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TOWARDS SDG 1: HELPING SMALL FARMERS BY SAVING CROPS FROM PARASITIC WEEDS

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YOUNG REVIEWERS:


ANNAMARIA
AGE: 15


ATHENA
AGE: 14


DEAN
AGE: 14


HIND
AGE: 15

The United Nations Sustainable Development Goal 1 (SDG 1) aims to end poverty by ensuring that everyone's basic needs are met for healthy and happy life. Farming can help lift entire communities out of poverty because it provides farmers with enough food to eat and sell to others. Science helps address important challenges to farming, such as pests and weeds, which can destroy farmers' crops and put them at risk of poverty. In this article, we present our research on controlling a weed that harms important cereal crops like rice, millet, sorghum, and maize. Using a method called suicidal germination, weed seeds can be tricked into germinating early, which causes them to die before they can cause damage to crop plants. By using special chemicals to trigger this process, the number of weed seeds in soil

can be reduced, helping farmers grow more crops, maintain healthier soil, and improve their livelihoods.

Watch an interview with the authors of this article to learn even more! (video 1).

ISABELA

AGE: 14

HOW FIGHTING WEEDS CAN HELP END POVERTY AND SAVE OUR PLANET?

Sustainable Development Goal 1 (SDG 1)—No Poverty—is one of the 17 goals set by the United Nations in 2015, aiming to "end poverty in all its forms everywhere". This goal seeks to eliminate the lack of food, water, and sanitation that characterize poverty. SDG 1 is about ensuring that all people's basic needs are met for a healthy and happy life. Even though poverty has been cut in half since 2000, we still need to do a lot more to help people earn better incomes and have easier lives. Food is a basic human need. To make sure we can feed a growing population, famers need to grow more food from their crops. In Africa and other regions, weeds cause big problems for agriculture, including the loss of certain crops. Weeds can also harm the soil, worsening the damage caused to crop plants. In addition, climate change and rising global temperatures are creating more extreme weather events like **droughts**, which further harm the soil and plants. These threats destroy farmers' crops, putting them, their families, and their communities at risk of hunger and poverty.

DROUGHT

The condition of receiving very little rain for a long time, leading to water shortages.

People cannot thrive if they are struggling with hunger and are unable to provide for their families. That is why removing harmful weeds helps advance SDG 1, because it helps crops grow better so farmers can provide more food, and it also helps farmers earn a fair income [1, 2]. Stopping harmful weeds from growing is closely linked to other important SDGs, too. For example, SDG 2—Zero Hunger—focuses on making sure everyone has enough healthy food and supports farming that protects the planet. This goal is also connected to SDG 13—Climate Action—which calls for urgent action on climate change and its effects on people's lives. Finally, it is also linked to SDG 15—Life on Land—which aims to protect and restore nature and stop the damage to our environment. Can you imagine the huge difference we can make just by eliminating these harmful weeds?

THE IMPORTANCE OF CEREALS

A cereal is a grain used for food. Our breakfast foods, especially bread, are made from cereals. Cereal crops like wheat, maize, rice, sorghum, and pearl millet are some of the most commonly grown crops and are vital for human nutrition, as they provide starch, protein, and vitamins. They are also key ingredients in animal feed and serve as raw materials for industries such as poultry feed and cattle feed. Cereals play an important role in the food supply, international trade, and economic growth. Unfortunately, African farmers are facing several challenges in cereal production, including lack of money to buy farming machines and tools, bad land, drought, pests, diseases, and weed **infestations**. On average, the cereal **crop yields** in Africa are 44% lower than global yields. As a result, many African farmers experience poverty and lack of food due to reduced cereal production [1].

INFESTATION

The state of being invaded by pests or parasites.

CROP YIELD

The amount of a crop produced from a given area of land.

WHAT IS STRIGA AND WHAT IS ITS IMPACT IN AFRICA?

Weeds are unwanted plants that stop crops from growing well, as they compete with crop plants for space, soil, water, and nutrients. Weeds cause problems for farming, use up valuable water supplies, and can sometimes destroy entire crops. **Parasitic weeds** are particularly bad. These weeds survive by attaching to crop plants and stealing their food and nutrients, harming them in the process. Root-parasitic weeds—weeds that attach to the roots of other plants—have infested cereal crops in sub-Saharan Africa, the Middle East, and parts of Asia. Among these weeds, Striga plants are the world's worst damaging ones [3].

PARASITIC WEEDS

Weeds that must attach to another plant (called the host) to obtain nutrients or water, often harming the host plant.

Striga is a harmful weed that attacks cereal crops and creates big problems for farmers in Africa. Striga causes huge crop losses, costing billions of dollars every year [1]. Striga hurts two groups: small farmers, whose crops are reduced, and people who buy or sell cereals, as there is less food to go around. Striga is making hunger and poverty worse for millions of people in Africa. This parasitic weed is spreading fast across many African countries, affecting almost half of the farmland [4]. It is hard to control because Striga seeds last a long time, spread easily, and grow in large numbers.

GERMINATION

The process by which a plant grows from a seed into a seedling.

PLANT HORMONES

Molecules produced within plants in very low concentrations that regulate all aspects of plant growth and development.

USING SCIENCE AND TECHNOLOGY TO SOLVE THE STRIGA PROBLEM

To tackle the Striga problem, our group is researching a technology called suicidal **germination**. To understand this approach, it is important to understand the Striga's complicated life cycle (Figure 1) [5]. After flowering, a single Striga plant can produce a large number of seeds that quickly build up in the soil. These tiny seeds can easily spread to new areas *via* wind and rainwater. Striga seeds can stay inactive in the soil for many years [6]. When conditions are favorable (hot and humid), the seeds become active. Once they detect certain chemicals from nearby crop plants, specifically a **plant hormone** called **strigolactone**, the Striga seeds germinate, developing a root-like structure called a **haustorium**, which allows them to attach to the crop plant's roots. After a few weeks, Striga grows out of the soil, makes flowers, and produces seeds for the next generation.

STRIGOLACTONES

A group of chemical compounds produced by roots of plants.

HAUSTORIUM

A rootlike structure from the root of a parasitic plant that grows into or around the root of host plant to absorb water or nutrients.

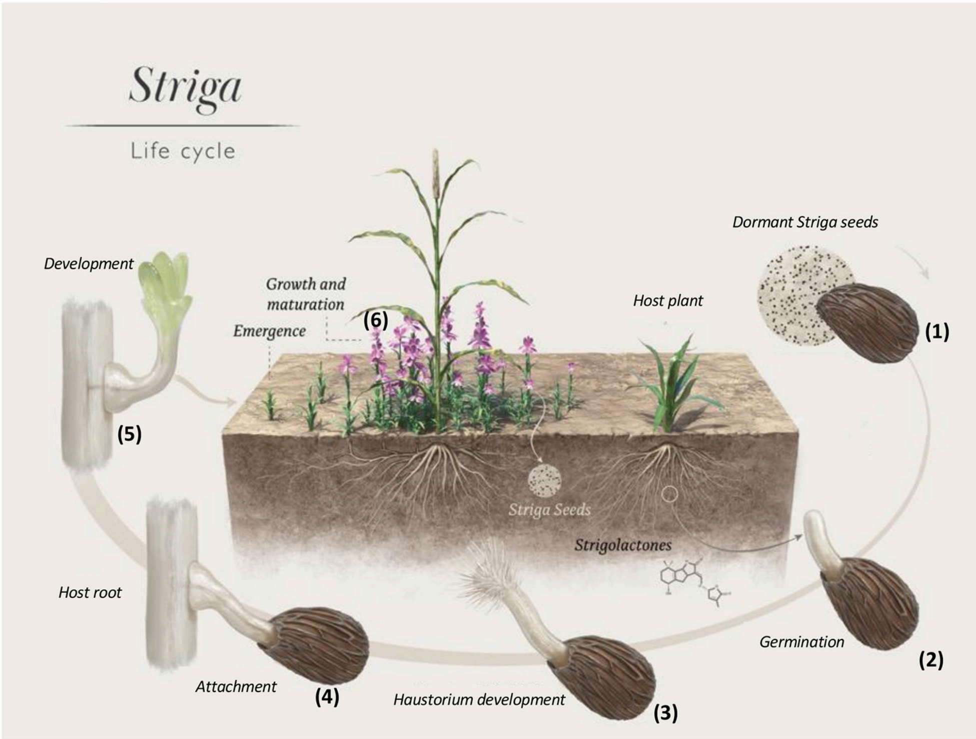

Figure 1

Figure 1

The Striga life cycle. **(1)** Striga seeds remain inactive in the soil for years. **(2)** Under hot and humid conditions, the seeds germinate after getting chemical signals from nearby plant roots. **(3)** They develop a root like structure called the haustorium, and **(4)** attach to the roots of the nearby crop plant to steal its food. **(5, 6)** They then grow out of the soil and produce flowers and new seeds.

To deal with this dangerous weed in African countries, we need to both reduce the number of seeds in infested soils and prevent further seed multiplication [7]. Our strategy uses the Striga life cycle against itself! Imagine Striga seeds as tiny, sneaky thieves hiding in the soil, waiting for a signal to wake up and steal food from crops. So, before planting a crop, our strategy is to trick the Striga seeds by sending out a fake signal, like a prank alarm clock, that awakens the seeds and starts germination. But they germinate too early, when there is no crop yet to steal food from, so they end up using all their energy and starve. This way, the seeds die before they can harm crop plants. The fake signal we send is a chemical produced in the lab that mimics the natural strigolactone hormone that crop plants produce (Figure 2). When the germinated Striga seeds die before they can attach to any crop plant, the number of seeds in infested soils decreases [8].

WHAT ARE THE CHALLENGES OF SUICIDAL GERMINATION TECHNOLOGY?

Although suicidal germination is a really cool and promising technology, it still has some drawbacks. For instance, producing these artificial signaling molecules is expensive. Also, we need to find less expensive ways to apply these chemicals over large pieces of land—like special tractors or watering systems. We also need to consider time of the application of these chemicals perfectly, adding them to soil when the weather is hot and humid, just the way Striga seeds like it.

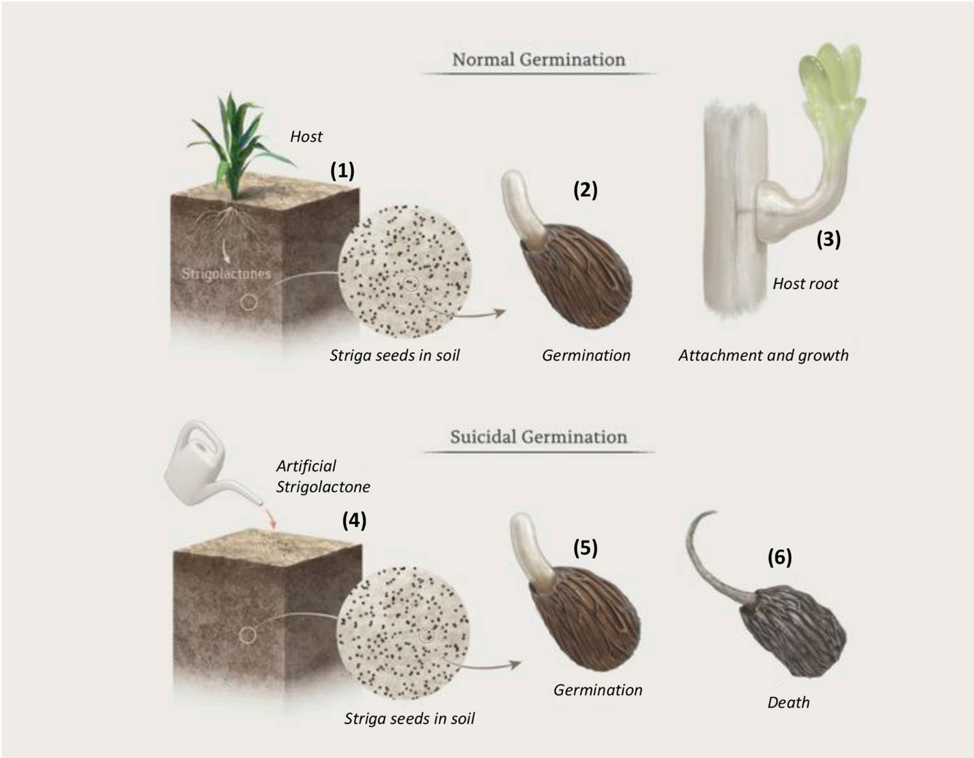

Figure 2

Figure 2

Suicidal germination technology. **(1)** Cereal crops release chemical signals such as strigolactones, which control how plants grow new branches or make it easier for plants to cooperate with helpful fungi in the soil. **(2)** Striga seeds in the soil can detect these signals, which trigger germination. **(3)** Germinated Striga attaches to crop plant roots, which harms the crop. **(4, 5)** By applying artificial signaling molecules similar to strigolactones in fields with no crops, we trick Striga seeds into germinating. **(6)** Without a host crop plant to attach and steal food from, the Striga seeds end up dying.

To overcome these challenges, we developed two new artificial strigolactones named MP3 and Nijmegen-1, and we collaborated with a big farming company to produce and sell them at a lower price. Using these molecules, we can successfully reduce Striga seeds in infested soils. Although these molecules seem to be safe and nontoxic, they still need to be tested further to make sure.

USING RAIN TO HELP SUICIDAL GERMINATION TECHNOLOGY

African agriculture faces challenges such as water scarcity, uneven fields, poor soil, and limited automation. Given these tough conditions, we created an application procedure for African agriculture (Figure 3) [7]. After rainfall on wet soil, we apply signaling molecules to start the germination of Striga seeds present in the soil. After a few days, these germinated seeds die because there are no crop plants around for them to attach to. In this way, we can lower the number of Striga seeds in the infested soils.

First, we tested this technology at King Abdullah University of Science and Technology (KAUST) in greenhouse experiments. We observed good control of Striga attack in these experiments. Next, we applied this technology in farmers' fields in Kenya, Tanzania, Burkina Faso, and Niger. We observed a 50%–70% control of Striga germination in the

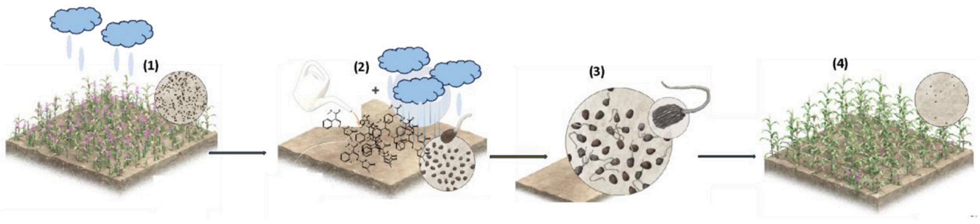

Figure 3

Figure 3

Our suicidal germination protocol. **(1)** Striga seeds become ready to germinate after a few rains. **(2)** When the rainfall starts, our artificial signaling chemicals can be applied to fields. **(3)** A few days later, Striga seeds die because there are no crop plants to attach to. **(4)** This reduces the number of Striga seeds in the infested soil so that cereal crops can then be grown with less chance of Striga attack.

fields. Thanks to our technology, the parasitic weed was controlled, and we observed good growth and yield of the cereal crops. These results show that our technology can help these countries to meet the targets of SDG 1. In addition to Striga, the chemicals we developed can be used to control other types of parasitic weeds. Additional types of chemicals can be added to enhance the effectiveness of suicidal germination technology. After suicidal death of Striga seeds, germination of remaining Striga seeds in the soil can be prevented by using still other types of chemicals.

SUICIDAL GERMINATION TECHNOLOGY CAN HELP FARMERS GROW MORE FOOD AND ESCAPE POVERTY

In conclusion, we have come up with a simple solution to a big problem in African farming. The new method, suicidal germination technology, has shown great results by controlling Striga weeds through lowering the number of their seeds in the soil. This technology will help poor farmers to clean their soil from Striga seeds, which means they will be able to grow a lot more food and earn more money. This progress supports SDG 1 - No Poverty by giving farmers a fair chance to grow healthy crops, improve their harvests, and earn a better living, all thanks to an effective technology that helps protect their fields from harmful parasitic weeds.

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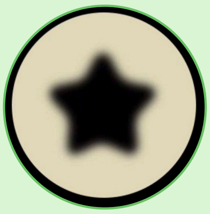
CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

ANNAMARIA, AGE: 15

Hi, my name is Annamaria, and I currently go to The KAUST School. I enjoy swimming, love the beach, adore reading, and have an orange cat named Tiger.



ATHENA, AGE: 14

My name is Athena, and I am a student at The KAUST School, in 9th grade. I enjoy reading books and playing sports.

DEAN, AGE: 14

My name is Dean and I am a student in The KAUST School—in 9th Grade. I enjoy reading books, watching TV, studying, and playing with my cat. I am creative and a visual learner.

HIND, AGE: 15

I have a strong interest in science, math, and problem-solving. I enjoy exploring solutions to real-world challenges and expanding my knowledge of how things work. I am involved in the Duke of Edinburgh program. In my free time, I pursue creative hobbies like playing the violin and reading.

ISABELA, AGE: 14

Hi, my name is Isabela, and I am currently a ninth grader in TKS. I am a visual learner who enjoys hands-on activities such as rock climbing, painting, and gymnastics.

AUTHORS

MUHAMMAD JAMIL

Muhammad Jamil holds a doctorate degree in Plant Physiology from Wageningen University Netherlands and a doctorate in Agronomy from University of Agriculture Faisalabad Pakistan. Currently he is working as Research Scientist in the Bioactives Lab at King Abdullah University of Science and Technology (KAUST) and engage in both basic and applied research across laboratories, greenhouses, and field settings in Europe and Africa. His primary goal of research is to develop practical and effective agricultural practices that enhance crop productivity and input-use efficiency sustainably and cost-effectively. As a weed biologist and physiologist, he possesses unique experience in cereal parasites affecting African agriculture and currently serve as the general secretary of the International Plant Parasitic Society (IPPS). His research mainly encompasses plant physiology, agronomy, and weed biology and ecology, aiming to improve crop yield through modern technologies. He investigates plant signaling (specifically strigolactones) and their interactions with parasites to control parasitic weeds a technology known as suicidal germination technology.

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Salim Al-Babili is a Professor of Plant Science and Bioengineering and the Dean of the Division of Biological and Environmental Sciences and Engineering at King Abdullah University of Science and Technology (KAUST) in Saudi Arabia. His research focuses on developing crops with enhanced agricultural performance and improved nutritional value. With deep expertise in engineering crops to increase provitamin A content, he has made significant contributions to the understanding of carotenoid-related metabolic pathways. His current work spans both fundamental and applied research in plant metabolism and hormone biology, with a particular emphasis on strigolactones and the discovery of growth regulators. In addition, Prof. Al-Babili is pioneering hormone-based chemistries to combat the root-parasitic plant Striga and is developing molecular tools to improve the resistance and performance of pearl millet—an essential and nutritious cereal for hot, arid climates. *salim.babili@kaust.edu.sa