Resisting Attack by a Cereal Killer!

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Homicide in a Wheat Field

Innocent Victims
Susceptible wheat seedlings lacking Hf-resistance genes

Crime Evidence
- Stunting
- Plant death
- Thin stands
- Low seed yield
- Poor seed quality

The Perpetrator
Aliases
- Gall Midge
- Hessian fly

Description
- Juvenile Delinquent (First-instar larva)
- Red in color
- 0.3 mm long
- Squirmy

Modus Operandi
- LURK among developing leaves
- UNRULY Gangs
- RELENTLESS attacks at the crown of the seedling

Caught in the act!!!

Murder Weapons
- Tiny mandibles that stab epidermal cells
- Poisonous saliva containing effectors that manipulate victim

Enslaves the victim to deliver nutrients to the larvae until the victim dies of exhaustion!!!
Resistance Mechanisms
- 2 broad processes that the larvae must alter in the plant to induce susceptibility
- Induce the plant to provide protection in development
- Establish nutrient sink to acquire nourishment
- Resistance means preventing larvae from inducing these changes

Overcoming Resistance Mechanisms
- Induce the plant to provide protection in development against weather and predators
- Some insects induce a gall for protection
- Hessian fly Induces stunting of the whole seedling

Plant stunting and nutrient delivery may be related
- Larvae induce permeability in the leaf elongation zone
- Cells that cannot maintain turgor pressure can’t elongate
- Cell permeability allows nutrients to leak to feeding sites

Permeability in Resistant and Susceptible Plants
- In resistant plants, permeability peaks 2 Days after egg hatch
- Corresponds to timing of defense compound delivery
- In susceptible, permeability increases and spreads over time

Consequences of induced permeability
- Decreased structural integrity results in the thinning and eventual lysis of susceptible plant cell walls seen by Harris et al.

Mechanisms of induced permeability degradation of structural integrity
- CTP mRNA abundance
- Carbohydrate abundance
- Wax monomer abundance

Breeding for Resistance to Hessian fly

- More than 33 R genes identified
- Only 6 are even partially effective in SE United States
- Newest gene, H33, on chromosome 3AS confers resistance to all tested field populations of Hessian fly from SE USA
- Tailor resistance in cultivars to target area of the US

Melissa McDonald

Mechanisms of Defense block prolonged permeability deliver defense molecules

- Resistant plant permeability and defense gene expression peak 2 DAH
- New R Gene H33
- Tailor resistance in cultivars to target area of the US

ROS-generating peroxidase activity increases along with production of superoxide and peroxide

J.Nemacheck, S.Subramanyam

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The Wheat Field’s Sweet Revenge

Subhashree Subramanyam & M. Giovanini

Mechanisms of Defense
silence genes for cell fortification

Lipid synthesis mRNA abundance

HFR-1 mRNA abundance

Fold change

Resistant

Susceptible

Control – Baseline

Days after egg hatch

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Breed for Host Plant Resistance

Use Molecular Genetics for New Resistance Strategies

Subhashree Subramanyam & M. Giovanini

Melissa McDonald
Consequences to the insect

- The larval midgut is the target for many plant defense molecules including lectins, which bind to a class of glycoproteins found on the lumen surface.
- Disruption of midgut microstructure decreases absorption of nutrients.

Cross section showing larval midgut and microvilli.

Lumen contents.

Consequences to the insect

Behavioral and Structural

Feeding for...
A. 3h on Susceptible wheat
B. 3h Starved on filter paper
C. 3h on Resistant wheat (microvilli misshapen, swollen, or destroyed)

After 24h on Resistant wheat
• Microvilli destroyed
• Lumen contents evacuated.

Avirulent larvae exhibit unusual behaviors and stop feeding.

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