Advancing Thailand's Rice Agriculture through Molecular Breeding

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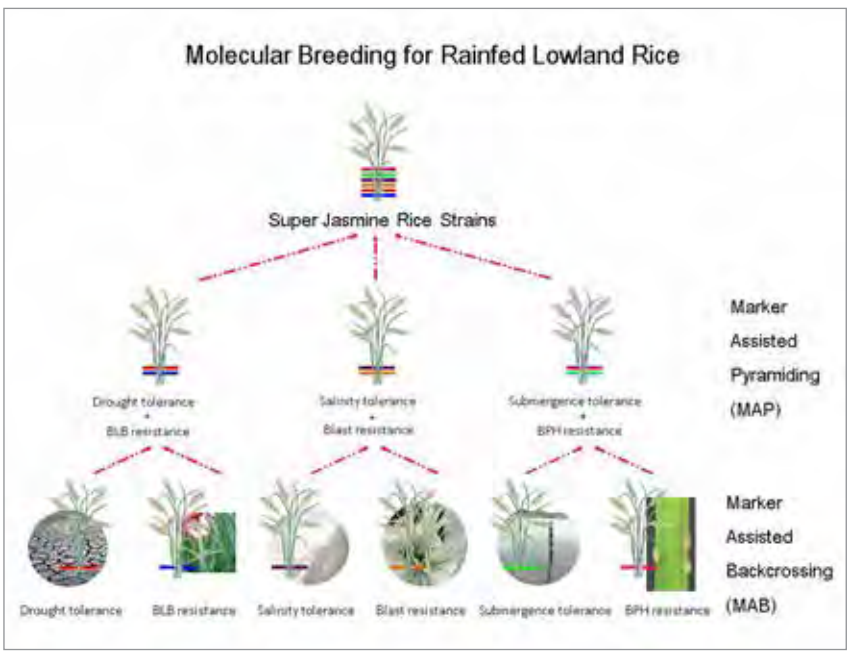
Background

A large proportion of the rice lands in the Mekong region are rainfed lowlands. Rainfed lowland rice is a major crop for farmers in Thailand and neighbouring Myanmar, Laos, and Cambodia. Thai scientists have been at the forefront of developing new rice varieties to help these farmers cope with problems common to the region including drought, flash floods, salinity, insect pests and plant diseases. They have leveraged upon advancements in biotechnology, especially in the areas of genomics and molecular genetics to overcome the limitations of traditional rice breeding approaches. For example, molecular marker assisted selection has been successfully applied in rice breeding programs to improve the effectiveness and precision of the selection process, as well as shorten the turnaround time and lower the costs of implementation.



Thailand's capacity in modern biotechnology was established with the setting up of the National Center for Genetic Engineering and Biotechnology (BIOTEC) in 1991. The Rice Gene Discovery Unit (RGDU) is a joint laboratory between BIOTEC and Kasetsart University and plays a key role in Thailand's rice research activities. Its researchers have identified and characterized valuable traits for rice breeding, including tolerance to abiotic stresses like submergence, drought and salinity. They have also characterized other useful traits including resistance to diseases like bacterial leaf blight, blast and pest, as well as those that conferred improved rice quality and nutritional values. The genes and quantitative trait loci (QTLs) controlling these useful traits have been identified and used in molecular-marker assisted selection rice breeding programs to create new improved rice varieties.

New and Improved Rice Varieties

Two rice varieties that are commonly targeted for improvements are the jasmine rice Khao Dawk Mali 105 (KDML 105) and glutinous jasmine rice RD6, which are highly adapted to the rainfed lowland areas of Thailand. Molecular breeding programs in Thailand have produced many improved rice

cultivars. Among them, three have shown great promise: Homali 80, Homcholasit and Thanyasirin. Homali 80 is a new version of KDML 105 which is tolerant to flash floods and can survive submerged under water for up to 3-4 weeks. It can only be planted during wet season. Homcholasit is also derived from KDML 105 and tolerant to flash floods. However, it can be planted throughout the year and provides a yield of 5 tons per hectare. Thanyasirin is a new version of the jasmine glutinous rice RD6 which possesses resistance to blast and yet retains superb cooking quality.

The Seed Production Training Program – Boosting Productivity and Overcoming Adversity

In 2008, the National Science and Technology Development Agency (NSTDA) launched a Seed Production Training Program (SPTP) to distribute new rice varieties to farmers and to promote seed production within the farming community. In the next 3 years, 960 tons of Homcholasit seeds and 1,170 tons of Thanyasirin seeds were produced under the program. For 2012, the SPTP is expected to produce 230 tons of Homcholasit seeds and 190 tons of Thanyasirin seeds, generating significant income for participating farmers.

The Phak Hai district in Phra Nakhon Si Ayutthaya province is a lowland area that is drained by the Chao Phraya River and its tributaries. During monsoon seasons, flash floods which affect large areas of rice paddy fields are common. This greatly impacts the

Homcholasit field in Phak Hai District: The top two photos were taken on Day 12 of the field completely submerged. The bottom photos were taken at the same sight after the water was drained. The plants were able to survive and produce flowers.

"Molecular breeding programs in Thailand have produced many improved rice cultivars."

livelihood of local farmers who normally cultivate Phitsanulok rice strain which does not survive when submerged under water for extended period of time. In early 2010, two tons of Homcholasit were given to farmers in the area who were also trained in seed production. In October that year, a two acre field of Homcholasit was flooded and the rice paddy completely submerged for 15 days under 1.5-2 meters of water. After the flood subsided, it was found that only 20% of the Homcholasit plants were damaged. The new rice variety therefore saved the farmers from completely losing their harvest for the year.

In 2011, Thailand experienced one of the most devastating floods in its history which according to the World Bank, caused over THB1.4 trillion in damages. Thailand's Department of Agriculture Extension estimated that about 2.85M acres of rice field were damaged by the flood. During the crop season in 2012, NSTDA launched a seed production program using the improved rice varieties, to produce seeds for distribution to rice farmers in the flood-affected areas. The program was met with strong support from the Siam Cement Group (SCG), Rajamangala University of Technology Lanna, Farm Chokchai Group as well as farmer cooperatives in Phra Nakhon Si Ayutthaya and Chainat provinces. This initiative contributed significantly to Thailand's flood rehabilitation efforts.

Spreading the Seeds of Success – Transferring Technology and Boosting Human Capital

The problems associated with rice production in Thailand are unique to the Mekong region. The technologies that were developed by Thailand to address these problems can therefore benefit their rice producing neighbours in the Mekong region. In 2004, with sponsorships from the Rockefeller Foundation, Kasetsart University and BIOTEC, the Rice Gene Discovery Unit (RGDU) set out to transfer marker-assisted selection technology for rice breeding to rice breeders in Myanmar, Laos, Cambodia, as well as those in Thailand. Scientists from the relevant rice breeding institutes in these countries, which include the Cambodian Agricultural Research and Development Institute (CARDI), Lao's National Agricultural and Forestry Institute (NAFRI) and Myanmar's Department of Agricultural Research (DAR), underwent a training program that span two years. In 2007, additional funding from the Generation Challenge Program enabled the molecular breeding activities to continue in the Mekong region countries. By the end of the program in 2009, new rice cultivars of

(Top) Phenotyping workshop on bacterial blight resistance and submergence tolerance screening in DAR. (Center) Phenotyping workshop on brown planthopper resistance and submergence tolerance screening in CARDI. (Bottom) Phenotyping workshop on blast resistance and submergence screening in NAFRI.

aromatic Manawthukha and salt tolerant Sin Thwe Latt (Myanmar), aromatic TDK1 (Laos), aromatic CAR3 (Cambodia) and Jasmine-quality IR57514 (Thailand) were developed and planted in research stations for preliminary yield evaluation.

The Generation Challenge Program continues to fund the next phase of the initiative, which aims to evaluate the promising rice lines in the farmer field and incorporate more traits to the improved rice varieties from the various participating countries. The research capacities of the participating institutes have also been enhanced. For example, submergence ponds as well as greenhouses for screening bacterial blight, blast and brown planthopper have been constructed at DAR, NAFRI and CARDI respectively. Furthermore, various Thai organizations and institutions including NSTDA, Kasetsart University and Ubon Rachatani University have given scholarships to suitable candidates from Myanmar, Laos and Cambodia to undertake Masters and Doctorate programs at Kasetsart University's Faculty of Agriculture. Since the inception of the program, 22 researchers from participating institutes have been trained and 10 graduate scholarships have been given out.

After three years of farmers' field trials in Myanmar, an aromatic Manawthukha line which has the quality of basmati rice and can yield 4.28 tons of rice per hectare is ready to be released to farmers. This is an improvement over the original line which has a yield of only 4 tons per hectare. Another line, a salt tolerant Sin Thwee Latt, which has higher yields and is more tolerant to salinity than the original line, will also be released to farmers whose fields are frequently affected by salinity issues. In Laos, yield trials of the fragrant TDK1 rice lines were conducted in 2011 in Vientiane, Savannakhet and Champasak provinces. Once the field trials are completed, the NAFRI will decide the line of rice to be released to the farmers.

The use of biotechnology has helped advance rice agriculture in Thailand. More importantly it has helped improved the livelihoods of local rice farmers and the competitiveness of the industry. And by sharing this know-how with neighbouring countries, Thailand is contributing to further development of region's agricultural sectors.

About the Authors

Dr. Theerayut Toojinda works as a Principal Researcher at the National Center for Genetic Engineering and Biotechnology (BIOTEC) and deputy director at Rice Gene Discovery Unit (RGDU), a collaborative unit between BIOTEC and Kasetsart University. Dr. Toojinda obtained his bachelor's degree in agricultural science and master's degree in plant breeding from Kasetsart University, Thailand and doctoral degree in crop science from Oregon State University. Before joining BIOTEC in 2000, Dr. Toojinda had experience working as researcher in several public and private sector in Thailand and overseas, namely CIMMYT (Bangkok), Boon Rawd Brewery Company Limited and as visiting scientist at the Scottish Crop Research Institute. He is the head of rice molecular breeding at RGDU and had worked as a project leader on the rainfed lowland and the Mekong projects.

Dr. Jonaliza Lanceras-Siangliw is a Researcher at the National Center for Genetic Engineering and Biotechnology (BIOTEC). She received her bachelor's degree in biology from the University of the Philippines and joined the International Rice Research Institute for three years. She continued her master's and doctoral degrees in tropical agriculture from Kasetsart University. After completing her PhD, she worked as project coordinator of projects directed on the improvement of rice for rainfed lowland environment and in particular, her research is focus on drought resistance in rice. She was the project coordinator of the Mekong project and trainer of staff coming from DAR, NAFRI and CARDI.