

2.8 Activities of 21st Century COE Researchers

(1) Dr. Hisashi Tomemori

Summary of research

Fundamental research for sustainable agricultural development in arid land was conducted.

(Recycling system of phosphate in soil-water by porous glass materials)

Phosphate which is increased by human activities is a key factor of eutrophication. In the meanwhile, phosphate is an essential element for normal growth of plants, and is applied to farmland as fertilizer to maintain high crop productivity. It is predicted that phosphate rock will be exhausted in 21st century. Therefore, the other phosphate resources are required.

We found that porous glass materials adsorbed the phosphoric acid in a solution¹⁾, and we discovered the mechanism²⁾. This year, we began to examine whether crops can actually use the phosphoric acid adsorbed onto porous glass materials.

1) Patent publication number: P2005-97065A

2) Inanaga, S., R. Nakazawa, H. Tomemori, A. Hirano, M. Murakami, H. Mochizuki, Mechanism of phosphate-adsorption onto porous glass materials, *Man & Environ.*, 31(1), 11-16, 2005

(Research and development of hydroponics systems)

In arid land, good-quality water for agriculture is difficult to get, and poor-quality water causes the salt accumulation problem by irrigation in many cases. Then, I studied hydroponics systems which prevents problems such as salt accumulation, and which can be adapted for the arid area. In this year, I designed the hydroponics system which can grow crops even if high-concentration salts are included in the culture solution. This topic is also studied the following year continuously.

(Examination activities)

A research on the actual condition of the afforestation in the Loess Plateau of China was conducted.

(2) Dr. Naru Takayama

Summary of research

Climatic Feature of Rainfall in the Loess Plateau in China

We have researched on environmental monitoring to support anti-desertification activities in the Loess Plateau. In this thesis, the spatial distribution, the variance (stability) and the trend of annual precipitation were studied. In addition, the stability of precipitation in the summer rainy season was estimated from the viewpoint of seasonal feature of precipitation. As a result, it was clarified that the rainy season is not equally stable between in the east side and in the west side of the Loess Plateau, even if the annual precipitation is at the same level.

Feature of Seasonal Rainfall and Estimation of Normals of Monthly Precipitation on the Loess Plateau of China

We proposed a simple statistical model to estimate the normals of the monthly mean of daily precipitation by using topographic factors calculated from the Digital Elevation Model on the Loess Plateau. This study first analyzed the relationship between the spatial distribution of monthly precipitation and aerological observation data to clarify the climate elements that dominate seasonal rainfall. Next, we used various topographic factors calculated from the Digital Elevation Model (GTOPO30; USGS) to analyze the topographic elements that dominate seasonal rainfall on a local scale. Finally, we suggested a statistical model to estimate normals of the monthly mean of daily precipitation over the Loess Plateau, and made normals of the monthly precipitation map.

Research Activities

The loess plateau in China is semi-arid area located at E100° to 115° and N34° to 40°. About 70% of the annual precipitation is concentrated in the summer and loess soil is very highly erodible, so a steep gully is

formed in Loess Plateau. I tried to construct model to estimate monthly precipitation over the Loess Plateau area by using routine meteorological data and digital elevation model (GTOPO30).

Publications:

- Takayama, N., Kimura, R., Kamichika, M., Matsuoka, N. and Xingchang Z., 2004: Climatic Feature of Rainfall in the Loess Plateau in China. *J. Agric. Meteorol.*, 60, 173-189.
- Takayama, N., Hayakawa, S. and Onomoto, S., 2005: Development of Frost Damage Prediction Technique Using Digital Elevation Model (DEM) in Air Temperature Estimation. *J. Agric. Meteorol.*, 60, 873-876.
- Takayama, N., Kimura, R., Kamichika, M., Matsuoka, M. and Xing-chang. Z., 2004: Feature of Seasonal Rainfall and Estimation of Normals of Monthly Precipitation on the Loess Plateau of China. *Monthly Weather Review*, (Submitted).

National work shops and meetings

- Takayama, N., Kimura, R. and Kamichika, M., 2004: Estimation of Normals of Monthly Precipitation on the Loess Plateau of China. *Abstracts of Annual Meeting of the Chugoku-Shikoku Chapter of the Society of Agricultural Meteorology of Japan* held in (Tottori City), 34-37.

(3) Dr. Hidetoshi Mochizuki

Summary of research

Latent heat transfer in salt-affected soils

The main objective of this study is to clarify the effect of latent heat transfer on salt-affected soil thermal conductivity, and its mechanism by theoretical analysis. Thermal conductivities of Tottori dune sand and Kaolin which is artificial nonswelling clay were measured under several water content, NaCl concentration, and temperature with heat probe method by KD2.

The latent heat component was separated from the apparent thermal conductivity according to its temperature dependence. The latent heat components were reduced by the addition of NaCl into the soils. The analysis more in detail based on the Philip and de Vries' model for Kaolin revealed that the phenomenological coefficient in the model decreased with the NaCl Concentration, although it was considered to be constant.

Thermal property of oil polluted soil

Soil pollution by oil such as fossil fuel is the serious problem all over the world. To remediate the polluted soil, some thermal techniques are applied. But the knowledge on the thermal properties of oil polluted soils is insufficient. In this study, Tottori dune sand and rape oil were applied to collect the information on the thermal properties of oil polluted soil. Thermal conductivity of oil polluted soil is a function of total liquid phase (water and oil) fraction, and oil-water mixing ratio. We tried to formulate it as a function of Total liquid phase fraction, and oil-water mixing ratio.

Publications:

1. Mochizuki, H., 2004: Research on Arid Land Science in Japan having no Arid Land, *J. of JSIDRE*, 72(10), pp. 899 (in Japanese)
2. Sakaguchi, I., Mochizuki, M., and Inoue, M., Inanaga, S., 2004: Latent Heat Transfer in a Salt-affected Nonswelling Clay, *J. Jpn. Soc. Soil Phys.*, 98, pp.3-10 (in Japanese)
3. Inanaga, S., Nakazawa, R., Tomemori, H. Hirano, A., Murakami, M. and Mochizuki, H., 2005: Mechanism of phosphate-adsorption onto porous glass materials, *Man & Environ.*, 31(1), pp.11-16 (in Japanese)
4. Mochizuki, H., Suko, T., 2004: Thermal conductivity of oil polluted soil, The Japanese Society of Irrigation, Drainage and Reclamation Engineering. 2004 Annual meeting, pp. 272-273 (in Japanese)
5. Koiwasaki, M., Mochizuki, H., and Suko, T., 2004: Thermal Conductivity Model of Oil-polluted Soil, 45th Japanese Society of Soil Physics Symposium, pp 46-47 (in Japanese)

(4) Dr. Ryoji Nakazawa

Summary of research

1. Recycling of phosphate in soil-water system by using porous glass materials

Eutrophication in closed water system (such as lakes and ponds) has been progressed by human activities year after year. Phosphate is a key factor of eutrophication, and is released from human activities. On the other hand, phosphate is an essential element for normal growth of plants, and is applied to farmland as fertilizer to maintain high crop productivity. The shortage of phosphate deposits within 21st century is predicted. We have been investigating the agricultural use of “porous glass material”. As a result, we discovered the decrease in phosphate concentration in solution by coexistence of the porous glass material. Porous glass materials are recycling materials made from milled waste glass (including bottles etc.) and heat-degradable and forming reagents (such as CaCO₃). Therefore, I had already analyzed the mechanism of the decrease in phosphate concentration by coexistence of porous glass material. Porous glass material was made from waste bottle glasses and several kinds of forming reagents. The phosphate-adsorption was caused by calcium added as forming reagents. Furthermore, it is shown that porous glass material which has higher phosphate-adsorbing capacity can be manufactured by the addition of large amount of CaCO₃. From bioassay with tomato plants, it is suggested that the phosphate-treated porous glass material contained phyto-available phosphate. From the above results, it is strongly suggested that phosphate in water systems can be removed by using porous glass material, followed by reuse of the phosphate-containing glass material as fertilizer.

2. Factors affecting the formation of water-stable aggregates with sandy soil

Improvement of soil properties is benefit for tree planting and food production in arid land. Especially, water conductivity and water-holding capacity should be improved in the land. To improve the two parameters simultaneously, the development of aggregates is useful. Especially, a water-stable aggregate that is not destroyed even by soaking is important for agriculture.

Several investigators reported the contributors of aggregates such as clay, humus, oligosaccharide, phenol compounds etc. It is speculated that these factors works as connector among bigger soil particles (such as sand and silt). However, the direct proof that those factors contribute to aggregates formation has not been reported. In addition, interactions between those factors in aggregates formation have not been determined.

Therefore, the degree of the contribution of those factors to aggregates formation compared quantifiably, and clarified the formation of water-stable aggregates with sandy soil.

I examined the effects of several reagents on the formation of water-stable aggregates with sandy soil. The findings indicated in this paper are as follows; 1) it is confirmed that water-stable aggregates is able to be formed even by using sandy soil as basic material. 2) It is suggested that oligosaccharide plays an essential role in the aggregates formation. 3) Diatomaceous earth (raw and amorphous) synergistically interacts with oligosaccharide in the aggregates formation. It is suggested that the efficient improvement of sandy soil can be conducted by simultaneous application of Diatomaceous earth and organic substance containing oligosaccharide such as sewage sludge and sea weed, etc.

Publications:

- (1) Nakazawa, R., Kameda, Y., Ito, T., Ogita, Y., Michihata, R., and Takenaga, H., 2004: Selection and characterization of Ni-tolerant tobacco cells. *Biologia Plantarum* Vol. 48, pp. 497 ~ 502
- (2) Inanaga, S., Nakazawa, R., Tomemori, H., Hirano, A., Murakami, M., and Mochizuki, H., 2005: Mechanism of phosphate-adsorption onto porous glass materials. *Man & Environment* Vol. 31. pp. 11~16
- (3) Inanaga, S., Tomemori, H., Nakazawa, R., and Hirano, A., 2005: Recycling system of phosphorous by using porous glass materials. Japanese Patent No. Toku-kai 2005-97065

- (4) Nakazawa, R., and Inanaga, S.: Factors affecting formation of water-stable aggregates with sandy soil. Soil Science and Plant Nutrition (submitted)

(5) Dr. Wei Liu

Summary of research

Study on a water collection system using wind power in arid regions

1. Characteristics of the water collection system

In this study, we propose the utilization of a cooling system using Peltier devices in combination with renewable energy for the production of water in arid regions for drinking, medical treatment and irrigation. A Peltier device has several noteworthy advantages of being small-sized and lightweight, and no moveable parts. It is environmentally friendly. In this study, experiments were performed in a controlled chamber, in which the temperature and relative humidity (RH) were adjusted as follows: 20 °C with 40, 60, 80% RH, and 30 °C with 40, 50, 60% RH with the heat exchanger widths 80mm and 120mm. The characteristics of the water collection system were determined. The influences of environmental condition and air flow rate on the water production rate were investigated. The results showed that the water production rate and air flow rate increased with increasing relative humidity. The cooled air temperature for maximum water production rate was observed at 2.5 to 4.8 °C below the dew point. It also showed that the heat exchanger width of 120mm produced the highest amount of water, 65.5 g per hour at 20°C and 80%RH among environment conditions.

2. Simulation of water production based on the meteorological data in arid regions

The meteorological data (temperature, relative humidity, and wind speed, wind direction) in arid regions near cool coastal deserts were investigated; and a place where water may be efficiently produced was selected among arid regions. As a typical example of a region possessing a climate characterized by high humidity and a good wind source, the study analyzed and characterized potential wind energy in Mauritania using location-specific meteorological data from 1st October 1999 to 30 October 2004. During the observation period, the average air temperature was 25 °C, relative humidity was 62%, average wind speed was 5.5m/s at the height of 12m. The wind speed value satisfied the standard given by NEDO (New Energy and Industrial Technology Development Organization Japan). Because a stable and strong wind was observed throughout the year, the observation site was judged to be suitable for wind power development. Assuming a wind turbine power output of 6 kW, the theoretical limit for water production was predicted on the basis of climate data for 12 water collection systems. The calculations predicted that, for example, on 20 June 2003, 11 liters of water could be produced, with the water production rate increasing from 15:00 PM to 3:00 AM, which corresponded to the change in relative humidity and electrical energy. In arid regions like Mauritania, the results appear to indicate that the use of wind energy to produce water is indeed feasible. Future research on this topic will be devoted to conducting outdoor experiments with the water collection system at the Tottori Sand Dune.

Publications:

- (1) Tsutomu, H., Kengo, N., Yutaka, H., Wei, L., Koutaro, T., and Kenji, T., 2004: A Study on a Water Maker System Using Peltier Devices. The Japan Society of Mechanical Engineers Branch conference, No.045-2 (I), pp.109-110 (in Japanese)
- (2) Tsutomu, H., Wei, L., Kengo, N., Yutaka, H., and Kotaro, T., 2004: A study on a water maker system using Peltier devices supplied with electricity by wind power for the purpose of use in arid regions. The 3rd World Wind Energy Conference and Exhibition, Beijing, China, CD-ROM
- (3) Tsutomu, H., Wei, L., Kengo, N., Yutaka, H., & Kotaro, T., 2005: A Study on a Water Maker System Using Peltier Devices. The 6th KSME-JSME Thermal and Fluids Engineering Conference, Jeju, CD-ROM

(6) Dr. Sheng Du

Summary of research

Growth, drought tolerance and water utilization patterns of the main forest trees in Chinese loess plateau

Desertification has been a serious environmental problem in the Chinese loess plateau. It not only provides a major source of loess dust (yellow sand) blowing into the Japanese archipelago and the Korean Peninsula, but also yields the big Yellow River a sever sedimentation. For the purpose of preventing desertification, reforestation has been carried out in this region for several decades. However, most of the plantations have not formed typical forests. A big problem is that little referential knowledge is available for local governments when they decide what species is planted. Few researches have been made of forest succession and stable ecosystem establishment in this region. Physiological and ecological studies are urgently needed so as to understand proper species and their growth patterns for the reestablishment of stable forest ecosystems in the area.

In the central loess plateau near Yan'an city, Shaanxi province, we comparatively investigated the growth, understory species diversity and seasonal changes of forest floor environment in natural *Quercus liaotungensis* forests and *Robinia pseudoacacia* plantations. The study sites, which are characterized as the landform of loess hills and gully, are located on a "mount" named Gonglushan (ca 36°25' N, 109°31' E, 1300 m a.s.l.), 10 km to the south of the city. Mean annual precipitation and air temperature are 527 mm and 9.8°C, respectively. Field investigation suggests that the *Robinia* forests tend to expose the floor and make the environment exceedingly dry and hot, harsh for succession, especially in spring when soil water is scarce and solar radiation is considerably strong, whereas the forest floor of *Quercus* is covered with various shrubs, grasses and litters, and has a relatively good microenvironment for growth and succession. Understory species composition was also different. *Quercus* forests had more trees and shrubs and showed higher biodiversity. Analysis of ring widths from increment cores revealed that radial growth variability of *Quercus* was correlated with both inter- and intra-annual climate variations. Ring growth was positively correlated not only with annually total precipitation, but also with precipitation in September of the previous year and that in April, May and June of the current year. High temperature did not favor radial growth in this area.

Measurements of photosynthesis revealed that *R. pseudoacacia* exhibited higher assimilation and transpiration rates and lower water use efficiency than *Q. liaotungensis*. Our studies suggest that in the central loess plateau region of northern Shaanxi province, *Quercus* forests could be established at shady and half-sunny slopes, whereas more drought-resistant indigenous species, conifers or shrubs for example, should be planted at sunny slopes to minimize water loss. *R. pseudoacacia* should be planted in relatively water-adequate places to fit its high assimilation rate and water consumption, albeit drought tolerant to some extent.

Publications:

- (1) Otsuki, K., Yamanaka, N., Du, S., Yamamoto, F., Xue, Z., Wang S. and Hou, Q., 2005: Seasonal changes of forest ecosystems in an artificial forest of *Robinia pseudoacacia* in the loess plateau in China. *Journal of Agricultural Meteorology*, 60 (5): 613-616
- (2) Du, S., Yamanaka, N., Yamamoto, F., Otsuki, K., Wang, S.Q. and Hou, Q.C.: The effect of climate on radial growth of *Quercus liaotungensis* forest trees in loess plateau, China. (Submitted)

(7) Dr. Tomoe Inoue

Summary of research

1. Current status and constrains of wheat yield in West and Central Asia

Through the "Japan-CGIAR Fellowship Program 2004", I had a opportunity to get training on "Breeding

cereals for stress tolerance” in the International Center for Agricultural Research in the Dry Areas (ICARDA) for two months. Under this training program, I had undergone the training on the topic: “Current status and constrains of wheat yield in West and Central Asia”. I collected information about this topic, and got many comments and suggestions from the scientists in ICARDA. Based on them, I have written the manuscript to submit the journal. Summary of the manuscript are as follows: In the West and Central Asia, wheat is the main crop, and most of it is cultivated in the dry land. Low productivity of wheat in the regions induced heavily reliance on import of wheat, except Turkey, Syria and Tajikistan. Moreover, West and Central Asia have high population growth rate. To support growing demand for wheat, the attainment of self-sufficiency of wheat will remain a critical objective in this region. In West and Central Asia, the most important abiotic and biotic constrains is drought. Drought inhibits every aspects of development and growth of wheat, hence grain yield. Although irrigation is very effective to increase the yield, available water for irrigation is very limited. Thus more effective use of water, e.g. supplemental irrigation for few critical stages of wheat, has to be developed. Additionally, the lack of identification of appropriate morpho-physiological traits related to drought resistance in wheat has prevented progress in genetic improvement in water-limited environments. Therefore, for further improvement of wheat yield in the dry land, studies on the physiological mechanism response to drought and the critical trait contributed to drought resistance has also been need.

2. Effects of soil moisture and re-distribution of assimilates on synthetic wheat yield in dry areas

Most countries in West Asia are experiencing food shortage in unbalance with the burgeoning population growth. These regions have been also suffered from vulnerable drought based on precipitation fluctuation. In wheat as one of main cereals, domestic production in most of these regions is far below the total demand. Technical development, particularly on drought tolerance using abundance of genetic resources and scarcity of water resources, should contribute to stable production of wheat in these regions. To improve the grain yield of wheat, wild relatives of wheat have been studied as genetic resources. Thus, in this study, the effect of soil moisture stress on productivity of synthetic bread wheat line derived from crosses with wild relatives are examined, and the use of genetic resources and water resources in terms of enhancement of drought resistance in wheat are evaluated.

Publications:

- (1)Inoue, T., Inanaga, S., Sugimoto, Y., and El Siddig, K., 2004: Contribution of pre-anthesis assimilates and current photosynthesis to grain yield, and their relationships to drought resistance in wheat cultivars grown under different soil moisture. *Photosynthetica*, Vol. 42, pp.99 ~ 104
- (2)Inoue, T., Inanaga, S., Sugimoto, Y., An, P., and Eneji, A.E., 2004: Effect of drought on ear and flag leaf photosynthesis of two wheat cultivars differing in drought resistance. *Photosynthetica*, Vol. 42, pp.559 ~ 565