Integrating pests into crop models

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Crop models

- Simulate plant development, dry-matter accumulation and yield based on observed soil and weather data
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Crop model development

- Developed based on experiments that run under optimal conditions
- Need to know the plant phenologic development and dry matter development under optimal conditions
- No drought stress
- No heat stress
- No N limitation
- No pests

Images: Pioneer.com, theorganicfarmer.com, NASA.gov
Coupling points of pests

At the level of:

- Inputs
  - Water, light, nutrient
- Rate processes
  - Photosynthesis, transpiration water uptake, senescence
- State variables
  - Number of organs, mass of tissues
Categories of pest damages

- Assimilate sappers

→ Assimilate (C and N) removal as function of pest number or activity

Images: tamu.edu, Wikipedia
Categories of pest damages

- Assimilate sappers
- Tissue consumers

Potato beetle
*Leptinotarsa decemlineata*

Cotton bollworm
*Helicoverpa zea*

→ Tissue type, rate and timing of consumption

Images: J. Hahn mnu.edu; extension.missouri.edu
Categories of pest damages

- Assimilate sappers
- Tissue consumers
- Stand reducers

→ Number (share) & distribution of lost plants + timing (compensation)

Images: A. Sisson, Iowa State University, Bugwood.org; Sreepatra.com
Categories of pest damages

- Assimilate sappers
- Tissue consumers
- Stand reducers
- Photosynthetic rate reducers

→ Level of pest infection on photosynthetic light response curve

Image: msue.anr.msu.edu; M. Grabowski, UMN Extension

Tomato ringspot virus
Secoviridae
Categories of pest damages

- Assimilate sappers
- Tissue consumers
- Stand reducers
- Photosynthetic rate reducers
- Leaf senescence accelerators

→ Added to other senescence drivers (self-shading, aging, drought, N-limitation)
Categories of pest damages

- Assimilate sappers
- Tissue consumers
- Stand reducers
- Photosynthetic rate reducers
- Leaf senescence accelerators
- Light stealers

Images: www.ag.ndsu.edu

→ Number, distribution, height and leaf area of weeds (or damaged crop leaves)
Categories of pest damages

- Assimilate sappers
- Tissue consumers
- Stand reducers
- Photosynthetic rate reducers
- Leaf senescence accelerators
- Light stealers
- Turgor reducers

→ Rate of feeding and secondary tissue death

Verticillium wilt

Images: wikipedia
Challenges

- Single pest often damages via several categories
- Quantify amount of damage per unit or number of pest
- Crucial for predicting yield effect of different pests
Example ex-post pest integration

- Effect of late leaf spot disease (*Cercosporidium personatum*)
- Necrotic lesions → photosynthesis↓ + leaf senescence↑
- PNUTGRO
- Coupling: diseased leaf area + defoliation damage
- UFGA8701.pnx
Time series

Days after Planting vs. Pod wt kg/ha

Legend:
- Red: Pod wt kg/ha (GOOD LEAFSPOT CONTR, TRT 1)
- Yellow: Pod wt kg/ha (NO LEAFSPOT CONTROL, TRT 1)
- Yellow with crosses: Pod wt kg/ha (UFGAS701 PNT, TRT 2)
- Red with crosses: Pod wt kg/ha (UFGAS701 PNT, TRT 2)
Summary and outlook

- Define how pests damage crops
- Ex-post integration of pest damage possible
- But not sufficient
- Dynamic modelling of crops and pests and their interactions
- Consideration of canopy microclimate

Image: Leakey, 2009
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