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How Viruses Attack on Plants

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Similar to how humans can catch a cold, plants are also susceptible to viral infections. Gaining a deeper understanding of the mechanisms that govern the interactions between plants and viruses is crucial for developing effective management strategies. It also opens the door for using biotechnological approaches to enhance plant immunity and engineer genetic resistance to viral diseases. This area of research is being actively explored by Dr. Hernan Garcia-Ruiz and his team at the University of Nebraska, USA.

Introduction

Plant viral diseases can lead to significant economic losses by reducing crop quality and yield. These effects are especially detrimental to developing countries, where agriculture plays a vital role in ensuring food security. Moreover, stringent sanitary measures designed to prevent the international spread of plant viruses can restrict the global trade of agricultural goods, further exacerbating the challenges posed by these infections.

How Do Plants Become Infected with Viruses?

Viruses can infect various types of plants, including crops, medicinal plants, and ornamentals, often starting with an insect bite. Once the virus enters a single cell, it relies on the cell's machinery to replicate itself, as it cannot reproduce independently. The newly produced viruses spread to neighboring cells, repeating the cycle. Over time, the virus reaches the plant's vascular system, enabling it to travel far from the initial infection site and infect different parts of the plant, from roots to young leaves.

Plants face a challenging battle against viruses, which have evolved strategies to overcome their defenses. To counteract the gene silencing mechanisms used by plants, viruses produce specific proteins capable of disrupting these defenses. They achieve this through various methods, often targeting key components of the plant's defense system for inactivation or destruction.

The outcome of the battle between plants and viruses largely hinges on the balance between the plant's antiviral gene silencing mechanisms and the virus's ability to suppress them. Over the past decade, this dynamic has been a significant focus of research. Dr. Hernan Garcia-Ruiz and his team are advancing critical studies aimed at identifying and characterizing cellular factors that influence plant susceptibility to viruses. By using model plants and RNA viruses, their work explores the mechanisms behind antiviral gene silencing. This research seeks to uncover how viral RNA is distinguished from non-target cellular RNA and to further elucidate the processes involved in antiviral gene silencing.

How Do Plants Defend Against Viral Infections?

Plants combat viral infections primarily through gene silencing, although the exact signal triggering the recognition of a viral presence remains unclear. Research by **Dr. Garcia**-Ruiz and his team has demonstrated that once a virus is detected, the plant's primary strategy is to break down and degrade the viral RNA to prevent the infection from spreading. This intricate defense mechanism depends on a coordinated series of proteins that specifically target and destroy viral RNA.

However, the plant's defense system against viruses is more complex than once believed. It involves multiple layers of responses rather than just identifying the key proteins. For instance, while plants may rely on a primary defense pathway, they also maintain a backup plan. If the preferred mechanism fails, an alternate set of proteins steps in to protect the plant, although this secondary response might be less efficient.

Certain proteins appear to be more effective in defending specific parts of the plant, such as leaves or flowers, while others exhibit a strong response regardless of location. Some proteins function independently, whereas others are more effective when working in coordination with multiple proteins.

The success of a plant's defense against a virus ultimately depends on the intricate balance and simultaneous operation of these mechanisms. Gaining insight into these responses is crucial for understanding how plants naturally resist viruses, why certain viruses exhibit high virulence in specific hosts, and how to develop sustainable antiviral resistance strategies for agriculture.

Viral Countermeasures

Viruses do not simply endure the plant's defense but also initiate their own counterattacks. They employ various strategies, such as targeting and dismantling the plant proteins involved in the defense response. However, each virus has its unique set of tactics, and the specific mechanisms behind these actions are still being uncovered.

Intricacies of Viral Infections in Plants

Plants can sometimes be infected by multiple viruses simultaneously, which can trigger a more robust response that interferes with the plant's defense mechanisms, leading to a complex set of symptoms. **Dr. Garcia-Ruiz's** study of maize plants affected by lethal necrosis in Kenya illustrates this phenomenon.

First identified in the 1970s in Kansas and Nebraska, maize lethal necrosis results from a synergistic co-infection of maize chlorotic mottle virus and other viruses such as sugarcane mosaic virus, wheat streak mosaic virus, or Johnson grass mosaic virus. The typical symptoms of this disease include yellowing leaves that dry from the edges, stunted plants that may be sterile, and malformed or rotting cobs.

In 2017, **Dr. Garcia-Ruiz** and his team observed an unusual symptom in maize plants in Kenya, where the plants exhibited bright yellow stripes with green edges, a deviation from the typical signs of maize lethal necrosis. Upon investigation, they found that the plants were infected with a combination of two, three, or even four viruses, including the maize yellow mosaic virus, which could account for the distinct symptoms. This situation was further complicated by the fact that other plants, such as sorghum and napier grass, were also susceptible to infection, making disease management particularly challenging.

These findings reveal the significant complexity of the maize lethal necrosis epidemic in Kenya. One critical area requiring further research is understanding how these viruses interact to overcome the plant's defenses. Given that the disease continues to spread and poses a growing threat to farmers, **Dr. Garcia-Ruiz's** work is just the beginning. Additional studies are needed to explore the role of silencing suppression and the contributions of various viruses to the disease, which will help in developing more precise diagnostic methods and effective management strategies.

An Ongoing Challenge for the Future

Researchers have discovered a few instances of natural genetic resistance to plant viral infections, and in some cases, they have successfully incorporated these resistant traits into commercial crop varieties. However, these examples are limited, and for many viral diseases affecting essential crops, there is still no natural genetic resistance available. Fortunately, with the advancement of genetic technologies such as genome editing and artificial gene silencing, it has become possible to engineer virus-resistant plants, effectively enhancing their immune responses. This approach, although based on different mechanisms, is conceptually similar to the way vaccines work in animals. To further optimize these strategies, it is crucial to understand how plants recognize viral invaders and how viruses evade the plant's defense systems.

While some viruses are responsible for human diseases, others severely impact key crops, leading to significant financial losses globally and posing a threat to food security in certain regions. The ultimate challenge for plant scientists, including experts like **Dr. Garcia-Ruiz**, is to translate this laboratory knowledge into practical, effective solutions that will help farmers manage plant diseases and protect crop yields.

Fig. 1 Mosaic

Fig. 2 Leaf Curl

Fig. 3 Leaf Roll

Fig. 4 Vein Banding

Source of fig: Virus and viral diseases in plants | PPT.