdisciplinary Study on the System of Egyptian Irrigation

Hiroshi KATO, Erina IWASAKI, Eiji NAGASAWA, Nobuhiro MATSUOKA, Nobuhiko FUWA, Hisao ANYOJI and Reiji KIMURA*

C) Free Subject

Reconstruction of Environmental Changes at Arid Regions

Kaoru KASHIMA and Masato SHINODA*

Hydrological cycle in grassland ecosystem in Mongolia and Kazakhstan

Yoshihiro IJIMA and Masato SHINODA*

Cross sections of wind ripples on various slopes in a coastal sand dune

Yoshinori KODAMA and Masato SHINODA*

Study on asian dust storm

Youichi KUROZAWA, Kazunari OHNISHI, Mikizo OKAMOTO and Masato SHINODA*

Mechanism and its interannual variability of the rainfall in Mongolia

Keiji KIMURA and Masato SHINODA*

Trends of sustainable urban development in arid land

Hiroki YAMASHITA and Masato SHINODA*

Improving a diagnostic model of drought and dzud in Mongolia and its application to the assessment of the global warming effect

Kaoru TACHIIRI and Masato SHINODA*

Evaluation of socio-economic impact caused by dust storm in Mongolia

Takahiro OZAKI and Masato SHINODA*

Relationships between the pastoralist's selection of camps and micro-meteorological conditions in Bulgan Prefecture, Mongolia

Yuki MORINAGA and Masato SHINODA*

Experimental study on soil respiration during freezing-thawing cycles

Tomoko NAKANO and Masato SHINODA*

Trends of industrial development in arid land

Hirofumi KITAGAWA and Masato SHINODA*

Prediction of yellow-dust using MODIS imagery

Masahiro TASUMI, Emi KANDA and Reiji KIMURA*

A study on small wind turbines suitable for arid land

Yutaka HARA and Reiji KIMURA*

Modelling of transpiration for Caragana stand

Nobuhiro MATSUOKA and Reiji KIMURA*

A study on water making system using renewable energy in arid land

Kotaro TAGAWA and Reiji KIMURA*

The results and the problems of the Chinese policy of reverting forests and grasslands to farmlands

Jianzhong ZHOU and Reiji KIMURA*

Studies on liquid water and solute movement in unsaturated coarse porous media

Tadao AODA and Hisao ANYOJI*

Effect of vegetation on groundwater in arid environment

Kei NAKAGAWA and Hiroshi YASUDA*

Evaluation and modeling of the water balance in a water harvesting system in the Loess Plateau, China

Tadaomi SAITO and Hiroshi YASUDA*

Physiological evaluation and linkage disequilibrium analyses on drought tolerant-related characters in isogenic wheat lines and synthetic wheat lines

Hisashi TSUJIMOTO, Hiroyuki TANAKA and Tomoe INOUE*

Ecophysiological studies on noxious weeds in semi-arid areas

Yukihiro SUGIMOTO and Tomoe INOUE*

Enhancing drought tolerance in wheat via improving the root permeability

Junichi KASHIWAGI and Tomoe INOUE*

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

Kazuhiro MATSUMOTO, Fumio TAMURA and Wataru TSUJI*

Elucidation of the phototolerance mechanism in the transgenic tobaccos that have higher capacity to detoxify lipid aldehydes

Junichi MANO and Wataru TSUJI*

Scoring traits related to water loss and water uptake in leguminous plants differed by drought tolerance

Hideki ARAKI and Wataru TSUJI*

Studies on the genetic variability on oil plant, Jatropha

Kiichi FUKUI and Atsushi TSUNEKAWA*

Comparative study on soil factor affected to biological production at desert

Kazuhisa HASEGAWA, Kensuke KONDO and Atsushi TSUNEKAWA*

Influence of aeolian sediment on carbon and nitrogen dynamics of surface soil in the steppe region, Mongolia

Maki ASANO, Kenji TAMURA and Atsushi TSUNEKAWA*

Estimation of grassland production in Loess Plateau China

Shohei SHIBATA and Mitsuru TSUBO*

The effect of soil microorganisms on water and salt stress resistance of trees

Kazuyoshi FUTAI, Fukuju YAMAMOTO, Yuko TAKEUCHI, Takeshi TANIGUCHI, Takashi MII, Tomotaka SUGIMOTO, Midori TOBIKAWA and Norikazu YAMANAKA*

Studies on social development in the Loess Plateau

Hiroshi NAWATA and Norikazu YAMANAKA*

Experimental studies on the salt tolerant characteristics of halotolerant plant and remediation and conservation of the saline soil

*Kenji IWAMA**, *Chihiro SHIOYA*, *Mami SAKAI*, *Mitsuhiro INOUE*, *Masayasu OKAZAKI* and *Norikazu YAMANAKA*

Nitrogen mineralization process in semi-arid soils

*Ryunosuke TATENO** and *Norikazu YAMANAKA*

Evaluation of salt tolerance and water and nutrient use of coastal plants using stable isotopes

*Naoko MATSUO**, *Nobuto OHTE*, *Rina KOYAMA* and *Norikazu YAMANAKA*

Functional coordination between reduction and recover of xylem hydraulic conductivity in *Salix* woody species

*Naoko MIKI**, *Yuki MURAKAMI*, *Mayumi OGASA*, *Lingli YANG*, *Ken YOSHIKAWA* and *Norikazu YAMANAKA*

Evaluation of pore-air behavior in unsaturated soil and its influence to hydraulic conductivity

*Kohji KAMIYA** and *Mitsuhiro INOUE*

Research on Non-destructive measurements of unsaturated seepage flow by using Ground-penetrating radar in arid land

*Yuji TAKESHITA**, *Mitsuru KOMATSU*, *Masafumi NAKAMURA*, *Taku YAMASHITA* and *Mitsuhiro INOUE*

Experimental study on water saving by using capillary barrier of soil

*Toshihiro MORII** and *Mitsuhiro INOUE*

Studies on leaching mechanism concerned density flow

*Yasutaka KIHARA** and *Mitsuhiro INOUE*

Preferential flow effect on solute leaching for sandy soil in arid land

*Hiroyuki CHO** and *Mitsuhiro INOUE*

Development of a new methodology for measuring continuous air content and air permeability in soil using sound resonance

*Kimihito NAKAMURA**, *Kotaro FUKADA* and *Mitsuhiro INOUE*

Measurement of fertilizer discharged from a yam field using cylinder wick samplers

*Koji INOSAKO** and *Mitsuhiro INOUE*

Research on groundwater management using plant transpiration and water uptake

*Yoshinobu KITAMURA**, *Katsuyuki SHIMIZU* and *Mitsuhiro INOUE*

The effect of soil water content on the initial growth of *Jatropha curcus* L.

*Toshihiko KINUGASA**, *Takayuki ANDO* and *Mitsuhiro INOUE*

Vegetable growth and quality under different irrigation conditions

Kensuke KONDO and Mitsuhiro INOUE*

Effect of sulfur-organic compound on alkali soil in P.R.China

Yuichi ISHIKAWA and Mitsuhiro INOUE*

Water-saving cultivation of grapevine in drylands

Fumio TAMURA, Ya-Li LI and Mitsuhiro INOUE*

The Utilization of Indigenous Technology for Water Resources and Rural Socio-Economic Development in Afro-Asia Regions

Ryuichi HARA and Takayuki ANDO*

(2) Summary of Joint Research

A-1) Land-atmosphere interaction in arid regions

Research on the atmosphere-ground surface interaction in arid region

Masao MIKAMI¹, Masahide ISHIDUKA² and Masato SHINODA³

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2: Faculty of Engineering, Kagawa University

3: Arid Land Research Center, Tottori University

Analyses of total saltation sand flux (Q) and dust flux (F) were evaluated using data obtained at a fallow wheat field in Australia during JADE IOP1 in 2006. Basic characteristics of these data are: (1) there is a clear particle size dependency of saltation sand flux among three different observation heights (5, 10, and 30cm) although no dependency is found on dust flux. (2) it is well known that both saltation sand flux and dust flux are proportional to 3rd power of friction velocity. However, our results suggested that these are seemed to be proportional to 4th or 5th power of u^* .

We have conducted intensive and long-term monitoring of dust outbreak processes at semi-arid grassland in Mongolia, Bayan-unnjuul, during 2009 early summer in order to understand dynamics of dust emission and ground surface conditions. Using long-term monitoring data from the middle of Feb. to the end of June in 2009, we analyzed the basic characteristics of saltation sand flux and dust concentration at this area. It was found that compared to 2008, 2009 dust emission was limited as compared in 2008 under similar friction velocity condition. It is suggested that dry dead grass grew up in 2008 remain on the site even in early summer season in 2009. For this reason, ground surface is covered by fibrous permeable obstacles. This may restrain dust emission from ground surface.

Producing a data base of vegetation changes in the dry steppe of Mongolia

Nachinshonhor URIANHAI¹ and Masato SHINODA²

1: National Museum of Ethnology

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1. Relation between precipitation and steppe productivity

Our result shows that steppe productivity positively respond to precipitation. It coincided with a previous research in North America that (Sala et al. 1988, Lauenroth et al. 1992). From 1999 to 2008, the CV (Coefficient of Variation) of precipitation is 44.2%, and CV of steppe productivity is 52.4% respectively. It means that the stability of the steppe system is very low.

2. Steppe productivity and its usage by pastoral nomadism

Grazing intensity shows same pulses with productivity of steppe community. It means that in the productive year steppe under high grazing intensity and in opposite case the grazing intensity was low. The results show that pastoral nomadism carries out an adjustment function in Mongolian steppe. It further suggested that this adjustment function of pastoral nomadism is very important to sustainability of Mongolian steppe ecosystem.

3. Herd size and pastoral nomadism

Our results also showed that yearly pastoral distance was different depend on herd size. Middle herd shows more long yearly pastoral distance than the case of little and big herd. Big herd owner have relatively high economical status, he can buy hay to decrease the pastoral distance. But decreasing of pastoral function may allow degradation of steppe ecosystem and decreasing of livestock welfare.

A development of the maps of wind erosion conditions using sub-surface thermal inertia retrieved from a surface heat budget model optimized by satellite data

Dai MATSUSHIMA¹ and Reiji KIMURA²

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This study clarified a relationship between subsurface thermal inertia and threshold wind speed of wind erosion, using a surface heat budget model and site measurements in semi-arid steppe. The surface heat budget model consists of two layers, which is vegetation canopy and soil surface. The main frame of the model is the heat budget equation on the earth surface implemented with the bulk equations and the force-restore model. The model employs the solar radiation, the air temperature, and etc. as input variables, and calculates the surface radiative temperature and surface fluxes as output. In this study, model parameters which determine the model output were not restrained and optimized daily using surface radiative temperatures measured at Bayan-Unjuul in Mongolia in 2008. The thermal inertia is included in the optimized parameters, and is theoretically correlated with the soil moisture, which implies the correlation with the threshold wind speed of wind erosion. The data of the threshold wind speeds of dust events confirmed in the site measurement was positive correlated with the thermal inertia, and the

correlation was formulated by a linear regression.

Next, a spatial distribution of the thermal inertia in a dust event day in 2008 was estimated using satellite surface temperatures, and a distribution map of the threshold wind speed was made using the regression formula. The thermal inertia estimated using satellite surface temperature agreed with that using the site measurement, on the other hand, estimated areas of wind erosion did not correspond with the atmospheric aerosol data of the routine meteorological observations.

A-2) Advanced utilization of water resources and water conservation for irrigation

Alternate watering with drip irrigation for mitigating greenhouse gas emissions and water use

Kosuke NOBORIO¹ and Hisao ANYOJI²

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Use of stable isotopes and micro-elements for tracing salt dynamics

Tsugihiko WATANABE¹, Takashi SHIBATA², Kume TAKASHI¹, Takanori NAGANO² and Hisao ANYOJI³

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Irrigation water and groundwater of Lower Seyhan Irrigation Project in Turkey were analyzed for strontium, oxygen and hydrogen isotopes and trace minerals for revealing dynamics of salinity in the command area.

The saline area in the coastal zone did not contain salt originating from the sea. Deep groundwater in the coastal zone was neither affected by sea water intrusion. It is likely that source of the salinity in the coastal zone is attributed to accumulation of salts contained in the river water due to evaporation.

Climate features linking to past draught in Central South America

Koji NISHIYAMA¹ and Hiroshi YASUDA²

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Drastic change in water level from dry to wet trend around 1970th can be recognized in the Pantanal region (Central South America) included in the La Plata river basin. Therefore, in this study, the patterns of important climate indices closely related to climate change were classified by using the Self-Organizing Map (SOM), which can convert complex nonlinear features into simple and understandable patterns

represented by two-dimensional coordinate system. In the next step, the SOM-based classified patterns were compared with annual water level recorded after 1948 at Ladario located in the target area. As a result, water level variation in Central South America is directly affected by the inflow of water vapor originating from the trade wind. On the other hand, the variation in the trade wind is indirectly controlled by Pacific Decadal Oscillation (PDO), which represents a pattern of Pacific ocean climate variations with inter-decadal time scale of 20~30 years. From these analyses, it was found that the climate features in dry period prior to 1970th correspond to a decrease in water vapor flow into Central South America due to the weakness of the tropical Atlantic Ocean trade wind together with negative PDO, which means a climate phase that Sea Surface Temperature (SST) in the Tropical Pacific Ocean is lower than average SST there.

A-3) Physiological and morphological responses to dry and saline conditions in plants

Mechanisms of drought, salt and excess water tolerance among millets

Asana MATSUURA¹, Kouhei MURATA¹ and Wataru TSUJI²

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1. Introduction

Water deficit is known to reduce grain yield and crop growth. Water stress may occur at any time during growing season at any place because climatic change is variable by accelerate global warming year by year. In the future, global warming is going to lead to more severe water stress and greater yield decreases. Breeding of drought tolerant crop is one way to increase of grain yield, however, it has progressed slowly over the past decade due to lack of understanding of the traits and mechanisms of drought tolerance even in rice. It is important to clear the target period and responses to water deficit for any crop. Grain yield decreased by water deficit during early reproductive development rather than the other growth stage for most crops because irreversibility of the early events is especially damaging in maize, rice and wheat. Millets is important genetic resources as a water saver because of C4 photosynthesis both on today and future. However, there is little research work conducted from the point of productivity. Moreover, which growth stage is susceptible to water deficit and the mechanisms of drought tolerance are not clear for millets. In this paper, the experiment focuses on the most susceptible growth stage to water deficit and the limiting factor for grain yield in two *Setaria* and *Panicum* species under the condition where the available water exist in deeper soil layer.

2. Mterials and Methods

Foxtail millet (*Setaria italica* (L.) P.Beauv.), little millet (*Panicum sumatrense* Roth.), common millet (*Panicum miliaceum* L.) and yellow foxtail millet (*Setaria glauca* (L.) P.Beauv.) were used. Seeds of each species were sown in sandy soil in polyvinyl chloride (PVC) tubes (7.5 cm in inner diameter and 70 cm in height) into a container at summer in a greenhouse at Tokai University, Kumamoto in Japan. Water stress treatment was initiated 25 days after sowing by submerging the PVC tubes to 5 cm height from the bottom into half strength of a Hoagland and Arnon's nutrient solution. As a wet treatment, the PVC tubes were submerged to 30 cm height from the bottom of PVC tubes in the nutrient solution. At the beginning of heading, half of the plants of wet treatment moved to dry treatment and the other plants continue to growth at wet treatment till harvest. The half of the plants of dry treatment moved to wet treatment and the other plants continue to grow at dry treatment till harvest. Soil samples were taken at heading and harvest from

each 10 cm layer to a depth of 70 cm.

3. Results and Discussion

Pattern of soil water content at different depths is similar for four millets: Water content was available water at the depths of 10-70 cm and 40-70 cm for the wet and dry treatment, respectively for all millets. Grain yield of *S.italica* did not change by the water stress treatment and those of the other millets remarkably decreased. Water stress treatment at pre- and post-heading similarly reduced grain yield in *P.miliaceum* and water stress treatment at pre-heading markedly reduced grain yield in *S.glauca* and *P.sumatrense*. Water stress treatment reduced grain number per panicle in *S.italica* and number of panicles in other three millets. There is significant correlation between total dry weight and grain yield in all millets and also between harvest index and grain yield in *P.sumatrense*. The ratio of leaf area to root dry weight decreased to 69 % by the water stress treatment in *S.italica* and *S.glauca* but increased in *P.miliaceum* and *P.sumatrense*. Water stress treatment did not change root dry weight density in *S.italica*, however, decreased at shallow depths and increased at deeper depths in the other millets. There are significant correlation between root dry weight and total dry weight in the millets except for *S.italica*. These results suggest that *Setaria* maintain plant growth by keep water balance at heading under water stress, moreover, *S.italica* did not reduce grain yield by keep root growth at all depths.

Silicon and phosphorus: uptake and accumulation by plants and effects on growth and yield under soil environmental-stress conditions

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(1) Yield improvement by silica fertilizer under soil drought condition:

Cucumber fruit form bloom, the tiny white power-shaped structure on the fruit surface, which contain much silicon. Application of silica as fertilizer to cucumber increase the survival ratio of fruit under drought condition. The formation of cucumber bloom can be altered by the pumpkin varieties as a rootstock. The seedling growth of blooming varieties of pumpkin was promoted by silica fertilizer more than that of bloomless pumpkin varieties. These results suggest the contribution of silica to drought tolerance of cucurbitaceous plants.

(2) Use of soil organic phosphorus by peanut roots

Toluidine blue staining and X-ray microanalysis were applied to visualize the presence of phytate phosphorus. The results suggested the uptake of phytate phosphorus by peanut roots when the concentration of soil phytate was high.

Responses to environmental stresses of some plant species grown in desertified grassland in North-East Asia

Hideyuki SHIMIZU¹, ZOU Chunjing¹, XU Zhenzhu¹, Yuji SASAGAWA¹, Shoko KOBAYASHI¹ and Wataru TSUJI²

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Desertification is one of the most serious ecological/environmental problems in arid/semi-arid region. The most effective way for desertification combating and ecological restoration is the vegetation rehabilitation. However, we have less knowledge on the growth of species grown in desertificated area. In the present research, we investigated the growth responses to water stress of shrub (*Artemisia halodendron*, *Artemisia ordosica*, *Artemisia frigida*, *Caragana korshinskii*, *Caragana microphylla*), grass (*Achnatherum splendens*, *Agropyron cristatum*, *Clinelymus dahuricus*, *Cleistogenes squarrosa*, *Leymus chinensis*, *Stipa krylovii*) and forb (*Medicago sativa*, *Melilotus suaveolens*, *Peganum nigellastrum*, *Chenopodium album*, *Salsola collina*) species grown in desertificated grasslands in North-East Asia.

Plants were watered with 30, 60, 90 and 120 mm/month (25.2, -9.7, -3.4 and -2.7 KPa treatment, respectively) and the growth was analyzed. Increasing water stress decreased the relative growth rate (RGR) of all species, while the eco-physiological response of each species was different from each other, within the shrub, grass or forb group. Some species decreased RGR markedly, while some decreased specific leaf area (SLA) indicating the leaf thickening, and some increased root/shoot (R/S) ratio showing more assimilates into roots.

In addition, the functional-structural plant growth model was developed by quantifying the morphological/structural and physiological/ecological responses to different environmental conditions. The model was developed and simulated by collecting the parameters with *A. halodendron*, *C. microphylla*, and *C. squarrosa*. As calculating the growth and partitioning from the regressions between water stress and RGR and water stress and leaf weight ratio (LWR), we succeeded to simulate the plant response to water stress with *A. halodendron*. The developed model should be useful for considering measures/forecasting of dust-sand storm, planting suitable species for suitable place, and so on.

A-4) Monitoring and modeling of plant production and ecosystem change in drylands

Cultivar differences in maintenance capacity of green leaves in crop plants under desiccated soils -Application on crop model-

Tohru KOBATA¹ and Atsushi TSUNEKAWA²

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- In vitro Evaluation of Stay-green for rice during the Post-Anthesis Period-

Tohru Kobata, Miwa Shinonaga, Atsushi Tunekawa and Mituru Tubo
(Faculty of Life and Environmental Science, Shimane University)

Abstract: Maintenance of green leaves under stress conditions plays an important role for grain production in crop plants. Hence, it was investigated whether cultivar parameter for the stay green capacity can be decided. Developments of conventional methods to detect stay green capacity after post-anthesis period were tried for rice (*Oryza sativa* L.). Incubated treatments were used for the detection of the stay green. Cut leaves were immersed in distilled water under dark conditions of 25 °C and green leaf color (SPAD value) and leaf area were monitored every day. There was a cultivar difference in decreases of SPAD value

and leaf area with the passage of day. The SPAD value and leaf area observed for pot plants subjected to soil desiccation in greenhouse conditions approximately coincided with them observed for the incubated experiment. Furthermore, optimized conditions for detection of stay green should be investigated.

Interaction growth-inhibition of the other plant by volatile allelochemicals associated with *Artemisia adamsii* leaves

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In overgrazed grassland in Mongolia, grass species such as *Stipa krylovii* have been decreasing, while *Artemisia* species which are less palatable to livestock, particularly *A. adamsii*, have become dominant. However, its ecology including allelopathic effects of *A. adamsii* on the vegetation is unknown. In this study, the effect of volatile organic compounds emitted from *A. adamsii* plants on growth of a coexisting species, *S. krylovii* was therefore investigated, and then its allelochemicals were identified.

Allelopathic activity of six Mongolian species was evaluated with the dish pack method, assaying inhibition of lettuce seed germination. An inhibitory rate of 85% was measured in the *A. adamsii* treatment, and this was over 30% higher than the other species. The EC₅₀ of the *A. adamsii* treatment was about 0.035g. In addition, when the sealed dish pack was opened, the seed germination was recovered, indicating that the volatile organic compounds do not damage seeds but regulate seed germination.

The effect of *A. adamsii* on *S. krylovii* was investigated. After *S. krylovii* was grown until the stage of three leaves, dry leaves of *A. adamsii* were placed around the *S. krylovii* plants with and without contacting the leaves to the plants (short plastic sheets were set around the lower part of the plants on the soil surface). On 50 days after the treatment, aboveground biomass of *S. krylovii* was measured. The volatile organic compounds inhibited the plant growth without the plastic sheet, though they did not with the sheet.

For identification of volatile allelochemicals of *A. adamsii*, water-evaporating extraction of 100 g of the dry leaves was assayed with GS-MA. Also a SPME method was employed to identify the volatile allelochemicals using 1 g of the dry leaves. Six large peaks were detected in the GS-MA method, and the results agreed with those of the SPME method. Two volatile organic compounds (cineol and camphor) were identified as the allelochemicals, as lettuce seed germination was inhibited by those compounds and the seeds germinated after the sealed dish pack was opened.

This study clearly shows that allelopathic activity of *A. adamsii* is large, compared with the coexisting species in the Mongolian vegetation. Because of little rainfall and dry growth environment, the volatile organic compounds that are emitted from the leaves and stems can be mostly involved in the allelopathic activity. In addition, the volatile organic compounds inhibited growth of the ex-dominant species, *S. krylovii*, and the allelopathic effect can be large under dry condition.

A-5) Eco-physiology of tree tolerance to water deficiency and salinity

Specific characteristics for salt tolerance mechanism of halophilous plants

Shingo TANIGUCHI¹ and Norikazu YAMANAKA²

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Drought, salinity and anaerobic stress tolerances of Salicaceae species widely planted in China

Fukuju YAMAMOTO¹, Fumiko IWANAGA² and Norikazu YAMANAKA²

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Salix psammophila and *Salix matsudana* are the important tree species for sand dune fixation and reforestation in the Mowusu Desert in northwestern China. We investigated the growth, photosynthesis, and cation distributions in 2-year-old hydroponically cultured cuttings of them exposed to various salt stresses for 6 weeks using 2/5 Hoagland solution. *S. matsudana* exhibited significant depression in growth and biomass increment at NaCl concentrations of 50 mM or more, whereas *S. psammophila* was strongly depressed only by the 100 mM NaCl treatment. Although *S. matsudana* exhibited higher rates of photosynthesis under salt-free conditions, the photosynthesis levels quickly decreased under higher salt conditions compared to those of *S. psammophila*. Ion distribution in leaves and roots differed between species. *S. psammophila* adapted to salinity by avoiding salt uptake, such that most external Na⁺ in the solution was excluded from the root system. *S. matsudana* showed salt uptake, however, most of the absorbed Na⁺ was compartmentalized to the root system, with little reaching the leaves when the salt concentration was under a certain threshold. The lower Na⁺/K⁺ ratio in the leaves of *S. psammophila* indicated that it was more tolerant to salt stress than *S. matsudana*. As a result, *S. psammophila* may survive more easily and thus can be used more widely than *S. matsudana* in saline soils.

A-6) Soil degradation in arid areas

Dynamics of matter in irrigated agricultural field in semi-arid regions

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2: Arid Land Research Center, Tottori University

Several previous papers reported that reduction of irrigation depressed ground water depth, and improved soil salinity of irrigated agricultural land under arid and semi-arid climate. However, in some case ground water level before the depression was 5 meters and deeper. It was curious that such deep saline ground water could rise up to surface, and changes in ground water depth could affect soil salinity of

several meters apart. Beside, many of those inland arid regions were bottom of sea during transgression periods and this made soils to have much carbonates and sulfates. Considering such situation laboratory experiment of irrigation and successive evaporation with and without effect of ground water was conducted.

Ground water, irrigation water and soil solution had different electrolyte, NaCl, KBr and CaSO₄, respectively. Distribution of these electrolytes may represent contribution of each source on evolution of salt profile. Repeating irrigation and evaporation caused salt accumulation and precipitation of salts at soil surface. Irrigation water derived salt distributed down to the depth around wetting front reached following the irrigation. Most of the irrigation derived salts concentrated at near surface and precipitated. This suggests salt moved down with infiltrating water and returned to surface by evaporation. Soil water derived salt also precipitated at surface however this was coming from 0 to around 10cm in depth where wetting front of irrigated water reached. Soil salt dissolved into irrigated water and move with the irrigation water derived salt. So that deeper layer had less modification in soil solution derived salt concentration.

Results of the experiment suggested that improve in salt accumulation by reduction of irrigation of salty ground water under arid and deep ground water condition may be mostly due to reduction of input of salt by irrigation and not be due to capillary rise of salty deep ground water.

Characterizing land degradation processes as affected by changes in soil surface environment

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Recent increases in rainfall acidity and intensity have generated interest in their effect on soil-bound ions (i.e. mineral cations or nutrient anions) in drainage. A soil column experiment was conducted under field conditions to characterize infiltrated soil water quality resulting from simulated rainfall treatments. Two rainfall treatments (neutral rain and acid rain) and four rainfall intensities (2, 4, 20, 80mm hr⁻¹) were investigated. Water draining through the soil column was sampled and analyzed for electrical conductivity (EC) and dissolved ion concentration. Results showed the acidic rain treatment caused more solute discharge than did neutral rain treatment. Infiltrated soil water quality was much higher than rain water, suggesting that changes in ionic concentration are due to leaching processes rather than ion exchanges. Moreover, highest solute concentrations was resulted from 80mm hr⁻¹ rain, being affected by rainfall intensity. Surprisingly, 80mm hr⁻¹ intensity when combined with acid rain treatment caused higher discharge solute concentrations than either treatment independently.

Prediction and control of salt accumulation in the upper root zone under sub-surface drip irrigation

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We conducted a greenhouse experiment using two soil tanks in each of which 16 TDR probes were inserted horizontally. Masa loamy sand and Kanto loam were filled into each tank and soybean was sown. After the leaf area became about 300cm², subsurface drip irrigation from a porous pipe inserted at a depth of 12 cm with 5000 ppm CaCl₂ solution was started. When the soil became saline enough to retard

transpiration, leaching through the subsurface porous pipe was performed. The wetting front reached to the soil surface and a part of salts presented above the porous pipe was transported to soil surface. We have also incorporated root water uptake submodel into our numerical model (WASH_2D) for two-dimensional water and solute movement. We have added thermal vapor diffusion by plainly inter/extrapolating measured soil temperature.

The numerical solutions by WASH_2D were in fair agreement with the measured water content and salt concentration as well as those distributions at the end.

B-1) Joint research on the prevention of desertification and the development and application of drylands through network of research institutes

An interdisciplinary study on the system of Egyptian irrigation

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The two of cowriters (Hiroshi Kato and Erina Iwasaki) made a field study in Rashda village, Dakhla Oasis in the Western Desert, and wrote a report on it. That field study focused on collecting data and information on the topography of the village residential area and the social life of villagers in it, and dealt with the economic life, especially agriculture only on small extent, based on the preliminary field survey. This study aims, as an interdisciplinary study, to analyze the economic life, focusing the irrigation and cultivation system, based on the data and information collected in the field survey in Rashda. The result of this study shows that the economic life in oasis region based on underground water clearly differs from that in the Nile valley completely dependent on the Nile. The detail of the result of the study will be published in English as a report titled "Rashda : System of Irrigation and cultivation in a village in Dakhla Oasis" forthcoming in the Journal of Mediterranean World, no. 20.

C) Free Subject

Reconstruction of environmental changes at arid regions

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The field surveys to reconstruct the environmental changes at arid regions were done in Mongolia, North-western China and Egypt in 2009. The sedimentary studies of inland lakes and peat lands presumed the fluctuations of precipitation and evaporation rates in millennium scale. The comparison surveys at Koyam-ike and Tougo-ike, Tottori Prefecture have started. The preliminary study was done in 2009, and the lake deposit drilling at the both lakes will be done in 2010. The results of the present surveys were reported at EAEP (East Asia Environmental Problem) 2009 which was held at Kyushu University on Dec. 2009.

Hydrological cycle in grassland ecosystem in Mongolia and Kazakhstan

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In this Fiscal Year 2009, new observational research had been started in grassland in north part of Kazakhstan. This study focuses on following three topics based on suggestion by Iijima et al. (2008) which had evaluated the impact of hydro-climatic conditions on the local surface energy balance and plant growth on seasonal and annual time scales in this region.

1. How is soil moisture refill during autumn to next spring?
2. Which layer of soil moisture is consumed during the plant growing season and especially in the dry period?
3. How will grassland respectively respond to under different water stresses, such as shortage of snow, summer and autumn rainfall?

In order to clarify these questions, combined techniques using hydro-meteorological (water flux) measurements, plant growth monitoring (plant height, coverage, and biomass) and stable isotope analysis by water sampling were newly installed in this site. Stable isotope ($\delta^{18}\text{O}$ and deuterium) of different source of water (rain, snow, soil moisture, plant leaf, etc.) in different season can identify the origin of the water and its movement. In this winter (2009-2010), we had contracted with Barayev Research Institute of Grain Farming (BRIGF) on cooperative observation. Then, we set up automatic weather system (AWS) at the observation field nearby the Institute and decided the experimental plots (snow removal plot, rain removal plot, control plot). Now, the collaborative researchers in BRIGF are collecting meteorological data and water sampling of precipitation and snow during this winter.

Cross sections of wind ripples on various slopes in a coastal sand dune

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Cross sectional shapes of wind ripples on various slope angles were investigated in the Tottori Sand Dunes, western Japan. We measured 684 cross sections of wind ripples, analyzed them by 13 components: 6 lengths, 1 height and 6 angles, with progressing angles of wind ripples and clarified the following three points. i) Wave lengths of wind ripples have a tendency to become larger from descending conditions (7 cm) to ascending ones (11 cm). ii) Schematic cross sectional shapes are divided into 4 types depending on progressing angles of wind ripples. iii) As approaching the critical progressing angles for wind ripples, one of the angles of slope compartments of wind ripples attains the angle of repose, which causes disappearance of wind ripples.

Study on asian dust storm

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Effects of Asian dust on human health are not well-known in Japan. We evaluated the associations between daily symptoms of healthy subjects and dust events in Yonago, Japan, using health survey sheets. The subjects were 54 healthy individuals who were distributed survey sheets on nasopharyngeal, ocular, respiratory, and skin symptoms, which were quantified from 1 to 25 February 2009. There were 6 Asian dust days in Western Tottori during same period. We investigated the symptoms of the subjects on Asian dust days and the comparison days, and drew comparison between the symptom scores and measures of suspended particulate matter (SPM) which is one of the indicators of Asian dust. The scores for symptoms were significantly higher on Asian dust days than in the comparison days. The skin symptom scores are positive-correlated with the SPM level.

Mechanism and its interannual variability of the rainfall in Mongolia

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The study area is Mongolia. The appearance frequency of the low pressure in the study area was decreased between 1999 and 2002. By the classification of the cyclone course and the water vapor transportation, the number of the low pressures moved from south-western Mongolia was decreased. On the other hand, the number of the low pressures moved from north-western Mongolia appears stably. The low pressure activity

in this analysis relates with precipitation in the summer Mongolia. Precipitation showed a tendency to decrease during 1993 to 2002, but, from 2003 to 2009, the tendency to decrease of the precipitation stopped.

Trends of sustainable urban development in arid land

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I studied about sustainable urban development in arid land in this year. My main research about the development of Dubai of UAE, is the economic strategy and sustainable urban traffic system. And I study the urban development of arid land about Las Vegas, Phenix in USA, Urmqi in China and Koral Gold Fields in India too.

Improving a diagnostic model of drought and dzud in Mongolia and its application to the assessment of the global warming effect

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The latest Intergovernmental Panel on Climate Change report stated that extreme climate events are becoming increasingly frequent and that this trend would continue into the future. However, few quantitative studies have examined the damage caused by meteorological disasters, and the conclusion that extreme climate events would continue is based mainly on a simple extrapolation of the currently reported climate trend. In this study, the risk of future winter disasters (dzud) in Mongolia is quantitatively estimated by applying an empirical tree-regression model to data derived from the basic local trend in an Earth system model (ESM, a climate model coupled with ecosystem models) projection (based on the Special Report on Emissions Scenario (SRES) A1B). The results indicate that dzud frequency during 2010–2099 will be lower than that during 1940–2003, mainly because of a slight increase in leaf area index (LAI) and a small decrease in the amount of snow. However, in southern Mongolia, a sudden drop in LAI could trigger a series of dzuds at the end of this century.

Evaluation of socio-economic impact caused by dust storm in Mongolia

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A field research was carried out to find out causes of economic and social damage in Berh, which was a mining town in Eastern Mongolia and had suffered severe damage from a sand storm that occurred in May 2008.

In the field research, I interviewed governors in the town and pastoralists in suburban area, to clarify the situation when the sand storm happened and life histories of informants as social background of the damage.

Through the investigation of field research data and discussion with prof. Shinoda, it became apparent that main causes of damage in Berh was the fact that the sand storm accompanied blizzard and passed through suburban area of Berh, which had very large population of pastoralists and high density of livestock.

Now, I am writing above-mentioned article dealing with historical process in which suburban area of Berh became to have large population of pastoralists and high density of livestock, after the collapse of socialism in Mongolia. This article will be published in July 2010.

Relationships between the pastoralist's selection of camps and micro-meteorological conditions in Bulgan Prefecture, Mongolia

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To verify the hypothesis that the Mongolian herders in the forest-steppe region tend to settle the winter camps on the thermal belt on a slope, the micrometeorological observations were carried out from August, 2008 to March, 2009 at the winter and summer camps of Mr. Chuluun, a herder who lives in Bulgan prefecture in Mongolia. Results of the verification of how herders utilize the microclimatic conditions in their pastoral animal husbandry, namely, the traditional knowledge of herders concerning the selection of the camps are as follows:

Temperatures of the two camps during the observation period show that the place for the summer camp tends to be lower especially at nighttime. As the altitude is about 80m higher at the winter camp than at the summer camp, it indicates the occurrence of the temperature inversion. The inversion is largest during cold season and the maximum difference of 13.6 degree Celsius between the two camps was observed at 8 o'clock on February 11, 2009.

Hourly velocity of wind in the two camps show that the wind speed is stronger in the summer camp, and the wind exceeding 4m/s is less observed in the winter camp. On the other hand, wind tends to stop more often at the summer camp, which is more obvious during cold season. Though the reason is not investigated here, this phenomenon may be related to the evidence that the cold air is unlikely to accumulate at the winter camp.

Results of the temperature and wind observations at the camps show that the place for the summer camp is colder and more windy compared with that for the winter camp. This is consistent with the traditional knowledge of the herders. The tendency of the temperature inversions between the two camps indicate that the winter camp is settled in the thermal belt while the summer camp is settled at its foot.

Experimental study on soil respiration during freezing-thawing cycles

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We focused on the ecosystem respiration from semi-arid grasslands during freezing-thawing cycles. The experiment was conducted in the growth chamber for cold-arid environments of ALRC. CO₂ flux was measured by a closed-chamber technique at a interval of 30-min under 24-hour temperature cycles which ranged between -10 C and 10 C. We found a reasonable result that the CO₂ flux was zero while the soil sample was frozen and CO₂ was released from the soil when thawed. However, we failed to control soil moisture of the sample in our experimental design. We will improve our experiment system and continue the study.

Trends of industrial development in arid land

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It used and it took a general view of the statistical material with mining resource development and for the industrial development in arid land. Up to now, arid land has tended to be considered as a place for mining resource development. It turned out that the city where new industry was assumed to be a base and economy was developing existed in arid land. It will be thought that it is necessary to examine the possibility of industrial development on arid land for the development of a sustainable region on arid land in the future.

Prediction of yellow-dust using MODIS imagery

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This research aims to develop a prediction method of yellow-dust generation using MODIS satellite imagery. In this year, potential of soil-moisture estimation via the land surface temperature was evaluated, as surface temperature is provided by MODIS and the soil-moisture condition strongly relates to yellow dust. Surface temperature is difficult to apply as a direct indicator of soil moisture, even though it shows a strong correlation with soil moisture, because the absolute value of surface temperature is affected by the day, time, location and surrounded micrometeorological conditions. Thus, upon using the temperature as index of soil moisture, a normalization technique of surface temperature, such as MTVDI, pioneered by Kimura (2007) and Senay et al. (2007) is useful. We evaluated the potential of MTVDI, as an indicator of

soil-moisture using the actual measured radiation and meteorological data of Shenmu, China. The evaluation was limited to 11:00am (typical satellite image time) of clear-sky days for future application with satellite imagery. The evaluation result indicated that the temperature index is applicable to estimate soil moisture during May and September when the minimum surface temperature does not reach to zero degree Celsius. This result, with additional research using satellite imagery, enables to evaluate large-scale distribution of soil moisture at the potential sites of yellow-dust generation during summer time. Estimation of soil moisture from MTVDI is difficult in winter, probably because the freezing-melting process of soil water disturbs the relation between MTVDI and soil water. However, risk of yellow-dust would be low in winter time at the study site, if considered the long period of snow-cover during winter. An interesting future study topic is to determine MTVDI without using ground-based weather observation. This technique enables to estimate global evapotranspiration (ET) purely by satellite imagery, which will be a big repercussion of this study.

A study on small wind turbines suitable for arid land

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Wind power, which is clean and renewable energy, is one of the promising energy sources useful for people in arid lands, as well as solar power. Especially, wind power would be the optimal selection in the dry areas located at middle or high latitudes with strong wind and relatively less hours of sunlight. However, in the present state of affairs, small wind turbines have many problems, like expensive introductory cost, lower energy efficiency than large-scale wind turbines, and low durability.

The goals of this study are to find out the optimal control methods for wind turbines installed in arid lands and to develop small wind turbines suitable for arid lands. For those purposes, natural wind variation patterns were analyzed and response of a wind turbine to the wind variation was investigated with both the data of the small vertical wind turbine installed in the Arid Land Research Center and the data of the wind measurement system installed near the wind turbine. In order to investigate the characteristics of speed variation of natural wind in the time domain of several seconds, a method of detecting specific wind speed patterns by using both correlation coefficient and root mean square (RMS) was proposed in this research. With that method, triangle-like wind speed patterns, which are often observed in natural wind variation, were detected from the wind data measured by a propeller-type anemometer. From the results of detection, we confirmed that the Λ -type patterns tend to have the maximum peak at one-third of the pattern width and, on the other hand, that the V-type pattern tend to have the minimum peak at two-third of the pattern width. Furthermore, investigation of the rotational response of the small vertical wind turbine to the specific wind patterns showed that the change-width of the rotational speed tends to become large as the initial wind speed of the pattern becomes large.

Modelling of transpiration for Caragana stand

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Evapo-transpiration of Caragana Chumulagu was modeled with meteorological parameters that are commonly observed in the world. Daily evapo-transpiration of Caragana plants in 1/5000a pots were measured by reduction of weight of pots and potential evapo-transpiration by Makkink method, leaf area and soil moisture are parameters for the model. Evapo-transpiration for the pots with sufficient soil moisture (Etp: g / day) is given as follows:

$$E_{tp} = (0.0106 \times LA + 14.8) \times R_s (\Delta / (\Delta + \gamma)) + 64.8$$

Where, LA, R_s , Δ , γ are leaf area (c m²), daily solar radiation (mm / day), gradient of saturated water vapor curve (hPa / deg), psychrometer constant (hPa / deg), respectively. When soil moisture is not enough, CWSI (crop water stress index) is given as follows:

$$CWSI = -0.636 \times \ln(C_v) + 2.12$$

where, C_v is the soil volumetric water content. In conclusion, 1/5000a actual evapo-transpiration for Caragana were planted in pots (E_t : g / day) was give as follows:

$$E_t = (0.636 \times \ln(C_v) - 1.12) \times (0.0106 \times LA + 14.8) \times R_s (\Delta / (\Delta + \gamma)) + 64.8$$

A study on water making system using renewable energy in arid land

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In this work, the development of electric power and water production system utilizing renewable energy such as wind and solar energies was performed to combat the desertification and to support greening the desert. The main researches on wind turbines suitable for desert environment and water maker for obtaining fresh water from the moisture air were carried out.

The novel multi-stages water maker using the Pertier device has been developed. The water maker unit which the Pertier devices are placed is stacked vertically. Experiments were conducted in a controlled chamber under several conditions of constant temperature and relative humidity. The effects of the electric power supplied to the Pertier device, the equipment configurations and the air-flow rate in the cooling channel on water production rate were investigated in the experiments. From the results, the empirical equation was conducted to predict the amount of water production from the temperature and relative humidity of the air, the configuration of the device, and the amount of supplied electric power.

The numerical analysis was carried out about the phenomena of cooling and condensation of the moisture

air in the cooling channel of the device. The basic equations about mass balance and heat balance of the air in the cooling channel. The model for numerical analysis was also proposed by simplifying the channel configuration. The numerical results of the air temperature in the channel were qualitatively agreement with the experimental results.

Wind tunnel tests for the straight-bladed vertical-axis wind turbines were carried out. It was assumed that the system would be installed in the cold and arid region in the northwest of China. Moreover, the wind turbine was imitated in the case of the attachment of icing or snow and roughness by sand dust on the blade of the turbine. According to the results, the attachment reduced the steady revolution and power coefficient of the straight-bladed vertical-axis wind turbines, and the reducing rates became larger as the weight of attachment and wind speed increased.

The results and the problems of the Chinese policy of reverting forests and grasslands to farmlands

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Because there are quite a few semi-arid and arid areas in north China, it seems possible to incorporate farmers as industrial workers and urbanize the whole area.

China has the highest foreign currency reserves in the world and it is reported that the amount reached 2 trillion dollars recently. China should import mutton, wool, cashmere in order to reduce the pressure on the stock production in the areas of desertification and supply the people with the imported goods. It is better for China to invest for preventing desertification and for protecting environment that to buy U. S. government bonds. The attempt to expand the consumption of chicken is also necessary. It seems possible to do so since the consumption of chicken is much larger than that of mutton in Japan.

Studies on liquid water and solute movement in unsaturated coarse porous media

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Pressure head showed hydro-static profile at the area from free water surface to 8cm high under the drying process in coarse porous media. In the area higher than 8cm from free water surface, pressure head did not show hydro-static. Therefore, former is capillary area and latter is pendular area.

Though at the pendular area, EC did not respond, EC increased at the capillary area.

Consequently, soil water in liquid phase could transmit pressure and move solute at the capillary area. However, at the pendular area, soil water is not able to transmit pressure, nor to move solute. Hence one is not use Darcy's law and Fick's law at pendular area to represent solute movement.

Effect of vegetation on groundwater in arid environment

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Laboratory column experiment was performed, in order to examine the effects of plant water use on groundwater and soil in the arid environment. The soil column was filled with mixed volcanic ash soil with dune sand. We selected *Epipremnum aureum* as the plant used in the experiment. The bottom of the column was connected through silicon tube to a Mariott pump filled up with a mixed solution which modeled saline groundwater. The column was sufficiently flushed with tap water before the start of the experiment. The vegetation was planted on the soil surface and the experiment was conducted for one week. After the experiment, the column was divided into ring segments and plant roots were removed. Part of the soil segment was used to measure water content and the rest was divided into solid phase and liquid phase samples by centrifugal separation. Sample solutions were analyzed for component concentration by ion chromatography.

The following results were obtained. Vertical distribution of the root dry weight decreases from soil surface to the bottom of the column. This shows negative correlation with the water content distribution. Change in weight of the whole column peak at around 1:00 p.m., and the temperature peak at around 12:00 a.m. It was not clear if the increase in weight is related to the water extraction by plant evaporation. However, it is clear that this experiment mimic the rise and descent of the groundwater level. According to the vertical profile of cation and anion in the liquid and solid phases, the soil column was affected by the influence of the modeled groundwater. From the distribution of adsorbed cation, Na⁺ was adsorbed and Mg²⁺ was desorbed at the lower part of the column because relatively large amount of Na⁺ was added in the modeled groundwater. From the distribution of adsorbed anion, almost the same amounts of SO₄²⁻ and Cl⁻ were adsorbed. Anion exchange reaction may not have occurred. Because of the relatively high concentration of Cl⁻ in the modeled groundwater, SO₄²⁻ strongly adsorbed. Vertical profiles of CEC and AEC were not constant and it became clear that they were affected by the influence of the modeled groundwater.

Evaluation and modeling of the water balance in a water harvesting system in the Loess Plateau, China

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The objectives of this study were evaluation and modeling of the water balance in a water harvesting system (fish-scale-pit: FSP) in the Loess Plateau, China. In this physical year, we focused on the evaluation of the water balance in the field. The results from the experimental site showed that the normal FSP was not necessarily effective in water storage in dry year. On the other hand, the FSP covered with gravel mulch reduced water evaporation from soil surface and this allowed rainfall recharges to the deep

soil. Monitoring of the soil surface condition in the FSP was started using a field camera system. Simulation of water movement in the FSP will be conducted using the observed data and Hydrus 2D/3D model.

Physiological evaluation and linkage disequilibrium analyses on drought tolerant-related characters in isogenic wheat lines and synthetic wheat lines

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Some lines in *Aegilops tauschii* that is the wild relative of common wheat might be possible to grow even on dry ground where common wheat cannot be grown, and these maintain a useful gene that relates to the drought tolerance. In this study, the physiological evaluation of the character related to the drought tolerance of the synthetic wheat bred by hybridizing *Aegilops tauschii* with a different origin and durum wheat cultivar, 'Langdon'. We also searched SSR marker tightly linked to the drought tolerance genes by linkage disequilibrium analysis.

As the results, the following three became clear.

1. Photosynthesis rate and dry weight of above-ground part decreased by the soil dryness in all lines. Four drought tolerance lines (604, 605, 609, 615) and three receptivity lines (603, 606, 618) were selected from these decrease rate in the dry area to the humidity area.
2. We selected 31 markers which have length polymorphism and found 4 markers (cfd61 (1D) 、 barc62 (1D) 、 gwm213 (4D)) tightly linked to the drought tolerance genes by linkage disequilibrium analysis.
3. Dry weight of above-ground part, photosynthesis rate, stomatal conductance, and water potential decreased by the soil dryness in all lines. We found one line, 609 had useful characters for drought tolerance because its decreasing rates of the dry weight of above-ground part and the photosynthesis rate were lower than those of Cham 6 and PS with drought tolerance. Moreover, photosynthesis might be chiefly controlled by the stomatal aperture because the correlation was found in the photosynthesis rate and the stomatal conductance.

Ecophysiological studies on noxious weeds in semi-arid areas

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The root parasitic plant *Striga hermonthica* constrains the production of several agronomically important poaceous crops in the arid and semiarid tropical regions of Sub-Saharan Africa. The parasite is incompatible with the model legume *Lotus japonicus*. Studies at the molecular and metabolic levels revealed that expression of the genes involved in the biosynthesis of vestitol, a legume-specific phytoalexin, was highly up-regulated in *L. japonicus* roots after challenge with *S. hermonthica*. High-performance liquid chromatography and mass spectroscopy demonstrated the presence of vestitol in

the exudates released from *L. japonicus* roots inoculated with *S. hermonthica*. Fluorescence, similar to that emitted by authentic vestitol, was observed on the surface of *L. japonicus* roots after challenge with *S. hermonthica*. Vestitol exerted limited inhibitory effects on *S. hermonthica* germination, but it significantly inhibited seedling growth. These results indicate that vestitol contributes, at least in part, to the host's defence mechanism and acts as a chemical barrier against the intrusion of *S. hermonthica* into *L. japonicus* roots.

Enhancing drought tolerance in wheat via improving the root permeability

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The objective of this study was to improve the drought tolerance in wheat through the root permeability for soil water uptake.

The transpiration of wheat germplasm developed at International Center for Agricultural Research in the Dry Areas (ICARDA), Syria, was investigated under soil water deficit conditions to characterize their drought tolerance performances. The experiment was conducted at poly-house rain out shelter set at Hokkaido University where drought environments could be created. Four wheat lines which were evaluated on their field performances under drought environments at ICARDA and 2: Arid Land Research Center, Tottori University (ALRC) were used; Cham6 (good performance under irrigated condition, as control), SW10 (drought tolerant line), SW8 (drought susceptible line), SW15 (poor performances under either irrigated and drought conditions). The seeds of each line were sown in 4.5L capacity pots on 27 April 2009, and the plants were cultivated in randomized block design with 7 replications. The pots were covered with polyethylene bags to prevent the soil water loss through evaporation. The daily evaporation was estimated by the previous day pots weight subtracted from the present pots weight during the experimental period. From 47 days after sowing, irrigation treatments, viz., optimal irrigation and withholding irrigation (drought), were put, and the relative transpiration ratio of the drought to irrigation treatment (RTR) was calculated to estimate the stomata sensitivity of each line to soil water deficit (Muchow and Sinclair, 1991). The threshold value where the RTR was sharply dropped was defined as the stomata closing point. The experiment was terminated as the RTR reached at 0.1. The shoot biomass, leaf area and root biomass was measured at the irrigation treatment initiation stage, stomata closing point, and experiment termination. The climatic conditions were monitored throughout the experimental period

Based on the results, the wheat lines tested in this study could be characterized as follows;

Compared to SW8 and SW15, Cham6 could hold the RTR at 1.0 even under more soil water depletion situation when the RTR of SW8 and SW15 was already dropped, which indicates Cham6 could maintain the stomata opened under severe drought condition. Interesting observation was made that the transpiration per unit root length on Cham6 was larger than the other lines, indicating higher water permeability of root systems on Cham6. In contrast, the roots of SW10 showed lower water permeability, which supported the results obtained at ICARDA and ALRC that SW10 showed conservative soil water use, and consequently this line could utilize the soil water at the maturity stage through which some seed yield could be always secured. In the transpiration efficiency (TE), it was higher in the drought treatment than the irrigated

treatment in all lines. There was no significant difference in TE among the lines under irrigation treatment, but Cham6 showed higher TE than the others under the drought treatment. This indicates that Cham6 might have effective growth (photosynthesis) mechanisms resulted from less unnecessary water loss.

The results obtained in this experiment were fairly interesting and encouraged us to continue this research activity. In next year experiments, the stability of these results could be evaluated.

I really appreciate Arid Land Research Center that kindly accepted me as a collaborator in 2009, and expect to continue this collaborative research in the next year very much.

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

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<Japanese pear>

1. Native mediterranean pear rootstock species *P. amygdaliformis* which shows strong salt tolerance and native Japanese pear rootstock species *P. calleryana* were hybridized, and the hybrid seedling was obtained. Next year, the selection as the salt tolerant rootstock species that has compatibility in Japanese pear will be done.

2, The addition of calcium in the growth medium was effective for ameliorating the excessive NaCl stress of Japanese pear rootstock seedlings.

<Apple>

Salt tolerance of apple rootstock species JM1, JM 2, JM 7, Aodai 3, *Malus prunifolia*, M 9 and M 27 was compared. However, we did not identify the difference because cutting of new shoots which is the standard method for Japanese pear was might not good for apple rootstocks. Next year, we will try again the same experiment except the shoot cutting.

Elucidation of the phototolerance mechanism in the transgenic tobaccos that have higher capacity to detoxify lipid aldehydes

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2-Alkenal reductase is an antioxidant enzyme that detoxifies the lipid peroxide-derived reactive aldehydes (RAL). Transgenic tobaccos that overproduce AER (AER lines) have tolerance to oxidative stress such as paraquat or strong light. In this study, aiming at elucidating the action of RAL on photosynthesis, we investigated the mechanism of phototolerance of the AER lines. AER lines showed tolerance to strong light

in the presence of CO₂ at the atmospheric level, but did not in the absence of CO₂. We found that AER had higher CO₂ fixation under saturating light than the wild type. These results suggested that the potential suppression of photosynthesis by RAL that are constitutively generated in leaves. It was expected that AER lines grow better than the wild type under strong light, but shoot dry weight after growth at 1000 $\mu\text{mol}/\text{m}^2/\text{s}$ was not significantly different between the AER line and wild type. Because a preliminary result suggest that the phototolerance of AER lines is more remarkable in senescing leaves than in young leaves, we build a new hypothesis that RAL affects Rubisco turnover in senescing leaves.

Scoring traits related to water loss and water uptake in leguminous plants differed by drought tolerance

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Crops tolerant to drought achieve preferable water relation as controlling water loss by transpiration and water supply from a root system. Controlling water relation is very complex because several traits are involved in it. Thus, it is usually difficult or time-consuming to quantitatively determine the extent of contribution of the traits to drought tolerance. Leguminous crops, e.g. cowpea (*Vigna unguiculata*), in arid area develop their drought tolerance through reducing water loss by closing stomata and restricting leaf area growth, and through increasing water supply by growing roots and enhancing efficiency of water transport. Quantifying or scoring contribution of each trait to water balance in plants will avail for selection on developing varieties at seedling stage.

Objectives of this study are:

- 1) identifying genetic variations in response of shoot and root growth, stomata and root hydraulic conductance to water shortage in cowpea and common bean
- 2) quantifying contribution of traits related with water balance through quantifying responses of the traits to water shortage

Seedlings of cowpea varieties and common bean were raised in 1 L plastic pots arranged in a growth chamber (Sub-tropic Desert Simulator) at ALRC and a vinyl house at Yamaguchi University. Limited water adjusting soil water content to 0.04 g/g was initiated approximately 3 weeks after sowing. All seedlings of cowpea varieties and common bean showed similar degree of stomatal closure under water deficit, and diminished development of leaf area. It can be concluded that there were less or no diversities in stomatal response to water deficit. Hydraulic conductance of roots reduced in the course of drought period regardless of species and varieties of cowpea. During the water deficit, any seedling except a drought tolerant cowpea variety could not increase root length. Measurements of hydraulic conductance of a root system suggested that increase in root length of the drought tolerant variety resulted in high ability in water transport through a root system.

The results indicated that quantification of traits controlling water uptake and total transpiration could allow to quantitative characterization on strategies for drought tolerance. This study also indicated that root growth under dried soil could be related to drought tolerance in cowpea.

Studies on the genetic variability on oil plant, *Jatropha*

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The final goal of our R & D is to produce the environmental stress tolerant *Jatropha* (*Jatropha curcas* L) by the application of the gene modification technology.

This year, we selected the Thai-variety *Jatropha* as a host line of transgenic *Jatropha*. Which has ideal physiological properties (e.g. Oil productivity, germination rate, growth rate), and is free from licenses or any other constraints.

The stems of this variety were transplanted from the Tottori University ALRC to Osaka University. The transformation experiments using this variety are currently being progressed.

Jatropha is being cultivated as a next generation's biofuel plant in Mexico. To investigate the local *Jatropha* cultivation of where, Dr. Ando and Dr. Cartagena made inspections in terms of the environmental condition, the local cultivar and the method of squeezing oil.

To discuss the next year's joint research plan, Dr. Fukui, Dr. Matsunaga, and Dr. Kohinata visited Tottori University and met Dr. Tsunekawa, Dr. Ando and Dr. Tomemori and Dr Tsujimoto. Then they proposed the joint research of the next academic year.

Comparative study on soil factor affected to biological production at desert

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Recover of grass and growth of crop were comparatively observed at pH9.0 shell fossil soil field in case of applied new ferrous iron.

Application of 5.0g Fe/m² in range of 0.5g to 5g was 20% affectively than other at recover of grass for sixteen month after sowing on Nihonkai shell fossil mine field.

New ironfertilizer and granular type fertilizer of oyster shell powder containing iron Fe5.0/m² were suited at upland rice in vinlhouse experiment to continue last year.

Fuether liquid type fertilizer containning 2.5%Fe were shown about 20% better growth of legume than contrast(-Fe field)under drop-irigation.

Influence of aeolian sediment on carbon and nitrogen dynamics of surface soil in the steppe region, Mongolia

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We report the age of the soil and the secular distortion of the surface soil properties in Mongolian steppe from 2004 to 2008. The result of 14-C age of pedogenic carbonate carbon was $11,600 \pm 57$ BP at deepest horizon. The results of soil organic carbon (OC) and total nitrogen (TN) contents of surface soil samples(0-5cm) in NG site increased from 2004 to 2006, but decreased in 2008. In contrast, OC and TN contents in G site were gradually decreased from 2004 to 2008. The result of soil particle size distribution showed no significant differences with age in G site, but in NG site, coarse sand content increased in 2008. The surface soil properties at NG site showed vary with the age, and affected by; 1) restoration of vegetation and deposition of litter; 2) Aeolian deposition of coarse sand and decrease of clay content.

Estimation of grassland production in Loess Plateau China

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[Study Contents]

A numerical simulation was carried out with TERC-RAMS which was one of the numerical weather prediction model to develop the meteorological data set for the plant production model of alfalfa in Loess Plateau, China. The results of simulation were compared with the observational data derived at the observational site which is located at the watershed of Liudaogou, and verified the adaptability for the net primary production(NPP) model of alfalfa.

[Condition of simulation]

Model:TERC-RAMS VER.3.0.

Boundary condition: NCEP/NCAR reanalysis data set.

Object place: Loess Plateau, China.

Period: March to August in 2007.(The dry matter weight of alfalfa were derived in this period at the test site.)

Topography: The SRTM-3 lattice topographical data(horizontal resolution is 90m) which is open by NASA. High-resolucional prediction for the area of about 9 square kilometers became possible by the technic of four phases of nesting.

[Results]

The result of simulation about air temperature near ground surface was compared with the observational value, and it was about 10 degrees Celsius higher in the seasonal variation. Because Loess Plateau is located in the deep inland and the ocean cannot be included in the first domain, it is thought that the interaction between land and ocean were not reflected in the simulation. But the precision of prediction was good in the diurnal variations. It became clear, if we can derive the observational date about air temperature within the domain, we can correct the error by a simple linear regression analysis.

The result of simulation about global solar radiation was compared with the observational value. The precision of prediction of solar radiation was good in sunny days. There was seen some days when the diurnal variation was not reproduction cloudy days. Because the model sometimes mistakes the appearance of the cloudy day. However, it was thought that the effect to the plant production is restrictive.

Therefore, as for the quantity of solar radiation, it became clear that the precision of prediction is acceptable to drive the NPP model of alfalfa.

In other words, it was able to confirm that TERC-RAMS could reproduce the distribution of air temperature and global solar radiation from spring to summer at the watershed of Liudaogou, and it was usable for the input of the NPP model of alfalfa.

[Further study]

We will make the simulation of the horizontal distribution of potential NPP of alfalfa during 2007-2008 years and make a comparison with the dry matter weight derived at the test site. So it is possible to evaluate the influence of water stress for alfalfa at the test site.

We will evolve a model to evaluate the water stress from the precipitation and the soil water content with TERC-RAMS and calculate the horizontal distribution of the balance between water stress and NPP. From the balance, we will be able to develop the danger map of desertification.

The effect of soil microorganisms on water and salt stress resistance of trees

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The trees of Japanese black pine, *Pinus thunbergii*, are supposed to be a good model of the plants distributing in arid and semi-arid regions. We have examined the role of symbiotic microorganisms in facilitating water relationship of Japanese black pine. The facts we have revealed so far are, (1) mutualistic ectomycorrhizal fungi improve drought tolerance of host pines by supplying water sparsely distributed in sandy soil, (2) bacteriophagous nematodes inhabiting rhizosphere of pine trees keep water content of sandy soil, (maybe due to the increase in bacteria population) thereby improve pine growth.

Studies on social development in the Loess Plateau

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Desertification of the Loess Plateau has a considerable impact on the lives of inhabitants (Nawata 2009a). It is important to address questions such as the following: How do human activities affect the process of desertification on the Loess Plateau? How can scientists apply research to local development on the Loess Plateau? Tottori University and the Institute of Soil and Water Conservation at the Chinese Academy of Sciences have already made several achievements through cooperative research. More integrated approaches will also be needed, incorporating diversified evaluation standards in land and resource management. These will require synthesizing the analytical methods and research achievements from the fields of natural science and the humanities/social sciences (Nawata 2008a).

Scientists in the fields of natural science and humanities/social sciences tend to approach issues in differing ways. Coordination and cooperation can develop only when specialists in every field of science try to understand methodologies that differ from their own and respect the research results produced by other experts.

As the first step in the process of fusion, it is important to consider the various analytical methods and perspectives used to assess the sustainability of life on the Loess Plateau and determine which are the most appropriate. Subjects and phenomena are equally important aspects of research. In order to handle livelihoods using the same scale and level, it will be necessary to determine first, how an integrated theoretical framework can be developed and second, what kinds of subjects and phenomena should be investigated. This paper develops a possible theoretical framework by first, assessing four analytical methods used in humanities/social sciences to explore lifestyles and second, identifying concrete subjects and phenomena to investigate at a village level.

The four analytical methods can be incorporated into a theoretical framework for combining the humanities/social sciences with natural science. These methods include 1) geography research methods (spatial elements analysis), 2) history research methods (temporal elements analysis), 3) ecological economics research methods (quantitative elements analysis), and 4) cultural anthropology research methods (qualitative elements analysis) (Nawata 2005).

Experimental studies on the salt tolerant characteristics of halotolerant plant and remediation and conservation of the saline soil

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Two experiments using hydroponic culture were conducted to evaluate the influence of salinity concentration in soil water on the growth of *Tamarix Austromongolica*. The cuttings with 20cm in size were fixed with the float boards, after they were cultivated in soil bed for 3 months. The boards were floated in 1/5000a Wagner pots of 2 liter culture solution adding NaCl for 5 weeks. In the first experiment, 4 experimental sections each of which included 6 Wagner pots were prepared in June, 2009, the NaCl concentrations were 0ppm, 10,000ppm, 40,000ppm, and 70,000ppm, respectively, and the differences of growth of *Tamarix* among these sections were observed. In the second experiment, another 4 sections were prepared in August and the NaCl concentrations were 0ppm, 10,000ppm, 20,000ppm, and 30,000ppm, respectively, according to the result of first experiment. As a result, the *Tamarix* cultivated with 10,000ppm of NaCl grew steadily equally as those with 0ppm, those with 20,000ppm and 30,000ppm hardly grew, and those with more than 40,000ppm died down. These experiments and another experiments using saline soils conducted for 4 years in our laboratory indicate the results that it is important for growth of *Tamarix* to reduce the NaCl concentration in the soil water around the root system.

Nitrogen mineralization process in semi-arid soils

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We investigated the effects of water and nitrogen addition on N mineralization rate of oak and black locust forest soils in Mt. Gonglushan, near Yanan, China. We conducted short term soil incubation under four treatments, i.e. control, water addition, nitrogen addition and water and nitrogen addition. As a result, net N mineralization rate of soils with water addition was almost the same as the value of control treatment, however net N mineralization rates of soils with nitrogen addition and with both water and nitrogen addition were higher than the value of control treatment.

Evaluation of salt tolerance and water and nutrient use of coastal plants using stable isotopes

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The relationship between the salt tolerance of coastal plants and the environmental conditions was examined on the Tottori Sand Dune to find the factors affecting the plant distribution on coastal sand dunes. Three study plots with different distances from the shoreline (the fore-, mid-, and back-dune in this order) were set on the dune. Soil moisture and salinity were measured on the fore-, mid- and back-dunes to evaluate the environmental gradient from the shoreline to the inland. Leaf and stem samples were collected from the five species, which were grouped by their distributions into the fore/mid, mid, and mid/back dune species. The long-term trend in water-use efficiency was estimated for the five species from the carbon isotope ratio of leaf organic matter. The long-term trend in stomatal conductance was also estimated from the oxygen isotope enrichment of leaf organic matter, defined as the difference in the oxygen isotope ratio between leaf organic matter and stem water. While the soil moisture was low at all points on the dunes, the soil salinity was significantly higher on the fore-dune than the mid- and back-dunes. The carbon isotope ratio of leaf organic matter in the fore/mid dune species was significantly higher than the mid and mid/back dune species, suggesting that the salt-tolerant species tended to have higher water-use efficiency. While the carbon isotope ratio of leaf organic matter in the fore/mid-dune species increased with increasing soil salinity, the oxygen isotope enrichment of leaf organic matter did not respond to the soil salinity. These results suggest that the plants increasing the water-use efficiency without decreasing stomatal conductance may dominate in the high-salinity fore zones of Tottori Sand Dunes.

Functional coordination between reduction and recover of xylem hydraulic conductivity in Salix woody species

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Vulnerability in hydraulic conductivity and refilling capacity were evaluated in terms of stomatal regulations of water loss and CO₂ uptake, using potted cutting tree of five Salix tree species growing in arid, semi-arid and humid area of temperate region; *Salix psammophila*, *Salix cheilophila*, *Salix matsudana*, *Salix integra* and *Salix subfragilis*. In cavitation vulnerable species, photosynthetic rate (A), transpiration rate (Tr), stomatal conductance (gs) and wood density (Dt) were relatively low, and daily minimum values of xylem water potential (Ψ_x min) was high. These species showed rapid recovery of hydraulic conductivity after release from water stress. While, cavitation resistance species appeared to have high A, Tr, gs, Dt and low Ψ_x min. Rapid recovery of hydraulic conductivity after its release was not observed in these species. These results suggested that cavitation resistance species could maintain the hydraulic function because of the xylem anatomical resistance to cavitation from high Dt (e.g. Hacke et al. 2000), although they did not have the high recovery capacity in hydraulic conductivity. In contrast, cavitation vulnerable species might perform water conduction by the constraint of the decrease in Ψ_x min with reducing water loss, besides by the capacity of rapid vessel refilling even though vessels lose their conductivity through water stress.

Evaluation of pore-air behavior in unsaturated soil and its influence to hydraulic conductivity

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In this research, a simple method for estimating the water characteristic curve from the drying characteristic curve measured by the laboratory evaporation test. The drying characteristic curves of unsaturated sandy soil were measured in a short time, and that the residual volumetric water content of water characteristic curve was determined from the drying characteristic curve. The inverse solution of the undetermined parameters in van Genuchten's equation for expressing the water characteristic curve was applied to the drying characteristic curve data. The water characteristic curve in the drying process estimated with the inverse solution was in good agreement with the measured one.

The influence of the diameter of specimen cylinder for the air permeability test on the measured coefficient of air permeability was evaluated. The value of air permeability coefficient is varied from the relationship between the diameter of specimen cylinder and the mean grain size of soil.

Research on Non-destructive measurements of unsaturated seepage flow by using Ground-penetrating radar in arid land

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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.

Experimental study on water saving by using capillary barrier of soil

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A simple soil layer system which is composed of a fine soil layer underlain by a coarse soil layer has a characteristic property of capillary barrier. Water infiltrated into soil is stored just above an interface between the fine and coarse soil layers due to a physical difference in water retention characteristics of the fine and coarse soils. As their roots can easily utilize the water stored in the upper soil layer, plants grow effectively even under water saving irrigation. In the study, an effect of water stored in the upper soil layer by the capillary barrier of the soil layer system on the plant growth was investigated in the sand soil field. Six experiment plots, each 70 cm wide and 90 cm long, were excavated into the depth of 40cm and veneer sheets were placed to retain soil wall, then the sand soil was filled back into the first two of six experiment plots along all the depth. A gravel layer 10 cm in thickness was placed at depth of 10 cm in other two experiment plots and at depth of 20 cm in the remaining two experiment plots. Potherb Mustard was seeded and thinned after about three weeks in all the experiment plots. Soil water changes in the experiment plot were measured after the plant seeding. At about 35days after the plant seeding, Potherb Mustard was harvested to measure plant height as well as dry mass of plant. It is found that (1) the infiltration water was effectively stored in the upper soil layer by the capillary barrier of the soil layer system, and (2) the water stored in the upper soil layer affects significantly the plant growth. Further studies are required to examine the effect of the capillary barrier of soil on the plant nutrition and to investigate the barrier property against salt concentration caused by capillary rise of groundwater.

Studies on leaching mechanism concerned density flow

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We measured water and salt behavior during leaching in soil columns which have produced salt accumulation artificially. Experiments were conducted using in columns with 5.0 cm in diameter. The following result was obtained. It has been found that leaching water amount of 50 mm was most efficient and .water supply by one time was more efficient than by two times.

Preferential flow effect on solute leaching for sandy soil in arid land

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For ponded infiltration into initially dry, two-layer porous media systems with a fine-textured top layer over a coarse bottom layer, wetting front instability occurs below the interface between those layers. We developed a Green-Ampt based expression for the pressure head in a developing induction zone below the interface and performed one-dimensional experiments using a cylindrical chamber with a 2 cm diameter and a height of 30 cm under the condition of a 1cm ponding depth maintained constantly. In the case of glass beads, our model equation is found to be valid even at the interface and in the fine top layer, but, for sand material, the flow behaved stably and our model could not be applied.

Development of a new methodology for measuring continuous air content and air permeability in soil using sound resonance

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Acoustic method for evaluating continuity between the atmosphere and the soil air has not been investigated. We evaluated the impedance at the sand soil sample surface using sound resonance and estimated the amount of air connected to the atmosphere and its conductivity in the sample. Sand and glass beads were used for a comparison of the air conductivity estimated using the acoustic method and the conventional method based on Darcy's law for air flow. Our results showed that impedance measurement provided good estimate values of continuous air content. We can determine the proportion of continuous air in the sample using entire volumetric air content determined by usual, mass and particle density measurement. Our results also showed that air conductivity estimate was reasonable in most cases with the exception, where the air vibrating in the sample was not identical to that flowing. Our calculation

procedure was valid until the amount of air in the sample was less than 20cm³. There is a range of estimates, which depends on the particle diameter of the sample and it is about a few centimeters in sample length.

Measurement of fertilizer discharged from a yam field using cylinder wick samplers

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In this study, cylinder type of wick sampler with 5 cm in diameter and 30 cm in length (CWS) were installed in a Chinese yam field in Hokuei cho. I used two CWSs. One was installed at the center of this field and the other was set at about 2 m south. The depth of sampling face of both samplers was 30 cm from soil surface. The farmer who is the owner of this field, conducted management practices for the yam cultivation.

The amount of water collected by the north one (N-CWS) was around 75 % of the south one (S-CWS). This field was irrigated to protect sand drifting and to supply soil water once every two days by sprinklers. According to results of measurement of soil water, the effect of sprinkler irrigation doesn't reach the point at 30 cm in depth. However, the amount of soil water collected by a CWS was 100 to 250 cm³ in a week without rainfall. On the other hand, it was increase in proportion to precipitation and S-CWS collected soil water more than 1000 cm³.

Variation in solute concentration of sampling water was small between samplers because fertilizer was drilled along ledges in this field. In this case, an amount of fertilizer supplied was almost same on each sampler. The concentration of T-N was around 200 mg/l and one of T-P was around 50mg/l. These values are very large and indicate that percolation loss of fertilizer is very great. The drilling of fertilizer causes excessive percolation loss because the amount of fertilizing is designed for a large area but is supplied for a small area in practice. These result shows that using slow-release fertilizer and re-considering fertilizing method are required for a Chinese yam field.

Research on groundwater management using plant transpiration and water uptake

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As a remedial measure to prevent waterlogging, biological drainage is noteworthy due to low-cost as compared with physical drainage. We conducted a basic research to make clear the water-absorbing ability of a plant and its transpiration features using two units of "desertification mechanism analysis systems" which consists of weighing lysimeter covered with chamber. Using this system we controlled temperature at 25.1°C, relative humidity at 59.9% and wind speed at 1.2m/s. We selected *Jatropha* trees as experimental plants. We prepared three treatments in respective columns: fresh groundwater for Column 1, fresh water and mulch for Column 2, saline water with EC value of 3 dS/m for Column 2. We set an initial

groundwater level of -55cm in each column, we monitored groundwater level, soil moisture contents, evapotranspiration (ET), air temperature, humidity, and so on using respective sensors. The results are summarized as follows: 1) Groundwater level lowered by 3.8cm in Column 3, 2.6cm in Column 1 and 0.9cm in Column 2. 2) The observed 10days-ET was 4.89mm in Column 1, 2.099mm in Column 1 and 0.799mm in Column 2, respectively. 3) The growing condition of each treatment was good enough and was almost the same with each other.

The effect of soil water content on the initial growth of *Jatropha curcus* L.

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Vegetable growth and quality under different irrigation conditions

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The objective of this study was to investigate the effect of different irrigation conditions on the vegetable growth and quality of mizuna (*Brassica rapa* L. Japonica Group). Mizuna 'Kyomizore' seeds were sown in a greenhouse. The experiment was conducted using 4 treatments with 2 different irrigation rates and 2 different soil conditions. The two different irrigation rates were irrigated with amount of 1/2 and 1/4 evaporation. The two different soil conditions were sandy soil and using gravel which has function of isolating capillary under 30cm depth. The different irrigation conditions effected with the growth and quality of mizuna. The irrigated of amount of 1/2 evaporation with using gravel treatment was maximum growth. This treatment was supposed with maximum soil water content. Thus, the adapted irrigation rate might be more than the amount of 1/2 evaporation. On the other hand, the irrigated of amount of 1/4 evaporation in sandy soil treatment was maximum sugar and carotenoid contents. This treatment was supposed with minimum soil water content. Thus, these results showed that it might be possible to grow better quality of mizuna with decreasing of irrigation rate in the later growth stage. In the future, it is needed to study for better irrigation conditions to be better growth and quality of mizuna.

Effect of sulfur-organic compound on alkali soil in P.R.China

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Saline-alkaline soil is mainly spread in northeast China, which causes poor soil physical properties in addition to plants' growth difficulty by high pH. Addition of sulfur materials was proposed in order to improve alkaline soil. The objective of the present study was to clarify the effect of mixture of sulfur and organic matter on grape growth in saline-alkaline soil in Gansu Province, P. R. China.

As the results in the FY, more soil samples were collected on several fields in urban area from Lanzhou city to Yinchuan city than the last FY. Field test to fresh soil showed that pH was 8.25 ± 0.3 and electric conductivity was 5.71 ± 5.39 dS/m. Northeastern provinces such as Shanxi and Heilong Jiang were reported to have severer alkaline soil than that of Gansu provinces, many of which can exceed pH 10.0. In Gansu, saline soil can be stronger limiting factor of plant's growth than alkaline soil.

Three local soils were incubated with sulfur material in laboratory for about three months. Soil temperature for the periods and soil chemical properties after the incubation were determined, and denaturant gradient gel electrophoresis (DGGE) were analyzed. The increase of soil temperature confirmed in the last FY in pot trials was not observed. That is because the pot scaled was so small that heat came from the sulfur oxidization could easily leak.

Soil pH decrease was observed in every soil, however the range of pH reduction is different in soils; a soil with higher pH showed more pH reduction. A soil with higher pH showed greater sulfate increase. The result came from sulfur oxidization and release of proton. DGGE after two weeks' incubation showed that microbe composition were different both between soils and between sulfur material applications. Change of microbe composition between sulfur material application was much greater. Microbe metabolism concerning of sulfur and micronutrient in the material was estimated to activated in the early period during the incubation.

Seedlings were transplanted on saline-alkaline soil where seedlings used to have poor survival, i.e. less than 20%, whereas by addition of sulfur materials, the survival rate increased up to 80% and still remained 9 month after the transplanting.

Water-saving cultivation of grapevine in drylands

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Water-saving cultivation of grapevine was conducted using wick irrigation system. The data of transpiration rate of each days during experiment period showed the wick irrigation system can supply enough water to grapevine growth. The sugar contents of these grape fruit was higher than the ordinal cultivated one, however, fruit weight was lower than those one. These results suggested that the wick irrigation system using the study have to improve to supply more water to produce a higher quality grape vine.

The Utilization of Indigenous Technology for Water Resources and Rural Socio-Economic Development in Afro-Asia Regions

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We held a joint research seminar with Prof. Sekandar Amanolahi, Shiraz University, Iran on " The Impact of Modernization on traditional Society" at the Institute of Modern Asian Studies, Daito Bunka University, Tokyo during 28 May to 11 June, 2009.

The traditional Iranian Society has changed drastically under the forces of westernization and modernization. The 80% of population resided in rural areas in which case they were engaged in farming and herding.

At the beginning of 1960's, The big wave washed over rural society and land reform has changed the traditional structure of society and agriculture, pastoral stock farming. The 1970's, oil boom, specifically, oil-government revenue, has brought rapid industrialization and acceleration of modernization, 1980's, the impact of Islamic revolution, in other words, Islamic government has brought new policies against land, water and agriculture environment .

Iranian rural society and agriculture, irrigation environment has been changed drastically during these 50 years over.