Application of the Integrated Aerobiology Modeling System to Soybean Rust Forecasting in 2006

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Integrated Aerobiology Modeling System (IAMS)

Spatial and Temporal Considerations

Model domain is 7-50°N latitude and 60-130°E longitude

Grid resolution = 10 km²

Standard pressure levels (surface, 1000, 900, 800, 700, 600, 500 mb)

Model time step = 1 hr
Data Sources

- NOAA Models (winds, temperatures...)
  - Rapid Update Cycle Forecast (RUC)
  - North American Mesoscale (NAM)
  - Global Forecast System (GFS)
- NEXRAD stage-4 radar (precipitation)
- NOAA satellites (precipitation)
- USDA crop statistics (soybean acreage for counties)
- Sentinel plot and mobile scout observations (crop stage, disease severity)
- Epidemiology field studies (aerobiological and epidemiological relationships)
Spore Release in Source Areas

Source area, growth stage, and disease incidence and severity derived from observations

Spore release occurs over a 6 hr mid-morning to mid-afternoon period
Escape of Spores from Infected Soybean Canopy

Spore escape fraction is calculated as a function of surface wind speed
Spore Transport and Mortality

Escaped spores spread out from mid-point of a grid cell along radi comprising a 15° arc centered on the wind vector.

Transport distance along each radi equals the wind run for the period of calculation.

Mortality by UV radiation is proportional to cloud-adjusted, surface solar radiation.
Wet and Dry Deposition of Soybean Rust Spores

Dry deposition occurs when it is not raining and is calculated as a linear function of mean downward vertical velocity for the period of calculation.

Wet deposition occurs when it is raining and is proportional to the precipitation total for the period of calculation.
Soybean Plant Growth and Soybean Rust Disease Submodels

Growing degree soybean crop model that calculates both LAI and phenological stages
Soybean cohorts in a grid cell are “planted” over a 8 week period
Soybean plant emergence and growth are functions of weather variables

Disease progress is a function of temperature, leaf wetness, current infection level, and amount of non-infected foliage
Map Interpretation

Extremely low levels

Moderate levels
Integrated Aerobiology Model System
September 1, 2006

Map Interpretation

- Extremely low levels
- Moderate levels
Integrated Aerobiology Model System

September 2, 2006

Map Interpretation

- Extremely low levels
- Moderate levels
Soybean Rust Observation Maps

1 week after Ernesto

3 week after Ernesto

2 week after Ernesto

4 week after Ernesto
Integrated Aerobiology Modeling System Output

23 September 2006

Aerial Concentration

Wet Deposition

Spores/Land Area (#/ha)

23 September 2006
Integrated Aerobiology Modeling System Output

Aerial Concentration

Wet Deposition

24 September 2006

Spores/Land Area (#/ha)

0 10^0 10^1 10^2 10^3 10^4 10^5 10^6 10^7 10^8 10^9 10^10 >10^10
Integrated Aerobiology Modeling System Output

Aerial Concentration

Wet Deposition

25 September 2006
Sentinel Plants - early to mid reproductive stage ("infection ready")
“Sentinel Plants” on which viable spores were deposited showed latent infections the following week.
The IAMS indicates that the first symptoms of soybean rust would become visible in a few counties scattered across the lower Ohio River Valley on the 11th day after spore deposition.
The first discovery of soybean rust in the region was made on the 13th day after deposition.
One week later, soybean rust had been discovered in numerous counties within the region. The model predicted pustules would become visible before infections were actually found. Possible reasons for the discrepancy are:

1-Use of “sentinel plants” in IAMS
2-Paucity of green soybean plants in field
3-Little urgency to scout
4-Model simplifications
5-Lack of model validation
One month after soybean rust spores had been deposited, symptoms of the disease had been discovered in 36 counties in the region.
Each observation in the histogram above represents the first positive find in a county.

Negative differences (yellow bars) in the histogram indicate that the model predicts symptom appearance prior to observation (i.e., for 1 county the model was 7 days ahead, for 1 county the model was 6 days ahead, for 2 counties it was 5 days ahead…. Positive differences (observations precede model predictions are represented by blue bars.)
Evaluation of Aerobiology Model Using Data from 23-24 September 2006 Soybean Rust Spore Incursion into the Lower Ohio River Valley (KY, IN, IL & MO)

IAMS Model Prediction of Symptom Appearance vs Discovery

Target “hypothetical” distribution

Observed distribution

# of Obs. = 36
Difference Between Prediction and When County Turned Red on USDA Website

IAMS Model
Prediction of Symptom Appearance vs Discovery

Target “hypothetical” distribution

Observed distribution # of Obs. = 36

IAMS Model
Prediction of Symptom Appearance vs Discovery

IAMS Model
Prediction of Symptom Appearance vs Confirmation

# of Obs. = 36

Number of Observations in Category

Difference (days)

-25 -23 -21 -19 -17 -15 -13 -11 -9 -7 -5 -3 -1 1 3 5 7 9

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Anticipated Changes in Aerobiology Model for 2007

- Sentinel soybean plant ("infection-ready") - risk assessment tool for mobile scouting.
- Improved canopy escape parameter - function of wind speed and crop stage (results of field research in FL).
- Automated soybean growth stage "biofix" for sentinel plot model runs.
- Adjustment of infection development for drought and extreme temperatures.
- Expanded multiple model ensemble approach with updated training for human interpretation.