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Service

Plant
Protection
and Quarantine

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STRATEGIC PLAN TO MINIMIZE THE IMPACT OF THE INTRODUCTION AND ESTABLISHMENT OF SOYBEAN RUST ON SOYBEAN PRODUCTION IN THE UNITED STATES

SOYBEAN RUST

Phakopsora pachyrhizi, P. meibomia

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EXECUTIVE SUMMARY

The 2002 report of soybean rust (*Phakopsora pachyrhizi*) damage in South America, renewed concern for the likelihood and effect of introductions of the disease into continental US ecosystems, particularly soybean production areas. Since May 2002, meetings and consultations have occurred within an ad hoc work group composed of USDA agencies representing the Animal and Plant Health Inspection Service (APHIS), Agricultural Research Service (ARS), and Cooperative State Research Extension and Education Service (CSREES), National Plant Board, stakeholders, and industry to identify an appropriate response to the introduction of the disease. Specific response components include stakeholder communication, education, and training; potential detection methods and alternatives; and mitigation measures to reduce the impact on US soybean growers once soybean rust is found in continental US growing areas. Unfortunately, technology to minimize the impact of soybean rust is not available. Management tools such resistant varieties and registered fungicides will be needed to reduce production losses attributable this disease.

Drawing upon the experience of how infestations in Zimbabwe, South Africa, Paraguay and Brazil have progressed in the last two growing seasons, we have learned that *P. pachyrhizi* infestations have spread rapidly due to its copious urediniospore production and ability to spread by wind currents and storms. The disease also has many other uncultivated, primarily leguminous hosts many of which grow throughout the United States. Considering these facts, there is general agreement that the attempt to contain and eradicate, the traditional response to an introduction of a serious exotic disease of a major crop, cannot be justified. Therefore, a regulatory (quarantine) would be ineffective in preventing the spread of the disease and eradication would not be technically possible.

USDA believes the foundation for the response to address the eventual introduction of soybean rust is an outreach program composed of stakeholder communication, education, and training and technology development. A successful outreach program will provide a vehicle for timely detections of the disease and implementation of mitigation measures to control the disease in production agriculture. USDA has a leadership role in coordinating activities preparing for the introduction of SBR into the Nation's soybean production areas and minimizing its long range impact through **exclusion, outreach, and technology development** promoting soybean rust management preparedness.

Exclusion

Stakeholders, including USDA, recognize that natural introductions of soybean rust into the US and its soybean production system will very likely occur, the only question is when that will occur. In the meantime, USDA intends to delay the human assisted introduction of the disease through its exclusion program. USDA recognizes its responsibility to prevent the introduction of foreign plant pests and diseases with the potential for adversely impacting production agriculture and the environment. APHIS- Plant Protection and Quarantine (PPQ) will continue to support permitting and inspection activities as components of its exclusion activities thereby reducing the risk of introducing SBR through human assisted channels. An effective program to reduce the human assisted movement of the disease will help to provide additional time in preparing for the entry of the disease.

Outreach

The principal components for an effective outreach program include communication, education, and training programs designed for producers, handlers, field scouts, crop specialists, and others engaged in soybean production, crop management, and identification. In addition, because soybean rust affects many non-cultivated host plants occurring throughout the US the outreach program should also target non-agricultural stakeholders.

We view the outreach program as the forum for the dissemination of information and training. This program will underpin the soybean rust detection program, development and distribution of a communication plan for the initial detection, and communication of management practices for production agriculture.

Technology Development

Federal and state cooperators and the scientific community should work together to support the development of technical information to be communicated through the outreach program, especially the identification of management practices for production agriculture. Soybean producers, handlers, and scientists believe access to registered fungicides and rust resistant varieties would be of the greatest value to mitigate production losses that would be caused by the disease.

PURPOSE AND DISCLAIMER**Purpose**

This plan has been developed to assist stakeholders in preparing for and mitigating the impact of the detection and establishment of soybean rust in US, especially in the Nation's soybean production areas. The procedures described in this document were developed by PPQ staffs through collaboration with other APHIS staff, National Plant Board, the Agriculture Research Service, Cooperative State Research, Extension, and Education Service, university scientists, and stakeholders.

Disclaimer

This document is not intended to be complete and exhaustive. The information given herein was taken from available literature and synthesized into a specialized document intended to assist further work, as stated above. Some key articles were not available at the time this was written, nor have all pertinent specialists and other members of the research community been consulted for their advice.

GENERAL INFORMATION

Action Statement

The information contained in this document is intended for use as guidance in designing a program to detect and respond to the establishment of soybean rust (*Phakopsora pachyrhizi* or *P. meibomia*) in the continental United States. This plan provides information on **exclusion**, **outreach**, and **technology development** supporting soybean production management practices.

Background Information and Introduction

Soybean rust is caused by two fungal species *Phakopsora pachyrhizi*, Sydow and Sydow known as the Australasian species, and *P. meibomia* (Arthur) Arthur. Both species have been known to in Brazil, Argentina, and Paraguay. While *Phakopsora pachyrhizi* has been reported in various countries including Argentina, Australia, China, Korea, Malaysia, Indonesia, Sierra Leone, Cambodia, New Guinea, Viet Nam, Ghana, India, Japan, Nepal, Taiwan, Thailand, the Philippines, Mozambique, Nigeria, Rwanda, Uganda, United States (Hawaii only), Zimbabwe, South Africa, Brazil, and Paraguay.

Phakopsora meibomia, a weaker pathogen than *Phakopsora pachyrhizi* has been reported in Costa Rica, Cuba, Dominican Republic, Guatemala, Mexico, Venezuela, Bolivia, Barbados, Trinidad, Chile, St. Thomas, Brazil, Colombia. The first detection of soybean rust in the United States was *P. meibomia* reported in Puerto Rico in 1976 and this species has proven to be a weak pathogen.

Phakopsora pachyrhizi, which is much more aggressive, was reported in Hawaii in 1995. Recent introductions of *P. pachyrhizi* in other parts of the world show a rapid spread causing severe damage in Zimbabwe (2000), South Africa (2001), Paraguay (2001) and Brazil (2002) where yield losses from this species have been reported from 10-60%.

There are 30 species in 17 genera of legumes, other than soybean reported to be hosts for soybean rust in nature, with 60 species in 26 genera that were successfully inoculated under laboratory conditions. One widespread host in the United States is kudzu, *Pueraria lobata* that could serve as an inoculum reservoir for soybean rust, continuing the presence of the disease. There are a variety of other important hosts that are leguminous crops or weeds that have shown varying degrees of susceptibility to both species of soybean rusts.

A virulent race of soybean rust, *P. pachyrhizi* introduced to the United States soybean production areas could cause large crop and economic losses to soybean growers and associated industries. In addition green, kidney, lima bean, and cowpea producers will experience losses.

Soybean rust spreads primarily by wind-borne spores and recent infestations in Southern Hemisphere countries like Zimbabwe, South Africa, and Brazil have been widespread in the same year they were first detected. Therefore, it is unlikely that a regulatory response to detection in the continental United States would be appropriate or effective.

Technical information indicates no soybean rust resistant or tolerant varieties are available. However, fungicides have been used effectively in other countries to mitigate the impacts on soybean production. There are currently a small number of fungicidal products labeled for rust on soybeans, but effective

dosage rates and application methods are lacking. Efforts are being made by chemicals companies and researchers to find additional efficacious chemicals, formulations, and application rates and methods.

RESPONSE COMPONENTS AND SUPPORT NEEDS

Exclusion

Stakeholders, including USDA, recognize that natural introductions of soybean rust into the US and its soybean production system will very likely occur; the only question is when this will occur. In the meantime, USDA intends to delay the human assisted introduction of the soybean rust through its exclusion program. USDA recognizes its responsibility to prevent the introduction of foreign plant pests and diseases with the potential for adversely impacting production agriculture and the environment. PPQ will continue to support permitting and inspection activities as components of its exclusion activities, thereby reducing the risk of introducing SBR through human assisted channels. An effective program to reduce the human assisted movement of the disease will help to provide additional time in preparing for the entry of the disease.

USDA-APHIS-PPQ has legislative authority under the Plant Protection Act to control the importation of commodities that may serve as pathway for the introduction of foreign plant and animal pests and diseases. The agency administers this responsibility through the agricultural quarantine inspection program at the Nation's international ports of entry and through PPQ permitting procedures.

To support the exclusion component APHIS will:

- ensure PPQ continues to prohibit or require appropriate treatment of articles moving into the United States that may serve as a pathway for the introduction of soybean rust. However, once the disease has been introduced into the United States, APHIS will review its policy regarding importation of soybean rust infected material consistent with its international trade obligations;
- liaison with security agencies to reduce the risk of the introduction soybean rust through a terrorist event;
- ensure that International Services provide periodic updates about soybean rust situations occurring in countries that may serve as a pathway into the US.

Outreach

The principal components for an effective outreach program include communication, education, and training programs designed for producers, handlers, field scouts, crop specialists, and others engaged in soybean production, crop management, and identification. In addition, because soybean rust affects many non-cultivated hosts occurring throughout the US the outreach program should include non-agricultural stakeholders.

We view the outreach program as the forum for the dissemination of information and training related to soybean rust. This program will serve to support the soybean rust detection program, development of a communication plan to notify stakeholders that the disease has been detected in the US, and communicating management practices for production agriculture.

USDA proposes to support and monitor detection activities for soybean rust through an extensive information and education program enhanced by training and the distribution of technical program aides. The goal of the program is to provide sufficient information that producers, state cooperators, field scouts, extension agents, and others that spend time in the “field” would recognize the symptoms of soybean rust. Those individuals would also be instructed how to take and submit samples for identification to local or regional diagnostic centers or report detection to local Federal/State officials. We have recommended survey and identification procedures in **Appendix I** and **Appendix II** respectively.

The planning and implementation of a surveillance program will require support for the following activities for survey:

- CSREES in cooperation with ARS and APHIS will develop technical information for survey training programs and program aides for distribution to stakeholders and interested parties;
- CSREES will identify and activate distribution systems to communicate technical information;
- CSREES in cooperation with APHIS and ARS will development a rust screening and identification system for submitted samples and information sharing about the process of submission;
- PPQ, State Plant Health Directors will have the responsibility to ensure initial detections of soybean rust are reported into the National Agricultural Pest Information System (NAPIS).
- PPQ in cooperation with ARS and CSREES will review existing air current data in an effort to correlate potential dispersal of the disease from known infected areas to potential survey locations in the United States and or natural land pathway movement northward.

Unfortunately, the United States will likely experience the introduction and establishment of soybean rust. It's therefore necessary to prepare a communication plan for advising Federal, state, producers, and other stakeholders that the disease has been found, refreshing the dialog regarding appropriate mitigation measures and future management practices.

- APHIS will be responsible for ensuring Federal and State officials, industry, and other stakeholders are alerted to initial detections of soybean rust in the US. This communication plan is shown in **Appendix III**.

The outreach program will recommend measures that could assist in mitigating the adverse impacts of the disease on soybean production. Currently the only available means for reducing losses caused by soybean rust is timed fungicidal applications. The agrochemistry industry, with assistance from APHIS, the Environmental Protection Agency and others will obtain registration for fungicides that have proven efficacy and have been successfully used against soybean rust in other countries. Options for obtaining a crisis exemption for certain compounds are currently being pursued as well. See **Appendix IV** for management practices information.

Work is underway in cooperation with EPA and industry to obtain appropriate labels for fungicides for producer use. It is becoming increasingly critical that research be initiated through ARS or CSREES

grants for the development of rust resistant or tolerant soybeans. The use of fungicides will facilitate soybean production in the short-term, but the long-term answer is resistant /tolerant soybean varieties.

The development of recommendations to mitigate the impact of soybean rust on soybean production needs support by:

- CSREES, with cooperation from APHIS and ARS will develop information for use in preparing technical training programs and program aides describing actions to reduce crop damage;
- CSREES will identify and activate distribution systems to communicate technical information;
- APHIS and the USDA Office of Pest Management Policy, in collaboration with the Environmental Protection Agency and industry, to pursue obtaining label revisions and/or approvals for US registered fungicides for use against soybean rust;
- APHIS in collaboration with EPA, scientists, and industry will develop technical application information (dosage, rate, etc.).

Technology Development

Federal and state cooperators and the scientific community should work together to support the development of technical information regarding management practices to minimize the impact of soybean rust on the production agriculture community. Soybean producers and handlers and scientists believe access to registered fungicides and rust resistant varieties would be of the greatest value to mitigate production losses caused by the disease.

Disease resistant or tolerant varieties have long been relied on as a means of reducing the economic impact of a serious plant disease. Field losses of 10%-60% have been reported in soybeans infected with soybean rust. Certainly, rust resistant varieties of soybeans would be very valuable in overcoming economic losses caused by the disease. The availability of soybean rust resistant cultivars is still 5-7 years away and should be considered a high priority for technology development.

A valuable tool in the management of soybean rust will be models for predicting outbreaks and tracking annual occurrences of the disease. These models will facilitate grower decisions for disease surveillance, monitoring, and timing of fungicide applications

- ARS and CSREES with cooperation of seed companies will develop commercially acceptable rust resistant or tolerant soybean varieties to minimize the economic impact of the establishment of soybean rust on the industry.
- CSREES and PPQ will support development of an early warning system to assist producers in management of the disease.

DETECTION SURVEY PROCEDURES

There is genuine concern in soybean producing states about the introduction of the rust and its potential impact. Based on infestation scenarios experienced in southern Africa and South America, it is much more likely that soybean rust will enter the United States by wind borne spores via wind currents from West Africa or northern South America and the Caribbean. It is also believed by scientists that the infestation will likely first be found in the Gulf Coast states.

The survey effort will be collaborative effort by Federal, State and stakeholders to detect soybean rust in the United States. The survey will depend on growers, handlers, field scouts, and others with soybean rust training or information that work and play out of doors. Because the disease has numerous hosts, cultivated and non-cultivated the disease is likely to be found anywhere where host material is available. Utilizing individuals with an understanding and awareness of the disease and its symptoms, knowledge of the local geography and working in soybean and other bean fields, and traversing the landscape increases the likelihood for detection. With such a corps of individuals more areas could be surveyed, larger geographical areas could be surveyed, areas could be surveyed more frequently, some areas would be under continual surveillance, and surveys could be conducted throughout the entire growing period.

Detection Survey

A systematic Cooperative Agricultural Pest Survey (CAPS) funded national survey is not planned for the detection of soybean rust. However, CAPS funding will be considered for proposals to establish collaborations and networks with growers, field scouts, scientists, researchers, and organizations that work in soybean fields or environs where soybean rust host material is present; training to identify symptoms of the disease; training for diagnosticians to identify the disease; and preparation and distribution of program aides or other educational material. Detection of soybean rust will be reported into the National Agriculture Pest Information System (NAPIS) by PPQ State Plant Health Directors or appropriate CAPS cooperator.

Detection surveys will normally be carried out by “surveyors” provided with information about the disease and its symptoms at any site where available host material exists. Growers, scientists, researchers, and others interested in detecting soybean rust should be encouraged to plant sentinel plots with early maturing soybean cultivars, prior to the traditional planting time as areas to bias the initial survey. Soybean experimental research plots are also areas to include in detection surveys. Soybean rust has shown some susceptibility on other bean species and some commercial plantings of these should be checked in detection surveys as well.

The weed kudzu occurs in large areas throughout the southern United States and can serve as a place for early detection surveys. We do not recommend the use of planting kudzu as a sentinel crop because of its invasiveness, but surveyors in kudzu-infested areas will be encouraged to inspect naturally growing plants for presence. It is thought that in Zimbabwe and Brazil, soybean rust may build up inoculum in hosts adjacent to soybean fields and serve as a reservoir when soybeans are not in the susceptible stages.

Survey procedures will vary depending on the feasibility of surveying plants in the field, season, environmental conditions and other factors. The actual inspection will consist of a thorough visual

examination of soybean plants in the field and of other host plants in the vicinity of the areas being surveyed. It is expected that individuals working in the field or traversing the environs would see visual signs of infection and either collect samples or report the location of the damage to local extension office. Information from South America indicates a distinct yellowing or browning of fields with high infection rates, and this character might be useful in pin-pointing to areas needing further investigation.

For early detection, check for pustules (blisters or lesions) and chlorosis (yellowing) on the undersides of the lower leaves of soybean plants before flowering. *P. pachyrhizi* is a monocyclic, obligate parasite that infects petioles, pods and stems of the plant, especially the undersides of leaflets. Inspection can begin at anytime during growth, however inspection of plants with well developed leaflets would be preferred. The lesions are fewer and smaller on the upper leaf surfaces. The disease is detected by inspecting the undersides of the leaves for uredinial pustules that are powdery and buff or pale brown. As the plants mature and the frequency of rainfall events increase, the severity of the disease increases as well. Lesions will be found in the middle and upper canopy in more advance infections. Eventually, defoliation and leaf drop will occur.

Collection of Specimens

The instructions for surveyors, growers, extension personnel, crop consultants, and field scouts encountering soybean rust like symptoms are detailed at the PPQ Soybean Rust Pest Alert website. Place leaf, stem, or pod samples in a self locking plastic bag and store under cool conditions. Alternatively, samples that must be kept under ambient conditions should be sealed in a paper bag to prevent mold growth. Once they can be refrigerated the paper bag can be placed in a self-locking plastic bag. It would be helpful if leaves can be placed between paper towels or pieces of paper to keep them flat. Care should be taken to ensure the outside of the bags are not contaminated by the sample.

Record the collection information (date, exact location of the field and sample location within the field, county in which collected, host plant and collector's name and phone number) on a piece of paper included with the sample. If the collector has a copy of the PPQ form 391, the pertinent sections of that form should be completed and submitted with the specimen to the state or university diagnostic laboratory.

Submit the sample through the appropriate State Department of Agriculture's diagnostic service or the land grant university's diagnostic laboratory in the state in which the sample was collected. Do not send suspect samples directly to the USDA Beltsville laboratory. It is essential that samples be screened by the appropriate university or state department of agriculture diagnostic laboratory to determine whether the disease is soybean rust or a disease that is similar to but not soybean rust.

A list of university diagnostic laboratories is available at the American Phytopathological Societies directory website:

http://www.apsnet.org/directories/univ_diagnosticians.asp

State Department's of Agriculture contacts are available at the National Plant Board website: <http://www.aphis.usda.gov/npb/npbmemb.html>

EXHIBIT

Specimen submission form for diagnostic laboratory to the APHIS National Mycologist.

This report is authorized by law (7 U.S.C. 147a). While you are not required to respond your cooperation is needed to make an accurate record of plant pest conditions.

FORM APPROVED
OMB NO. 0579-0010

U.S. DEPARTMENT OF AGRICULTURE ANIMAL AND PLANT HEALTH INSPECTOR SERVICE SPECIMENS FOR DETERMINATION		Instructions: Type or print information requested. Press hard and print legibly when handwritten. Item 1 assign number for each collection beginning with year, followed by collector's initials and collector's number. Example (collector, John J. Dingle); 83-JJD-001. Pest Data Section - Complete Items 14, 15 and 16 or 19 or 20 and 21 as applicable. Complete Items 17 and 18 if a trap was used.		FOR IIBIII USE LGT NO. PRIORITY	
1. COLLECTION NUMBER		2. DATE MO DA YR		3. SUBMITTING AGENCY <input type="checkbox"/> State <input type="checkbox"/> Cooperator <input type="checkbox"/> PPQ <input type="checkbox"/> Other	
4. NAME OF SENDER		INTERCEPTION SITE		5. TYPE OF PROPERTY (Farm, Feedmill, Nursery, etc.)	
6. ADDRESS OF SENDER				7. NAME AND ADDRESS OF PROPERTY OR OWNER	
ZIP				COUNTRY/ COUNTRY	
8. REASON FOR IDENTIFICATION ("X" ALL Applicable Items)					
A. <input type="checkbox"/> Biological Control (Target Pest Name)		E. <input type="checkbox"/> Livestock, Domestic Animal Pest			
B. <input type="checkbox"/> Damaging Crops/Plants		H. <input type="checkbox"/> Possible Immigrant (Explain in remarks)			
C. <input type="checkbox"/> Suspected Pest of Regulatory Concern (Explain in remarks)		J. <input type="checkbox"/> Survey (Explain in remarks)			
D. <input type="checkbox"/> Stored Product Pest		L. <input type="checkbox"/> Other (Explain in remarks)			
9. IF PROMPT OR URGENT IDENTIFICATION IS REQUESTED, PLEASE PROVIDE A BRIEF EXPLANATION UNDER "REMARKS".					
10. HOST INFORMATION NAME OF HOST (Scientific name when possible)			11. QUANTITY OF HOST NUMBER OF ACRES/PLANTS		
			PLANTS AFFECTED (Insert figure & indicate number or percent) <input type="checkbox"/> Number <input type="checkbox"/> Percent		
12. PLANT DISTRIBUTION		13. PLANT PARTS AFFECTED			
<input type="checkbox"/> LIMITED		<input type="checkbox"/> Leaves, Upper Surface		<input type="checkbox"/> Trunk/Bark	
<input type="checkbox"/> SCATTERED		<input type="checkbox"/> Leaves, Lower Surface		<input type="checkbox"/> Bulbs, Tubers, Corms	
<input type="checkbox"/> WIDESPREAD		<input type="checkbox"/> Petiole		<input type="checkbox"/> Buds	
		<input type="checkbox"/> Stem		<input type="checkbox"/> Flowers	
		<input type="checkbox"/> Growing Tips		<input type="checkbox"/> Fruits or Nuts	
		<input type="checkbox"/> Roots			
14. PEST DISTRIBUTION		15. <input type="checkbox"/> INSECTS <input type="checkbox"/> NEMATODES <input type="checkbox"/> MOLLUSKS			
<input type="checkbox"/> FEW		NUMBER SUBMITTED		LARVAE	
<input type="checkbox"/> COMMON		ALIVE		PUPAE	
<input type="checkbox"/> ABUNDANT		DEAD		ADULTS	
<input type="checkbox"/> EXTREME				CAST SKINS	
				EGGS	
				NYMPHS	
				JUVS.	
				CYSTS	
16. SAMPLING METHOD		17. TYPE OF TRAP AND LURE		18. TRAP NUMBER	
19. PLANT PATHOLOGY - PLANT SYMPTOMS ("X" one and describe symptoms)					
<input type="checkbox"/> ISOLATED <input type="checkbox"/> GENERAL					
20. WEED DENSITY		21. WEED GROWTH STAGE			
<input type="checkbox"/> FEW <input type="checkbox"/> SPOTTY <input type="checkbox"/> GENERAL		<input type="checkbox"/> SEEDLING <input type="checkbox"/> VEGETATIVE <input type="checkbox"/> FLOWERING/FRUITING <input type="checkbox"/> MATURE			
22. REMARKS					
23. TENTATIVE DETERMINATION					
24. DETERMINATION AND NOTES (Not for Field Use)					
FOR IIBIII USE DATE RECEIVED NO. LABEL SORTED PREPARED DATE ACCEPTED RR					

IDENTIFICATION PROCEDURES

Correct and proper identification is the key to determining whether a program will be attempted and, if so, the extent, direction, and magnitude of the program. It will also help determine program changes and program failures.

Identification Characters

Symptoms of soybean rust appear identical regardless if they are caused by *Phakopsora pachyrhizi* or *P. meibomia*. Host plants infected with soybean rust first show small lesions which gradually increase in size, turning gray to tan or brown. They become polygonal shape restricted by leaf veins and may eventually reach 2 to 3 square millimeters.

Infection begins on the lower first leaves of plants and appearing as chlorotic or mosaic like areas with uredinia observed usually at or after the plant flowering stage. Lesions may appear on the petioles, stems, pods, but are most common on the leaves, especially on the lower surfaces. As the plant matures and sets pods, infection progresses rapidly under the right environmental conditions (moisture, high humidity and heat) to cause high rates of infection in the middle and upper leaves of the plant. Clouds of spores have been observed within and or above canopies of highly infected plant stands.

Plants show two different lesion reactions to infection by soybean rust. Tan lesions consist of small uredinia surrounded by slightly discolored necrotic areas on leaf surfaces. Early stages show an ostiole, or small hole, where urediniospores emerge. As uredinia become larger, they release masses of tan colored urediniospores that give the appearance of light brown to white raised areas. Uredinial pustules become more numerous with advancing infection and often they will coalesce forming larger pustules that break open releasing masses of urediniospores.

The other type of lesion that occurs as a different reaction of the plant to soybean rust infection is the reddish-brown lesion. These lesions have larger areas of necrosis that is reddish brown surrounding a very limited number of uredinia that usually have few urediniospores visible on the surface.

Early symptoms of soybean rust symptoms can be easily be confused with bacterial pustule, *Xanthomonas campestris* pv. *phaseoli* (Smith) Dye or bacterial blight, *Pseudomonas glycinea* Coerper and brown spot (*Septoria glycines*). These bacterial diseases also occur often on the underside of soybean leaves causing a raised, light brown blister within a lesion. These bacterial leaf lesions vary from small specks to large irregular brown areas which form when small lesions coalesce. A hand lens or dissecting microscope are usually used to distinguish bacterial disease symptoms from rust, but early stages of both diseases are difficult to distinguish if no spores or bacteria are evident.

The more advanced raised blister-like pustules of the bacteria resemble the uredial cones, (or pustules) of the rust but can be distinguished by two microscopic characteristics. The uredial pustules open through a round ostiole while the bacterial pustule is torn across by a fissure. Also, white clumps of urediniospores can generally be observed lodged on top of the uredial cone sometimes emerging in columns. Breaking open the pustule will reveal large numbers of urediniospores. These rust spores can be identified by mounting them on a microscopic slide and examining them under a compound microscope. Bacterial pustule will produce bacterial streaming when sectioned infected material is observed under a compound microscope and no spores will be observed.

Photographs of soybean rust symptoms and urediniospore morphology are available on PPQ's Pest Detection website at: http://www.aphis.usda.gov/ppq/ep/pestdetection/soybean_rust/soybeanrust.html

Examination of the morphology of soybean uredinia and urediniospores found in rust cone pustules cannot be used to confidently distinguish *Phakopsora pachyrhizi* from *P. meibomia*. Differences can be seen to distinguish them based on the telia and teliospores however these are seldom seen in nature. Therefore, the only definitive methods for correct identification of soybean rust are molecular techniques (PCR).

The Agriculture Research Service laboratories in Ft. Detrick, Maryland have developed primers for polymerase chain reaction (PCR) identification of *Phakopsora pachyrhizi* and *P. meibomia* and made them available to the USDA, APHIS, PPQ National Mycologist in Beltsville, Maryland. In using PCR techniques, DNA is extracted from spore or infected leaf samples, ground up and purified before being analyzed for the presence of key sequences of DNA that distinguish it from related species

Diagnostic Laboratory Instructions

If university or state department's of agriculture laboratories determine the samples submitted to be *Phakopsora* spp. on soybean or another leguminous hosts, further identification to the species (*P. meibomia* or *P. pachyrhizi*) level will be necessary. There are no *Phakopsora* species on legume hosts recorded in the continental United States. A new *Phakopsora* record, because of its potential economic importance, will require verification by a USDA, APHIS National Mycologist in Beltsville, Maryland. Additionally, species determination based on urediniospores is only possible through polymerase chain reaction (PCR) procedures, the primers of which currently reside with USDA.

Diagnostic laboratories should contact Drs. Mary Palm (301) 504-5327 or John McKemy at (301) 504-5280 if a *Phakopsora* spp. on a legume host is found. At the same time, the State department of agriculture in the state detected should be contacted before samples are forwarded. After consultation with Drs. Palm or McKemy, samples should be properly secured, documented on the accompanying PPQ form 391 and sent overnight freight to:

Dr. Mary Palm
USDA, APHIS, PPQ
Bldg. 011A, Room 329, BARC-West
10300 Baltimore Blvd.
Beltsville, MD 20705-2350

COMMUNICATION PLAN

Once soybean rust is detected in the United States, prompt communication with all affected and interested parties is essential. After PPQ's National Mycologist confirms the disease, PPQ and APHIS' Legislative and Public Affairs (LPA) staff will communicate the detection in the following manner:

- Plant Protection and Quarantine will notify leadership of the National Association of State Departments of Agriculture through a conference call.
- Plant Protection and Quarantine will notify the President of the National Plant Board through a telephone call.
- Plant Protection and Quarantine will notify the United Soybean Board through a telephone call.
- Plant Protection and Quarantine will notify the American Phytopathological Society of the soybean rust detection through email.
- LPA will issue a press release announcing the detection of soybean rust. This may be done jointly with the affected State and/or the United Soybean Board.
- LPA will distribute press release to all interested soybean and industry publications. LPA will coordinate answers to media inquiries.
- LPA's legislative personnel, along with USDA's Office of Congressional Relations, will contact representatives in the affected state(s), along with other interested stakeholders.
- PPQ will post notification on soybean rust web site.

MANAGEMENT PRACTICES

The occurrence of this disease will have an impact on the production of soybeans in the United States. Because of the severity of the disease and costs to control field infections it is likely the production of soybeans in southern-most states could become unprofitable. Growers can expect an increase in production costs related to fungicides and their application to protect the crop.

It is suggested that prior to the establishment of the disease, growers consider removing non-cultivated soybean rust host material from field borders. The removal of this material will reduce the amount of hosts available, thereby reducing the amount of available host material to initiate an infection while decreasing the availability of sites for inoculum buildup.

The best long term strategy for minimizing the effects of soybean rust in the United States is in the development of resistant varieties. There are thousands of plant lines of soybean in germplasm repositories and screening for soybean resistance has been on-going for several years in other countries and the US in the containment facilities at the Agriculture Research Services Foreign Disease-Weed Science Research Unit in Ft. Detrick, Maryland. However, the availability of cultivars with good resistance and other characters desired in soybean for commercial production are still 5 to 7 years away.

Fungicides have been shown to be effective in controlling soybean rust in Zimbabwe, South Africa and Brazil. Efforts to obtain a Federal Crisis Exemption for some candidate fungicides are currently being made at the Department level and the major chemical companies that already have fungicides on the market are making efforts to get labeling changes approved through EPA.

Once an effective fungicide or fungicides, are available for use by growers, a recommendation would be made to extension scientists, crop consultants and growers to have sentinel plantings placed strategically in soybean growing areas that would allow for early detection of the disease, which would facilitate producer decisions about protectant applications of fungicides. Since soybean rust manifests primarily on maturing plants, the sentinel plantings should occur about 3 weeks before the commercial crop. This provides an opportunity to observe the first signs of the disease on the sentinels thereby allowing time to effect control of the pathogen in commercial plantings before the disease becomes epidemic. An early protectant application of fungicide will be needed around flowering time when sentinel plants are infected. Subsequent applications may be necessary as the crop matures and the disease begins to intensify.

Dr. Clive Levy, with the Commercial Farmer's Union of Zimbabwe reported that once an infestation of soybean rust is detected, if early enough, effective control was obtained with carefully timed fungicide applications. Detection early in the season with properly timed application of fungicides appears to present the best alternative for controlling soybean rust in the United States. In areas of high rust severity, the first application is at first flowering and then two more applications in 21 day intervals thereafter. In areas with lower severity, the last application is not necessary. In Zimbabwe some farmers found a schedule of first applications 50 days after planting, then at 70 and 90 days after planting. In all cases, but especially in the first applications, it is most effective to apply the fungicides in such a manner that the lower canopy is receives treatment.

Currently there are no fungicides registered for soybean rust control in the United States. It is important that more than one fungicide be available in the event they are needed for soybean rust control so that resistance development is minimized.

Once the disease is established in the United States, a valuable tool to assist in the management of soybean rust would predictive models that would forecast the occurrence and movement of the disease in the nation's soybean crop. This information would be extremely useful to producers and others for surveillance and monitoring activities and timely applications of fungicides.

Through cooperation, education, and training growers will be provided with the tools to make informed decisions about managing soybean rust and soybean production.

SUMMARY OF RECOMMENDATIONS**• Exclusion**

- ensure PPQ continues to prohibit or require appropriate treatment of articles moving into the United States that may serve as a pathway for the introduction of soybean rust. However, once the disease has been introduced into the United States, APHIS will review its policy regarding importation of soybean rust infected material consistent with its international trade obligations;
- liaison with security agencies to reduce the risk of the introduction soybean rust through a terrorist event;
- ensure that International Services provide periodic updates about soybean rust situations occurring in countries that may serve as a pathway into the US

• Outreach

(The planning and implementation of a surveillance program will require support for the following activities.)

- CSREES in cooperation with ARS and APHIS will develop technical information for survey training programs and program aides for distribution to stakeholders and interested parties;
- CSREES will identify and activate distribution systems to communicate technical information;
- CSREES in cooperation with APHIS and ARS will development a rust screening and identification system for submitted samples and information sharing about the process of submission;
- PPQ, State Plant Health Directors will have the responsibility to ensure initial detections of soybean rust are reported into the National Agricultural Pest Information System (NAPIS).
- PPQ in cooperation with ARS and CSREES will review existing air current data in an effort to correlate potential dispersal of the disease from known infected areas to potential survey locations in the United States and or natural land pathway movement northward.

(The development of recommendations to mitigate the impact of soybean rust on soybean production needs support by:)

- CSREES, with cooperation from APHIS and ARS will develop information for use in preparing technical training programs and program aides describing actions to reduce crop damage;
- CSREES will identify and activate distribution systems to communicate technical information;

- APHIS and the USDA Office of Pest Management Policy, in collaboration with the Environmental Protection Agency and industry, to pursue obtaining label revisions and/or approvals for US registered fungicides for use against soybean rust;

- APHIS in collaboration with EPA, scientists, and industry will develop technical application information (dosage, rate, etc.).

- **Technology Development**

- ARS and CSREES with cooperation of seed companies will develop commercially acceptable rust resistant or tolerant soybean varieties to minimize the economic impact of the establishment of soybean rust on the industry.

- CSREES and PPQ will support development of an early warning system to assist producers in management of the disease.

SOYBEAN RUST HOSTS

Because of confusion over the taxonomy of the pathogens causing soybean rust, *Phakopsora meibromiae* and *Phakopsora pachyrhizi*, the list of the hosts of *Phakopsora pachyrhizi* may be incomplete; however, according to various recent references, a large number of legume species are host plants for *Phakopsora pachyrhizi*. *Glycine max*, *G. sojae*, *Pachyrhizus erosus*, *Pueraria lobata*, and *Vigna unguiculata* are the principle hosts (CABI, 2001). The following table (e-mail from Hartman citing Tschanz, 1985 & 1982; Ono *et al.*, 1992; use information from Bailey & Bailey, 1976) lists legume species that develop rust symptoms and uredinia and urediniospores when inoculated with *Phakopsora pachyrhizi*:

Scientific Name Common Name

Alysicarpus glumaceus Alyce clover (Naturalized in West Indies and FL?)

Cajanus cajan Cajan, pigeon pea Widely cultivated in trop. countries

Centrosema pubescens Butterfly pea Frequent in fields; W. Indies & Mex.

Crotalaria anagyroides Rattlebox Tropical northern South America

Delonix regia Royal Poinciana Wide-branching tree

Glycine canescens Soybean relative

G. clandestina Soybean relative

G. falcata Soybean relative

G. max Soybean Major agricultural crop in US

G. tabacina Soybean relative

Lablab purpureus Hyacinth bean (*Dolichos vavilab*)

Lotus americana (Not in *Hortus Third*)

Lupinus hirsutus Blue lupine (Annual; southern Europe)

Macroptilium atropurpureum Siratro; purple bean Grows wild in Cen. and S. America

Macrotyloma axillare (Not in *Hortus Third*)

Medicago arborea Medic (Shrub; southern Europe)

Melilotus officinalis Yellow sweet clover Eurasia; naturalized in N. America

M. speciosus (Not in *Hortus Third*)

Mucuna cochinchinesis Velvetbean relative

Neonotonia (Glycine) wrightii Glycine (Old World probably)

Pachyrhizus erosus Yam bean; jicama C. America; naturalized in south FL

Phaseolus lunatus Butter bean, lima bean Tropical SA: important edible bean

P. vulgaris Kidney bean; green bean Tropical America; widely cultivated

Rhynchosia minima (Not in *Hortus Third*) Creeping tropical weed

Sesbania exaltata Colorado River hemp NY to FL; west to southern CA

S. vescaria (Not in *Hortus Third*)

Trigonella foenum-graecum Fenugreek (Asia & southern Europe; forage)

Vigna unguiculata Cowpea, black-eyed pea Widely planted in warm regions

There are additional hosts (Ono *et al.*, 1992).

Kudzu, *Pueraria lobata*, is a host; in addition,

Pueraria phaseoloides is a host (McBride, 1998; Ono *et al.*, 1992). Because kudzu is a common weed in the southeastern United States, it might serve as a continual source of inoculum.

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