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INTEGRATION OF SOYBEAN RUST RESEARCH – USDA PERSPECTIVE

A. Rick Bennett
USDA – Agricultural Research Service
Integration of Soybean Rust Research – USDA Perspective

A. Rick Bennett
USDA-Agricultural Research Service

Phone: 301-504-6915
Email: rbennett@ars.usda.gov
What is soybean rust?

Why are we concerned?

Where does soybean rust occur?

What are the symptoms, biology and host range?

What are we doing about it?
Soybean Rust

Caused by two species of fungi:

- *Phakopsora pachyrhizi*
  - aka “Old World” isolate
  - More aggressive pathogen

- *Phakopsora meibomiae*
  - aka “New World” isolate
  - Not as aggressive
**Soybean Rust - Phakospora pachyrhizi**

- Not seed borne
- Readily spread by wind
- Will not over winter in the midwest
- Needs live host to survive/reproduce
Why are we concerned about soybean rust?

- The lack of resistance in U.S. commercial soybean cultivars and germplasm accessions.

- The demonstrated ability of the pathogen to drastically reduce yield on soybean in countries where the disease occurs.

- The ability of urediniospores of rust fungi, as a group, to quickly disseminate the pathogen, frequently over long distances.

- Reports of the disease occurring in new locations.
## Recent Reports of Soybean Rust

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hawaii</td>
<td>1994</td>
</tr>
<tr>
<td>Uganda</td>
<td>1996</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>1998</td>
</tr>
<tr>
<td>South Africa</td>
<td>2001</td>
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<tr>
<td>Paraguay</td>
<td>2001</td>
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<tr>
<td>Brazil</td>
<td>2002</td>
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<td>Argentina</td>
<td>2002</td>
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<tr>
<td>Bolivia</td>
<td>2003</td>
</tr>
<tr>
<td>Columbia</td>
<td>2004</td>
</tr>
<tr>
<td>U.S.</td>
<td>2004</td>
</tr>
<tr>
<td>Country</td>
<td>Yield loss (%)</td>
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<tr>
<td>---------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Australia</td>
<td>60-70</td>
</tr>
<tr>
<td>India</td>
<td>66</td>
</tr>
<tr>
<td>Indonesia</td>
<td>81</td>
</tr>
<tr>
<td>Japan</td>
<td>15-40</td>
</tr>
<tr>
<td>Philippines</td>
<td>30-80</td>
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<tr>
<td>South China</td>
<td>10-50</td>
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<tr>
<td>Taiwan</td>
<td>12-80</td>
</tr>
<tr>
<td>Thailand</td>
<td>10-40</td>
</tr>
<tr>
<td>Vietnam</td>
<td>50-100</td>
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</table>
Soybean Rust Causes

- Premature defoliation
- Increase in number of unfilled pods/plant
- Decrease in number of normal pods/plant
- Decrease in number of seeds/plant
- Decrease in weight of seed/plant
- Decrease in 1000-seed weight
- Decrease in germinability of seed
Symptoms
Hosts of Soybean Rust

LEGUMES (Papilionoideae)
- Cultivated Crops:
  - *Glycine max* (soybeans)
  - *Phaseolus lunatus* (lima and butter beans)
  - *Phaseolus vulgaris* (green beans, kidney beans)
  - *Vigna unguiculata* (cowpeas)
  - *Cajanus cajan* (pigeon peas)
  - *Pachyrhizus erosus* (yam bean, jicama)
- Ornamental plants:
  - Hyacinth bean, lupine, royal poinciana
- Wild hosts:
  - Kudzu, sweet clover
Current Research Efforts

- Develop rapid diagnostic methods.
- Fungicide evaluations.
- Screen soybean germplasm for resistance.
- Develop risk assessment model.
- Evaluate remote sensing for monitoring disease spread.
- *Phakopsora* genome sequencing project and gene expression studies.
- Assess the genetic diversity of the pathogen population.
- Develop methods for “fingerprinting” pathogen isolates.
- Characterize gene and protein expression in an “immune reaction”.

Identification Methods
DNA-based Diagnostics

- Detection of soybean rust pathogens
  - Spores
  - Infected plant material

- Differentiation of soybean rust pathogens
  - *P. pachyrhizi*
  - *P. meibomiae*
DNA-based Diagnostics

- Rapid detection methods
  - Traditional PCR
    Identification in 1 to 2 days
  - Real-time PCR
    Identification in less than 1 day
Control/Management Strategies for Soybean Rust

- Short-term Fungicides
- Long-term Resistant varieties
Photo courtesy of Dr. Clive Levy, Commercial Farmers Union of Zimbabwe
# Fungicide Types

<table>
<thead>
<tr>
<th>Protectant</th>
<th>Curative</th>
</tr>
</thead>
<tbody>
<tr>
<td>• +/- Absorbed</td>
<td>• Absorbed</td>
</tr>
<tr>
<td>• +/- Translocates</td>
<td>• Translocates</td>
</tr>
<tr>
<td>• Prevents infection</td>
<td>• Kills fungal tissue</td>
</tr>
<tr>
<td>• Use pre-infection</td>
<td>• Use after infection</td>
</tr>
<tr>
<td>• Strobilurins and Chlorothalonils</td>
<td>• Triazoles</td>
</tr>
</tbody>
</table>
Fungicides Registered for Soybean Rust

Chlorothalonil
- Bravo (Syngenta)
- Echo (Sipcam Agro)

Strobilurins
- Quadris (Syngenta)
- Headline (BASF)
General Guidelines for Fungicide Use

- First application needs to be at or soon after first flower - earlier applications have not provided an economical benefit
- None to three applications may be needed
- 14 - 20 days between applications - depends on environment, fungicide and rate of use
- The fungicide needs to penetrate the canopy
A Brief Summary From the USDA-ARS International Fungicide Efficacy Program
Fungicide Efficacy Trials in Southern Africa and South America

Trials done in Paraguay, and Zimbabwe in 2002-03 and 2003-04 growing seasons.

Fungicides that are or could be used in the USA

Defined protocol including internal spreader rows and early maturing border

Split plot design to compare 2 vs. 3 applications
Brief summary of the 2004 fungicide efficacy data.

- All the products registered and labeled for management of soybean rust or on the Section 18 Emergency Exemption list reduced disease severity and protected yields, but not equally.
- Fungicides differed in residual activity when the 2 vs. 3-applications were compared for both yield and final disease severity.
Resistance
A set of 18 bordered 6 X 12 cell planting flats allows for 1144 accessions with checks to be evaluated as single plants in the first screen. A second replicated screen of 375 to 380 accessions uses the same design.
Germplasm Screening: International Collaborators

- **China:**
  - Dr. Ma Zhanhong
    China Agricultural University

- **Thailand:**
  - Dr. Srisuk Poonpolgul & Mrs. Montha Nuntapunt
    Thailand Dept. of Agriculture

- **Zimbabwe:**
  - Dr. Clive Levy, Commerical Farmers Union of Zimbabwe
  - Mr. Jacob Tichagwa, Seed Co.

- **South Africa:**
  - Dr. Rikus Kloppers
    PANNAR Seed

- **Brazil:**
  - Dr. Tadashi Yorinori
    Embrapa soja

- **Paraguay:**
  - Mr. Wilfrido Morel Pavia
    Centro Regional de Investigacion Agricola
Protocols for Sentinel Plots, Mobile and Industry Monitoring

Collaboration Between ARS, CSREES, APHIS, State Land Grant Universities And Industry

www.soydiseases.uiuc.edu
Monitoring Program

1. Fixed-site sentinel program
2. Mobile survey
3. Industry survey
4. Sample submission through National Plant Diagnostic Network
5. International monitoring
Objectives of Monitoring

1. Serves as a warning network for new disease observations - provides a “real time” map on the occurrence of soybean rust
2. Quantify timing of spore production in source areas - this will help drive the aerobiology prediction system
3. Provide epidemiological data on spread over time and space
Pathogen Characterization

- Reaction phenotype
- DNA fingerprinting
- Molecular signatures
Genomic Approaches

- Comparative genomic sequencing project
  - *P. pachyrhizi* & *P. meibomiae*

- Gene expression (Expressed Sequence Tags)
  - Germinating urediniospores
  - cDNA libraries from infected soybean plants

Cooperative Agreement between USDA-ARS & DOE/Joint Genome Institute
Expected Outcomes of the *Phakopsora* Genome Sequencing & EST Projects

- Identify biochemical pathways as targets for new fungicides.
- Identify target sequences for molecular diagnostics and isolate identification.
- Suggest candidates for genes mediating host-pathogen responses by identifying those with a signature of strong positive selection.
- Determine evolutionary relationships with other fungi.
Ultimately…

Identify genes involved in resistance and develop transgenic plants with broad spectrum resistance, able to combat the soybean rust pathogen.
National Strategic Plan for the Coordination and Integration of Soybean Rust Research

Asian Soybean Rust

*Phakopsora pachyrhizi*