Less salt, please

by Peter Fredenburg

Farmers hampered by salt-affected soils in Bangladesh are set for relief as researchers breed salinity tolerance into locally popular rice varieties

JOSE RAYMOND PANALIGAN

DR. ISMAIL (*right*) shows former Bangladeshi Minister of Agriculture M.K. Anwar (*center*) and IRRI senior economist Mahabub Hossain how researchers select for salt-tolerant rice plants in an IRRI greenhouse.

Salt makes its way into the rice paddies of coastal Bangladesh every which way. During the dry season, when the flow of fresh water out to the mouth of the Ganges is weakest, saltwater rides inland on the tide and saline groundwater rises and spreads laterally across the delta. Salinity is less prevalent during the monsoon but can still poison rice crops as it lingers in the soil, percolates into paddies from the brackish ponds of neighboring shrimp farmers, and, during drought, rises as in the dry season.

FAIZABAD (India) farmer Bismillah Khan shows the rice he obtained from the salt-tolerant variety he grew in an on-farm trial. His regular, nontolerant crop is in the field in which he stands. The combination of salt stress and drought meant he had to harvest his crop early and feed it to his cattle. The good performance of the new varieties encouraged him to invest in supplementary irrigation, which allows a good crop even under the prevailing harsh conditions.

"Nearly 1 million hectares along the Bangladesh coast are affected by varying degrees of salinity," reports Zeba Islam Seraj, a professor of biochemistry and molecular biology at the University of Dhaka. "Salinity gradually declines as you go from west to east, from Satkhira, which is highly saline, through Khulna, Barisal, and Noakhali, where salinity is moderate but widespread. Continuing further to the southeast along the Chittagong coast, there are some pockets that are highly saline."

Dr. Seraj is a co-principal investigator of a project in the Generation Challenge Program (GCP)—an initiative to use molecular biology to help boost agricultural production and, consequently, the quality of life in developing countries—that aims to revitalize marginal rice lands by discovering and breeding into popular rice varieties genes for tolerating soils that are saline or deficient in phosphorus (see *Opposites attract … attention* on pages 34-36 of *Rice Today* Vol. 5, No. 2). As the focal collaborator in Bangladesh, she is responsible for the molecular evaluation and selection of rice lines bred by the Bangladesh Rice Research Institute (BRRI) to insert into popular farmers' cultivars the gene *Saltol*, short for "salt tolerance."

Using marker-assisted selection, which allows rapid screening of large numbers of plants, the International Rice Research Institute (IRRI) and its collaborators in the GCP project have mapped *Saltol*—which accounts for 40–65% of the salt tolerance observed—to a small segment of rice chromosome 1. Importantly, *Saltol* and the other identified loci confer salinity tolerance at the seedling stage.

"This is essential in the monsoon season, when salinity tolerance is mainly needed during seedling transplantation and for a few weeks thereafter, until the monsoon rains have washed the salt from the soil," explains Abdelbagi Ismail, the IRRI senior plant physiologist who is the principal investigator of the GCP project.

Rice is susceptible to salinity during two periods of its growth cycle. The first is the seedling stage and the second begins a few days before panicle initiation and ends with flowering and pollination. As Dr. Ismail explains, salt tolerance at the seedling stage is sufficient for the crop grown in the monsoon season, known as *aman*, from June or July to October, provided that there is no drought. This is the traditional season for rice cultivation in Bangladesh, but the spread of tube wells in recent years has allowed farmers to irrigate and grow a second crop in many areas. For this expanded *boro* (dry) season, farmers seed rice in November and transplant seedlings in December and January.

"The seedlings initially grow slowly due to the cold of winter, and the rice is finally harvested in April or May," says Dr. Seraj. "Boro rice needs to be slightly cold tolerant and photoperiod insensitive"—that is, bred to ignore the lengthening or shortening of daylight hours, which plants use to stay synchronized with their natural growing season. Short-duration high-yielding varieties are preferred because of the high cost of pumping irrigation water.

As the boro season coincides with high river water salinity, which begins to rise in February and peaks in April and May, rice grown in this season must tolerate not only moderate salinity during the seedling stage but also much worse salinity during the critical period from panicle initiation to flowering. As food security and farmers' well-being in Bangladesh depend increasingly on boro rice, rice varieties that yield well under high salinity stress are needed more urgently than ever.

The GCP project aims to breed *Saltol* into at least one aman variety and one boro variety already popular with farmers. M. Abdus Salam, the chief scientific officer and head of BRRI's Plant Breeding Division, has crossed a derivative of the traditional variety Pokkali called FL378, which has the *Saltol* gene, with popular aman varieties, and these will be grown out at BRRI's research campus at Gazipur in July 2007. Initial crosses of FL378 and boro varieties are under way, and seeds will be available in April 2007. As Dr. Salam makes the crosses and backcrosses to advance the breeding material, Dr. Seraj will collect leaf samples for testing with newly developed molecular markers (easily detectable stretches of DNA) for both *Saltol* and the popular variety background. Based on the results of this marker-assisted selection, she will advise Dr. Salam and the BRRI team on which plants to use in further crosses.

ABDELBAGI ISMAIL (3)

A FIELD SITE in Uttar Pradesh, India, offers a glimpse of the highly saline soils that confound farmers. Use of salt-tolerant varieties together with proper management—which includes application of organic manure—allowed rice to be grown in these soils for the first time ever (*crop at back*). A screening nursery at the Central Soil Salinity Research Institute Regional Station in Lucknow (*inset*) shows the stark difference in performance between salt-tolerant and regular varieties under salt stress.

The aim is to develop improved varieties that are identical to popular farmers' varieties in every way except that they have the *Saltol* gene and so are able to provide a reasonably good yield under conditions of moderate to high salinity in which salt accounts for 0.4–0.5% of the soil.

Dr. Seraj notes that the various coastal soils of Bangladesh display a range of mineral deficiencies and toxicities. "Some are high in calcium and magnesium, or low in zinc, potassium, and phosphorus, or have toxically high levels of boron and sulfur," she says. "We'll need to develop many different rice varieties that tolerate these specific local stresses if we are to cover the coastal region as a whole."

Salinity and other soil problems in coastal Bangladesh have severely limited the introduction of modern high-yielding rice varieties, as few are adapted to the difficult growing conditions there. Along the severely salt-affected southwest coast, where rice cultivation is largely restricted to the rainy season for lack of fresh water in the dry season, 16 of the 20 most popular varieties are landraces (traditional farmers' varieties), despite offering very low yields of only 2–2.5 tons per hectare.

"The popular landraces of this region are well adapted to the prevailing growing conditions, including soil salinity," observes Dr. Seraj.

Dr. Salam is the site coordinator for a sister project led by Dr. Ismail under the Challenge Program for Water and Food (CPWF), which aims to harness the productivity potential of salt-affected areas of three river basins, including the Ganges. In that project, the partners use the newly developed lines that have the *Saltol* locus and also search for additional sources of saline tolerance.

"*Saltol* and other genes conferring tolerance at the seedling stage could be sufficient for the wet season," Dr. Ismail observes. "However, for the boro season, additional genes for higher tolerance during flowering and pollination are needed."

It is no coincidence that Dr. Salam—who was the 2006 recipient of IRRI's Senadhira Rice Research Award—will handle, through farmer participatory varietal selection, the final testing of the GCP's *Saltol* varieties in 2008.

"The two projects actually work closely together to maximize the benefits," explains Dr. Ismail. "The molecular markers for *Saltol* developed through the GCP will help speed the breeding progress of the CPWF project, and the material will be further tested and scaled out through CPWF activities, as well as other networks. Neither of the two projects could achieve this without the other."

Adapted from GCP 2006 Partner and Product Highlights, *published by the Generation Challenge Program (www.generationcp.org).*