Rice Production in Southeast Asia for Sustainable Agriculture and Environment -International Collaboration for Rice Technology Development

Shu Fukai
School of Land, Crop and Food Sciences, The University of Queensland, Brisbane, Australia.
s.fukai@uq.edu.au

Abstract: While rice is the staple food in Southeast Asian countries, yield and production are low in Thailand, Laos and Cambodia where irrigation water is limited. This paper describes some examples of international collaboration projects conducted in these countries and Vietnam involving scientists from Australia.
Keywords: Rice, Southeast Asia, rainfed lowlands, international collaboration

1. Rice production in SE Asia

Rice is the staple food of many people in Southeast Asia. Rice production has increased greatly in recent time in SE Asia, but this occurred mostly in irrigated areas. The progress has been much slower in countries where the proportion of irrigated rice is small ie, Thailand, Laos and Cambodia. While rice is important export commodity, particularly in Thailand, farmers in rainfed lowland areas tend to grow rice for their home consumption, and inputs to grow rice are limited. Infrastructure such as road and transport system is rather poor, causing further problem in marketing of rice and other commodities.

However, growing environments are changing rapidly in these countries, because of increased mechanization, commercialization, and trade within country as well as with neighbouring countries. Another important recent event is that most countries in SE Asia have achieved rice self sufficiency. There are many factors for the increased rice production, and one factor is improved technology of rice growing as a result of international collaboration in research. With the achievement of self sufficiency, there is opportunity to market rice and diversifying cropping to develop more profitable agricultural systems.

This paper describes our efforts to increase rice production and profitability in these countries through international collaborative projects.

2. International collaboration

There have been many Australian projects to promote rice production in SE Asia. The Australian Centre for International Agricultural Research (ACIAR) is the main Australian institution that funds research in agriculture. The following information is taken from its Annual Operational Plan 2006-2007 (ACIAR 2006). ACIAR provides funds to international agricultural research centres such as IRRI, and also commissions Australian institutions to conduct research overseas. The former is known as multilateral projects and includes core funding to international centers. The latter is known as bilateral projects, and around three quarters of the total ACIAR research funds are expended in the bilateral program. The total budget of ACIAR in 2005-06 is estimated to be around $54 million AUD. In 2004-05, the total active bilateral project number was 201, and 41 new bilateral projects commenced. The number of commencing projects is planned to go up to 61 in 2005-06, and further to 74 in 2006-07. In addition to the direct research funding ACIAR also provides funds for capacity building. This includes John Allwright Fellowships, which are research postgraduate scholarships provided to those scientists from partner countries engaged in projects funded by ACIAR. The number of scholarships has been around 10 a year, but is expected to increase to 25 in 2006-07.

In 2005-06, ACIAR provided the largest research budget allocation to SE Asia (48%), followed by Papua New Guinea and Pacific Island countries (24%), North Asia (13%), South Asia (12%) and Southern Africa (3%). The allocation for SE Asia is divided into Indonesia (18%), Vietnam (10%), Philippines (9%), Cambodia (5%), Laos (3%), East Timor (2%) and Thailand (1%).

There are four discipline areas the largest being Cropping Systems (30%), followed by Livestock Systems (25%), Natural Resource Management (23%) and Economics/Farming Systems (22%). There are 13 programs across the four discipline areas. The Cropping Systems includes Crop Improvement and Management, Crop Protection and Horticulture Programs while Natural Resource Management includes

Forestry, Land and Water Resources, and Soil Management and Crop Nutrition. In SE Asia, the largest program in terms of funds allocated is Fisheries (16%), followed by Crop Improvement and Management (13%), Crop Protection (12%) and Agricultural Systems Economics and Management (11%).

These bilateral ACIAR projects may be 1 year pilot projects to conduct preliminary research or may be 3-5 years full projects with the budget of often around 1 million AUD. Each project is managed by a commissioned Australian institution, and the designated project leader in the institution together with partner institution scientists will develop project proposal under the guidance of the relevant ACIAR program manager. Once the project is approved by ACIAR and the relevant minister in the partner country, the Australian scientists engaged in the project visit the partner country frequently. The scientists from both countries conduct research, in most cases by designing and running experiments, and analyzing and discussing experimental findings to make further progress to achieve the objectives of the project.

In addition to these bilateral projects, which form the main activity of ACIAR, there are smaller projects funded directly to partner institutions without the direct involvement of Australian institutions. This scheme operates in Cambodia and Laos. The Cambodian Agriculture Research Funds has been operational since 2002, and 39 projects totaling around $900,000AUD have been funded. These projects are 1-3 years duration and cover a wide range of topics in different discipline areas of crop production and protection, aquaculture, and animal husbandry, and tend to be orientated towards more practical technology application. The largest number of projects is provided to the Cambodian Agricultural Research and Development Institute (14), followed by the Royal University of Agriculture (9). The Lao Agricultural Research Funds has just commenced in 2006, and 13 projects of 1-3 years duration covering a wide range of areas have been funded for a total of $100,000AUD. Nine projects are run by the National Agriculture and Forestry Research Institute. While these projects are rather small in terms of funding, they meet the need of local agriculture research and development.

In addition to these projects funded by ACIAR, there are a number of large agriculture projects in the region directly funded by AusAID (Australian overseas aid agency). For example in Cambodia there are Cambodia Australia Agricultural Extension Project (CAAEP, Phase 2- 20.4 million AUD for 2001-2007) and Agriculture Quality Improvement Project (AQIP -20.7 million AUD for 2000-2008). In Vietnam, there is Collaboration for Agriculture and Rural Development (CARD 19.5 million AUD for 2004-2010). In the CARD program there will be up to 130 agricultural research projects to increase the productivity and competitiveness of Vietnamese smallholder agriculture and related rural enterprise. They are competitively funded, and scientists from Australian and Vietnamese institutions jointly apply for a research fund. One of the objectives of CARD is to strengthen Vietnam’ capacity to effectively manage its agricultural research programs.

Because rice is the most important crop for SE Asian countries, a number of collaborative research funds have been provided to increase rice production. It should be pointed out however that there is tendency for the funds provided to lead towards more diversification in agriculture, particularly as most countries have recently met their rice self sufficiency goal. In these countries rice research is traditionally strong, and there is now needs to strengthen research capacity for other crops. Following are some examples of collaborative projects that aim to increase rice production, farmers’ profitability and agricultural sustainability in SE Asia. These examples are taken mostly from the results of an AusAID funded project in Cambodia, three ACIAR projects (the first two projects were for Thailand and Laos, and the last one was for Laos and Cambodia) and a CARD project in Vietnam.

3. Cambodia- Development of rice varieties and increasing cropping intensity

One of large AusAID projects was CIAP, Cambodia-IRRI-Australia Project (1989-2001). It is considered as a very successful project providing rice research infrastructure and delivering well adapted rice varieties and sound management systems at the time when Cambodia struggled economically and socially. A number of international rice scientists were stationed in Phnom Penh and assisted development of Cambodian scientists and the rice industry. A number of Cambodian scientists were trained in Australia and obtained formal academic qualifications from Australian Universities. The Cambodian Agricultural Research and Development Institute was subsequently established to continue the work of CIAP involving rice, and to commence work on research and development of industries based on other crops.

During the CIAP time, a number of rice varieties were rediscovered and collected. Pure line selection followed and this activity resulted in 18 varieties being released. Altogether CIAP-CARDI has released 35 rice varieties since 1989. Recent emphasis has been improvement of grain quality particularly of aroma, which resulted in release of popular medium maturing variety Phka Rumdoul. Some of the released varieties were gradually taken up by farmers and have contributed to the increase in rice yield in recent time. A large number of trials (often exceeding 300 trials) throughout the country have shown that some of these improved varieties (IR66, CAR3, CAR4, CAR6, Riang Chey) exceed yield of farmer's popular varieties by 20%. Recent findings from CARDI indicate that these varieties are well accepted by farmers in many provinces. The percentage coverage estimated by a senior agricultural officer in each of 8 Provinces suggests 20-70% in wet season and 70-100% in dry season of rice area is occupied by these varieties, particularly CAR4, CAR6 and Phka Rumduol. The estimated benefit of using these varieties over the farmer's popular varieties from these 8 Provinces alone would be around 25 million US dollars per annum.

One of major constraints for rice production in Cambodia is drought. With the release of high yielding medium maturing varieties, late maturing varieties have been replaced by medium maturing varieties, increasing the chance to escape from severe drought that commonly set in at the commencement of dry season. The collaborative rice variety project between CARDI and the University of Queensland with funding from ACIAR and the Rockefeller Foundation has identified several drought resistant varieties, including CAR3 and CAR6. Most promising drought resistant varieties have been crossed with popular varieties with good grain quality, and progenies are being advanced for yield testing in the near future.

One major development in 1990s was the increase in areas where double cropping of rice was practiced within a wet season. While rice crops in Cambodia are mostly grown under rainfed conditions without irrigation, wet season is sufficiently long in some areas to grow two crops of rice. This double cropping practice is also assisted by the rapid expansion of the use of underground water using tube wells. The traditional rice varieties in Cambodia are strongly photoperiod sensitive and flower mostly in November- December, and can not be planted early in the season in the double cropping system. However high yielding photoperiod insensitive varieties such as IR66, IR72 and Kru were released from the rice breeding program and they are suitable to grow in the early wet season and can be harvested in August to allow transplanting of photoperiod sensitive varieties to utilize remaining wet season. This system has spread rapidly from Takeo Province to other parts of the country and has contributed to increased farmer's income per unit land area.

Results of our research in a project funded by ACIAR indicate that the main rice crop in wet season is not affected by the presence of rice in early season. The main wet season rice is considered as most important and hence farmers do not wish to see its yield reduced by having early season rice. While most farmers are not able to grow rice for the whole farm in early wet season, they could often plant early wet season rice in part of the farm. The rice from the early wet season is considered as a bonus. The economic analysis conducted by our group shows a large advantage of double cropping of rice. However this is a labour intensive system, particularly around August when one crop is harvested and the next crop transplanted. Thus this is practiced where farm labour is abundant, and the farmer may revert back to the single rice cropping when the farm loses labour to a nearby city.

While the Cambodian rice research has enjoyed international collaboration particularly through the funding from the Australian Government, CIAP was completed several years ago now, and AusAID's direct assistance to CARDI was just completed in 2006. The research emphasis of CARDI is now not only on rice but on other crops, such as maize, mungbean, tomatoes and banana. New international collaboration with other countries will be very timely, and is required to maintain the momentum of the Cambodian agricultural research.

4. Thailand- development of drought resistant rice varieties.

While Thailand enjoys more economic prosperity than some other countries in SE Asia, the rice yield is low compared to most neighbouring countries. This is related to the harsh environment where most rice crops are grown in the country, particularly in NE Thailand where the largest area of rice is grown under rainfed lowland conditions and crops often encounter severe drought problems.

There are a few reasons for frequent occurrence of drought problems in NE Thailand; similar problems also occur in Northern Thailand, Laos and Cambodia, but to a lesser extent. Low rainfall is the major reason for the frequent drought problem; in some areas of NE Thailand mean annual rainfall is less than 1000mm. When there is good rainfall early in the season, farmers may sow seeds in nursery too early, and there may be no standing water at the time of transplanting forcing the farmers to use old seedlings for transplanting later when there is good rainfall, or some times resulting in complete crop failure. Another reason for frequent drought occurrence is the sandy nature of the lowland soils where water holding capacity is low and water loss from deep percolation is high.

Another reason is that the rainfed lowland paddies in NE Thailand are mostly on sloping land, and the rice paddies located towards the top of the slope (toposequence) which often have sandier soil tend to lose more water vertically to lower depth, but also laterally to paddies at lower positions, causing earlier development of drought in the top positions (Tsubo et al. 2006). Thus it is common to have drought almost killing the rice plants in the top position while at lower positions there is still standing water.

The problem of drought is often aggravated by the use late maturing varieties in NE Thailand. Rice varieties commonly grown in Thailand are strongly photoperiod sensitive, and they flower late when often late season drought has already commenced. The Thai breeders have realized the variation in drought development across the toposequence positions, and are using this variation in their breeding program to minimize the effect of drought (Jongdee et al. 2006). Thus early maturing varieties are tested at the top position, and later maturing ones at the lower positions in their breeding program.

In our collaborative project, we selected varieties that were more resistant to drought than the current varieties. This was done after establishing drought screening in the field in SE Thailand. In the screening method commonly used, different rice varieties are planted a few weeks later than the common time for planting in the wet season, so that the varieties have good chance of being exposed to drought around flowering. Standing water is drained and the varieties are exposed to prolonged drought conditions which reduce grain yield to half the normal yield without any water stress. Using this screening system, several varieties were selected and then crossed with popular commercial varieties so that there would be new varieties which are similar to the current varieties in grain quality and other characters but are more drought resistant. It will take a few more years before the new varieties can be tested for their performance at different locations in NE Thailand.

A number of organizations in different countries in SE Asia and elsewhere in the world are fully aware of the major drought problem for rice production, and a number of projects are currently going on to develop drought resistant varieties that are suitable for drought-prone areas. A new initiative is taken recently by IRRI to develop a Frontier project on rice drought resistance. Recently there has been good advance in molecular techniques for development of varieties adapted to stress environments. The new initiative is to utilize these new technologies for development of drought resistant varieties. A number of organizations in SE Asia and other rice growing regions are going to work for the international collaborative project.

5. Laos- Increasing rice cropping intensity for self sufficiency

While rice yield increased and self sufficiency was achieved recently for the whole country, rice is often in a short supply for many people in Lao PDR. According to FAO, under-nourishment concerned 21 % of the population in 2001-2003. Laos was selected in 2005 as one of the pilot countries in FAO Trust Fund Project funded by the Japanese Government to develop a national information system on food insecurity and vulnerability. One third of the Lao population was reported to experience rice deficit for four months in a normal year. The prevalence of food insecurity is especially high among the rural population living in mountainous areas.

Northern Laos is mountainous and crop production is limited. The Lao Government was engaged in a major irrigation development project including the northern area to increase production of crops, particularly rice. The availability of irrigation water has allowed the rice cropping in the dry season and hence double cropping of rice. The irrigated rice was planted to around 100,000ha at the turn of the century. Similar to the case in Cambodia, our research shows that the addition of rice does not affect the yield of main wet season rice, and in most cases dry season yield is higher. Thus the rice production can be doubled in areas where irrigation water is fully available in the dry season and where double cropping of rice is practiced. High and stable rice yield in lowlands in northern region is important for food security for the people in the region. This is also important in attracting for people to change from shifting cultivation of upland rice in hilly areas to lowland cultivation in the valley where irrigation water is available. With increasing human population, shifting cultivation is no longer sustainable for agriculture production and also for environment.

One of the major constraints for rice production in the dry season in the Northern region is low temperatures that prevail in winter months which coincide with planting of dry season rice. Our experiments indicate that December-January planting is risky in high altitude areas of Northern Laos, as germination and young seedling growth can be severely affected by the low temperature in these months. November seeding is recommended, but in some cases this flexibility may not exist as often the wet season crop is still being harvested in November, or irrigation water may not be available at the time.

With the assistance from Japanese scientists we have developed a plastic protection method for high altitude area (above 500 m.a.s.l.). The use of plastic cover at the seedbed increases air temperature by 3-4 degrees even early morning when temperature is the lowest, and this increase is sufficient for germination and sound development of seedlings for transplanting. Crop yield using such seedlings is often higher than that using unprotected seedlings.

Direct seeding is becoming an increasingly popular establishment method in the lowland environment of Laos, particularly in areas where labor is becoming less available for transplanting. This can be environmentally risky however particularly in wet season where control of weeds is difficult. We are suggesting to use row planting for ease of weed control. Direct seeding is likely to be more suitable for dry season irrigated areas where water control is much easier. Thus we are promoting direct seeding in the dry season to save labour cost. It will be interesting to see if the dry season irrigated rice will remain as it is with crop being established from transplanting or if the direct seeding with reduced cost is sufficient to make rice as a viable option when the market economy develops further. It should be pointed out that the dry season rice cultivation developed only recently in Laos, and the rice grain is often traded in contrast to the wet season rice which is more traditional and often used for home consumption. Thus the dry season rice is more amenable to be replaced with another crop if that crop produces higher returns. This diversification of course gives more pressure for production of more rice in the wet season in which rice is unlikely to be replaced by other crops in a large scale in the near future.

6. Vietnam- beyond rice self sufficiency

The progress in agricultural production is very rapid in Vietnam in recent years and rice is exported in a large quantity. However the quality of rice is not high, and one reason for this is high grain cracking. In Mekong River Delta (MRD) which is the main rice growing region in Vietnam, post-harvest losses from harvesting to storage of rice range from 7 to 26%. According to various village level millers, the cracking during milling can be as high as 40% in the wet season. The value of the cracked grains of rice is substantially reduced in the market.

Incorrect harvesting time and improper drying practices are major factors that cause the losses due to cracking. Cracking may develop in the field as a result of changes in grain moisture or during sun drying when hot days are followed by humid nights. Due to lack of the labourers during the harvesting time farmers are not always able to harvest it in time.

The winter rice is normally sun-dried whereas in the wet season only 10-15% of rice is estimated to be mechanically dried. The flat-bed dryer is the only dryer type which has survived in MRD because it is simple, requires low investment capital cost and has reasonably low drying cost. However, flat-bed dryer requires more labours with less uniformity of rice moisture in the bed and occupies large space. The air reversible flat-bed dryers may produce more uniformity of grain moisture. The drying operating conditions of these dryers should be improved to obtain an optimum output.

Through our CARD project on rice grain cracking we are installing simple dryers at villages to demonstrate their effectiveness in reducing grain cracking. We are currently testing the performance of different types of dryers. A reversible flat bed dryer appears promising;

- The effect of air reversal is very apparent in reducing the final moisture differential which can influence head rice yield during milling
- Air reversal also decreased the drying time

We are also examining the timing of rice harvesting in the field in relation to grain cracking. 5 days delay in harvesting from the optimum time resulted in an increase of grain cracking from 5 % to 24% in one variety, indicating the importance of timing of harvesting in the field. The delay in harvesting can be reduced with the introduction of two wheel reaper. We are currently installing reapers to examine their effect on rice grain cracking.

While we try to reduce grain cracking in the field in Vietnam, we are also studying the theory of grain cracking and drying temperature conditions that can reduce cracking. Tempering of rice at high temperature (80 C) for a few hours increased mechanical strength of rice grain.

References

Tsubo M, Basnayake J, Fukai S, Sihathep V, Siyavong P, Sipaseuth, Chanphengsay M. 2006. Toposequential effects on water balance and productivity in rainfed lowland rice ecosystem. Field Crops Research 97: 209-220.

Jongdee B, Pantuwan G, Fukai S, Fischer K. 2006. Improving drought tolerance in rainfed lowland rice: an example from Thailand. Agricultural Water Management 80: 225-240.