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Toxins: As a Secret Weapon of Pathogen

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Pathogenic fungi and bacteria produce a variety of toxins that directly affects host cells, causing harm or possibly even the host's death. These toxins, essential weapons of pathogens, can be highly potent even at minimal concentrations. They disrupt cellular processes by interfering with enzymatic and osmotic activities, manifesting as physiological disorders in plants. Toxins are classified based on their origin, interaction with hosts, and specificity. Pathotoxins, phytotoxins, and vivotoxins are categorized by their production and role in disease. Additionally, toxins are either host-specific, targeting particular plant varieties, or non-host-specific, affecting a broad range of species. Prominent examples include HC-toxin, victorin, and T-toxin as host-specific toxins, and tentoxin, tabtoxin, and phaseolotoxin as non-host-specific toxins. This classification highlights the intricate role of toxins in plant-pathogen interactions and provides a foundation for understanding plant disease mechanisms.

Introduction

Different toxins produced by pathogenic fungi and bacteria that harmful to the host plants and cause symptoms such as chlorosis, wilting, necrosis, water soaking, and ultimately plant death. These poisonous substances are pathogen weapons that can be lethal at very low concentrations. The pathogen produces specific chemicals during the host-pathogen reaction, which cause severe damage to plants and are responsible for the disease's symptoms. Certain toxins are specific to the host plant, while others are active on a broad range of hosts (non-host-specific). Toxins harm the host plant by interfering with the enzymatic and osmatic reactions of the cell. Plant diseases arise due to disruptions in physiological processes caused by metabolic reactions. Since deBary introduced a theory of plant disease that is commonly referred to as the "toxin theory,". There are different toxins that are linked to different plant diseases. The primary principle of the toxin theory is that any or all of the disease's symptoms could be caused by a toxin that a pathogen has developed. The theory was rekindled with the discovery of the host-specific toxin victorin.

Classification of Toxins According to Their Source of Origin

A. **Pathotoxins:** The term "pathotoxin" refers to a toxin that a pathogen produces during pathogenesis. They contribute to the emergence of the disease and cause the disease's characteristic symptoms in susceptible plants. They could be created by the infection or by the pathogen interacting with the host. For instance, the cause of the victoria blight of oats: *Cochliobolus victoriae* (*Helminthosporium victoriae*) produces victorin.

B. **Phytotoxins:** The toxins that are created when a host and a pathogen interact, supporting in the development of disease that is only suspected rather than established. They indicate no correlation between the production of toxins and pathogenicity and them mostly non-specific in nature. For example, alternaric acid produced by *Alternaria solani* and lycomarasmine produced by *Fusarium lycopersici*.

C. **Vivotoxin**: A substance that the pathogen produces in the infected host but which is not the primary inciting agent of the disease is known as a vitotoxin. For example, *Fusarium* sp. is caused by fusaric acid wilt.

Classification of Toxins According to Specificity of Toxins

A. Host specific or Host selective:

a) HC-toxin: The HC-Toxin, which is generated by the fungus *Cochliobolus carbonum (Helminthosporium carbonum)* and causes the leaf spot disease in maize, is another illustration of a host-specific toxin. Only specific varieties of maize (corn) are affected by the toxin. While the molecular and biochemical underpinnings of resistance are well understood, the toxin's mechanism of action is currently poorly understood.

b) HV-toxin or Victorin: This toxin is produced by the fungus *Cochliobolus victoriae* (*Helminthosporium victoriae*), which causes blight disease in oats. The Victoria cultivar, acquired from South Africa in 1927, is a source of resistance to numerous illnesses. Because of its resistance to the majority of crown rust (*puccinia coronata avenae*) and smuts (*U. avenae*), this is used in breeding programmes. Victoria blight could be caused by a cultivar that was descended from Victoria is one of the most potent, selective toxins available. *Cochliobolus victoriae*, the fungus that causes oat blight, produces this toxin, which is known to be host-specific and highly mobile in the plant. This disease results in necrosis of the base of the root and stem as well as leaf blight symptoms.

c) T toxin: This toxin is great example of a host-specific one. The common corn disease known as "Southern Corn Leaf Blight" is caused by the fungus *Cochliobolus heterostrophus*, which was formerly known as *Helminthosporium maidis*. This fungus is the source of the toxin. Race T of the fungus first identified in the United States in 1968 is the source of T-toxin. It was discovered that maize cultivars with normal cytoplasm were resistant to both the toxin and the fungus. The toxin primarily damages the mitochondria of vulnerable cells, which prevents the synthesis of ATP.

B. Non-host specific or non host selective

a) Tentoxin: Alternaria produces a toxin called tendin, which is responsible for leaf spots. Inactivating the protein, that binds. inhibits the phosphorylation of ADP to ATP as well. resulting in the suppression of chlorophyll synthesis.

b) Tabtoxin: also known as wild fire toxin, is produced by the tobacco wildfire disease-causing Pseudomonas syringae pv. tabaci bacteria. A yellow halo surrounds necrotic lesions on the leaves in this disease. The majority of bacterial toxins, such as tabtoxin, are monotropic and only have one effect on the host cell, whereas most phytotoxins are pleiotropic and have multiple effects. The antibiotic tabtoxinine β-lactamaction is derived from it as a precursor.

c) Phaseolotoxin: Phaseolotoxin functions as an inhibitor of disease resistance. It binds to the active site of cells to activate the enzyme orithine carbamoyltransferase, which changes ornithine into citrulline.

Conclusion

Toxins play a central role in the pathogenicity of fungi and bacteria, acting as primary agents that disrupt plant physiological processes and cause disease symptoms. Their classification—based on source, interaction, and specificity—provides critical insights into their functions and mechanisms. Understanding host-specific toxins such as HC-toxin and non-host-specific toxins like tabtoxin underscores the complexity of host-pathogen dynamics. This knowledge is instrumental in devising strategies to mitigate plant diseases by targeting toxin production, activity, or host-pathogen interactions. Future research into the molecular pathways and biochemical effects of these toxins could advance the development of resistant crop varieties and enhance sustainable agricultural practices.