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The riverside agriculture scenery, Morocco, the Atlas Mountains (Photo by M. Takahashi)

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JIRCAS
JAPAN INTERNATIONAL RESEARCH CENTER FOR AGRICULTURAL SCIENCES

JIRCAS International Symposium Resilient Food Production Systems: The Role of Agricultural Technology Development in Developing Regions

After the Great East Japan Earthquake, building communities resistant to disasters became the focus of rural development. In Japan, protective measures were applied by the agricultural sector to mitigate future disasters. Farmlands and facilities across the country were strengthened, not only in terms of infrastructure but also in terms of relevant policy changes.

Compared to Japan, the condition of agricultural environments in developing regions are much more fragile due to a variety of risks that make food production unstable. Global environmental problems attributable to climate change have recently emerged, with developing regions being the most vulnerable.

In African regions, specifically the Horn of Africa and the Sahel, people suffer from hunger and poverty due to drought, desertification, and crop damage from plant diseases and insect infestations. Internal factors such as political instability, lack of market options, and underdeveloped infrastructure aggravate the situation. This has become one of the highest priority global issues facing humanity. For example, in the Sahel, desert locust plague, a major agricultural risk, broke out over the politically unstable region of West Africa. Swarms spread far and wide, moving, as if intentionally, even toward areas beyond the reach of pest control officers. In the Horn of Africa, a severe drought occurred from autumn 2010 until early 2012. Considered the worst drought in 60 years, it caused serious food shortage and triggered one of the worst famines in recent history. Assistance from all over the world poured in to alleviate the problem, however, this solution was only temporary. Food security as well as social stability must be recognized and addressed as key regional issues for the affected areas to recover.

The 19th JIRCAS International Symposium will be held on November 28-29 with the title, "Resilient Food Production Systems: The Role of Agricultural Technology Development in Developing Regions." Diversified approaches for the establishment of resilient food production systems will be tackled. These approaches include crop breeding, cultivation technology, water and soil management technology, monitoring technology and forecast system for pest and extreme weather events, and socio-economic measures such as index insurance. Traditional technologies which have been locally developed to cope with such risks are also important and will be reassessed. Furthermore, there will be a discussion on policies allowing the dissemination of developed technologies for actual practice on agricultural fields.

The symposium's main theme, "resilience", generally means resistance to risks. This includes adaptability to risks and the ability to recover from damaged condition after disaster occurs. The symposium will not tackle risks that occur once every several hundred years, rather, it will discuss those that recur within a few years. We have invited Dr. Shenggen Fan of the International Food Policy Research Institute and Prof. Chieko Umetsu from Nagasaki University as keynote speakers. They will present papers on "Building Resilient Food Systems: Policies and Technologies" and "Resilience of Social-ecological Systems for Food Security", respectively. A total of 12 speakers will present papers focusing on resilience to extreme weather events (resulting to drought, flood etc.) affecting the livestock sector and the production of upland crops and paddy rice. This will be capped by a session on risk recognition and monitoring system. A panel discussion, titled "Role of Technological Development and Japan's Contribution" will be conducted by noted specialists in soil, weather, agricultural economy, and biodiversity studies, with JIRCAS moderating the talk.

The symposium aims to share research outcomes relating to the establishment of resilient food production systems across Asian-African continents, promote multidisciplinary communication, and encourage exchange of ideas among active experts, including researchers, engineers, and policy-makers, for the development of future agricultural technologies. Moreover, the fifth Tokyo International Conference on African Development (TICAD V) to be held in Yokohama in June 2013 will lend further support to the initiative. The JIRCAS International Symposium has been authorized as one of TICAD V partner projects. It is fervently hoped that the results of the discussions will contribute greatly to agricultural development in Africa.

Tomoyuki Kawashima
Program Director
Environment and Natural Resource Management
JIRCAS

Adaptation to Increased Flood Risk under Climate Change: Toward Sustainable Dyke Systems in Flood-prone Rice-growing Areas in Mekong Delta

1. Introduction

Vietnam is the world's second largest rice exporter, with 90% percent of rice exports produced in the Mekong Delta region. However, it is being threatened by sea level rise and river flooding. According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), the densely populated mega deltas in South and Southeast Asia face the greatest risk. To address the report, the government of Vietnam formulated a National Target Program in 2008 to respond to climate change. In it, they acknowledged the need to cope with three key issues -- salt-water intrusion, flooding, and lack of fresh water -- as soon as possible.

Mekong Delta, whose floodwaters enter Vietnam from Cambodia, is located in a vast network of distributaries at the mouth of Mekong River. Riverine and tidal floods are common, reaching even the upper Mekong Delta plain (inundation levels between 1 ~ 3 m). Nevertheless, the area remains active as a rice granary due to its nutrient-rich soils and dense waterways and canals.

Two types of dyke systems were constructed to reduce vulnerability in high-flood areas such as An Giang and Dong Thap Provinces adjacent to the Cambodian border: a high embankment called "full-dyke", which completely prevents farmland from flooding; and a low embankment called "semi-dyke", which prevents flooding up to the summer-autumn rice harvest but allows flood inflow after harvest (Photo 1).

Photo 1. Rice cultivation during high flood (Chau Doc District in An Giang Province)
(Left: paddy fields enclosed by semi-dyke; Right: paddy fields enclosed by full-dyke)

Triple rice cropping became possible in farmlands enclosed by full-dykes as rice can be grown even during peak flood season (September to November). In response to farmers' request, the Vietnamese government made it a policy to construct dykes, hence areas with full-dyke systems expanded rapidly in the past 10 years especially in An Giang Province. However, negative impacts caused by preventing floodwater into the farmland and by employing a triple rice cropping system soon became apparent.

The current state of the full-dyke system in a flood-prone rice granary area in Mekong Delta is discussed in this article, based on a survey conducted in An Giang where a JIRCAS climate change project is located (Figure1).

2. Expansion of full-dyke systems in a high-flood rice granary area

The first full-dyke in Chau Phu District in An Giang Province was built in 2001 on a small sandbar along Mekong River, but it was only in 2006 when full-dyke systems began to expand rapidly. The areas covered by semi-dykes

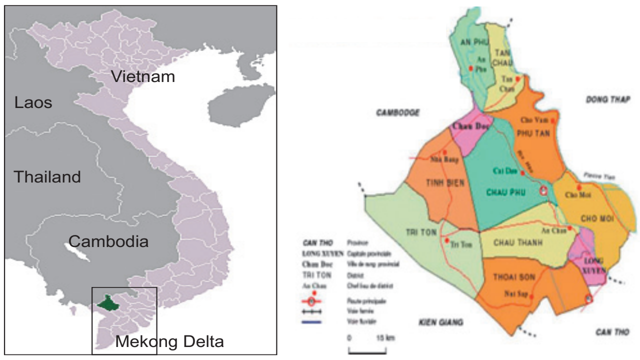
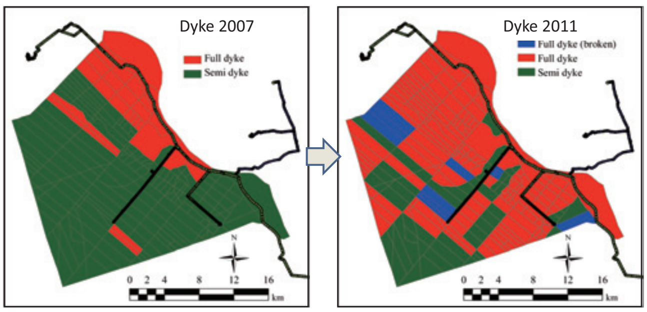


Fig. 1. Mekong Delta (left) and An Giang Province (right)



2007

note: Blue regions indicate full-dyke areas collapsed by the 2011 flood.
2011

Fig. 2. Expansion of full-dyke systems in Chau Phu District, An Giang Province

and full-dykes in Chau Phu District in 2007 and 2011 are shown in Figure 2. Areas covered by full-dyke systems increased from only around 20% in 2007 to more than 80% by 2011.

3. Advantages and disadvantages of full-dyke systems

There are several advantages and disadvantages of full-dyke systems. Full-dykes protect farmlands from floods throughout the year, allowing farmers to grow and harvest rice up to three times a year. However, it has also been documented that full-dykes have many disadvantages (Table 1).

The scale of the large flood that occurred along Mekong River in 2011, which caused many full-dykes in An Giang Province to burst, was comparable to that in 2000. The upper part of Photo 2 shows the inundated area in Chau Phu District in An Giang caused by the collapse of the full-dyke in 2011. The full-dyke was built in 2010 but was destroyed by flood the following year. The damaged area was approximately 110 hectares. The collapsed dyke has been repaired by the local government, but the full-dyke system was found to have safety problems. The lower part of Photo 2 shows part of the full-dyke prevented from collapse by stacking sandbags.

Table 1. Pros and cons of full-dyke systems

Advantages	• Realization of triple rice cropping • Infrastructure such as roads and settlements as well as agricultural lands are protected from flooding throughout the year
Disadvantages	• Construction costs are high compared to semi-dykes • Soil fertility declines due to sediment and nutrient starvation • Pests and diseases tend to increase due to triple rice cropping • Water quality deteriorates due to increased usage of chemical fertilizers and pesticides • Flood mitigation function is reduced, increasing flood occurrences downstream • Problems on its stability and safety as many full-dykes were breached by the 2011 flood

Photo 2. Flooded area in Chau Phu District, An Giang Province (2011)

4. Summary

Sea level rise and increased flood frequencies have been attributed to climate change caused by global warming. The highly-productive ricelands of the Mekong Delta region are among those affected by these phenomena. Lately, deeper floods lasting over longer periods have affected rice cultivation, raising concerns about the future of rice production. Construction of full-dykes progressed rapidly during the past decade, expanding triple rice cropping in the region. The system increased rice production in the area but it also prevented the nutrients normally carried by floodwater from reaching the farms, resulting to an obvious decline in soil fertility and an increase in pest population. Because of this, chemical fertilizers and pesticides became widely used, which in turn deteriorated water quality in full-dyke areas. Clearly, there is a need to establish a sustainable dyke system that reduces flood risk while maintaining riceland productivity in flood-prone rice areas in Mekong Delta.

Hideto Fujii
Crop, Livestock and Environment Division
JIRCAS

Damage from Cold and Snow Disaster (*Dzud*) and Countermeasure in Northeast Asia

A dzud, in Mongolian, is an abnormal winter weather condition in northeast Asia characterized by snowy and cold winters so harsh that livestock are unable to graze through the snow cover, causing starvation and eventually death. Apparently, damage to Mongolia due to dzud has gotten worse in recent years (Fig. 1). It has also inflicted serious damage and has affected farm management in the region.

Extreme weather is the main reason for livestock mortality in Mongolia. On the other hand, the country's livestock population was basically constant up until the early 1990s, but the introduction of market economy led to high demand for animal products such as cashmere wool and meat. As a result, livestock population grew rapidly to cope with demand. On average, dzuds strike every 10 years, but it was noted to have occurred more frequently during the past 10 years, disrupting its normal cycle. This further increased grazing pressure resulting to pasture degradation, and it has been a contributing factor of the *dzud*.

Therefore, it is important that a diversified risk management and a grassland conservation system are established. The objective of the JIRCAS research project in the region is to develop livestock farming systems which contribute to the mitigation of risks to herder-households and grasslands caused by extreme weather events. The collaborative research focuses on the following countermeasures:

First, procedures for producing and disseminating rapidly-updated carrying capacity maps at a regional scale will be developed. These maps will give estimates of reasonable grazing density during autumn to spring to reduce damage to pasture. To produce the maps, maximum pasture biomass in a year will be determined during summer seasons using satellite remote sensing technology, and animal intake will be determined by seasons and pasture types.

Second, information on promising fodder crops and the elucidation of a sustainable cropping system to minimize soil degradation will be provided. Techniques for the preparation and conservation of supplemental feeds by ensiling local feed resources will be developed to reduce feed deficiency during cold seasons. Early fattening techniques for young animals by supplemental feeding will be promoted, and value-added dairy products will be produced to contribute to risk reduction and to stabilize herders' household economies.

Third, herder- and farm-management techniques that are resilient to risks will be elucidated, and a risk-resilient pastoral management system will be recommended.

The Mongolian government is now identifying effective ways to reduce the risk of dzud and bring improvements to the animal husbandry sector. The parliament approved in 2010 the "Mongolian National Livestock Program", which settled relevant issues and contained a comprehensive plan for the next 10 years. Three percent (3%) of the annual national budget has been allocated to carry out the program, whose targets and contents are in agreement with the JIRCAS project. We hope that our research activities could help solidify the program, and that the results would influence policy making decisions by Mongolian leaders.

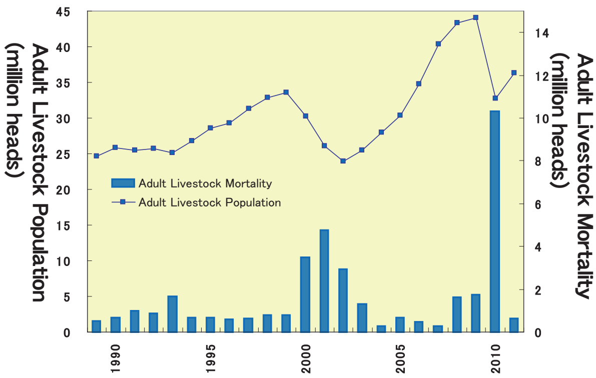


Fig. 1.

Seishi Yamasaki
Crop, Livestock and Environment Division

Conservation Agriculture Promotion in Africa and China

Rainfed upland cropping is a major agricultural production system widely practiced by farmers around the world. However, crop yield in rainfed upland ecosystems vary according to rainfall; therefore, cropping techniques that can overcome unstable rainfall conditions are highly necessary. In view of the situation, the Food and Agriculture Organization of the United Nations (FAO) and several other international agricultural research organizations strive to promote conservation agriculture (CA) in developing countries.

According to FAO (2007), CA is "a concept for achieving sustainable and profitable agriculture." It has three key principles: 1) cropping under non-till or minimum tillage to achieve minimum soil disturbance, thereby reducing soil erosion and promoting biological cultivation by soil animals such as earthworms, 2) mulching the soil surface with crop residue or organic materials to reduce runoff and conserve more water in the soil, and 3) diversifying cropping pattern by intercropping, crop rotation, or relay cropping to keep the soil healthy and to improve soil fertility. Because of these obvious benefits, CA has been considered as one among many resilient food production systems necessary for increasing food security.

CA promotion in Africa and in China will be presented at the upcoming JIRCAS International Symposium. Dr. Lamourdia Thiombiano, FAO Subregional Office representative for Central Africa, will present several case studies of CA promotion and discuss the challenges for its wide adoption in African countries. China, on the other hand, has developed different types of non-till or minimum tillage seeders tracked by relatively small tractors, significantly boosting CA promotion in recent years. Dr. Hongwen Li, professor at China Agricultural University and chairman of Conservation Tillage Research Center (CTRC) under the Ministry of Agriculture, will introduce the history of CA promotion in China and present the effects of CA on stable food production under rained agriculture, based on long term experiments.

JIRCAS has launched a project on the development and evaluation of CA-based cropping systems in the savannas of West Africa. We are currently conducting several experiments on six sites (annual rainfall: 700 to 1500 mm) from Burkina Faso to Ghana. We have already installed runoff plots in order to monitor soil erosion, water runoff, and soil moisture with different treatments in three of the six sites. We have also conducted a cropping system survey by interviewing farmers, revealing that CA adoption poses a variety of difficulties in different regions. Through this research, we intend to address these problems by proposing cropping systems suited to different agro-ecological regions, with due reference to the symposium's presentations and discussions.

Fig. 1. Lesotho farmers undergo training on the use of non-till planters.

Fig. 2. Developed in China, this minimum tillage seeder plants wheat seed into corn residue.

Fujio Nagumo
Crop, Livestock and Environment Division

Strengthening the Resilience of Agriculture in Bangladesh to Disaster Shock

Bangladesh, a tropical country located between India and Myanmar, is one of the most densely populated areas in the world. Given this fact, food demand is high, which in turn creates greater demand on agriculture. Despite the influx of active foreign direct investment, half of the total labor force remains engaged in agriculture. Half of the country's total land area is occupied by farmlands, of which over 70% are paddy fields for rice production.

Agriculture plays a very important role in people's livelihoods in Bangladesh. However, it is often saddled by problems and damages caused by frequent and large-scale disasters. Natural disasters are mainly attributed to the country's geography characterized by a tropical monsoon-type climate, with extensive alluvial plains and flat, coastal regions dissected by Ganges River.

Ganges River and its tributaries rise from the western Himalayas, flows through India and into Bangladesh where it empties into the Bay of Bengal, inundating wide areas during rainy seasons. The Bay of Bengal is prone to low pressure systems which sometimes develop into devastating cyclones, hitting the country with strong winds, extreme rainfall, and storm surges (Figure 1).

Fig. 1. Damage from a storm surge: a village inundated by water from a dike break
（photo：Shintaro Kobayashi）

Natural hazards which regularly cause agricultural damage in Bangladesh include not only floods and cyclones but also dry spells and cold waves (Figure 2), triggering

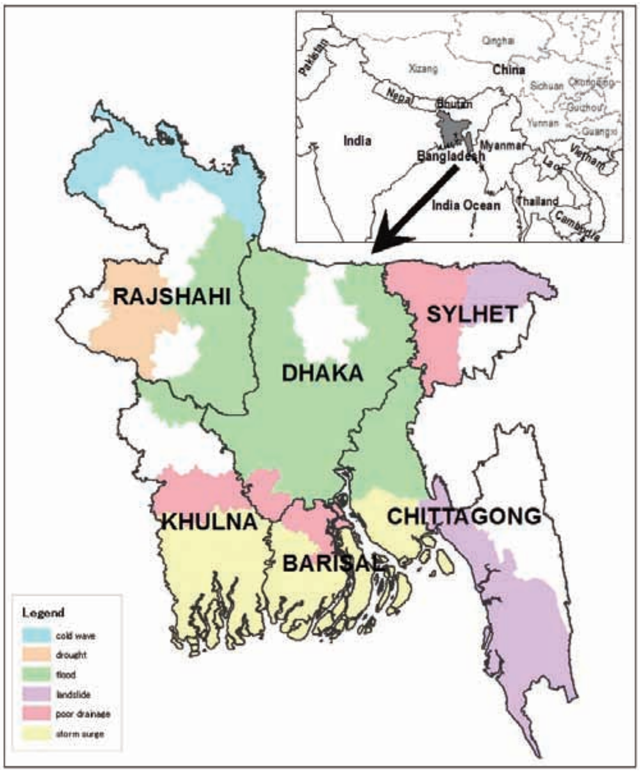


Fig. 2. Recurrent disasters and main affected areas

crop failures, disrupting production, and damaging infrastructures. According to a report published in 2007 by the Intergovernmental Panel on Climate Change (IPCC), an international scientific organization that evaluates present and future climate situations, it was projected that total precipitation and frequency of extreme rainfall events would increase in South Asia, including Bangladesh. Likewise, the intensity of cyclones would increase, though its frequency would decrease. More recent publications also show similar projections, implying an increase in agricultural field inundation induced by heavy rains and an increase in saline water intrusion caused by storm surges. If the projections hold true, then agriculture in Bangladesh would become more vulnerable to disasters, further threatening rural livelihood and national food security. As a precaution against the negative impacts of climate change, appropriate measures must be taken.

JIRCAS is working jointly with Bangladesh Rice Research Institute (BRRI) in order to strengthen the resilience of agriculture in Bangladesh to disaster shock.

BRRI has long been working on cultivar improvement to create environment-adaptive rice varieties (e.g.,salinity-tolerant and submergence-tolerant varieties). This joint research will conduct prior evaluation of new agricultural technologies such as new varieties. For this purpose, it will develop an evaluation system, composed of a land suitability assessment model, a rice supply-demand model, and a world food model, that projects the effects of new agricultural technologies on food markets (Figure 3). We expect this joint research to realize agricultural environments resilient to disaster shock in Bangladesh and international food markets.

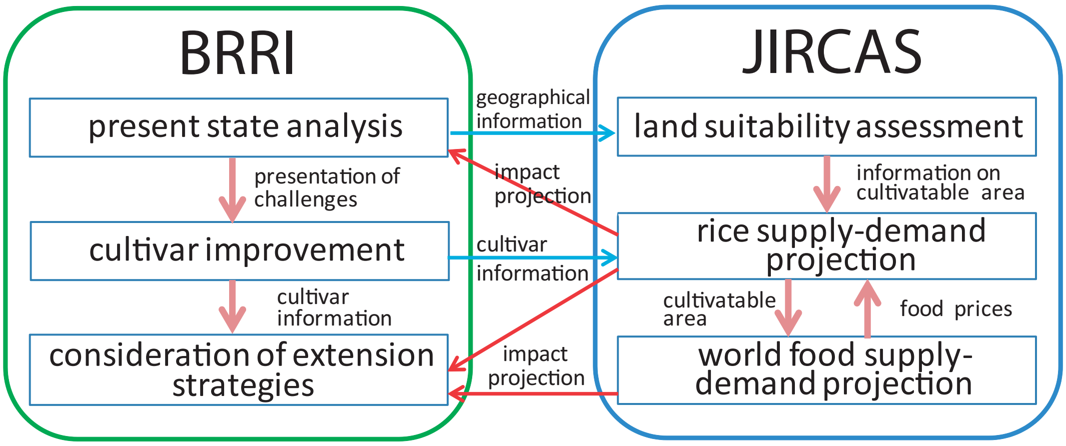


Fig. 3. Information use model of JIRCAS-BRRI joint research

Shintaro Kobayashi
Social Sciences Division

Preventive Control of the Desert Locust (*Schistocerca gregaria*) in Africa: Current Practice in Mauritania

The desert locust (*Schistocerca gregaria*) is one of the most destructive pests in the world. Desert locust populations sometimes increase explosively to form swarms, initiating a locust plague (Photo 1). The plague can affect 20% of the earth's surface across Africa, the Middle East, and Southwest Asia, comprising over 65 countries at risk to swarms and invasions.

Photo 1: Desert locust swarm in Nouakchott, Mauritania

Desert locust plagues have the potential to damage the livelihood of a tenth of the world's population, mainly by devouring agricultural harvest. The swarms may cover several hundred square kilometres during plagues and contain 50 million locusts in each square kilometre. The locust consumes the approximate equivalent of its body mass every day in green vegetation, thus crop damage by such swarms can be extensive since a square kilometre of insect population can consume about 200 tonnes of vegetation or crops per day.

The locust changes behavioural, morphological, and physiological characteristics in response to its population density. This phenomenon is known as phase polyphenism. Individual locusts that are at low population densities are called solitarious, whereas those at high population densities are called gregarious. Gregarization is very much linked with locust outbreaks. When locust nymphs become gregarious, they change body colours from green to yellow and black (Photo 2), while the adults change from brown to

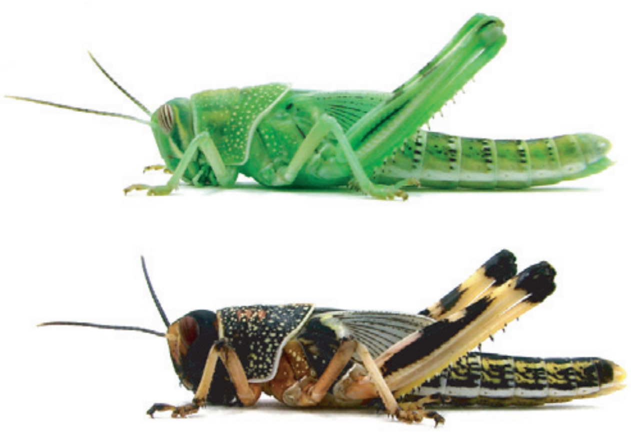


Photo 2: Last instar nymphs of the desert locust: solitarious (upper) and gregarious (lower) phases

red or yellow. In addition, wing lengths of gregarious locusts become longer relative to body lengths, and food plant range tends to be wider than that of solitarious ones.

Distribution range of the desert locust is categorized into two areas: one is recession (quiet periods) and the other is invasion area. The locust is found at very low densities in the desert as a solitary phase in a recession area (Fig. 1). With some favourable breeding conditions, the locust increases its population and gregarizes to extend its habitat to an invasion area.

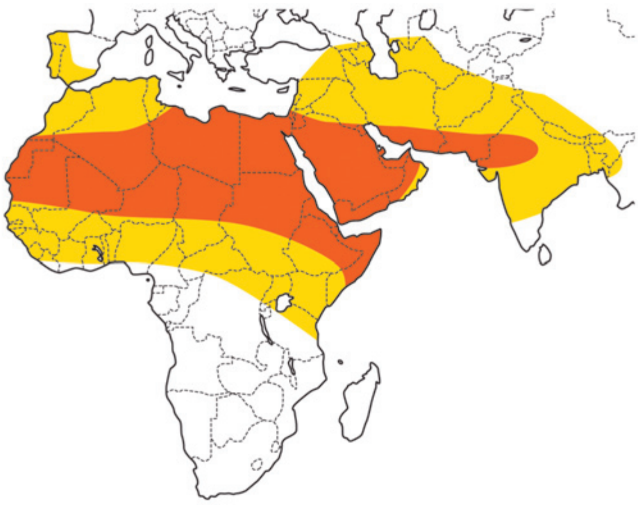


Fig. 1: Distribution of the desert locust: recession (orange) and invasion (yellow) areas.

Mauritania is located in the recession area, with the Mauritanian National Anti-Locust Centre (CNLA) in charge of monitoring and controlling the desert locust to help reduce poverty and ensure food security in Mauritania and neighbouring countries. The centre promotes preventive controls by breaking the breeding sequence of gregarious populations at an early stage. This means that well-directed and correctly implemented surveys are necessary in order to obtain precise information on the locust and allow early warning and rapid treatment in a safe and effective manner. When high locust population densities are found along with favorable ecological conditions, a decision is made regarding pest population control. The decision depends on the location, behaviour, maturation, and density of infestations as well as on the resources available. Pesticides and application methods are chosen so as to provide control that does as little environmental harm as possible. The centre is constantly looking to improve its methods, making sure that pesticides are used efficiently and with minimal environmental impact. It is involved in research into reduced dosage application and new, alternative pesticides such as the fungal biopesticide *Metharrizium anisoplae*. The preventive approach seeks to monitor locust breeding areas and spray as gregarizing populations of the locust are identified. However, this is difficult in practice as many of the principal breeding zones are located in remote areas and are difficult to reach.

In contrast to the practical method as preventive control, another approach is by understanding the mechanism of phase polyphenism and the process of gregarization in the desert locust. It may hold the key to solving locust problems, hence numerous studies were conducted under laboratory conditions, especially in Europe, during the last century. However, elucidation of the mechanism and the process as mentioned above remains unclear, probably because little studies have been carried out in the field. Understanding the ecological aspects of the locust in nature is essential since this organism is sensitive to its population density and surroundings.

JIRCAS has started investigations on the field survey methods with CNLA in 2011 to better understand the ecology and behaviour of desert locusts in the field. We have found that solitarious nymphs have a feeding preference for particular plant species during certain development periods of the nymphal stages, and that they show a series of curious behaviours at night. We will do further studies on the locust in order to produce environmentally-safe, efficient, and sustainable pest control measures.

Satoshi Nakamura
Crop, Livestock and Environment Division

JIRCAS TODAY

◯ Open House 2012 (Tsukuba)

The annual Open House was held on April 20-21 (Fri-Sat) with the theme, "Finding Solutions to Global Food and Environmental Problems." The event's main activities were as follows: research poster presentations, tropical fruit tasting and replica exhibit, a guided tour of the shrimp culture facility, microscope observations, traditional/international costume-fitting, and hibiscus and pineapple seedling giveaways. Twelve mini-lectures consistent with the main theme were also presented.


Mini-lecture


Orientation prior to microscope observations

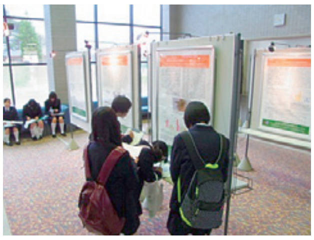

HS students diligently taking notes


Exhibit at the Tsukuba Agriculture Research Gallery

◯ 2012 Biomass Expo

The 2012 Biomass Expo was held from May 30 to June 1 (Wed-Fri) at the Tokyo Big Sight Exhibition Hall to present the latest on biomass-related research. Displayed at the JIRCAS booth was a scale model of a production facility for producing biodegradable plastic and ethanol from oil palm trunk waste materials. The production of ethanol from cassava pulp and sago palm and the development of biomass-degrading enzymes were also highlighted. Likewise, a Clean Development Mechanism (CDM) project activity utilizing biogas digesters as a means of implementing rural development in Vietnam was introduced through a scale model showing the VACB system.

◯ Participation during NARO's Summer Open House

The National Agriculture and Food Research Organization (NARO) in Tsukuba held its Summer Open House on July 28 (Sat) with the theme, "Feel Nature's Blessings and Agricultural Wisdom." An exhibit was organized at the Tsukuba Agriculture Research Gallery to promote its activities. Items displayed at the JIRCAS booth included posters on current research and an oil palm trunk (stem) specimen. Also, a microscope was set up for kids to observe the surfaces of different materials such as coins, shrimp exoskeleton, etc.


Children look under the microscope.

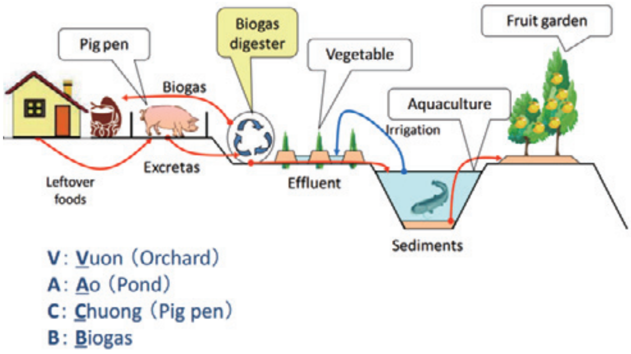
◯ Research Outputs (Press Releases)

(1) A biogas project that reduces global warming and benefits low-income farmers in Vietnam has been registered by the United Nations (UN) Clean Development Mechanism Executive Board (CDM-EB).

JIRCAS helped establish the CDM project in Can Tho City, Mekong Delta, Vietnam. Following approval by both the governments of Japan and Vietnam, the project, titled "Farm Household Biogas Project Contributing to Rural Development in Can Tho City", was registered by the CDM-EB on August 15. Farm households were able to generate biofuels from pig manure through this project.

Greenhouse gas (GHG) emission reduction was made possible by providing biodigesters (BD) to farm households in rural areas in Can Tho City. Biodigesters converted manure to biogas, thus reducing the amount of fuel wood and fossil fuel used for cooking and boiling water. Odor as well as water pollution was also minimized.

Recognizing that low-income farmers can benefit directly from this low-cost technology, the Can Tho model will be refined further for future expansion.



An Overview of the VACB System

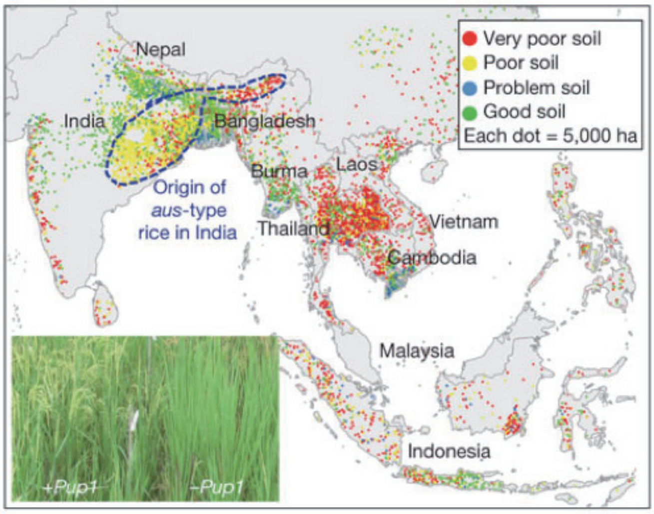
As demonstrated in Vietnam, the VACB system is composed of an orchard, a pond, and a pigpen whereby biogas is produced by anaerobic fermentation. The system makes the most out of limited resources and is an effective farm diversification scheme.

(2) A gene responsible for better phosphorus uptake in rice has been identified. This gene, called *PSTOL1* (for **p**hosphorus-**s**tarvation **tol**erance) will help improve rice production in developing countries whose soils are deficient in phosphorus.

JIRCAS, in collaboration with the International Rice Research Institute (IRRI) and the National University of Milano, Italy, identified the gene from an Indian rice variety known to thrive in phosphorus-deficient soils.

PSTOL1 is considered responsible for the synthesis of enzymes involved in early root development, growth, and proliferation, thereby enhancing its ability to absorb soil phosphorus. With the discovery of *PSTOL1*, a 50% improvement in phosphorus absorption in low-phosphorus soils can be expected, which in turn will result to a marked increase in rice yield.

*The research paper, “The protein kinase Pstol1 from traditional rice confers tolerance of phosphorus deficiency”, was published online and in print by the British science journal, *Nature*, dated August 23, 2012.



Problem soils in Asia and the origin of stress-tolerant *aus*-type rice varieties

Soils deficient in phosphorus are widespread in Asia and Africa. Initially discovered in a traditional Indian rice variety, the *PSTOL1* gene -- identified to be responsible for improved phosphorus uptake -- helps address this problem.

For more information, please check the JIRCAS website.

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