2.7 Activities of Foreign Researchers

(1) Professor Anthony Egrinya Eneji

Visiting Professor (Jun. 2005-May 2006)

University of Calabar, Nigeria

Title: Developing Sustainable Dryland Cropping Systems in arid zones based on soil conservation and waste recycling.

1. Summary of research activities (Jun. 1, 2005 to May 31, 2006)

My research and academic activities included a greenhouse experiment, lectures, a seminar, field trip to China and participation in conferences.

2. Related Publications

1. **Eneji, A. E.**, S. Yamamoto, G. Wen, S. Inanaga, and T. Honna (2005). A comparative evaluation of wet digestion and dry ashing methods for the determination of some major and minor nutrients in composted manure. Toxicological & Environmental Chemistry, 87 (2): 147-158.
2. **Eneji, A. E**., X. J. Li, P. An and S. Inanaga. Effectiveness of mulching versus incorporation of organic materials in alleviating water deficit stress in wheat based on eco-physiological parameters (in preparation).
3. El-Sharkawi, H., T. Honna, S. Yamamoto and **A. E. Eneji** (accepted, in press). Biological Nitrogen Fixation by Native Microorganisms in a waste-amended Paddy Soil. J. Sust. Agr .
4. Irshad, M. and **A. E. Eneji**. Phosphorus and metal fractions in paddy soils under different fertilizer management. Bioresource Techol.(submitted).

3. Other publications

1. **Eneji, A.E**., S., Inanaga, S. Muranaka, P.An, J. Li, T. Hattori, and W. Tsuji, (2005). Effect of calcium silicate on growth and dry matter yield of Chloris gayana and Sorghum sudanense under two soil water regimes. Grass and Forage Science. 60: 393-398.
2. **Eneji, A.E.,** S. Inanaga, S. Muranaka, P. An, J. Li, T. Hattori, and W. Tsuji (2005). Comparison of silicon sources for dry matter yield and nutrient uptake among four species of the gramineae under deficit and adequate irrigation. In Li et al. (eds). Plant Nutrition for Food Security, Human Health and Environmental Protection. Tsinghua University Press: 626-627.
3. Inanaga, S., **A. E. Eneji,** P. An, and H. Shimizu (2005). A recipe for sustainable agriculture in dry lands. In K. Omasa, I. Nouchi and L.J. De Kok (eds).Plant responses to Air Pollution and Global Change. Springer-Verlag (Tokyo), 285-293.
4. Li, J., S. Inanaga, Z. Li, P. Wang and **A. E. Eneji** (2005). Optimizing irrigation scheduling for winter wheat in the North China plain. Agricultural Water Mgt. 76:8-23.
5. Abe, J., A. Lux, S. Muranaka, T. Hattori, **A. E. Eneji**, P. An and S. Inanaga (2005). Silicon deposition in roots and leaves varies among forage grasses. Root Res. 14 (4): 117.
6. An, P., S. Inanaga, X. J. Li, H. Shimizu and **A. E. Eneji** (2005). Interactive effect of salinity and air humidity on two tomato cultivars differing in salt tolerance. J. Plant. Nutr. 28: 459-473.
7. Irshad, M., T. Honna, **A. E. Eneji**, S. Yamamoto and E. Haytham (2005). The use of halophytes in saline wastelands. J. Arid Land Studies 14 (3):199-207.
8. Irshad, M., T. Honna, S. Yamamoto, **A. E. Eneji**, N. Yamasaki and E. Haytham (2005). Nitrogen

mineralization under saline conditions. Comm. Soil Sci. Plant Anal. 36: 1681-1689.

9. Li, X. J., P. An, **A. E. Eneji**, K. Hamamura, A. Lux and S. Inanaga (2005). Growth and yield responses of two soybean cultivars to defoliation and water stress. Biologia, 60/4: 467-472.
10. Li, X. J., P. An, S. Inanaga, **A. E. Eneji** and A. M. Ali (2005). Mechanisms promoting recovery from defoliation in determinate and indeterminate soybean cultivars. J. Food, Agr. Env.Vol 3 (3&4): 178-183.
11. Li, J., **A. E. Eneji**, L. Duan, S. Inanaga, and Z. Li (2005). Saving irrigation water for winter wheat with phosphorus application in the north China plain. J. Plant Nutr. 28 (11): 2001-2010
12. Li, X.J., P. An, S. Inanaga and **A. E. Eneji** (accepted, in press**).** Salinity and defoliation effects on soybean (Glycine max L. Merr.) growth. J. Plant Nutr.
13. Zhang, M., Liusheng Duan, Jianmin Li, **A. E. Eneji,** Xiaoli Tian, Zhixi Zhai, and Zhaohu Li (accepted, in press). Brassinolide alleviated the adverse effect of water deficit stress on photosynthesis and antioxidant mechanism of soybean (Glycine max L.). Env. &Exp. Bot.
14. Dehghanisanji, H., V. Rasiah, T. Yamamoto, M. Agassi, H. Anyoji and **A. E. Eneji** (accepted, in press). Improvement of saline water use under drip irrigation. Agr. Water Mgt.
15. Hattori, T., K. Sonobe, S. Inanaga, P. An, W. Tsuji, H. Araki, **A. E. Eneji** and S. Morita. Short-term stomatal responses to light intensity and osmotic stress in silicon-applied and silicon-deficient sorghum seedlings. Env. & Exp. Bot. (submitted).
16. Ravolonantenaina, A. H., J. H. Rakotondrainibe, T. Yamamoto, **A. E. Eneji** and H. Yasuda. Technical evaluation of the borehole project in Mahajanga region of Madagascar and its effect on rural development. TRANSJIRE (submitted).
17. Zhang, M., Xiaoli Tian, Jianmin Li, **A. E. Eneji**, Liusheng Duan, Zhixi Zhai, and Zhaohu Li. Uniconazole-induced tolerance of Soybean (Glycine max L.) plants to water deficit stress in relation to changes in photosynthesis, hormones and antioxidant system. J. Plant Phyiol (submitted).
18. Li, J., H. Liu, L. Duan, **A. E. Eneji**, Xiaoli and Zhaohu Li. Spike differentiation in winter wheat (Triticum aestivum L.) mulched with plastic film during over-wintering period. J. Crop Improvement (submitted).
19. Duan, L., C. Guan, J. Li., **A. E. Eneji**, Z. Li and Z. Zhai. Compensative effects of chemical regulation on physiological damages caused by water deficiency during the grain filling stage of wheat. Biologia Plantarum (submitted).
20. El-Hassan, W.H.A., Y. Kitamura, F.S. Gamal and **A.E. Eneji** (accepted, in press). Assessment of surge irrigation technique under furrow irrigation system in the Nile delta. Int. J. Agr. Res.

** All manuscripts listed as submitted or in preparation have an above average chance of being accepted for publication.

4. Conferences and workshops attended.

1. Working visits to several institutes (China Agricultural University, Beijing Normal University and CAS Research Center for Agricultural Resources, Institute of Genetics and Developmental Biology) in P.R. China, Feb 28-March 6.
2. XV International Plant Nutrition Colloquium in Beijing, People's Republic of China; September 14-19, 2005.
3. Joint Research Symposium of the ALRC, Tottori University in December, 2005.

5. Seminars and Lectures

I gave the following seminar and lectures at the Arid land Research Center:

1. The state of agricultural production and research in Africa (seminar).
2. Nutrient management in dry land farming systems.
3. Requirements for productive agriculture in dry lands.
4. Global drought and agricultural production.
5. Silicon and drought stress management in plants.
6. How to do agricultural research and write reports

6. Other academic and research-related activities

In addition to the above, I carried out editorial work on numerous scientific documents, especially research manuscripts for staff and students of the ALRC and Faculty of Agriculture. I was also actively involved in advising graduate students on the design, analysis and interpretation of their data. In addition, I maintained a significant international collaboration on research on stress physiology as evidenced from some of the manuscripts listed above.

7. Result of my research during June 2005- May 2006

The objective was to determine soil water conservation and physiological growth of wheat (*Triticum aestivum* L.) using composted manure applied either as mulch or incorporated with soil at 20 Mg ha^{-1}. Haruhikari, a relatively drought-sensitive wheat and Hongmangmai, a drought-tolerant wheat, were the cultivars studied under adequate and deficit irrigation. Fourteen weeks after sowing (WAS), the number of tillers and leaves was significantly reduced by 19 and 30% under deficit irrigation and Hongmangmai produced slightly (10%) more tillers than Haruhikari. Unlike mulching, the incorporation of manure had favourable effects on plants by increasing the shoot dry mass (SDM) by 36% and number of tillers and leaves by 40%. Haruhikari produced substantially (29%) greater root mass under adequate irrigation but Hongmangmai produced slightly (2.7%) more roots and responded much better to manure use under deficit irrigation. As a result, Hongmangmai suffered less severe reductions in tillers and biomass under water stress. In comparison, the mulched manure treatment saved 15 and 64% more water than the control and treatment incorporating manure, but this advantage in water saving did not translate to superior plant growth. Leaf water potential (ψ_l) under adequate irrigation significantly exceeded that under deficit irrigation by 27% and the ψ_l of Haruhikari exceeded that of Hongmangmai by 15%. However, the water-stress tolerance of Hongmangmai was confirmed as it maintained much higher net photosynthetic rates (P_N) at lower leaf water potential. Reductions in P_N and intracellular carbon-dioxide concentration (C_i) of the cultivars under deficit irrigation were accompanied by decreases in stomatal conductance (g_s) and transpiration rate but on average, the g_s of Hongmangmai significantly exceeded that of Haruhikari by as much as 53% under adequate irrigation and 22% under deficit irrigation. The implications of these results will be discussed in a full paper.

8. Acknowledgement

I sincerely acknowledge the tremendous all-round support of Prof. Dr. Shinobu Inanaga and his immense contribution to the success of my research activities at the ALRC. I thank Assoc. Prof. Ping An for being such a wonderful hostess and for efficiently facilitating my routine research activities. Thanks also go to Mr. Watanabe, Head of Administration, ALRC and his team of able staff. The untiring, prompt and diligent assistance of Ms. K. Takahashi and Ms. E. Tomemori is heartily acknowledged. I enjoyed the immense support of many undergraduate, graduate and post-doctoral students of the Laboratory of Plant Eco-physiology, several of whom willingly and enthusiastically assisted in greenhouse experiments.

(2) Professor Jiemin Wang

Visiting Professor (Oct. 2005-Sep. 2006)

Cold and Arid Regions Environmental and Engineering Research Institute, CAS, China

Title: Investigation and comparison the energy, water and carbon dioxide exchanges of ecosystem in Japan

I would like to thank my host Assoc. Professor R. Kimura, also, Prof. Kamichika, Prof. Tsunekawa, Prof. Shinoda, Assoc. Prof. Yasuda, and many other colleagues, and all members of Administrative Office headed by Mr. Watanabe, for giving me the opportunity to spend one year as a visiting professor in ALRC. I enjoyed the time I spent in Tottori University, both professionally and socially.

1. Summary of research activities (Oct. 1, 2005 to Sep. 30, 2006)

Keynote lectures and seminars

1) 'Monitoring ET with remote sensing and the management of water resources on a Basin scale', ALRC Annual meeting, Dec. 6, 2005.
2) 'Turbulent flux observations on complex terrain and some new issues on Eddy-covariance Method', ALRC, Mar. 6, 2006.
3) 'A study on vegetation cover dynamics in NW China by using GIMMS NDVI data', ALRC, Jun. 12, 2006.
4) 'A further study on the retrieval of surface evapotranspiration with satellite remote sensing', ALRC, Jul. 27, 2006.

Lectures to students in ALRC on 'Introduction to Remote Sensing and Its Application'

1) 'Spatial data acquisition', May 12, 2006
2) 'Basics of atmospheric radiation', Jun. 2, 2006
3) 'Image visualization and manipulation', Jun. 9, 2006
4) 'Retrieval of land surface parameters', Jun. 16, 2006

Scientific meeting presentations, visits and lectures in other universities

1) Dec. 13 to 14, 2005, Chiba University, attended the '11th CEReS International Symposium on Remote Sensing: Special theme on Maximization of the use of satellite data for understanding the earth environment'. Poster presentation: 'Monitoring ET with Remote Sensing and the Management of Water Resources on a Basin Scale'.
2) Dec. 15, 2005, a visit to the National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, gave a lecture entitled 'Monitoring evapotranspiration with remote sensing and the flux measurements in China'.
3) Mar. 23-24, 2006, invited by Nagoya University to give two lectures there, entitled 'Retrieval of evapotranspiration by remote sensing on a river basin scale' and 'Flux measurements and related studies on complex terrain'.
4) Apr. 27, 2006, invited by DPRI, Kyoto University, to give a lecture there, entitled 'Monitoring ET with Remote Sensing and the Management of Water Resources on a Basin Scale'.
5) May 18-28, 2006, a visit to ALRC and IWSC/CAS stations on Loess Plateau of China. Dr. Kimura was the group leader of this visit. I was mainly participating in the field investigation and other works in Liudaogou basin, Shenmu County, Shaanxi Province, and gained a better understanding on ALRC's Program for Arid Land Science (21st Century COE Program).
6) Jun. 5-6, 2006, invited by Tokyo University of Information Sciences (TUIS) and gave a lecture in the university, entitled 'Evaluation of ET from remote sensing data and the water management on

a Basin scale'. As a representative of my institute (CAREERI/CAS), I also signed a contract with TUIS on using its MODIS Products for a joint study of ET retrieval over Hai River Basin of China.

7) Aug. 27-29, 2006, attended the 'International Conference on Dryland Studies and Combating Desertification', with a poster presentation 'A study on vegetation cover dynamics on Loess Plateau by using GIMMS NDVI data'.
8) Sep. 11-14, 2006, attended the 'Joint Conference on Environmental Engineering in Agriculture 2006', Hokkaido University, Sapporo.

2. Assistance to students

In addition to give lectures on 'remote sensing', with Dr. Kimura together, I have many time discussions with students, such as Ms. Erdenebayar Munkhuutsetseg, Mr. Mohamed Abdelmoneim, and many others, including assisting them in writing manuscripts submitted to reviewed journals.

3. Title of articles related to my researches in ALRC

1) J. Asanuma, I. Tamagawa, H. Ishikawa, Y. Ma, T. Hayashi, Y. Qi, J. Wang, Application of the band-pass covariance technique to portable flux measurements over the Tibetan Plateau. Water Resources Research, Vol. 41, W09047, doi: 10.1029, 2005
2) J. Asanuma, I. Tamagawa, H. Ishikawa, Y. Ma, T. Hayashi, Y. Qi, J. Wang, Spectral similarity between scalars at very low frequencies in the unstable surface layer over the Tibetan Plateau. Boundary-Layer Meteorology (Accepted)
3) J. Wang, R. Kimura, and W. Basitiaanssen, Monitoring ET with Remote Sensing and the Management of Water Resources on a Basin Scale. Proceedings of the 11th CEReS International Symposium on Remote Sensing, pp 237-242.
4) K. Yang, T. Koike, H. Ishikawa, J. Kim, X. Li, H. Liu, S. Liu, Y. Ma, J. Wang, Turbulent flux transfer over bare soil surface in arid and semi-arid regions. Part I: Characteristics of heat transfer. (Submitted to Journal of Applied Meteorology and Climatology)
5) K. Yang, T. Koike, J. Wang, H. Ishikawa, J. Kim, X. Li, H. Liu, S. Liu, Y. Ma, Turbulent flux transfer over bare soil surface in arid and semi-arid regions. Part II: Evaluation of schemes for thermal roughness length. (Submitted to Journal of Applied Meteorology and Climatology)
6) J. Wang, R. Kimura, N. Guo, A study on vegetation cover dynamics on Loess Plateau by using GIMMS NDVI data. (In preparation)
7) J. Wang, R. Kimura, Eddy covariance fluxes measurements in mountainous terrain. (In preparation)

4. Some research results

1) Evaluation of ET from remote sensing data and the water management on a Basin scale

This is my main theme of study during this one year visit. Two aspects are included: (i) Algorithm development; (ii) Application for the water management of a river basin scale.

I have been involved in this study since early 1990's. Many algorithms have been developed in last 15 years, among them the surface energy balance based SEBAL, SEBS and METRIC are most popular for some operational use. However, a careful investigation reveals the major weakness of all these models - the inferring of basic atmospheric variables. Near surface meteorological fields (mainly wind, temperature, and humidity) are essential in the calculation of basic surface energy components (as well as the 'atmospheric correction' for satellite data) and they are difficult to be derived from remote sensing. A further study should combine remote sensing schemes with mesoscale atmospheric models. A more determinative wind

and temperature field near surface can be obtained by numerical simulation and data assimilation, in both prognostic and diagnostic ways. 1° by 1° reanalysis field is quite easy to be accessed nowadays. Computer ability is also much more improved for this purpose than a few years before.

The shortage of water resources is serious in Hai River Basin (and other basins in north China). Managing water resources on the basis of evapotranspiration (ET), retrieved mainly from satellite remote sensing, is a new approach introduced in the GEF Hai Project. The SEBAL, and its new improvements, will be used for this purpose. Data from the MODIS and Landsat TM/ ETM+ are used to evaluate daily, seasonal and annual ET per county and per land use category. Preliminary validations showed a satisfactory agreement. Further studies will be continued, with an independent validation program to check and improve the ET retrieval algorithm. It is aimed to obtain a real saving of water resources through an ET reduction strategy, having more water resources remaining in the basin for production and environmental use, including that more freshwater discharges into the Bohai Sea.

A similar algorithm is also to be used for the Loess Plateau, in both a small basin – Liudaogou – for water balance investigation and a larger scale for land surface – atmospheric interaction study, in the context of combating desertification in the dryland area of Loess Plateau.

2) Turbulent flux observations on complex terrain with eddy-correlation technique

Currently, the global Fluxnet Program (under IGBP-iLEAPS) has more than 300 stations, the CEOP (under WCRP-GEWEX) has 36 sites (each site comprises a number of stations), besides, there are numerous stations running under other projects. All of the major stations in these programs measure heat, water vapor, and CO_2 fluxes with eddy-correlation (EC) method. EC is a direct flux observation technique rather 'simple' in principle, however, since last decade, the problem of 'Flux Underestimation' by EC has been intensively discussing, such as the 'energy imbalance' problem in studying surface energy/water cycles, the 'underestimated CO_2 flux' problem in studying the surface ecosystem exchange, etc. These problems become more sever in 'difficult' yet very common conditions, including heterogeneous vegetation, topographic relief, and meteorologically unfavourable conditions (weak turbulence, intermittency, and unstationarity). Recent developments on these studies are investigated. Particularly, some recommendations on using EC in rather simple conditions are given. We have a flux station in the coniferous forest of Qilian Mountain of west China. Three months data collected in July through September, 2005, have been carefully analyzed. All the statistics including heat and H_2O/CO_2 fluxes showed a reasonable quantitative value and temporal trend. However, nighttime results are very scattered, possibly from the effects of mountain slope induced flow separation and intermittence, which is still difficult to understand at this moment. More observation data are needed.

3) Vegetation Cover Dynamics in Northwest China and on the Loess Plateau by Using GIMMS NDVI Data

Climate change and land conversion activities (such as the 'Grain for Green' in China) are altering biology states, especially for arid and semiarid ecosystems. Satellite monitoring provides information on seasonal and inter-annual vegetation response over various spatial and temporal scales. The GIMMS (Global Inventory Modeling and mapping Studies) NDVI data, based on seven AVHRR data sets, have supplied 15-daily vegetation coverage of the entire earth since 1981, at a spatial resolution of 8 km. This dataset has large improvements than the former PAL (Pathfinder AVHRR Land) NDVI, with better correction for sensor degradation and inter-calibration differences, satellite orbit drifts, volcanic eruptions, etc., reduces the NDVI anomaly greatly.

Data of GIMMS NDVI, 1981 to 2003, have been used to study the vegetation cover dynamics of Northwest China as well as the Loess Plateau. These are the areas with temperature raising and precipitation change unevenly in the 23 years, and sensitive for global warming study.

Monthly and yearly NDVI changes have been analyzed for the typical surface vegetation regions, including grassland, rain-fed cropland, forest, and desert, on the Loess Plateau. Surface observation data of nearly 60 stations in the area, mainly temperature and precipitation in the same period, are collected. Correlations between temperature / precipitation and NDVI are calculated.

Mean NDVI and its annual variation keep roughly unchanged for the whole Loess Plateau during the 23 years. However, vegetation changes are quite different for different landscape and areas. One dominant feature is the vegetation increasing in most areas of the Loess Plateau, mainly lower vegetated areas in middle and northern parts of the Plateau. This is particularly clear for the east part of the Maowusu (Wu Us) desert, including Yulin, Shenmu, and Fugu counties of Shaanxi Province and Yijinhole, Dongsheng, Zhunger, and a few other counties of Inner Mongolia, where the NDVI increases about 20% in last 20 years. Even the lower vegetated Wushen-Qi has also shown vegetation increasing in last 20 years. This is a more quantitative verification of the reports, 'The greening of Mu Us Deseart', of recent years in China, which may be relevant to the government 'Grain for Green Project'. On the other hand, vegetation in some areas has been declining, such as the Ziwuling forest area, middle and southern Shanxi province. For very dry area, such as the Kubuqi Desert, vegetation keeps a low level as early 1980's.

Correlations between NDVI and temperature, also, NDVI and precipitation, are positive for most areas. The correlation between NDVI and temperature is mostly larger than 90%, and seems more dominant for the vegetation increasing areas of the Loess Plateau. For lower vegetated areas, such as the east part of Mu Us Desert, precipitation has actually not much change (even slightly lower) in last 20 years; some stations show a negative correlation between NDVI and precipitation.

This confirms the study we did for a much larger area of Northwest china, which also showed vegetation increasing in lower vegetated areas, decreasing in forest areas, and higher correlation between NDVI and temperature. Responses to temperature / precipitation variation are different for different vegetated areas, also for different growing period.

(3) Professor Velupillai Rasiah

Visiting Professor (Oct. 2005- Sep. 2006)

Department of Natural Resources & Mines, QLD, Australia

Title: Research on the beneficial utilization of urban drainage / sewerage water and saline water

1. Summary of the research activities (Oct. 1, 2005 to Sep. 30, 2006)

i) Conceptualized, formulated, and designed a research project with a Ph. D. student in the drainage requirements for saline water drip irrigated conditions in a dune sand for a simulated semi-arid environment for sustainable soil resource use.

ii) Advised and contributed in the statistical analysis, discussion of analysis, and preparation and presentation of results as journal papers and seminar presentations of a research carried out by a Ph. D. student in "Drip irrigation of saline water in dune sand in simulated semi-arid environment". The major topics include assessment of; irrigation inputs, schedules, water (Kws) and salinity (Kss) stress coefficients, water and salinity stress days, leaf water potential (LWP), salinity response models. And the integration of Kss, Kws, LWP, and yield.

iii) Advised and contributed in the statistical analysis, discussion of analysis, and preparation and presentation of results as journal papers and seminar presentations of a research carried out by a Ph. D. student in 'Physico-mechanical processes involved sediment generation from simulated acid soil.'

iv) Advised and contributed in the statistical analysis, discussion of analysis, and preparation and presentation of results as journal papers and seminar presentations of a research carried out by a Ph. D. student in of research by a Ph. D. student in "Improving Resistance to Erosion in Yamaguchi Acid Soil using Artificial Zeolite and Hydrated Lime Amendment"

v) Joint research with a Ph. D. student in "Sediment generation and re-deposition processes using and Digital Elevation Models (DEM) and upscaling".

vi) Repeated laboratory experiments undertaken by Ph. D. students to clarify and rectify mistakes that were apparent in their first research data.

2. Title of articles related to my research here

i) B.A. Ould Ahmed, T. Yamamoto, **V. Rasiah,** and H. Anyoji (2006). The impact of saline water irrigation management options in a dune sand on available soil water and its salinity (Accepted in J. Agricultural Water Management).

ii) Ould Ahmed, T., Yamamoto, **V., Rasiah,** M., Inoue, H., Anyoji. (2006). Statistical discrimination of irrigation input variables-induced temporal sensitivity of stress indicators (to be submitted to Arid Land Research and Management).

iii) Andry Henintsoa, Yamamoto Tahei, **Rasiah Velu,** Fukuda Mitsuo. (2006). Improving Resistance to Erosion in Yamaguchi Acid Soil using Artificial Zeolite and Hydrated Lime Amendment. In review**:** Transactions of The Japanese Society of Irrigation, Drainage and reclamation Engineering.

iv) H. Andry, T. Yamamoto, **V. Rasiah**, and M. Fukuda (2006) Physico-mechanical processes involved in sediment generation in a simulated acid soil (in review CATENA**).**

v) M. A. M-Abd Elbasit, H.Yasuda, **V. Rasiah** and H. Anyoji. (2006). Discrimination of Intra-Rainfall Event Soil Microtopography Changes Using Automated Digital Photogrammetry. In review: PEDOSPHERE.

vi) **Rasiah V**, Webb I, Cogle AL, Anyoji, H. (2006.) Chloride Distribution Dynamics in a Dryland Regolith as Signature Indicator of Potential Salinity Risk (in review and to be published by International Centre for Agriculture Research in Dry Areas- ICARDA).

vii) Bouya Ahmed Ould Ahmed, Tahei Yamamoto, **Velu Rasiah**, and Hisao Anyoji (2006). Title: Assessment of salinity response functions for simulated semi-arid environment (to be submitted to J. Arid Land Research and Management).

3. Results (summary) of the research- item (i) of 1.

Preliminary results of the leaching experiment to sustain soil resource sustainability

Under my guidance and conceptualization a greenhouse experiment was conducted in 2006 spring, to determine the appropriate leaching practices and amounts in plots that were irrigated with saline water in 2005. The major objective in this experiment was to sustain the soil resource sustainability through leaching of the salt that accumulated during the previous growing season. The growing season leaching was kept at minimum because of high percolation losses in the dune sand. The off-season leaching was perceived as another alternative to minimize salt accumulation and to have fields with minimum or no slat in the root-zone for the succeeding season. Saline water (7.3dS m^{-1}) and water quality (0.11dS m^{-1}) were used for leaching using 50mm and 25mm, respectively, for the former and latter waters, respectively, at each leaching. The initial salinity in the leached profiles ranged from 16±3.8, 27±7.8 to 38.5±5.8dS m^{-1}.

After leaching with 100 mm of quality water, at 25 mm per leaching, the salinity decreased to 2.3±0.8, 1.68±0.6, and 1.6±0.4, respectively. The corresponding decrease when leached with saline water was 5.1±1.1, 5.31±2.1, 5.45±1.4 dS m^{-1}, respectively. When leached with 200 mm of saline water, at 50 mm per leaching, the salinity decreased to 6.92±1.2, 4.6±1.5, and 4.22±2.1 dS m^{-1}, respectively. The results indicated leaching with quality water leached almost all the salt to that accumulated during saline water irrigation during the 2005 growing season. Leaching with saline water led to substantial quantities of the salt leached out from the root-zone and is less than the risk level for sorghum in 2006. Also, using large quantity, 50 mm per leaching compared with 25 mm seems to have no advantage in salt removal from the root-zone. In the absence of quality water, off-season leaching with saline water at small doses is recommended to sustain soil resource sustainability. The details of the data will be presented by the Ph. D. student in his thesis. Further, repeated leaching studies are recommended for 2007.

Results of item (ii) of 1

The performance of saline-water drip irrigated sorghum grown in dune sand for a simulated arid environment was analyzed. The crop potential evapotranspiration (ETc), computed on a daily basis was matched against the amount of water available in the 0-10 cm, 10-25 cm, and 0-25 cm segments of the profile. The results indicated the amount of water available in the 0-25 cm segment was sufficient to meet ETc, particularly during the critical crop growth stage, when crop was irrigated at 100% open pan (EP1.00) everyday. The number of water stress days during the whole growing season ranged from 7 to 90d. The multiple regression analysis indicated an interaction term involving water and salinity stress determined grain yield.

The cumulative recharge by irrigation in the top 25 cm of the profile ranged from 309 to 662 mm and depended on irrigation input amounts, which ranged from 382 to 765 mm, and frequency. The cumulative ETc was 578 mm. The daily recharge matched against the corresponding ETc indicated that grain yield might have been impacted by water stress in the 50% irrigation input, regardless of the frequency, but not in the 100% input treatments. The daily ECsw in the root-zone matched against the FAO threshold (13.6 dS m^{-1}) indicated the possibility of salinity stress during the late maturity stage in the 50% input treatment, regardless of the irrigation frequency, but no stress in the 100% input treatment. Though there was no water or salinity stress in the every second day 100% input treatment, the significant relative yield reduction, compared with the daily 100% input, is attributed to inherent limited available water capacity and rapid percolation losses between irrigations in this sand. The results indicate daily irrigation at 100% input is the most appropriate saline water irrigation management option for this dune sand.

The statistical parameters; mean, median, percentile value (PCV), and coefficient of variation (CV), were assessed for their ability to discriminate the impact of irrigation management options; two irrigation input amounts at two frequencies, and three salinity levels, on the stress indicators for available soil water (Kw), soil water-salinity (Ks), and leaf water potential (LWP). The Kw, Ks, and LWP varied temporally on a daily basis and depended on the irrigation input, frequency, the salinity of the irrigation water used. The statistical parameters; mean, median, CV, and the PCV, for the time series Kw data indicated the impact of irrigation input amounts, at a given frequency, or vice versa on water stress (Kw) was consistently best discriminated by PCV,CV, and followed by median, and a similar trend was observed for salinity tress (Ks). The impact of different salinity levels on Kw and Ks was consistently discriminated by CV and PCV, and that on LWP by PCV and median. The time series analysis indicated

that PCV consistently discriminated the impacts of irrigation input, frequency, and the salinity of the irrigated water on the stresses associated with available soil water and its salinity.

Saline-water drip irrigated sorghum varietal (3varities) response under conditions of limited available soil water in dune sand was assessed using salinity response function. Four salinity response models were assessed for their ability to discriminate salinity-induced grain yield differences under very limited available soil water. Salinity response analysis indicated the four models were equally good in fitting the grain yield data, but the modified discount model consistently produced the best fitting for the tested varieties. The coefficients for the model parameters indicated that varietal yield differences to salinity stress was best discriminated by the values of the parameters. Analysis of the data indicated the impact of salinity stress on varieties were best discriminated by the parameters; salinity threshold (*Ct)*, salinity tolerance index (*ST-index*), and the salinity at which 50 % grain reduction (C_{50}) occurred. The analysis indicated the variety BK 16 was the most tolerance to salinity stress.

Results of items (iii) and (iv) of 1

The physico-mechanical processes involved in the impact of deforestation and subsequent cropping induced changes in soil acidity in the tropical regions of developing countries on runoff (RO) and sediment (SD) generation is poorly understood. The (i) the changes in RO and SD generation processes and (ii) link between the changes in deforested Tohaku clay (Japan) artificially acidified were explored. The simulated acid soil was subjected to rainfall intensities of 30 and 60 mm hr^{-1} and time incremented RO SD samples analyzed indicated the process was described by an elongated S-shape function consisting three phases. Across intensities the SD increased with increasing acidity in each phase from and the SD increases with increasing acidity were linked to increases in crust and seal formation and decreases in unsaturated hydraulic conductivity.

The effect of amendment induced changes in surface runoff (SR) and sediment (SC) generation in Yamaguchi acid soil in Japan indicated that both SR and SC were decreased by amendment incorporation and the reduction increased with rates of application of amendments. The highest reduction was found for zeolite at 15 % and the lowest for lime at 0.5 %. The zeolite and hydrated lime incorporation increased wet aggregate stability and decreased dispersible clay and these changes led to increases in soil water retention, infiltration, and sub-soil water transport. The improvements in soil water properties led to delayed SR and sediment generation and consequently low total sediment. The results suggest that increase in wet aggregate stability and reduction in clay dispersion through zeolite and hydrated lime amendment in acid soils led to the increase in resistance to sediment generation through improvement in soil water properties.

Results of item (v) of 1

The changes in soil surface microtopography have an impact on soil-water interaction processes during rain events. Rainfall simulator experiments were conducted to assess capability of fixed cameras-base photogrammetry system to measure soil surface microtopography changes during simulated rain event. The automated photogrammetric system is capable to generating three dimensions (3D) vision of the soil surface during rain, which provided time evolution of soil microtopography changes which was then link to soil-water interaction processes. Two digital elevation model (DEM) rectification methods were used in order to detect these changes. The DEMs accuracy was assessed using measured coordinate and elevation (x, y and z, respectively) checkpoints and compared with photogrammetrical estimated values. The root mean square error (RMSE) to x-direction, y-direction and z-direction were 2.08, 2.59 and 1.96 mm, respectively. The changes on the surface were assessed using three roughness indices. The soil surface

random roughness (RR), limited elevation difference (LD) and limited slope (LS) indices decreased with time steps. The method successfully generated dense DEM of the soil surface during simulated rainfall event.

Seminars and Conferences

I gave the following open-seminars at ALRC.

1. My career in Water & Soil resources sustainability issues under cropping.
2. Dynamics of salt dynamics after forest clearing for grazing and the potential for salinity development in a semi-arid catchment in Australia.
3. Dynamics of the environmental contaminant Nitrate in fluctuating groundwater in a wet tropical catchment in Australia.
4. A low-tech and low-cost soil physical property as a holistic soil physical health indicator.

I was the presenter (bold and underlined) and principal author or co-author in the following presentations at national and international conferences.

1**. Rasiah** Velu and Anyoji Hisao. (2005). Nitrate in Groundwater under Cropping and its Environmental Association. Annual meeting of ALRC, Tottori University, held at ALRC on December 6, 2005.
2. **Rasiah** V, Webb I, Cogle AL, and H. Anyoji. (2006). Chloride Distribution Dynamics in a Dryland Regolith as Signature Indicator of Potential Salinity Risk. Oral presentation at the Eighth International Conference on Development of Drylands, held in Beijing, China February 25-28, 2006.
3**.** Ould Ahmed, B.A, Yamamoto, T. Inoue, M., **Rasiah** V. (2006). Salinity stress coefficient as an indicator of soil and leaf water stress. Oral presentation at the 7th International Micro-Irrigation Congress, held in Kuala Lumpur, Malaysia form September 10-16, 2006. Paper No. P2015.
4. Ould Ahmed B. A., Yamamoto, Y., **Rasiah**, V., and Inoue, M. (2006). Comparison of Three Varieties of Sorghum Grain Yield Response to Salinity under Drip Irrigation System. Oral presentation at the Annual meeting of Japanese society of irrigation and drainage, 2006. Utsunomiya University, Utsunomiya, Japan 7-10 August.
5. Ould Ahmed, B. A., Yamamoto, T., **Rasiah**, V., H. Anyoji1 (2006) Sensitivity of stress indicators for sorghum under saline water drip irrigation. Oral presentation. At the Annual meeting of Japanese society of irrigation and drainage, 2006. Utsunomiya University, Utsunomiya, Japan 7-10 August.
6. Andry Henintsoa, Yamamoto Tahei, **Rasiah** Velu, Fukuda Mitsuo. (2006). Simulated Acid Soil Erosion Linked to Selected Physical Properties. Oral presentation. At the Annual meeting of Japanese society of irrigation and drainage, 2006. Utsunomiya University, Utsunomiya, Japan 7-10 August.
7. Henintsoa Andry, Tahei Yamamoto, Velu **Rasiah**, and Mitsuhiro Inoue (2007). Effectiveness of Sedum Plant on Yamaguchi Acid Soil Erodibility**.** To be presented at the Annual meeting of American Society of Agricultural Biological Engineers in USA in June/July 2007.

Miscellaneous

1. Reviewed and edited several abstracts, manuscripts, power point presentations, and research programs of graduate students, postdoctoral fellows, and professors.
2. Participated and contributed (not just a spectator) in most of the seminars held at ALRC.
3. Held regular discussion with graduate students on statistical analysis of data, interpretation of results and write up of journal papers and thesis. In essence serving as mentor.
4. Organised contact points in an Australian university for research students at ALRC for potential joint research ventures.

(4) Professor Mohan Chandra Saxena

Visiting Professor (Jun. 2006- May 2007)

Previous affiliation: International Center for Agricultural Research in the Dry Areas (Syria), India

Title: Research on the beneficial utilization of urban drainage / sewerage water and saline water

1. Summary of research activities (Jun. 1, 2006 to Mar. 31, 2007)

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 *Jatopha 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.*

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 Aug. 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 Nov. 2006;
f. Holding technical discussions with *Jatropha* germplasm scientist at the Indian Agricultural Research Institute, New Delhi, 18-22 Nov. 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 Dec. 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 Mar. 2007.

i. 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
j. 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;
k. 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; and
l. Assisting the Director of ALRC in the matters related to collaboration with ICARDA, Aleppo, Syria.

2. Title of articles related to my research here

Following articles were prepared and submitted during my stay here although some of these are not directly related to the research that I did here:

* Saxena, M.C. 2007.Challenges and opportunities for Food Legumes Research-global perspectives. *In* M. Kharkwal (ed.). Proceedings of Fourth International Food Legume Research Conference on Food Legumes for Nutritional Security and Sustainable Agriculture, New Delhi, India, 18-22 Oct. 2005.

* Saxena, M.C. 2007. *Jatropha curcas* L., an excellent source of renewable energy in the dry areas. *In* El-Beltagy, A., M. C. Saxena and Wang Tao (eds.). Human and Nature – Working Together for Sustainable Development in Drylands. Proceedings of the Eighth International Conference on Development of Drylands, 25-28 February 2006, Beijing, China. ICARDA, Aleppo, Syria

* Saxena, M.C. 2007. Meeting the challenge of water scarcity for agriculture in the dry areas. Proceedings of 'International Symposium on Dryland Ecology and Human Society (ISDEHS)' in UAE, 4-7 December 2006

* Saxena, M.C. 2007. '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 Mar. 2007.

It is proposed that after a few more experiments are completed by the student following papers will be prepared:

- Effect of salinity stress on imbibition and rate of germination of *Jatropha curcas* seeds.
- Effect of frequency of irrigation on the growth and consumptive use of water by *Jatropha curcas* plants.
- Effect of osmotic stress on leaf gaseous exchange and consumptive use of water by *Jatropha curcas* plants.
- Effect of the deficiency of macrometabolic mineral nutrients in growth medium on the growth, foliar symptoms and nutrient concentration in Jatropha curcas plants.

3. Result of the research done during my stay at ALRC

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 4^{th} day (T3) and every 6^{th} 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 6^{th} 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 umol CO_2 m $^{-2}$ 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 mol H_2Om $^{-2}$ 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 mmol H_2O m $^{-2}$ 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: **(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) 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 (300g 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 a 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 CO_2 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.

(5) Assoc. Professor Yuanrun Zheng

Visiting Assoc. Professor (Oct. 2006- Sep. 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

1. Summary of research activities (Oct. 1, 2006 to Mar. 31, 2007)

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 affect by both natural conditions and human disturbance. Therefore, it is a complicated process to restore desertified land.

In this research, we mainly focused on the two matters:

1) What will happen in desertified zone without further human disturbance?
2) To understand the character, 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 researches during last half year could be summarized below:

1) To analyze existing data gained both in field and laboratory and to prepare manuscripts.
2) To inquiry literature and to make new experiment plan based on the previous results.
3) To prepare and to conduct new experiments.

2. Title of articles which is related to my research here

* Yuanrun Zheng, Zhixiao Xie, Charles Roberts, Ping An, Lei Zhang, Guangsheng Zhou, Hideyuki Shimizu, and Sam Drake. Modeling seasonal evapotranspiration of arid lands in China. Journal of Arid Environments (submitted).
* Yuanrun Zheng, Glyn M. Rimmington, Lei Zhang, Ping An, Guangsheng Zhou, Xiangjun Li, Lijun Chen, Hideyuki Shimizu. Response of 4 dominant species collected from a sand dune in central Inner Mongolia to air temperature and soil moisture. Environmental and Experimental Botany (submitted).
* Mingqing Zheng, Yuanrun Zheng, Guangsheng Zhou, Yuzhen Wu, Ping An, Carol C. Baskin, Jerry M. Baskin. Effects of watering regime and depth of burial on seedling emergence of four dominant psammophytes in the Mu Us sandy land, Inner Mongolia, China, and relevance to revegetation of a desertified region. Seed Sciences Research (submitted).

* Yuanrun Zheng, Zhixiao Xie, Guangsheng Zhou, Ping An, Sam Drake, Glyn M. Rimmington, Hideyuki Shimizu. The balance between natural drivers and human disturbance creates dynamic stability of a shrub ecosystem, with implications for restoration (primary evaluation by some experts).
* Yuanrun Zheng, Zhixiao Xie, Guangsheng Zhou, Ping An, Xiangjun Li, Sam Drake, Glyn M. Rimmington, Hideyuki Shimizu. Response of 4 dominant species from Ordos plateau to CO_2 enrichment and increasing temperature (Preparation).
* Yuanrun Zheng, Zhixiao Xie, Guangsheng Zhou, Ping An, Xiangjun Li, Sam Drake, Glyn M. Rimmington, Hideyuki Shimizu. Water using characteristics of 4 dominant species from Ordos plateau (Preparation).

3. Result of my research which I get during my stay

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.

Actual evapotranspiration (Ea) simulation result showed that estimated annual Ea was below 50 mm in 34% of arid land in China, below 100 mm in 55% of the sites and less than 200 mm in 85% of the sites. Ea peaked from May to August. From September Ea decreased dramatically for sites of all types, with most showing less than 10 mm each month. Monthly Ea was lowest during November and December, at less than 5 mm.

(6) Assoc. Professor Muhammad Irshad

Visiting Assoc. Professor (Oct. 2006- Sep. 2007)
Water Management Department,
Government of North Western Frontier Province (NWFP), Pakistan
Title: Monitoring Soil and Crop Nitrogen Dynamics under Sodic Conditions

1. Summary of research activities (Oct. 1, 2006 to Mar. 31, 2007)

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.

2. Articles related to the previous and current studies:

1. Zahoor, A., Faridullah., Haytham, E. S., **Irshad, M.,** Honna, T., Yamamoto, S. and Al-Busaidi A.S. (2007) *In press* Changes in Water-extractability of Soil Inorganic Phosphate Induced by Chloride and Sulphate Salts. Environmental Science and Pollution Research
   http://www.scientificjournals.com/sj/espr/abstract/doi/espr2006.06.309
2. Zahoor, A., Honna, T., Yamamoto, S., **Irshad, M.**, Haytham E. S., Abou El-Hassan, W. H. and Faridullah: (2007) *In press* Wheat (*Triticum aestivum* L.) response to combined organic and inorganic phosphorus fertilizers application under saline conditions. Acta Agriculturae Scandinavica.

http://www.informaworld.com/smpp/content~content=a769551217~db=all~order=page

3. **Irshad, M**., M. Inoue, M. Ashraf, A. Zahoor and Faridullah (2007) The Mitigation Challenge of Salt-affected Soils in Pakistan J. Food Agric. Environ. 5 (2): 84-87.
4. Al-Busaidi, A., T. Yamamoto, M. Inoue, **M. Irshad**, Y. Mori and S. Tanaka (2007) *In press* Effects of seawater salinity on salt accumulation and barley (*Hordeum vulgare* L.) growth under different meteorological conditions 5 (2) (J. Food Agric. Environ.)
5. **Irshad, M.,** M. Inoue, M. Ashraf, Faridullah and A. Tsunekawa (2007) *In press* Land Desertification-An Emerging Threat to Environment and Food Security of Pakistan
   Journal of Applied Science.
6. **Irshad, M.,** M. Inoue, S. Yamamoto, A. Zahoor, M. Ashraf and T. Honna (2007) *In press* Phosphorus and Metal Fractions in Paddy Soils under Different Fertilizer Management. (J. Sustainable Agriculture)
7. **Irshad, M.**, M. Inoue, A. E. Eneji, S. Yamamoto and T. Honna (2007) *In press* Evaluation of Nutrients Release in Salt-Saturated Soils (Commun. Soil Sci. Plant Anal.)
8. **M. Irshad,** M. Inoue, M. Ashraf and A. Al-Busaidi (2007) *In press* The Management Options of Water for the Development of Agriculture in Dry Areas (J. Applied Sciences)
9. Al-Busaidi, A., T. Yamamoto, M. Inoue, Y. Mori, **M. Irshad** and A. Zahoor (2007) *In press* Monitoring Saline Irrigation Effects on Barley and Salts Distribution in Soil at Different Leaching Fractions. (Asian Journal of Plant Science**)**
10. Al-Busaidi, A., T. Yamamoto, M. Inoue, A. E. Eneji, Y. Mori, **M. Irshad** (2007) Effects of Zeolite on Soil Nutrients and Growth of Barley Following Irrigation with Saline Water (Submitted to J. Plant Nutrition).
11. Zhang, Q. T., M. Inoue, K. Inosako, **M. Irshad,** K. Kondo and G. Y. Qiu (2007) The Ameliorative Effect of Mulching on the Growth of Swiss Chard (*Beta vulgaris* L.) and Salt Accumulation under Saline Irrigation (Submitted to Sand Dune Research)
12. Busaidi, A., T. Yamamoto and **M. Irshad** (2007) The Ameliorative Effect of Artificial Zeolite on Barley under Saline Conditions (Submitted to J. Applied Sciences)

3. International Conferences

1. **Irshad, M.,** M. Inoue and M. Ashraf (2006) A Comprehensive Overview of Soil Salinization in Pakistan. International Symposium on Drylands Ecology and Human Security (ISDEHS) Dubai-Sharjah, Dec 4~7, 2006.
2. Ould Ahmed, B. A., T. Yamamoto, M. Inoue and **M. Irshad** (2006) Saline Water Drip Irrigated Sorghum Varieties Response for Low Available Soil Water in Dune Sand International Symposium on Drylands Ecology and Human Security (ISDEHS) Dubai (Sharjah), Dec 4~7, 2006.
3. Honna, T., A. E. Eneji and **M. Irshad** (2006) Effective Use of Organic Matter in Dryland Agriculture Presented in 8th Dec 2006 Beijing-China.
4. **Irshad,** M., M. Inoue, A. Zahoor and M. Ashraf (2007) Water Resources Management as an Option for Sustainable Agriculture in Arid and Semi-Arid Areas. ECO Summit 2007 at Beijing-China May 22~27, 2007).
5. **Irshad, M.,** M. Inoue, A. Zahoor and T. Honna (2007) Changes in the Forms of Elements in Paddy Soils under Organic and Inorganic Fertilization. International Symposium on Organic Matter Dynamics in Agro-Ecosystems France at Poitiers-France July 16~19, 2007.

4. Open seminars delivered at ALRC

a. Salinization- a major issue in Pakistan

b. Efficiency of Nitrogen Use under Saline Conditions
c. Integrated Water Resources Management as an Effective Tool for Dryland Agriculture
d. Land Degradation- A Challenge to the Food Security of Developing World

5. Miscellaneous academic activities:

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 above during the 6 months stay at ALRC.

6. Summary of the above manuscripts as first author:

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, $NaNO_3$ and Na_2SO_4 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 Na_2SO_4 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 H_2O-P, $NaHCO_3$-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 > $NaHCO_3$ > H_2O. 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) The Mitigation Challenge of Salt Affected Soils in Pakistan (Review article)

The constraints on the availability and quality of land and water coupled with increasing degradation of natural resources are the major challenges of Pakistan. The development of sustainable land-use system must be emphasized to address these emerging challenges. Soil salinity, sodicity and waterlogging are amongst the significant land problems not only causing desertification but also possess greater economic and social consequences. Since the location of Pakistan is in the arid and semi-arid zone, therefore, high evapo-transpiration rate is the basic cause of salt accumulation in soils. Presently more than 6 million hectares of land are salt-affected. The issue is particularly related to the vast irrigation system in the country. The intensive use of surface irrigation has altered the hydrological balance of the irrigated areas. Mismanagement, incorrect irrigation and lack of drainage have resulted further salts accumulation in the soils. Thus there is a major imbalance in the amount of salt entering and leaving the soils. The magnitude of the problem can be ascertained from the fact that the productive land is being degraded by salinity at an alarming rate of about 0.02~0.04 million hectares annually. Remedial measures are being considered seriously by the people. Large numbers of projects have been launched on this aspect. The modified hydrological approach in conjunction with the chemical and biological reclamation would essentially manage salt-affected soils. Integrated efforts are needed to effectively mitigate salt-affected soils for perpetual productivity. For this purpose, public participation and the encouragement of non-governmental agencies is absolutely imperative. This paper discusses the nature and causes of soil salinization and reviews options available for improved utilization and management of saline lands in Pakistan.

d) Land Desertification- An Emerging Threat to Environment and Food Security of Pakistan (Review article)

The natural resource base of land, water and vegetation in arid and semi arid areas is highly fragile and greatly vulnerable to degradation. There is a serious problem of desertification in many parts of Pakistan. Population pressure along with the demand for more food, fodder and fuelwood has generated a chain of interrelated economic, social and environmental issues associated with the land degradation inside Pakistan. A variety of natural and human factors are contributing to desertification and severely impairs the biological productivity of lands across the country, including dwindling vegetation cover, overgrazing, flooding, overexploitation of water and land resources, overcultivation of marginal lands, deforestation, soil erosion, salinization, sodication and the use of inappropriate technologies. Unsustainable agricultural activities including inadequate soil conservation, cultivation of steep slopes, cultivation without adequate fallow periods, unbalanced fertilizer use and improper irrigation management coupled with the misuse of prime agricultural land for urbanization / industrialization had a devastating impact on land resources. The increased pressure on land with low productivity and environmental pollution through industrial wastes has further exacerbated the prevailing condition. In spite of the concerted national efforts to mitigate the effects of drought, combating desertification is still one of the major challenges to the people of the country. The action necessary to help avert desertification is to educate people as to the value of precious land and water resources. The present deserted situation is directly related to the failures of the unrealistic resource management policies. Various approaches are being applied to arrest the menace of desertification. The institutional set-up for formulation and implementation of programs and policies is being strengthened in the country. Numbers of land reclamation projects have been launched. The activities and efforts already underway by several public and private organizations, departments, NGOs and rural support programs to combat desertification are required to be strengthened, integrated and supplemented through a nationally

supported, coordinated and monitored system. This paper reviews some of the causes of desertification, identifies the patterns of land degradation and highlights the future prospects of combating desertification in Pakistan.

e) The Management Options of Water for the Development of Agriculture in Dry Areas (Review article)

The natural resource base of land, water and vegetation in arid and semi arid areas is highly fragile and greatly vulnerable to degradation especially in the developing countries. The demand for water is constantly increasing as a result of population growth and the expansion of agriculture and industry. Fresh water resources are limited in the arid and semi-arid areas whereas the existing water resources are often overused and misused. The lack of water management in the arid areas generated numerous economic, social and ecological issues. Agriculture currently accounts for nearly 70-80% of water consumption in the developing countries. 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. More efficient use of existing water resources and adequate management of soils could prove to be the effective tool for improving arid lands. The technologies, skills and capital resources required to overcome the poor and extreme distribution of water resources through storage and transfer are not available and widely used. As a consequence there is critically low access to water for agriculture, drinking and sanitation, and the environment. Poor access to water is among the leading factors hindering sustainable development in semi-arid and arid regions. Conventional irrigation management should be revised to ensure maximum water productivity instead of land productivity for dry farming systems. Under conditions of increasing water scarcity, the key to sustaining rural livelihoods is improving the productivity and reliability of rainfed agriculture by using limited rainfall more productively, through optimal on-farm soil, water and crop management practices that conserve soil moisture and increase water use efficiency. Conserving and augmenting water supplies through rainwater harvesting and precision irrigation provide new opportunity for productive dry land farming. Without action, it has been reported that in 2025, two thirds of the world's population would live in water stressed areas. One of the actions necessary to help avert water crisis is to educate people as to the value of this precious resource. A productive water-use system in arid and semiarid areas, where the annual rainfall is scanty, the evaporation rate is higher than precipitation and characterizes insufficient renewable water resources, is the urgent need of the farmers. This paper reviews options available for improved utilization and management of water resources and examines the future prospects of sustainable agriculture in water scarce areas.

f) Monitoring Manure Effects on Crop and Soil Nutrient Release under Water Deficit Conditions (Summary of current study)

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 will be statistically analyzed at significance level of 5% to determine the treatments effects.