ELIMINATING AFRICA'S PARASITIC 'WITCH WEED'

Revealing a sensitive germination receptor in parasitic plants brings researchers closer to eradicating a MAJOR SOURCE OF AFRICAN CROP DAMAGE AND FOOD INSECURITY.

From summer to autumn in sub-Saharan Africa, green fields of rice, corn, and other crops are often covered with small purple flowers called *Striga*. These eye-catching flowers are known as 'witch weeds,' as they survive and spread by parasitizing the roots of other species of plants, depriving their hosts of nutrients and water.

Root parasitic plants cause as much as US$10 billion in agricultural damage in their native sub-Saharan Africa each year, and a solution to protect crop fields against such invasions has been elusive.

Striga seeds are tiny and powdery, and each flower can produce more than 100,000 seeds at a time, making it impossible to remove them once they have been scattered by the wind over a field. Furthermore, these seeds are remarkably hardy: they can stay dormant in the dry and barren soil for decades. Then, once they detect host plants nearby, they start to germinate and migrate up their roots.

"In Africa, root parasitic plants pose a major problem for food production," says Yoshiya Seto, an associate professor at Meiji University's School of Agriculture in Tokyo, Japan, who has been studying how receptor proteins in these weeds recognize host plants.

Other work on creating crops that are resistant to those harmful plants doesn't necessarily provide a flexible enough, long-term solution, says Seto. As long as the seeds remain in their fields, famers will be restricted to a small number of resistant crops and their land could be a risky proposition for decades.

"We need to develop effective techniques to control root parasitic plant germination, to eradicate these weeds and help farmers, and people suffering from hunger in Africa, and elsewhere," Seto says.

DO NO HARM

In the 1960s, researchers discovered that the seeds of root parasitic plants are induced to germinate when they sense a chemical molecule called strigolactone, secreted from their host plant's roots. But why the host plants produce and exudate such a chemical into the soil was unknown.

Japan has significant expertise in the chemistry of natural plant products, and researchers have been actively studying molecules associated with the germination of root parasitic plants, despite these crop pests not being highly problematic locally.

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▲ ***Striga*, a beguilingly beautiful root parasitic plant, causes as much as US$10 billion in agricultural damage in sub-Saharan Africa each year.**

In 2005, a Japanese research group reported that strigolactones act as a signal to induce symbiosis with arbuscular mycorrhizal fungi, a microorganism that helps uptake nutrients such as phosphorus and nitrogen from the soil into host plants.

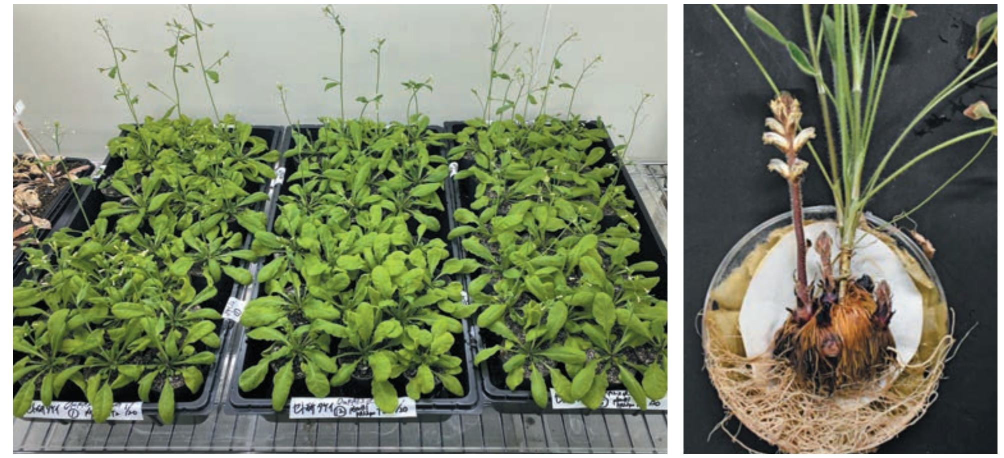
Then in 2008, another Japanese group announced a finding that strigolactone also functions as a plant hormone to regulate shoot branching. "As it seems strigolactones have many roles to play, it's important to preserve important functions for plant growth, while suppressing their parasitic impact," says Seto.

THE RIGHT RECEPTORS

The discovery that strigolactones act as an important plant hormone, as well as the discovery of related receptor proteins, saw researchers focus on the parasite's own receptor proteins, in the hope that they can be modified to be less sensitive to germination by a crop or made more sensitive so that farmers can use strigolactones to force *Striga* to germinate erroneously and die out before planting.

In early 2023, Seto's group, in collaboration with researchers at the Salk Institute for Biological Studies in California, United States, reported on a receptor in another major root parasitic plant, *Orobanche minor*, that is highly sensitive to strigolactones[1].

The finding followed previous work on *Striga* plants in 2015 by three independent groups from Japan and other countries. These researchers looked into a dozen receptors that had been supposedly able to sense strigolactones, and concluded one of them showed an extremely high sensitivity. Work is ongoing, but these groups have yet to develop a viable way to stimulate 'suicidal germination' in *Striga* using this receptor. However, one of these group has discovered a chemical that is quite active as a suicidal germination inducer, notes Seto.



▲ **Japanese root parasitic plant *Orobanche minor* (right) and hundreds of modified *Arabidopsis* (left) were used to gain insights into how to develop a viable suicidal germination strategy to rid crop fields of root parasitic *Striga*.**

Meanwhile, Seto has also been conducting equivalent investigations in the Japanese root parasitic plant *Orobanche minor*, as there are concerns that it may begin impinging on local agricultural lands.

Orobanche minor has at least five genes linked to strigolactone receptors from the *KAI2* divergent (*KAI2d*) group, the same genetic umbrella under which the receptors identified by other groups working on *Striga* in 2015 originate.

Seto's team looked at the function of these genes using a common model plant, *Arabidopsis*, into which each the five genes were introduced.

By adding a synthetic strigolactone analog to seed culture mediums, the researchers observed that modified *Arabidopsis* models expressing two of the *Orobanche minor* genes, *KAI2d3* and *KAI2d4*, could germinate.

The model expressing *KAI2d3* also showed a high sensitivity to the strigolactone molecules, and will be the focus of Seto's next research project.

SUICIDAL GERMINATION

This finding has supported what may be the most promising strategy for getting rid of root parasitic plants yet — seed strigolactone molecules in fields before farmers start to grow crops, forcing the seeds of parasitic plants to germinate in the absence of host plants and then wither away.

This method, however, is thwarted by the limited level of strigolactone produced by plants for viable extraction needed for such a large-scale application.

Seto has a plan. "If we found molecules produced by microorganisms that act on the strigolactone receptor, we could produce a 'suicidal germination inducer' using fermentation," he explains. He is now searching molecules that do this in metabolites produced by plant pathogenic microorganisms.

"We believe that finding such molecules could pave the way to develop a practical and sustainable 'suicidal germination inducer'," he says. And that, he says, could change the future of African food security.

CULTIVATING CARE

Conventional genetic experiments don't work in root parasitic plants, therefore the team examined the function of receptor candidate genes using *Arabidopsis*. While these experiments weren't technically difficult, the process of creating genetically modified *Arabidopsis* was incredibly labour and time-intensive.

The success of the experiments, says Seto owed much to Saori Takei, the first author of the 2023 paper, who is also based at Meiji University and spent several years growing hundreds of modified *Arabidopsis* plants in order to make their experiments possible. This process can seem frustratingly slow, but careful cultivation has the potential to form the foundation to save hundreds of thousands of lives. ■

REFERENCE

1. Takei, S. *et al. Plant and Cell Physiol.* (2023).

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