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Global Rice Science Partnership
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The genes that could beat the "AIDS of rice"

Yellow plague. RYMV is the most problematic disease affecting irrigated and lowland rice in West and Central Africa. It is unpredictable and has great potential to wreak havoc in lowland rice.

Pepito Cabauatan/IRRI (insets: AfricaRice)

Rice yellow mottle virus is such a devastating disease in the irrigated and lowland rice fields of West and Central Africa and some other parts of the continent that it has been called the "AIDS of rice" by the farmers. When destructive outbreaks occur, farmers are usually left with little to harvest. Now, using marker-assisted breeding, researchers at AfricaRice are closing in on halting this fearsome scourge.

Rice yellow mottle virus (RYMV), first discovered in Kenya in 1966, is a plant virus that is spread by insects or inadvertently transmitted by farmers through damage inflicted on rice plants during cultivation. Endemic to Africa, RYMV effects intensified in irrigated rice production where

high-yielding varieties had been introduced, since the vast majority of irrigated varieties are extremely susceptible to it.

By 1990, RYMV had spread to almost all West and Central African nations, Madagascar, and Tanzania. It had become a major problem in Mali, Niger, and in the lowlands of Burkina Faso, Côte d'Ivoire, Senegal, and Sierra Leone. But, RYMV can potentially infect lowland rice anywhere on the African continent, according to AfricaRice.

Finding a cure for the "AIDS of rice"

Dubbed by the farmers and consequently the media as the "AIDS of rice," in terms of field losses, the seemingly unstoppable destructive force of RYMV has been measured at 64–100% in Mali and at 58–68% in Niger, according to an AfricaRice report.

AfricaRice, in close collaboration with IRD,[1] in Montpellier, France, has been working on RYMV since 1994, shortly after the first outbreaks. In 1995, AfricaRice discovered Gigante, a traditional rice cultivar from Mozambique, which is virtually immune to the disease. Determining the genetic basis of Gigante's resistance was given top priority. AfricaRice's marker-assisted breeding (MAB) work targeting RYMV has been carried out with IRD and various partners in the national agricultural research and extension systems (NARES).

[1]Institut de recherche pour le développement

AfricaRice (3)

The promise of genes. Dr. Ndjiondjop of AfricaRice (*right*) helps NARES to run their own molecular labs and molecular breeding projects being implemented in Burkina Faso, Mali, and Nigeria. This will facilitate the expansion of molecular research activities throughout sub-Saharan Africa.

Giant step for gene therapy

"Molecular biology research is contributing significantly to defeating RYMV," says Marie-Noëlle Ndjiondjop, molecular biologist at AfricaRice.

Dr. Ndjiondjop identified and mapped Gigante's resistance gene, *rymv1-2*, in 1999. It is the gene that makes Gigante resistant to a whole spectrum of RYMV isolates from diverse locations. Dr. Ndjiondjop then joined AfricaRice to head up the then still fledgling molecular biology facility in Bouaké, Côte d'Ivoire. Starting in 2001, Dr. Laurence Albar added to the work at IRD, where, over the next 5 years, she did the fine mapping, positional cloning, gene identification, and detection of allelic forms.

In 2005, a USAID-funded project enabled AfricaRice to carry out MAB to incorporate *rymv1-2* into elite rice cultivars grown in Burkina Faso, Gambia, Guinea, and Mali and to introduce molecular-marker work into NARES breeding programs.

"We are now using molecular breeding to improve RYMV resistance of West African elite rice cultivars," says Dr. Ndjiondjop.

Harnessing the power of gene resistance

At least two elite varieties were proposed by each NARES program and backcrossed three times to the donor, Gigante. Resistant lines were identified by a combination of "foreground" and "background" markers. Foreground markers occur in the DNA close to the RYMV resistance gene in Gigante and therefore show that any particular plant has the gene. Background markers are from the elite variety and show how similar the plant is to the elite variety. The resulting lines are near-isogenic lines (NILs), that is, they are similar to the elite variety, except that they carry the RYMV resistance gene from Gigante.

The promising resistant NILs underwent further screening using a purified virus isolate under controlled conditions. Trials were conducted at multiple locations in the target countries to confirm their resistance to diverse natural populations of RYMV.

Molecular mechanics. Introducing molecular-marker work into the breeding programs of the NARES can contribute to the rapid creation of new RYMV-resistant varieties. DNA laboratory and field technicians are trained by AfricaRice to transfer resistance genes into elite varieties.

Hope against a rice virus of mass destruction. Plantlets suitable for DNA extraction for marker-assisted selection. The identification of resistance genes *rymv1-2* and *rymv2* is leading to the development of RYMV-resistant varieties.

Spreading the resistance

Fixed (pure-breeding) RYMV-resistant NILs were then sent to the NARES for complete evaluation and incorporation into breeding programs. The best NIL from each elite parent was selected for further trials in the four project countries plus Côte d'Ivoire, Ghana, Liberia, Niger, Nigeria, and Sierra Leone. This activity was funded by USAID through the West and Central African Council for Research and Development. Several of these lines are expected to be released in some of the countries in the near future.

In 2010, AfricaRice and IRD discovered a second resistance gene, *rymv2*, and a new allelic form of the first gene in African rice (*Oryza glaberrima*) varieties. As an insurance policy against the possibility that RYMV could overcome the current single-gene resistance, the AfricaRice breeding strategy is to "pyramid" or introduce two resistance genes into varieties for hot-spot areas.

Making MAB more available to plant breeders

"MAB training activities have helped NARES programs to use the techniques to speed up the process of developing RYMV-resistant rice varieties," says Dr. Ndjiondjop.

AfricaRice has trained 41 NARES researchers in molecular breeding, including four PhD students from Benin, Burkina Faso, Côte d'Ivoire, and Niger. These trainees are dedicated to applying molecular breeding and transferring the technology to other staff members in their respective countries. AfricaRice also helped purchase equipment and establish the first national molecular-biology laboratories in Burkina Faso, Gambia, Guinea, and Mali.

"Trained national staff members need these facilities to introduce MAB into their respective breeding programs and to transfer RYMV resistance genes into elite varieties," says Dr. Ndjiondjop.

She is now helping to strengthen the capacity of the breeding teams, so that they can make the most of their new molecular labs. "This will be the final step to keep the virus at bay so that African farmers will never again be thrown into despair by the sight of their fields being devastated by RYMV," she concluded.