

1. Research Activities (Apr. 2007- Mar. 2008)

1.1 Outline of Research Activities

(1) Center

Arid Land Research Center (ALRC) is an independent department of Tottori University and at the same time is a National Joint-use Research Facility. The mission of the ALRC is to conduct research on desertification and to develop sustainable agricultural practices in arid and semi-arid areas. The door is open to all teachers of universities who are engaged in this field of study.

Tottori University had undertaken the 21st COE Program “Program for Arid Land Science” for five years, terminated in March 2007. The 21st COE Program had contributed to promoting arid land science, development of human resources that made young scientists more creative and lead their scientific field, and establishing international networks of arid land science and education. For further development of the achievements of the last 21st COE Program, Tottori University applied the Global COE Program “Global Center of Excellence for Dryland Science” to the Ministry of Education, Culture, Sports, Science and Technology in 2007, and it was adopted.

The aim of this program is to construct the new arid land science that is unparalleled worldwide. The ALRC etc. (including the predecessor), have accumulated knowledge and technology of plant production and vegetation recovery in sands over the past 80 years. We are advancing this knowledge and technology to those that are used easily for the arid lands on the world. To achieve our goal, we fuse knowledge and technology of public health. The mission of this program is to contribute towards environmental sustainability through development of technical package that will be easily adopted by arid land inhabitants. Achievement of this objective forms the foundation of designing our national arid land science as a worldwide top-level program in this field. Consequently this will contribute to increasingly technological support of Japan as a UNCCD ratification country.

In 2001, we started for the Core University Program (by JSPS) focusing on combating desertification and developmental utilization in inner area of China between Arid Land Research Center, Tottori University and Water and Soil Conservation Research Institute, CAS in China.

Organization, Management, and Funding Subsidies

ALRC is managed by the Director, a Conference composed of professors and associate professors, a Board of Management composed of members from outside as well as professors of ALRC, the five research divisions, the office section and the technical section. In practice the Conference and the Board of Management operate our Center.

The five divisions are:

- 1) Climatology and Water Resources
- 2) Biological Production
- 3) Afforestation and Land Conservation
- 4) Socioeconomics
- 5) Health and Medicine

The full-time divisions from 1) to 4) have five professors, six associate professors, one Junior Associate professor and three Assistant Professor. The other division has one associate professor. The all division has two visiting professors and one associate professor from Japan and three visiting professors from abroad. In

addition, 13 project researchers are stationed at ALRC. Ten office staff (six clerks and five associate clerks), four technical officers and a research support technician support the research and education.

Joint-Use Research, Education, Publication

During the fiscal year of 2007, 59 Joint-Use Researchers (Teachers from national and private universities) were attached to the Center. The number of students as of October 2007 is 47 (19 Ph.D. Students, 18 Master Students, 8 Undergraduate Students, 2 Research Student).

Seminars were often held by a large number of internal and external experts. The foreign visiting professors periodically give seminars.

Annual report has been published since the establishment of ALRC, which provides a brief overview of the activities in its various divisions and also summarizes our research and education.

The seminar of Joint Research was held on December 4, 2007 at Arid Land Research Center, Tottori University.

On September 24-25, Core University Program 'CAS-JSPS Core University Program Japan-China joint open seminar on combating desertification and development in inland China of year 2007' was held in China.

(2) Divisions

1) Division of Climatology and Water Resources

Prof. Masato SHINODA (Climatology)

The climatological subdivision conducts research on eco-climate system dynamics in arid region; interaction between the large-scale climate and terrestrial ecosystems (including agricultural ecosystems) through water, energy, and carbon circulation. Focus is placed on climate change analysis in arid region, drought sciences, and early warning system of meteorological disasters. We also started research on dust emitting processes in Mongolia that are related to the arrival of dust to Japan. Major study topics are as follows: also focuses on land-surface processes generating the Asian dust.

- (1) Drought experiment in a Mongolian grassland
- (2) Climate memory dynamics of terrestrial ecosystems over the Asian-African arid region
- (3) Developing an early warning system of drought and dzud in Mongolia (JICA project)
- (4) Asian dust emission and land-surface (soil moisture, vegetation, and snow cover) conditions (Global COE program).

The Nobel Peace Prize for 2007 was shared between the Intergovernmental Panel on Climate Change (IPCC) and Albert Arnold (Al) Gore Jr. for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change. I have been serving as author or expert reviewer of the Second to Fourth Assessment Reports of the IPCC.

Prof. Hisao ANYOJI (Irrigation Engineering)

The irrigation engineering subdivision is carried out research on efficient use of water in irrigation, accurate estimation of plant transpiration and soil evaporation and reduction of soil evaporation in irrigation in order to prevent the desertification and to develop the sustainable agriculture in arid and semiarid regions.



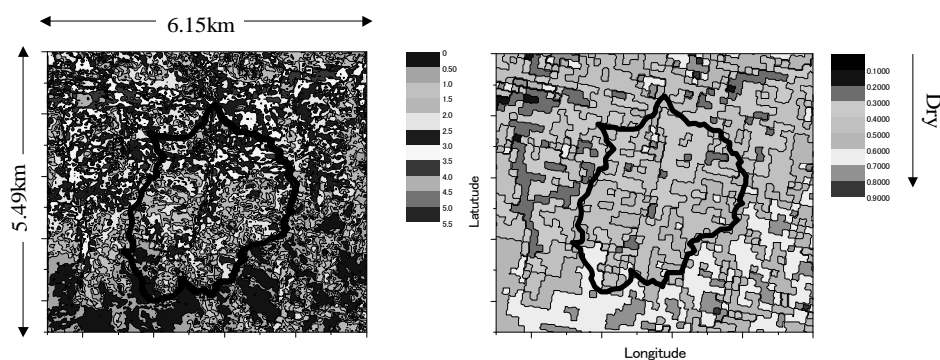
In 2007, our efforts in Japan have been made to carry out research on hydraulic design of irrigation systems, partitioning of plant transpiration and soil evaporation from evapotranspiration and reducing of soil evaporation by sand mulch. We collected data on irrigation at the national water research center in Egypt. Also, we investigated many big irrigation projects in Egypt with researchers in the national water research center.

Cooperative researches had been conducted with the following researchers: Professor Nishiyama, S. (Faculty of Agriculture, Yamaguchi University), Associate professor Noborio, K. (Faculty of Agriculture, Meiji University) and Dr. Aoda, T. (Faculty of Agriculture, Niigata University). The titles for these research projects are listed in the joint research section of this Annual Report.

Assoc. Prof. Reiji KIMURA (Meteorology)

The Meteorology Subdivision conducts research on the monitoring and modeling of the land surface humidity using the meteorological data and remote sensing techniques, especially in the Loess Plateau, China (see the figures). In addition, study on the dust outbreak started under the fund by Global COE program. Main topics is to make clear the effect of vegetation cover and surface soil water content on the dust emission in East Asia: China and Mongolia.

Overseas research activities during the fiscal year include visits to the National Water Research Center (NWRC) of the Ministry of Water Resources and Irrigation (MWRI), Egypt, under the fund by KAKENHI (19405037) (Project leader: Kunio Hattori).



Spatial distribution of ET (Left side) and wetness index (Right side) on July 2, 2004 in Liudaogou river basin, China.

Assoc. Prof. Hiroshi YASUDA (Hydrology)

The Hydrology Subdivision conducts research on precipitation, groundwater, soil water and erosion in order to evaluate the hydrological environment in arid land. The research topics in this fiscal year are:

- Hydrological environment of a dam farm land in Chinese Loess Plateau.

- Analysis of precipitation time series in Chinese Loess Plateau.
- Infiltration characteristics of soil in Sinai, Egypt.

As overseas activities of this year are:

Field survey in Chinese Loess Plateau (2 times).

Attendance to the Joint seminar in Yanglin as the substitute of the leader and subleader.

Lund Institute of Technology for analysis of field experiments in Sinai of Egypt.

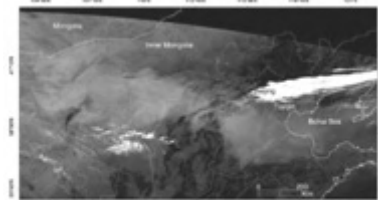
Evaluation of effects of habitat fragmentation by man-made structures on endangered Ungulates in Mongolian grasslands.



2) Division of Biological Production

Prof. Atsushi TSUNEKAWA (Conservation Informatics)

The Conservation Informatics Subdivision conducts research on the monitoring and modeling of the plant production and ecosystem change in the dry lands. Particular efforts are being made to clarify the interaction between the atmosphere and the land surface (vegetation and soil) through water and dust, and to develop methodologies for evaluating the sustainability of ecosystems and local communities in dry lands. The research of the subdivision is driven by combining the use of information technologies such as numerical modeling, remote sensing and geographic information systems (GIS); field observations; and experiments using Center's facilities. The main research topics in the fiscal year were as follows:



Yellow dust observed by MODIS on 28 April 2005.

- Monitoring the habitat environment of Mongolian gazelles in the steppe
- Monitoring the Yellow dust from Northern China (see the figure)

Research grants in the fiscal year include:

Evaluation of effects of habitat fragmentation by man-made structures on endangered Ungulates in Mongolian grasslands

Japan Society of the Promotion of Science Grants-in-Aid for Scientific Research (A), 2006-2009
(Project Leader: A. Tsunekawa)

Overseas research activities during the fiscal year include visits to the Institute of Soil and Water Conservation (ISWC) of the Chinese Academy of Science (CAS) in the Central China to work out a master plan for developing a community-based participatory system for combating desertification in Inland China and deploying environmental education in the decertified area.

Assoc. Prof. Ping AN (Plant Ecophysiology)

Physiological responses of plants to salt and drought stresses

Assoc. Prof. Mitsuru TSUBO (Plant Production Science)

Research activities of the Plant Production Science Subsection are carried out in a wide range of fields such as crop ecophysiology, micrometeorology, ecoclimatology and agrometeorology. A research

technique employed in the subdivision is simulation modelling, and also field work and indoor experiment are conducted to built and test plant growth and production models. The current research topics are:

- Plant canopy structure and radiation balance under stressed conditions of water
- Water movement in soil-plant atmosphere continuum under dry conditions
- Plant response to drought
- Model development of plant growth under drought
- Risk assessment of plant production under drought
- Framework of a drought early warning system.

The major research activities during the fiscal year were summarized as follows:

- Evaluation of crop production under water harvesting system in a semi-arid region of South Africa
- Modelling plant growth and production in dry grasslands in Mongolia and the Loess Plateau, China.

Assist. Prof. Wataru TSUJI (Crop Ecophysiology)

The Crop Eco-physiology Subdivision conducts research on the elucidation of eco-physiological characteristics of crops, and development of appropriate cultivation technology in arid land. Particular efforts are being made to clarify the mechanisms of drought and salt resistance in several crops, and to develop new crop cultivation technology to achieve higher yield under drought stress condition. The research of the subdivision is driven by combining the basic research in Japan using the Center's facilities and applied research at real drylands in abroad. In the fiscal year, I started the experiments in ICRISAT (International Crops Research Institute for the Semi-Arid Tropics).

The main research topics in the fiscal year were as follows:

- Demonstration of cultivation technology by “defoliation” to increase grain yield and to enhance water use efficiency under drought stress condition.
- Inspection of “seed-hardening” technology to enhance germination and initial growth under drought stress condition.
- Analysis of responses to nutrient and water in the soil in *Jatropha curcas* L., biodiesel plant.

Research grants in the fiscal year included:

- Development of theoretical model and its demonstration for cultivation technology by defoliation to improve water use efficiency in dryland agriculture.
Japan Society of the Promotion of Science, Grant-in-Aid for Young Scientists (B), 2007-2009
(Project Leader: W. Tsuji)
- Analysis of mechanisms of salt tolerance in buckwheat.
Japan Society of the Promotion of Science, Grant-in-Aid for Scientific Research (C), 2007-2009
(Project Leader: A. Matsuura)
- Re-inspection of role of hydraulic signal in stomata closure process.
Japan Society of the Promotion of Science, Grant-in-Aid for Exploratory Research, 2006-2007
(Project Leader: H. Araki)

Overseas research activities during the fiscal year included visits to ICRISAT for discussion about collaborative research and experiments, and to the Institute of Soil and Water Conservation (ISWC) of the Chinese Academy of Science (CAS) for participation of the “China-Japan Joint Open Seminar on Combating Desertification and Development in Inland China” in “Core University Program”.

Assist. Prof. Takehiko ITO (Animal Ecology)

The Animal Ecology Subdivision conducts research on the ecology of wild animals and conservation of ecosystem and biodiversity in drylands. Main targets are ecological and conservational study on wild large herbivores, such as Asiatic wild ass and Mongolian gazelle, inhabiting Mongolia. We use satellite tracking to describe their long distance movements, and combine the use of remote sensing, geographic information systems (GIS), and field observations to analyze factors of their habitat selection and movement, and influences of climate fluctuation and artificial constructions on them.



A satellite-collared Asiatic wild ass in Mongolia

In the fiscal year, we captured Asiatic wild asses and Mongolian gazelles, and started satellite tracking of them in southeastern Gobi, Mongolia. We are collecting their location data through the internet, and analyzing their movements. We also surveyed environmental condition in habitats of wild animals, interviewed local peoples, and inspected advanced national parks in Africa.

Research grants in the fiscal year include:

Evaluation of effects of habitat fragmentation by man-made structures on endangered ungulates in Mongolian grasslands

Japan Society of the Promotion of Science Grants-in-Aid for Scientific Research (A), 2006-2009
(Project Leader: A. Tsunekawa)

Overseas research activities during the fiscal year include field researches in Mongolia, and attending international conference and inspecting advanced national parks in South Africa and Tanzania.

Assist. Prof. Tomoe INOUE (Crop Physiology)

Research has been conducted to identify the morph-physiological parameters that is available for selection criteria on breeding for drought tolerance in wheat, and to improve supplemental irrigation for further effective use of scarce water in the arid land. In the fiscal 2007, in collaboration with scientists at the International Center for Agricultural Research in the dry areas (ICARDA, Syria), I studied on the contribution of pre- and post-anthesis assimilates to grain yield of synthetic hexaploid wheat derivatives, durum wheat and spring bread wheat genotypes differing in drought tolerance under rainfed and supplemental irrigation conditions.

Also I started to study on the mechanisms of water and nutrient flow from host plants to striga (*Striga hermonthica*) which is the noxious root parasitic weed and one of the serious constrains on crop production in the arid land.

During the fiscal 2007, I visited ICARDA to conduct joint research on the “Breeding Cereals for Stress Tolerance” as a JIRCAS Post-doctoral Fellow for 4 months. Under the Global COE Program, I visited ICARDA twice and the Agricultural Genetic Engineering Research Institute (Egypt) once to discuss and conduct joint research on drought tolerance in wheat. To develop the joint research proposal on striga, I visited the Agricultural Research Corporation (Sudan) and Sudan University of Science and Technology by the Asia Africa Science Platform Program

3) Division of Afforestation and Land Conservation

Prof. Shigenobu TAMAI (Revegetation Science)

The Revegetation science subdivision conducts research on the afforestation in semi-arid areas. Main research topics of subdivision are as follows.

- Studies on the distribution of plants in semi-arid land and its specific characteristics
- Studies on the relationships between water and nutrient dynamics, and the growth of trees,
- Studies on the maintenance mechanisms of plant community.



Seedling production in North East Brazil

As the overseas activities of the fiscal year, the ecological research on *Tamarix* forests was carried out at salt accumulated areas of Inner Mongolia, China in August. In September, field survey on the application of Zeolite-Cotton to greening was conducted in Rio Grande do Norte of Brazil.

In Japan, study on water and nutrients dynamics of tree was conducted using saplings of *Populus alba*. Experiments on the salt tolerance of *Tamarix austromongolica* was conducted using facilities of the Arid Land Research Center.

Prof. Tahei YAMAMOTO (Land Conservation)

The main studies in this subdivision were on the dynamics of moisture and salt in the soil under arid conditions. The mechanism of soil erosion by water and break down of soil aggregate were also studied in order to promote research on the mechanism and control of desertification. The staff consisted of Dr. T. Yamamoto (Professor) and Ms. N. Hamamoto (Associate Clerk assigned to the entire Division) and eleven students. Five students (included three foreign students) and three students graduated from the doctoral course and the master course at the United Graduate School of Agricultural Sciences, respectively. Dr. Yamamoto attended the 2007 ASAE meeting in Milwaukee, USA during June 17-20 and presented the research entitled 'Evaluation of Biochemical Clogging of Filters and Emitters on Microirrigation Scheduling'. Also, he visited in Israel, as a member of project consultation team on the Japan-Israel joint training program for Egypt course on irrigation during Dec. 6-15,2007. Purposes of the mission were as follows; (1)to advise to improve programs and curriculum of irrigation course, (2)to implement a lecture on water saving irrigation & soil improvement, (3) to discuss course contents for local adoption training & next year's courses with the relevant Organizations and (4)to exchange information with the relevant Organizations.

Assoc. Prof. Norikazu YAMANAKA (Plant Ecology)

The plant ecology subdivision conducts research on the revegetation in arid areas based on plant ecology. Main research topics of plant ecology subdivision are as follows.

- Studies on the maintenance mechanisms of plant community.
- Studies on the ecosystem restoration
- Studies on the drought and salt tolerance of trees and improvement of stress tolerance.
- Studies on the vegetation dynamics in coastal sand dunes

As the overseas activities of the fiscal year, the research on ecosystem restoration was carried out in the Loess Plateau of China in May and September. In August, the research on salt accumulation in *Tamarix*

forest was carried out at salt accumulated areas of Inner Mongolia, China. The ecophysiological study on halophyte was also conducted in the Taklimakan desert of Xinjiang Uyghur Autonomous Region of china in September.

In Japan, study on the spatial distribution and seasonal change of nitrogen was carried out in the Tottori coastal sand dunes. Experiments on the salt tolerance of *Tamarix* species, the effects of salt stress to the growth and ectomycorrhizal symbiosis of pine and the osmotic adjustment mechanisms of trees were conducted using facilities of the Center.



Biomass measurement of *Tamarix* forest in Inner Mongolia, China

Assoc. Prof. Mitsuhiro INOUE (Soil Water Management)

The Land Conservation Subdivision conducts research on soil degradation mechanisms (soil erosion and salt accumulation), and suitable soil management for sustainable agriculture. Several efforts are being made to proffer proper land conservation that is required to prevent soil degradation in dry lands. In this fiscal year, three doctoral foreign students (Mauritania, Madagascar, Oman) obtained the degree of Ph. D. in September, 2007. Two doctoral Japanese students obtained Doctor's degree and three Japanese students also obtained Master's degree in March, 2008.

Some research topics in the fiscal year were as follows:

- Effect of application of soil amendment to degraded soil.
- Measurement of water flow and solute transport in salt affected soil and determination of leaching fraction
- Preventing soil degradation and water saving irrigation scheduling on vegetated sloping land
- Development of simple and quick measurement of downward flux in unsaturated soil
- Reduction of evaporation from soil surface using various mulching
- Prediction of water flow and solute transport during subsurface drip irrigation
- Evaluation of water content and salt concentration in highly saline sandy soil
- Groundwater control by bio-drainage to prevent salt accumulation
- Rakkyo cultivation and appropriate nitrogen application on sand dune field

Overseas research activities during the fiscal year include two times visiting China supported by Core-University Program, and a research presentation in Australia (Adelaide) in March, 2008 for the attendance of 2nd International Salinity Forum.

4) Division of Socioeconomics

Assoc. Prof. Hiroshi NAWATA (Cultural Anthropology)

The Cultural Anthropology Subdivision conducts research on sustainable use of biological resources and local development through the participation of local people, on the basis of cultural anthropological research on pastoral system, indigenous knowledge and resource management.

The main research topics and research grants in the fiscal year were as follows:

- Basic Studies to Combat Desertification by Applying Traditional Pastoral Systems: Japan Society of the Promotion of Science Grants-in-Aid for Young Scientists (B), 2005-2007 (Project Leader: H. Nawata)
- Studies on Land Use Change before and after 'Grain for Green' Project of China: Showa Shell

Research Grant for Environmental Studies, 2006-2007 (Project Leader: H. Nawata)

- Practical Research for an Understanding of the Hunger and Civil War of Africa on Educational Fronts in Japan – With the photograph “A Vulture and a Child” : Research Grant Program, the Toyota Foundation, 2006-2007 (Project Leader: H. Nawata)
- Practical Research for Rethinking the Hunger and Civil War in Africa: Tottori University Public Awareness Grant, 2006-2007 (Project Leader: H. Nawata)
- A Study of Human Subsistence Ecosystems among Arab Societies – To Combat Livelihood Degradation: Research Institute for Humanity and Nature, Incubation and Feasibility Studies, 2006-2007 (Project Leader: H. Nawata)

5) Division of Health and Medicine

Visiting Assoc. Prof. Shinji OTANI (Health and Medicine)

The previous measures for preventing desertification are tree plantation, civil engineering work, and economic regulations, etc. based on mainly the studies in agriculture, engineering, and economics. There have been few studies on the health of the residents of the site, that is, the healthcare/medical studies regarding the influence of desertification on human health or the like. In this circumstance, we have researched with the aim of developing “healthcare and medicine in arid land” as a new research field. In the Global COE Program titled “Global Advance of Arid Land Science,” we survey the health condition of residents, and pursue the prevention of health disorder, heat stroke, nutritional abnormality, etc. caused by dust (yellow sand) seen in arid land, and design countermeasures.

Recently, the yellow sand blown toward Japan is a big issue. We worry that yellow sand may have started affecting human beings and animals, and so we hope to clarify the influence of yellow sand on human beings and animals in China, Mongolia, and Japan. We plan to research comprehensive measures against yellow sand in collaboration with other groups.

(3) Foreign Researchers

Dr. Mohan Chandra SAXENA (Arid Land Ecophysiology)

June 2006 – May 2007

International Center for Agricultural Research in the Dry Areas, Syria

Title: Response of *Jatropha curcas* to salinity and osmotic stress

Jatropha curcas (*Euphorbiaceae*) is a deciduous perennial shrub tree adapted to the marginal areas in semi-arid and arid regions. It produces seeds rich in oil (>30%) that can be used in producing biodiesel. It is however an underutilized species and very little research has been done on its growth, development and adaptation to different environments. Information on these aspects, particularly on the ecophysiological adaptation of this species in the arid and semi-arid environments, is important for full exploitation of its potential. Hence, following experiments were conducted in collaboration with a graduate student to develop some understanding on these issues that would help in the production agronomy of this important crop:

- a. *Experiment 1*: Effect of saline water on the water imbibition and germination of *Jatropha curcas* provenance from India.
- b. *Experiment 2*: Response of *Jatropha curcas* seedlings to soil moisture stress as varied by frequency

- of irrigation.
- c. *Experiment No. 3*: Response of *Jatropha curcas* seedlings to osmotic stress created by addition of polyethylene glycol 6000 to simulate soil moisture stress.
 - d. *Experiment No. 4*: Gaseous exchange behavior of *Jatropha curcas* leaves at different time intervals after same day exposure to osmotic stress in the nutrient solution by addition of polyethylene glycol 6000.
 - e. *Experiment No. 5*: To develop, study, describe and photograph symptoms of macronutrient deficiencies in *Jatropha curcas*.
 - f. *Experiment Number 6*: Effect of manner of seed placement on the germination of seeds of *Jatropha curcas*.
 - g. *Experiment Number 7*: Effect of seed soaking for 24 hours on the germination of *Jatropha curcas* under two growth media.
 - h. *Experiment Number 8*: Study on the survival and establishment of *Jatropha curcas* saplings in the Arid Land Dome and over wintering.
 - i. In addition, a study was conducted, with the help of Dr T Hattori and Ms Matsunaga, on the anatomical structure of the cross section of *Jatropha* leaf and petiole to look in to the indications about the nature of photosynthetic system operating in the *Jatropha* plant.

Following experiments have been planned to be conducted by Ms. Matsunaga under the supervision of Drs Tsubo and Dr Tsuji and the plant material has been prepared:

1. *Experiment Number 9*: Effect of boron content in water on the germination of *Jatropha curcas*
2. *Experiment Number 10*: Effect of boron content in irrigation water on the growth of *Jatropha curcas* seedlings
3. *Experiment Number 11*: Photosynthetic response of *Jatropha curcas* plants to different temperatures.

My other research and academic activities during this period included the following:

- a. Conducting a graduate course on 'Dryland Ecophysiology;'
- b. Discharging the responsibility as the Master of Ceremony of the International Symposium on 'Living with Deserts II' organized by the UNU and ALRC in collaboration with other institutions at UNU Headquarters in Tokyo on 25 August 2006;
- c. Visiting the Cold and Arid Regions Environmental and Engineering Research Institute (CAREERI) of the Chinese Academy of Science in Lanzhou, China, 14-23 August to work on the scientific manuscripts of the Chinese participants in the 8th International Conference on Dryland Development (ICDD);
- d. Attending and chairing a panel discussion on biofuels during the Triennial Conference of the Global Forum for Agricultural Research (GFAR) at New Delhi, India, 7-12 November 2006;
- e. Attending the 5th SUMAMAD Project Workshop at ICARDA, Aleppo, Syria, 13-16 November 2006;
- f. Holding technical discussions with *Jatropha* germplasm scientist at the Indian Agricultural Research Institute, New Delhi, 18-22 November 2006;
- g. Delivering a keynote address on 'Meeting the challenge of water scarcity in dryland agriculture' and convening a session on the same topic during the 'International Symposium on Dryland Ecology and Human Society (ISDEHS)' in UAE, 4-7 December 2006.
- h. Delivering an invited lecture on 'Response of some food and forage legumes to drought stress in a

dry Mediterranean environment' in the 2nd International Crops Seminar-Advances in Crop Management Techniques in Arid and Semi-Arid Regions organized by the Japanese Society of Crop Science at Ibaraki University, 28-30 March 2007.

- i. Delivering a seminar in the meeting of the division of the Environmental Sustainable Development of the United Nations University, Tokyo on 15 May 2007 on the invitation from the Vice Rector of the UNU.
- j. Delivering three seminars to the students and faculty at the ALRC; and participating in the seminars and research program discussions of the students and faculty members of the Division of Biological Production.
- k. Reviewing and editing scientific manuscripts of the students and researchers of the Division of Biological Production, particularly of the Sub-division of Ecophysiology, and the students of Sub-division of Land Conservation;
- l. Completing the editing of the Proceedings of 8th International Conference on Dryland Development, including more than ten contributions from the ALRC students and staff members. The proceedings will be printed by middle of July by ICARDA; and
- m. Assisting the Director of ALRC in the matters related to collaboration with ICARDA, Aleppo, Syria.

Result of the research

Experiment 1: The objective of the study was to find out how the levels of NaCl in the water would affect the rate of water imbibition and germination behavior using solutions containing 0 (T1), 60 (T2), 120 (T3), and 240mM NaCl (T4). Ten seeds were used for each treatment. The 120 and 240 mM NaCl reduced imbibition as compared to 0 and 60mM NaCl. At the end of 30hr, the imbibition was about 40% for T1 and T2, 35% for T3 and 33% for T4 on the basis of the air-dry weight of the seeds. The germination percentage at the end of 28 days was 70% in T2 and T3 and 50% in T1 and 0 in T4 treatment. The results showed that *J. curcas* seeds could germinate well in water with a NaCl concentration of up to 120 mM, and the germination starts when the seeds have imbibed about 35-40% water on the air dry weight basis.

Experiment 2: The experiment examined the effect of soil moisture stress on the growth and some physiological parameters of 45 days old seedlings of an Indian provenance of *J. curcas* to generate information that might help in designing drought management strategies for good establishment of the plants. The experiment was conducted in plastic house using 5000 ml plastic pots filled with Dune sand and vermiculite mixture (70%-30% on volume basis). Treatments included irrigation every day (T1), every second day (T2), every 4th day (T3) and every 6th day (T4) with the amount of water lost per pot by evapotranspiration. The total number irrigations given was 36, 18, 9 and 6 in T1, T2, T3, and T4, respectively. The respective consumptive use (CU) of water was 5894, 6665, 5721 and 4328 g per pot, the relative values being 100, 113.1, 97.1 and 73.4%, respectively. Thus, the highest CU was obtained when irrigation was given every second day and it decreased when frequency of irrigation was either increased or decreased. The plants were tallest and gave highest dry matter yield under T2. Results showed that irrigation every day was not suitable in this sandy soil perhaps because it caused temporary anaerobic conditions, which adversely affected the plant growth. Small magnitude of soil moisture stress faced by the plants under every second day irrigation proved beneficial, but the stress caused by irrigation every 6th day was drastic and resulted in significant reduction in growth and consumptive use of water. The results suggest that the *Jatropha curcas* can withstand moderate soil moisture stress during the seedling stage and

daily irrigation was not needed during this period.

Experiment No. 3: The objective was to investigate the effect of different levels of osmotic stress in the growth medium on growth, leaf gaseous exchange properties and the consumptive use of water of the seedlings of an Egyptian provenance of *J. curcas* grown on dune sand. While the plants were initially raised in a plastic house, the stress application and plant response study were done in a growth chamber. The treatments consisted of the water potential of 0, -0.32, -0.89 and -1.91 M Pa, designated as T1, T2, T3 and T4, respectively, created over the basic osmotic concentration of the full Hoagland solution by adding 0, 400, 600 and 800 ml per liter of a stock solution containing 300 g of PEG 6000 per liter while preparing the full Hoagland nutrient solution for each treatment. There were four replications. Results showed that the cumulative water use (CU) increased linearly from 3 September to 20 September, but the slope was the highest for T1 and it decreased as the level of osmotic stress increased. The CU on 20 September was 3511, 2523, 2051 and 1391 g/pot in T1, T2, T3, and T4; thus CU decreased by 28.1% under T2, 41.6% under T3, and 60.4% under T4 as compared to T1. Results on gaseous exchange in the leaves showed that all the parameters were adversely affected by an increase in the osmotic stress, although the magnitude of effect differed with the parameter studied. Averaged over the three dates of observations the photosynthetic assimilation rate was $15.55 \text{ } \mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$ under T1. It decreased by 12.4, 38.9 and 66.4% by the treatments T2, T3, and T4, respectively, as compared to T1, showing that the relative decrease got accentuated as the osmotic stress increased. The average stomatal conductance under T1 was $0.352 \text{ mol H}_2\text{O m}^{-2} \text{ s}^{-1}$. It decreased with increase in osmotic stress by 35.5, 71.6, and 87.8% with T2, T3 and T4 treatments, respectively. The average transpiration rate was $5.12 \text{ mmol H}_2\text{O m}^{-2} \text{ s}^{-1}$ under T1 and it decreased as the osmotic stress increased; the decrease was 27.9%, 56.6% and 77.7%, respectively for T2, T3 and T4 as compared to T1. The data on plant growth parameters are yet to be analyzed.

Experiment No. 4: The objective of the study was to examine the effect of the exposure of 75 days old plants of an Indian provenance (India 2) of *J. curcas* to the moisture stress, created by addition of 600 ml of a stock solution of PEG 6000 (300 g PEG L^{-1}) per liter of the full strength Hoagland solution, on photosynthetic rate, transpiration, stomatal conductance and carbon dioxide concentration in the stomatal cavity at three short intervals (1:00, 3:00 and 5:00 pm, i.e. 3, 5 and 7 hr after the imposition of stress). The effect on the daily evapotranspiration and cumulative water use till 8 days after the imposition of stress was also studied. Treatment T1 was control (i.e. full strength Hoagland solution) and T2 was the stress treatment where the osmotic potential was increased to get water potential of about -0.89 M Pa. There were two replications because of shortage of plants. The highest photosynthetic rate, stomatal conductance and transpiration rates were at 1:00 pm and the least at 5:00 pm. The CO₂ concentration in the stomatal cavity however showed the reverse trend. Osmotic stress resulted in a significant decrease in photosynthetic rate, stomatal conductance and transpiration rates at all the three times of the measurement. The stress reduced the photosynthetic rate by 73.6% at 1:00pm, 77.6% at 3:00 pm, and 75.7% at 5:00 pm. The corresponding reductions were 78%, 76.2% and 71.2% in the stomatal conductance and 77.7%, 77.0% and 70.1% in the transpiration rate. Thus, all the three parameters were adversely affected by the osmotic stress by nearly the same magnitude. The daily consumptive use of water, monitored till 8 days after the start of osmotic stress treatment, was adversely affected by stress. The magnitude of decrease was 52.1% after one day, reached the peak of 71% after 3 days and then started declining steadily till five days and then faster till the 8 days when the decrease was only 40.4%. This shows that there was a trend for adaptation of the plants to stress with the passage of the time. The cumulative water use increased linearly with time, but the slope was much higher in case of T1 (no stress) than under T2 (stress). The final CU was 2183 g per pot under T1 as

against 908 g per pot under T2; thus the osmotic stress decreased the cumulative evapotranspiration by 58.4%.

Experiment No. 5: The objective of this experiment was to develop nutritional deficiency diagnostics in *Jatropha* seedlings to facilitate fertility management in the field. The study was carried out in plastic house in sand culture using washed dune sand and an Indian provenance (India 2). Seven different Hoagland nutrient solutions were used to grow the plants. One of them was complete solution (containing N, P, K, Ca, Mg, S, Fe-EDTA and mixture of other micronutrients) to serve as control ('Complete'). The other six solutions missed either nitrogen (designated -N) or phosphorus (-P) or potassium (-K) or calcium (-Ca) or magnesium (-Mg) or sulfur (-S). By 8 August, the -N plants started showing loss of green color. By 15 August the difference became clearer and by 10 September, conspicuous yellowing of the whole plant and stunted growth was observed. There was however no leaf drop or necrosis. By this time, symptoms of deficiency also started appearing in plants under -P and -S, where as plants under -K, -Ca and -Mg had as well or even better growth than those under 'Complete' nutrient treatment. The growth suppression and symptoms of deficiency in -N, -P and -S became more clear as plants grew further up to 3 October 2006. The older leaves under -N started drying out and there was gradation in the loss of green color, older leaves being more yellow than the younger ones. Plants under -K, -Ca and -Mg, however, continued to show as good growth as plants under 'Complete' nutrient treatment and no symptoms of deficiency developed. Growth studies showed that the final plant height was 33.4 cm under control and it decreased by 33% under -N, by 22% under -P and by 21% under -S. The corresponding decreases in leaf dry weight were by 40%, 43% and 28%; stem dry weight were 36, 36, and 15%; total shoot dry weight were by 38%, 39%, and 22%; root dry weight were 6%, 7% and 3%; and the shoot/root ratio were by 34%, 35% and 18%. The other treatments were either at a par or slightly better than control. The results helped in quantifying the growth effects because of shortage in N, P and S in the growth medium. Lack of development of other macronutrients tested may be attributed to the contamination that might have come with the sand-vermiculite ball around the roots that was transferred to the pots at the time of transplanting. The leaf, stem and root dry matter will be analyzed for N, P, K, Ca, Mg, S and Fe content to relate to the observed growth response of plants to variations in the macronutrients in the growth medium. The photographs developed showing N, P and S deficiency (Photos 1, 2 and 3) would be of help in field diagnosis of these deficiencies. The experiment will have to be repeated with larger number of replications and by avoiding any contamination to develop clear diagnosis of deficiency of K, Ca, Mg, and Fe.

Experiment Number 6: The objective of the experiment was to see whether the manner in which the seed is placed in the seed bed would affect the rate of emergence. The treatments consisted of the following: (1) Flat with caruncle down; (2) Vertical with caruncle up; (3) Flat with caruncle up; and (4) Vertical with caruncle down. The seeds were sown at 2cm depth in vermiculite +sand mixture (1:1 on volume basis) and irrigated with tap water. They were allowed to germinate at room temperature of about 23° C. The germination was fastest in # 4 followed by # 1, followed by # 3, followed by #2. Thus it would be better to dibble the seeds with caruncle down to hasten germination.

Experiment Number 7: The objective was to see whether the rate and percentage of germination was improved by seed soaking and how this was affected by the growth medium. The treatments consisted of the two soaking treatments (no soaking; and soaking in demineralized water for 24 hours) and two growth mediums (dune sand; and Vermiculite). The seeds of an Indian provenance were surface sterilized with 5% domestic bleach for 5 minutes, thoroughly washed with demineralized water, and then used for soaking for 24 hours (soaking started on 7th May). Thin black polyethylene pots containing 1000 g of air dry dune

sand or equivalent volume of vermiculite and with free drainage were used as the germination medium. The pots were kept on a bench in a plastic house with ambient temperature fluctuating between a minimum of 3°C to a maximum of 38°C. The seeds under soaking treatment had imbibed 64.5% water on air dry basis. The air dry weight per seed was 0.6929 g and the weight of water-imbibed seed was 1.1435g per seed.

The emergence results showed that seed soaking overnight was not congenial for the germination as the germination of soaked seeds was only 28.6 % in sand medium and 20% in vermiculite as against the respective values of 71% and 60% for un-soaked seeds. The rate of germination was also slightly faster in the un-soaked seeds and in the sand medium. Germination percentage was better in sand than in the vermiculite medium. However, once germination was complete, the expansion of first cotyledonary leaves was faster in vermiculite than in sand. The study therefore suggests that it would be better to use un-soaked seed and plant them in sand medium to get better germination.

Experiment Number 8: The objective of this study was to see whether the saplings of Egyptian provenance of *Jatropha curcas* could get established on the sandy soil of Arid Land Dome and over winter in its Sub-tropical Desert Section, where temperature is maintained between 25°C to 45°C and the relative humidity is around 30%. The plants were 94 days old when they were used for transplanting on 20 October 2006. The number of leaves ranged between 12 and 18. Two were transplanted in the ground and the other two were kept in big plastic pots (25cm diameter, 30cm height). The medium was compost and dune sand mixed in 1:1 proportion and fertilized with 15-15-15 NPK compound fertilizer at 200kg per ha. The transplanting in the Arid Land Dome was done on 20 October 2006. The saplings transplanted in the ground were drip irrigated, while those in the pots were irrigated by rose can using tap water. The temperature in the dome ranged between 15°C and 38°C throughout the period while the radiation was natural, as is common at the ALRC site (35°32' N, and 134°13' E). The plants got established well within a week and started making good growth by throwing out new leaves and gaining thickness of stem. In late November 2006 they started dropping the leaves and by mid December 2006 the drop was complete. The amount of leaf drop was measured in the pots on 21 May 2007. The number of leaves dropped during the winter were 18 and 12, in pots #1 and #2 respectively and the respective dry weight of the liter was 5.476 and 3.055 per pot. This amounted to an average litter yield of 875 kg per ha, which should help in improving the soil properties. The plants remained without any leaves throughout the winter (minimum temperature ranging from 8.1°C to 15°C), and early spring (minimum temperature ranging from 18.1°C to 21.5°C) and redeveloped leaves in early May 2007. The mean plant height and plant girth (stem diameter at the base) on 21 May was around 22 cm and 2.5 cm respectively, and the number of leaves were 4 to 7. The plants grew better in the pots than in the ground, perhaps because of better light intensity.

Anatomy of the leaf of *Jatropha curcas*: Transverse sections of a fully opened leaf of 25 days old plant was examined with scanning microscope. The sections revealed that the stomata were located mainly on the lower part of the leaf. The upper epidermis had barrel shaped cells, closely followed by a single layer of palisade cells filled with chlorophyll. The palisade layer was followed by spongy parenchyma and then the lower epidermis. The vascular bundles and phloem tissues were spread at small intervals. The vascular tissues appeared to be lined by bundle sheath, but this would need confirmation. The sections of leaf are shown in Photos 1-4 and that of petiole in Photo 5.

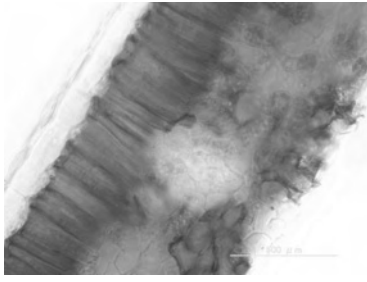


Photo 1. Transverse section showing upper epidermis, palisade layer, spongy parenchyma and vascular bundle.

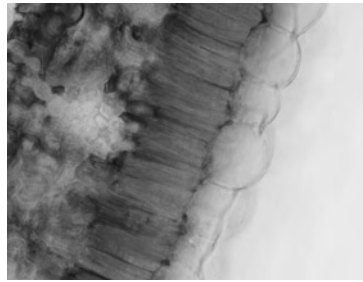


Photo 2. Transverse section showing vascular bundles

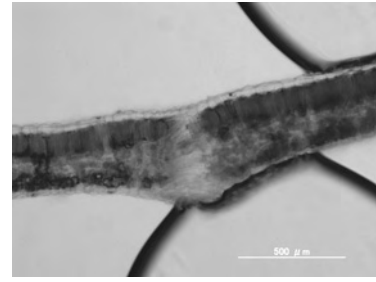


Photo 3. General view of transverse section of leaf showing a vein

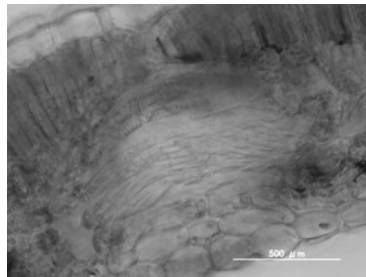


Photo 4. Transverse section of leaf showing the vein area

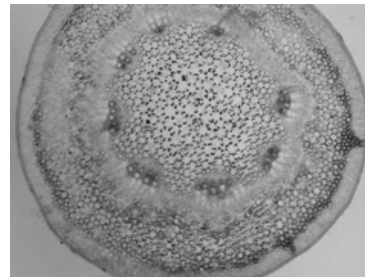


Photo 5. Cross section of petiole

Dr. Yuanrun ZHENG (Plant Ecophysiology)

October 2006 – September 2007

Institute of Botany, CAS, China

Ordos Sandland Ecological Station, CAS, China

Title: Assessment of situation and cause of desertification and its synthetic restoring technology in semi arid area, China

The Ordos Plateau, which is regarded as a zone seriously affected by desertification, is situated in the southern part of Inner Mongolia, northern China. Many researches and restoration efforts have been made to mitigate the effect of desertification. However, Desertification and restoration of vegetation are affected by both natural conditions and human disturbance. Therefore, it is a complicated process to restore desertified land.

In this research, we mainly aimed to understand the characteristics of plants, e.g. seed germination, seedling emergence, seedling growth and responses to climate warming, of main indigenous species used in combating desertification, and thus to improve the techniques for combating desertification. Based on above considerations, the research activities could be summarized below:

1. Seminars, teaching courses, and instruction for master course students

- (1) Five seminars related to desertification combating in Ordos plateau had been presented, titled “The synthetic regime for combating desertification in Ordos plateau”, “The characteristics of regional climatic change and social-economic perspectives related to desertification in Ordos Plateau of China”, “Did climate drive ecosystem change and induce desertification in Otindag sandy land of China over the past 40 years?”, “Germination characteristics of 9 key species in relation to sandy environments and air seeding”, “Effects of burial in sand and water supply regime on seedling emergence of six

psammophytes”.

- (2) Teaching course lasted 3 days for master course students from Tottori University had been conducted during August 6-8, 2007. The main contents covered: “Desertification and case study in Ordos plateau of China”, “Case study for desertification in Otindag sandy land and Loess Plateau of China”, “Seed characteristics, germination and its significance for combating desertification”, “Case study for seed germination and seedling emergence in Ordos plateau of China”, “Experiment design and data presentation”, “How to get publication in English journal”.
- (3) Master course student, Yuki Demachi, was assigned to be instructed. Her experiment, data analysis and thesis preparing are going well. Now.

2. New experiments

Seeds of two *Artemisia* species that were key species in desertified area in Ordos plateau from tree sites were collected, and germination experiments under different temperature and PFD were done during Apr. 20 to Sep. 3.

3. Data analysis and paper writing

Based on previous field data, laboratory experimental data and new data here, seven papers have been prepared.

Result of the research

From the results of seedling emergence experiment and growth experiment we concluded that higher temperatures, associated with global warming, may be harmful for *A. ordosica*, *A. sphaerocephala*, under current precipitation levels. Our findings support the proposal that *A. ordosica* mixed with *C. korshinskii* will prove beneficial for re-vegetation of degraded areas of the Ordos plateau and that *C. korshinskii* will withstand higher temperatures resulting from global warming.

Our experiment of four psammophytic species under increasing temperature and elevated CO₂ indicated that elevated CO₂ increased total biomass, height growth, net assimilation rate and water use efficiency, and decreased transpiration for two *Artemisia* species and *Hedysarum leave* generally, while elevated CO₂ significantly increased ratio of below to above- ground biomass, leaf area, height increment and water use efficiency for *C. korshinskii*. Compared to growth at ambient temperature, rising temperature tended to increase biomass and water use efficiency for four species. These findings are applicable to similar shrub species distributed in arid and semi arid environments, and help to choose appropriate species for revegetation under global warming in Inner Mongolia.

Related to build indicator system for combating desertification, the field data showed that vegetation could be grouped into three types both in semiarid and arid area. Canonical correspondence analysis (CCA) results suggested that CCA axis 1 highly correlated with soil water content, organic matter and total N in surface layer of soil in semiarid area, axis 2 was related to organic matter, total N in 20 cm, soil water in 10 and 20 cm, and Mg²⁺ in surface layer of soil, but negatively related with Na⁺ in surface layer of soil. While in arid area, the factors that highly correlated with axis 1 were total P, organic matter and total N in surface layer of soil, and soil electrical conductivity in 20 cm, the main correlates of axis 2 were soil water in 50 cm and total P in 20 cm. Plant communities dominated by *Stipa bungeana*, *Artemisia ordosica*, and *Agriophyllum squarrosum* could be indicator of slight, medium and extreme desertification in semiarid area, while plant communities dominated by *Ephedra przewalskii* and *Carex physodes* could be indicator for medium, *Carex physodes*, *Artemisia Songorica* and *A. xerophytica* for severe and *Haloxylon persicum* for extreme stages in arid area.

Dr. Muhammad IRSHAD (Soil Science)

October 2006 – September 2007

Water Management Department, Government of North Western Frontier Province, Pakistan

Title: Monitoring Soil and Crop Nitrogen Dynamics under Sodic Conditions

My research and academic activities included a growth-chamber experiment, lectures, open seminars, overseas conferences and participation in the various classes / seminars. The focus of my research is to monitor nutrient dynamics in the soil-plant system under saline / water deficit conditions. The research interest is related to the mitigation of the adverse effects of salinity / sodicity on crops and soils using waste amendment. The use of marginal waters for agriculture is also the special focus of my studies. The current work is being carried out in collaboration with my host scientist Dr. Mitsuhiro Inoue (Assoc. Professor) in the Land Conservation sub-division.

I edited abstracts, scientific documents, especially research manuscript for staff, Master and Ph. D students in the ALRC and Faculty of Agriculture; helped the students in thesis writing. Attended classes / delivered few lectures to the Master-course students. I have collaborated actively in the research carried out on the aridity and published / submitted articles as depicted from the manuscripts listed below during the one year stay at ALRC.

Result of the research

a) Evaluation of Nutrient Release in Salt Saturated Soils

The effect of irrigating with saline water on native soil fertility and nutrient relationships is not well understood. In a laboratory experiment we determined the extent of indigenous nutrient [calcium (Ca), magnesium (Mg), potassium (K), manganese (Mn) and zinc (Zn)] release in salt saturated soils. Soils were saturated with 0, 75 and 150 mmolc L⁻¹ NaCl solution and incubated for 1, 5, 10 and 15 days. The saturation extracts were analyzed for pH, ECe as well as water soluble Ca, Mg, K, Mn and Zn and the remainder soil samples were analyzed for exchangeable forms of these elements. In a sub-experiment three soil types (masa, red-yellow and andosol) were saturated individually either with 100 mmolc L⁻¹ of NaCl, NaNO₃ and Na₂SO₄ salt. These salts were also compared for the above nutrients release. Results showed that the soils treated with NaCl released higher amount of water soluble nutrients whereas exchangeable forms of the elements decreased significantly. Except for Zn, the average concentrations of these nutrients in the soil solution increased significantly with time of incubation. However, the concentrations of the exchangeable forms varied inversely with time of incubation. The masa soil exhibited the highest concentrations of Ca and Mg whereas K was highest in andosol. The extract from soils treated with NaCl contained greater amounts of soluble cations whereas soils treated with Na₂SO₄ produced the lowest concentration of these elements irrespective of the type of soil used.

b) Phosphorus and Metal Fractions in Paddy Soils under Different Fertilizer Management

For the sustainable nutrient management in rice, it is important to understand the long-term effects of fertilizer or manure application on the chemical forms of elements in soils under cultivation. This experiment was carried out to characterize sequentially extracted forms of phosphorus (P) and selected heavy metals [copper (Cu), zinc (Zn), nickel (Ni) and lead (Pb)] in a paddy soil after long-term application of cow manure, oil-seed cake and inorganic fertilizers. The P forms studied were H₂O-P, NaHCO₃-P, NaOH-P and HCl-P. The soil treated with organic fertilizers had greater accumulation of all forms of P.

The total P in the soil increased up to 5.8 times in cow manure, 4.6 times in oil-seed cake and 3.6 times in the inorganic fertilizer as compared to unamended control. Water soluble P was highest in the soil treated with inorganic fertilizer but the HCl-P and NaOH-P constituted the largest P fractions in the soils. Regardless of the amendment, extractants were considerably varied for P release as follow: HCl > NaOH > NaHCO₃ > H₂O. Marked changes were also noted for heavy metals due to long-term manure or oil-seed cake application. Nickel, Pb and Zn were dominant in carbonate and residual fractions whereas Cu was mostly present in the organic form. Soil treated with organic fertilizer contained more Cu and Zn whereas variations in Ni and Pb were not statistically significant. Potassium, Ca and Mg increased substantially with organic fertilizers. Relatively lower amounts of readily extractable elements in the soil surface could reflect their loss to the waterways or exhaustion by rice plants.

c) Monitoring Manure Effects on Crop and Soil Nutrient Release under Water Deficit Conditions

Fresh water resources are limited in the arid and semi-arid areas whereas the existing water resources are often overused and misused. The productivity of water use in agriculture needs to enhance in order both to avoid exacerbating the water crisis and to prevent considerable food shortages. In arid and semiarid environment, growing season evapotranspiration is usually higher than the corresponding seasonal precipitation. This necessitates the need for water conservation in the root-zone. Manuring soils is a common cultural practice that has been widely used on farms to conserve soil-water in the root-zone.

Usually the arid and semiarid soils are deficient in organic matter. Therefore there is a need to apply wastes in arid soils. Moreover, it is also necessary to develop a preliminary understanding on the interaction of deficit water and organic manures in desert soils. The literature on the response of crops to short-term application of organic manure under water deficit conditions is insufficiently reported. Therefore an experiment was conducted to evaluate manure effects on growth and physiological characters of crop and nutrient release from the soil under water deficit environment.

For this purpose wheat (*Triticum aestivum* L.) was grown in the pots using sand dune soil for 8 weeks under controlled growth-chamber conditions at Arid Land Research Center. The pots were treated with the irrigation regimes as follow i) daily irrigation ii) irrigation every 2 days and iii) irrigation every 4 days using the same amount of water. The irrigation was applied up to field capacity after gravitational measurement of pots. The soil was amended with composted cattle manure (containing 1% N, 2% P and 3.3 % K) at the rate of 0, 10 and 20 t ha⁻¹. A basal dose of NPK was also applied as fertigation. The crop parameters measured during the experiment were: plant fresh and dry biomass, crop evapotranspiration, water use efficiency, chlorophyll, photosynthetic and transpiration rates. The plant shoot samples are also being processed for chemical analyses (macro and micro elements). The soil analyses will be carried out to determine the magnitude of essential nutrients and organic matter changes. Soil electrical conductivity and pH will also be measured. The data are being processed and analyzed to determine the treatment effects and draw conclusions from the experiment.

Dr. Ahmed El Tayeb OSMAN (Range and Pasture Management)

June 2007 – May 2008

Arabian Peninsula Regional Program,

International Center for Agricultural Research in the Dry Areas, Dubai, UAE

Title: Water use efficiency of forage grasses from arid environments with particular emphasis to root development, soil moisture depletion and carbohydrate reserves

Experiment 1

Research Title: Water use efficiency of forage grasses from arid environments with particular emphasis on root development, soil moisture depletion and carbohydrate reserves.

Abstract:

Indigenous perennial grasses are widely distributed in the United Arab Emirates and other countries of the Arabian Peninsula (AP). Their survival under limited rainfall and heavy utilization in open grazing lands, suggests a potential role as forage and for rehabilitation of degraded rangelands. Forage production, water use efficiency, root development and carbohydrate reserves were investigated for three grasses of the Arabian Peninsula and one exotic species. The grasses were: Buffel grass (*Cenchrus ciliaris* L.); dakhna (*Coelachyrum piercei* Benth.) Bor. and da'ay (*Lasiurus scindicus* Henr. from Emirates together with one commercial species: rhodes grass (*Chloris gayana* Kunth). These were grown under controlled environment of a green house at the Arid Land Research Center, Tottori University during 2007-2008. The four grasses were sown in PVC pots 22 cm-diameter and 110 cm height filled with sandy soil to 100 cm depth. The pots received 2.4 g fertilizer containing NPK (13:13:16) plus 1.6 g micronutrients and 4.0 g Ca Hydroxide (for soil pH) before transplanting the four grasses in July 31, 2007. There were 20 pots representing the 4 grasses and a control. The pots were placed on a metal rack 13 cm above ground in a randomized complete block design with four replications. Five of the pots were each fitted with 4 soil moisture sensors at 12.5, 37.5, 62.5 and 87.5 cm down the soil profile. The pots were irrigated daily with 500 ml tap water. On Sep 3 the pots were harvested and the plants discarded, marking the beginning of the study. The pots were then irrigated daily with 150 ml and drainage water was collected daily before irrigation. Soil moisture was monitored by taking sensors readings once a week before irrigation throughout the study. The grasses were harvested at four growth cycles, oven dried and weighed. The first harvest was made 35 days from the beginning of the study (Oct 8). At the beginning of the second growth cycle, the pots were irrigated daily with 100 ml (split 50% in morning and 50% in the afternoon). The second harvest was made when plants were 37 days old (Nov 14). At the beginning of the third growth cycle the pots were fertilized with the same fertilizers applied at the beginning of the study and the irrigation level was reduced to 50 ml daily (split between morning and afternoon) and this was continued till the end of the study. The third harvest was made when the plants were 51 days old (Jan 4, 2008). The fourth and final harvest was made when the plants were 35 days old (Feb 12). After the fourth harvest, 12 of the pots (three for each species) were cut horizontally into four strata (25 cm each), the soil washed and the roots collected and stored in sealed plastic bags containing 75% Ethanol. Additionally 4 pots, representing the four species were cut vertically and whole roots were collected the same way above. Root length was measured using Comair Root Scanner. The roots were then thoroughly washed with tap water and oven dried (80 °C), weighed, ground and stored for carbohydrates (NSC) analysis.

Both Rhodes grass and Labeid maintained the highest DM yield throughout the study (4 growth cycles) with no significant difference between them. This was matched by Dakhna in the first growth cycle only. Recovery after harvest became weak for Dakhna and Da'a starting the second growth cycle and stopped re-growth completely in the third and fourth cycles. Similarly the water use efficiency (WUE) of the species followed the same pattern of the DM yield, with no significant difference between Rhodes and Labeid or Dakhna in the first growth cycle. The differences were significant between Rhodes and Dakhna; Rhodes and Da'a in the second growth cycle. WUE could not be computed for Dakhna and Da'a in the 3rd and 4th growth cycles.

Rhodes and Labeid showed the most extensive root development in the soil profile (Figure 1), explaining their persistence and high productivity. The highest root accumulation for all grasses was found on the top and bottom strata of the profile.

Lebeid and buffel grass were the highest in total NSC in their roots over the other two grasses. Total NSC followed the same pattern of root development, being highest at the top and bottom strata. The two other species were very low in total NSC in their roots, mostly a reflection of their low DM production rather than the percent NSC content.

1.1 Introduction:

The Arabian Peninsula is considered a water scarce region. Agriculture consumes most of the water available (76%) mainly for forage production and forestation. Utilizing the adapted genetic variation of indigenous forage species, could offer some solution by identifying forages with high water use efficiency and good feed quality for livestock. Indeed some of the collected forage species in the Arabian Peninsula have proven higher dry matter yield, feed quality and water use efficiency than the traditionally grown Rhodes grass.

In the present study three indigenous grasses from the Arabian Peninsula (Emirates) namely: Labeid (*Cenchrus ciliaris*), Dakhna (*Coelachyrum piercei*) and Da'a (*Lasiurus scindicus*) were compared with Rhodes grass (*Chloris gayana*) for their root development, carbohydrates reserves, forage production and water use efficiency under controlled environment. Data were also collected on soil moisture depletion and water drainage under the different species.

1.2. Materials and Methods

Three indigenous grass species plus, one exotic forage (see above) were compared for their forage productivity, water use (depletion of soil profile), water use efficiency and root development under controlled irrigation treatments and environment (Air conditioned green house) at the Arid Land Research Center, Tottori University. The four grasses were sown in peat moth then transplanted into large PVC pots (110 cm height and 22 cm diameter) filled with sandy soil to 100 cm. The pots were covered (wrapped) with insulating sponge which has aluminum foil on its outer surface. There were 20 pots four of these were check (no plants) for monitoring irrigation and soil moisture. The 20 pots were arranged in a randomized block design (four grasses and a check), with four replications. The pots were placed on metal rack 13 cm above ground. Plastic pans (26 cm diameter) were placed under each pot to collect drainage water.

Fertilizers NPK (2.415 g per pot), supplying 0.314 gm N, 0.314 g P and 0.386 g K and micronutrients (1.61 g per pot) and calcium hydroxide (4.025 g per pot) were added (top dressing) before transplanting grasses on July 31, 2007.

At the beginning of the study, irrigation was applied at 500 ml on daily basis using an automatic drip irrigation system fitted with a gauge. Water depletion in the soil profile was monitored in five pots using sensors. The sensors were installed at 12.5, 37.5, 62.5 and 87.5 cm soil depth (inserted horizontally along one side of the pot). The sensors measure Soil Thermal Conductivity ($W m^{-1} °C^{-1}$); which later converted to volumetric water content using a calibration curve. The soil moisture was monitored once a week in the 5 pots (representing the 4 grasses and the control).. On September 3, the plants on all pots were cut to ground level and discarded, marking the beginning of the experiment. Four forage harvests were made at the end of the following growth cycles: 35, 37, 51 and 39 days. Irrigation was adjusted at the beginning of the growth cycles to 150, 100, 50 and 50 ml daily for the four cycles, respectively. In the first cycle

irrigation (150 ml) was applied in the morning, while in the last three cycles it was applied in the morning and afternoon (equal amounts). Fertilizer (the same amount applied earlier) was applied again at the beginning of the second crop cycle.

1.3 Data collection

1.3.1 Irrigation, drainage and soil moisture

Irrigation was monitored on daily basis (morning and afternoon) depending on the crop growth cycle, Using three pots (control with no plants) water was collected from the dripper in each pot in a plastic jar, weighed and poured back into the same pot. Drainage water was collected on daily basis, before the morning irrigation, weighed, recorded and discarded. Total water application and total drainage was computed on weekly basis during crop growth cycles. Soil moisture recording was done once a week by recording the Thermal conductivity ($W m^{-1} °C^{-1}$) using KD2 Thermal Properties Analyzer. The readings were later on converted into volumetric water content using calibration curve. Temperature and relative humidity inside the green house were recorded (at one hour interval) throughout the experiment.

1.3.2 Dry matter (DM)

At the end of each crop growth cycle (Judged by 10% flowering of Dakhna), the plants were harvested to ground level, oven dried ($80^{\circ}C$) weighed and discarded.

1.3.3 Roots

At the end of the fourth growth cycle, 12 pots were cut (saw) each into 4 strata (25 cm). The stratum was placed on a wire mesh (2 mm) and a jet of water was applied to wash the soil. The roots were collected and placed in sealed plastic bags containing Ethyl alcohol (75%) and the bags stored in a refrigerator. One replication (4 pots) representing the four grasses were cut vertically, soil washed and the roots collected (whole root) as described above. Root length was measured using Comair Root Length Scanner. The roots were then thoroughly washed with tap water, placed in paper bags, oven dried ($80^{\circ}C$), weighed and stored for analysis of non structural carbohydrate (NSC). The NSC analysis was carried with the help of Dr. Hideki Okamoto (Hokkaido Prefecture).

1.3.4 Water Use Efficiency (WUE)

The dry matter yield data and the irrigation data were used to calculate WUE in $kg DM per m^{-3}$

1.3.5 Data analysis

The data on DM, drainage water and WUE were analyzed as a complete block design while the data on root length, root DM and carbohydrates were analyzed as split-plot design (Steel and Torrie, 1960), using analysis of variance to evaluate statistical significance between species means and root means different strata. Computations were carried out using a statistical package of Systat Software Inc. (SigmaStat 3.5). Tukey Test was used to compare means ($p=0.05$)

1.4 Results

1.4.1 DM yielded

Both Rhodes grass and Labeid maintained the highest DM yield throughout the study (4 growth cycles) with no significant difference between them. This was matched by Dakhna in the first growth cycle only. Recovery after harvest became weak for Dakhna and Da'a starting the second growth cycle and stopped completely in the third and fourth cycles. With the exception of Dakhna, none of the grasses produced any flowering during the four growth cycles.

1.4.2 WUE

Similarly the water use efficiency (WUE) of the species followed the same pattern of the DM yield, with no significant difference between Rhodes and Labeid or Dakhna in the first growth cycle. However, the differences were significant between Rhodes and Dakhna; Rhodes and Da'a in the second growth cycle. WUE could not be computed for Dakhna and Da'a in the 3rd and 4th growth cycles.

1.4.3 Drainage water

The drainage water was highest under Da'a in the first growth cycle, which was significantly higher than under Labeid and Dakhna. No significant differences were recorded among the four species in the following growth cycles or when the total drainage of the 4 growth cycles was compared for the five treatments (four grasses and a control).

1.4.4 Grass roots

Both Rhodes and Labeid showed the most extensive root development in the soil profile (Figure 1). The highest root accumulation was observed at the top and bottom strata of the profile for all grasses.

1.4.5 Carbohydrates

Labeid and buffel grass were generally higher in Non Structural Carbohydrate percentage than the other two grasses. The difference became greater over the other two grasses when the total NSC was computed (total DM X %NSC) due to the greater difference in root DM among the species. Total NSC followed the same pattern of root development, being highest at the top and bottom strata.

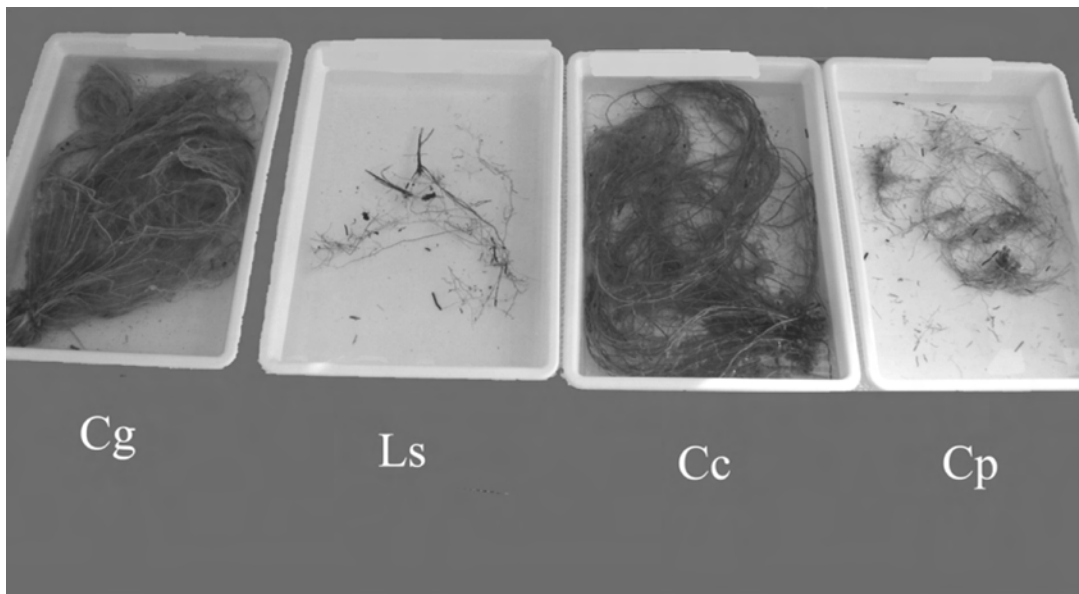


Figure 1. Root length in 196 days after transplant of seedlings of Rhodes grass (Cg), Da'a (Ls), Labeid (Cc) and Dakhna (Cp) into PVC cylinders (22 cm diameter) filled with sand to 1-meter depth.

Experiment 2

Research Title: Growth of four grasses on clay soil with particular emphasis on forage production, water use efficiency, soil moisture depletion and persistence under frequent cutting.

2.1. Introduction

The performance of four perennial grasses (three from United Arab Emirates and one commercial variety) under experiment 1 (described above) seems very different from an earlier field experiment in

United Arab Emirates. For example two of the grasses (Ls and Cp) stopped re-growth after the second growth cycle. The same grasses produced new growth each time for 40 growth cycles under the field study in Emirates. Also in the above green house study although Cc and Cg grasses remained most productive and persistent to frequent harvests, similar to their performance under field condition in Emirates, but their performance under green house was different from that under field study. These differences could be due to the soil characteristics (sandy vs. loamy), and irrigation. Under the previous field study soil was loamy and the irrigation was applied once everyday compared with the green house, where the soil was sand and the irrigation was applied twice daily. In the present study (Experiment 2) the performance of the same species is compared under green house conditions using clay soil and one irrigation level.

2.2. Materials and Methods

Three indigenous grass species from Emirates plus one commercial grass variety (see Experiment 1) were compared for their forage production, water use (depletion of soil profile), water use efficiency and persistence under frequent cutting. The grasses were first sown in peat moth for two weeks then transplanted into small pots (13.2 cm at top, 9 cm diameter at bottom and 10 cm height), filled with clay soil to 9 cm height (850 g). The soil used was Tohaku soil, which has the following physical and chemical properties: Bulk density (1.19 g m^{-3}), clay content (440 g kg^{-1}), sand (240 g kg^{-1}), silt (320 g kg^{-1}), organic matter (2.88 g kg^{-1}), pH (5.8), field capacity ($0.42 \text{ cm}^3 \text{ cm}^{-3}$). Soil nutrients content were as follows: N (53 mg kg^{-1}), Olsen P (4.45 mg kg^{-1}). Fertilizer (0.06 g) supplying NPK (13:13:16) was added (top dressing) before transplanting two-weeks old grass seedlings on Jan 22, 2008. The pots were arranged in a randomized complete block design, with four replications. The pots were irrigated with 140 ml (FC) every 3 days till Feb 17, when all pots were harvested marking the beginning of the study. The grasses were harvest twice during the study: after 42 day's growth cycle (Mar 30) and 39 days growth cycle (May 8). Water depletion in the soil profile was monitored using sensors and KD2 Thermal Properties Analyzer which measure Thermal conductivity ($\text{W m}^{-1} \text{ }^\circ\text{C}^{-1}$). The sensors were placed vertically into the soil (8 cm) in the center of each pot. The sensors readings were later converted to volumetric water content as described for experiment 1.

2.3 Data collection

2.3.1 DM production

All pots were harvested in Feb 17 to 1 cm above ground marking the beginning of the first crop growth cycle. Irrigation was applied to FC (140 ml water) once every 3 days. Soil moisture recording was done on the day of irrigation (before and after irrigation). The grasses were harvested on Mar 30 and May 8 by cutting to ground level, the forage was oven dried (80°C), weighed and discarded.

2.3.2 WUE

Water use efficiency ($\text{DM kg m}^{-3} \text{ water}$) was calculated from total DM yield divided by total irrigation water used in each crop growth cycle. Temperature and relative humidity inside the green house were recorded (one hour interval) throughout the experiment.

2.3.3 Data analysis

The data from experiment 2 is being analyzed for randomized complete block design

Other research and technical activities

- Delivering four seminars for students and faculty at the ALRC; and participating in seminars at the Arid Land Research Center and the Faculty of Agriculture. Also participated in research program discussions of the students and faculty members of the Plant Production and Plant Ecophysiology sub-divisions
- Reviewing and editing scientific manuscripts of graduate students and researchers (different sub-divisions of ALRC and Faculty of Agriculture) for conferences and Journal publications.
- Acted as reviewer for the Journal of “Grass and Forage Science’ during June 2007.
- Discharging the responsibility as the Master of Ceremony during the Plenary Meeting for Collaborative Project “Global Center of Excellence in Dryland Sciences” held at ALRC on July 28, 2007.
- Acted as a reviewer on research proposals submitted to the Arab Science and Technology Foundation during July 2007.
- Participated in a field visit to dairy and beef cattle farms in Tottori Prefecture with Veterinary Science Group (Tottori University), involving five farms in Nov. 2007. The visit included discussions with farmers on farm management for livestock.
- Delivering an invited keynote address on “rehabilitation of the war-affected rangeland in Kuwait” during a technical meeting in Geneva invited to by PPSC Technical Review Committee and Observers from Kuwait NFP, the UNCC and the Kuwait Oil Company, Geneva, 13-16 March 2008.
- Visited the United Nations University, Tokyo in April 2008 and participated in group discussion on management of natural resources under arid land environments.
- Delivered a lecture on the activities of ICARDA in the Arabian Peninsula with particular emphasis on rangeland and forage production during my visit to the United Nations University on April 2008.
- Assisted the Director General of ALRC and head administration office in matters related to collaboration with ICARDA, Aleppo, Syria.

Dr. Muhammad IRSHAD (Soil Science)

October 2007 – September 2008

Water Management Department, Government of North Western Frontier Province, Pakistan

Title: Research on the improvement of sodic soil using organic amendment

The focus of my research is to monitor nutrient dynamics in the soil-plant system under saline and water deficit conditions. Mitigating the adverse effects of marginal quality waters on crops and soils using waste amendment is also my research objective. Major research activities included the publication of several articles in collaboration with other researchers in the field of sustainable management of agriculture in arid land as depicted from the given list of manuscripts. Reviewing and editing of scientific documents of students and researchers in the ALRC and Faculty of Agriculture were part of major activities this time. Other activities included growth-chamber experiments together with Dr. B. A. Ould Ahmed and Prof. M. Inoue, open seminars, overseas conferences and participation in the various lectures as well as seminars.

Result of the research

- 1) Interrelation of irrigation frequency and manuring on the growth and water use efficiency of wheat

under arid condition

Good water management along with appropriate soil amendments is necessary for sustainable crop production. An experiment was conducted to evaluate the response of wheat (*Triticum aestivum* L.) to manuring and irrigation frequency in sandune soil under growth chamber conditions for eight weeks. Manure was applied at the rate of 0 (M0), 10 (M1) and 20 Mg ha⁻¹ (M2) along with daily, 2 or 4 days irrigation frequencies denoted as W1, W2 and W3, respectively. Irrespective of the manure the daily irrigation gave 18 and 25% higher biomass yield as compared to W2 and W3, respectively. Application of M1 and M2 enhanced dry matter yield by 57 and 107%, respectively whereas the number of tillers were increased by 69 and 117%, respectively as compared to unamended soil. The cumulative evapotranspiration (ET) was slightly increased in M1 whereas in M2 it was similar to M0 in spite of the higher plant biomass. Thus, the manured soil saved higher magnitude of water than control soil. The water use efficiency (WUE) of crop under M1 and M2 treatments was increased by 42 and 115%, respectively than M0. For both ET and WUE, irrigation frequencies were varied as W1 > W2 > W3. Photosynthetic rate (P_N), transpiration rate and stomatal conductance (g_s) apparently decreased with longer irrigation period. However, plants maintained dark green color in W3. As expected the cumulative ET was positively associated with P_N , g_s and transpiration rate.

2) Bioavailability of plant nutrient in manured soils irrigated with saline water

The experiment was carried out under growth chamber conditions where alfalfa plants were irrigated every day or 2nd day regularly either with tap water or saline water (ECw: 2 dS m⁻¹). Plants were grown for 2 months. Poultry and cow manures were applied at the rate of 20 t ha⁻¹. This study showed a significant interaction of saline water and manure on the dry matter production of alfalfa. A retarded plant growth was noticed with saline water as well as deficit irrigation. Manure treatments substantially enhanced plant biomass and the growth was varied in the order of cow manure > poultry manure > control. The treated soil samples are being analyzed for bioavailability of essential plant nutrients. Statistical regression will be determined between the nutrient solubility and biomass production in manured soils under the effect of saline or non-saline waters.

Dr. Richard James THOMAS (Natural Resources Management)

December 2007 – May 2008

International Center for Agricultural Research in the Dry Areas, Syria

Title: Review of how an integrated approach to natural resources management can contribute to combating desertification

1. Publications

- Review paper entitled “Addressing land degradation and climate change in dryland agroecosystems through sustainable land management” written and submitted to the Journal of Environmental Monitoring for their 10th Anniversary Special Issues. If accepted this will also be a feature photograph on the cover page of the journal.
- Finalization of a research article on the ‘Opportunities to reduce the vulnerability of dryland farmers in Central and West Asia and North Africa to climate change’. To be published in June issue of Agriculture, Ecosystems and Environment.

2. Development of a challenge program research proposal

- Attendance at CGIAR Annual General meeting in Beijing Dec 1-5 to present a luncheon seminar on

the Oasis consortium to combat desertification

- Attendance at Oasis consortium proposal writing group held at the UNCCD, Bonn, Germany Jan 15-23, 2008.
- Attendance at the CGIAR Science Council meeting on the Oasis and other Challenge Programs Jan 29-Feb 6, 2008
- Attendance at second meeting of Oasis writing group at UNCCD, Bonn, Germany, March 10-16, 2008.
- The output of these meetings is a research proposal to be considered as a global challenge program for funding by the CGIAR and others in may 2008.

3. Joint program in M.Sc.'s degree Integrated Land Management in drylands

This degree program is a joint venture between UNU, IRA and INAT in Tunisia, CAREERI in China, ICARDA and recently ALRC, Tottori. Five lectures have been prepared for the 4 M.Sc. students who will attend the course at ICARDA for two weeks starting March 26, 2008.

In addition a planning meeting was held at ALRC on March 5 with representatives from ALRC, Tottori University, UNU and ICARDA to plan the next phase of the M.Sc. program that will include Japanese students.

4. Revision of manuscripts from ALRC staff

Scientific and English language editing of four manuscripts from ALRC staff were completed.

(4) Project Researchers

Dr. Hisashi TOMEMORI (Protected Cultivation)

The Protected Cultivation Subdivision conducts research on the sustainable cultivation method in the dry lands. Particular efforts are being made to improve the method of cultivation of physic nut (*Jatropha curcas* L.) which is the representative biodiesel fuel plant in dry land.

The main research topics in the fiscal year were as follows:

- Ecophysiological studies of physic nut
- Study of the irrigating method for the root systems of physic nut
- Low-temperature tolerance of physic nut
- Pruning method for physic nut
- Supply of phosphoric acid using porous glass materials

Overseas research activities during the fiscal year were as follows:

- Research on cultivation of the material plants of biodiesel fuel in India
- Studies about the rural development in India using physic nut

Dr. Hidetoshi MOCHIZUKI (Soil Physics)

I conducted research on the topic, "the effects of organic matters on the soil thermal properties." The organic matter content is listed as one of the key factors to evaluate the soil quality. But the effects of



organic matters on soil thermal properties are less studied than other factors like soil water content and temperature. The objective of this research was to clarify the effect of organic materials on soil thermal conductivity, which is one of the key soil thermal properties. Three organic materials, peat moss, leaf mold, and oil cakes, and Tottori dune sand were used for the thermal conductivity measurements. The soil thermal conductivity was measured by KD2. The sand thermal conductivities were decreased exponentially with the increasing in the organic material contents, regardless of volumetric soil water contents and organic materials. But the degrees of decreasing were different from each of organic materials. For the analysis with normalized standard, the thermal conductivities were plotted against the ignition loss of each sample. But the decrease in the thermal conductivity was not described as a simple equation. It suggested that each of organic materials has their own thermal properties. Although one particular value proposed by previous research was used for the thermal analysis of soil layers, we have to pay attention to the organic materials themselves for the precise analysis.

Dr. Xiangjun LI (Crop Physiology)

Effect of cytokinin application on growth recovery after defoliation in soybean

It is well known that soybean can compensate for defoliation through two mechanisms: compensatory leaf regrowth and delayed senescence. And also, the difference in defoliation-tolerance among various cultivars was resulted from the difference in leaf regrowth ability and leaf senescence after defoliation. Cytokinins, as one type of plant hormones, have physiological function to promote leaf expansion and to delay leaf senescence; it may be assumed that cytokinin application could promote the growth recovery following defoliation in soybean. To test this hypothesis, two experiments (a pot experiment in growth chamber and a field experiment in green house) were conducted.

Pot experiment: a determinate cultivar Enrei, which is related sensitive to defoliation, was exposed to two defoliation (nondefoliation and 75% defoliation) treatments and two cytokinin treatments (0mM and 0.01mM, spraying 6-Benzylaminopurine solution for four times) when soybean were at R₂ (plants had at least one flower in the two uppermost nodes) and R₅ (Beans beginning to develop in a pod at one of the four uppermost nodes on the main stem with a fully developed leaf) stages. Defoliation at R₂ and R₅ stage resulted in significant decrease in leaf area and dry mass. There were not significant difference in leaf area and dry mass between defoliated plants with or without cytokinin treatment at 27 days after defoliation. However, the defoliated plants with cytokinin application had higher photosynthetic ability and higher stomatal conductance, also its leaf senescence was more delayed compared with the defoliated plants without cytokinin application. Those changes may be advantageous for the recovery at late growth stage.

Field experiment: In field experiment, the material and the treatments methods was same with the pot experiment. The decrease in yield caused by defoliation at R₂ or R₅ stage was 30.2% and 42.5% respectively. Cytokinin application significantly reduced the decrease in yield. At R₂ stage, defoliated plants with cytokinin application had higher yield (154.6g m⁻²) than that without cytokinin application (140.9 g m⁻²). At R₅ stage, the same tendency was observed, although it was not significant. Those results indicated that cytokinin application promoted the recovery following defoliation. Compared with defoliated plants without cytokinin application, the increase in yield in defoliated plants with cytokinin application may be explained by higher photosynthetic activity in leaf and less leaf abscission, which resulted in higher leaf area and dry mass in late growth stage.

The disagreement of results in pot and field experiments indicated that this is essential to examine the effectiveness of cytokinin application in promoting crop defoliation-tolerance in future study.

Dr. Taiichiro HATTORI (Crop Nutrition)

Relationships between crop nutritional acquisition and drought tolerance are investigated from aspects of crop nutrition and physiology. In fiscal year 2007, effects of silicon application on water uptake ability of various gramineous crops, and effects of partial root drying on water use efficiency of crops are mainly studied. In studies regarding silicon effects on crops, a collaborative research are conducted at field scale with prof. Dr. Zhang Xiyang in the Center for Agricultural Resources, Institute of Genetics and Developmental Biology, Chinese Academy of Sciences. Research grants in the fiscal year include 'Studies on mechanisms of silicon dissolution from soil particles by plants. Japan Society of the Promotion of Science Grants-in-Aid for Young Scientist (B), 2006-2007 (Project Leader: T. Hattori)'. However, in November, 2007, the researches are temporary suspended and Grants-in-Aid for Young Scientist (B) was declined in accordance of position transfer to the Graduate School of Agricultural and Life Sciences, the University of Tokyo. Current research topic is the cultivation of dedicated energy crops for bioethanol.

Dr. Takashi KUME (Soil Hydrology)

The Isotopic Soil Hydrology Subdivision conducts research on identification of the salt of the large irrigation district where soil salinization has been observed due to irrigation and drainage problems. Particular efforts are being made to classify characteristics of water samples, such as irrigation water, drainage water, river water, ground water, lagoon water, and sea water, using strontium isotope ratio ($^{87}\text{Sr}/^{86}\text{Sr}$) and sulfur isotope ratio ($\delta^{34}\text{S}$). The research of the subdivision is driven by combining the use of water chemical analysis and remote sensing in addition to measurement of stable isotopes. The main research topics in the fiscal year were as follows:

- Measurement of environmental stable isotopes (the Lower Seyhan Irrigation Project, Turkey and Nagapattinam district, Tamil Nadu, India)
- Monitoring the vegetation change in Karapinar, Turkey

Research grants in the fiscal year include:

- 1) Drylands Environmental Sustainability Integrated Research Areas (Karapinar, Turkey)
Turkish Foundation for Combating Soil Erosion, for Reforestation and the Protection of Natural Habitats (Project Leader: Umit Y.Gurses, General Director of TEMA)
- 2) Vulnerability and Resilience of Social-Ecological Systems
(Project Leader: Assoc. Prof. Chieko Umetsu, Research Institute for Humanity and Nature)

Overseas research activities were as follows:

- The Lower Seyhan Irrigation Project, Adana, Turkey for Isotope study
- Karapinar, Turkey for conservation of desertification of the central Anatolia region
- Nagapattinam district, Tamil Nadu, India and Tamil Nadu Agricultural University, India for assessment of the effect of the tsunami December 2004 on agricultural production system

Dr. Makiko YAMAMOTO (Tree Ecophysiology)

Ecophysiological responses to drought stress were investigated in several tree species used to afforestation in semi arid land for understanding of drought tolerance required for a more insightful selection of reforestation species. Overseas research activities during the fiscal year were performed field survey in Mu-us sandy area of Inner Mongolia, China. Diurnal changes in leaf pressure potential of 4 tree species, *Salix psammophila*, *S.matsudana*, *Artemisia ordosica* and *Caragana korshinskii*, which have been planted for sand dune stabilization and shelter woods of pasture in Mu-us sandy area, were measured and

turgor maintenance of these trees were evaluated (see the figure).

Effects of natural types (S)-(+)-abscisic acid treatments on growth and ecophysiological characteristics of tree saplings were compared among 4 species including *Robinia pseudoacacia*, which is exotic species in the Loess Plateau of China, has been used for plantation in the region, and *Quercus liaotungensis*, *Syringa oblata* and *Platycladus orientalis*, which are indigenous species, have been showed ability to make stable ecosystems. The cultivation methods of these tree saplings were considered for progress of drought tolerance.

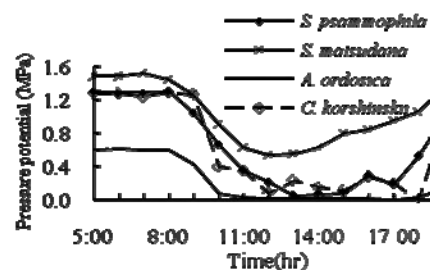


Fig. Diurnal changes in leaf pressure potential

Dr. Atsushi SUETSUGU (Soil Science)

1. Functional gene array analysis of salinity responses of *Bradyrhizobium japonicum* USDA110

Legume production in arid and semi-arid areas can be significantly enhanced by salinity-tolerant nitrogen-fixing microorganisms. Various adaptive tactics utilized by nitrogen-fixing microorganisms in response to salinity stress have been identified; however, the diversity of tactics employed in a single rhizobial strain is not sufficiently understood. Functional gene arrays (FGAs) have the potential to monitor the diversity of stress response within a single microbial strain. We conducted FGA and real-time RT-PCR analyses of salinity responses in stationary phase *Bradyrhizobium japonicum* USDA110 (a symbiont strain primarily for *Glycine max*) subjected to 72 h of high salinity stress (1.0 M NaCl) in yeast extract-mannitol (YEM) static liquid medium at 303 K. The FGA comprised 50 probes for three categories of functional genes that have been demonstrated to be associated with stress alleviation or nitrogen cycling: (1) compatible solute/exopolysaccharide production, (2) chemotaxis/cell motility, and (3) nitrogen fixation/denitrification. The salinity stress induced the simultaneous enhancement of transcriptional activity in both compatible solute/exopolysaccharide production and chemotaxis/cell motility genes, thereby indicating the diversity of salinity responses within a strain. Multiple genes for compatible solute production (ectoine, betaine, and trehalose) were activated by salinity, whereas proline (*putA*) and dihydrodipicolinate (*dapA1*) genes were deactivated. Many denitrification genes (e.g., *nirK*, *napA*, and *norB*) were deactivated by salinity. Two copies of *fixK* (*fixK3* and *fixK5*) were activated by salinity, whereas *fixK2* was deactivated. No significant salinity responses were detected for the *nif* and *nod* genes. These observations indicated that some salt-stressed *B. japonicum* USDA110 cells suppress nitrate respiration and redistribute fixed nitrogen to compatible solutes.

2. ^{13}C PST/MAS and CP/MAS NMR for estimation of biodegradation properties of environmental organic matters at hydrated and desiccated states

For a precise estimation of the fate of organic matters (OMs) in the environment, the stability of macromolecular structures of the OMs and its relation to the surface hydration properties should be understood. In the present study, the biodegradation properties of environmental OMs (a sewage sludge and a peat) under a wet (-30 J/kg water potential; the optimum moisture for aerobic biodegradation) and an extremely dry (-100 kJ/kg water potential) conditions were investigated by 70-days laboratory incubation. Incubated samples were subjected to chemical analysis and molecular mobility analysis at hydrated (D₂O-added) and desiccated states. Chemical composition and molecular mobility of the OMs were estimated by the ^{13}C pulse saturation transfer/magic angle spinning (PST/MAS) and the cross polarization transfer (CP)/MAS nuclear magnetic resonance spectroscopy (NMR). The results suggested that an

experience of aerobic condition made the hydrophobic aromatics in the peat to be irreversibly mobile. The increase in molecular mobility was explained by fragmentation and surface exposure of polymerized aromatics. However, the mobilized aromatics performed still more resistance to further biodegradation compared to the mobile aliphatics in the OMs. In the sewage sludge, some of the fragmented (poly)saccharide structures in the incubated sewage sludge could be re-stabilized by hydrogen bonding upon hydration.

Dr. Shiwen WANG

1. The effects and mechanisms of coronatine-induced drought tolerance in maize

Maize is an essential crop for global food security and is grown worldwide, supporting one third of the food source. Intermittent drought often occurs in maize production, inducing extensive yield losses. Maize is sensitive to water deficiency, particularly at the flowering stage. However, drought stress has become more frequent with global climate change and environmental pollution, and has adversely affected maize production. Thus, improving crop tolerance of environmental stress is necessary to ensure food security. Plant growth regulators, both natural and synthetic, are widely used in agricultural production for improving crop yield. My current research is *effects and physiological function of coronatine on plant growth and development*. Coronatine is a structural and functional analogue of jasmonic acid and has antagonistic or synergic relations with many phytohormones. The results showed that under drought stress simulated with 20% polyethelene glycol, foliar application of coronatine: *I*. Significantly increased maize biomass by 33% in only 8 days after drought stress. *II*. Decreased leaf transpiration rate and increased its relative water content. *III*. Increased the contents of soluble sugar, soluble protein and proline in leaves. *IV*. Increased the activities of antioxidant enzymes, alleviated lipid peroxidation and affected the activities of RuBP and PEPC. *VI*. Activity is 100 times that of JA. Our present research has shown that coronatine has a high efficacy for improving drought tolerance in maize seedlings and potential value as a plant growth regulator for improving the maize drought tolerance.

2. Effects of enhanced UV-B radiation on the growth and development of maize (Zea mays L.)

The crop production may be affected by increased the UV-B radiation arouses from the stratospheric ozone depletion. The increased UV-B radiation arouses from the stratospheric ozone depletion has potentially deleterious for agricultural production and natural ecosystem. Most studies that carried out in greenhouse or growth chamber might exaggerate the deleterious of increased UV-B radiation because it neglected the restore ability of PAR. So we investigated the effects of increased UV-B radiation on maize growth, yield and quality under ecologically realistic condition (in field condition) for long term. Effects of enhanced UV-B radiation on the pollen and pollinated grain development in maize were also studied. These researches are considered to be of great importance in right evaluation the adverse influence of increased UV-B radiation on the crop production with ozone depletion in future.