

**FACULTY OF AGRICULTURE SCIENCES AND
ALLIED INDUSTRIES**

LECTURE 13

Microbial Toxins in Plant Disease

Toxins act directly on living host protoplasts, seriously damaging or killing the cells of the plant. Some toxins act as general protoplasmic poisons and affect many species of plants representing different families. Others are toxic to only a few plant species or varieties and are completely harmless to others.

Toxins injure host cells either by affecting the permeability of the cell membrane or by inactivating or inhibiting enzymes and subsequently interrupting the corresponding enzymatic reactions. Certain toxins act as antimetabolites and induce a deficiency for an essential growth factor.

A. Toxins That Affect a Wide Range of Host Plants

Several toxic substances produced by phytopathogenic microorganisms have been shown to produce all or part of the disease syndrome not only on the host plant, but also on other species of plants that are not normally attacked by the pathogen in nature. Such toxins, called nonhost-specific or nonhost-selective toxins.

These toxins increase the severity of disease caused by a pathogen, i.e., **they affect the virulence of the pathogen**, but are not essential for the pathogen to cause disease, i.e., **they do not determine the pathogenicity of the pathogen**.

1. Tabtoxin

Produced by the bacterium *Pseudomonas syringae*; *pv. tabaci*, which causes the wildfire disease of tobacco.

Toxin-producing strains cause necrotic spots on leaves, with each spot surrounded by a yellow halo.

Sterile culture filtrates of the organism, as well as purified toxin, produce symptoms identical to those characteristic of wildfire of tobacco not only on tobacco, but in a large number of plant species belonging to many different families.

Tox⁻ strains show reduced virulence and cause necrotic leaf spots without the yellow halo.

Tabtoxin, through tabtoxinine, is toxic to cells because it inactivates the enzyme glutamine synthetase, which leads to depleted glutamine levels and, as a consequence, accumulation of toxic concentrations of ammonia. The latter uncouples photosynthesis and photorespiration and destroys the thylakoid membrane of the chloroplast, thereby causing chlorosis and eventually necrosis.

2. Phaseolotoxin

Phaseolotoxin is produced by the bacterium *Pseudomonas syringae* pv. *phaseolicola*, the cause of halo blight of bean and some other legumes.

Phaseolotoxin is a modified ornithine–alanine– arginine tripeptide carrying a phosphosulfinyl group.

Phosphosulfinylornithine is the biologically functional moiety of phaseolotoxin. The toxin affects cells by binding to the active site of and inactivating the enzyme ornithine carbamoyltransferase, which normally converts ornithine to citrulline, a precursor of arginine. By its action on the enzyme, the toxin thus causes the accumulation of ornithine and depleted levels of citrulline and arginine.

Phaseolotoxin, however, seems to also **inhibit pyrimidine nucleotide biosynthesis, reduce the activity of ribosomes, interfere with lipid synthesis, change the permeability of membranes, and result in the accumulation of large starch grains in the chloroplasts.**

B. Host-Specific or Host-Selective Toxins

A **host-specific** or **host-selective** toxin is a substance produced by a pathogenic microorganism that, at physiological concentrations, is toxic only to the hosts of that pathogen and shows little or no toxicity against nonsusceptible plants.

Most host-specific toxins must be present for the producing microorganism to be able to cause disease.

1. Victorin, or HV Toxin

Victorin, or Hv-toxin, is produced by the fungus *Cochliobolus (Helminthosporium) victoriae*.

The primary target of the toxin seems to be the cell plasma membrane where victorin seems to bind to several proteins. The possible site of action of victorin seems to be the glycine decarboxylate complex, which is a key component of the photorespiratory cycle.

2. T Toxin [Cochliobolus (Helminthosporium) heterostrophus Race T Toxin]

T toxin is produced by race T of *C. heterostrophus (Bipolaris maydis)*, the cause of southern corn leaf blight.

The T toxin apparently acts specifically on mitochondria of susceptible cells, which are rendered nonfunctional, and inhibits ATP synthesis. The T toxin reacts with a specific receptor protein molecule (URF13) that is located on the inner mitochondrial membrane of sensitive mitochondria.

3. HC Toxin

Race 1 of *Cochliobolus (Helminthosporium) carbonum (Bipolaris zeicola)* causes northern leaf spot and ear rot disease in maize. It also produces the hostspecific HC toxin, which is toxic only on specific maize lines.

Resistant corn lines have a gene (Hm1) coding for an enzyme called HC toxin reductase that reduces and thereby detoxifies the toxin. Susceptible corn lines lack this gene and, therefore, cannot defend themselves against the pathogen.