It has been said that plant breeding is both a science and an art. If that is the case, those who know and have worked with ASA and CSSA Fellow Sanjaya Rajaram see him as both a persistent, hard-working scientist and a true artist.

In addition to his impressive training in wheat breeding, Rajaram (“Raj” to his friends) has an eye and an innate feel for wheat. The art of breeding is something he tries to pass on to those he has mentored throughout the years.

CSSA Fellow Maarten van Ginkel, Deputy Director General for Research of ICARDA (International Center for Agricultural Research in the Dry Areas) and a former colleague of Rajaram’s, recalls a day out in the fields. Rajaram was with him, selecting from tens of thousands of wheat lines which lines should be included in further research and which should not. Wanting to learn the trade, van Ginkel asked how he was making his decisions.

“Raj moved his forefinger to his mouth and said, ‘Shhh,’” van Ginkel remembers. “The message was clear: don’t talk, watch.”

In addition to his ability to get a feel for the wheat varieties, Rajaram can actually identify varieties in the field just by looking at them. He would even spot mislabeled varieties while walking with colleagues.

“Raj has a tremendous memory for wheat varieties,” says ASA, CSSA, and SSSA member Hans-Joachim Braun, a former student of Rajaram’s and now the director of the Global Wheat Program at CIMMYT (International Maize and Wheat Improvement Center). “We would walk in the fields, and I would give him a pedigree. Once in a while he would say, ‘That looks wrong.’ I’d check it, and he would be right.”

Rajaram’s scientific prowess and artistry was demonstrated for many years as he led the Global Wheat Breeding Team at CIMMYT from 1973–1995 and directed the Global Wheat Program from 1996–2002. In recognition of his work, Rajaram was recently awarded the 2014 World Food Prize. The prize is especially fitting for Rajaram since he learned from and worked with Norman Borlaug, creator of the prize and a famous artist in the wheat breeding world himself.
Inspiration and Education

While Rajaram learned a lot about the art of breeding from Borlaug, his journey in the world of agriculture began long before they met. He was born in 1943 in the Indian state of Uttar Pradesh. Growing up in a rural part of India, Rajaram was surrounded by farming. By the time he attended secondary school, he had realized that agronomy was likely the best field to go into if he wanted to help his local community.

“But that was not the only motivation,” Rajaram says. “When I began university, I very much got interested in the biological sciences. I wanted to go into the more applied side of biological science, and that was agronomy.”

After finishing his bachelor’s and master’s degrees in India, Rajaram was offered a Rotary Club scholarship to the University of Sydney in 1965. There, he received his Ph.D. studying wheat and rust disease resistance with Irvine Watson. Watson had been classmates with Borlaug at the University of Minnesota, and eventually the work that Rajaram was doing on rust resistance came to the attention of Borlaug, who was in Mexico at CIMMYT. Rajaram was offered a two-year post-doctoral fellowship with Borlaug. He gladly accepted the position and began his research in Mexico in 1969.

Working with Borlaug was both challenging and exciting, says Rajaram, adding that he was a tough man. “I like to describe him as a general and a soldier combined. He was not the general sitting back. He was deciding the strategy and fighting the war as well.”

The CIMMYT Years and Beyond

Rajaram worked on a variety of projects, first as a post-doctoral fellow with Borlaug and later in leadership roles at CIMMYT. One large undertaking involved crossing winter wheat with spring wheat to create hearty varieties resistant to disease. Historically, winter wheat was adapted to northern latitudes, while spring wheat was grown in warmer climates, such as Mexico. In the mid-1970s, Rajaram wanted to broaden the horizon of the CIMMYT spring wheat by crossing it with winter wheat varieties and “borrowing” some of the winter wheat characteristics. He was in close communication with Warren Kronstad at Oregon State University, who was doing the reverse—improving winter wheat by crossing it with spring wheat.

Crossing spring and winter wheat was not a simple task. For Rajaram, breeding the two different varieties meant creating cold conditions in Mexico for the winter wheat. Refrigerators were used to house the winter wheat until it would flower at which point it could be transferred to greenhouses. Luckily, funding at CIMMYT was plentiful during this time, so extensive projects such as this were possible.

“This was not an easy undertaking. This was a large-scale mixing of two distinct, different gene pools,” Rajaram explains. “But I was very persistent. I was able to get a

Opposite page: Photo courtesy of ICARDA. Above: The wheat program staff in Obregón, Sonora, Mexico. From l to r: José de Jesús Martínez Santana, Sanjaya Rajaram, Norman Borlaug, and Warren Kronstad. Photo courtesy of CIMMYT.

Above: Sanjaya Rajaram in the field with Norman Borlaug. Photo by Gene Hettel/CIMMYT.

doi:10.2134/csa2014-59-11-10
high degree of stripe rust resistance, drought tolerance, and many other characteristics of the winter wheat phenotype [into spring wheat].”

One of the major problems facing wheat growers in Mexico and other countries around this same time was leaf rust. Rajaram and his colleagues developed wheat varieties that could slow down the development of the disease. Instead of killing the fungus completely (and risking the development of resistant pathogens), the idea was to slow the disease enough that yields would not be affected. To achieve this, Rajaram and his colleagues used multiple genes that had smaller effects instead of a single gene with a strong effect. These genes could then be bred into wheat varieties grown in various areas throughout the world.

“With leaf rust, you don’t want to completely clear the fungus, conceptually. I was not sure in the beginning that this concept would work,” Rajaram says. “But with the help of Ralph Caldwell [at Purdue University], my team was able to build the gene pool with the slow rusting genes inserted. Basically what that does is create stable resistance across global environments.”

Throughout his career at CIMMYT, Rajaram traveled and worked in most of the major and minor wheat-growing regions. He promoted improved varieties and breeding methods in many different areas of the world, such as China, Central Asia, and South America. In Brazil, for example, wheat varieties faced a specific soil problem—aluminum toxicity in acid soils.

Most of the wheat grown around the world does not encounter aluminum toxicity. But when the acidity levels of soils increase, aluminum is released and can very negatively affect plant growth and health. When the CIMMYT wheat varieties were grown in the acidic soils of Brazil, yields suffered. Rajaram established a wheat breeding program between Mexico and Brazil involving government institutions and private centers. They were able to select for a high-yielding CIMMYT-type wheat that was resistant to the aluminum toxicity in the soils.

“The Brazilian wheat was yielding one or two tons per hectare, and the new wheat with aluminum toxicity resistance was giving six or seven tons,” Rajaram says. “This was a tremendous breakthrough for Brazil.”

Rajaram worked on these projects and many more until his retirement from CIMMYT in 2002. In 2005, he began working with ICARDA in Syria to establish and lead an integrated crop breeding program there. He stayed in Syria for eight years and continues to consult with ICARDA. Rajaram is also the owner and director of Resource Seed Mexicana, a small private company specializing in wheat development and promotion. He remains an active, broad-range consultant working in multiple countries including the United States, Mexico, India, and Australia.

Overall, Rajaram’s work during more than four decades has resulted in as many as 480 new wheat varieties. Seeds from these varieties are found in 51 countries on six continents. He has been awarded more than 80 honors throughout the world, and his contributions to the field have been both far-reaching and transformative for scientists, trainees, farmers, and consumers.

Colleagues Recognize Raj

Beyond the boundless work in both breeding and training that Rajaram has done throughout his career, those who worked with him speak highly of his character and his
leadership. For Braun, Rajaram’s respect for those around him is what struck him right away when he went to work at CIMMYT.

“You came to him as a student and immediately you were treated like an important person,” Braun says. “He greeted everybody, no matter if you were a student or if you were a president. He truly values the people. I think that’s one of the reasons why he maintained tremendous relationships over the years with so many people.”

Jesse Dubin worked with Rajaram at CIMMYT and was associate director of the Global Wheat Program when Rajaram was the director. He remembers Rajaram’s hands-on approach to the job and his ability to lead the demanding CIMMYT program.

“The program is very large, and he was able to juggle that and still get out in the field,” Dubin says. “Raj was out there very early in the morning, we were all out there just like Borlaug wanted, to work our tails off and get as much material as possible into the national programs.”

Getting material out to other programs is the name of the game for CIMMYT. The center does not release varieties itself. Instead, it provides germplasm that’s open stock for anyone to use.

“The germplasm we produce is what the economists call intermediate public goods,” Dubin explains. “The national programs work with [CIMMYT’s] material and get it ready to go to farmers’ fields. Those programs release the varieties.” The best products from the national programs then get cycled back to CIMMYT for further breeding efforts.

Rajaram took the responsibility to provide material for other programs, and ultimately the farmers of the world, very seriously. This was a lesson that Braun learned well. As a young, enthusiastic scientist just starting out, Braun had many ideas for improving the program and the wheat they were breeding. Rajaram said that they could try new things, but they must first try them on a small scale. He had clear reasons for this careful approach to progress—he wanted to be sure that any change they made produced a better product than what they had before.

“He said that if we don’t deliver the varieties that the farmers need, it will not be the scientists who suffer, it will be the poor farmers who suffer,” Braun says. “We have a moral obligation to deliver the best varieties to the poor farmers of the world.’ That was his exact quote. I am now in his chair, and I understand extremely well what that means.”

It is for that dedication, along with his work ethic and his great productivity, that those who worked with him feel the World Food Prize was a long time coming. The immensity of his work is widely recognized among those in the field. But the reach of his wheat varieties is unknown by most people throughout the world, many of whom have unwittingly benefited from it. Braun minces no words as he talks of Rajaram’s impact.

“He is, together with Norman Borlaug, the most influential wheat breeder in the last 50 or 60 years,” says Braun. “There are very few, if any, plant breeders in the world who have had a bigger influence over such a long period. His varieties are grown on around 60 million hectares. That is remarkable by itself.”

For van Ginkel, there is another number that exemplifies Rajaram’s far-reaching efforts. “There are so many varieties on so many hectares. I see it as much more, as his impact on human lives,” he says. “His varieties provide the mean global average of annual wheat intake to the equivalent of 2.5 billion people, the majority of those in developing countries.”

And the reach of Rajaram’s impact on people extends even further—to those he taught. “Not only do his wheat varieties feed billions of people,” he explains, “but he has trained more than a thousand young wheat breeders and published many articles showing how others can do the same.”

Van Ginkel then recalls an old expression. Provide a person with a fish, and they can feed themselves for a day; teach them to fish, and they can feed themselves for a lifetime. “That is what Raj achieved,” he says decisively. Using that analogy, Rajaram not only taught others how to fish, but he stocked the pond with the best fish he could find.

C. Schneider, science communications coordinator for ASA, CSSA, and SSSA

Dr. Rajaram working with women farmers in India. Photo courtesy of the World Food Prize.