Special supplement focusing on IR8

rice TODAY

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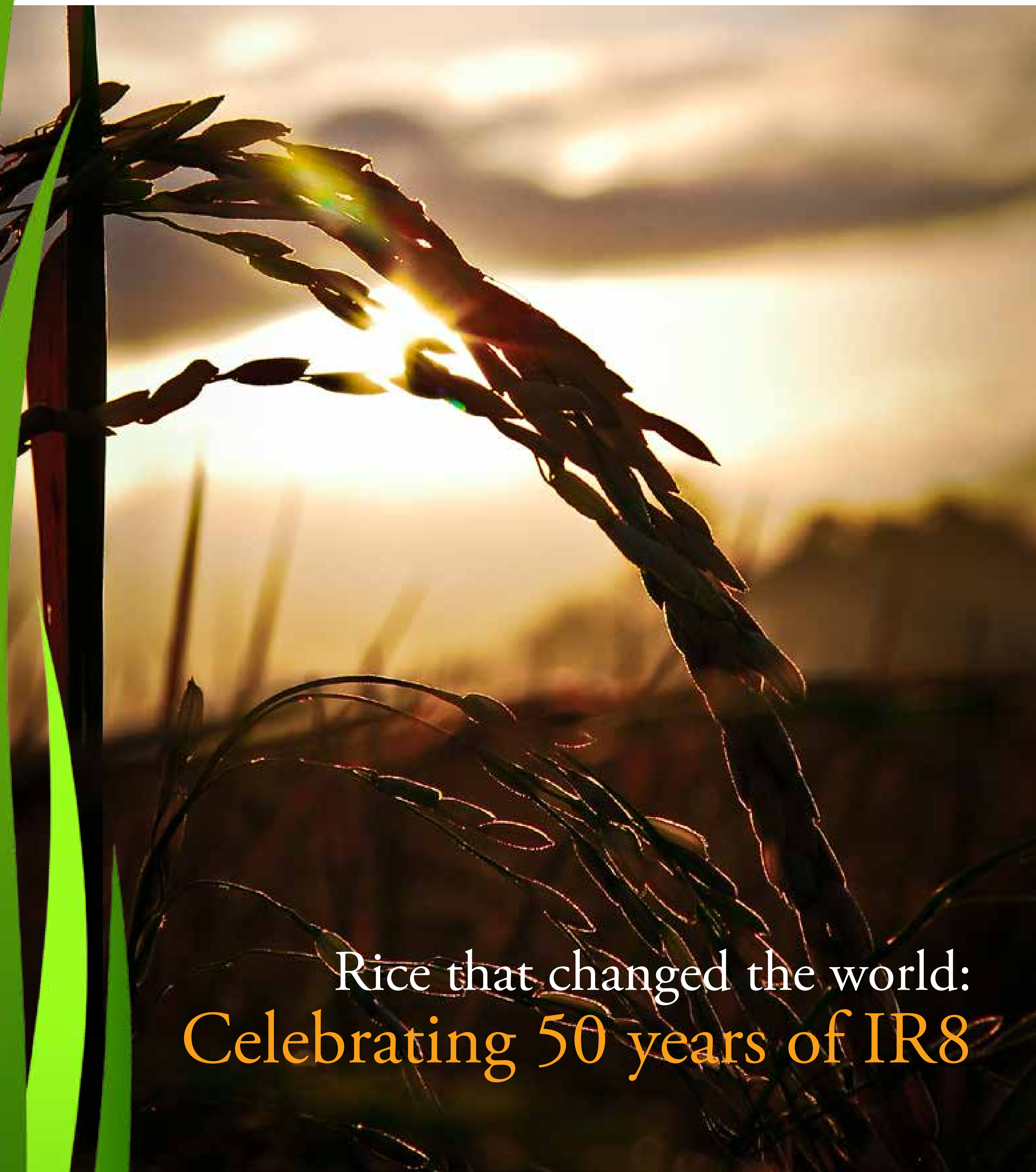

Rice that changed the world:
Celebrating 50 years of IR8

Changing the world with seeds: The breeding history of IR8

In the 1950s, Asia is on the brink of famine. Food is scarce and millions of people are in danger of suffering from starvation. So, in 1960, the International Rice Research Institute is established with an urgent mission to develop a high-yielding rice variety.

1962

IRRI breeder Peter Jennings and his team make crosses using various dwarf and tall rice varieties as parents, one of which is between Dee-geo-woo-gen (DGWG), a dwarf variety from Taiwan, and Peta, a tall variety from Indonesia.

1963

In the segregating F_2 populations coming from the 1962 crosses, Jennings discovers the existence of a single recessive gene for shortness (later to be called *sd-1*).

1964

From the F_4 generation of the Peta × DGWG cross, IRRI breeder Hank Beachell selects a single plant and designates it as IR8-288-3.

1965

The first cooperative trials of IR8-288-3 and other promising lines are conducted in the Philippines, Hong Kong, Malaysia, Thailand, and Taiwan.

1966

During the dry season, IRRI agronomist S.K. De Datta demonstrates IR8-288-3's significant yield potential. IRRI tests IR8-288-3 widely and multiplies the seed as rapidly as possible.

3 June: Philippine President Ferdinand Marcos visits IRRI and is impressed with IR8-288-3.

12 June: The Philippine press dubs IR8-288-3 as a "miracle rice," the first time the term is used.

26 October: U.S. President Lyndon B. Johnson visits IRRI to inspect IR8-288-3 in the field.

14 November: IRRI's seed committee names line IR8-288-3 as variety IR8.

28 November: IRRI announces the official release of IR8 as its first rice variety. As the prototype for future modern rice varieties, IR8 is credited with jumpstarting the Green Revolution in rice.

1967

In India, Mr. Nekkanti Subba Rao, a progressive farmer in Andhra Pradesh, tests IR8 on his farm to demonstrate its high yield potential to neighboring farmers.

In subsequent years, IR8 is called Magyaw in Burma, Padi Ria in Malaysia, Peta Baru 8 in Indonesia, Lua Honda in Vietnam, and Milagro Filipino in Mexico.

CONTENTS

rice TODAY

Special supplement focusing on IR8

About the cover

The development of IR8 signaled the dawn of modern rice varieties and the beginning of the first Green Revolution. More popularly known as the Miracle Rice, its impact on hunger was felt across Asia and as far as Latin America. Over the next few decades, IR8 led to more than 300 innovative rice varieties using its genetic building blocks. Owing to these new varieties, global rice production increased from 257 million tons in 1966 to 626 million tons in 2006.
(Photo by Isagani Serrano, IRRI)

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IRRI is the world's leading international rice research and training center. Based in the Philippines and with offices located in major rice-growing countries, IRRI is an autonomous, nonprofit institution focused on improving the well-being of present and future generations of rice farmers and consumers, particularly those with low incomes, while preserving natural resources. It is one of the 15 nonprofit international research centers that are members of the CGIAR consortium (www.cgiar.org).

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IR8—a rice variety for the ages

It was 50 years ago this 28 November that the International Rice Research Institute (IRRI) released a rice variety under the nondescript name IR8. However, it would soon be dubbed by the media as the "miracle rice" that poor farmers, especially in Asia, were hoping for because the continent was desperate for food after World War II. And rice was—and is—Asia's lifeblood. Ultimately, this first effective semidwarf variety would indeed change the food situation in Asia and beyond, kicking off what we now call the "first" Green Revolution.

As the first feature on *Breeding history* (page 4) in this special issue of *Rice Today* commemorating IR8's golden anniversary points out, Robert Chandler, IRRI's first director general, in 1960, assembled a team of scientists (see *The Brains and Brawn behind IR8* on page 36) with a singular mission—to develop high-yielding rice varieties. They knew that the architecture of the tropical rice plant was the main constraint to any significant yield increase. Traditional rice varieties are tall, with long, weak stems. When a farmer fertilizes a tall plant, it "lodges," or falls over. So, they needed to create a shorter rice plant!

Only 3 years later, in July 1963, IRRI's first rice breeder, Peter Jennings (photo on facing page), was making his routine visit to the experimental rice plots on the Institute's research farm. That particular morning, it was goosebump time! He was walking in a plot of F_2 (second-generation) rice plants, derived from a small set of 38 crosses he and colleagues had made earlier. Some of these crosses involved three dwarf rice varieties from Taiwan, China (Dee-geo-woo-gen [DGWG], Taichung Native 1, and I-geo-tze), and Peta, a tall, vigorous variety from Indonesia. As he told me during his 2007 Pioneer Interview, he had that day what he called "his epiphany."

He observed tall plants and short plants in a ratio of 3:1—classic Mendelian inheritance—indicating that he was observing the action of a single recessive gene for shortness (later to be called *sd1-d*). Well, the rest is history as selections from the DGWG × Peta cross in later generations ultimately resulted in IR8. This new semidwarf was about 120 cm tall with strong stems that held the plant upright, even when heavily fertilized. It was also nonsensitive to photoperiod, or daylength, which meant it could be grown at many latitudes around the world, at any time of the year. It would be the precursor of most succeeding improved modern rice varieties.

It was incredible that, in just 6 short years after IRRI's founding, the breeders were able to come up with a rice variety, from the eighth cross (Dee-geo-woo-gen × Peta) of only 38 crosses made, as impactful as IR8 was so quickly. The number of crosses was ridiculously low by today's standards and they didn't have the array of breeding tools then that IRRI's modern breeding factory has today, such as marker technology, multi-location trials, and rapid generation advance (page 32). Dr. Jennings attributed IRRI's success—perhaps more in his day than now—to mixing luck with science (see *Luck is the residue of design* on page 17).

This year (2016) is also the golden anniversary of the historic visit to IRRI of Lyndon Johnson, the first and only U.S. president to come to the Institute. He arrived on 26 October 1966 and gave a rousing speech (page 24) after inspecting IR8 in a field plot.

IR8 had an immediate impact in many Asian countries, Vietnam being a shining example. IR8's official name in Vietnam was Lua Than Nong, or *Rice of the Farming God*. But Vietnamese farmers quickly dubbed IR8 Lua Honda—or *Honda Rice*—because one good crop brought in enough extra income to buy a new motorbike (page 9).

Of course, IR8 also made a great impact in staving off famine in India.

In 1967, master farmer Subba Rao, near his village in the state of Andhra Pradesh, tested IR8 on his farm and supervised its first large-scale demonstration and multiplication for other farmers. The next year, IR8 seeds were distributed throughout the country. So, in addition to being called *Dhaan Pandit* (rice expert) by his neighbors, he is also known, to this day, by the moniker "Mr. IR8." (See page 22 for the fascinating story about his role in both the first and second Green Revolutions in India.)

Starting during the same year that IR8 was officially released to farmers in the Philippines, loop surveys—the longest duration farm surveys known to be in existence—were conducted during the wet and dry seasons every 4 to 5 years in the country's Central Luzon region (page 28). The data have revealed some interesting trends in rice farming and farm practices. Featured is one enterprising farm family that has participated in the surveys since the beginning.

We most often hear about the impact that IR8 had in Asia. However, few are aware that, also in 1966, it extended the first Green Revolution to Latin America. It began in Colombia and spread rapidly through the continent's tropics and later to its temperate areas. (See page 19 for some insights from Peter Jennings about the rice revolutions in Latin America that started with IR8.)

Also in Latin America, impressed with the high yields of IR8—Mexican farmers quickly embraced the new variety. Known in Mexico as *Milagro Filipino* or "Philippine Miracle," it is—incredibly—still the country's most widely grown rice variety (page 20).

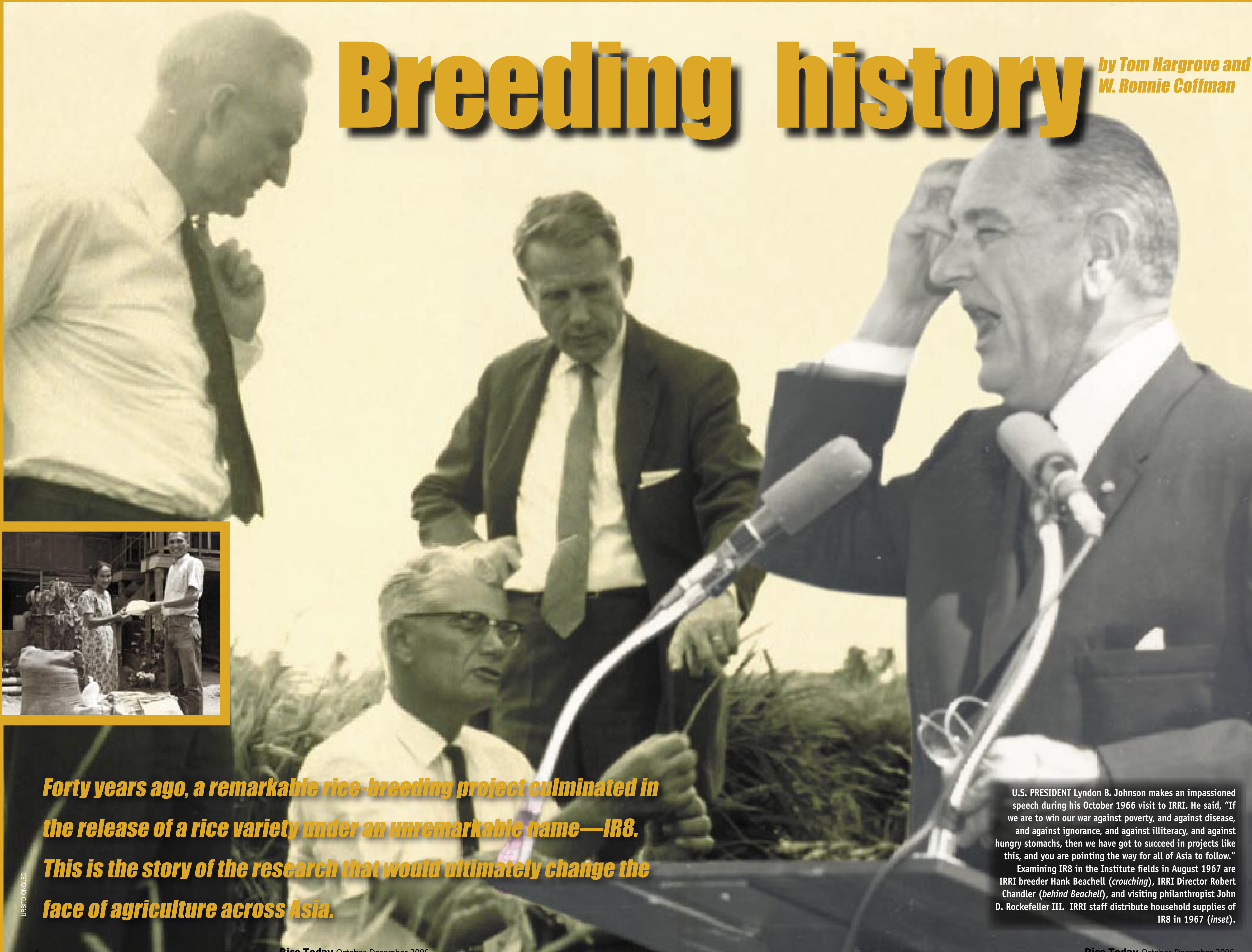
The first Green Revolution produced IR8 and its successor rice varieties for irrigated fields that were highly responsive to fertilizer and that were a major reason for achieving the phenomenally high yields. And, as we know, they spread rapidly across the rice-growing regions, including rainfed areas. However, these varieties often break down when abiotic stresses occur in the unfavorable environments. Read on page 26 why stress-tolerant high-yielding rice varieties designed specifically for rainfed areas have become so important and learn about the link between rice genes and rice farmers.

Perhaps another very important contribution of IR8 was spelled out 36 years ago in IRRI's 1980 publication *Beyond IR8, IRRI's second decade*. It was stated then—and I believe it is still true today—that "IR8 led to close collaboration between IRRI and the national rice research programs in Bangladesh, Burma (now Myanmar), Indonesia, India, Pakistan, the Philippines, Sri Lanka, Thailand, Africa, and Latin America." Indeed, the ultimate measure of IRRI's success has been the adoption of the evolving breeding methods and techniques by national rice programs through collaboration with them.

I hope you enjoy this special issue commemorating the release of IR8. Happy reading!

Gene Hettel

Gene Hettel
Former editor-in-chief and now consulting editor at IRRI



Breeding history

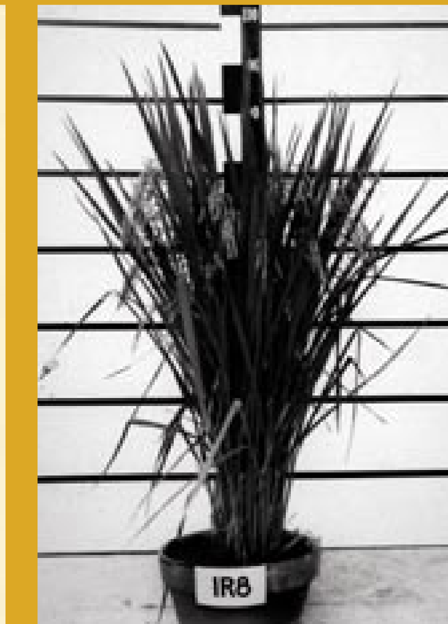
by Tom Hargrove and W. Ronnie Coffman

Forty years ago, a remarkable rice-breeding project culminated in the release of a rice variety under an unremarkable name—IR8. This is the story of the research that would ultimately change the face of agriculture across Asia.

URBITO ONGLEO

U.S. PRESIDENT Lyndon B. Johnson makes an impassioned speech during his October 1966 visit to IRRI. He said, "If we are to win our war against poverty, and against disease, and against ignorance, and against illiteracy, and against hungry stomachs, then we have got to succeed in projects like this, and you are pointing the way for all of Asia to follow." Examining IR8 in the Institute fields in August 1967 are IRRI breeder Hank Beachell (*crouching*), IRRI Director Robert Chandler (*behind Beachell*), and visiting philanthropist John D. Rockefeller III. IRRI staff distribute household supplies of IR8 in 1967 (*inset*).

URBITO ONGLEO



IRRI

Asia was desperate for food after World War II. Only massive shipments of U.S. grain prevented famine.

Rice was, and is, Asia's lifeblood. That's why the Ford and Rockefeller foundations pooled resources and, in 1960, established a modern research center to focus on the world's most important crop: the International Rice Research Institute (IRRI), based in Los Baños, Philippines.

Robert Chandler, IRRI's first director, assembled a team with a mission: to develop a high-yielding rice variety.

IRRI scientists knew that the architecture of the tropical rice plant was the main constraint to yield increases. Traditional rice varieties are tall, with long, weak stems. When a farmer fertilizes a tall plant, it "lodges," or falls over. Photosynthesis ceases, and grain rots in the water, or rats eat it.

A short, nonlodging rice plant that would convert nutrients to grain and hold the panicle (the terminal shoot of the rice plant that produces grain) upright—a dwarf or semidwarf—was needed to accelerate rice production.

IRRI didn't invent the dwarf concept. Scientists had already established it in other crops. Dwarf sorghum was already available. And semidwarf rice varieties

THE TALL Peta variety, one of IR8's parents, towers over its more resilient offspring. Because of its shorter, stouter stature, IR8 was less prone to lodging (falling over), which caused severe yield losses in the taller traditional varieties.

IRRI

had already been developed and released in mainland China, largely unknown to the rest of the world.

More significant, in 1946, S.C. Salmon, a geneticist with General Douglas MacArthur's Occupation Army in Japan, had sent seeds of Norin 10, a dwarf wheat variety that he found in a Japanese agricultural experiment station, to Orville Vogel at Washington State University. Within a few years, Dr. Vogel had developed Gaines, a semidwarf wheat variety that spread rapidly across the U.S. Pacific Northwest. Vogel sent seeds with the Norin 10 dwarfing gene to Norman Borlaug of the Rockefeller Foundation wheat program in Mexico. Dr. Borlaug used those seeds to breed semidwarf wheat varieties. The most successful was 8156—given that name for Dr. Borlaug's 8,156th cross. 8156 yielded bountifully and made Mexico self-sufficient in wheat production by the mid-1960s. Seeds of 8156 spread to Pakistan, where it was called "MexiPak," then to Turkey, Iran, and India.

In 1949, the Food and Agriculture Organization of the United Nations established the International Rice Commission, which commissioned an indica-japonica hybridization project based in Cuttack, India. Its mission was to cross the short japonica, or temperate, rice with taller indica, or tropical, varieties, to develop short-statured varieties with higher yield potential. Shorter rice varieties such as ADT 27 and Mahsuri, selected from the japonica × indica crosses, were widely planted across the Indian subcontinent in the 1960s.

Meanwhile, U.S. rice breeders were irradiating seeds of tall U.S. varieties, hoping to induce a short-statured mutant. Among those pioneers were Nelson Jodan of Louisiana State University's rice research center in Crowley, Louisiana, and Henry ("Hank") Beachell of the Texas A&M University rice research center near Beaumont, Texas. But their selections had high sterility and were not successful.

In 1957, the Rockefeller Foundation sent Peter Jennings, a young plant pathologist, to Arkansas, Texas, and Louisiana to learn about rice in order to develop new rice varieties for Latin America. The Rockefeller Foundation then sent Dr. Jennings to Mexico and Colombia.

Dr. Jennings and Sterling Wortman, later to become IRRI's associate director, traveled across Asia in 1960, looking at rice varieties, meeting rice scientists, and interviewing prospective trainees and staff. "Be on the lookout for a dwarf rice," Dr. Beachell recalls advising them. Dr. Beachell visited the fledgling IRRI as a consultant in 1962, then returned to Beaumont.

In India, Drs. Jennings and Wortman encountered Taichung Native 1 (TN1), a Taiwanese variety that was probably the first widely grown semidwarf variety in the tropics. TN1 yielded far better than tall varieties, but was highly susceptible to major disease and insect pests.

Dr. Jennings joined IRRI as head of the Varietal Improvement Department in 1961. Among the germplasm assembled at that time was Dee-geo-woo-gen (DGWG) from China, a parent of TN1, and clearly its source of dwarfism. But at that time the nature of inheritance of DGWG's short stature was unknown.

Dr. Chandler described DGWG as "a high-yielding, heavy-tillering, short-statured variety from Taiwan."

Dr. Jennings and Akiro Tanaka, hired from Japan as IRRI's first plant physiologist, conceptualized the semidwarf rice plant and systematically studied the causes, and effects, of lodging during IRRI's first 3 years. In his 1982 book, *An adventure in applied science: a history of the International Rice Research Institute*, Dr. Chandler wrote about lodging research:

> *By supporting tall varieties such as Peta and MTU-15 with bamboo sticks, Jennings found that tall varieties yielded essentially as well as did lodging-resistant varieties. Moreover, the lodging-susceptible varieties, when supported, responded well to nitrogen applications, whereas the unsupported plants showed a decided negative response. … This proved beyond doubt that lodging per se was the primary cause of low yields when traditional tropical varieties were subjected to modern management methods.*

Dr. Chandler made several references to IRRI's breeding objectives in the first IRRI Annual Report (1961-62). The section "Varietal Improvement" almost gives a blueprint for the

AFTER A BUMPER crop in his first season growing IR8, Indian farmer K.N. Ganesan was so moved by the new variety that he named his second son in its honor—IR-ettu in Tamil, and signed as Irettu. Here, father and son stand in a field of a different variety, IR50, in 1983.

GENE HETTEL

variety, yet to be developed, that several years later would turn rice production on its head:

> *It would seem that the following plant type might be useful in the near future throughout much of the tropics—a combination of short, stiff culms bearing erect, moderately sized, dark-green leaves; responsiveness in yield to fertilizer; mid-season maturity and in most cases, photoperiod sensitivity to permit double cropping practices. These objectives are being pursued [...] with both indica by indica and indica by japonica hybridization.*

Not much was known about the genetics of tropical rice varieties at the time, so IRRI hired a geneticist—Te Tzu Chang, from Taiwan—in its first group of scientists. Dr. Chang began studying the inheritance of plant height.

Jennings made 38 crosses in late 1962; 11 of them included the dwarf parent DGWG, TN1, or I-geo-tze (IGT)—another dwarf from Taiwan.

The eighth IRRI cross—from which IR8 was eventually selected—was of Peta, a tall, vigorous variety from Indonesia, and DGWG. From that cross, 130 seeds were formed. Those seeds were planted in pots in IRRI's screenhouse and produced the first, or F_1, generation of plants. All were tall.

Seeds from the F_1 plants were sown in the field, and produced about 10,000 second-generation (F_2) plants that segregated by height in a ratio of three talls to one dwarf. Dr. Jennings immediately recognized this as a Mendelian ratio—named after Gregor Mendel, who became known as the father of genetics for his 19th-century research into the inheritance of traits in pea plants. This was a key result—it meant that dwarfism in DGWG was controlled by a single gene and was therefore simply inherited, making the job of developing a commercially usable semidwarf variety immeasurably easier.

Dr. Jennings immediately brought Drs. Chandler and Wortman to the field to see the segregating plants. He then cabled the good news to Dr. Beachell in Texas. "That's when we knew we had it [meaning that DGWG could be used to breed an improved semidwarf variety]," Dr. Beachell recalled years later.

With this discovery, Dr. Jennings persuaded Drs. Chandler and Wortman to exchange a cytogenetics position in the Varietal Improvement program for a second breeder to help with the increase in field work that would obviously come. They agreed, and Dr. Jennings suggested Dr. Beachell, who arrived in 1963.

Tall, late-maturing plants from the Peta-DGWG cross were discarded, and only short, early-maturing plants were saved. Seeds were "bulked" and planted in a nursery where they could be screened for susceptibility to the rice blast fungus. In 1963, Dr. Jennings departed IRRI for study leave, leaving the material in the hands of newly arrived Dr. Beachell. From the third (F_3) generation, Dr. Beachell selected 298 of the best individual plants. Seeds from each plant were sown as individual "pedigree rows"—the fourth (F_4) generation.

From row 288, a single plant—the third one—was selected and designated IR8-288-3. Its seeds, the F_5 or fifth generation, were grown to produce the basic IR8-288-3 seed stock.

IR8-288-3—which was eventually named as variety IR8—was a semidwarf rice, about 120 cm tall with strong stems that held the plant upright, even when heavily fertilized. It was also nonsensitive to photoperiod, or daylength, scientists would later learn. That meant it could be grown in many latitudes, at any time of the year.

"The seed [of IR8] was uniform enough for trials in other countries, but a couple of years later Dr. Beachell devoted considerable effort to producing an extremely pure strain that would serve as a uniform seed source of IR8 for the future," Dr. Chandler wrote.

Meanwhile, seeds of IR8-288-3 and other promising lines were being sent for testing by national rice programs across Asia.

"IRRI's policy was free access to all of our genetic material," Dr. Beachell said. "It was made available to the world."

In the 1966 dry season, S.K. De Datta, a young Indian agronomist who had joined IRRI in early 1964, examined the fertilizer response of IR8, along with other rice varieties. "We wanted to determine maximum yields under the best management possible," he said.

Dr. De Datta was amazed when he harvested the trials in May. IR8 averaged 9.4 tons per hectare, yielding as high as 10.3 tons per hectare in one trial. Average yields in the Philippines then were about 1 ton per hectare.

Dr. De Datta took his yield data to Dr. Jennings, then to Dr. Beachell. "Let's go see Bob [Chandler]," Dr. Beachell said.

But, at that moment, Dr.

IRRI STAFF load IR8 seeds for distribution to farmers in 1966.

IRRI

Chandler was chairing a seminar—the news would have to wait another hour. After what seemed much longer, Drs. Beachell and De Datta finally saw their director. Sensing the pair's excitement, Dr. Chandler suggested they move to his office.

Dr. De Datta showed his data, and Dr. Chandler was excited.

"The whole world will hear about this," Dr. Chandler said. "We're going to make history!" He then shook hands, congratulating Dr. Beachell for helping develop IR8 and Dr. De Datta for discovering and demonstrating the semidwarf's yield potential.

"The IR8 yield data were the most exciting thing that ever happened to me," Dr. De Datta later recalled.

Soon, similar reports of dramatic yield increases were coming to IRRI from across Asia, including 11-ton harvests in Pakistan.

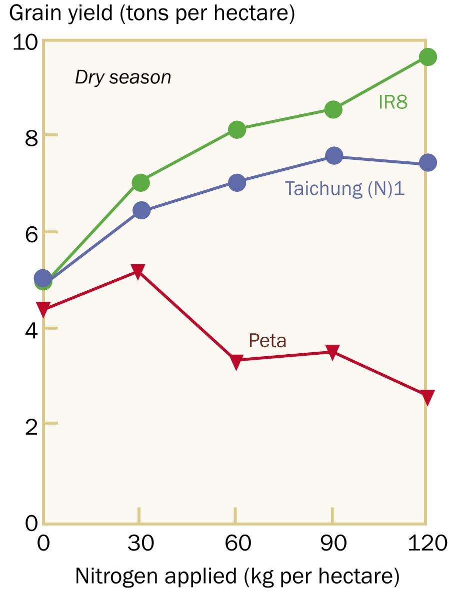
Dr. De Datta prepared his widely published "yield response" graph, showing how yields of IR8 rose with increased fertilization, while those of traditional varieties actually declined (see figure *above*).

Philippine President Ferdinand Marcos heard about the new rice, and flew to IRRI by helicopter on 3 June 1966. Dr. Jennings and others briefed the president by a plot of IR8 next to Peta, a tall, traditional variety.

Dr. De Datta recalls President Marcos's reaction: "Do you mean that little rice can out-produce our vigorous Philippine varieties?" the president asked. Dr. De Datta assured him that it could.

"*No kidding?*" Marcos responded.

President Marcos soon ordered that IR8 seeds be multiplied as



THE RESPONSE TO nitrogen fertizer of two semidwarf rice varieties—IR8 and Taichung Native 1—and of Peta, a tall, traditional variety, in the 1966 dry season on IRRI's experiment farm.

rapidly as possible. Marcos's goal was to make the Philippines self-sufficient in rice production during his first term of office.

It was. During the last half of 1966 alone, 2,359 Philippine farmers came to IRRI by bus, on bicycle, and on foot, from 48 of the country's 56 provinces, to get seeds.

The new rice yielded bountifully, but had major disadvantages. Foremost was its bold, chalky grain, which distracted from its market appearance as polished rice. The grain also had high breakage during milling. And IR8 had high amylose content, which made it harden after cooling. (Dr. Beachell remembers a young Filipina saying, "I don't like IR8 because it scratches my throat.")

Dr. Beachell recalls the consensus view of the IRRI seed committee: "We needed to move as fast as possible. There was not enough rice to go around. We had to have something to alleviate the rice shortage. Enough rice was more important than grain quality.

"So, would we release the line as a variety, or wait to improve it? We knew IR8's limitations, but also knew we had the plant type. IR8 would be the prototype for future varieties. We decided to spread it."

The seed committee decided to formally name IR8-288-3 as IR8 on 14 November 1966. The news was released on 28 November.

Dr. Chandler later wrote:

> *He [Beachell], Jennings, and Chang made a fine team. When I was asked, some years later, who, among the three senior scientists in the Varietal Improvement Department, should receive the coveted John Scott Award for the creation of IR8, I replied that the prize should be split among the three: Jennings for selecting the parents and making the cross, Beachell for identifying IR8-288-3 from among the multitude of segregating lines, and Chang for having brought to the immediate attention of IRRI breeders at the start the value of the short-statured varieties from Taiwan such as Dee-geo-woo-gen, I-geo-tze, and Taichung Native 1.*

Pioneer rice scientists such as Drs. Jennings, Beachell, Chang, and De Datta, as well as others who played key roles in developing and testing IR8—such as Dr. Tanaka and another plant physiologist, Benito Vergara—proved Dr. Chandler right. IR8, and IRRI, did indeed "make history." IR8 changed the world food situation and initiated what is now called the Green Revolution in rice.

IR8 PICTURED next to its parents: Peta, a tall, vigorous variety from Indonesia, and the Taiwanese dwarf variety DGWG.

IRRI

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W. Ronnie Coffman, a former IRRI rice breeder, is now international professor of plant breeding and director of international programs, College of Agriculture and Life Sciences at Cornell University in New York, USA.

The author (*left*) with former Viet Cong political officer Tran Van Rang on the Xa No Canal in the lower Mekong Delta in 1988. Rang has just explained why he didn't have me killed 18 years previously, when he'd had the chance.

VO-TONG XUAN

I Remember Honda Rice

by Tom Hargrove

How the first Green Revolution rice variety—IR8—influenced life and death in the Mekong Delta during the Vietnam War

The Green Revolution in rice has been documented throughout much of Asia, but few think of Vietnam in the 1960s and '70s as a "Green Revolution country." That's because IR8 arrived at the height of a brutal war that overshadowed an agricultural transformation in the countryside. Rice means life itself in Vietnam, and was used both as a weapon and as a tool for peace. I have strong memories of the Vietnam War: Huey choppers, mortars, ambushes, and needless deaths. But I also remember Honda Rice.

Tom Hargrove, August 2006

A VIETNAMESE family of five on a motorbike in 1974. Vietnamese farmers quickly dubbed IR8 "Lua Honda" (Honda Rice) because one good crop bought a new motorbike.

IRRI

4 June 1988, in Hau Giang Province, Vietnam (Chuong Thien Province during the war)

I'm stunned. I struggle for the right words, then simply ask, "Why didn't you kill me, Tu Rang?"

"Because you brought the new rice seeds, and our farmers needed them."

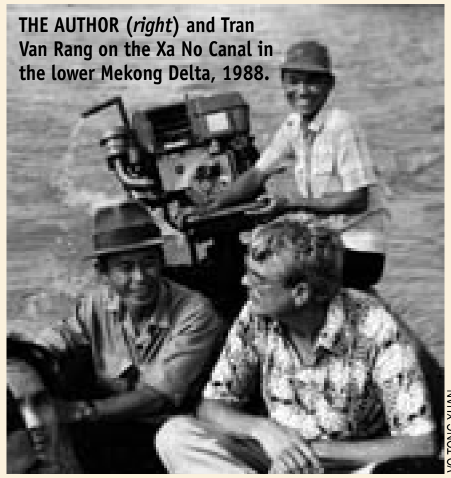
"But did you know I was a U.S. Army officer?"

"Of course. Your civilian clothes didn't fool anyone."

The former Viet Cong—literally, Vietnam Communist, the common name for the National Liberation Front during what was known in Vietnam as the American war—and I look into each other's faces, something we never did in 1969-70. He's smiling, but he's hard—it shows. He's also telling the truth. I can sense it.

"I was less than a kilometer away whenever you traveled this canal in 1969," Tran Van Rang says. Today, Tu Rang is vice-chairman of the Vi Thanh People's Committee. But, two decades ago, he was the local Viet Cong political officer. I know that political officers held ultimate power in the Communist infrastructure—they gave orders to military commanders.

"You were entering *my* territory when you came here," Tu Rang continues. "The local farmers all supported the Revolutionary Forces, and reported on you.



THE AUTHOR (*right*) and Tran Van Rang on the Xa No Canal in the lower Mekong Delta, 1988.

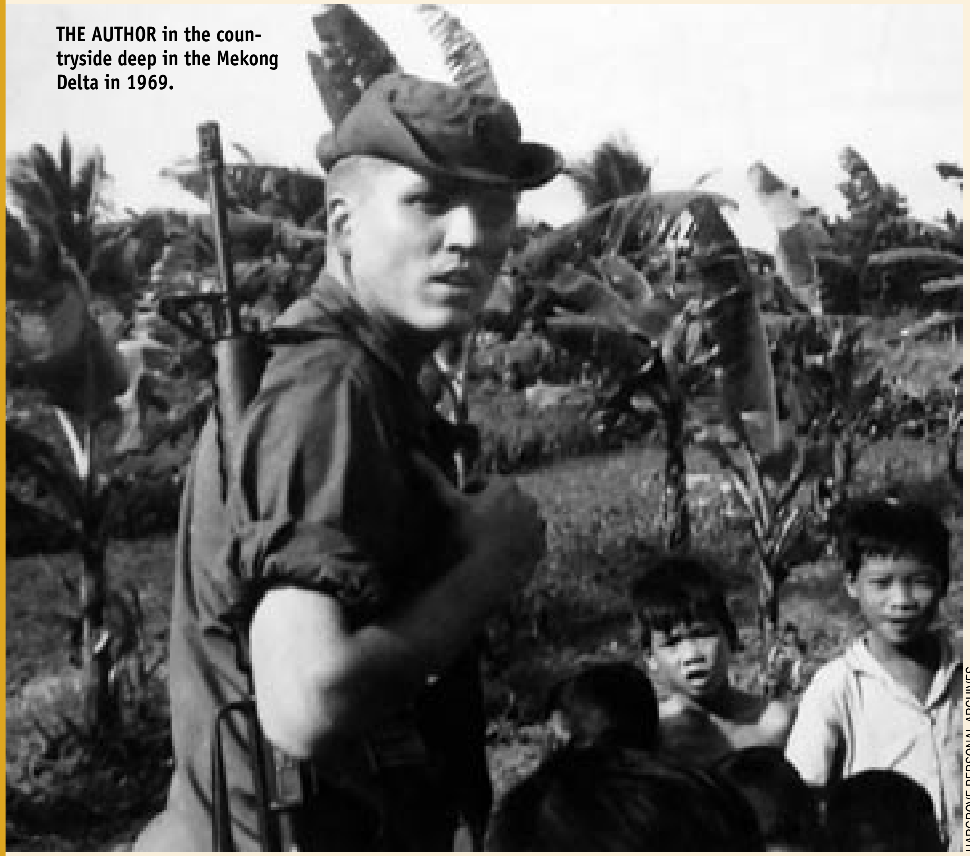
VO-TONG XUAN

"But I didn't have you killed because of the new rice seeds."

This trip is getting heavy, I think, as our sampan cuts north through the muddy waters of the Xa No Canal.

New rice seeds. To me, they're one of the world's most powerful tools for peace. That's why I made the Green Revolution my profession.

But I learned about those seeds—especially IR8 or Honda Rice—here, in the midst of carnage. Had there been no Vietnam War, rice wouldn't have become such a part of my life.



THE AUTHOR in the countryside deep in the Mekong Delta in 1969.

HARGROVE PERSONAL ARCHIVES

Now I must face a new reality: those rice seeds probably *saved* my life.

The lower Mekong Delta is peaceful and beautiful now. But I remember it as ugly, dangerous, and one of the most tragic places on Earth. To me, this is still 1969-70. We've just passed Duc Long. I remember friends being killed in an ambush north of this village ... in a sampan that I was supposed to have taken. Tu Rang must have ordered that ambush. I know I'm safe now, but I've never traveled this canal without an M-16 and bandolier of ammunition.

"Has any other American been here since the war?" I ask Dr. Vo-Tong Xuan, my host and vice-president of the University of Can Tho. Xuan, who is now the rector of Angiang University, in the Mekong Delta, had worked as a research fellow at the International Rice Research Institute (IRRI), where I'd worked since 1973.

"No, you're the first foreigner—of *any* nationality—to be in the lower Ca Mau Peninsula since the war ended in 1975."

I can do it only because I work with rice.

2006: looking back

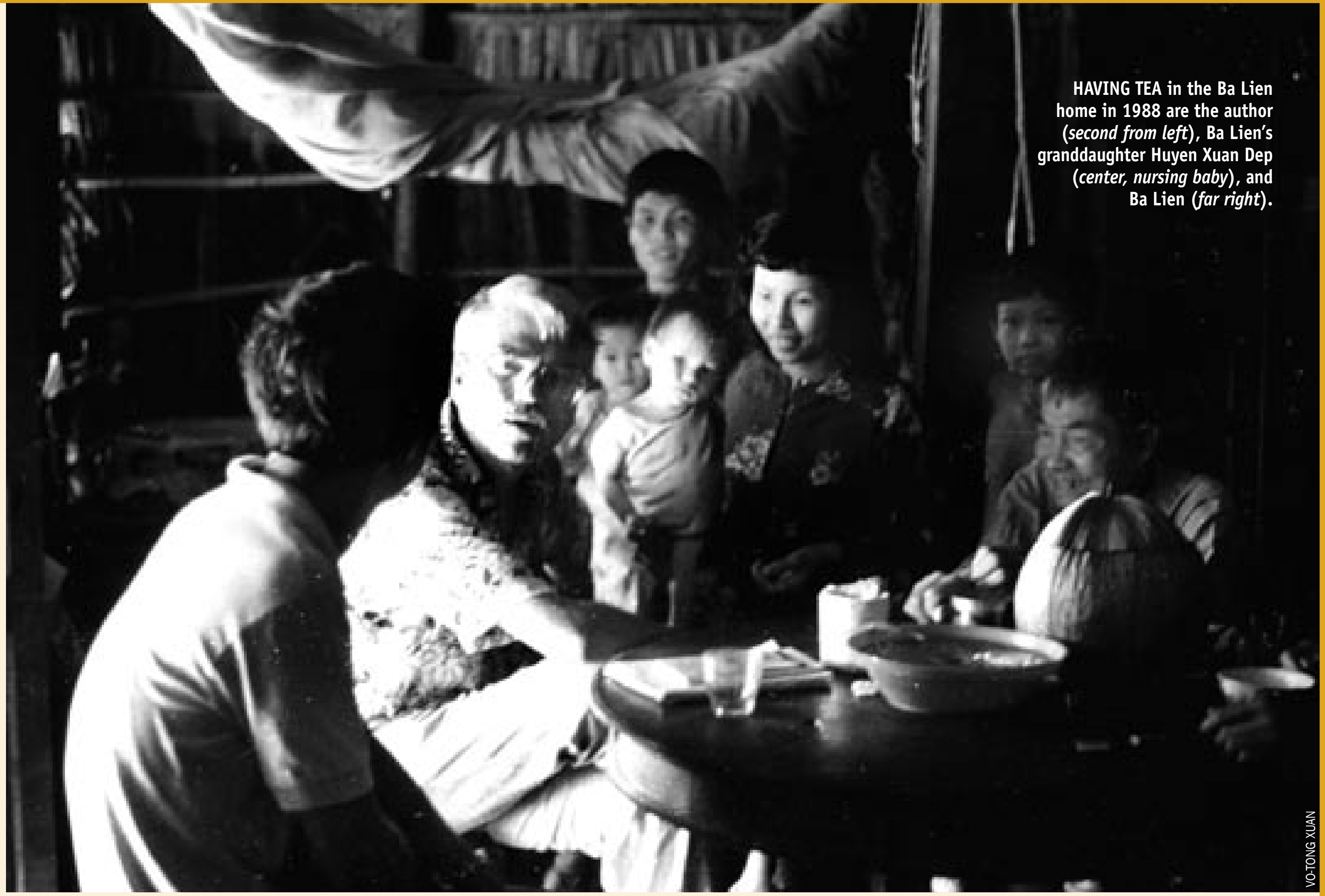
Vietnam veterans and historians have recently queried me about the origin and history of the term Honda Rice in the Vietnam War. Interesting, considering that the war ended 31 years ago. Or did it? Wars never really go away, for those who lived them.

War and rice. Anyone who wants to understand the Vietnam War should know the role that rice played. I learned about rice as a young U.S. Army officer deep in Vietnam's heavily contested Mekong Delta at the height of the war, in 1969-70.

IRRI released the semidwarf IR8 to farmers in late 1966. Within a couple of years, it was the most widely grown rice variety ever known. IR8 launched the Green Revolution in Asian rice.

The Western press called IR8 the miracle rice. Its official name in Vietnam was Lua Than Nong, or "Rice of the Farming God."

But Vietnamese farmers



HAVING TEA in the Ba Lien home in 1988 are the author (*second from left*), Ba Lien's granddaughter Huyen Xuan Dep (*center, nursing baby*), and Ba Lien (*far right*).

VO-TONG XUAN

quickly dubbed IR8 Lua Honda—or Honda Rice—because one good crop bought a new motorbike.

How did I get into rice in Vietnam? I was raised on a West Texas cotton farm. I received my B.S., a double degree in agricultural science and journalism—along with an Army officer commission—from Texas A&M University in 1966. I then finished an M.S. at Iowa State University and, in 1968, reported to Infantry Officers School at Ft. Benning, Georgia.

I arrived in Vietnam in June 1969 as a first lieutenant. The legendary John Paul Vann (made famous by the book and movie *A Bright Shining Lie*) ran the war in the Mekong Delta. Vann reviewed my records, saw my farm and educational background, and assigned me, as an adviser to the Vietnamese military and government, to Military Assistance Command-Vietnam (MAC-V) Team 73 in Vi Thanh in Chuong Thien Province, in Vietnam's southern Ca Mau Peninsula. Seventy percent of Chuong Thien's population was rice farmers.

Chuong Thien was an awful place for a dryland cotton farmer. The average elevation was less than 1 meter, and 97% of its land was covered by water—rice fields or swamp—during the 6-month monsoon season.

Chuong Thien was also a Viet Cong (VC) stronghold. The U.S. military constantly classified it as one of the two least secure South Vietnamese provinces. Putting it another way, Chuong Thien was one of the VC's two *most secure* provinces.

A dozen U.S. advisers were killed in Chuong Thien during my 1-year tour. Five were killed in sampans. These boats were our only transport, unless we could hitch a ride on helicopters, along the rivers and canals during 6 or 7 months of monsoon rain. No one survived a sampan ambush.

Our casualties may not seem high, but only 160 Americans were stationed in Chuong Thien, and only 30 or 40 advisers worked outside the small provincial HQ in Vi Thanh.

Chuong Thien was also the only Delta province with no civilian agricultural adviser, assigned by the U.S. Agency for International Development (USAID). The word was, none would go there. But no one asked if I *wanted* to go to Chuong Thien—the Army sent me.

U.S. President Lyndon B. Johnson, or LBJ, had visited IRRI in October 1966, accompanied by Philippine President Ferdinand Marcos. LBJ appreciated farmers, and went into the IRRI experiment fields to see IR8 (see main photo, pages 34-35). LBJ made a historic flight later that day, to Cam Ranh Bay, Vietnam, "to visit our boys over there." Johnson later pressured USAID to promote the hardy IR8 in Vietnam.

IR8 had arrived in Chuong Thien Province in 1968—a year before me. The first IR8 seeds were smuggled into Vietnam in 1967 by my colleague Jose Ona, a Filipino agronomist who had done his M.S. research at IRRI, then was hired as USAID rice agronomist for the Mekong Delta. A friend at IRRI had harvested the

IR8 seeds from IRRI experimental plots, and given them to Ona.

Ona then set up IR8 demonstration plots in each province of the Mekong Delta. I feel safe in saying that no farm technology—anywhere—ever spread faster than IR8 seeds in the Delta, even at the height of the fighting.

A farmer named Ong Ba Lien planted the first Honda Rice seeds in Chuong Thien Province in late 1967. He was the best farmer in the region, and Ona and I later tested and demonstrated IR8 and IR5, another IRRI variety, on his farm. I felt not only welcome but, rarer in those days, *safe* on Ba Lien's farm, even though the area ranged from dangerous to suicidal for Americans.

When I arrived in 1969, farmers were already growing IR8 on almost 1,000 hectares across the province.

I was soon bringing IR8 seeds to farmers, who suffered as much as any people I've ever known, across Chuong Thien, a province that the war had torn brutally. We traveled mostly by sampan on brown-water canals and rivers with Vietnamese agricultural cadres and soldiers.

But sometimes by Huey helicopters. I could spot IR8 easily from choppers, because it reminded me of a "crew cut." IR8's short, stiff stems held it erect, while the tall traditional varieties fell over and lay flat. Thus, IR8 could convert nutrients to heavy heads of grain, and hold them upright.

That genetic trait made IR8 outyield any rice that tropical Asia had ever known. Farmers started harvesting 5 or 6 tons per hectare from fields where yields had stagnated at 1 or 1.5 tons for centuries. Traditional rice varieties took 160 to 200 days to mature, so farmers could grow only one crop per year using the monsoon rain. IR8 matured in about 130 days, so farmers could grow two crops per year. The new rice was also nonsensitive to daylength, so farmers anywhere could grow it, at any time of the year.

By mid-1970, IR8 was planted on about half of Chuong Thien's rice land, land that was scarred by bomb and artillery craters.

That's what made it tough to come to a personal peace with Vietnam. In my other role, as an Army officer, I called a lot of the bombs and artillery that left those scars, and sometimes killed or maimed farmers who were grateful for the IRRI seeds. War and peace. Working with both was hard.

The new rice seeds were the only good thing—other than wonderful Mekong Delta farm families—that I saw in the war.

To me, new seeds offer hope. Maybe that's why I made rice improvement—then later, overall international agricultural development—my profession after Vietnam.

But I learned about those seeds in a setting of death.

What did the Viet Cong think about IR8? In the first couple of years, the VC opposed IR8, calling it a plot of the "imperialistic Americans." But, in 1970, the VC changed its position and issued a new directive. VC cadres were now to learn IR8 culture, and take the new seeds to contested or "liberated" (meaning VC-controlled) zones.

THE AUTHOR (*far right*) and Vietnamese staff at the Rice Research Station in My Tho, in the Mekong Delta in late 1974, a few months before Saigon fell.

HARGROVE PERSONAL ARCHIVES

DESPITE THE TURMOIL of the war, IRRI maintained a presence in Vietnam. Here, the Institute's inaugural director, Robert Chandler, talks to trainees from the National Rice Production Training Center just outside Saigon in August 1969.

IRRI

IR8 in North Vietnam

Information is scarce about how IR8 and other IRRI varieties spread in North Vietnam during the war. I've read that in 1968 or 1969, an Eastern European vessel—I believe it was Polish—purchased a shipload of IR8 seeds at Dhaka (then in East Pakistan) and quietly off-loaded the seeds at Haiphong, the main North Vietnamese port. From there, the seeds went to farmers in the Red River Delta.

A former high-ranking North Vietnamese agricultural official told me that IR8 reached North Vietnam in other ways. Some of the few North Vietnamese soldiers who went back north on the Ho Chi Minh Trail carried a kilo or two of IR8 seeds.

IR8 was called Nong Nghiep 8, or "Agriculture 8," in North Vietnam. But I'm sure the farmers weren't told that the high-yielding seeds were bred at an institute then funded entirely by the Ford and Rockefeller foundations, spawned by capitalism. Yet neither foundation intended for those seeds to be used for war.

Back to the Mekong Delta, two decades later

The Army discharged me in 1970. In early 1973, I joined IRRI, the source of those seeds that had impressed me so greatly. My family and I moved to the Philippines, and I spent the next 19 years following the world's rice crop.

In 1988, IRRI sent me to Vietnam to write about IRRI's impact there. It was my first return since the war ended in 1975. I probably could have returned to Vietnam years earlier, but I was afraid of how I might react, emotionally.

"Can we go look at the rice in the old Chuong Thien Province?" I asked my friend and host, Dr. Vo-Tong Xuan.

That led to the most emotional journey of my life. Soon after arrival in Vi Thanh, Tu Rang, Xuan, and I were traveling by sampan 8 kilometers up the Xa No Canal to visit Ong Ba Lien, the farmer who had planted the first IR8 in Chuong Thien.

I was never sure about Ba Lien's politics. I doubted that he had any. Honda Rice, or IR8, was the bond of our friendship.

Tu Rang speaks: "Of course, Ba Lien supported the National Liberation Front during the war. His two sons-in-law were Viet Cong colonels. One was a revolutionary hero. And his wife is my aunt, and helped us gather information on you."

"Ba Lien never told me *that,*" I reply.

"How *could* he?"

Tu Rang's words are numbing, but I knew that most farmers along the Xa No probably supported the VC, at least at night. I bear no animosity; I'm still alive.

We dock along the canal and follow the ex-VC to a familiar palm thatch home beneath coconut palms, surrounded by bougainvillea, in a grove of banana, papaya, and mangosteen. The house is so much smaller than I remember.

Ba Lien is in his seventies now, and his beard is scraggly and white, but I recognize him easily. We shake hands and embrace. We sit at a round table, where we had often shared

THE AUTHOR (*tallest*) and Ong Ba Lien (*center, next to the author*) at the Ba Lien home. I had just given Ba Lien's granddaughter, Huyen Xuan Dep (*holding book*), a Vietnamese copy of *Field Problems of Tropical Rice*, an IRRI booklet that helps identify common pest and soil problems.

VO-TONG XUAN

simple meals of fish and rice. A crowd gathers, and someone pours green tea. I talk about my family, IRRI ... anything to hold back the emotion as Ba Lien throws me back in time.

"Do you remember Jose Ona, who brought the Honda Rice?" I ask. Xuan translates. "And how in 1970, Jose smuggled 2 kilograms of IR20 seeds from the Philippines?"

Those IR20 seeds—the first in all of Vietnam—were precious, because IR20 was IRRI's first improvement over IR8. Yields were slightly lower, but IR20 had better grain quality and resisted several insects and diseases without pesticides. Ona and I gave the IR20 seeds to Ba Lien in trust, because we knew he'd give them the care they deserved. Within a few years, IR20 had replaced IR8 across the Mekong Delta.

Yes, Ba Lien remembers the same things I remember—Honda Rice, Ona, IR20.

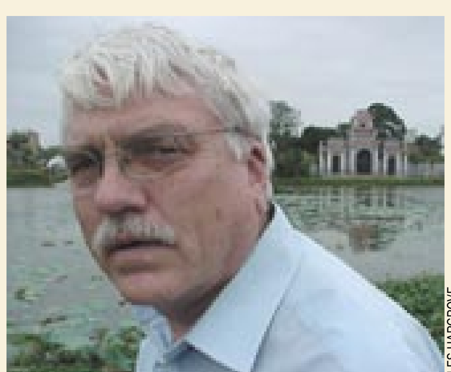
A shrill voice breaks my thoughts: "Uncle Tom! The tall American!" A young woman rushes through the crowd and grasps my shoulder. Xuan asks her to slow down, then translates.

"I remember you so well. I'm Huyen Xuan Dep, Ba Lien's grandaughter—the little girl you carried around the farm on your shoulders." She now balances her own baby on a hip.

All I can say is, "Yes, but I can't do that now." I can't talk anymore, so Ms. Dep and I walk outside to the concrete patio where Ba Lien dries rice.

I pull a copy of *Field Problems of Tropical Rice*, in Vietnamese, from my bag. I coordinated publication of the IRRI booklet, with 158 color photos to help farmers identify rice pests. I'm proud that Xuan and I raised the money to print 160,000 copies of the Vietnamese edition—enough to give one copy to every agricultural brigade in Vietnam.

Ms. Dep clutches at, then flips through, the booklet. She thrusts an open page at me. "This is our problem now!" It's thrip damage.



MILES HARGROVE

THE AUTHOR in 2003, during his fourth return to Vietnam since the war. This time, my son Miles and I were filming a documentary.

I introduce her to entomologist Nguyen Van Huynh, like Xuan, an IRRI alumnus. We all go to the field.

The rice looks bad, and Huynh confirms that thrips are the problem. IRRI variety IR13240, resists most pests, but not thrips. Huynh tells her how to save the crop, if she can get the chemicals.

We go back to the house. "What happened to the bomb shelter?" I ask. "It was in that corner."

"We don't need a bomb shelter anymore." I'd made a bad joke, and everyone knew it. But it was okay.

It's finally time to leave. About 30 Vietnamese have gathered at the canal to see us off. "We know it was hard for you to come here," Ms. Dep says, as tears streak her cheeks. "We are deeply moved that you remember us after all the years."

I should have taken *her* child for a ride around the farm on my shoulders, I think. But it's too late now.

A dozen Vietnamese are crying as we climb into the sampan for the trip back to Vi Thanh. Me too, I guess.

Much of this article is adapted from Hargrove's book A Dragon Lives Forever: War and Rice in Vietnam's Mekong Delta, *originally published by Random House/Ivy, now available from AuthorHouse.com.*

Conducted by Gene Hettel

GENE HETTEL (3)

IRRI 50 1960-2010 Rice Science for a Better World

Luck is the residue of design

Peter Jennings, the International Rice Research Institute's first rice breeder (1961-67), with a long career in Latin America after his work in Asia, kicks off this historic series with a singular wit. He played a major role in the development of IR8, the rice variety that would ultimately change the face of agriculture across Asia (see Breeding History *on pages 34-38 of* Rice Today *Vol. 5, No. 4). He reminisced on a warm, muggy day (20 July 2007) at his home in Gainesville, Florida. Here are edited highlights of the interview.*

A matter of 5 minutes

I started graduate school at Purdue University in 1953. I was there almost 3½ years for my master's and doctorate. During my second year, a Mexican kid—Ignacio Narvaez—was in the office adjacent to mine. Ignacio was a wheat breeder for the Mexican Ministry of Agriculture associated with the [Nobel Laureate Norman] Borlaug group and he talked about Mexico and his work. I said to myself, "I want to work in international agriculture." I was consumed by this. But everything I tried to become affiliated with the Rockefeller Foundation was useless. Nothing happened. Rockefeller didn't need another plant pathologist.

So, I finished in 1957. Jobs were scarce. There was one job available in Madison, Wisconsin—a forage pathologist for the U.S. Department of Agriculture, which I was about to accept. At Purdue, I lacked one form for my doctoral thesis. I went to the dean's office in the School of Agriculture to pick it up. While I was talking to the secretary, Dean Ernest C. Young—also a consultant to the Rockefeller Foundation who knew me because of my frustrated attempts to get into the Foundation—walked by. He said, "Peter, what are you going to do?" I said, "Well, Dean, I'm going to go to Wisconsin." He responded, "Didn't you want to work with Rockefeller?" I said, "Yes." He said, "Wait a minute." The dean walked into his office, picked up the phone, and called George Harrar [then RF's director for agriculture and later RF president, 1961-72]. He left the door open so I could hear. He said, "George, I've got a kid here. He set some sort of an academic record here at Purdue and he wants to work for you and what are you going to do about it?"

So, I had two phone conversations with George Harrar. During those conversations, he said something I never forgot, "Would you want to live in the Philippines?" I said, "Of course!" That night, I had to look in my atlas to see exactly where in the Pacific the Philippines were. He said, "Well, we're going to do something there. It's going to take 3 or 4 years to get organized. Meanwhile, we'll have to find something for you to do [ultimately, brief stints in Mexico and Colombia]."

I have a profound belief in predestination, fate, and luck. Had I been 5 minutes earlier or later that morning at Purdue in the dean's office, I would not have crossed paths with Dean Young, there would have been no phone conversations with Harrar, and I would have had a career as a forage pathologist in the U.S.

George Harrar—he was magnificent!

So, I got a job with the Rockefeller Foundation in 1957. Terrific! What's the significance of this? Bob [IRRI's first director general, Robert F.] Chandler's book [*An Adventure in Applied Science*] cites the year 1958—about a year and a half after my telephone calls with Harrar—as the time when the Rockefeller and Ford Foundations first connected to thrash out the concept of IRRI. Harrar had "IRRI" on his mind when he talked to me much earlier on the phone about rice and the Philippines. You don't see that in Chandler's book. The driving force behind IRRI was George Harrar. He was magnificent, a giant!

Getting germplasm in the early days

When I finally got to IRRI in October 1961—as a breeder, not a pathologist—the first challenge was to assemble a comprehensive world collection of rice varieties. For germplasm, IRRI had only some 300 odd varieties. I spent a lot of time wandering back and forth in the mud trying to look at these plants. I wrote a letter, co-signed by T.T. Chang [IRRI geneticist, 1961-91], requesting any germplasm in small seed samples, and sent it to rice workers or experiment stations in some 60 countries. These were the days when it was pretty easy to move germplasm from one country to another. The response was wonderful. Within months, boxes and boxes of seed packages were coming in. I guess within 2 or 3 years we had several thousand accessions.

Increasing rice yields

Another challenge was more complicated. Chandler kept preaching: increase yield! Okay, that's easy to say, but how do you do it? I spent a lot of time talking with Akira Tanaka, head of IRRI's Plant Physiology Department [1962-66]. We tried to develop a mental image in our minds of what the leaves, stems, culms, and general architecture would look like on an ideal rice plant that would yield more. We determined that, if we were going to make any progress, we had to dramatically change the plant type.

The first seminar I gave at IRRI was on what an ideal plant type had to look like if we were going to get higher yield. I wrote that up and sent it to *Crop Science* [Plant type as a rice breeding objective, 4:13-15, 1964]. There were no data, it was just philosophy. For some reason, *Crop Science* published it. Years later, I reread that paper, long after IR8 came out [in late 1966]. And it just seems to me that IR8 looks very much like what we were theorizing.

An epiphany

Well, the rest is history and just sheer luck. And it goes back to that first set of 38 crosses [that ultimately led to IR8] we made in late 1962. About half of them involved the three famous Taiwan short-statured varieties [Dee-geo-woo-gen, Taichung Native 1, and I-geo-tze]. They looked terrible under Philippine conditions. They were riddled with bacterial leaf blight. They were shaded by tall things. They were sterile and miserable, but short!

We grew out the F_1s [first generation]—38 combinations, which is ridiculous by today's standards. Thirty-eight crosses in a year—absurd! But that's what we had. So, we grew out the F_1s; they were terrible. They were worse than the parents themselves. They were gigantic—6–7 feet tall. We harvested the seed from each of the single crosses—38 populations. And for not having anything else, we had a large F_2 [second generation] population—4,000–6,000 plants from each single cross.

Maybe a month after transplanting, one day we looked out there. The plants from the first cross were tall—terrible. It was a jungle. It was bad. Then, we came onto the plants from one of the crosses that involved one of the three Taiwan short-statured varieties. We looked down the rows. Something had happened! It was an epiphany! I never had an experience like that in my life—before or since. There were tall plants and there were short plants, but there were no intermediate plants! The short ones were erect, darker green, and had sturdy stems and a high number of tillers. We counted the tall plants and short plants. Essentially, the ratio of tall to short was 3 to 1—obviously a single gene recessive for shortness! It may sound something like arrogance, but I contend that I knew, at that moment, the significance of this.

Mixing good science with luck

When I was a little boy, I was a fan of an American baseball team, the Brooklyn Dodgers. Their famous general manager was Branch Rickey. This wizard said, "Luck is the residue of design." I think he was right. Some people are lucky, some people are not lucky. Luck does appear on its own volition, I know, from time to time. But luck is a consequence of putting a lot of mental observational evidence all together and all of a sudden it happens, it works. There is always luck. But sometimes you earn your luck. You influence your luck for sure.

Go to http://tinyurl.com/Jennings-Pioneer to watch Peter Jennings interview in which he discusses more of his version of the IR8 story, distributing IR8 in the Philippines, his impressions of Bob Chandler and other colleagues during the early days, his rice work in Latin America including genetic versus agronomic advances, and his view on what are the challenges for IRRI as it approaches its 50th anniversary.

URBITO ONGLEO

IRRI'S FIRST rice breeder, Peter Jennings, briefs visitors on IR8 in April 1966 just 7 months before its official release.

grain of truth

PETER JENNINGS

Rice revolutions in Latin America

In 1962, scientists at the International Rice Research Institute (IRRI) debated the cause of low and stagnant rice yields in the tropics: was it variety or crop management? This debate ended with the release of the semidwarf IR8 in 1966, initiating the Green Revolution. The same variety, in the same year, extended this revolution to Latin America, beginning in Colombia and spreading rapidly through the tropics and later to the temperate areas.

The Green Revolution in the Americas was genetic with little contribution from agronomy. Its impact was approximately two additional tons per hectare. On a national basis, this spectacular advance terminated within a few years when essentially all of the irrigated and favored upland ecologies converted to semidwarf varieties. From then on, yields did not increase. On individual farms, the revolution ended after the first harvest. Replanting with IR8, or any other semidwarf, did not result in higher yield. It was a momentous, one-time contribution followed by a persistent yield barrier lasting some 30 years.

On individual farms, the Green Revolution ended after the first harvest

During this period of stagnancy, national yield averages in a few Latin American countries increased modestly, reflecting a shift from favored upland to irrigated cultivation. Neither higher yielding varieties nor improved crop management played a role. In tropical Asia, national averages slowly and steadily moved upward after the Green Revolution. I suspect this reflects better water management and conversion from rainfed and other less productive ecologies to irrigated rice.

An inability to further increase yields engendered another round of debate. The majority view, contending that more productive varieties were needed, led to massive investment during the past 25 years in biotechnology and genetics and underinvestment in crop management. The implicit thought is that greater yield capacity is required for higher farm productivity. At the Latin American Fund for Irrigated Rice (FLAR), we hold the minority view that the constraint today is agronomic, not genetic. Our contention is based on two observations.

First, the release of nearly 400 semidwarf varieties over three decades did not increase farm yield. Further, we contend that none of the newer semidwarfs surpasses IR8, Jaya, or Bg-90, the first modern varieties, in yield capacity. Second, every year, a few farms scattered around the hemisphere yield 9-11 tons per hectare or more—roughly double national averages and an indication that existing varieties have considerable unexploited yield capacity. Thus, the problem is not yielding ability.

To narrow this yield gap, FLAR, with support from the Common Fund for Commodities, initiated a crop management program in 2003 under the leadership of agronomist Edward Pulver. This began the identification of six regional agronomic deficiencies: inappropriate seeding dates missing peaks of solar radiation after panicle initiation; extremely heavy seeding densities causing lodging, disease, and pest attacks; repeated aerial spraying rather than seed treatment to control insects; deficient weed control; poor fertilization practices including the application of urea into water; and late establishment of permanent irrigation.

Solutions for each deficiency were packaged together for on-farm demonstrations. After three years, results from several hundred thousand hectares in several counties confirm that an Agronomic Revolution is now in progress. This second revolution, devoid of any genetic contribution, has so far had an impact equal to that of the Green Revolution, increasing farm yield by roughly two tons on average.

Well-managed farms, now yielding 8-11 tons per hectare, confirm that the yield constraint since the introduction of modern varieties in the 1960s has been poor crop management. The key to Dr. Pulver's approach lies in the simultaneous reduction of multiple farm constraints as contrasted with typical agronomy directed toward individual problems.

FLAR believes that once the Agronomic Revolution is widely adopted, productivity will again become stagnant. We contend that the new productivity constraint will revert to varietal yield capacity, as it was pre-Green Revolution. Thus, the present problem of poor crop management, now being resolved, will be succeeded by the need for more productive varieties. FLAR has combined two underappreciated traits—delayed leaf senescence (ageing), or "stay-green," and huge panicles—while maintaining heavy tillering capacity. We expect the enhanced yield capacity of this new plant type will catalyze a second genetic Green Revolution.

Thus, we observe alternating yield constraints: firstly genetic (pre-Green Revolution), then agronomic (post-Green Revolution) followed by the need for a second genetic Green Revolution. Many years separate these quantum leaps in productivity and each advance is achieved with little contribution from the other discipline. In part, this results from the failure of breeders and agronomists to develop strategy jointly. Further, the decades of little progress following the adoption of semidwarfs indicate a misidentification of the yield constraint as institutions directed resources inappropriately. Researchers, like generals, often fight new battles with strategies and tactics of previous wars.

Dr. Jennings, a principal scientist with FLAR, founded the breeding program at IRRI (1961-67), where he discovered the semidwarf gene and led the breeding of IR8.

SKULL AND RICE decorate Dia de los Muertos festival in Mexico City.

ALEJANDRO DE LA CRUZ

Rice revival in the land of maize

by **Nathan Russell**

MEXICAN RICE COUNCIL (2)

ARROZ A LA tumbada, a popular Mexican mix of seafood and rice with other local ingredients.

Anyone worried about the impacts of trade liberalization on developing-country rice sectors should take a close look at Mexico's experience and learn from a recent campaign—led by the Mexican Rice Council and its partners—to revive national production. That may sound like odd advice. After all, Mexico is not widely perceived as being strong on rice—a distinction that in Latin America goes instead to Brazil, Colombia, Peru, and others.

Maize gods, move over!

On the contrary, this is the country where, thousands of years ago, farmers domesticated maize, which was central to Mexico's pre-Columbian cultures and continues to be a mainstay of the national diet. More than half a century ago, Mexico also provided Nobel Peace Prize winner Norman Borlaug with an ideal setting in which to breed modern wheat varieties, which formed the genetic foundations of a global Green Revolution. Both crops are now the focus of a major initiative—called MasAgro—aimed at strengthening Mexico's food security, in which the International Maize and Wheat Improvement Center (CIMMYT) is working closely with the country's Secretariat of Agriculture, Livestock, Rural Development, Fisheries, and Food (SAGARPA).

Yet, within this country's original but eclectic culinary traditions, rice has also found a place of distinction. This began when rice was introduced from Spain during colonial times and came to fruition in the country's postrevolutionary period. As Mexican society quickly urbanized and incomes rose after the 1940s, more and more consumers turned to rice, because it offered convenience, while also contributing to a diverse and nutritious diet.

The simple dish of Mexican-style rice—prepared with a tomato sauce and generally served separately as *sopa seca* (dry soup)—thus became a standard feature of the national cuisine. Particularly in rural areas, it is hard to imagine a wedding or other family gathering without big clay pans of Mexican-style rice. The grain is used in more elaborate dishes as well, mixed with seafood and other local ingredients. It even takes the form of *orchata,* a refreshing drink made from boiled rice water with cinnamon, and a popular dessert consisting of *arroz con leche* (rice with milk).

Institutional green revolution

Mexico's rice production rose to meet increasing demand, reaching more than 800,000 tons on nearly 270,000 hectares by 1985.

The country's varied agro-ecosystems provide diverse, low-lying niches for irrigated and rainfed rice, giving farmers a welcome alternative for rotation with sugarcane and other crops. Today, rice cultivation is scattered across a dozen states, with four of them—Nayarit, Campeche,

RICE production regions of Mexico.

Veracruz, and Michoacán—accounting for about two-thirds of national production.

The worldwide Green Revolution in rice greatly boosted the production of the crop in Mexico, starting in the 1960s. Impressed with the high yields of IR8—the world's first modern semidwarf rice—growers quickly embraced the new variety, which had resulted from the work of Peter Jennings and others at the International Rice Research Institute (IRRI). Known in Mexico as *Milagro Filipino* or "Philippine Miracle," it is still the country's most widely grown rice variety.

So, just as a Mexican political party institutionalized the country's postrevolutionary socioeconomic program, farmers moved to institutionalize the Green Revolution in rice by making IR8 an enduring feature of the nation's diet and agricultural landscape.

Down but not out

Mexico's rice revolution lost ground, however, when the government began implementing trade liberalization policies in the 1980s. By 2013, domestic production had steadily declined to just 200,000 tons, while imports had expanded to 800,000 tons.

DR. JENNINGS, IRRI's first rice breeder, briefs visitors about IR8 in April 1966, just before it is released to Mexico and the world.

URBITO ONGLEO

A FIELD of Milagro Filipino (IR8) in Nayarit State (star on map).

Even as the country was flooded with cheap long-grain rice, Mexican growers clung to Milagro Filipino. The reason is that its medium-sized grain and special cooking properties had earned the loyalty of many consumers in central and western Mexico, securing a premium-price niche for this variety in the market.

The country's rice sector faced especially trying times in the wake of the global food price crisis of 2007-08, explained Ricardo Mendoza, CEO of the Mexican Rice Council, which receives support from both the rice processing industry and producers. The government reacted by eliminating rice import duties to avoid shortages. Several Asian countries—Pakistan, Thailand, and Vietnam—seized the opportunity by boosting rice exports to Mexico. This put even greater pressure on Mexican growers and also revealed how excessive dependence on rice imports was undermining national food security.

A comeback in the making

Mexico's rice sector has confronted this situation through a two-pronged strategy focused on (1) creating a fair playing field for the country's rice producers and (2) making the home team more competitive. The strategy's modest aim is to restore a prudent balance between domestic production and rice imports.

To this end, the Mexican Rice Council—together with the National Rice Production Committee and the National Council of Mexican Rice Producers—has made a strong case to the government for restoring a 20% duty on imported rice from countries with which Mexico does not have trade agreements. This will prevent dumping of cheap rice in the Mexican market. The measure is strongly supported by SAGARPA and is widely expected to be finally approved by the Economics Secretariat within the coming months, according to Mr. Mendoza.

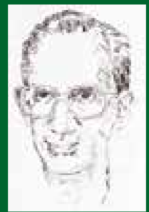
He also believes that Mexico can be more competitive in rice production, especially if growers take up more productive long-grained varieties on a large scale. To this end, the country has introduced experimental rice lines from the International Center for Tropical Agriculture (CIAT) and the CIAT-supported Latin American Fund for Irrigated Rice (FLAR). Several new varieties developed from these lines by researchers at the National Institute of Agricultural, Livestock, and Fisheries Research (INIFAP) have been released recently.

The country's rice organizations have also obtained extensive training from FLAR scientists in improved management practices (including the use of water harvesting), which will narrow the gaps between the high genetic potential of the new varieties and their actual performance in farmers' fields. This is critical for giving Mexican rice growers a competitive edge in high-potential production areas.

"FLAR's integrated approach to crop management helped us a lot," said Mr. Mendoza.

If all goes well, he expects that, by 2018, Mexico's rice production should be able to meet 40% of demand. "We're hoping that 2015 will be the year of the turnaround," he said.

Mr. Russell is the head of Communications and Knowledge Management at CIAT.



Indian farmer kick-starts two GREEN REVOLUTIONS

IRRI ARCHIVES

MANZOOR HUSSAIN DAR, IRRI

NEKKANTI SUBBA RAO helped kick-start both the first and second Green Revolutions in India by promoting and distributing IR8 in 1967 and Swarna-Sub1 in 2009.

by **Gene Hettel**

A while back, I read an interesting story extolling the merits of the new flood-tolerant rice, Swarna-Sub1, in the newsletter of the Stress-Tolerant Rice for Africa and South Asia (STRASA) project. The author, Manzoor Hussain Dar, International Rice Research Institute (IRRI) senior associate scientist based in India, included two photos of the same farmer, Nekkanti Subba Rao, in the same field on his Andhra Pradesh farm.

Spanning two Green Revolutions

I found this striking because the photos had been taken 42 years apart! One depicted a young 29-year-old farmer in 1967 clutching a bundle of lush grain-laden panicles of IR8, the rice variety that started the first Green Revolution (GR1.0) in the 1960s. The other showed a wizened 71-year-old in 2009, still with a twinkle in his eyes and the same bright smile, in a similar pose.

However, this time, Mr. Subba Rao was grasping a bundle of panicles of Swarna-Sub1, a popular variety (Swarna) made flood-tolerant by incorporating the *SUB1* gene. Many have since considered Swarna-Sub1 and other popular varieties with a *SUB1* background to be the launching pad for the second Green Revolution (GR2.0), which is being publicized to leave no poor farmer behind (see *Green Revolutions 2.0 & 3.0: No farmer left behind* on pages 32-35 of *Rice Today*, Vol. 14, No. 2).

Well, the *Rice Today* staff needed to look no further for a cover photo subject to grace this issue, which is celebrating 50 years of rice research in India. It was an easy decision. The 1967 photo was on the cover of our October-December 2006 issue to observe the 40th anniversary of the release of IR8 in Asia.

Mr. Subba Rao's farming livelihood and his on-farm research have spanned the same period. During this time, he has continuously collaborated with the All India Coordinated Rice Improvement Project in testing new varieties, producing certified seeds, and establishing beneficial links between scientists and farmers. Truly, this has made him an integral part of the history of the Green Revolutions in India.

Testing and distributing IR8 and Swarna-Sub1

He proudly recalled that, in 1966, he was one of the first farmers to plant Taichung-Native 1 (TN1) for national demonstrations. TN1 was actually the first indica rice variety carrying the semidwarfing gene, *sd1*, derived from Taiwanese variety Dee-geo-woo-gen, which is also a parent of IR8. However, IR8 and subsequent IRRI varieties proved to be more disease resistant and quickly replaced TN1.

In 1967, Mr. Subba Rao tested IR8 on his farm and supervised its first large-scale demonstration and multiplication—on about 2,000 hectares near his home village of Atchanta—following instructions from the government of India. The next year, IR8 was planted on 1,600 hectares in his village and the rest was history, with the seeds soon being distributed throughout the country. So, in addition to being called *Dhaan Pandit* (rice expert) by his neighbors, he is also known by the moniker "Mr. IR8," which still resonates with many Indian farmers to this day.

Dr. Dar, who coordinates research and seed upscaling and dissemination-related activities for STRASA in stress-prone rainfed lowlands in South Asia, has had the privilege of working with this pioneer farmer for the last 6 years. "Mr. Subba Rao has been instrumental in promoting and distributing Swarna-Sub1," he says. "In fact, in 1979, he grew, tested, and inspired his neighboring farmers to grow the original Swarna, even before it was officially released, because of its high-yielding and good eating qualities. After its release, Swarna covered the entire Godavari Belt in India and continues to be the variety of choice among millions of farmers in India and neighboring countries."

JEC NARCISO, IRRI

IN THE IRRI fields during his 2014 visit, "Mr. IR8" visits a demonstration plot of rice variety IR8, which launched GR1.0.

Unfortunately, Swarna yields often decrease during seasons with lots of flooding. So, Mr. Subba Rao was especially excited when IRRI breeders incorporated the *SUB1* gene into Swarna. It was a dream come true.

IRRI

MR. SUBBA RAO and Dr. Dar confer often on the latest available technologies that may benefit the farmers of the region.

Says Dr. Dar: "Mr. Subba Rao evaluated Swarna and Swarna-Sub1 side by side in his field and invited hundreds of farmers to come see the difference. Luckily, for observational purposes, the seedlings got submerged that season and Swarna-Sub1 performed so much better than Swarna. He distributed Swarna-Sub1 seed from his 2008 kharif harvest to other farmers, who multiplied it during the rabi season 2008-09. This resulted in the spread of Swarna-Sub1 to nearly 1,000 hectares during the 2009 kharif season in a dozen surrounding villages."

A farmer-scientist

"In 2012, I gave him 1 kilogram of seed of Ciherang-Sub1, a short-duration, flood-tolerant variety with high grain quality," says Dr. Dar. "Not surprisingly, he multiplied it in the kharif and also cultivated it during the following boro season. It had higher yield than other popular rabi rice varieties and thus spread through hundreds of hectares in a few years and has become a popular variety. Through the local university, he has also helped distribute 1,000 mini-kits of Ciherang-Sub1 to the farmers before its release. That's how he works.

"I consider Mr. Subba Rao a scientist himself," says Dr. Dar. "He is truly an inspiration to the farmers in the area and has a large following. He is the best promoter around of the new technologies and he creates a lot of awareness among the farmers."

No stranger to IRRI

In 1985, during IRRI's 25th anniversary, the Institute organized a multilevel symposium that included scientists, political leaders, and—most importantly—14 outstanding farmers identified from 10 nations. Two Indians were in that group to visit the Philippines, Sardar Jagjit Singh Hara from the Punjab (see *In the Punjab: an outstanding farmer revisited* on pages 34-35 of *Rice Today*, Vol. 8, No. 2) and Andhra Pradesh's own Dhaan Pandit! Mr. Subba Rao and his fellow outstanding farmers generously shared their experiences with IRRI scientists and scholars during that event. He was part of the group because he was already averaging 8 tons per hectare on his 10-hectare farm back then in the mid-1980s.

ISAGANI SERRANO, IRRI

MR. SUBBA RAO speaks during IRRI's 2014 Farmers' Day.

"Science has a great role to play in helping farmers because the cost of cultivation continues to increase and outbreaks of insect pests and diseases result in severe losses," he said to the participants during the 1985 symposium. He added that community participation and proper government policies could significantly influence returns.

Flash forward 29 years to 1 October 2014. Mr. "IR8" was back at IRRI Headquarters in the Philippines to mingle with more than 400 Filipino farmers during the Institute's *Araw ng Magsasaka sa IRRI* (IRRI's Annual Farmers' Day). He repeated his 1985 message to a new attentive audience by sharing his experiences, practices, and insights. It is clear that he brims with pride about his role in helping usher in both GR1.0 with IR8 and GR2.0 with Swarna-Sub1 and the even better varieties that are following.

"He is always excited about innovative varieties and technologies," concluded Dr. Dar. "I wish I had a new product to give him every year because, through his network, we can best bestow maximum benefits to the thousands of farmers in the region."

Mr. Hettel is editor-in-chief of Rice Today *and IRRI historian.*

Also 50 years ago…

U.S. President Johnson makes historic visit to IRRI with stirring words

by Gene Hettel

This year, 2016, IRRI is observing and celebrating the 50th anniversary of the release of IR8, the first semidwarf rice variety that would ultimately change the face of agriculture across Asia, Latin America, and elsewhere. However, it is also the golden anniversary of the historic arrival of the first and only U.S. president, Lyndon Johnson, who visited the institute on 26 October 1966. He came to see—and find out more about—this miracle rice called IR8.

Braving the mud, LBJ went out into a rice plot to inspect the variety that was making so much of a stir in the media. As the iconic photo shows, IRRI Director General Robert Chandler, Jr. briefed LBJ and Philippine President Ferdinand Marcos, explaining the importance of semidwarfness in the new variety. Also in the photo are Peter Jennings (standing) and Hank Beachell, the IRRI breeders responsible for IR8's development.

LBJ then came up out of the field and, under a hot blazing sun just before 1 p.m., he delivered an inspiring speech to the awaiting crowd of IRRI staff members and other visitors.

The U.S. president was an accomplished orator and at his best that day, flanked in the photo by Philippine and U.S. First Ladies, respectively, Imelda Marcos (left) and Ladybird Johnson. He concluded, speaking of IRRI, with the words, "You are pointing the way for all of Asia to follow and I hope they are looking. I hope they are listening. And I hope they are following." You can experience the goosebumps that I get every time I listen to those words delivered so dramatically in the brief video excerpt we have of that speech.

For almost five decades, that brief video clip was all that we had of the presidential speech at IRRI. Then, just last year, we discovered the full transcript of his speech on the website of the American Presidency Project. S

So, here is most of LBJ's presentation on that historic day, which contain some interesting historical background.

"We meet here in a new Asia. In this Asia, the old barriers of indifference and rivalry are slowly being overcome—and a new spirit of cooperation is taking shape. Today, while our Asian friends still need a helping hand, they want to match it with their own efforts—aimed toward their own goals.

This rice research institute here in Los Baños is a product of intelligent assistance. Two American foundations [Ford and Rockefeller] have given support. One of the moving forces behind the creation of the Institute, I am proud to say, was that great former president of the Rockefeller Foundation, whose vision, whose genius did so much to help in this work—Dean Rusk. The institute's director today is a New Hampshire man, who just addressed us, Dr. Robert Chandler. Yet, the professional staff includes scientists of seven nationalities; two-thirds of them are Asian.

In its short 4 years of existence [apparently using 1962 as the date when IRRI's research program began, not the 1960 date of its founding], this Institute has produced promising new strains of higher-yielding rice, which are now being planted in the soil of many countries. One strain developed here [IR8] has been called the "miracle" rice.

I am glad to know that the institute is prepared to make these seeds available to all nations—to all nations whatever their politics and ideology. The need for food transcends all the divisions man has created for himself.

Man's greatest problem is the fearful race between food and

population. If we lose that race, our hopes for the future will turn to ashes. And, the shocking truth is that, as of now, as we speak here today, we are losing the war on hunger. There are nations of the world with declining standards of living—where population growth is already outrunning the supply of fundamental food stocks.

At the same time, the stocks of surplus-producing nations have rapidly declined. There was in 1961 a grain surplus of 136 million tons. The figure for 1967 is down from 136 million to 50 million. A rice surplus of over a billion tons existed in 1956. It has now dropped to a mere 300 million tons—or less than a third of what it was 10 years ago. These are danger signals that we cannot ignore.

Between now and 1980, we must prepare to feed one billion more people. That may sound like a bloodless, economic abstraction. But we must learn to hear what it says in human terms:

One billion more people means one billion babies. And four out of five of those babies will be born in countries that cannot, today, feed their people from their own resources. Now, somehow or other, we must do something about this. We must overcome this. And you are doing something about it right here. This is one of the most encouraging things that I have seen.

And you here at Los Baños are pointing the way that we will need to be pointed throughout all of Southeast Asia. Drawing on your experiments, these new rice strains, the technical training you are giving in conjunction with the College of Agriculture at the University of the Philippines—which has your President [Marcos] so excited and who has described it to me fully today—will, I think, do more to escalate the war against hunger than anything that I know of that is being done today. So, I congratulate President Marcos.

I say that that is the only war that we really seek to escalate. We believe we can win this war against hunger. Yet victory will not come easily. These young people believe—and they are right, I think—there is nothing natural or God-given about poverty or hunger and disease. Some of them react against an unjust state by professing empty ideologies.

But some—and they are represented here at Los Baños—realize that only knowledge, skill, and hard work can provide fruitful avenues to a decent future.

In every country—but particularly in Asia, Latin America, and Africa—there is a desperate need for skilled men and women who can release their brothers from the barrios of poverty.

For, if the world's need for food is to be met, it will be by scientists and economists who will discover better seeds, who will find better methods of planting, who will give us better ways of distributing the harvest of the earth. It will not be by "miracles," but by the qualities of dedicated minds that we find working right here tonight in the new Los Baños rice strain.

I want to thank Dr. Robert Chandler. I want to express my admiration to him and to all the members of the staff of this great institute. I want to commend President and Mrs. Marcos for their interest in this kind of development.

If we are to win our war and the only important war that really counts, if we are to win our war against poverty, against disease, against ignorance, against illiteracy, and against hungry stomachs, then we have got to succeed in projects like this. You are pointing the way for all of Asia to follow and I hope they are looking. I hope they are listening. And I hope they are following." ■

Mr. Hettel is an IRRI consultant based in the Philippines.

Shalabh Dixit: The link between rice genes and rice farmers

by Alaric Francis Santiaguel

A quantitative trait locus (QTL) is an incredibly small section of DNA that, in the hands of critical-thinking scientists, has the potential to change the world.

A QTL is a segment of an organism's DNA that contains a gene or genes linked to a particular trait. In the rice plant, for example, it can control height, built-in resistance to a disease, or the ability to produce more grain. It is within this complex inner universe of genes and DNA strands where Shalabh Dixit works in his role as a scientist in the International Rice Research Institute's (IRRI) Plant Breeding Division. He searches for untapped genetic materials to develop new rice varieties that are tougher and more productive.

Dr. Dixit, 32, grew up in Chhattisgarh, also known as the "rice bowl" of India. His home state accounts for more than 9% of India's total rice area and it has more than 20,000 recorded rice varieties. Although he doesn't come from a farming family—his father is an orthopedic surgeon and his mother is a retired school teacher—Dr. Dixit has rice science flowing in his veins. His passion for rice genetics is rooted in his childhood years.

"A large part of Chhattisgarh, more than 80%, is rainfed, and drought is one of the major problems affecting farmers," he points out. "Growing up there, I have seen the impact of environmental stresses. When I started doing rice breeding and drought research, I was able to immediately connect with that time back home when I saw all the problems and crop losses due to drought."

Agriculture was not his first career choice but you wouldn't know it when you see his commitment to his chosen profession. Once he gets into it, there is no stopping him. In an interview, Dr. Dixit talks about his work that links the microscopic world of rice genes with the farmers who grow one of the world's critically important staple crops.

DR. DIXIT (*left*) briefs Takehiko Nakao (*right*), president of the Asian Development Bank, on flood-tolerant rice at IRRI's headquarters in Los Baños, Philippines. (Photo by Isagani Serrano, IRRI)

Why is your work in enabling rice to thrive under various environmental stresses important?

I am a geneticist and a plant breeder. I previously worked on developing drought-tolerant rice and, more recently, started working on flood-tolerant rice. Our work is important in our present-day scenario because incidences of drought and flooding are increasing due to climate change. I believe we need more rice varieties that are not just tolerant of drought but of flood and salinity as well, and at the same time, resistant to diseases. Multiple-stress tolerance in rice varieties is a must to ensure the stability of rice production in increasingly unpredictable weather scenarios. It is time to start thinking about raising the bar and developing varieties that have a minimum set of traits that relate to yield stability and quality.

Why are you focusing on rainfed or unfavorable areas rather than on irrigated or favorable areas?

Large rainfed areas are planted with rice varieties that were not developed strictly for rainfed areas. The first Green Revolution in the 1960s produced IR8 and its successor rice varieties for irrigated fields that were highly responsive to fertilizer and high yielding. These varieties spread rapidly across the rice-growing regions, including rainfed areas. But these varieties break down when stresses occur and don't yield much. That's why stress-tolerant high-yielding rice varieties designed specifically for rainfed areas are so important.

Major breakthroughs are still needed for the favorable irrigated rice environments as well but my interest has been in the rainfed ecosystem. I connect better to it maybe because I have seen the problems firsthand back home. Rice yields are low in these areas. There is a big gap in yield potential between rainfed and irrigated environments, which makes it important to focus on the former. These areas are also home to the poorest farmers. If we can close this gap, even by a ton per hectare, then we can produce a lot more rice to feed future populations and make an impact targeted to the most deprived members of society.

Another new scenario in recent years is the increasing occurrence of environmental stresses in favorable rice areas. These areas need stress-tolerant varieties also because climate change will eventually affect them. For example, irrigation water is becoming scarcer. Flooding and salinity can happen in these areas as well. It looks like it is not going to be about favorable and unfavorable ecosystems individually in the future. Instead, it will be about finding a set of traits that allow the varieties that have them to thrive no matter where farmers grow them.

What is the best thing about your job?

I have mostly worked in identifying and mapping QTLs and genes and developing products that contain them. A mapping population is a specific kind of population you develop by crossing two parents—one tolerant and one susceptible—primarily to identify the QTLs. It's not necessarily to release a variety right away; however, that does happen.

For example, while we were doing the mapping, we saw some lines that looked to be promising. We pulled out some promising lines from my mapping population, continued making selections, and a new line of drought-tolerant rice was released as a variety (IR91648-B-20-B-3-1) in the Philippines in June 2016.

The normal process is to identify a QTL and put it in a recipient variety. Usually, we refine it more by using different breeding procedures before we actually develop a product. But, that one line already had a potential for release; it just needed some selection and purification—a stroke of luck. [See a video featuring former IRRI breeder Peter Jennings who made the cross resulting in IR8, about luck being the residue of design at https://goo.gl/hsebvt.] It doesn't happen very often when working with these complex traits in rice.

The most beautiful thing is when you put a QTL in a variety and it performs the way you want it to and it's something new that you created. Every time I make crosses, and this works when I test the progeny, it gives me the most amazing feeling. It is the feeling of developing something new that connects my genetic work with developing products that could change millions of lives in the real world!

Breeders had no idea how large the impact would be when they developed IR8, the first semidwarf variety that started the Green Revolution in rice, or the recently released flood-tolerant Sub1 lines. Now, these are planted on millions of hectares around the world. I am working to develop a product with the same potential—this is the most important thing that keeps me going. Whenever I identify a QTL, develop a population or a breeding line, or conduct basic genetic work, that's the one thought always in the back of my mind.

So far, what have been your biggest achievements at IRRI?

Locating the QTLs and developing products with them are my biggest achievements at IRRI so far. I have developed drought-tolerant lines for Nepal using QTLs that we identified. I also helped develop drought-tolerant versions of rice varieties from India, Korea, and Taiwan. I have developed drought- and flood-tolerant IR64, which is still a popular variety in Asia, and Thadokkham1 from Lao PDR under Dr. Arvind Kumar, leader of the South Asia Plant Breeding Group at IRRI. All these lines have the potential to be released as new varieties.

What are you working on now?

I am working on developing rice that can germinate under water or lines tolerant of anaerobic germination, stagnant flooding–tolerant rice, and rice that can survive even longer periods of submergence than we have now.

Hopefully, more high-yielding good-quality rice with adaptability to rainfed areas in Asia and Africa will follow in the coming years. My target is the next two years.

You said agriculture wasn't your first career choice. When did you realize that this was the right career for you?

I realized it soon after starting my bachelor's degree program in agriculture. But one part of it had the most impact on me. In India, there is a 6-month period called the rural agricultural work experience before you can earn your degree in agriculture. You go to a village and stay there for a semester or visit there every day and work with farmers and participate in their day-to-day activities.

I had some technical knowledge from what we studied in school. We tried to apply what we learned in the classroom in the real world during this period. Seeing how things work and learning how farmers see and do things affected my views a lot. If you think about how farmers would react to what you are about to develop, you always make a better decision. When you see the possibility of the impact you can make, it gives you a new perspective.

How important are farmers in your work as a plant breeder?

I'd like to visit the farmers who plant the varieties I helped develop. I have visited some farmers in Nepal, Bangladesh, India, and Vietnam. I still have some more to visit. Last year, I went to Odisha. This is a regular process for looking at flood-tolerant lines that I carry out every year. We visited farmers' fields planted with Swarna-Sub1.

I want to talk with the farmers and listen to what they like and, more importantly, what they dislike in a variety because that will help improve the breeding program. This is the most important feedback.

Participatory varietal selection is the most important point of feedback. You can develop as many varieties as you want, but, if farmers don't like them, they won't use them.

What is your advice to upcoming plant breeders?

You have to move from writing papers to developing actual products. Publishing papers about your work in journals is good. Finding QTLs and genes is even better. But it's mandatory to develop products if you are a plant breeder. It is what we aim for, and this cannot stop in any way. Every plan, every vision, and every experiment should be in this direction. This is what brings the greatest value to all the basic research and genetic work we do. We're doing all this to help change the lives of millions for the better. ■

Mr. Santiaguel is managing editor of Rice Today.

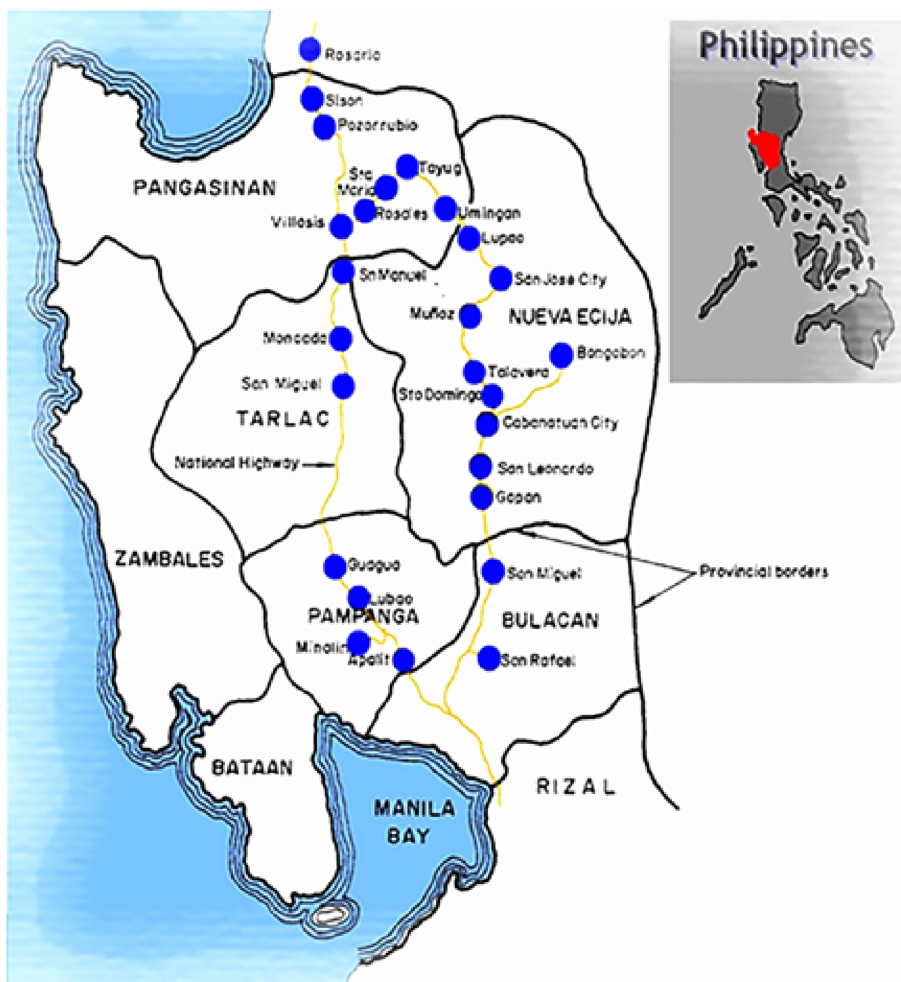
50 years of tracking farming changes in the Philippine rice granary

by Piedad Moya, Kei Kajisa, Randolph Barker, Samarendu Mohanty, Fe Gascon, and Mary Rose San Valentin

Loop surveys were conducted in the wet and dry season every four to five years from 1966-67 to 2011-12—the longest farm surveys in existence—in which detailed records were kept on production systems and family activities. This article discusses a survey of about 100 farmers in Central Luzon, Philippines (map). The route of the survey forms a "loop" along the national highways in the region.

A major objective of the loop surveys, now marking their 50th anniversary in 2016, has been to provide feedback to rice scientists and others about changes in farming and farm practices in Central Luzon—the "backyard" of the International Rice Research Institute (IRRI). The survey has also included information on farm families and sources of family income. It raises questions regarding the future of rice farming in the so-called "rice granary of the Philippines" as families have come to rely on nonfarm sources of income.

The farms have been and remain small, approximately 2 hectares. The families have been large, on average six members per household. The completion of the Pantabangan Dam in 1975 and the establishment of the Upper Pampanga Integrated Irrigation System (UPRIIS) represented the first major irrigation project in the region. The adoption of low-lift pumps and shallow tubewells from the 1990s onward have allowed farms to intensify. Irrigation expansion was essential for the Green Revolution to be successful.



Profitability of rice farming—who benefits more?

We typically find in technological innovations in agriculture that falling prices (Fig. 1) more than offset higher yields (Fig. 2)—the larger portion of benefits going to consumers (consumer surplus), not to producers (producer surplus). But, other changes need to be taken into account over time such as land reform and falling land rents, mechanization, and the reduction in labor inputs.

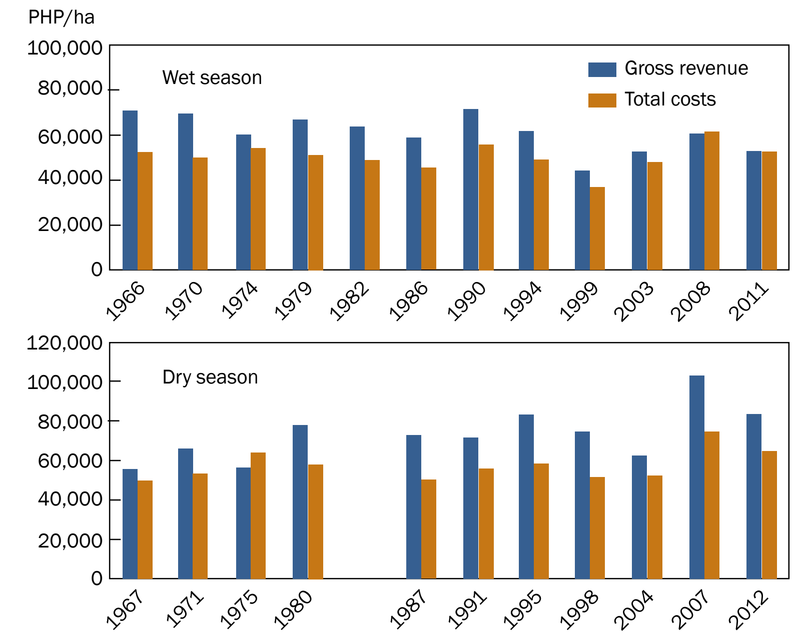


Fig. 1. Trends in gross revenue and total costs, WS and DS, Central Luzon Loop Survey, 1966-2012.

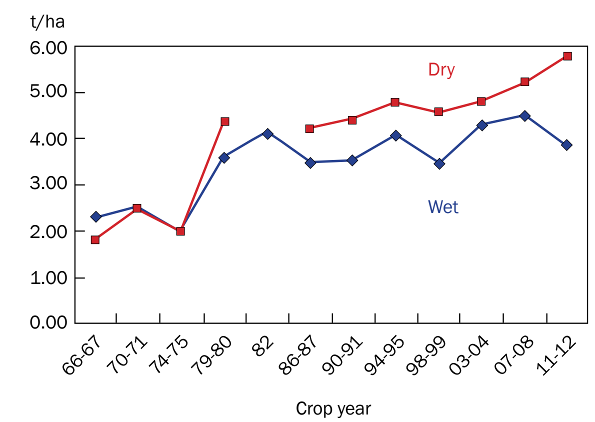


Fig. 2. Trends in yield per ha, sample farms, Central Luzon Loop Survey, 1966-2012.

Changes in sources of household income (%), six selected case studies, Central Luzon Loop farmers, 1960 to 2000.

Sources of income	1960s	1970s	1980s	1990s	2000s
	Percent				
Rice	67.9	86.1	37.3	37.8	17.1
Nonrice crop			16.2	9.7	5.0
Livestock and poultry			7.2	26.6	6.2
Off-farm employment	32.1	13.9	34.3	21.8	33.6
Remittances			3.3	4.1	27.9
Other sources (rentals, etc.)			1.7		10.2

Trends in net returns over paid-out costs and in net profit are shown in Figure 1 (values are in 2012 constant prices in pesos per hectare). In the dry season in our surveys, income (net returns over paid-out costs) and net profit have remained reasonably steady.

The situation for the wet season is very different. Both net returns and net profit have been declining over almost the entire five decades. The net returns over paid-out costs are positive, but, in the last two survey years, net profit has been zero. This has been accompanied by a decline in area planted to rice in the wet season among our survey farmers.

Sources of farm household income

For a small sample of a dozen farmers, for whom we had reliable records, we conducted a series of a dozen case studies in 2013 and 2014. One objective was to examine the source of farm household income as shown in the table below.

Briefly, in the 1960s and 1970s, around 70% of family income was from rice production. By the 1980s and 1990s, rice represented only a third of family income, with other farm and nonfarm activities accounting for the rest. By the 2000s, income from rice accounted for less than 20% and from remittances over a quarter of family income.

However, with hired laborers, the production of rice continued. As noted earlier, land planted to rice in the wet season was declining somewhat but was offset by increasing yields in the dry season with the expanding use of low-lift pumps for irrigation. There were no signs of an active land market as the majority of farmers were happy to have benefited from the agrarian reform and they had become landowners.

Conclusions and implications

We would like to conclude with some implications for the future path of development in the Philippines' rice sector. There is much discussion in the literature about the need for Asian economies to expand farm size to take advantage of the scale

Surveys say…

Trends in rice productivity and varietal improvement. The first modern or high-yielding variety, IR8, was released in November 1966. These modern varieties were widely adopted by Filipino farmers beginning in the 1970s and, within just a little over a decade, yields had roughly doubled from 2 to 4 tons per hectare (Fig. 2). Since the 1980s, growth in yield has plateaued in the wet season but has exceeded 5 tons per hectare on average in the dry season.

In addition to the increase in yield, three other factors are related to varietal improvement in irrigated rice—shorter growth duration from 150 to 110 days, the development of varieties resistant to insects and diseases, and higher grain quality.

Often referred to as a mega-variety, IR64, released in 1985, was the most popular farmer variety planted for almost the next two decades, from 1986 to 2004.

Adoption of biochemical technology. The trend in the use of nitrogen fertilizer, principally urea, has followed the pattern of yields, increasing from almost nothing to 100 kg of N per hectare (Figs. 3a and 3b). Phosphorus and potassium applications have been minimal.

It was gradually discovered that overuse of insecticides had a negative impact, not only on crop yield but also on animal and human health. Around 1980, our survey farmers began reducing the amount of insecticide from around five to two applications (Figs. 4a and 4b).

And, the recommendation is now to use no insecticides for the first 40 days. Although the Philippines today is one of the lowest users of insecticide, overuse remains common in many parts of Asia, resulting in unnecessary crop losses.

Trends in labor use and labor-saving technologies. Initially, labor input per hectare increased with the adoption of HYVs in the 1960s and 1970s (Fig. 5). But, subsequently, labor-saving technologies have been widely adopted, thus reducing manual labor requirements from 80 to 60 person-days per hectare in the wet season and from 80 to 40 person-days per hectare in the dry season. Mechanization of land preparation and harvesting-threshing has accounted for much of this reduction. Increased use of herbicides (Figs. 4a and 4b) and direct seeding in the dry season have also reduced labor input.

In part, as a result of these changes, family labor as a portion of total labor in rice production per hectare has declined over time from 50% to around 20%. Rice production is no longer a family enterprise as most of the tasks are performed by hired labor with the farmer (often one of the siblings as those in our original survey have retired or died) making the management decisions. ■

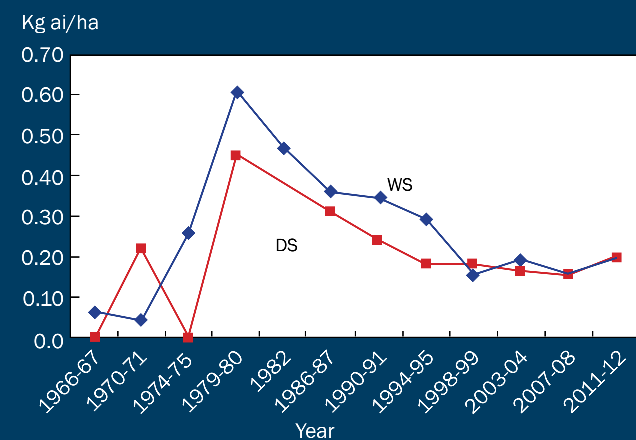


Fig. 4a. Trends in insecticide use in kg active ingredients per ha, WS and DS, Central Luzon Loop Survey, 1966-2012.

Fig. 3a. Trends in N fertilizer price, WS and DS, Central Luzon Loop Survey, 1966-2012.

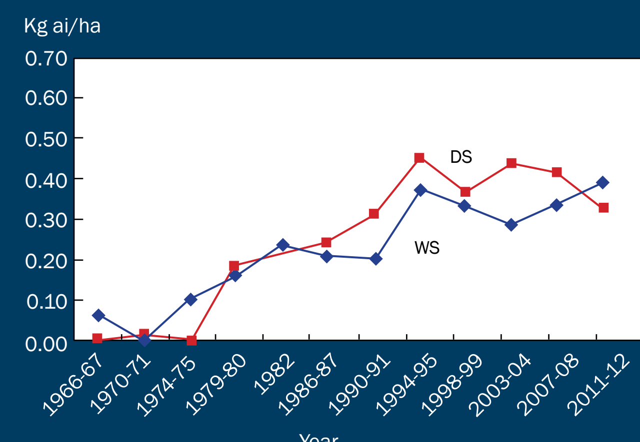


Fig. 4b. Trends in herbicide use in kg active ingredients per ha by season, Central Luzon Loop Survey, 1966-2012.

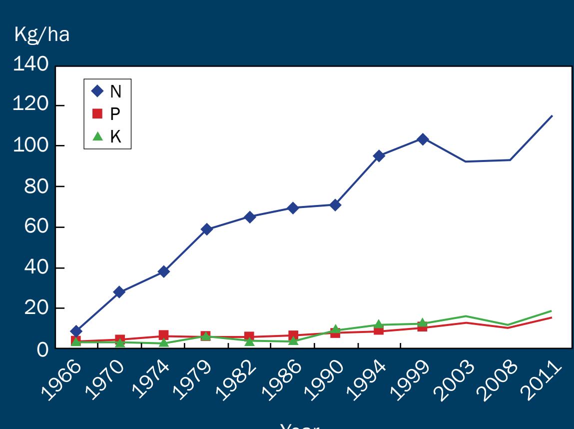


Fig. 3b. Trends in fertilizer use per ha, WS, Central Luzon Survey, 1966-2012.

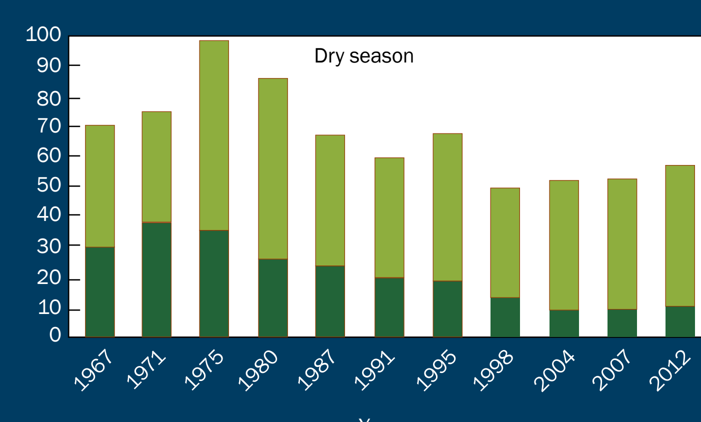


Fig. 5. Labor use by source, person-days per hectare, WS and DS, Central Luzon Loop Survey, 1966-2012.

economies of large mechanization. However, this transition must be accompanied by rising wage rates and an active land market. Slow industrial development, rapid population growth, and prolonged land reform have slowed down this transition in the Philippines so far.

Since 2010, the economy has been growing rapidly and, if this growth is pro-poor and raises the wage rates of agricultural laborers, the incentive for mechanization will increase. However, the process may not work smoothly as long as the land market is still inactive. We have to pay attention to how recent economic growth would lead to further mechanization.

Declining profitability in the wet season is another crucial issue. The percentage of GDP from agriculture and the percentage of GDP from remittances of overseas workers are both about 10%. The Philippines has been importing rice and exporting labor. Research on sustainable rice production in agro-ecologically unfavorable conditions—flooding, drought, salinity—is at the top of IRRI's agenda in plant breeding. In the next survey round, we may see more farmers planting flood-tolerant varieties in the wet season and perhaps adopting hybrid varieties in the dry season.

Finally, it should be noted that the 2015-16 survey is already completed and is being reviewed by the Social Sciences Division (SSD) at IRRI. There are plans to continue the periodic survey in the future. ■

Ms. Moya is a consultant and former senior research manager at SSD, Dr. Kajisa is a professor at Aoyama Gakuin University in Japan and former senior agriculture economist at SSD, Dr. Barker is Professor Emeritus at Cornell University and IRRI, Dr. Mohanty is a principal scientist and head of SSD, Ms. Gascon is a former SSD associate scientist, and Ms. San Valentin is a researcher at SSD.

This article is a synthesis of the IRRI book: Changes in rice farming in the Philippines: Insights from five decades of a household-level survey. The pdf of the book can be downloaded at goo.gl/Lk1Pji. Individual household data can be accessed online.

An enterprising farming family

In 2012 and 2014, we conducted a series of interviews of farm families that had been surveyed from the beginning. The purpose was to look beyond the survey data and into family and farming issues. We focused on how the farm households and farm enterprise had changed over time. The table in the main text summarizes the change over time in sources of income. Although the sample was small and the experience of individual farmers differs, the major changes are reflected in the broader sample. We recorded the experience of one farm family, the Santoses.

In 1966, at the time of our first interview, the Santos family had 1 hectare of rainfed land. That year, they did not harvest anything because their rice was washed out by flooding. The family looked elsewhere for income—raising hogs and driving a truck.

With the coming of irrigation and new rice technology, rice yield increased from less than 2 tons per hectare for one crop to more than 4 tons per hectare for two crops.

As the farm prospered, the family also grew, with six daughters and one son. Juan and Maria, the heads of the family, made a major effort to see that each of the seven children received a good education. Six of the children found employment off the farm, two of them overseas.

After Juan, the patriarch of the family, fell ill and passed away in 2007, a daughter, Fely who has been involved in farming activities since she was 15, took over the farm management. On 19 November 2013, we met Fely, who is now in charge of the family's 3.5-hectare farm. She employed two permanent laborers.

But Maria did not stay idle. She opened up a small store in 2007. Some time ago, a rice mill was put up by a rice dealer in this area. This prompted the family not to sell its paddy and instead the paddy was taken to the local mill and the miller kept the bran as payment for the milling. The milled rice is now sold in their store. As of our last visit in October 2013, the price in the market for palay was PHP 15.50/kg (dried). However, the price of milled rice was PHP 35.00/kg, a handsome profit for the store.

The family living quarters are on the second story of a house behind their store (see photo). We were surprised to learn that there had been a flood in October 2013, with the water rising to knee-deep in their two-story living quarters. They had planned to harvest the rice on a Friday but, like a tsunami, the flood arrived without warning the day before. Fortunately, the flood lasted only a couple of days and they were able to harvest most of the rice. In the house, they lost their Christmas decorations and were trying to recover photographs from their family albums.

Despite these unpleasant intervals, for the Santos family, growing rice and educating siblings have had their rewards. The house has been rebuilt and furnished with air conditioning, TV, and other amenities with the help of the children's remittances. The living quarters are a story off the ground because of the frequent flooding in the wet season.

Of course, not all farmers in our survey were as fortunate as the Santoses. After the eruption of Mt. Pinatubo in June 1991, one farmer could grow only one crop of rice annually. Another farmer lost half a hectare of land to highway construction without compensation. Despite advances in technology, rice farming remains a risky business. ■

IRRI's new breeding factory

by **Lanie C. Reyes**

Transforming from research-driven to product-oriented breeding processes

THE CORE TRB team members take a break in one of their multi-environment trial plots. Foreground: Eero Nissilä; middle row (*left to right*): Glenn Gregorio, Bert Collard, Richievel Ibanez; background (*left to right*): Rafiqul Islam, Gina Vergara, Michael Thomson, Alice Laborte.

ISAGANI SERRANO

The road toward global food security is not without challenges. The population will balloon to 9 billion in 2050. The signs of climate change have never been so real—frequent floods, droughts, and storm surges. Storm surges make farmland in coastal areas too salty for most crops to grow. Also, pathogens and pests evolve. Therefore, a rice variety may lose its resistance to new strains of pathogens or insects.

"With so many challenges that we are facing now, we can't just continue with what we are doing," said Eero Nissilä, head of the Plant Breeding, Genetics, and Biotechnology Division (PBGB) at the International Rice Research Institute (IRRI). "There need to be changes in the way we do breeding at IRRI."

IRRI plant breeder Bert Collard agrees. "A revolution in rice breeding is what we need now," Dr. Collard said. "Not much has changed for the last 50 years. The methods used today in Asia are generally the same as the ones used in the 1960s-'70s. More importantly, the rate of yield increase or genetic gain for irrigated varieties is less than 1% per year."

Doubling genetic gains

Thus, Dr. Nissilä and his team are now restructuring IRRI's entire breeding operations. Transforming Rice Breeding (TRB), a project funded by the Bill & Melinda Gates Foundation, is one important component of this new breeding factory, which focuses on irrigated rice. IRRI is aiming to double the rate of genetic gains—the increase in crop performance that is achieved through genetic improvement programs per unit time of breeding—or even make it higher (more than 2%).

"To make breeding more efficient, we need to change how we organize our breeding operations," Dr. Nissilä said. "We need to restructure the overall breeding pipeline."

A shorter cycle

Traditional breeding takes 8 to 9 years to develop a variety and even longer for the variety to reach farmers. Now, the breeding process has been shortened to about 6 years (See *How a modern variety is bred* on pages 11-12, Vol. 9, No. 1 of *Rice Today*).

"In breeding, one year is significant," said Dr. Nissilä. "Investments in plant breeding with costs incurred during the phase of developing varieties are only realized when farmers grow the varieties. A longer breeding cycle means economic opportunity cost to farmers of losing the chance to grow better varieties earlier."

A 1999 study conducted by IRRI shows that reducing a breeding cycle by 2 years has an economic benefit of about US$18 million over the useful life of the variety.[1]

[1] Pandey S, Rajatasereekulb S. 1999. Economics of plant breeding: the value of shorter breeding cycles for rice in Northeast Thailand. Field Crops Research 64:187-197.

Breeding by demand

Taking a cue from breeding in the private sector, IRRI's breeding pipeline should run like a business operation—production by demand. For Dr. Nissilä, this should be the underlying philosophy of the new breeding pipeline.

"That's why the TRB team is working closely with IRRI's Social Sciences Division to better understand the needs of farmers," said Dr. Collard. "This will help guide us in 'must have' traits as well as 'good to have traits' in our breeding objectives."

The team recognizes that national programs have different needs. It could be a breeding line, a gene donor, or a gene marker. If a researcher needs only a gene marker and wants to do the breeding in a lab himself or herself, IRRI will provide some help on how to use that marker. If a national program is interested only in salinity tolerance, the team will use its trait pipeline to provide the best package of salinity tolerance for the national program's breeding. On the other hand, if a national program needs a new rice variety, then the team will use its product development pipeline.

"We can help organize a national program's overall product development and product profiling when needed," Dr. Nissilä said. "We will not only give a trait, say, salinity tolerance, but, it can be combined with many traits that one needs in one's 'market,' so to speak. We can fit their needs.

"But, our aim in the future is that we won't be doing the 'job,'" he added. "We want them to do it themselves. Our role will be more of a consultant and provider of training. Then, we exit when they are already able to do the work."

The role of hubs

"But, if national programs want us to do this in the first round, we will breed the variety itself," said Dr. Nissilä. "This is where our regional breeding hub system comes into the picture. Our hubs in India, for the South Asian region, and in Burundi, for East and Southern Africa, allow us to localize the breeding process—we select and produce the material in the region where it will be used."

IRRI now has many modern breeding options for a more efficient and cost-effective process than the conventional pedigree method. The conventional breeding way goes like this: choose plants with the desired trait, cross-pollinate them, wait for the offspring to reach maturity, select the best performers, and then repeat the process to the n^{th} degree until one obtains a plant that fits farmers' need.

Today, these modern methods include marker technology, multilocation trials, and rapid generation advance (RGA). RGA produces fixed lines or plants that no longer segregate. Scientists call them "homozygous" or "genetically stable." "In RGA, plants are grown at high density with low nutrients in greenhouses or screenhouses so that they flower and mature earlier, thus shortening their life cycle," said Dr. Collard. "Therefore, several generations (e.g., three to four) can be advanced in one year." In addition to time savings, this method also saves labor and resources, and costs considerably less than other methods.

THIS GREENHOUSE facility employs RGA techniques to develop new irrigated breeding populations. RGA technicians (*from left*) Joseph Beredo, Rhulyx Mendoza, and Herman Hermosada grow the rice plants in small trays to quicken flowering and maturity. Tens of thousands of breeding lines can be advanced for 3-4 generations in a year in an area of less than 400 m^2.

BERT COLLARD (3)

New breeding pipeline model

The new structure of IRRI's breeding pipeline will hopefully be a model for the national programs to follow. Historically, the national partners have modeled their programs on IRRI's old system.

"We hope that the new processes of rice breeding at IRRI will help catalyze new thinking in the national programs so they can also restructure their own factory," Dr. Nissilä said.

"There is a great interest in Africa and Asia to do the same," said Dr. Collard. "There may be some reluctance about specific aspects because it is a 'big change' generally. But with the criteria of time and efficiency, it wins hands-down."

Breeding economics

To have an evidence-based comparison between the old and the new system, IRRI will conduct a benefit-cost analysis.

"IRRI has never put value to its costs until recently," Dr. Collard recalled.

In terms of full-cost recovery, IRRI's breeding pipeline is working to improve efficiency in three areas. First is the use of knowledge capital. The pipeline should maximize the use of expertise in the Division.

Second is the use of a running budget. Will it be split into a hundred small activities or put in a strategically based operation?

Third is the use of investment. "This is important since it is a technology-driven operation and this will ensure an efficient use of investment," said Dr. Nissilä. "This is where our cross-cutting strategy comes in. For instance, instead of adding seven more molecular labs, we will have one world-class lab!"

With one state-of-the-art facility servicing all breeding pipelines, the use of expertise will be more efficient because activities won't overlap or be duplicated compared to having several scientists working on their own in their respective small labs.

Moreover, Dr. Collard mentioned that the team is implementing computerized systems for data collection and exploring using mechanization in field trials to save on time and labor.

So, with efficient use of knowledge capital, a running budget, and investment capital coming into play, Dr. Nissilä concluded that there is no better way of organizing breeding operations.

Measuring success

In any business operation, one is usually asked how to be sure that the money is used efficiently for its intended purpose. According to Dr. Nissilä, the new breeding pipeline has put in place some indicators of success.

The first is cost-efficiency. What costs what? The second is progress. Have we increased the genetic gain as promised? The third is impact. What products are used in the national programs? How many farmers' seeds were produced? How much income did these products make for farmers?

"And, of course, one more measure of success is making our national partners more independent and their breeding activities more sustainable," Dr. Collard said.

A never-ending story of service

Will there be a time when IRRI's new breeding pipeline will no longer be needed in the future? "Breeding is a never-ending story of service, because the technology upstream is developing," Dr. Nissilä explained. Things that are not normal today will be routine tomorrow. To stay alive in this business, we need to have a very wide product portfolio and diverse expertise.

"Besides, the needs are very wide. For example, in Rwanda, they will need our lines while in India we need collaboration in genomics and biotechnology applications."

The story has started

But, even before the funding of the foundation arrived in November 2013, Dr. Nissilä and his team had started carrying out some changes in IRRI's rice breeding pipeline (See *The pipeline grows stronger* on pages 14-15, Vol. 12, No. 2 of *Rice Today*). They restructured the breeding activities from research-centric to a product-oriented pipeline. Now, the TRB project brings the resources as the fuel to propel the new factory of irrigated variety pipelines.

Many examples of change are brewing in IRRI's new breeding factory. One is the modernization of IRRI's data collection and analysis and the organizing of a load of information on rice breeding.

MECHANIZED HARVESTING of direct seeded breeding trials greatly increases the efficiency of field operations. This is old news for developed country or private company breeding programs, but novel for rice breeding in Asia. Research technician Luisito Caracuel (*left*) watches closely as the first direct seeded irrigated field trial (2014 dry season) is harvested using the combine harvester.

In fact, the Institute has come a long way in terms of its baseline. In IRRI's classic book on breeding called *Rice Improvement* by Jennings, Coffman, and Kauffman,[2] which was published in 1979, data or analysis was not even mentioned, Dr. Collard said. "During that time, plant breeders decided whether a plant was good or bad 'by eye assessment,'" he added.

Today, decision-making strongly depends on data collection and analysis. "After field work, we spend a significant time in our office analyzing data," said Dr. Collard. "Modern techniques such as the use of new statistical analysis, computerized data management, and molecular breeding approaches may be small things. But, the sum of all these spells a great difference in streamlining high-quality data for a more efficient way of breeding."

A significant improvement of IRRI's breeding program in the last 2 years has been its testing of breeding materials at multilocations much earlier than before. With this multilocation trial system and regional hubs, the effectiveness of the development of new varieties will improve. Furthermore, decentralized breeding in hubs allows easy seed transfer of IRRI breeding material to the region.

With the TRB project, Dr. Nissilä and his team in the PBGB Division are looking forward to a future when farmers need not wait long to plant an improved variety apt for the challenges of the time.

"The TRB project aims to accelerate the current breeding pipeline in developing varieties, shorten the breeding cycle, and dramatically increase the efficiency of breeding operations," said Dr. Collard. "But, the big picture of this project is to help resource-poor farmers in Asia and Africa improve their food and income security."

Ms. Reyes is the managing editor of Rice Today.

A COMPUTERIZED STATIONARY thresher is used to dramatically reduce the time for processing data from field trials. Threshing and yield data are generated in minutes per sample and electronically recorded.

[2] See http://sn.im/rice-improvement

THE BRAINS AND BRAWN BEHIND IR8

Dr. Robert Chandler was appointed by the Rockefeller and Ford Foundations to be IRRI's first director general and charged with a mission to develop higher-yielding rice varieties in the face of famine in Asia. In the final analysis, he was certainly the right person in the right place and at the right time to get the ball rolling for rice research in the early 1960s.

One of his outstanding leadership qualities was his attention to careful staffing. The way he assembled an international team of rice researchers, including Peter Jennings, Hank Beachell, Akira Tanaka, T.T. Chang, S.K. De Datta, and many others, was brilliant. Chandler found persons who had the background and who wanted to do the job. He then gave them an environment in which they could excel. The persons had to be well qualified in the basics of their fields but prior knowledge of rice was far less important under Chandler's management than a desire to take the ball and run with it.

Of Chandler, Peter Jennings (see below) said that "he was well named: Robert 'Flint' Chandler. He was 'flinty,' a stereotypical New England Yankee, very direct, hyper-enthusiastic. He maintained a profound barrier between himself and his staff; he was nobody's pal. But with all of that, he was, by far, the best director of an institution I've seen in 50 years."

Dr. Peter Jennings (photos now and then) was IRRI's first rice breeder, charged with heading the then Varietal Improvement Department in 1961. Prior to this, in 1957, the Rockefeller Foundation had sent Jennings, a young plant pathologist with a PhD from Purdue University, to Arkansas, Texas, and Louisiana to learn about rice initially to develop new rice varieties for Latin America.

During his time in Texas, he spent a training period with Henry "Hank" M. Beachell, the rice breeder at the rice research station in Beaumont. Jennings would later recommend that Beachell, whom he called the best rice breeder in the world at the time, be brought to IRRI as a consultant for one month (see more about Beachell below) and ultimately come to IRRI as a second rice breeder on the staff.

The Rockefeller Foundation then sent Jennings to Mexico and Colombia. In Colombia, he developed an excellent rice research and training program. After a trip through Asia in the autumn of 1960, Jennings developed a keen interest in the rice problems of the Asian tropics, so it was only logical that he move on to IRRI to help it develop its fledgling rice research program. He was perhaps the linchpin in the development of IR8.

During that 1960 trip, Jennings and **Sterling Wortman**, a plant geneticist for the Rockefeller Foundation (see below), who later became IRRI's associate director, traveled across Asia, looking at rice varieties, meeting rice scientists, and interviewing prospective trainees and staff for the new IRRI. In India, they saw Taichung Native 1 (TN1), a Taiwanese variety that was actually the first semidwarf variety in the tropics, grown mostly in Taiwan. Having Dee-geo-woo-gen (DGWG) as the dwarf parent (as did the future IR8), TN1 yielded much higher than tall varieties, but was highly susceptible to major diseases and insect pests. So, there was still a great need to develop a much better semidwarf variety.

Jennings recently pointed out there were probably other short-statured rice varieties grown by farmers in the early 1960's, most likely in China. "However, the inheritance of this shortness was unknown," he said. "IR8 was a hugely important discovery, not only for its high-yield potential, but also for helping breeders discover that shortness in these varieties was controlled by a single recessive gene, identified as ***sd-1***. This discovery allowed breeders everywhere to use these genes to produce hundreds of new semidwarf varieties

Jennings and Akiro Tanaka, IRRI's first plant physiologist (see below), conceptualized the traits of a semidwarf rice plant and systematically studied the causes, and effects, of lodging during IRRI's first 3 years. By then, the 38 crosses made using the materials, which might emulate the required traits, including the Peta × DGWG cross, had been made. Ultimately, Jennings discarded the tall, late-maturing plants from the Peta × DGWG cross and others and saved only short, early-maturing plants.

See more details about this in the introduction, *IR8, a rice variety for the ages*, on page 4. Also, Jennings eloquently tells the full story in an IRRI Pioneer Interview from July 2007.

In 1967, after his work in Asia was completed, Jennings returned to Colombia, where he had a long career in Latin America. See his piece on the *Rice revolutions in Latin America* on page 19.

Henry "Hank" M. Beachell (photos at top of page 38 in 1967 with Chandler and John D. Rockefeller III and in 2006 on his 100th birthday with Nobel Laureate **Norman Borlaug**) arrived in 1963 at IRRI from the Beaumont Experiment Station in Texas as IRRI's second full-time rice breeder. Jennings, who was about to depart on a sabbatical leave, wanted to have a breeder of the stature of Beachell to pick up where he had left off. And that he did.

From the third generation (F_3), Beachell selected 298 of the best individual plants. Seeds from each plant were sown as individual "pedigree rows"—the fourth generation (F_4). He selected from row 288 a single plant—the third one—and he designated it IR8-288-3. Its seeds, the fifth generation (F_5), were grown to produce the basic IR8-288-3 seed stock. IR8-288-3 was eventually named as variety IR8.

The seed of IR8 was uniform enough for trials in other countries, but, a couple of years later, Beachell devoted considerable effort to producing an extremely pure strain

that would serve as a uniform seed source of IR8 for the future. Meanwhile, IRRI sent seeds of IR8 and other promising lines to national rice programs across Asia for testing.

In a 1994 video, Beachell confessed tongue-in-cheek that he was foolish enough to actually eat IR8, but that he wanted to eat it right out of the pot. "I didn't want it to set around very long because it would get hard and would indeed scratch the throat," he said. "But cooking and milling quality were secondary; the main thing was production at the time."

For his body of work in Texas, IRRI headquarters, and IRRI outreach in Indonesia, he was named a co-winner of the 1996 World Food Prize. He passed away at his home in Texas just 83 days after celebrating his 100th birthday on 21 September 2006.

Mr. Rodolfo "Rudy" Aquino, a 25-year-old research assistant at the time on IRRI's national staff, worked with Peter Jennings in 1962 to come up with a list of 38 crosses including both short- and tall-statured materials from Taiwan, Indonesia, and elsewhere.

Among his unsung tasks was indeed a historic one in that he was the technician who actually did the pollinating for many of the crosses involving the material mentioned, one of which (Dee-geo-woo-gen × Peta) ultimately led to IR8. He served IRRI for 35 years (1962-97), working his way up to senior associate scientist on the national staff before retiring in 1997. During that time, he was involved in practically every step or phase of breeding rice, singly or jointly with his fellow researchers.

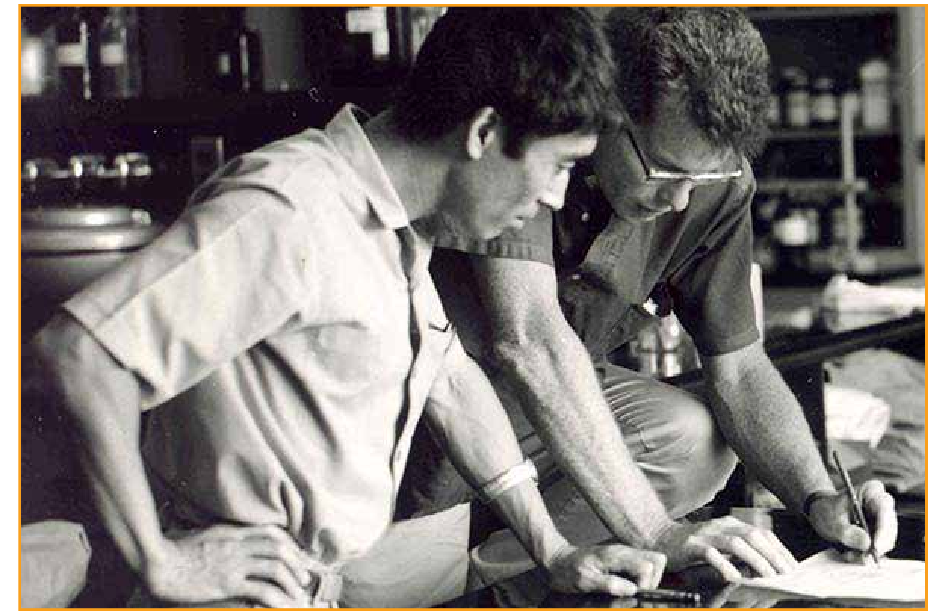
In 1995, he was deservedly named one of *20 great Asians* by *Asiaweek* Magazine. Aquino, who lives in Bi ñan, Philippines, with his wife, Rosalie, wrote recently, "I am grateful for the opportunity to have worked with IRRI. It helped me fulfill my dream to be a rice researcher and worker."

In addition to Aquino, two "estimable" assistants on IRRI's national staff completed Jennings' four-person breeding team: **Rizal M. Herrera** and **Jose C. de Jesus**.

According to Jennings, both contributed mightily. They began at IRRI as research aides in 1961. Herrera spent 36 years at IRRI where he eventually became a senior assistant scientist in the Plant Breeding, Genetics, and Biochemistry Division. De Jesus spent 39 years at IRRI eventually becoming an assistant scientist II.

Dr. **Akira Tanaka**, IRRI's first physiologist, arrived at the institute in April 1962 to head the fledgling institution's Physiology Department. Japanese researchers, such as Tanaka, played a key role at IRRI as it set the stage for the start of the Green Revolution.

According to Peter Jennings, Tanaka was, by far, the most experienced rice scientist at IRRI in those days. The photo shows Tanaka (left) conferring with Jennings during the early 1960s.



"Tanaka's love was mineral nutrition, particularly deficiencies, but his job at IRRI was really to take the tropical rice plant apart, analyze it—the stems, the leaves, the architecture," said Jennings. "He had all this experience and his contribution to the development of IR8 was equivalent to that of a breeder. He helped to define the course, the way. Without Tanaka, I think, IRRI would have struggled longer in developing the first semidwarf rice variety. He lives in my mind as a superb scientist who had an immeasurable impact on the development of semidwarf rice varieties that revolutionized the world's rice production."

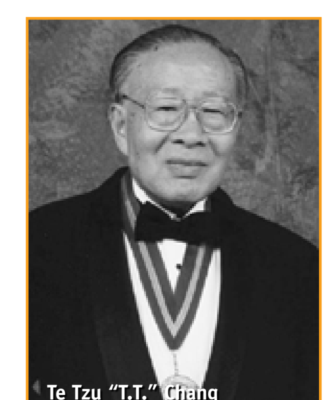
Tanaka, who returned to Japan in 1966 to continue his research career, passed away there on 28 August 2016.

Other contributors

Dr. **Sterling Wortman,** a plant geneticist, who was a key leader in the Green Revolution, worked most of his career for the Rockefeller Foundation, which sought to fight famine in poor regions of the world by developing high-yielding "miracle grains." As already mentioned, in the early days, before becoming assistant, and then associate, director of IRRI (1960-64), he traveled with Jennings around Asia to find rice varieties for crossing and possible new staff for IRRI to set the stage for the breeding program to get on track. Robert Chandler said, "Wortman's contribution to the progress of IRRI in those early years cannot be overestimated." Unfortunately, he passed away in 1981 at the young age of 58.

Sterling Wortman

S.K. De Datta



Te Tzu "T.T." Chang

During the 1966 dry season, Dr. **S.K. De Datta**, a young Indian agronomist who had joined IRRI in early 1964, demonstrated IR8's yield potential. He examined the variety's fertilizer response, along with that of other varieties. "We wanted to determine maximum yields under the best management possible," he said.

De Datta was amazed when he harvested the trials in May. IR8 averaged 9.4 tons per hectare, yielding as high as 10.3 tons per hectare in one trial. Average yields in the Philippines then were about 1 ton per hectare. "The IR8 yield data were the most exciting thing that ever happened to me," recalled De Datta, who spent 28 years at IRRI as an IRRI agronomist and principal scientist (1964-92).

Not much was known about the genetics of tropical rice varieties in the early 1960s, so Robert Chandler, in 1961, hired IRRI's first geneticist, **Te Tzu "T.T." Chang**, from Taiwan, as part of the institute's original group of scientists. Chang began studying the inheritance of plant height. He also assisted Jennings in quickly assembling a large collection of rice varieties, including the short-statured varieties from his native Taiwan.

Chang and Jennings co-signed a letter that was sent to rice workers and experiment stations in around 60 countries requesting any germplasm (in small seed samples) they would be willing to share with IRRI. According to Jennings, the response was wonderful. "Within months, boxes and boxes of seed packages came in," he said. "And within 2 or 3 years, we had several thousand accessions."

From that early assemblage of germplasm, Jennings and his team made the crosses that ultimately resulted in IR8. Chang, who spent 30 years at IRRI collecting and storing rice varieties from all over Asia and the world, founded the International Rice Germplasm Center, one of the predecessors of the institute's Genetic Resources Center. He passed away, at age 78, in 2006. ■

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