

4 PROJECT 4

Managing resources under intensive rice-based systems

The highly productive favorable irrigated environment produces nearly three-quarters of the world's rice. The doubling of rice production in Asia over the past 30 years has arisen largely from increased production in the two major intensive rice production systems—double cropping of rice and the rice-wheat rotation—brought about by improved rice varieties, expanded irrigation, and higher rates of fertilizer use.

Yield growth, however, has stagnated in recent years. If this trend continues, it will be difficult to grow enough rice to satisfy a growing population of urban poor and rural landless, especially when combined with postharvest losses. Further, as laborers move in

increasing numbers away from farms to find jobs in the cities, farmers need solutions to the problems of worsening labor shortages and a consequent increase in labor costs. At the same time, shortages of irrigation water and farmers' misuse of agro-chemicals are causing environmental concern.

Current irrigated yields in the rice-rice and rice-wheat systems, averaging 5 tons per hectare, are well below the estimated potential yield of 8 tons per hectare of existing rice cultivars. Farmers need new knowledge, techniques, and practices to bridge this gap. Without appropriate knowledge, it will be difficult for farmers to increase yields and achieve both increased profitability

and minimal environmental impact.

New knowledge-based technologies and machinery that are environmentally sound, socially acceptable, and profitable to farmers can enhance and sustain the productivity of favorable environments. Such technologies must integrate management of soil, water, weeds, pests, and diseases and at the same time conserve biodiversity and environmental health. Fully developing these technologies requires research on crop physiology, nutrient cycling, pest ecology, the rice crop in its environs, and mechanization systems, as well as a thorough understanding of farmers' management approaches and limitations.



Output 1: Crop and soil management practices and strategies developed and deployed for sustaining productivity, enhancing profitability, and minimizing environmental impact in intensive systems

In 2005, we developed an initial framework for integrated management of nutrients, the crop, and water aimed at increasing input-use efficiency in intensive rice systems. Within this framework, we undertook a series of projects, both at IRRI headquarters and with our national partners throughout Asia.

We conducted field experiments at four sites in China with two cultivars and six nitrogen (N) treatments to develop parameters for quantifying a healthy rice canopy. Work continued

on site-specific nutrient management (SSNM)—the practice of tailoring fertilizer use for individual fields and seasons—which is now well developed for rice. IRRI now has an SSNM Web site (www.irri.org/irrc/ssnm). We are developing locally adapted SSNM recommendations for major rice-growing areas and we completed an assessment of SSNM and its effect on profit and nitrous oxide emissions in Vietnam, the Philippines, and southern India. We are also developing the concept of canopy management and evaluating this for integrated nutrient and disease management, and we examined the interactions of water and residue management on greenhouse gases and nutrient supply. In 2005, we also established a collaborative project in Vietnam, which began in January 2006. This involves two activities: national extension of SSNM through training programs for extension workers in northern and southern Vietnam that are supported by the Vietnam National Agricultural Extension Centre, and a collaborative research initiative in northern, southern, and central Vietnam with support from the Ministry of Agriculture and Rural Development for developing improved practices for integrated management of nutrients, the crop, and water to close the yield gap in irrigated rice.

Our research on N uptake indicates that the practical limit to the recovery of fertilizer N (the fraction of applied fertilizer N taken up by the plant or crop) was just less than 60%. At least 40% of the N is lost even when using an “ideal fertilizer” delivered so as to provide the plant with its exact needs at any time. This loss occurs because the biophysical processes in the soil (such as microbial activity) have as equal an access as roots to nitrogen in the available soil pool. This understanding will guide the establishment of the practical limits to N recovery.

In 2005, IRRI developed a young robust seedling technique for enhancing fast revival of seedlings soon after transplanting and vigorous early growth and canopy development. This has been well tested and the general principles established: transplanting of seedlings at the four-leaf stage and no tillers in the nursery result in an additional yield of 1–2 tons per hectare. In addition, a modified mat nursery to produce robust young seedlings in 15 days has been introduced and is being evaluated in Timor-Leste and a modified mat nursery for boro (dry-season) rice is being tested in West Bengal, India. The private sector in India has also shown support, with seed companies such as Bioseeds-Hyderabad and Annapoorna-West Bengal adopting the young robust seedling technique to increase the seed yield of their seed producers.

Burning crop residue can have harmful environmental effects and it destroys vegetative matter that could benefit the soil and the succeeding crop. In 2005, we evaluated alternative residue management practices and their effects on soil fertility and crop production. This included examining

the effects of hastening residue decomposition on organic acids, nutrients, and greenhouse gases and the effects of residue management with various crop, soil, and water management options on soil properties and soil-supplying capacity of nutrients. Initial results from research on the integration of SSNM with residue management indicate that more N is needed early on, at the time residues are incorporated into the soil. In partnership with NARES, we also evaluated practices of reduced tillage and management in rice-rice and rice-wheat systems.

Output 2: Improved pest management practices to increase productivity and conserve and enhance the environment developed and deployed

In recent years, IRRI has had success with an entertainment education (EE) approach to motivating farmers to improve their crop management practices. In 2005, we continued an EE campaign to reduce insecticides in the Mekong Basin. In July 2004, radio soap operas—with storylines designed to educate farmers on the best practices in





reducing pesticides—were launched in Vietnam and Lao PDR. These continued in 2005, with 104 episodes broadcast in each country. In Vietnam, an additional 35 episodes were developed to be broadcast between January and June 2006. Following the launch of the Environmental Soap Opera for Rural Vietnam, farmers in Vietnam’s Vinh Long Province used 38% fewer insecticide sprays per season per year and the project won the World Bank Development Marketplace 2005 award.

Research into the relationships between arthropod biodiversity and pest control function indicated that increased predator diversity is associated with increased predation rates in some pest species. We also evaluated farmers’ adoption of the trap barrier system for rodent management. The main constraint to adoption is the community participation requirement, which makes the system difficult to scale up without added incentives.

traditional Philippine variety) with PSBRc82 (a modern indica variety). Lodging and stem borer incidence of Malagkit Songsong were higher when it was planted alone than when it was grown in mixture plots. Lodging and susceptibility to pests discourage farmers from growing Malagkit Songsong on a large scale despite its high market value. Interplanting with a high-yielding modern variety can now be considered an option for improving yield and increasing production.

Characterizing pest ecology in a range of ecosystems will help determine how pest populations are controlled and how plant resistance and natural enemies may interact in controlling pest populations. Patterns of key insect pests and their natural enemies were characterized for cultivated rice, and for wild grass and wild rice habitats. Planthoppers and natural enemies appear more abundant in grass habitats than

In 2005, we determined the impact of interplanting different rice varieties—four rows of a modern variety interplanted with one row of a traditional variety in a repeating pattern—on diseases, insect pests, and agronomic performance in both indica- and japonica-growing areas. We conducted on-farm experiments in both the wet and dry seasons in which we interplanted Malagkit

Songsong (a

in rice, indicating that grass habitats may be important in conserving natural enemies of rice pests.

Weeds are a major problem in most rice-based ecosystems. In 2005, we assessed how well different cultivars naturally suppressed weeds, identifying differences in early vigor and competitiveness in a range of cultivars. Differences in vigor as early as 12 days after seeding may indicate abilities of rice varieties to suppress neighboring weed plants and, consequently, be a guide for breeding highly weed-competitive rice varieties. The weed-suppressive effects of different water regimes—covering duration and depth of flooding—were also assessed for a range of weed species. This detailed knowledge of the effect of submergence on weeds will be used to develop decision tools and to guide the application of crop management options.

Output 3: Mechanization systems developed that improve the efficiency and sustainability of rice production

Postharvest losses, through spoilage or pest infestation, are a serious burden on farmers. Appropriate postharvest management systems can prevent debilitating losses. In 2005, approaches for reduced postharvest loss and improved grain storage were adapted to local conditions in several countries and provided for wide-scale delivery. We field-tested the 50-kg hermetic storage bag, known widely as the “superbag”—made from a laminated plastic that incorporates a gas barrier that restricts oxygen and water vapor movement—in Lao PDR, Cambodia, Vietnam, Myanmar, Indonesia, and the Philippines. The superbag helped achieve improved seed quality in Lao PDR and Myanmar and improved aroma of grain in Cambodia.

A comparison of seven cropping systems allowed us to assess the

economic and environmental impact of different rice cropping systems. Energy balance showed that puddled transplant and broadcast systems were the most efficient. Alternate wetting and drying did not increase water-use efficiency.

IRRI continued its work to identify and evaluate equipment and techniques that enhance crop production and processing. In 2005, we developed dry laser land-leveling equipment in Vietnam, wet-leveling systems in China, and a rice hull furnace, which is now being successfully used by the Philippine Rice Research Institute (PhilRice). We also modified and tested a direct-seed-drill prototype for direct seeding and fertilizer application in puddled and dry-seeded soils. Rice crops were successfully established at the same time as fertilizer incorporation in wet puddled and dry systems in the Philippines.

Rodents can do major damage to rice stores. In 2005, we developed rodent identification and management strategies for grain storage systems. In trials, there was only one reported rodent attack on 50-kg storage bags and one attack on a 5-ton storage system. Trials will be undertaken at the farm level in 2006.

Output 4: Resource-use efficiency in the rice-wheat system increased

IRRI's investigation of ways to improve yields and sustainability of the important rice-wheat cropping system in the Indo-Gangetic Plains of South Asia focused in 2005 on an integrated system incorporating tillage, nutrients, weed management, and water use in the rice crop. To investigate the interactions among these factors, we conducted multilocation trials in India, Nepal, Pakistan, and Bangladesh. Data are now being collected, compiled, analyzed, and interpreted, and two research papers have been submitted to international refereed journals.

One hundred drum seeders were imported from Vietnam to India for evaluation of row seeding in puddled soil in countries that use the rice-wheat system. Findings so far are that, by using the drum seeder, the cost of cultivation can be substantially reduced, with some water saving.

To develop efficient crop establishment methods for rice in the rice-wheat system, we evaluated resource-conserving technologies in farmers' fields. Several on-farm technology trials were carried out at five sites in Bangladesh, Nepal, Pakistan, and India. Key technologies include zero-tillage, laser leveling, dry direct seeding, drum seeding, bed planting, residue management, weed management (including through brown manure), the leaf color chart (used by farmers to check the crop's N needs), and integrated crop management (ICM).

We also evaluated the effects of direct-seeding practices on weed species composition and weed management in more than 100 farmers' field trials in the states of Uttaranchal, Uttar Pradesh, and Bihar in India. The information obtained on weed species shifts and ecology will help guide management options. Overall, results are promising, with the technologies leading to an increase in farmers' income and therefore good potential for widespread adoption.

To help farmers maximize the potential of the rice-wheat system, we refined, standardized, validated, and calibrated an existing simulation model to evaluate various management options to increase water- and nitrogen-use efficiency as well as overall productivity of the system. This model, known as the denitrification and decomposition model, was evaluated for its ability to simulate N dynamics and balances in the rice-wheat cropping system in the Indo-Gangetic Plains, using a range of



management practices. Knowledge of the magnitude of N losses in different transects of the Indo-Gangetic Plains will allow us to develop appropriate N management practices and recommendations.

To assess the influence of soil management on soil nutrient-supplying capacity, we examined soil organic matter and soil physical properties in a range of areas using the rice-wheat system. Soils were analyzed for various soil parameters and soil organic matter levels, and the relationship between these properties and the soil's nutrient-supplying capacity was established. This work will allow accurate assessment of soil health and productivity and allow the development of appropriate on-farm management strategies.

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