Research Program on Rice Global Rice Science Partnership

Annual Report 2011

Uprooting underground killers

Deadly parasites. Despite its attractive flowers, *Striga hermonthica* is an efficient pest that does its dirty work under the ground. The roots of *Striga* attach to the roots of the rice plants to suck out their nutrients and moisture. Heavy infestation can result in complete crop failure.

AfricaRice (4)

Parasitic weeds of the genus Striga*—also known as witchweeds—are a major threat to upland rice production in several parts of Africa. The roots of* Striga *seedlings penetrate the root cells of host plants, among them, rice, and leave them weak and unproductive. AfricaRice and its partners are making significant headway in the struggle to control* Striga *in rice fields across the continent.*

Attractive as it might seem to have a plethora of pink or orange flowers brightening up a rice field, *Striga* is an extremely sinister bedfellow. These parasitic weeds get their nutrients and water directly from the host plant's root system and the host plant's energy is diverted to support the parasite.

Starving the enemy. Mamadou Cissoko, a PhD student at the University of Sheffield, is looking for postattachment resistance that prevents the development of *Striga* in rice after it has germinated and attached to the roots.

Heavy infestation can result in complete crop failure.

Two main species of *Striga* attack rice in Africa. *Striga hermonthica* is a problem in Côte d'Ivoire, northern Nigeria, and Uganda. It infests about 40% of all cereal-producing areas (including sorghum, millet, and maize) of sub-Saharan Africa, causing US$7 to $13 billion in losses annually, according to figures cited by Infonet Biovision.[1] *Striga asiatica* is prevalent in Madagascar, Malawi, and Tanzania and causes severe damage in rice, particularly in areas with erratic rainfall and poor soil fertility. Both species are difficult to manage because the first 4 to 7 weeks of their life cycle take place underground, inaccessible for mechanical control. *Striga* can be controlled by herbicides, but effective and affordable herbicide technologies are not yet available for rice farmers in Africa.

[1]www.infonet-biovision.org/default/ct/112/pests#612.

Fatal chemical attraction

Each *Striga* plant is capable of producing up to 250,000 tiny seeds, which can remain viable in the soil for many years. *Striga* seeds germinate only in the presence of host-derived chemicals such as strigolactones, as this guarantees the existence of a suitable host to parasitize. Rice roots exude such strigolactones.

"The very small seeds of *Striga* have very small energy reserves," explains AfricaRice weed scientist Jonne Rodenburg. "Hence, they have to tap into host-plant resources very quickly."

Getting at the root of the problem

As part of a project funded by the UK Department for International Development and the Biotechnology and Biological Sciences Research Council, and led by the University of Sheffield, Dr. Rodenburg's team field-screened 18 upland NERICA varieties, their parents, and resistant and local checks for their resistance to both species.

"From work on sorghum and maize, it is known that durable resistance is hard to find," says Dr. Rodenburg. "*Striga* species are genetically highly variable, and so they tend to overcome resistance based on a single mechanism very quickly. It takes only one or a few plants able to circumvent the resistance to reinfest a whole field over a few cropping seasons."

AfricaRice has partnered with Wageningen University to look at preattachment resistance. Muhammad Jamil, a PhD student with Prof. Harro Bouwmeester, screened upland NERICA varieties and their parents in the laboratory to identify and quantify strigolactones.

Varieties that produced significantly fewer strigolactones showed lower *Striga* infestation, whereas those that produced the largest amounts of strigolactones showed the most severe infestation (see box).

Meanwhile, Mamadou Cissoko, a PhD student at the University of Sheffield, under the supervision of Prof. Julie Scholes, was looking for postattachment resistance or mechanisms for preventing the development of *Striga* in rice after it has germinated and attached to the roots.

More information:

Jamil M, Rodenburg J, Charnikhova T, Bouwmeester HJ. 2011. Pre-attachment Striga hermonthica *resistance of New Rice for Africa (NERICA) cultivars based on low strigolactone production. New Phytol. 192(4):964-975.*

Cissoko M, Boisnard A, Rodenburg J, Press MC, Scholes JD. 2011. New Rice for Africa (NERICA) cultivars exhibit different levels of post-attachment resistance against the parasitic weeds Striga hermonthica *and* Striga asiatica*. New Phytol. 192:952-963.*

A genetic block

"The work going on in Sheffield is very exciting," says Dr. Rodenburg. "They have identified the chromosome carrying *Striga* resistance genes." This could lead to the identification of the first *Striga* resistance gene in any cereal crop (the only *Striga* resistance gene currently known is in the legume cowpea).

"Thirty years of research on *Striga* resistance in maize and sorghum have not brought scientists as close as we seem to be after just a few years," Dr. Rodenburg says. "This will pave the way for targeted breeding using molecular markers."

Marker-assisted breeding has the potential to insert a single gene—in this case, the gene for *Striga* resistance—into an already adapted and popular rice variety. This would accelerate the process of making *Striga*-resistant rice available to farmers. However, this step is still a few years down the road.

Sifting through the gene pool

In the meantime, Dr. Rodenburg and his partners are excited by the findings of the pre- and postattachment resistance screening, and by the fact that some NERICA varieties exhibit both resistance mechanisms and also show resistance in the field against both *Striga* species.

"Rice varieties (or breeding lines) that exhibit the complete range of pre- and postattachment and field resistance are just the sort of thing that we were looking for," Dr. Rodenburg says. "The next step in this process will be to screen more adapted varieties and to test a subset of the resistant NERICA varieties in participatory varietal selection trials.

"We will do this in Uganda, where the need for *S. hermonthica* resistance is urgent, and in Madagascar and Tanzania, in some of the most important hot spots for *S. asiatica* in upland rice," he adds.

Screening work in Madagascar, which also includes promising local and advanced varieties, is carried out in collaboration with FOFIFA (the Madagascan national program) and the Centre de coopération internationale en recherche agronomique pour le développement.

Understanding the invisible enemy

In the future, AfricaRice will work with the University of Sheffield, Makerere University, Kenyatta University, and CIAT on identifying multiple quantitative trait loci (QTLs) and candidate resistance genes that underlie rice resistance to different *Striga* species and ecotypes, and characterize—for the first time—*Striga* loci that enable parasites to overcome specific host resistances.

Combined with participatory varietal selection trials, this effort should validate and enhance previous findings and make adapted cultivars with durable broad-based resistance available to farmers.

Standing up to *Striga*. Rice varieties exhibiting resistance to *Striga* (*right*) are able to fight off infestation because they produce significantly smaller quantities of strigolactones, chemicals necessary for the germination of *Striga* seeds (preattachment resistance) or they prevent germinated *Striga* from establishing a viable connection with the host (postattachment resistance).