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Phytoalexin: A Plant Defensive Tool

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SUMMARY

Phytoalexins are natural substances that are being secreted and accumulated temporarily by plants in response to any stress factor. They have repressive action against fungi, bacteria, nematodes, insects and other stress factors. They are generally lipophilic compounds that have the ability to bypass the plasma membrane and act inside the cell. The toxicity in the plant occurs as a function of their acidic character, the high number of hydroxyl and substituents. This article mainly deals with concept of phytoalexin, their types and mode of action.

INTRODUCTION

Phytoalexins may be defined as "low molecular weight, anti-microbial compounds that are both synthesized and accumulated in plants after being exposed to microorganisms or abiotic stress factors (Van Etten *et. al.*, 1994). The term phytoalexin is derived from two Greek words- phyton meaning plant and alexin mean ward off. The concept of phytoalexin was proposed by Muller & Borger (1940).

Concept of Phytoalexins

Phytoalexins are synthesized only when the host cells come into contact with the pathogen or stress entity. The defence reaction is initiated only in the living cells. The inhibitory material is usually a chemical substance and may be regarded as a product of necrobiosis of the host cell. Phytoalexin is nonspecific and its resistant state is not inherited. However, the defence reaction is confined to the tissue colonized by the pathogen and its immediate neighbourhood.

Importance of Phytoalexins in Defence

The restriction in pathogen development is positively correlated with phytoalexin production. Phytoalexins must accumulate to antimicrobial levels at the infection site in resistant plants or cultivars that could cease the pathogen growth. There is strong evidence that the phytoalexins have vital importance in resistance, and the absence of these compounds would result in enhanced susceptibility (Mert-Turk, 1998; Hammerschmidt, 1999).

Characteristics of Phytoalexins

- Fungitoxic and bacteriostatic at low concentrations.
- Produced in host plants in response to a stimulus (elicitors) and metabolic products.
- Absent in healthy plants
- Remain close to the site of infection.
- Produced in quantities proportionate to the size of the inoculum.
- Produced in response to the weak or non-pathogens than pathogens
- Produced within 12-14 hours reaching a peak around 24 hours after inoculation.
- Host-specific rather than pathogen-specific.

Synthesis and accumulation of phytoalexins are shown in diversified families, viz.,Leguminosae, Solanaceae, Malvaceae, Chenopodiaceae, Convolvulaceae, Compositae and Graminaceae.

Different Types of Phytoalexins

- **Rishitin**: Muller and Borger (1940) were the first to demonstrate that the potato tubers carrying the gene R_1 for late blight resistance responded when inoculated with an avirulent race of *P. infestans* by producing a phytoalexin that inhibited the development of a virulent race.
- **Pisatin**: It is produced in pea in response to inoculation with many fungi or injury. Mainly production of pisatin by peapods occurs on being inoculated with *Monilia fructicola.*

- **Phaseollin**: It is similar to pisatin in chemistry and function. It is fungicidal at high concentrations and fungistatic at low concentrations against *Sclerotinia fructigena*.
- **Glyceollin**: It is formed in soybean plants infected with the fungus *Phytophthora megasperma* f.sp. *glycinea*. Inoculation of fungal races resulted in higher concentrations in incompatible host cultivars than in inoculations of fungal races on compatible cultivars.
- **Gossypol**: It is an ether soluble phenol. It is produced in diseases like leaf spot of wheat (*Septoria tritici*) and black spot of rose (*Diplocarpon rosa*).
- **Capsidiol**: It is a sequisterpene phytoalexin produced in pepper fruits inoculated with a non - pathogenic fungus.
- **Isocoumarin**: Isolated from carrot root tissues inoculated with a fungus non-pathogenic to carrot, *Ceratocystis fimbriata*. It can also be produced in response to a no. of non-pathogenic microorganisms such as *Helminthosporium carbonum, Fusarium oxysporum* f.sp. *lycopersici*.
- **Ipomoeamarone**: It is an abnormal sesquiterpinoid induced in sweet potato tissue infected with black rot fungus *Ceratocystis fimbriata*.
- **Trifolirhizin**: It is a new glucoside which has been isolated from the roots of red cloves. Its structure indicates that it is chemically closely related to pisatin.
- **Medicarpin**: Alfalfa (*Medicago sativa*) inoculated with a series of pathogens and nonpathogens have been studied for phytoalexin production. The antifungal compound was isolated and identified as Medicarpin.
- **Camalexin**: An indolic secondary metabolite is a major phytoalexin in *Arabidopsis thaliana*. Its synthesis is stimulated by a variety of microorganisms.
- **Xanthotoxin**: It is isolated from parsnip root discs inoculated with *Ceratocystis fimbriata.*

Role of Phytoalexin in Plant Defence

Keen (1992) stated several points that signify the role of phytoalexins in disease resistance which includes localization and timing of phytoalexin accumulation in infected tissue. It shows a strong positive correlation of rapid phytoalexin production with incompatible interactions in gene-for-gene plant-pathogen systems. It associates rapid phytoalexin accumulation with resistance genes that condition rapid restriction of pathogen development. Increase of plant tissue resistance by stimulation of phytoalexin production before inoculation.

Mechanism of Elicitation of Production of Phytoalexin

The production of phytoalexins after infection possibly suggest that a product of host-pathogen interaction is involved in triggering phytoalexin biosynthesis. A variety of pathogen- and plant-produced molecules, collectively known as elicitors, will initiate phytoalexin production and trigger other defence responses. The modern synthesis of the gene-for-gene hypothesis states that resistance occurs only when the product of a pathogen avirulence gene interacts with the product of a plant resistance gene. The high degree of specificity in gene-for-gene systems provide a good framework to determine whether the product of the avirulence gene can also act as a race-/cultivar-specific elicitor of defence responses like phytoalexin accumulation. In the past few years, many resistance and avirulence genes have been cloned and sequenced. This evidence is accumulating that the interaction of the resistance gene and avirulence gene products results in the expression of defence genes and ultimately, cessation of pathogen growth. In several demonstrated or putative gene-for-gene systems, resistance has been associated with phytoalexin production.

CONCLUSION

Phytoalexins are simply a component of the disease resistance in plants against various stress. The inhibitory material is a chemical substance and may be regarded as a product of necrobiosis of the host cell. The resistant state is not inate. They show nin specificity in its toxicity towards fungi. Challenge is to identify the complete biosynthetic pathway and the key enzyme to employ these compounds to counterpart high degrees of pathogen stress.

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