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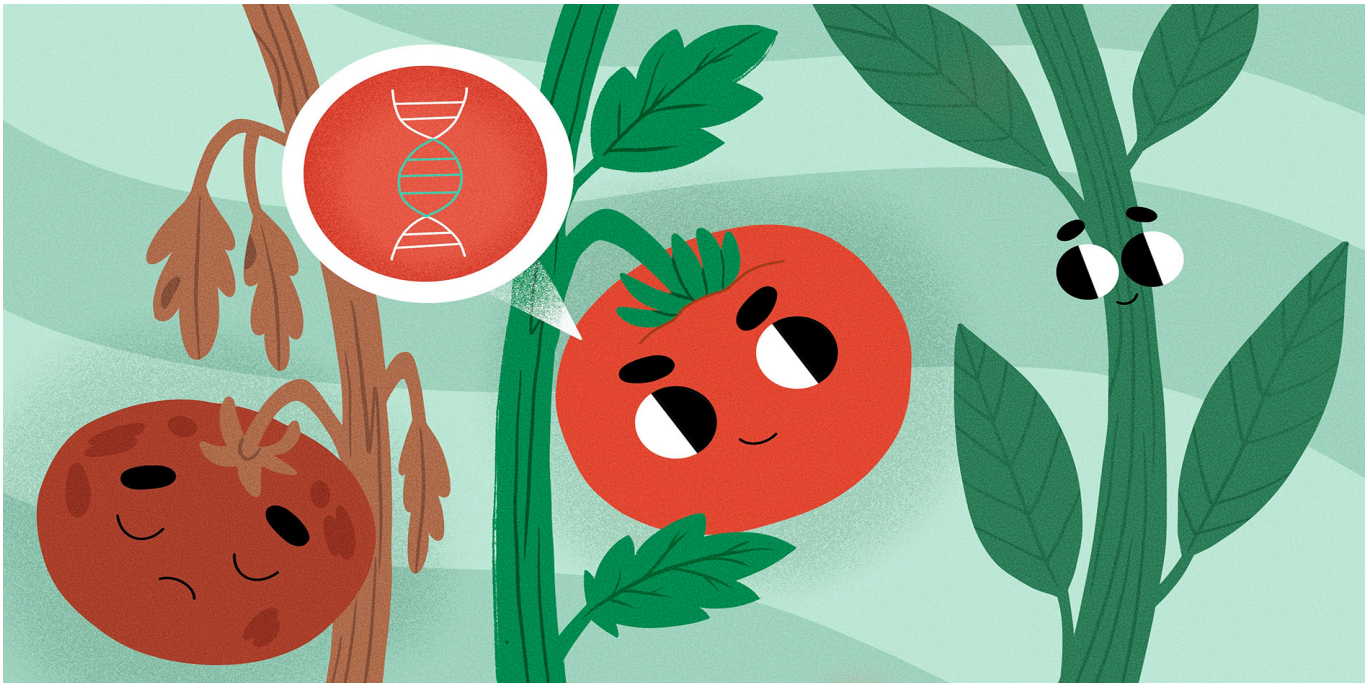
Published: 22 January 2024
doi: 10.3389/frym.2023.1207431



DEVELOPING CROPS THAT CAN FIGHT OFF PARASITIC PLANTS

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Do you know that there are plants that steal food from other plants, damaging and even killing them? Are you curious about how and why they do it? Parasitic plants are unwelcome guests in agricultural fields and they can be extremely hard to get rid of, costing farmers a lot of money. In this article we will tell you about parasitic plants and how scientists are trying to fight them.

WHAT ARE PARASITIC PLANTS?

Most plants produce their own food and oxygen. But how can plants be so efficient and self-reliant? The answer is simple, they perform photosynthesis. Plants provide for themselves with just a few ingredients: water, carbon dioxide, and sunlight. However, some plants are **parasitic**, which means they have a different lifestyle than most plants. The growth of parasitic plants depends either totally or in part on the nutrients produced by another plant, called the host plant.

PARASITIC

Organisms that live on other animals or plants of a different type and feed from them.

The parasitic plant damages the host plant, often causing its death (Figure 1).

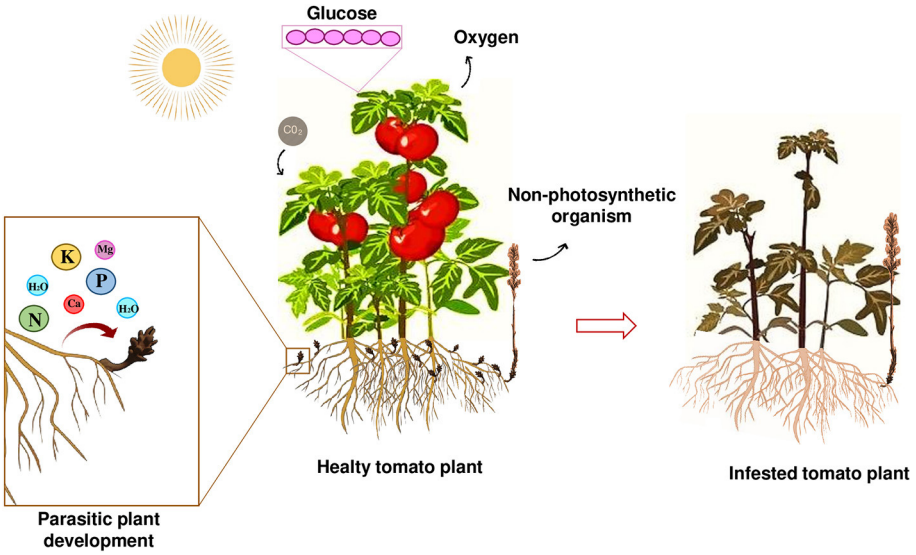

Figure 1

Figure 1

The parasitic plant constantly steals water and nutrients from the roots of the host plant, in this case a tomato plant. This is an example of a holoparasitic plant—the parasitic plant is entirely dependent on the host plant because it cannot perform photosynthesis itself. To spread, the parasitic plant sends up a flowering shoot that produces many dust-like seeds. Eventually, the host plant dies.

There are two main types of parasitic plants. Some are unable to perform photosynthesis and, because of that, these parasitic plants are totally dependent on the host plant. Such plants are called **holoparasites**. The other type of parasitic plants is called **hemiparasites**. These are parasitic plants that need to steal some nutrients from a host plant, but they can perform photosynthesis, too. Parasitic plants can also be divided into those that are specific, meaning they use only one type of host, and those that are generalist, meaning they attack multiple species, without any preference [1].

HOLOPARASITES

Plants that are not capable of photosynthesis and cannot complete their life-cycle without exploiting a suitable host from which they obtain all nutrients and water.

HEMIPARASITES

Plants that can make food through photosynthesis after absorbing water and mineral nutrients from a host plant.

DEALING WITH PARASITIC PLANTS IS DIFFICULT

Parasitic plants are found almost all over the world. When lots of them grow in a farm field, they can reduce the quantity and quality of crops [2]. Parasitic plants can reproduce very quickly and easily, so most strategies used to manage unwanted plants do not work very well on them. The impact of parasitic plants has increased in recent years because they have spread to new areas.

Parasitic plants pose a serious threat to agriculture. As unwanted guests in cultivated fields, they must be removed. However, as we just mentioned, removing them is not always easy and can cost a lot of money. Several control methods have been proposed including chemical (substances used to control undesirable vegetation (herbicides) and that inhibit the germination of seeds), farming practices (crop rotation, fertilization, time of planting), physical methods (soil-disinfestation based on solar heating, burning),

mechanical methods (hand-pulling), and biological methods (introduction of fungi that specifically attack weeds and insects that feed on their seeds). One of the most promising control approaches is to develop crop plants that are resistant to parasitic plants, which you will learn about as you keep reading.

STRIGOLACTONES

Chemical compounds that attract some parasitic plants and make their seeds germinate.

HAUSTORIUM

A rootlike structure capable of penetrating a host plant and absorbing that plant's nutrients and water.

TUBERCLE

A small, thick, rounded structure that develops on the surface of the haustorium, to store nutrients and water.

BROOMRAPES, THE WORST OF THE UNWELCOME GUESTS

Broomrapes are among the most destructive and difficult-to-eliminate parasitic plants for crops, causing farmers to lose enormous amounts of money. There are over 200 species of broomrapes in the world. Some species are holoparsites and others are hemiparasites. Similarly, some are generalists, others are specialists.

Scientists are trying to understand what makes broomrapes such effective parasites, with the hope that this knowledge can be used to fight these parasitic plants. They found that the seeds of broomrapes germinate (sprout) in response to substances that are released by the roots of the host plant, known as **strigolactones**. Strigolactones help the newly germinated plant to detect the presence of roots and to move toward the host plant. At this point, the germinated plant forms a structure called a **haustorium**, which allows the parasite to insert into the roots of its host. From the haustorium, a storage organ called a **tubercle** is formed, which absorbs nutrients and water from the host plant and grows in size. Then, the tubercle develops a single flowering shoot that emerges above ground, producing many dust-like seeds that can survive for more than 15 years (Figure 2).

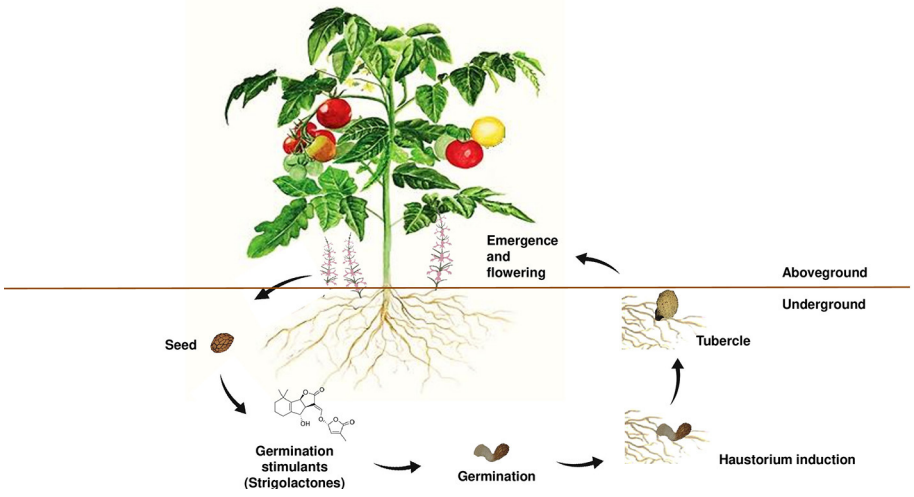

Figure 2

Lifecycle of a broomrape. The dust-like seeds in the soil detect molecules called strigolactones, released by the roots of the host plant, and begin to germinate (sprout). A rootlike structure called the haustorium emerges from the seed, which allows the parasite to insert into the root tissues of its host. A storage organ called the tubercle is formed from the haustorium, which grows as nutrients and water are absorbed from the host. Finally, a single flowering shoot emerges from the tubercle and pushes its way out of the ground to produce a new generation of seeds.

MAKING RESISTANT PLANTS

Parasitic plants seriously threaten the production of tomatoes. However, scientists have found that there is a wild tomato species from the Galápagos Islands, Peru, and northern Chile that is resistant to broomrapes. This wild tomato species does not release strigolactones from its roots and thus does not attract broomrapes and cause them to develop.

Scientists want to create a variety of tomato plant that can resist the broomrapes [3]. There are two ways to create protected tomato plants, one is by **breeding** that variety, and the other option is to use **biotechnology** methods (Figure 3). Breeding plants involves crossing plants with different desirable characteristics, such as high yield and resistance to parasites. Biotechnology methods involve the transfer of a portion of DNA (for example that responsible for resistance to a parasite) from a donor plant to an acceptor. In our laboratory, we are testing various types of wild tomatoes for their resistance against parasitic plants. This will allow us to identify the most resistant varieties that can then be used to produce resistant tomato plants by breeding (Figure 3).

BREEDING

The science of reproducing plants in a way that introduces certain traits that are often desirable, like resistance to parasites or high yield.

BIOTECHNOLOGY

Scientific methods of changing living things to solve problems and develop new and useful products intended to improve human health and society.

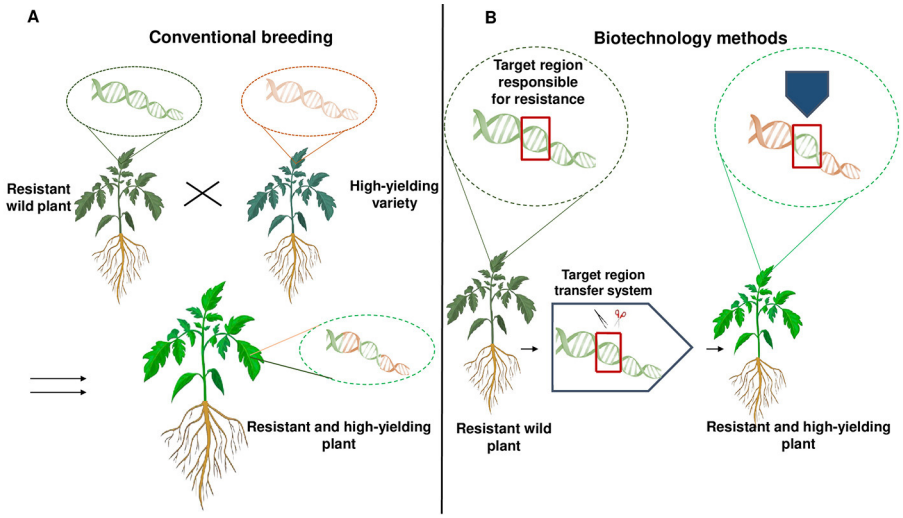

Figure 3

(A) Conventional breeding consists of crossing (mating) plants with the desired characteristics. Here, a resistant wild plant is mated with a typical variety that produces a lot of tomatoes (high yield). Among the offspring, some plants will have both traits—parasite resistance and high yield. **(B)** Using biotechnology methods, the part of the DNA responsible for the resistance to a parasite is identified in a donor plant (i.e., a wild tomato plant) and is transferred into a typical, parasite-sensitive tomato variety using laboratory methods—making that plant resistant to the parasitic plant.

We can also use biotechnology methods to block the production and release of strigolactones from the roots of tomato plants. By doing that, we can prevent the germination of the parasitic plant seeds. You can read more about how we produced plants that are resistant to broomrapes in this Frontiers for Young Minds article.

We believe that breeding techniques and biotechnology methods are the keys to protect crops from parasitic plants, as they are more environmentally friendly than other methods, like the use of chemicals. With the help of many scientists and farmers around the world, and more people like you who understand the threat

posed by parasitic plants, we are hopefully moving toward more sustainable agriculture.

ACKNOWLEDGMENTS

The authors thank Gaetano Aufiero and Carmine Fruggiero for the critical evaluation of the manuscript and all members of the GenoPom lab for the interesting point of view provided during the drafting. This work was supported by the University of Naples Federico II, grant Programma STARPLUS 2020 Finanziamento della Ricerca di Ateneo Linea A, project Dissection of the TOMato-ORobanchaceae interplay: a step toward the development of Resistant Varieties through new plant breeding techniques (TOMORRoV).

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SUBMITTED: 17 April 2023; **ACCEPTED:** 27 December 2023;
PUBLISHED ONLINE: 22 January 2024.

EDITOR: Martha Helena Ramírez-Bahena, University of Salamanca, Spain

SCIENCE MENTORS: Fares Z. Najar and J. Abraham Avelar-Rivas

CITATION: Cannavacciuolo O, D'Angelo D, Nicolia A and D'Agostino N (2024) Developing Crops That Can Fight Off Parasitic Plants. Front. Young Minds 11:1207431. doi: 10.3389/frym.2023.1207431

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.

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Danya is a young scientist who has great aspiration to form her environmentally friendly business. She loves nature and has a fascination with plants.

JOCELYN, AGE: 15

I am from Mexico and I like animals and plants and go out to discover new traditions and cultures. My favorite subjects at school are chemistry and mathematics.

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