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SOYBEAN RUST: GLOBAL CONSIDERATIONS IN PREPARATION FOR DISEASE OCCURRENCE IN THE UNITED STATES

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 United States (US) ecosystems, particularly soybean production areas. Today this disease is present in most areas of the world where soybeans are grown; however, it is not known to occur in the continental US or Europe. In 1994, soybean rust was discovered in Hawaii which renewed concern that it was a real threat to US soybean production. From 1994 to 1998, it was confirmed in Eastern and Southern Africa. More recently, in 2001 and 2002, it was confirmed in Brazil, Paraguay, and Argentina. The question then became not "if" but "when" it would occur in the continental US. Considering the recent spread of soybean rust (caused by *P. pachyrhizi*) into the Hawaiian Islands, West Africa, and South America, it is suspected that long-range transport of the pathogen occurs during storms or other adverse environmental conditions. Eradication from infested areas is not feasible, given that the host range of this disease includes 35 leguminous species, and the small size and tremendous numbers of rust spores. The fact that this rust fungus cannot overwinter in colder, northern areas, gives indication that it must reinfest those areas each year via wind transport.

Drawing on the experience of countries where the disease occurs, an ad hoc working group, composed of US Department of Agriculture agencies, National Plant Board, stakeholders and industry, has held meetings and consultations 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 currently available. Management tools such resistant varieties and registered fungicides will be needed to reduce production losses attributable this disease.

The Disease: Infestations in Zimbabwe, South Africa, Paraguay and Brazil during the last two growing seasons have demonstrated that *P. pachyrhizi* infestations have spread rapidly due to its copious urediniospore production and ability to spread by wind currents and storms. Any environmental conditions adequate for soybean growth appear suitable for disease development, but warm, humid conditions are especially conducive to the development of this disease. 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. Epidemics can be devastating within a few weeks under severe disease conditions. The disease also has many other uncultivated, primarily leguminous hosts. 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 US is kudzu, *Pueraria lobata*, that could serve as an innoculum 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. Yield losses from soybean rust are reported to range from 10 to 50% in the Eastern Hemisphere (Japan, southern China, Thailand). In Taiwan, yield losses have been reported as high as 90% in selected fields. It has been estimated that this pathogen has the potential in the U.S. to reduce yields by at least 10% averaged across the soybean production areas. Higher losses, up to 50%, are possible under warm, humid conditions, such as are often experienced in the Mississippi Delta and southeastern coastal areas especially where the rust pathogen may overwinter. Similar losses are expected on certain other leguminous crops including cowpeas, pigeon peas, lima beans, and kidney beans. 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. Further details and pictures of this disease can be viewed on the USDA/APHIS web site at: **http://www.aphis.usda.gov/ppq/ep/pestdection/soybean_rust/soybeanrust.html**

The Pathogenic Agent: Soybean rust is caused by two fungal species P. pachyrhizi, Sydow and Sydow known as the Australasian species, and *P. meibomiae* (Arthur) Arthur. Both species have been known to occur in Brazil, Argentina, and Paraguay, while P. pachyrhizi has been reported in various countries including Argentina, Australia, Canada, China, Korea, Malaysia, Indonesia, Sierra Leone, Cambodia, New Guinea, Viet Nam, Ghana, India, Japan, Nepal, Taiwan, Thailand, the Philippines, Mozambique, Nigeria, Rwanda, Uganda, US (Hawaii only), Zimbabwe, South Africa, Brazil, and Paraguay. *P. meibomiae*, a weaker pathogen than *P. 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. meibomiae* reported in Puerto Rico in 1976. *P. 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 from10-60%. A virulent race of soybean rust, P. pachyrhizi introduced to the US soybean production areas could cause large crop and economic losses to soybean growers and associated industries.

Technology Development: Cultivar resistance would be the most economically viable solution to soybean rust. Unfortunately, there is little resistance in commercial soybean cultivars currently grown in the US. The availability of soybean rust resistant cultivars is probably five to seven years away in this country. Several lines of research have been undertaken to identify and develop resistant cultivars. Classical plant breeding approaches as well as DNA sequencing strategies are being employed.

Fungicides would appear to be a more feasible first step to control an introduction or early epidemic. Fungicides have been shown to be effective in controlling soybean rust in Zimbabwe, South Africa and Brazil. The most likely fungicide candidates appear to be the strobilurins (azoxystrobin), the EBDCs (mancozeb), and the triazoles (triadimefon, difenoconazole, tebuconazole). Comparative efficacy testing of fungicides likely available in the US is ongoing. There are currently a small number of fungicidal products labeled for rust on soybeans, but effective dosage rates and application methods must be determined. Efforts are being made by chemicals companies and researchers to find additional efficacious chemicals, formulations, and application rates and methods. The US is initiating cooperative efforts to conduct field trials in Africa and South America.

Detection is an important aspect of reducing disease impacts. There should be training to identify symptoms of the disease and the pathogen. Primers have been developed for polymerase chain reaction (PCR) identification of *P. pachyrhizi* and *P. meibomiae*; key sequences of DNA distinguish these rusts from related species. Information from South America indicates a distinct yellowing or browning of fields with high infection rates; this characteristic might be useful in pin-pointing areas needing further investigation. The use of sentinel plantings would facilitate decisions about protectant applications of fungicides. Since soybean rust manifests primarily on maturing plants, the sentinel plantings should occur about three weeks before the commercial crop, allowing time to effect control of the pathogen in commercial plants before the disease becomes epidemic. A valuable tool in the management of soybean rust will be models for predicting outbreaks an tracking annual occurrences of the disease. These models will facilitate grower decisions for disease surveillance, monitoring, and timing of fungicide applications.

Outreach/Training: 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.

If soybean rust is detected, growers should prepare to spray immediately. It will be too late to prevent disease, if growers wait for the appearance of rust symptoms. To this end, state extension specialists - especially in the most vulnerable states - have been encouraged to set up indicator plots of susceptible legumes for early detection of soybean rust. This will enable growers of soybeans and other susceptible legumes to achieve the highest possible management of soybean rust through prophylactic spraying.

GLOBAL NEEDS FOR MINOR USE PESTICIDE REGISTRATION

The relatively small market potential for pesticide use on small acreage crops such as fruits and vegetables has often meant a lack of adequate pest management options. For economic reasons, the pesticide industry usually focuses on primary crops such as grain and oilseed commodities for development and registration of pesticides. Frequently these so-called "minor" crops make significant contributions to regional economies. This situation has produced cooperative efforts on the part of governments and growers with pesticide manufacturers in generating data that contributes to minor use registrations. A pioneer in this area is the U.S. IR-4 Minor Use Program, a publically funded program that has actively conducted research and submitted petitions for registration since 1963(web site: **http://www.cook.rutgers.edu/~ir4**). Canada now has a minor use program, and Mexico is participating in a number of the U.S. IR-4 activities. A key goal is harmonization of approaches and data exchange among countries. Actually minor use pesticide registration programs are in various stages of development worldwide. The IUPAC Environmental Chemistry Division has initiated an information exchange project to address the need for communication and data-sharing among countries. For additional information on these efforts, contact Dr. Don Wauchope (**don@tifton.cpes.peachnet.edu**).

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