U.S. Department of Agriculture

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INTEGRATION OF SOYBEAN RUST RESEARCH – USDA PERSPECTIVE

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Integration of Soybean Rust Research – USDA Perspective

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- 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

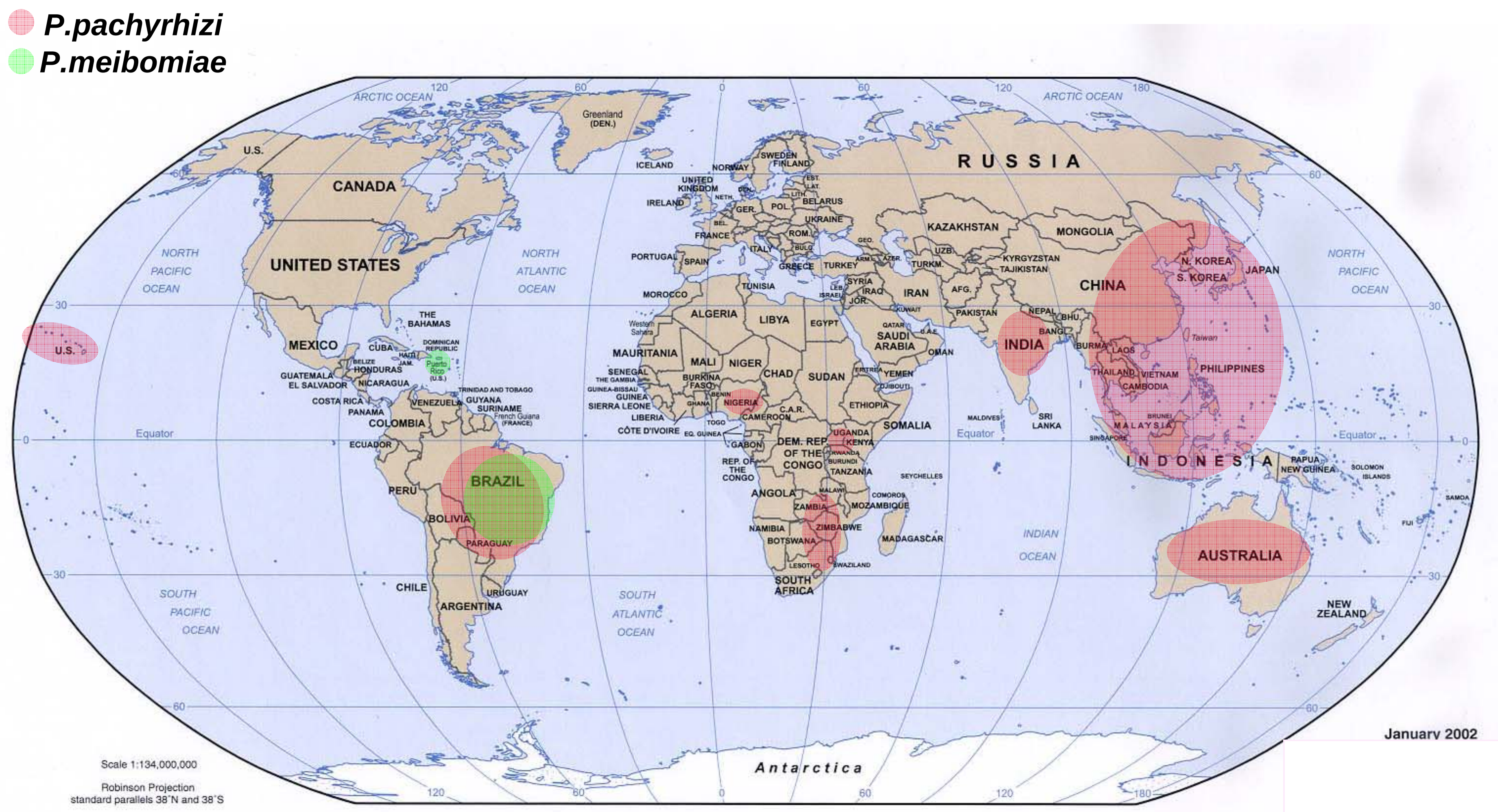
- **Caused by two species of fungi:**
  - ☞ ***Phakopsora pachyrhizi***
    aka “Old World” isolate
    More aggressive pathogen
  - ☞ ***Phakopsora meibomiae***
    aka “New World” isolate
    Not as aggressive

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.



P.pachyrhizi
P.meibomiae
ARCTIC OCEAN
Greenland (DEN.)
U.S.
CANADA
RUSSIA
UNITED STATES
NORTH PACIFIC OCEAN
NORTH ATLANTIC OCEAN
MEXICO
BRAZIL
BOLIVIA
PARAGUAY
PERU
CHILE
ARGENTINA
URUGUAY
COLOMBIA
VENEZUELA
NIGERIA
INDIA
CHINA
JAPAN
N. KOREA
S. KOREA
PHILIPPINES
THAILAND
VIETNAM
CAMBODIA
LAOS
MALAYSIA
INDONESIA
AUSTRALIA
ZAMBIA
ZIMBABWE
UGANDA
KENYA
SOUTH AFRICA
SOUTH PACIFIC OCEAN
SOUTH ATLANTIC OCEAN
INDIAN OCEAN
Equator
Antarctica
Scale 1:134,000,000
Robinson Projection
standard parallels 38°N and 38°S
January 2002

Recent Reports of Soybean Rust

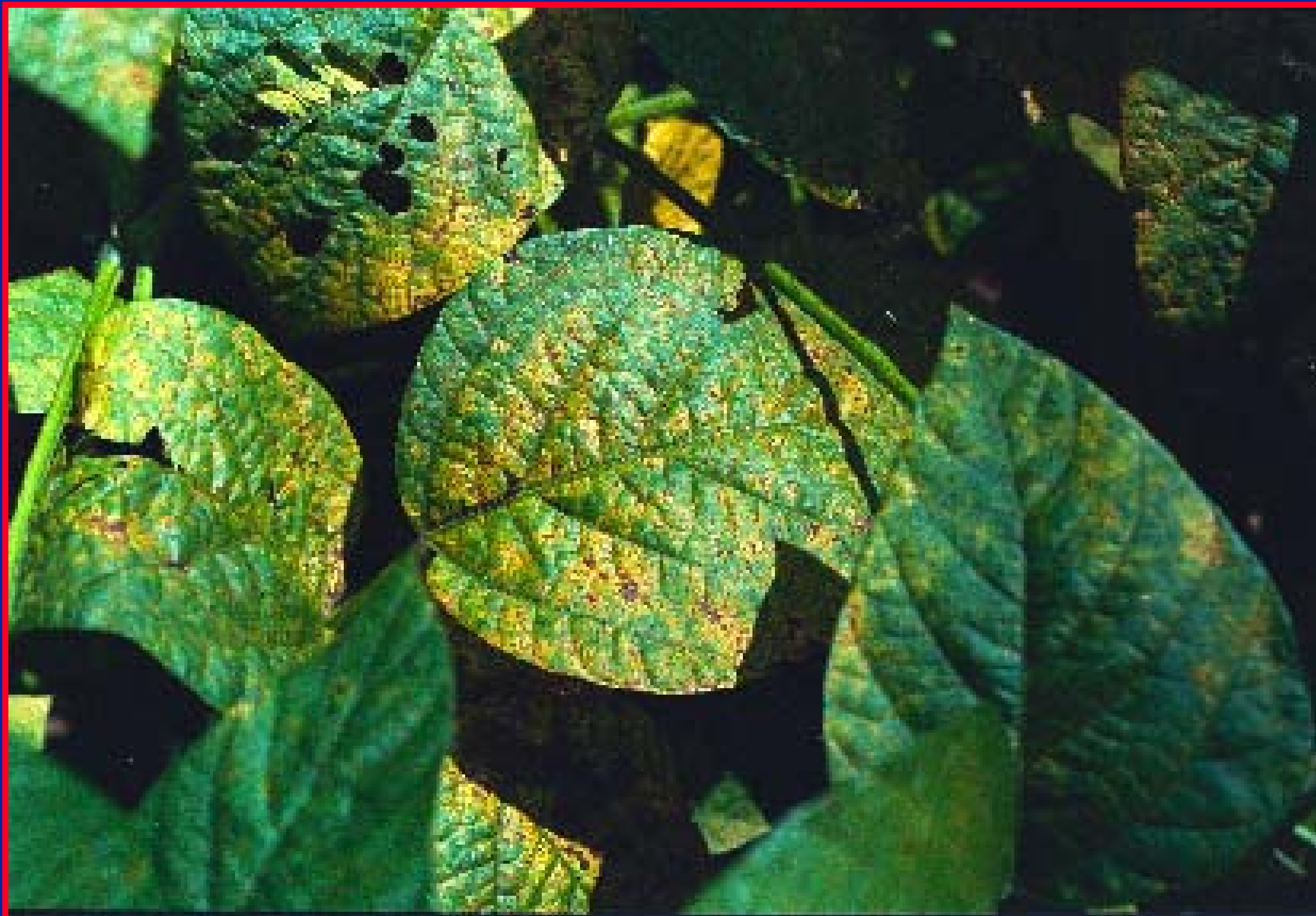
Hawaii	1994
Uganda	1996
Zimbabwe	1998
South Africa	2001
Paraguay	2001
Brazil	2002
Argentina	2002
Bolivia	2003
Columbia	2004
U.S.	2004

Country	Yield loss (%)
Australia	60-70
India	66
Indonesia	81
Japan	15-40
Philippines	30-80
South China	10-50
Taiwan	12-80
Thailand	10-40
Vietnam	50-100

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

Protectant

- +/- Absorbed
- +/- Translocates
- Prevents infection
- Use pre-infection
- Strobilurins and Chlorothalonils

Curative

- Absorbed
- Translocates
- Kills fungal tissue
- Use after infection
- Triazoles

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

MATO GROSSO

Primavera do Leste, MT: 21.02.03

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

Preliminary Screens

A set of 18 bordered 6 X 12 cell planting flats allows for1144 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.


RUST
SCREENING
TRIAL

Germplasm Screening: International Collaborators

- **China:**
  - Dr. Ma Zhanhong
    China Agricultural University
- **Thailand:**
  - Dr. Srisuk Poonpolgul & Mrs. Montha Nuntapunt
    Thailand Dept. of Agriculure
- **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

United States Department of Agriculture

Research, Education & Economics

Agricultural Research Service

National Program Staff

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Version 1.1

National Strategic Plan for the Coordination and Integration of Soybean Rust Research

Asian Soybean Rust

Phakopsora pachyrhizi