UNIVERSITY OF ARKANSAS
DIVISION OF AGRICULTURE

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Agriculture and Natural Resources

Asian Soybean Rust

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Introduction

Asian soybean rust is a serious disease threat to Arkansas and U.S. soybean production. On November 10, 2004, the disease was confirmed in two soybean fields in Louisiana and shortly thereafter in Mississippi, Florida, Georgia, Alabama, Arkansas, Missouri, South Carolina and Tennessee. The disease was found on soybean plants that remained green very late in the season due to various factors. It was also noted on kudzu in Florida. All available evidence suggests that the disease was introduced by windborne spores carried from the northern edge of South America to the southern U.S. by Hurricane Ivan in September. On February 23, 2005, Asian soybean rust was confirmed as surviving on kudzu in Pasco County, Florida, indicating successful overwintering.

This fact sheet is intended to provide information on biology, identification and control of the disease.

Cause

Soybean rust is caused by the fungus *Phakopsora pachyrhizi*, originally reported in Japan in 1902 and not known outside the Eastern Hemisphere until 1994, when an isolated outbreak occurred in Hawaii. A similar fungus named *Phakopsora meibomiae* has been present in parts of the Caribbean and South America for many years but causes only a mild rust disease on soybeans and other legumes. *P. meibomiae* has not been found in the continental U.S.

Since 1902, *P. pachyrhizi* has become a problem in various parts of Asia and Australasia.

During the 1990s, the disease was reported in Africa, spreading to various soybean-producing countries there.

In 2000-2001, *P. pachyrhizi* was detected in Paraguay, South America, and confirmed in Brazil and Argentina in 2002 and Bolivia in 2003. It has caused major problems in these countries since its introduction.

In 2004, the disease was confirmed in Colombia, South America, north of the equator, making its introduction into the southern U.S. imminent – and this later occurred in September via Hurricane Ivan. Reasons for the rapid geographic spread of Asian soybean rust from Asia to Africa and the Western Hemisphere during the past decade are not well understood.

Symptoms

Earliest symptoms may include tiny brown or brick-red dots on the upper leaf surface. The dots can best be seen by holding the leaf up to a light source. Pustules (1/16″ – 1/8″ across) form on the underside of leaves, opposite the upper surface dots. These pustules have raised centers that eventually break open as a circular pore to exude masses of urediniospores (Fig. 1, middle right). Pustules and spore masses can best be seen with a 20X or stronger hand lens.

Lesions and pustules may appear polygonal (angled sides bordered by small leaf veins). The lesions and pustules may be tan-colored on some plants and reddish-brown on others.

Symptoms of soybean rust may be confused with certain other soybean leaf diseases that are common in Arkansas, including bacterial pustule and brown spot. Bacterial pustule may form raised pustules, although not always. These pustules do not contain spore masses, and they break open with a slit or crack rather than a circular pore as do soybean rust pustules.

As soybean rust becomes more severe, infected leaves fall off, leading to a "shutdown" of the plant and premature maturity. This results in severe yield loss and small seed size.

Disease Cycle

The Asian soybean rust fungus can reportedly infect at least 95 legume species (Table 1).

Kudzu, a common roadside plant in the southern U.S., is a preferred host. Other preferred hosts include lima beans, green beans, cowpeas and certain clovers. Consequently, soybean rust may be a concern for home gardeners and vegetable producers as well as commercial soybean growers.

The Asian soybean rust fungus has one type of important windborne spore in nature, called the urediniospore (Fig. 1, lower left and right). Unlike many rust fungi, urediniospores of Asian soybean rust can directly penetrate and infect leaves, not requiring stomates or natural openings in the leaf for entry. Under favorable conditions, the cycle from penetration and infection to production of new urediniospores can be as short as 9 days. Production of new spores from original pustules can continue for 2-3 weeks; however, secondary pustules may form around the original, continuing spore production for up to 15 weeks after infection. This long period of sporulation enables the rust fungus to survive unfavorable weather during the growing season.

At least 6 hours of leaf wetness is needed for infection, with 10-12 hours considered very favorable. The fungus is able to infect soybeans at temperatures from 59-82° F although development at higher temperatures is likely if adequate leaf wetness is present. Mild temperatures from 70-80° F and heavy dew or light rainfall strongly favor epidemics. *P. pachyrhizi* can infect stems, pods and petioles but prefers leaves. In other countries, the disease is first noticed in the lower canopy, usually about first flowering (R1-R2), then rapidly develops throughout a field. Thus early identification is critical to prevent major losses.

Table 1. Plants reported as hosts of the soybean rust pathogen, *Phakopsora pachyrhizi*.

Alysicarpus glumaceus	Alyce clover
Alysicarpus nummularifolius	
Alysicarpus rugosus	Alyce clover
Alysicarpus vaginalis	Alyce clover
*Cajanus cajan**	Cajan, pigeon pea
Calopogonium mucunoides	
Canavalia gladiata	Swordbean
Centrosema pubescens	Butterfly pea
Clitoria ternatea	Kordofan pea, butterfly pea, Asian pigeon wings
Coronilla varia	Crownvetch
Crotalaria anagyroides	Rattlebox
Crotalaria saltiana	Rattlebox
Crotalaria spectabilis	
Delonix regia	Poinciana or royal poinciana
Desmodium triflorum	Three-flower beggarweed
Erythrina subumbrans	Dadap
Erythrina variegata	Indian coral tree
Glycine canescens	Soybean relative
Glycine clandestina	Soybean relative
Glycine falcata	Soybean relative
*Glycine max**	Soybean
Glycine soja	

Glycine tabacina	Soybean relative
Kennedia prostrata	
Kennedia rubicunda	
Lablab purpureus	Lablab, hyacinth bean
Lespedeza bicolor	Lespedeza
Lespedeza striata	Lespedeza
Lespedeza stipulaceae	Lespedeza
Lotus spp.	Trefoil
Lotus americana	
*Lupinus**	Lupines
Lupinus albus	White lupine
Lupinus angustifolius	Narrow-leaved lupine
Lupinus hirsutus	Blue lupine
Lupinus luteus	Yellow lupine
M. speciosus	
Macroptilium atropurpureum	Siratro, purple bean siratro
Macrotyloma axillare	
Medicago arborea	Medic
Medicago lupulina	Black medic
Melilotus officinalis	Yellow sweet clover
Mucuna	Velvetbeans
Mucuna cochinchinesis	Velvetbean relative
Neonotonia (Glycine) wrightii	Glycine
*Pachyrhizus ahipa**	Yam bean
*Pachyrhizus erosus**	Yam bean, jicama, chop suey bean
*Phaseolus lunatus**	Butter bean, lima bean
*Phaseolus vulgaris**	Kidney bean, green bean
Pisum sativum	Peas (green)
Psophocarpus tetragonolobus	Winged bean or Goa
*Pueraria lobata**	Kudzu
*Pueraria montana var. Lobata**	Kudzu
Pueraria phaseoloides	Tropical kudzu
Rhynchosia minima	
Senna obtusifolia	Sicklepod
Senna occidentalis	Coffee senna
Sesbania exaltata	Colorado River hemp, hemp sesbania, coffeebean
Sesbania macrocarpa	Peatree or Colorado River hemp
Sesbania vescaria	
Trifolium repens	White clover
Trifolium incarnatum	Crimson clover
Trigonella foenum-graicum	Fenugreek
Trigonella foenum-gracecum	Fenugreek
Vicia angustifolia	Narrow-leaf vetch
Vicia dasycarpa	Wooly-pod vetch
Vicia faba	Broadbean or fava bean
Vicia narbonensis	Broad-leaved vetch
Vicia villosa ssp. varia	Woolypod vetch
Vigna mungo	Urd or black gram
*Vigna radiata**	Mung bean
*Vigna unguiculata**	Cowpea, black-eyed pea, yardlong bean
Voandzeia subterranea	Bambara groundnut

*Preferred hosts. Other hosts were minor or determined experimentally under artificial conditions.

There are many references for this list. We primarily used the *2004 Crop Protection Compendium* (CAB) and its references with additions from the USDA Office of Pest Management Policy list *Known Host Crops for Phakopsora pachyrhizi* obtained from Kent Smith.

Yield Loss

Soybean rust has been reported to cause 80 percent or more yield loss under the right conditions. The average yield loss in a given area may be much less and is influenced by many factors. All soybean cultivars currently grown in the U.S. and Arkansas are considered susceptible. Research on development of resistant varieties continues.

Control

Cultural practices such as early planting, wider row spacings or early maturing cultivars have been suggested as methods to minimize disease severity. These practices, however, are unproven in our environment and could actually increase disease severity.

For example, if soybean rust were to move northward into Arkansas from overwintering sites along the Gulf Coast or the Caribbean area during the late summer, then early planting and early maturing cultivars would be a good option. However, if the disease enters the state during April and May, then early planted Group III or IV varieties would likely be heavily damaged since temperature and rainfall patterns for Arkansas during May and June favor soybean rust development. Also, early planted and early maturing soybeans could serve as a "rust bridge" to later planted fields by providing large areas of host plants for buildup of the fungus. Some experts believe that July and August conditions in Arkansas may be too hot and dry most years to encourage maximum rust development.

At this time, practices that result in high yield potential should be the approach to use, since fungicides will be the main control method and high yielding soybeans can best absorb this extra input cost.

Consequently, fields planted very late (June-July) or very early (March-April 10) or fields with historically low (<40 bu) yield potential will be at greatest risk for economic losses if soybean rust proves serious in 2005. Marginal production systems will not be able to justify the added cost of two fungicide applications that may be necessary to control soybean rust. Other crops, including grain sorghum, should be considered on marginal soybean land.

Wider row spacing has been reported to improve fungicide effectiveness slightly because of better canopy penetration and coverage, but it has apparently not diminished the number of applications needed. Wider rows may increase ground sprayer options and could delay a rust epidemic for a day or two compared to dense canopies, allowing slightly more time to react and easier scouting. However, wider-spaced rows may also reduce overall yield potential.

Drilled soybeans in 7-inch rows or broadcast soybeans with thick stands may increase soybean rust severity because the plant canopy closes more quickly, resulting in a more humid environment that favors rust. Dense canopies also reduce fungicide coverage. On the other hand, narrower rows and denser canopies can improve weed control.

Research on the best combination of cultural practices to enhance yield potential and minimize diseases will be a strong focus for soybean rust workers during the next few years in the U.S.

The only proven method of control for soybean rust will be the application of fungicides that are effective against soybean rust (Table 2). If soybean rust is present in the field or in nearby fields before the crop has reached the R3 growth stage, then it is likely that two applications will be necessary, based on data from other countries. Fungicide labels suggest the first application either at the first sign of disease, or usually between R1 (first flowering) to R3 (3/16″ long pod on any of the four upper nodes). The first application is critical for control. A second application will likely be needed and labels typically suggest 7 to 21-day intervals between applications, depending on the fungicide. Certain materials may be restricted to only one or two applications per season, so the label should be carefully studied before use.

Scouting treated fields should be done after the first application to judge the aggressiveness of the disease and the need for a second application. Scouting should be conducted daily, using a hand lens to examine the underside of leaves for fresh pustules (Fig. 1, middle left). Once a week during the three weeks after the first fungicide application, 50 leaves should be collected randomly during scouting. Randomly select 20 leaflets from the 50-leaf sample and place in a simple moist chamber consisting of a plastic ziploc bag containing a moist (not wet) paper towel. Inflate the bag slightly by blowing air into it and incubate the leaves at room temperature for 24-72 hours, examining the leaves for pustules periodically. Keep the bag out of direct sunlight. An ice chest should be used for storing leaf samples (ice is not needed) while transporting.

As of March 7, 2005, Quadris® and Headline® fungicides (strobilurins) were fully labeled on soybeans in the U.S. for soybean rust and other diseases. These fungicides are most effective when applied before infection.

Table 2. Fungicides approved as of 12/16/04 for control of soybean rust in Arkansas during 2005.

<table>
<tr><th>Product</th><th>Active Ingredient</th><th>Type of Label</th><th>Approved</th><th>Rate Range</th><th>Chemistry</th></tr>
<tr><td>Quadris</td><td>Azoxystrobin</td><td>Section 3 (Full)</td><td>Yes</td><td>6.2 - 9.2 fl oz/A</td><td>Strobilurin</td></tr>
<tr><td>Headline</td><td>Pyraclostrobin</td><td>Section 3 (Full)</td><td>Yes</td><td>6 - 12 fl oz</td><td>Strobilurin</td></tr>
<tr><td>Tilt</td><td>Propiconazole</td><td>Section 18 (Emergency)</td><td>Yes</td><td>4 - 8 fl oz</td><td>Triazole</td></tr>
<tr><td>Propimax</td><td>Propiconazole</td><td>Section 18 (Emergency)</td><td>Yes</td><td>4 - 8 fl oz</td><td>Triazole</td></tr>
<tr><td>Bumper</td><td>Propiconazole</td><td>Section 18 (Emergency)</td><td>Yes</td><td>4 - 8 fl oz</td><td>Triazole</td></tr>
<tr><td>Folicur</td><td>Tebuconazole</td><td>Section 18 (Emergency)</td><td>Yes</td><td>3 - 4 fl oz</td><td>Triazole</td></tr>
<tr><td>Laredo EC</td><td>Myclobutanil</td><td>Section 18 (Emergency)</td><td>Yes</td><td>4 - 8 fl oz</td><td>Triazole</td></tr>
<tr><td>Laredo EW</td><td>Myclobutanil</td><td>Section 18 (Emergency)</td><td>Yes</td><td>4.8 - 9.6 fl oz</td><td>Triazole</td></tr>
<tr><td>Stratego</td><td>Propiconazole + Trifloxystobin</td><td>Section 18 (Emergency)</td><td>Yes</td><td>5.5 - 10 fl oz</td><td>Triazole + Strobilurin</td></tr>
<tr><td>Quilt</td><td>Propiconazole + Azoxystrobin</td><td>Section 18 (Emergency)</td><td>Pending</td><td>14 - 20.5 fl oz</td><td>Triazole + Strobilurin</td></tr>
<tr><td>Domark 230ME</td><td>Tetraconazole</td><td>Section 18 (Emergency)</td><td>Yes</td><td>4-6 fl oz</td><td>Triazole</td></tr>
<tr><td colspan="6">The following are approved chlorothalonil products on soybeans that have soybean rust on their labels as of December 9, 2004. Chlorothalonil has some activity against soybean rust as a protectant but no systemic properties. Reports from other countries indicate it is used as a rotation product with the more effective fungicides listed above, especially if the more effective strobilurin/triazole fungicides are in short supply.</td></tr>
<tr><td>Bravo WeatherStik</td><td>Chlorothalonil</td><td>Section 3 (Full)</td><td>Yes</td><td>1.5 - 2.25 pts/A</td><td>Chlorothalonil</td></tr>
<tr><td>Echo 720</td><td>Chlorothalonil</td><td>Section 3 (Full)</td><td>Yes</td><td>1.5 - 2.5 pts/A</td><td>Chlorothalonil</td></tr>
<tr><td>Echo Ultimate</td><td>Chlorothalonil</td><td>Section 3 (Full)</td><td>Yes</td><td>1.36 - 2.27 lbs/A</td><td>Chlorothalonil</td></tr>
<tr><td>Equus 720SST</td><td>Chlorothalonil</td><td>Section 3 Suppl.</td><td>Yes</td><td>1.5 - 2.5 pts/A</td><td>Chlorothalonil</td></tr>
<tr><td>Equus DF</td><td>Chlorothalonil</td><td>Section 3 Suppl.</td><td>Yes</td><td>1.25 - 2.2 lbs/A</td><td>Chlorothalonil</td></tr>
<tr><td colspan="6">Read and follow all labels. The label is the law. Section 18 labels must be in possession of the applicator and section 18 pesticide applications must be reported to the Arkansas State Plant Board. The Domark Section 18 Label was pending in Arkansas as of April 5, 2005.

Many fungicides have restrictions on the labels regarding application, drift or runoff into streams, ponds or other aquatic environments or “sensitive” areas. Toxicity to fish, mollusks or other aquatic organisms is largely unknown in natural environments; however, some fungicides listed have been shown to be toxic to aquatic organisms under controlled laboratory experiments. Therefore, IT IS IMPERATIVE THAT ALL APPLICATORS READ LABELS CLOSELY AND USE ALL NECESSARY PRECAUTIONS.</td></tr>
</table>

Another fungicide currently labeled is chlorothalonil (trade names Bravo®, Echo®, Equus®), which reportedly has some preventative activity against soybean rust as well.

Thiophanate-methyl fungicides such as Topsin® and TM85® are registered for use on soybean but are not considered effective on soybean rust.

All U.S. soybean production states asked for emergency exemptions for a number of other fungicides during 2004 for Asian soybean rust. As of March 7, 2005, propiconazole (Tilt®, Propimax® and Bumper®), myclobutanil (Laredo®) and Laredo EW®, tebuconazole (Folicur®), and tetraconazole (Domark®) were approved. Triazoles are upwardly-mobile fungicides that may suppress established infections ("curative").

A mixture or a sequential application of a strobilurin and a triazole fungicide is considered the most effective fungicide program in other countries for the control of soybean rust. Emergency exemptions for the fungicides Quilt® and Stratego®, both premixes of a strobilurin and a triazole, were submitted in 2004, and Stratego® has been approved. Other fungicides may be available in the future.

Thorough coverage of soybeans will be essential for these fungicides to be effective. Labels should be closely followed to assure good coverage. Additional tips on ground sprayer setup and spraying fungicides can be obtained from various spraying systems manufacturers. Tips for both ground and aerial application can be found at http://www.aragriculture.org/agengineering/pest/default.asp, authored by Dr. Dennis Gardisser.

Estimated fungicide costs to control soybean rust reportedly range from $15-$18 per acre per application. Assuming two applications will be needed, total fungicide cost to control soybean rust will likely range from $30-$36 per acre. In some areas, costs may be higher than these estimates.

As previously noted, this level of input cost favors high-yield soybean production and will discourage soybean production on fields with marginal yields if soybean rust becomes an annual problem.

University of Arkansas Division of Agriculture Response

Before the arrival and subsequent overwintering of Asian soybean rust, the Division established the Arkansas Working Group on Introduced Plant Diseases. This group of scientists drafted a plan to deal with Asian soybean rust that included submission of Section 18 requests for new fungicides for Arkansas (accomplished in 2004); training of 500-700 "first detectors" to help monitor for the disease in 2005 (accomplished); grower education during the winter (accomplished); establishment of the Arkansas Soybean Rust Alert Network (in progress); establishment of sentinel plots throughout the state (started in March, 2005); establishment of soybean rust webpage – http://www.aragriculture.org/cropsoilwtr/soybeans/default.asp; establishment of fungicide testing and other applied research (in progress); upgrading the Plant Disease Clinic (in progress); and creation of a regional Mid-South Asian Soybean Rust project (in progress).

These activities should result in early warning, consistent updates and better preparation by Arkansas soybean growers and industry to deal with this new threat.

For additional information or the latest updates, contact your local Cooperative Extension Service county agent.

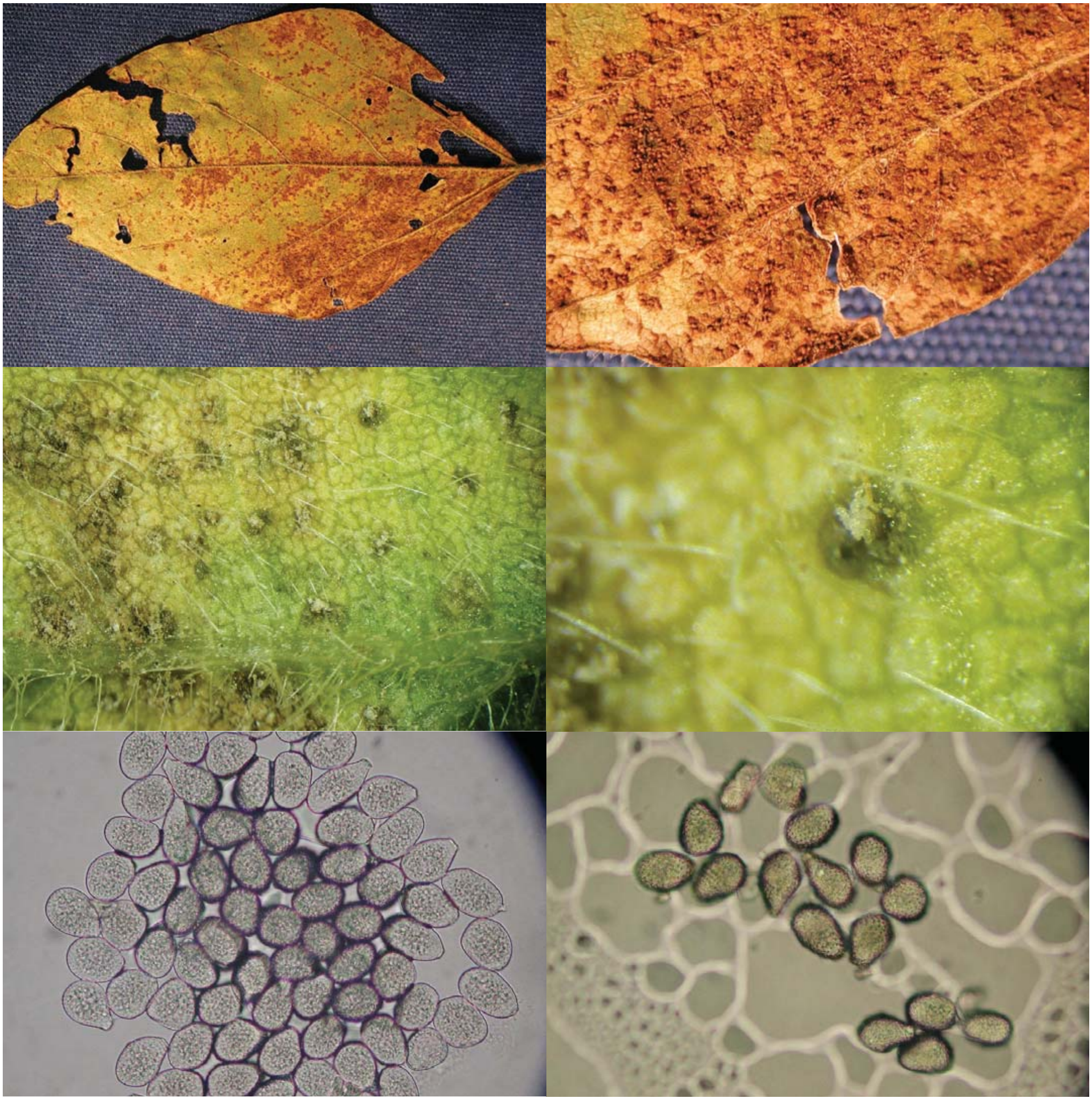

Figure 1. Upper left: Undersurface of lower soybean leaf from infected plant in eastern Arkansas collected November 19, 2004 (photo by Mark Trent). Upper right: Magnified image of rust pustules from upper left photo (also by Mark Trent). This would be similar to the magnification produced by a 14X hand lens. Note that pustules stick up from the leaf surface as tiny bumps 0.5-2 mm in diameter and may have a hole in the top. Middle left: Magnified image of pustules after incubation in a plastic bag with moistened paper towel overnight. Note spores are oozing from the tops of the pustules (photo by Rick Cartwright). Middle right: Closer view of spores (whitish grains) oozing from pustules under a well lighted dissecting scope (photo by Rick Cartwright). Lower left: Spores from middle right specimen mounted in water and viewed at 400X using a compound microscope and bright field lighting (photo by Rick Cartwright). Lower right: Spores mounted in an air drop within a water mount at 400X showing the rough surface of the spores (photo by Rick Cartwright). A good website for additional images is http://www.ppdl.purdue.edu/ppdl/pubs/soybean_rust_symptoms_web.pdf.

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