DEVELOPMENTS IN NATURAL RESOURCE MANAGEMENT TO SUPPORT RICE FOOD SECURITY

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ABSTRACT

The Irrigated Rice Research Consortium (IRRC) of IRRI has been involved in collaborative research with Indonesia for the past II years. Research includes site-specific nutrient management, crop establishment, post-harvest management, weed management, and rodent management. The nature of the collaboration has shown marked changes over the past decade, these include: (i) Development of new research theories (e.g. ecologically-based management of pests); (ii) Studies of how farmers adapt and subsequent adoption new technologies; (iii) An increase awareness of technologies that provide environmental benefits; and, (iv) A stronger focus on the social dimensions that influence adoption of technologies. Together these advances have had a major influence on national policies for rice production in the lowland irrigated and favorable rainfed agro-ecosystems. There also has been a strengthening of the research and extension capacities of Indonesian colleagues. The results of the collaboration between IRRC and Indonesian institutions over the past 10 years are impressive. The partnerships have contributed significantly to the sustainable growth of rice production in Indonesia. However, we are not resting on these achievements; there are a number of collaborative research projects at an early stage of development, particularly on more efficient use of water. The future of research on natural resource management of rice-based cropping systems holds much promise. Indeed, we expect these partnerships to gain higher profile at a national level with a greater emphasis being placed on environmentally sustainable production of rice, particularly where it is grown intensively in the lowlands.

Keywords: *IRRC, natural resource management, research, extension, Indonesia.*

INTRODUCTION

More than 2.7 billion Asian rice farmers and consumers depend on the productivity of irrigated rice systems for their livelihoods and/or food security. To meet this demand, irrigated rice production needs to be efficient in using land,

labor, and water to attain sustainable production, at the same time ensuring it is profitable, affordable, and environmentally sustainable. To this end, the Irrigated Rice Research Consortium (IRRC) of the International Rice Research Institute (IRRI) was established in 1997, with support from the Swiss Agency for Development and Cooperation (SDC), to provide a framework for partnership between IRRI and the national agricultural research and extension systems (NARES) that facilitates and strengthens NARES research and technology delivery. Through a collaborative research agenda, the development and delivery of appropriate technologies, identification and addressing regional research needs in irrigated rice, the IRRC with strong involvement of the NARES, IRRI scientists, and other stakeholders, strives to contribute directly and indirectly to the Millennium Development Goals. The IRRC is active in 11 Asian countries namely Indonesia, Malaysia, Philippines, Myanmar, Vietnam, Laos, Cambodia, China, India, Bangladesh, and Sri Lanka.

The emergence of the rice crisis in the first half of 2008, with global rice stocks at the lowest levels for a generation, has led governments of Southeast Asian countries having to set targets for increases in national rice production through to 2010. The targets for mean annual increases in production from 2008 to 2010 are 1.6% in Vietnam, 2.7% in Cambodia, 4.4% in Myanmar, 5% in Indonesia, and 7.3% in the Philippines and Lao PDR. These are challenging targets because the average yield increase in rice production for Asia from 1990–2005 was on average only 1.40% per year (IRRI 2008a) and little extra land will be converted to rice production. Indeed, most countries are losing prime rice production land to urban and industrial growth. Vietnam lost 337,490 ha of rice lands from 2000–2006 (48,200 ha per year), and Indonesia loses about 40,000 ha per year, mainly in Java. This immediate need for increased rice production has sharpened the focus on how new natural resource management technologies can be integrated to increase rice yields in the intensive agro-ecosystems. The activities of the IRRC therefore have a high profile in the region.

The IRRC has four problem-solving Work Groups (WG) established on the themes that link directly to the Millennium Development Goals namely:

(i) Productivity and environmental sustainability (Productivity and sustainability WG),
(ii) Increase productivity under water - scarce conditions (Water saving WG),
(iii) Improving labor productivity (Labor productivity WG), and,
(iv) Improving post production techniques and diverse rice markets (Post production WG).

A fifth WG on the integrated management of pests and diseases will be formed in early 2009.

These work groups develop and validate technologies that cut across rice production processes and the value chain. Innovative and participatory approaches, such as farmer field schools, field days, participatory research, the development of a national technical team for nutrient management, and stra-

tegic use of web technology (including the development of e-learning and simple decision keys) have been important pathways used to enhance the technical development of field extension officers and the knowledge base of farmers. We have focused on two approaches. The first is linking with national initiatives (e.g. P2BN and Prima Tani) and assisting with developing extension materials, and effective processes and pathways for research dissemination at a national level. The second is an understanding of technologies suitable to local conditions (at both a landscape and field scale) as the starting point for adoption and scaling out. Social scientists, extension specialists, and communication specialists have been worked closely with natural resource scientists in designing and implementing such approaches and programs.

A critical component of IRRC is the "IRRC <Country> Outreach Programs" (ICOP, e.g., IRRC Indonesia Outreach Program), which is led and coordinated by a key NARES partner of the IRRC. In the ICOPs, the WGs and NARES contribute collaboratively through expanded activities for validation, integration, and scaling out of the principles, approaches, and technology options. The ICOP is the principal platform through which the IRRC technologies are scaled out in collaboration with or through the programs initiated, led, and sponsored by the NARES of that country. To this end, the ICOPs facilitate the delivery, promotion, and uptake of technologies by national programs. The focus, priorities, and strategy of the ICOPs varies among the participating countries, depending on the stage of economic development and poverty, and the capacity of the NARES and the partnership.

With the problem solving work groups and ICOP's, the IRRC involves multi-stakeholder processes and social learning that effectively identify solutions to farmers' problems and facilitate timely adoption of lowland rice production principles and technologies in a wider scale. Through its ICOP's, the IRRC also serves as an international platform providing effective mechanism to support research-extension partnerships, including partnering with nongovernment organizations (NGOs), the private sector, policy makers and the farmers in the promotion of sustainable and benefit-enhancing technologies for irrigated rice-based systems.

IRRC IN INDONESIA

The IRRC of IRRI has been involved in collaborative research with Indonesian partners for the past 11 years. Research includes site-specific nutrient management (SSNM), insect management, crop establishment, post-harvest management, water management, weed management, rodent management and integrated crop management.

Location Specific Nutrient Management & the Nutrient Manager

Collaboration on the development and evaluation of SSNM, coordinated by the IRRC Productivity and Sustainability WG, started in 1998. Currently there are

activities through on-farm research and training in North Sumatra, East Java, and West Java. SSNM is an approach of supplying plants with nutrients to optimally match their inherent spatial and temporal needs for supplemental nutrients (see Buresh and Witt 2007; IRRI 2008b). The aim is to enable farmers to dynamically adjust their fertilizer use to optimally fill the deficit between the nutrient needs of a high-yielding crop and the nutrient supply from naturally occurring indigenous sources such as soil, crop residues, organic inputs and irrigation water. It emphasizes 'feeding' rice with nutrients at the proper time and proper amounts.

In Indonesia over the past decade, there have been a number of projects that have a strong emphasis on nutrient management. These include Reversing Trends of Declining Rice Productivity (RTDP), Reaching Toward Optimum Productivity in Intensive Rice Systems (RTOP), Crop and Resource Management Network (CREMNET), Integrated Crop Management (ICM), and SSNM. Each of these projects has generated high quality research. A challenge has been integrating the findings from these different projects into a cohesive national approach to nutrient management. Without such a synthesis then there have been subtle but important differences in the recommendations on nutrient management for rice crops that has often led to confusion for extension professionals. In 2007, the Productivity and Sustainability work group played a pivotal role in bringing together key Indonesian agencies from research and extension to from a national fertilizer work group. This led to the formation of a nutrient management technical team that developed a consensus approach to nutrient management for rice - location specific nutrient management. The technical team also has taken on the challenging tasks of developing effective research-extension partnerships, developing and implementing support material and training workshops for extension specialists, and providing policy advice. In 2008, the training materials on location specific nutrient management have been disseminated in Indonesia through 60,000 farmer field schools.

In parallel to the activities of the national fertilizer work group, Buresh and his co-workers at IRRI have developed an interactive computer-based decision tool that consists of 10 key questions with multiple choice answers (see IRRI 2008b for details). Known as the Nutrient Manager, the answer to the questions leads to a printout of fertilizer recommendations. An Indonesian version has been developed and evaluated through collaborative partnerships with four partner agencies within the Indonesian Agency for Agricultural Research and Development (IAARD). The computer module has now been validated in five provinces and is available in Bahasa Indonesia under the title of PuPS 1.0 - *Pernupukan Padi Sawah Spesifik Lokasi* or "Rice Fertilization for Specific Location".

Post-harvest Management- Broad Impacts

An estimated 10–15% of the rice produced by Indonesian farmers does not reach the markets because post harvest losses are high along the value chain.

These losses consist of shattered grains during harvesting and transport, grains eaten by animals and spilled in sun-drying, and losses in rice mills due to poor equipment, maintenance and low quality raw material (paddy). In addition the remaining rice that reaches the market is often of poor quality with low head rice, many broken grains, wrong moisture content and discolored grains from delays in post harvest operations and improper drying. The poor quality grain is often downgraded to Grade 3, which sells at highly discounted prices, typically around 20% less than Grade 1. Improved post harvest management and technologies can therefore help increase the milled rice available in the country and can significantly lead to better quality and healthier rice production to the uplands and thus the need to use fire for clearing land. The results of this collaboration have been encouraging and we look forward to seeing clearer skies over South Sumatra as the benefits of this collaborative project flow through to neighbouring villages.

Water Saving Technologies- An Emerging Demand

Water-saving activities are becoming in high demand in some regions of Indonesia. The Water Savings Work Group of the IRRC is collaborating with scientists at the Indonesian Center for Rice Research to validate the promising results obtained on alternate wetting and drying (AWD) technology in the Philippines and China: AWD entails an irrigation schedule where, contrary to the normal practice of continuous flooding, water is applied to the field a number of days after the disappearance of ponded water (Bouman and Tuong 2001; Tabbal *et al.* 2002). The simple scientific principle being exploited in a strategic manner is that it is the water availability to the root zone that is the key determinant to the productivity of the plant. Therefore the rice plant does not need to be flood irrigated with the exception of the flowering stage when rice is particularly sensitive to water stress. Once the AWD technology has been verified by ICRR at their Sukamandi research farm, it will then be tested under field conditions in South and Southeast Sulawesi, where water shortage has been identified as a key constraint to rice production in the dry season.

Weed Management

Direct-seeding of rice crops is increasing in popularity in some provinces of Indonesia. With direct seeding, there is high reliance on herbicides resulting in an undesirable shift in weed species and concerns about environmental contaminations (Azmi *et al.* 2005). The collaboration of the Labor Productivity WG with ICRR has a strong focus on the changes in weed species and their population dynamics resulting from the transition to direct seeded rice from transplanting. This work is building on the results from similar but longer term projects in India, Bangladesh, and Vietnam.

The research collaboration on weeds also has involved the characterization of weedy rice, and considering appropriate management strategies for Indonesian agro-ecosystems. Weedy rice is difficult to manage because of its similarity to domesticated rice plants. It is an emerging problem in Indonesia that needs to be closely monitored.

The future emphasis will be on factors influencing the demographic machinery of weed communities and linking this to a better characterization of the socioeconomic impacts of major weeds in lowland rice ecosystems in South Sumatra, South Sulawesi, Southeast Sulawesi, and West Java. This knowledge will provide a platform for developing strategies for sustainable integrated weed management. The promotion of biological and cultural control options, and minimizing the use of herbicides, are seen as important components for the development of sustainable rice-farming systems in the region.

Ecologically Based Rodent Management-Indonesia is A Leader in

SE Asia Rodents are the number one pre-harvest pest in Indonesia. Losses on average are 17% per year (Singleton 2003). To put this into perspective, a loss of 17% amounts to enough rice to feed 25 million people for a year. The ICRR rodent laboratory is a leader in rodent management in Southeast Asia. Through linkages with IRRI and scientists in Australia, they have developed a good understanding of the population ecology of specific rodent species, leading to effective community methods of control that are simple to apply and environment friendly. Village scale field trials in the lowland irrigated rice crops in Java in Indonesia resulted in a 50% reduction in the use of chemical rodenticides and increased yields by about 0.5 t/ha (Singleton *et al.* 2005). The ICRR rodent specialists are linking with the IRRC in adaptive research projects in Sumatra and Sulawesi. Studies include household surveys in rural communities on their knowledge, attitudes and practices associated with managing rodent problems (Sudarmaji *et al.* 2003). These sociological studies were conducted in parallel to studies on the population ecology and breeding biology of the major pest species in lowland irrigated rice systems. The integration of findings from social and natural sciences provided an excellent foundation to develop, refine and promote ecologically based rodent pest management (EBRM) in Indonesia. EBRM combines both cultural and physical rodent management practices such as: (i) ensuring synchrony of cropping (crops planted within 2 weeks of each other); (ii) implementing short 2-week rat campaigns at key periods (1 week prior to transplantation, or within 2 weeks of crop initiation) in focal refuge habitats such as village gardens and the banks of main irrigation channels; (iii) reducing the width of irrigation banks in the fields to less than 30 cm to prevent nesting by rats; (iv) improving the general hygiene around villages and village gardens; (v) promoting synchronous fallow; and (vi) using a community trap-barrier system (CTBS) (Singleton *et al.* 2005).

EBRM has been reported to be economically profitable in a major review of its impact in Vietnam. There the key to success was the adoption through community participation of a set of technologies that were attuned to farmers' norms, beliefs, and practices (Palis *et al.* 2004). Issues relating to the adoption and sustainability of EBRM in lowland irrigated rice fields in Indonesia are currently being studied in South Sulawesi and West Java. Likewise, the social and cultural mechanisms involved in maintaining community participation are being explored to further understand the conditions under which EBRM works and does not work.

A current project on the sustainable implementation of EBRM (2006–2009) has the principal aim of sustaining the positive gains attained from previous projects. This project involves CSIRO, ICRR, BPTP Maros, and IRRI with strong collaboration with provincial agricultural departments. Scaling out of project activities through increases dissemination to farmers is targeted for 2008–2009.

CONCLUDING REMARKS

The nature of the collaboration between the IRRC and our Indonesian partner agencies has shown marked changes over the past decade, these include:

(i) Development of new research theories (e.g. ecologically-based management of pests);
(ii) Studies of how farmers adapt and subsequent adoption new technologies;
(iii) An increase awareness of technologies that provide environmental benefits; and,
(iv) A stronger focus on the social dimensions that influence adoption of technologies.

Together these advances have had a major influence on national policies for rice production in the lowland irrigated agro-ecosystems. There also has been a strengthening of the research and extension capacities of Indonesian colleagues.

In addition to these national initiatives, provincial initiatives that have an adaptive research focus have been established. This is a bottom-up approach, in which researchers and extension agencies have developed a program of activities based on the important needs of and constraints to rice production identified by farmer groups. New projects in South Sumatera, South Sulawesi, and Southeast Sulawesi facilitate learning and adaptive management for irrigated rice. The IRRC aims to increase efficiency of rice production by 10% through matching crop management technologies with the needs of farmers. Given the variability in the biophysical and social environment across the provinces, a necessary precursor to adoption is that the adaptive integrated crop management package be flexible enough to meet the needs and requirements

of local farmers, but still general enough to allow future scaling out for sustainable and widespread adoption. Using a social anthropological platform, we will develop a strong understanding of the economic, social, and cultural factors that influence the farm-level adoption process. An important output of these studies will be the identification of technological limitations that affect the adoption and adaptation of technologies. This approach has required the assembly of multistakeholder teams that span research to extension at the provincial level, to extension and outreach at the sub district or *kabupaten* level. The team includes researchers from the ICRR, IPJU, and local universities, extension specialists from AIATs and *Dinas Pertanian* in each of the provincial headquarters, and extension staff at the district and sub district levels.

The results of the collaboration between IRRC and Indonesian institutions over the past 10 years are impressive. The partnerships have contributed significantly to the sustainable growth of rice production in Indonesia. However, we are not resting on these achievements; as indicated, there are a number of collaborative research projects at an early stage of development in Indonesia. The future of research on natural resource management of rice-based cropping systems holds much promise. Indeed, we expect these partnerships to gain higher profile at a national level with the "rice crisis" leading to a greater emphasis on environmentally sustainable increases in production of rice, particularly where it is grown intensively in the lowlands.

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REFERENCES

Azmi M,, Chin D.V,, Vongsaroj P., and Johnson D.E. 2005. Emerging issues in weed management of direct-seeded rice in Malaysia, Vietnam, and Thailand. *In*: K. Toriyama, K.L. Heong, and B. Hardy (eds). Rice is life: scientific perspectives for the 21st century. Proceedings of the World Rice Research Conference, 4–7 Nov 2004, Tokyo and Tsukuba, Japan. International Rice Research Institute, Los Banos, Philippines, and Japan International Research Center for Agricultural Sciences, Tsukuba, Japan. Pages 196–198.

Bouman, B.A.M. and Tuong T.P. 2001. Field water management to save water and increase its productivity in irrigated lowland rice. Agricultural Water Management, 49:11–30.

Buresh R.J. and Witt C. 2007. Site-specific nutrient management. *In*: Proceedings of the IFA International Workshop on Fertilizer Best Management Practices, 7–9 March 2007, Brussels, Belgium. International Fertilizer Industry Association. Paris, France. Pages 47–55.

International Rice Research Institute. 2008a. Background Paper: The rice crisis: What needs to be done? Los Banos (Philippines): IRRI. 12 p. www.irri.org.

International Rice Research Institute. 2008b. Site-specific nutrient management. www.irri.org/irrc/ssnm.

Palis F.G., Sumalde Z. and Hossain M. 2004. Assessment of rodent control projects in Vietnam: Adoption and impact. Impact Assessment Series No. 24. March 2004. Australian Centre for International Agricultural Research. Canberra, Australia.

Sudarmaji, Singleton G.R., Herawati N., Djatiharti, A. and Rahmini. 2003. Farmers' perceptions and practices in rat management in West Java, Indonesia. *In*: G.R. Singleton, L.A. Hinds, C.J. Krebs, and D.M. Spratt (eds). Rats, mice and people: Rodent biology and management. ACIAR Monograph 96. Australian Centre for International Agricultural Research. Canberra, Australia. Pages 389–394.

Singleton G.R., Sudarmaji, Jacob J. and Krebs C.J. 2005. Integrated management to reduce rodent damage to lowland rice crops in Indonesia. Agriculture, Ecosystems and Environment, 107:75–82.

Singleton G.R. 2003. Impacts of rodents on rice production in Asia. IRRI Discussion Paper Series No. 45. Los Banos, Philippines. 30 p.

Tabbal, D.F., Bouman, B.A.M., Bhuiyan, S.I., Sibayan, E.B. and Sattar, M.A. 2002. On-farm strategies for reducing water input in irrigated rice; case studies in the Philippines. Agric. Water Management, 56:93–112.