Bangladesh combats the WHITE PLAGUE

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Salt may be a blessing to good cooking, but, in rice cultivation, it is a deadly sin

Each year, during the boro season (November-May), salinity is so high that a white film of salt covers paddy fields in the coastal areas of Bangladesh. For Bangladeshi farmers, this white color on top of their soil is a warning sign that their land is "sick." Salinity is even dubbed the "white plague" in Australia's newspapers and magazines, which indicates the seriousness of the problem when it strikes.

Salinity affects around 1 million hectares in Bangladesh. Some climate experts say that sea-level rise will cause the country's landscape to become "sicker."

No other country in South Asia is more vulnerable to sea-level rise than densely populated Bangladesh.[1] With higher sea level, more areas would be affected by cyclonic surges; inland freshwater lakes, ponds, and aquifers could also be affected by saline-water and brackish-water intrusion according to the Intergovernmental Panel on Climate Change.[2]

Md. Lutfor Rahman, a 62-year-old farmer in Satkhira, is not an alien to salinity. "Everything is lost to salinity," Mr. Rahman said with a sigh. He was referring to the 10,000 taka (US$135) and the labor he had invested in his 0.2 hectare of land. Now, his family is left with nothing but a cow. "These rice stalks will be used as her feed," said Mr. Rahman.

His next step is to find a job as a laborer and earn a daily wage of 150 to 200 taka ($2–3). "But, only God knows how soon that will be," he added.

The salty challenge

Salt as a seasoning goes well with rice—especially in developing countries, where the poor use salt as a dish to accompany their boiled rice. But, in rice cultivation, salt has a negative effect. Once salt gets to the roots, it becomes detrimental to the whole plant.

According to Dr. R.K. Singh, International Rice Research Institute (IRRI) plant breeder who is now based in Africa, there are two ways to combat the problem of salinity—either change the plant's growing environment (make it normal) or change its genetic architecture so that it can grow in such areas.

"The first approach requires major engineering processes to improve soil quality, which are often expensive for small and marginal farmers," Dr. Singh said. "The second approach, which is breeding crop varieties with *built-in* salinity tolerance, is the most promising. It needs fewer resources, is economical, and is socially acceptable."

For IRRI, making plants tolerate salt stress, up to an extent, is the way to go. The Institute has invested its resources for many years to develop varieties that can solve farmers' problems in saline-prone areas.

Farmers' defense

It has been more than a decade now since the discovery of *Saltol*—a gene that confers salinity tolerance (see *Less salt, please* in *Rice Today*, Vol. 6, No. 2). Glenn Gregorio, an IRRI plant breeder, credited most of salinity tolerance to the development of IR66946-3R-178-1-1, popularly known as FL478. The *Saltol* gene had been incorporated into this variety, and had shown significant tolerance of salinity.

Since then, through molecular-assisted breeding, the IRRI multidisciplinary team on salinity tolerance composed of physiologist Abdelbagi Ismail, molecular biologist Mike Thomson, Dr. R.K. Singh, and Dr. Gregorio as well as country partners in Asia and Africa were able to introgress *Saltol* into popular rice varieties.

One of these varieties is BRRI dhan47, which was released in Bangladesh in 2007. It is an IRRI-bred variety, labeled as IR63307-4B-4-3, which was evaluated and released by the Bangladesh Rice Research Institute (BRRI) in collaboration with the IRRI team for salinity tolerance now headed by Dr. Gregorio.

"The development of BRRI dhan47 is one of the best results of a strong collaboration between IRRI and BRRI," said Dr. Md. Abdul Mannan, BRRI director general. "The transfer of materials from IRRI that can perform in stress conditions and the Institute's assistance in our manpower development through both short- and long-term training have played a key role in this project."

"Now, BRRI dhan47 is creating enthusiasm among Bangladeshi farmers in coastal areas because it is helping them alleviate their poverty and secure their food for the whole year," said Dr. Md. Rafiqul Islam, principal plant breeder on salinity tolerance at BRRI.

Just a bund away from Mr. Rahman's farm, a 0.4-hectare rice field is teeming with ripening rice grains. It is owned by Sirajul Islam, 50. Just like Mr. Rahman, he experimented by planting different kinds of varieties each season, hoping that one could survive the land's salinity.

BRRI dhan47 helps farmers like Md. Lutfor Rahman to overcome salinity in Bangladesh.

[1] Sarwar GM, Khan MH. 2007. Sea Level Rise: A Threat to the Coast of Bangladesh. Internationales Asienforum. Vol. 33 (3–4):375-397.
[2] www.ipcc.ch/ipccreports/sres/regional/300.htm.

The only difference between them is that Mr. Islam tried BRRI dhan47.

"With the way my rice is growing now, I am expecting a good harvest," Mr. Islam said.

"BRRI dhan47 is better," Mr. Rahman readily agreed.

Another farmer in Satkhira, Abu Abdullah, 35, was also enthusiastic. He had good reasons. Three years ago, he could not harvest anything because his fields had become too "salty" for his regular variety. During those lean years, he borrowed money even at a very high interest rate of 2% per week.

He said that he was more than happy to see that rice could once again grow on his "salty" land. And, he is expecting to harvest 4 to 5 tons at the end of the boro season.

Now, Mr. Abdullah hopes to start repaying his loans. "I may not be able to write off all my debts immediately, but, at least, I can program my payments in 2 years," he said.

Just like most farmers in the world, Bangladeshi farmers are mostly subsistence farmers. They cultivate rice on a piece of land for their food.

"When salinity strikes, they can no longer grow food and they can't afford to buy food," explained Dr. Islam. "For these people, there is no option. For them, the difference of having salinity-tolerant varieties is between nothing and something."

And, this "difference" could eventually have an impact nationwide.

(*Left to right*) DR. MD. Rafiqul Islam, plant breeder; Dr. Md. Khairul Bashar, director for research; Dr. Md. Abdul Mannan, director general of BRRI; and Dr. Glenn Gregorio, IRRI plant breeder, discuss the traits of BRRI dhan47 at BRRI research station in Gazipur District, Bangladesh.

"Our food security depends entirely on rice production," said Dr. Md. Khairul Bashar, BRRI director for research. "Even if salinity-tolerant varieties cover only half a million hectares that are affected by salinity, the effect will be tremendous," he added.

Dr. Gregorio is also happy to see this positive result because to make rice withstand salinity is the heart of his team's job at IRRI. "Seeing our work in the field gives us this great feeling of fulfillment," he shared.

"Humble" rice

Aside from its yield, farmers prefer BRRI dhan47 because of its erect flag leaves. Dr. Gregorio described it as a "humble" variety. At a distance, the grains are not noticeable at once because of the crop's green, erect flag leaves on top of the rice fields. But, hidden just below the green flag leaves are stooping panicles heavy with round fat grains—making the grains less conspicuous to birds.

"BRRI dhan47 is not a lodging type," said Dr. Islam. "It remains erect when some varieties bend over from the force of a strong wind.

"The farmers also like its long stalks of 100–110 centimeters, which stay green even at maturity, because they use them as feed for their cattle and roof thatches for their homes," he added.

SALINITY-TOLERANT BRRI dhan47 is not a lodging type, has erect flag leaves, which hide its grains from the birds, and long, green stalks that can be used as roof thatches and feed for the cattle. It can yield 4.0 to 7.2 tons per hectare.

To the rescue

BRRI dhan47 also made its mark in helping the lives of Bangladeshi farmers when cyclone Aila decimated the rice fields in the southern part of the country in 2009. Aila brought with her sea water that encroached on ponds and rivers. "Some fields remained flooded by sea water for some time, thus increasing the salinity in the soil," Dr. Islam said.

The variety was then considered as a solution by the United Nations Food and Agriculture Organization (FAO) to help Bangladeshi farmers recover from the disaster. FAO, through the Department of Agricultural Extension, distributed 62.5 tons of BRRI dhan47 seed to 15,000 farm households affected by the cyclone.

Afterward, an FAO-commissioned study assessed the performance of BRRI dhan47 in the Aila-affected southern region.[3] The results showed that BRRI dhan47 did perform well. Being able to tolerate salinity up to 12 deci-Siemens

[3] Islam SMF. 2010. Impact Assessment Report of TCP/BGD/3204(E): A Focus on Performance Assessment of BRRI dhan47 in the South. Dhaka. FAO. 42 p.

per meter, the variety was able to give farmers a good harvest that ranged from 4.0 to 7.2 tons per hectare, with an average of 5.5 tons. It is found to be profitable, with an average net return of 35,693 taka ($483) per hectare and a mean benefit-cost ratio of 1.73.[4]

Version 2.0

Without a doubt, BRRI dhan47 has made a positive impression on farmers. But, "BRRI dhan47 is not a perfect variety," stated Dr. Gregorio. "Just like an electronic gadget, it is just the 'first model.' The next variety will be even better."

Achieving a better model, however, requires knowledge of what farmers like or how farmers define a "better" variety. This is why IRRI plant breeders, along with their national partners, involve farmers in a process called participatory varietal selection (PVS).

Through PVS, plant breeders were able to learn that, aside from salinity tolerance, farmers in Satkhira prefer the long, slender type of rice grains, while farmers in Sonagazi like short, bold ones. Farmers also favor the nonshattering type of variety because they carry newly harvested panicles from their fields to be threshed at their homes.

Although farmers are satisfied with the amount of rice that BRRI dhan47 yields, it goes without saying that farmers desire a better-yielding salinity-tolerant variety in the future.

Good seed

Saltol contributes about 45% of the salinity tolerance in rice. But, even with this quantifiable success, Dr. Gregorio and his team continue to roll up their sleeves in order to pinpoint the location of the gene on the chromosome. Their aim is to improve the performance of salinity-tolerant varieties and to minimize trial and error in breeding. So, they have embarked on fine-mapping and marker-assisted backcrossing for the *Saltol* gene.

Using new sources of germplasm in mapping more quantitative trait loci (QTLs) for salinity tolerance, they discovered major QTLs on chromosomes 1, 7, 8, and 10. And, they were able to identify three putative candidate genes, *SKC1*, *SalT,* and *pectinesterase*.

"We are presently working toward identifying and combining more genes related to salinity for more stable tolerance," Dr. Gregorio said.

For Dr. Gregorio, developing these varieties for farmers is important. "Everything starts with a good seed," he said. "One may have good management practices, but, if the seed is not tolerant of a stress like salinity, it will fail. A good seed, however, even with fewer good management practices, can yield something somehow."

Moreover, good seeds enable farmers to be more confident in investing in their crops—applying some inputs such as fertilizers.

A FARMER signs up for the participatory varietal selection activity in Pirojpur District, Bangladesh.

A dynamic business

BRRI dhan47 has attracted more players in the business of development. Extension workers from the Department of Agricultural Extension in Bangladesh played an important role in creating awareness about BRRI dhan47. Nongovernment organizations were also involved in extension work and helped in the distribution of seeds.

Even the private sector has played a critical role in the wider and more sustainable adoption of this technology. How? When private companies produce and sell salinity-tolerant seeds, they help ensure that seeds that get to the farmers are "pure and certified" and of high quality. Otherwise, if low-quality seeds reach farmers, the credibility of the technology will naturally suffer.

Too much is at stake when it comes to the delivery of a technology that combats climate-related problems such as salinity. Once salinity reaches the soil and water in farmers' rice fields, it can literally obliterate rice production in just a few days.

Because salinity is a real threat to farmers' food security, IRRI, through its projects, such as the Consortium for Unfavorable Rice Environments (CURE), now funded by the International Fund for Agricultural Development, and Stress-Tolerant Rice for Poor Farmers in Africa and South Asia (STRASA), which is funded by the Bill & Melinda Gates Foundation, facilitates and coordinates the efforts of these different stakeholders in order to distribute seeds of stress-tolerant rice varieties, including BRRI dhan47, to more farmers the quickest way possible.

"As of now, more than 500 tons of BRRI dhan47 seeds have been produced and distributed through STRASA partners in south and southwest Bangladesh over the last 2 years," said Dr. Umesh Singh, senior scientist and STRASA regional coordinator for South Asia. "Approximately 450 tons of seed have been produced during the 2010-11 boro season, which will be available to farmers in the next crop season."

The outlook for the future through the lens of climate change seems bleak, and maybe even scary for rice production in coastal areas. More areas may be affected by salinity. But, with climate-change-ready rice varieties such as BRRI dhan47, the future is brighter. As the "first model" that can combat salinity, BRRI dhan47 is a good start in securing this staple food in saline-prone areas of Bangladesh.

[4] Comparison of the present value of an investment decision or project with its initial cost. A ratio of greater than 1 indicates that the project is a viable one.