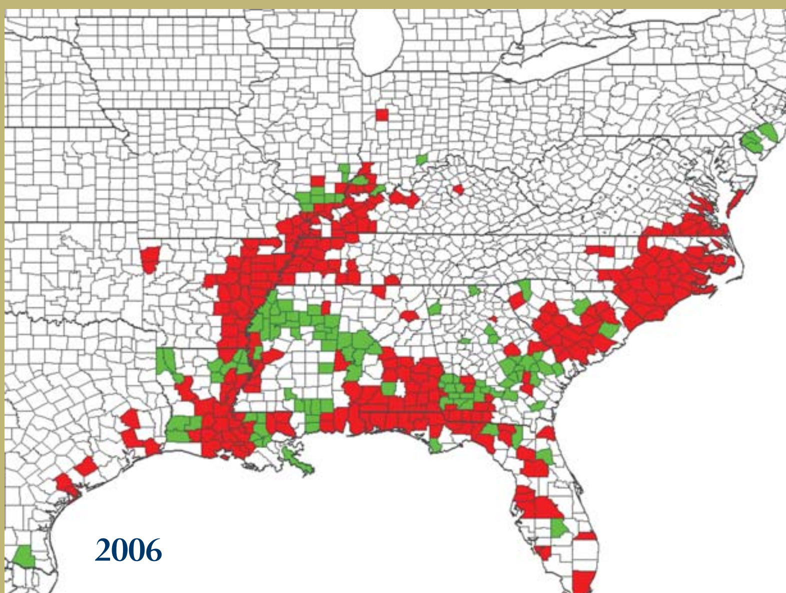
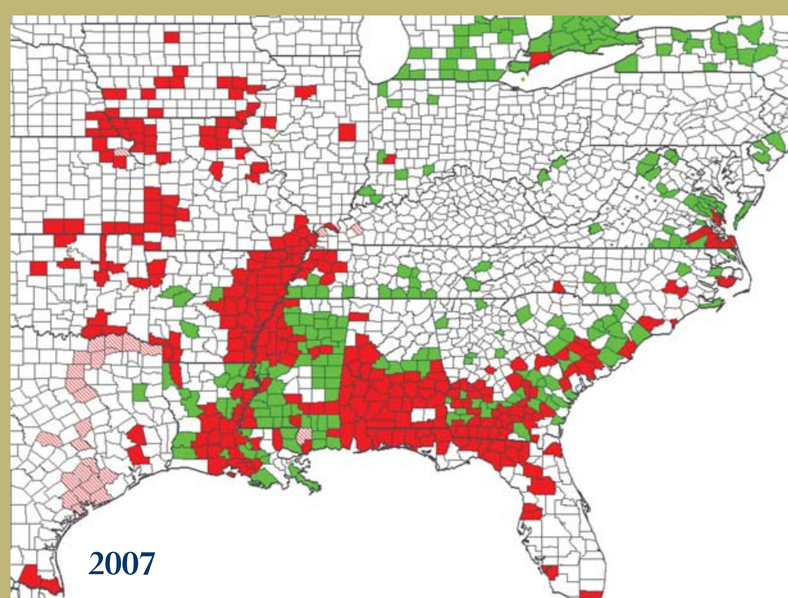
Soybean Rust Management *in the* Mid-Atlantic Region





Underside of leaf heavily infested with soybean rust. Lesions with multiple pustules.

Enlarged view of lesion on underside of a leaf showing multiple pustules per lesion.

Cover maps downloaded from http://www.sbrusa.net/. Red indicates counties where rust has been found. Green indicates counties which have been scouted but no rust was found.

Inside cover photos courtesy of J. T. Yorinori, Ph.D., Embrapa Soja, Londrina, Brasil.

Soybean Rust Management *in the* Mid-Atlantic Region

Edited by:
John D. Mueller
Stephen R. Koenning
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Introduction

The soybean checkoff is proud to partner with your cooperative extension and research specialists to bring you this updated version of Soybean Rust Management in the Mid-Atlantic Region. This publication contains the most current, accurate, and concise information based on factual observations by researchers who have studied rust behavior and movement over several growing seasons here in the southeast. Much of the research conducted in order to make the recommendations found in this guide was funded, in part, by your soybean checkoff. We hope this information will assist in your decisions as you strive to become more productive and profitable.

Three years after throwing Asian Soybean Rust into the soybean management mix, several questions have been answered and theories have been developed. The sentinel plot monitoring system has worked very well. As rust spreads, most of the first finds are in sentinel sites. Rust has not been a problem prior to flowering – therefore, applying fungicides before the R3 growth stage is not recommended unless pressure is severe. Timing applications of appropriate fungicides is very important both in protecting a crop and saving money by eliminating unnecessary sprays. Untreated test plots have shown yield reductions, but yield losses in properly treated commercial fields have been minimal. While rust is known to have over ninety-five host species, including kudzu and legume crops, it has not affected either vegetable production or wildlife food plots. Finally, rust spores seem to be very susceptible to ultraviolet rays and extreme heat – several years of drought and fairly inactive hurricane seasons have quite possibly slowed the incidence and severity of rust.

The best decisions are made with the most information. This wisdom applies to protecting your crop from soybean rust, so be proactive, prepare, and have a plan before hooking up to the planter. Know your soil, plant varieties, soybean growth stages, short and long-term weather forecasts, and the budget within which you are working. Prepare for other perennial pests and nutrient requirements, as healthier plants are less susceptible to disease in general. Use this book, the USDA Soybean Rust website, attend grower meetings, and stay informed.

Five years ago the soybean checkoff funded the first research in the U.S. to identify rust-resistant soybean varieties. So far, two genes have been identified that could lead to rust resistance in the near future. Additional work is being conducted to develop new fungicides and evaluate alternative management techniques. Your checkoff is committed to building a strong future for soybean farmers. You can always count on your cooperative extension service professionals and your farmer-leaders to work together in *making your checkoff payoff*.

Aaron Wood

Aaron Wood
Executive Director
South Carolina Soybean Board

SCSB
SOUTH CAROLINA SOYBEAN BOARD
Making Your Checkoff Pay Off.

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Soybean Rust Management Plan

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A Brief History of Rust in the Western Hemisphere

Layla Sconyers, ***Post-Doctoral Research Associate, University of Georgia-CPES, Tifton***
Steve Koenning, ***Extension Plant Pathologist, North Carolina State University***

Rust in South America: Soybean rust was first observed in South America in 2001 in Paraguay. Since 2001 it has been found in Brazil, Bolivia, Argentina, Colombia, and Uruguay. By 2004, most of the soybean acreage in Brazil received multiple applications of fungicides. In 2005 the number of fungicide applications for soybeans in South America ranged from less than 1 in Argentina to as many as 5 in parts of Brazil and Bolivia. Rust was relatively light in many areas of Brazil in 2005-2006 because of drought, whereas other areas with abundant rainfall saw severe pressure from rust.

In parts of Brazil and Argentina fungicide applications started two to three weeks before flowering. Rust was widespread in Argentina in 2004-2005, but yield loss from rust was considered minimal, and Argentina had record soybean yields.

Argentina was expecting severe rust in 2005-2006, because of a mild winter that resulted in large amounts of volunteer soybean that were infected with rust. Soybean rust, however, did not develop as anticipated in Argentina even in the northern states of Entre Rios and Missiones. There were periods of drought in southern Argentina that may have impeded development of rust there, but more than adequate rainfall occurred in northern areas. Some crop professionals suggested that variation in day/night temperatures south of Brazil impeded rust development. The crop consultants in Argentina take a more conservative view on management of soybean rust. In general, their recommendation is to wait until rust is found before making fungicide applications.

Detection of Rust in the United States: In November 2004, soybean rust was first detected in the continental United States in a production soybean field at the LSU AgCenter in Baton Rouge, Louisiana. In the following weeks, the disease was found in Alabama, Arkansas, Georgia, Florida, Mississippi, Missouri, South Carolina and Tennessee. At that time many researchers felt that soybean rust could become widespread in the Southeast and Midwestern states in 2005.

Rust in the United States During 2005: Potential yield losses for the United States crop in 2005 were estimated to be between 10 and 50%, but as much 80% if no action was taken for disease management. In order for disease to develop to this level, optimal environmental conditions and over-wintering on a host in a no-frost region would have to occur. It was predicted that the disease would survive on kudzu or other legumes in southern no-frost regions or be blown into the United States from the Caribbean, Central America or South America. However, by the end of 2005, soybean rust was only observed in the Southeast, and the disease did not reach levels predicted for 2005 (*Fig. 1*).

Soybean rust was detected first in 2005 on kudzu in Pasco County, Florida. The disease was later detected on volunteer soybeans in April in Seminole County, Georgia. Soybean rust was not detected again on soybean or kudzu for nearly two months, although weather conditions associated with multiple tropical storms seemed favorable for disease development, especially in Georgia. The disease was found on roadside kudzu in Jefferson County, Florida on 14 June 2005. Further spread of soybean rust was slow from June to July 2005, despite seemingly optimal conditions for disease. During this time, many soybean cultivars planted in the Southeast were approaching the bloom stage (R1). June was typified by cooler than average temperatures, and widespread rainfall events in the Southeast. Soybean rust detections began to increase in August when soybeans were reaching R3-R4 growth stages. Positive detections continued through November. Overall, 35, 10, 47, and 22 counties in the United States reported soybean rust in August, September, October and November, respectively (*Fig. 1*). This increase in the number of detections occurred during a time in which temperatures rose by 5-10 degrees on average and rainfall decreased. With a few exceptions, soybean rust was not detected in many commercial fields until the R4 stage or later.

It was also noted in 2005 that soybean rust began in discrete focal points in the lower soybean canopy within a field, and then the disease would move upward within the canopy and to adjacent soybean plants within approximately 7-10 days, before spreading over the entire field. Large scale defoliation of fields over a brief period of time, as has been reported in South America, was not observed.

Soybean rust was widespread by the end of the 2005 growing season in the Southeast; however, northern spread in the region appeared to be slow. When most of the United States crop had been harvested in mid-November, soybean rust was found as far north as Caldwell County, Kentucky, as far east as Hyde County, North Carolina, and as far west as Liberty County, Texas.

Maps showing the distribution of rust through time on a state by state basis are available at *http://www.sbrusa.net/*.

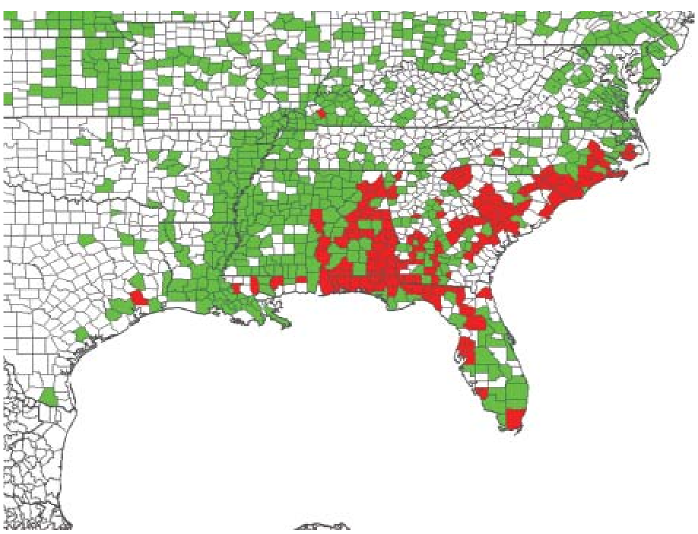

Figure 1. Final distribution of rust in 2005. Map available at http://www.sbrusa.net/.

Asian Soybean Rust in Georgia

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Asian soybean rust, caused by the fungal pathogen *Phakopsora pachyrhizi,* has occurred in Georgia annually since 2004. The disease has been detected on soybeans, kudzu, and Florida beggarweed growing in the state. The threat of Asian soybean rust has forever changed production practices for soybean producers who have not typically applied fungicides for the control of disease. Today, nearly every soybean producer in Georgia is prepared to make one or more fungicide applications to protect their crop from Asian soybean rust.

History: The first discovery of Asian soybean rust in Georgia was made by county agent Rome Ethredge in Seminole County in mid-November 2004. Within the next week, Asian soybean rust was detected at other locations across the Coastal Plain of the state. It is extremely unlikely that soybean rust would have been in detected in Georgia in 2004 had it not been for the earlier discovery by Dr. Ray Schneider at Louisiana State University. Apparently, Asian soybean rust developed late enough in the season in 2004 that yields in commercial fields were not affected, although it is impossible to confirm this.

The spread of Asian soybean rust into Georgia was similar in 2005 and 2006. In 2005, an initial find was made on volunteer soybean plants in April in Seminole County; however little, if any, spread from that source is believed to have occurred. Based upon the results from monitoring sentinel plots across the state, lasting epidemics of Asian soybean rust were first detected in both years in extreme southwestern Georgia in mid-July. The disease then spread to soybean and kudzu growing throughout nearly the entire state. In 2005 it was estimated that soybean rust was spreading north within the state at a rate of approximately 60 miles per week.

In 2005 and 2006 the spread of Asian soybean rust and yield losses to the disease were quite variable. In some fields, especially those that received irrigation through center pivot systems, Asian soybean rust spread relatively quickly and uniformly across the entire field. Yield losses between untreated plots and plots treated with fungicides could be as high as 20+ bu/A. In fields that were not irrigated it could take as long as six weeks to spread from one end of the field to the other and yield losses were closer to five bu/A.

The spread of Asian soybean rust was very different in 2007 than it had been in 2005 (*Fig. 1*) and 2006 (*see cover map*). The disease was first detected on private research farms in Brooks and Tift Counties and was not detected in sentinel plots until August. The extreme drought experienced in Georgia in 2007 not only delayed the start of the rust epidemic, but it also limited the spread of the disease. As of late December 2007, Asian soybean rust was confirmed in at least 51 counties within the state, but was never found outside of the coastal plain or the lower piedmont region (Macon in Bibb County) (*see cover map*). Despite the slow spread of the disease in 2007, results from fungicide studies indicate that the disease did affect yields in southern Georgia.

Management: Soybean producers in Georgia have used fungicides to protect against Asian soybean rust annually since 2005. Although producers did not typically use fungicides on soybeans prior to 2005, most were familiar with fungicides based upon experiences with diseases of peanut and other crops. It is estimated that 65%, 45%, and 70% of the soybean acreage in Georgia was treated with at least one fungicide application in 2005, 2006, and 2007, respectively. In 2007, approximately 90-100% of the acreage in southwestern and south-central Georgia was treated; 40-60% of the acreage was treated in southeastern Georgia, and little acreage was treated in northern Georgia due to extreme drought.

The fungicides that seem to be most popular with soybean producers in Georgia include Folicur and other tebuconazole products, Headline (pyraclostrobin), Stratego (trifloxystrobin + propiconazole) and Quadris (azoxystrobin). The popularity of these fungicides is related to efficacy, cost, and use of the same products for management of peanut diseases.

Most soybean producers in Georgia report that they look to Cooperative Extension for guidance on when to spray their soybeans for control of rust. Others get their recommendations from the popular press or from agrichemical distributors. Some growers will automatically tank-mix a fungicide with their Dimilin and boron that is to be applied at the R3 (pod set) growth stage to insure that the crop is protected.

Current recommendations from the University of Georgia Cooperative Extension are that growers should wait to apply a fungicide for control of Asian soybean rust until soybean rust is detected in the local region, the crop has reached reproductive growth stages, and weather is favorable for disease spread. Growers who automatically spray a fungicide at the R3 growth stage will likely protect their crop; however the application may not be needed if the disease is slow to spread. A second fungicide application may be needed in some situations.

Over-Wintering of Asian Soybean Rust in Georgia: Prior to the arrival of Asian soybean rust in the continental United States it was believed that the disease would not survive in Georgia because freezing temperatures would kill all kudzu and volunteer soybeans. It is now known that patches of kudzu infected with Asian soybean rust can survive the winter in southern Georgia despite freezing temperatures. These patches of kudzu are typically found in protected areas around buildings and other structures in the southern tier of counties. It is not clear how the spores from these small patches of kudzu influence the development of Asian soybean rust in the following growing season.

Growers with questions about control of Asian soybean rust are encouraged to contact their county agent with the University of Georgia's Cooperative Extension Service for more information and the latest fungicide efficacy data.

Asian Soybean Rust in South Carolina

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Asian soybean rust has occurred annually in South Carolina since the late fall of 2004. Although kudzu is a known host of Asian soybean rust the primary host in South Carolina appears to be soybean. In Florida and along the Gulf coast rust overwinters on volunteer soybeans and kudzu. However, each winter in South Carolina freezing temperatures kill off the volunteer soybeans and kudzu. Therefore, rust must start over yearly in South Carolina with inoculum blowing in from Georgia, Florida, and possibly other areas such as Texas or Mexico.

Rust in 2004: Asian soybean rust was first found in South Carolina in mid-November 2004. Most soybeans had been harvested and finds were limited to volunteer beans along hedge rows and turn rows or in weedy areas of fields. Rust was also found in small soybean patches under street lights or where soybean plants were still green due to viral infections. Rust was found only in Allendale, Barnwell, Calhoun, Hampton, Horry, Jasper, and Pickens Counties. Rust appeared so late in 2004 that any yield losses would have been minimal. Killing frosts in mid November eliminated any detectable rust in South Carolina in the late fall of 2004.

Rust in 2005: In 2005 rust progressed systematically across Georgia. South Carolina growers could watch it come nearer each week as it was detected in monitoring plots in Georgia. Rust was first detected in South Carolina on August 14 in 2005 and then spread rather quickly across the state. Rust was eventually found in 19 South Carolina counties (*Fig. 1*). Documenting yield losses due directly to rust was difficult in 2005. Many early planted fields were past the R5 growth stage when rust was detected and did not need to be sprayed. Most of the fields that were in growth stages susceptible to yield losses due to rust were sprayed with fungicides in a timely fashion. This eliminated any severe yield losses due to rust. Fungicide trials did detect yield losses due to rust that exceeded 10%.

Rust in 2006: In 2006 the progression of rust across Georgia was much more erratic. Rust was detected in South Carolina counties along the Georgia border before it was detected in corresponding counties on the Georgia side of the Savannah River. Unlike 2005 when it was first detected along the Georgia border, in 2006 rust was first detected in Calhoun County on August 17th. After a brief lag it was found in Orangeburg County on August 28th and then rust spread rather rapidly throughout the state. By the end of September it was found in 14 more counties and by the end of the growing season rust had been detected in 23 South Carolina counties (*see cover map*). Like 2005 many early-planted, early maturity group fields were past the R5 growth stage when rust was present in adjoining areas. These fields did not need to be sprayed with fungicides. Most later-planted fields that were in growth stages susceptible to damage from rust were sprayed with fungicides. Therefore yield losses due to rust in commercial fields were minimal.

Rust in 2007: Rust behaved very differently in 2007 in South Carolina than in the previous two years. Severe droughts in Georgia and South Carolina limited the spread of rust. Rust was not detected in South Carolina until September 10th when it was found in Hampton County. Unlike most previous finds rust was well developed in this field with more than 50% of the leaves affected. It is quite possible that rust had been in this field for 2 to 3 weeks prior to detection since the site had not been sampled for almost 3 weeks. Unlike 2005 and 2006, when Asian soybean rust eventually spread throughout the soybean producing counties of South Carolina, it was detected in only 8 counties. This is compared to 19 counties in 2005 and 23 counties in 2006. Four of the eight counties (Charleston, Colleton, Dorchester, and Georgetown) were relatively close to the coast where rainfall was heavier and more consistent during the late summer. The other four counties (Barnwell, Calhoun, Hampton, and Orangeburg) were in the southern half of the state and were sampled very intensively. Only traces of rust were found on kudzu in 2007 until late October. The relatively late appearance of rust in South Carolina meant that even more than in 2005 and 2006 fields were past the susceptible growth stages when rust appeared and did not need to be sprayed with fungicides. The unfavorable weather conditions for rust development in many parts of the state allowed growers to skip fungicide sprays. This was an economic plus for these growers since yields in many of these fields were low due to the drought. However, there were quite a few fields sprayed for rust in 2007. Many of these sprays were as much a response to the high market price of soybean and early season expectations of good yields than to actual pressure from rust. Despite the low levels of rust these fields were sprayed to control rust and as protection against the other foliar and pod and stem diseases. More than 50% of the soybean fields south of the Santee Cooper lakes were sprayed with a fungicide. North of the lakes drought conditions were so severe that yields were severely limited as was the spread of rust. Less than 33% of the fields north of the lakes were sprayed.

Management: Fungicide sprays over the last three years and the high market value of soybeans have caused growers to reevaluate how they grow soybeans in South Carolina. Producers are more actively managing their soybean crops and as long as prices remain high are willing to spray fungicides not just to manage rust, but to reduce the risks of late season fungal diseases. Growers rely heavily on the system of sentinel plots established not only in South Carolina but in Georgia and other parts of the Southern United States. Results from these plots are reported in the South Carolina Rust Newsletter and on the USDA web site at *http://www.sbrusa.net/*. South Carolina growers have learned to spray fungicides only after individual fields are past the flowering stage and if rust is present in their area. This system has allowed growers to control rust in a very efficient, low risk and cost effective manner.

Soybean Rust in North Carolina in 2007

Steve Koenning, ***Extension Plant Pathologist, North Carolina State University***

Soybean rust has been detected in North Carolina every year since 2005. Rust was found in 17, 44, and 6 counties in 2005 (*see Fig. 1, pg. 2*), 2006 (*see cover map*), and 2007 (*see cover map*) respectively. For the most part it has not required fungicide sprays and only in 2006 was it recommended that fungicides be sprayed in the southeastern counties on late-planted late-maturity soybean. Yield increases in these areas were on the order of 4 to 5 bushels per acre.

Soybean rust generally moves from south to north from Florida to Georgia and finally to North Carolina and Virginia. Much of this movement is by local spread which is relatively slow. Tropical systems that moved through the state from the south have generally resulted in either delivery of spores or in providing a conducive environment for rust to develop. In 2005 this was Ophelia and in 2006 tropical storm Ernesto coincided with development of rust in North Carolina. There was some concern in 2007 when a tropical storm moved through in June which could have brought spores from Florida. This did not happen because Florida and South Georgia were extremely dry and if there was any spore production in Florida prior to this time it was very minor. You have to have spores for a transport event (movement from one location to another).

In general we will likely need a wet spring and summer with lots of "gray days" to have an epidemic that requires fungicide sprays over large areas of the state. This can be expected about one year in five to one year in ten in North Carolina. Dr. Jim Dunphy and I maintain a network of communication with agricultural concerns to provide warnings about the need to spray for rust, and this will be in place again in 2008.

Asian Soybean Rust in Virginia

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Steve Rideout, ***Assistant Professor of Plant Pathology, Eastern Shore AREC, Painter***
David Holshouser, ***Associate Professor, Tidewater AREC, Suffolk***

History of Early Detection: Several approaches are vital for early detection of soybean rust because of the capability for long distance transport of spores in air currents. Compounding the threat is the capability of the fungus to produce high numbers of spores after an infection and the ability to repeat cycles of infection and spore production in periods as short as 10 days. Efforts coordinated and funded at the state and national level in the U.S. have established an elaborate network of sentinel plots and monitoring for early detection of soybean rust. The findings are continuously updated whenever the disease is found in a new county or state and especially when soybeans are in the most vulnerable stages from flowering (R1) to full seed (R6). These updates are posted on the USDA Soybean Rust Information Site, *http://www.usda.gov/soybeanrust/,* to provide continuous updates on disease progress and risk. The site also includes a battery of information about the disease and recommended control measures. The ultimate goal is to alert growers in areas of moderate to high disease risk in time for fungicide applications to provide effective disease control.

Plant pathologists and the soybean agronomist in Virginia and all soybean producing states have participated in this program since its inception. For example, intensive scouting supported by laboratory work in 2004 detected the first occurrence of soybean rust in South Carolina in mid-November. The disease was not detected in North Carolina, Virginia or states northward along the Atlantic Coast. In 2005, soybean rust was detected on August 14 in South Carolina and for the first time in North Carolina on October 25. The disease was subsequently confirmed on soybean in 18 counties of North Carolina, but not detected in Virginia (*see Fig. 1, pg. 2*). The epidemic of 2006 reached even further northward in that disease outbreaks occurred on soybeans as far north as Illinois and Indiana and east to Virginia (*see cover map*). The first occurrence of soybean rust in Virginia was on 9 October 2006 in Chesapeake. Thereafter, the disease was confirmed in 18 counties (*Fig. 2*). No significant losses of yield in 2006 occurred in Virginia due to low incidence and its appearance after plants had reached the full seed stage (R6). In spite of severe drought throughout the mid-Atlantic Region in 2007, soybean rust was detected on October 19 in Chesapeake, Virginia and field sampling up to November 10 confirmed the disease in eight counties (*Fig. 3*). In both 2006 and 2007, the disease appeared to follow the same pathway from South Carolina to eastern North Carolina and northward into the Tidewater Area and eastern Virginia. This pattern of occurrence of soybean rust suggests that disease is likely to pose a chronic threat for reducing yield in years of normal or above normal rainfall and especially when tropical storms move inoculum northward from the Gulf Coast into the mid-Atlantic Region when soybeans are flowering or as early as beginning pod (R3).

Disease Control: Based on the limited experience of only 3 years, it appears that higher levels of inoculum and more favorable weather for disease will be necessary for the disease to threaten soybean production in Virginia. Such conditions could greatly increase the risk for disease outbreaks by the time that soybeans are at beginning pod (R3) and prior to the full seed stage (R6). For effective disease control under these conditions, it will be imperative that sentinel plots and commercial fields be monitored for early detection of disease incidence in Virginia and states to the south and west of Virginia. Currently, Virginia growers are being warned of a high risk for infection whenever the disease is detected within 100 miles of their location and the crop is more than 2 weeks from reaching growth stage R6.

Field trials in Virginia have produced data showing that control of chronic diseases (Cercospora blight, anthracnose, frogeye leaf spot, etc.) by fungicide sprays with a strobilurin fungicide (Stratego, Headline, Quadris) can increase yield by amounts that pay for fungicide and application costs. Like soybean rust, chronic diseases are more aggressive in years of normal or above normal rainfall. In dry years as in 2007, these diseases and soybean rust are less aggressive and fungicide sprays are less likely to increase yield and profitability. Should soybean rust and chronic diseases pose significant risk for disease loss, the most profitable decision appears to be application of a tank mix of a strobilurin and triazole fungicide. This combination has broad spectrum activity against foliar diseases, and is expected to manage the risk for rust or other foliar pathogens developing resistance. To be effective and profitable, growers in Virginia need to monitor the spread of rust into the region and time the fungicide spray(s) according to the "100 mile rule" and prior to growth stage R6. This approach is expected to allow for a single application of fungicide to be effective in control of soybean rust and chronic foliar diseases in most years.

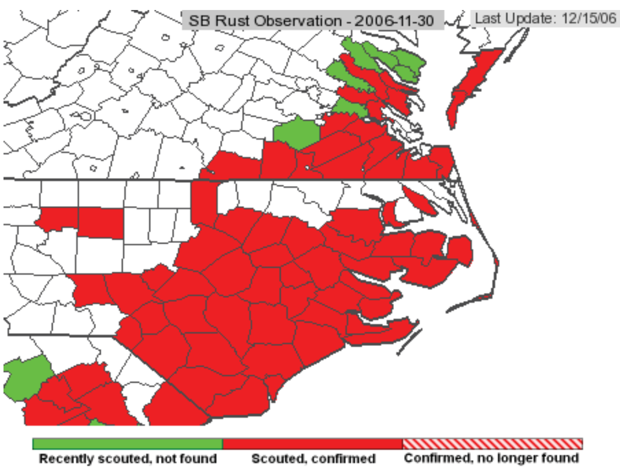

Figure 2. Incidence of soybean rust on 10 November 2006 (red indicates counties with disease; green indicates counties scouted and no disease found).

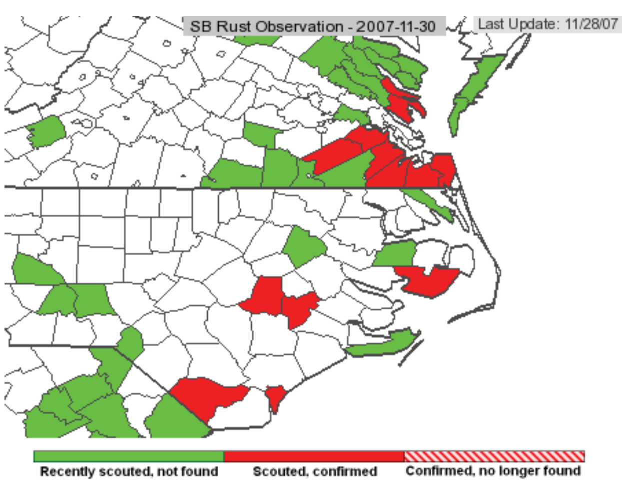

Figure 3. Incidence of soybean rust on 10 November 2007 (red indicates counties with disease; green indicates counties scouted and no disease found).

Soybean Rust Identification and Life Cycle

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Symptoms on Leaves: Soybean rust symptoms first appear as tiny brown or red spots on the upper leaf surface (*Fig. 4*) after fungal spores, called urediniospores (*Fig. 7*), are blown into fields and land on soybean leaves. If conditions are favorable (temperatures are 59-84 degrees F with long dew periods or frequent rain events), tiny spots can appear at least 4 days after infection on the upper leaf surface and volcano-shaped pustules (*Figs. 5 & 6*) can be seen with a high-powered hand lens or microscope after at least 10 days on the lower leaf surface.

Unfortunately, the spots and pustules are extremely TINY initially and can EASILY go unseen or mistaken for other diseases such as brown spot, bacterial pustule and downy mildew. One rust pustule can produce spores for at least 3 weeks (*Fig. 8*). After spore release, wind can carry these spores and spread infection to other soybean plants or weed hosts. Increase in spread and severity of rust has been related with canopy closure, crop flowering and bean production.

Overwintering: This infection cycle continues until the plant is defoliated or weather conditions are no longer favorable. During the winter months, soybean rust can survive on kudzu in southern no-frost regions such as Florida and southern Georgia. However, if there is a lack of moisture during this time in these areas or cold temperatures kill/damage the kudzu, the fungus that causes soybean rust may not survive. There is still a great deal to learn about the over-wintering stage.

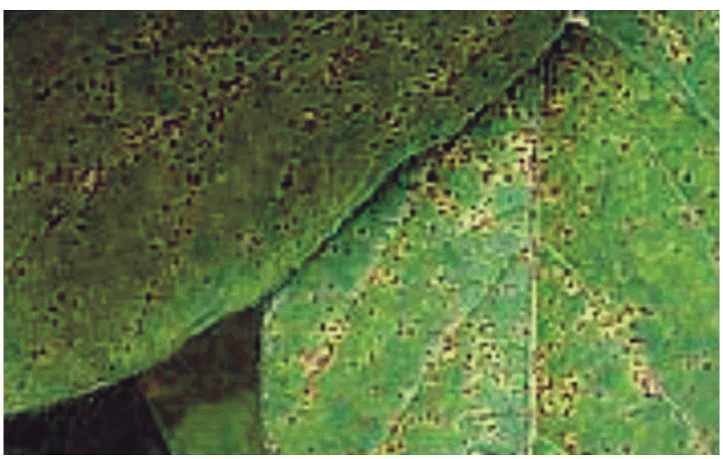

Figure 4. Typical brown-red soybean rust lesions on the upper leaf surface. Note the non-descript yellowing around some of the lesions.
Photo courtesy of USDA.

Figure 5. Close-up (60X) view of volcano-shaped pustules on kudzu. Pustules on soybeans and other hosts will look very similar. There may be a slight difference in color only.

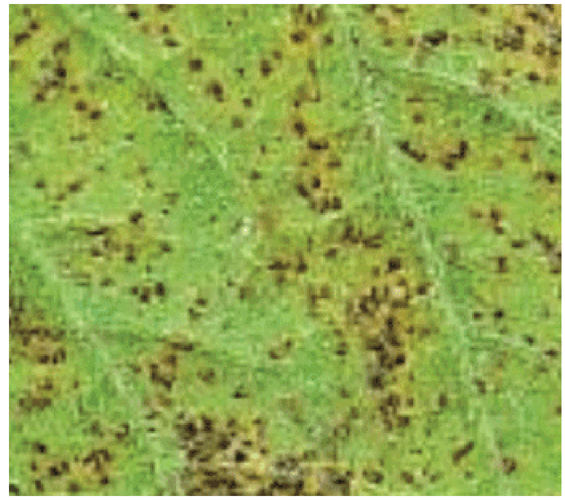

Figure 6. Raised volcano-shaped soybean rust pustules on lower soybean leaf surface.

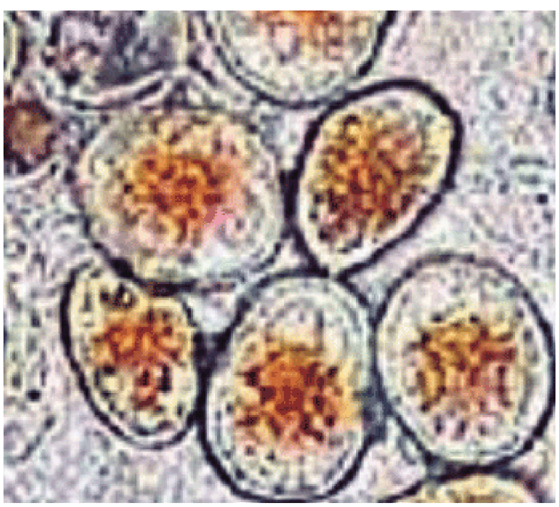

Figure 7. Soybean rust spores viewed under microscope at 400X.

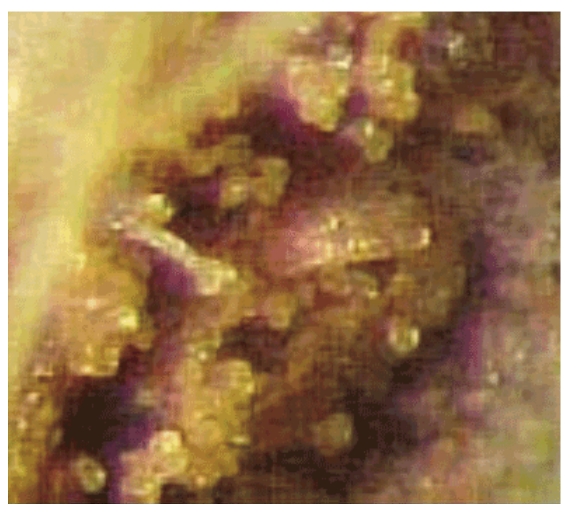

Figure 8. Close-up (60X) view of volcano-shaped pustules on Florida beggarweed. Note the light tan color compared to the darker brown of pustules on kudzu in Figure 5.

Other Crops and Weed Hosts Commonly Found in the Southeastern United States: Many legumes are hosts for the fungus which causes soybean rust. However, in the United States the incidence of soybean rust on vegetables in the field has been minimal. There also have been very few reports of soybean rust on weeds in the field. Many of these hosts are susceptible to infection by other species of rust which have similar symptoms The susceptible crops and weed hosts found in the Southeastern United States are listed below:

Common vegetable and weed hosts of soybean rust:	
Beans - Green, Succulent, Garden or Snap	Kudzu*
Bean - Lima or Butter	Lupine - Blue, White, and Yellow
Florida Beggarweed	Peatree or Colorado River Hemp
Blackeyed Pea, Cowpea or Yardlong Bean	Pigeon Pea
Broadbean or Fava Bean	Urd or Black Gram
Clover - Crimson and White	Winged Bean
Coffee Senna	Woolypod Vetch
Crotolaria	
* Believed to serve as one of the the primary over-wintering sources. Over-wintering potential of the other hosts such as Beggarweed, Clover and Coffee Senna is unknown.	

Monitoring Rust Movements

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Sentinel Plots in the Southeastern United States: As part of USDA-APHIS, United Soybean Board and North Central Soybean Research Programs, the progress of soybean rust development was monitored in 2005, 2006, and 2007 in over 500 sites in 31 states. The greater the perceived risk in each state the larger the number of monitoring sites. In the Mid-Atlantic area Georgia and South Carolina have been running 20 to 30 plots whereas North Carolina and Virginia run 10 to 15 plots. In each state the monitoring program is supervised by the state Extension Soybean Pathologist. Additionally, pathologists and regulatory scientists may conduct surveys to detect soybean rust. This information is logged into a database and counties that have been checked and found free of rust are colored green on the USDA Soybean Rust Web site. Also, any rust detected in samples submitted to plant diagnostic clinics are also logged into this site. This program has been extremely effective in detecting soybean rust before rust has been found in commercial fields, and is the basis on which extension professionals make their recommendations to apply fungicides. All of this information can be easily accessed at *http://www.sbrusa.net/*. This is a near real-time report of the assessments of risk by local plant pathologists. Another source of information is the North Carolina Rust forecast site *http://www.ces.ncsu.edu/depts/pp/soybeanrust/*.This site provides information on likely movement of spores from sources of rust.

Figure 9. Array of spore traps present at the Edisto Research and Education Center in South Carolina.

Value of Spore Traps in Predicting Spread: As part of a study conducted by Syngenta Crop Protection and the University of Arkansas, spore traps have been placed the last 3 years in sentinel plots throughout participating soybean-producing states. The traps are used to collect rust spores onto a microscope slide coated with petroleum jelly. The slide is placed inside of a plastic tube that is used to capture wind-blown spores. The purpose of this study was to determine if these spore traps could be used to provide an additional warning tool for soybean rust by detecting the presence of rust spores that may lead to the development of the disease.

Currently, the spore traps provide an indication that soybean rust spores MAY be in the area. This does NOT necessarily mean that soybean rust will occur. In 2005, ‘rust-like’ spores were detected as far north as Minnesota and Canada, yet soybean rust never developed north of Kentucky. At present, researchers are trying to improve upon their ability to identify to species the spores caught in the traps. There are 3 reasons why these spore traps are currently poor predictors of disease spread:

1. **Without a PCR or an ELISA assay of these slides, we cannot say with 100% certainty that we have soybean rust. Without a soybean rust DNA or protein confirmation, there is a possibility that the 'rust-like' spore captured in the trap is not soybean rust.**

2. **The viability of the spores (their ability to infect soybean) can not be determined.**

3. **Even if they are soybean rust spores, a susceptible plant (a soybean or one of the weeds or vegetables listed previously) and favorable weather conditions must be present to have soybean rust. In many cases the number of spores recovered is so low that it would take one generation (seven to ten days) for the disease to develop to detectable levels.**

Since this disease has the potential to spread quickly, there is a need for a quick field diagnosis. Unfortunately, there are no accurate tests available for rapid field diagnosis of soybean rust (such as ELISA quick strips, etc.). Researchers are currently working on the development of more rapid diagnostic tests.

Common Diseases of Soybean in the Mid-Atlantic Region

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Common diseases of soybean are caused by viruses, bacteria, fungi and nematodes. Some diseases are spread by insect vectors and nematodes while others are spread by wind, splashing rain, or movement in soil. The best way to determine if disease control would be profitable is to first identify the diseases that are capable of causing economic yield losses. Symptoms of disease include the plant damage caused by a pathogen and the reaction of plants to infection. Signs are the visible evidence of the pathogen. Some diseases have characteristic symptoms and signs that are identifiable in the field. However, several soybean diseases can share common symptoms and are difficult to identify in the field even with a hand lens. Whenever in doubt, always contact your county Extension Agent for assistance in identifying the disease or collecting samples for submission to a State University diagnostic clinic.

Most of the common diseases of soybean can be managed efficiently by adopting long-term production strategies. These strategies should include maintaining a favorable soil pH and fertility level for crop growth, effective weed and insect control, and cropping systems that offer disease suppression through crop rotation and variety selection. The following photographs were selected to illustrate frequently used diagnostic symptoms and signs used for identification of specific soybean diseases. For simplicity, most of these pictures were taken where only one disease was present which may or may not be the case. When more than one disease is present, symptoms can be more complex and require microscopic examination of samples by a trained observer for disease identification.

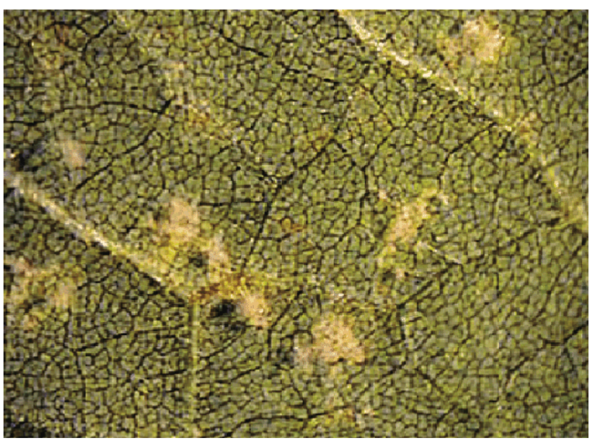

Figure 10. Yellow spots with downy mildew

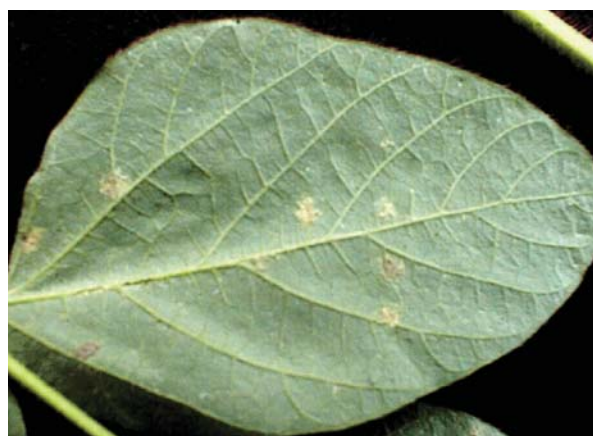

Figure 11. Mildew on lower leaf surface

Downy mildew *(Peronospora manshurica)*

Symptoms: Pale green to yellow spots on upper leaf surface. Infected pods show no visible symptoms, but seed can be smaller.

Signs: Mold and spores of fungus are visible on undersurface of leaves in yellow spots (*Figs.10 and 11*). Seeds at harvest may be covered with crusty-appearing mold and spores.

Control: Use seed treatment, crop rotation, and less susceptible variety.

Figure 12. Disease on upper/lower leaf surface

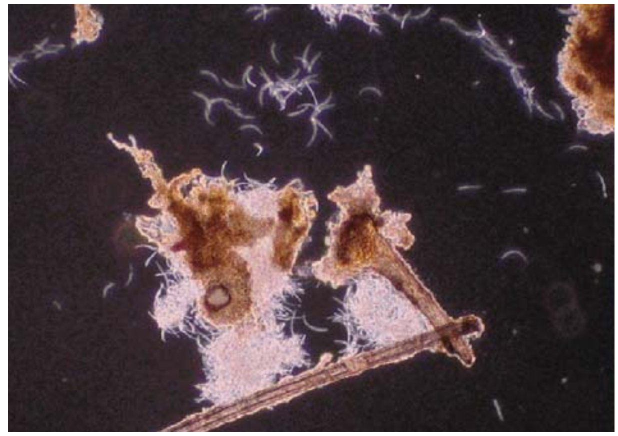

Figure 13. Pycnidia and spores of fungus

Brown spot *(Septoria glycines)*

Symptoms: Lesions are not distinctly different from similar diseases. Spots begin as irregular minute specks that expand into larger brown spots. Appears first on lower-most leaves and may spread to upper leaves (*Fig. 12*). Disease is usually not of economic importance.
Signs: Tiny fruiting bodies of fungus (pycnidia) are immersed in necrotic tissue. Spores are curved, and exude from pycnidia in curled masses that are visible with stereomicroscope (*Fig. 13*).
Control: Increase tillage to bury infested soybean debris, rotate crops, and plant disease-free seed. Fungicides are not recommended since disease has little or no impact on yield.

Figure 14. Spots on upper/lower leaf surface

Figure 15. Sporulation of fungus in lesion

Frogeye leaf spot *(Cercospora sojina)*

Symptoms: Small spots with dark reddish-brown margin. Old lesions have papery tan to white center. Spots usually develop in mid-season in young, upper leaves of plant (*Fig. 14*). Older, fully expanded leaves or leaves that develop in dry weather may escape disease.
Signs: Light gray to white spores of fungus are produced in moist, humid weather (*Fig. 15*).
Control: Select less susceptible variety, increase tillage, use crop rotation, seed treatments, and apply fungicide spray at R2 or R3.

Figure 16. Cercospora blight of leaves

Figure 17. Infected pods

Figure 18. Purple seed stain

Cercospora blight and purple seed stain *(Cercospora kikuchii)*

Symptoms: Leaves have reddish-purple coloration and bronzing from beginning of and through seed development on upper leaves (*Fig. 16*). Round reddish-purple lesions develop on pods which later become purplish black (*Fig. 17*). Infected seeds have purple stain (*Fig. 18*).
Signs: Sporulation occurs in minute lesions in humid, wet weather. Spores are long and filiform and distinguishable only under a microscope.
Control: Variety selection, seed treatment, crop rotation and fungicide application at early pod (R3).

Figure 19. Target spot lesions on lower leaves

Figure 20. Lesions on upper leaves

Target spot *(Corynespora cassiicola)*

Symptoms: Round to irregular, reddish-brown lesions surrounded by dull green or yellowish green halo. Larger spots may contain light and dark rings, hence the name, target spot (*Figs. 19 and 20*).
Signs: Spores of the fungus are not visible without a microscope.
Control: Some varieties have resistance. The benefit of a fungicide spray for control of target spot has not been demonstrated in the Mid-Atlantic region.

Figure 21. Black fruiting bodies at random

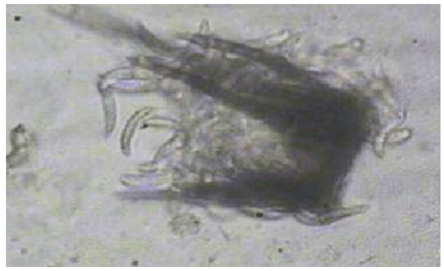

Figure 22. Microscopic view of fruiting body and spores

Figure 23. Seed infection

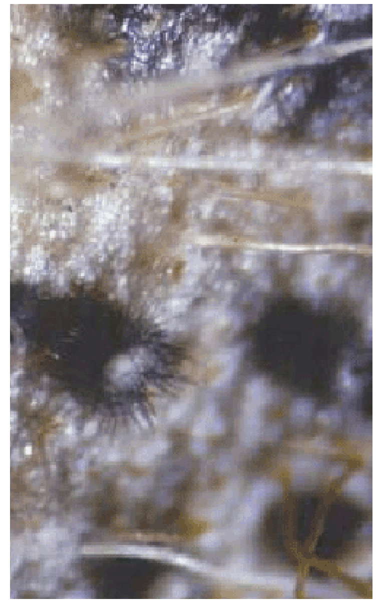

Figure 24. Fruiting bodies of fungus on infected leaf

Anthracnose *(Colletotrichum truncatum)*

Symptoms: Brown lesions develop on stems, pods and leaves (*Fig. 21*). Infected tissues turn brown and senesce early.

Signs: The fungus produces randomly distributed, black fruiting bodies with black hairs (setae) and numerous canoe-shaped spores (*Figs. 22 and 24*). Pods infected early fail to produce seed; late infections result in shriveled or moldy seed with dark lesions on seed coat (*Fig. 23*).

Control: Tillage to bury infested crop residues, crop rotation, seed treatment, fungicide application at beginning pod stage (R3), and avoid delays in harvest.

Figure 25. Black fruiting bodies of fungus in rows on stems

Figure 26. Normal Seed

Figure 27. Fungus on seed is white and chalky

Pod and stem blight *(Phomopsis longicolla)*

Symptoms: Causes blight of stems, pods and leaves (*Fig. 25*). Infected seed are shriveled, have cracks on the surface and have a chalky appearance (*Fig. 27*).

Signs: Black fruiting bodies of fungus (pycnidia) are in rows on blighted stems and scattered on blighted pods and leaves. Mold on seed colonized by the fungus appears chalky.

Control: Tillage to bury infested residues of previous soybean crop, crop rotation, seed treatment, foliar spray of fungicide at beginning pod (R3), and avoid delays in harvest.

Figure 28. Early symptoms on young leaves

Figure 29. Lesions merge to cause blight of leaf

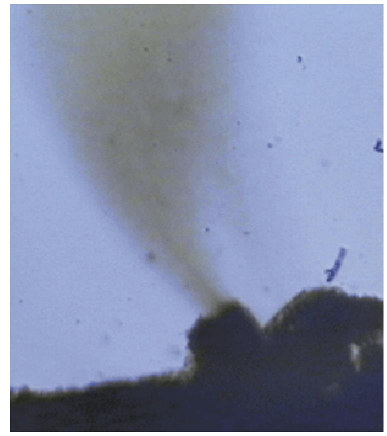

Figure 30. Bacterial streaming from blighted tissue

Bacterial blight *(Pseudomonas syringae pv. glycinea)*

Symptoms: Leaf spots appear water soaked at first. Yellow halos develop around lesions with brown centers (*Fig. 28*). Over time, dead tissue falls out causing a tattered appearance (*Fig. 29*).
Signs: Bacteria stream from infected tissue placed in water and viewed with microscope (*Fig. 30*).
Control: Avoid highly susceptible varieties, plant pathogen-free seed, and use tillage to enhance decay of infested crop residues.

Figure 31. Lesions on upper and lower leaf surface

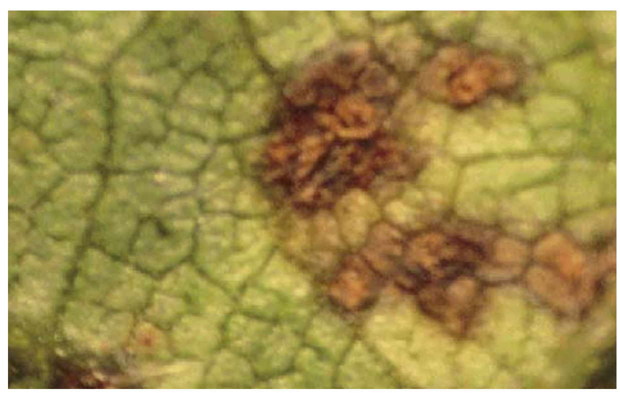

Figure 32. Pustules on lower leaf surface

Bacterial pustule *(Xanthomonas campestris pv. glycines)*

Symptoms: Begins as minute lesions with elevated centers (*Fig. 31*). Pustules form in center of lesions mostly on lower leaf surface (*Fig. 32*). Pustules can be confused with soybean rust.
Signs: None other than pustules formed by enlargement of host tissues on underside of leaves.
Control: Most soybean varieties have some resistance to the disease. Use same procedures as recommended for bacterial blight in problem fields.

Examples of Soilborne Diseases of Soybean:

Figure 33

Figure 34

Soilborne diseases often produce symptoms of disease in leaves that may include wilting (charcoal rot, Sclerotinia), yellowing between veins and/or necrosis between veins (brown stem rot, sudden death syndrome, red crown rot) or mild yellowing between veins similar to manganese deficiency (soybean cyst nematode) (*Figs. 33 and 34*).

Figure 35

Figure 36

Charcoal rot (*Macrophomina phaseolina*)

Symptoms: Stunting and reddish brown to black discoloration of lower stem in seedlings. Taproot and lower stem of older plants have reddish to brown stains (*Fig. 35*). Black flecking under the bark and black streaking in wood of taproots are diagnostic symptoms.
Signs: Black sclerotia of causal fungus in taproots (*Fig. 36*).
Control: Crop rotation, good soil fertility for maintaining crop vigor, and irrigation to minimize stress.

Figure 37

Red crown rot (*Cylindrocladium parasiticum*)

Symptoms: Yellowing and browning between veins of upper leaves similar to brown stem rot and sudden death syndrome.
Signs: Red fruiting bodies of fungus develop on stems at the soil line (*Fig. 37*).
Control: Crop rotations without legume hosts (peanut, alfalfa, etc.), delayed planting until soil temperatures are warmer.

Figure 38

Figure 39a

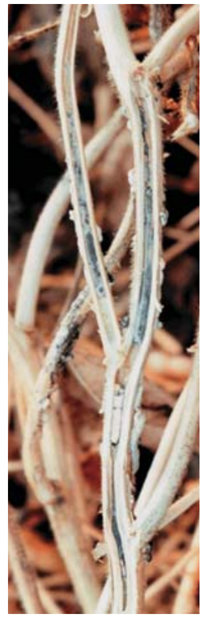

Figure 39b

Sclerotinia stem rot (*Sclerotinia minor; S. sclerotiorum*)

Symptoms: Wilt and eventual death of portions above stem infections. Stem lesions are tan to nearly white, with reddish discoloration at margins (*Fig. 38*).

Signs: Fungus produces black sclerotia on stems, and inside pods and in the pith of stems: (*Fig. 39a*) small sclerotia = *S. minor*, (*Figure 39b*) large sclerotia = *S. sclerotiorum*.

Control: Crop rotation with non-host crops (cotton, corn, or other grass type crops), soil tillage to bury inoculum, and use of tolerant varieties.

Figure 40

Sclerotium blight (*Sclerotium rolfsii*)

Symptoms: Light brown lesions develop on stems near soil surface and later darken. Yellowing and wilting are usually the first symptoms.

Signs: The fungus grows from infection sites and produces a white mat of mold on infected stems (*Fig. 40*). Numerous tan to brown resting bodies (sclerotia) about the size of mustard seed are produced by the fungus.

Control: Crop rotation with non-host crops (corn, or other grass-type crops), tillage to bury inoculum and reduce carryover and planting less susceptible varieties.

Agronomic Facts the Grower Needs to Know

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Don't Panic: While it is uncertain whether Asiatic Soybean Rust will be a serious economic problem in the Southeast in 2008, the potential is there. It may or may not become widespread, develop very quickly, or come early enough to be a problem. With the potential for this disease to develop, there are several agronomic facts that should be considered if producing soybeans in Georgia, the Carolinas, or Virginia.

Most growers probably do not need to be advised against panicking, but a plan of soybean rust disease control needs to be in place in the event that the disease does spread rapidly. There is no doubt that soybean rust can be an additional and unwanted headache in soybean production, but we do have fungicide tools at our disposal to control this disease. Soybean rust has garnered much attention by the press in the past. This year will probably be no different. Producers may also feel pressed by the agricultural chemical industry to use certain products. While there are differences in products, the key factors with controlling soybean rust are timing of application and thorough coverage.

Seriously consider crop insurance. This is the kind of situation that insurance was designed for - there is potential for serious losses, but the likelihood of that happening is low enough that insuring against that loss is not terribly expensive. Having this safety net will go a long way in helping make sound decisions about controlling this disease.

Understanding the Growth Habit of Soybeans: Due to the potentially rapid spread of soybean rust and the difficulty in identifying it, most literature focuses on spraying soybeans at specific growth stages. Most often mentioned are the reproductive stages, designated as R1 through R8. Stages R1 and R2 refer to bloom development, R3 and R4 refer to pod development, R5 and R6 refer to seed development, and R7 and R8 refer to maturity of the plant. It is believed that the reproductive stages are the critical time to spray with fungicides because rust seldom develops earlier in the season than first bloom (*see Management of Asian Soybean Rust, pg. 31*).

Below is a brief discussion of soybean growth stages. A field is considered to be at a particular stage when 50% of the plants are at that stage.

Stage	Comments
VE	Soybeans have just emerged from the ground. The only leaves present are the cotyledons.
VC	A pair of "unifoliate" leaves has developed just above the cotyledons. At this time both sets of leaves, (the cotyledons and the unifoliates), are arranged opposite each other on the stem. After this point all new foliage will consist of trifoliates (3-leaflets) arranged alternately on the stem.
V1	One trifoliate leaf on the plant in addition to the cotyledons and the unifoliate leaves.
V2-Vn	Until the plant starts to bloom the growth stages are discussed in terms of main-stem trifoliate leaves. Determinate varieties may develop as many as 16 to 20 main-stem leaves prior to flowering.
R1	One bloom present on the plant. This first flower will generally appear towards the bottom half of the plant.
R2	Full bloom. Flowers are present to the top two nodes of the plant. Typically occurs 1 day after R1 in Georgia, the Carolinas, and Virginia.
R3	Pods can be observed at any one of the uppermost four nodes on the plant. Typically occurs 10 to 12 days after R2.
R4	Full pod. Pods at any one of the top 4 nodes of the plant are ¾" long. Typically occurs 8 to 10 days after R3.
R5	Beginning seed. Seeds in the pods are 1/8" long at any one of the top 4 nodes of the plant. Typically occurs 9 to 11 days after R4.
R6	Full seed. Seeds fill the pod cavity at any one of the top 4 nodes of the plant. Typically occurs 13 to 17 days after R5. After this point beans should be safe from the effects of rust, and fungicides cannot legally be applied.
R7	Beginning maturity. At least one mature pod can be found on the plant. Typically occurs 17 to 21 days after R6. Plants are considered physiologically mature, and thus safe from frost.
R8	Full maturity. 95% of the pods are their mature color. Typically occurs 9 to 11 days after R7. Beans are close to being harvest ready.

The reproductive stages are also shown schematically on the inside back cover of this publication.

Agronomic Considerations:

Fertility and pH

Correct any pH and nutrient deficiencies prior to planting. A healthy plant can withstand stress better than an unhealthy plant. Correcting low pH will pay for itself in the absence of any disease. Also correct any other known nutrient deficiencies, particularly potash. Liming and fertilizing fields at higher than recommended rates are not expected to add any additional resistance to soybean rust.

Pest and Weed Management

It is important to control pests. Pests that should not be ignored include stink bugs, soybean looper and velvetbean caterpillar in Georgia and perhaps South Carolina, soybean aphid in Virginia and maybe North Carolina, and corn earworm in Virginia and the Carolinas. A standard recommendation in the Coastal Plain of Georgia is to apply Boron to aid in pod set and Dimilin for the control of velvetbean caterpillar at the R3 growth stage. This practice should be continued in Georgia. (Research and farmer experience in the Carolinas and Virginia have not shown an economical response from this treatment in their states). In fact, the timing of this application corresponds with the growth stage at which soybeans are most susceptible to rust. Preliminary research indicates that fungicides may be applied with this treatment.

Weeds must also be controlled, especially early in the season. This is a given with or without the added pressure of soybean rust. Although fungicides may be compatible with glyphosate, in most years, weed control should be taken care of prior to spraying for rust.

Consider Earlier Varieties

Variety selection should primarily focus on nematode and disease resistance, and yield potential. Once selections have been made for a particular farm, you may want to increase the acreage of your earliest variety at the expense of your latest variety. Caution is advised though, since earlier maturing varieties also have fewer days to grow big enough to produce a profitable yield, especially under drought conditions. Also, the yields and quality may be lower if soybean harvest is delayed due to unfavorable weather conditions. Most growers are probably already growing the earliest maturing varieties they consider economically feasible. Theoretically a shift toward earlier maturity is probably more important in Georgia (where the threat of rust is greater) than in Virginia (where the threat of rust is less). Prevailing weather patterns should be considered. Early maturing varieties require moisture during the months of July and early August, typically a drier period in South Georgia. Later maturing varieties require rainfall in late August and early September, typically a wetter period in South Georgia. The bottom line is do not sacrifice potential yield for a disease that may not be a problem.

Planting Considerations

If double-crop soybeans look no more profitable than full-season soybeans at wheat planting time, skip the wheat and grow full-season soybeans.The full-season soybeans will be safe from rust and frost sooner than double-crop soybeans will. For each 3 weeks earlier planting, you can typically harvest about 1 week earlier.

Do not start planting earlier than you’ve been starting. In Virginia and North Carolina, this recommendation is to ensure that soil temperatures are warm enough for rapid emergence and reduced root-rot disease likelihood. In South Carolina and Georgia, this recommendation is to avoid premature flowering and subsequent yield reductions. In addition, complete your planting season as soon as practical. Delayed final planting has a lower yield expectation and a predicted greater vulnerability to rust.

Narrow rows may have a greater likelihood of rust development, but also higher yield potential than wide rows (especially in very early plantings, double-crop situations, and on the more productive soils). Do not give up yield to deal with a problem you may or may not see.

Plant populations should not be altered because of rust concerns. Lower populations have only a slightly lower theoretical vulnerability to rust. The general trend is for growers to plant more seeds than they need to, and these growers could probably help profits by lowering planting rates a little.

Watch the Sentinel Plots

Be sure to identify a nearby sentinel plot, preferably to the south or southwest. Soybean rust will most likely travel north or northeast. All states in the Southeast (including the state to the south of yours) plan to have sentinel plots well distributed around the state. Paying attention to the progression of the disease will buy valuable time when planning for treatment of soybean rust. See the website at *http://www.sbrusa.net* for a current report on the status of rust development in the US.

Keep track of confirmed sightings, and try to sort out rumors from facts. There will be reliable reports in all four states of where rust is and is not. Typically, our county Extension agents will know, as will our consultants, Certified Crop Advisers (CCAs), and Department of Ag personnel.

Follow Rust Forecasts

They are not perfect, and they don't all forecast the same thing, but they are useful. They do a good job of telling plant pathologists and agronomists where to focus their scouting for the disease.

Final Thoughts

Since rust will most likely come to your field on air currents from the south, there is no reason to think tillage (or absence of tillage) would influence rust likelihood or severity. As far as equipment goes, it is important to have a sprayer ready, and fitted with nozzles that give medium to fine droplets at volumes of at least 15 GPA (this is not a typical herbicide nozzle). After rust gets into the county is a poor time to be looking for a sprayer, parts for a sprayer, or a custom applicator. Know how you are going to spray before it is time for you to spray.

Scout your soybeans diligently. While no one knows exactly what "diligently" means, it makes more sense to increase scouting intensity than to decrease it. Since rust invariably starts on the bottom side of the bottom leaves, that's where successful scouting for rust is going to have to be focused, and that cannot be done from the cab of the pickup.

Deciding whether to spray, with what and when, is covered in more detail in another section of this bulletin. Being informed and prepared will make this decision much easier. Therefore, decide whose advice you want to trust, and whose you do not. To the extent that you have an opinion on your local advisors, make that decision now before rust actually gets here.

Table 1. Recommendations for Managing Soybean Rust

Stage of Development		Days to R7		Fungicide Recommendation if:		
Number	Description	Full Season	Double Crop	No Rust Confirmed within 100 miles	Rust Confirmed within 100 miles	Rust Observed in field
	Vegetative			Do Not Spray	Do Not Spray	**T** or **C** fb **T** or **C** fb **T** or **C** Also See Footnotes
R1 or R2	Early or Full Bloom	65	55	If frogeye leaf spot is identified on a susceptible variety: **S** fb **N** or **N** fb **S** or **S** fb **C**	**S**, **T**, or **C** fb **S, T** or **C**	Same as above
R3	Small Pods	53	47	Same as above	Same as above	**T** or **C** fb **T** or **C**
R4	Full Sized Pods	44	38	If frogeye leaf spot is identified on a susceptible variety: **N** fb **S** or **S** fb **C**	Same as above	Same as above
R5	Small Beans	34	30	If frogeye leaf spot is identified on a susceptible variety: **S**	**S, T,** or **C**	**T** or **C**
	Full-Size Beans	19	17	Do Not Spray	Do Not Spray	Do Not Spray
R6	>1 Pod/Plant Mature Color	0		Do Not Spray	Do Not Spray	Do Not Spray

S denotes a strobilurin fungicide, **T** denotes a triazole, **C** a combination of the two, and **N** denotes a nitrile fungicide. **fb** means followed by.

Footnotes:

Growth stage descriptions apply to the top 4 nodes on the main stem. This is a critical distinction for indeterminate varieties. Stage R1 is first bloom, R2 is full bloom, R3 has small pods, R4 has full sized pods, R5 has small beans in the pods, and R6 has full sized beans in the pods in at least one of the top 4 nodes.

We would increase the 100 mile threshold by up to 50 miles if rust is moving fast, conditions favor rust, and your acreage is large. We would decrease it by up to 50 miles if rust is moving slowly, weather is dry and hot, and your acreage is small.

Three weeks after the first fungicide application, assess the need for another application. Consider the development of the disease to date, the stage of growth of the soybeans, and how favorable the weather appears to be for rust development.

Check specific product labels for use guidelines and precautions, including at which growth stages the fungicide may and may not be sprayed, how many times it may be used on the same field in the same season, how close to harvest it can be sprayed, and in the case of section 18 cleared fungicides, whether it is cleared for use in your state. The label is the law.

Avoid using the same chemical alone in two consecutive applications.

No fungicide with a section 18 clearance should be used more than twice in the same year. No more than 3 applications can contain a section 18 cleared fungicide.

Higher labelled rates provide longer residual activity, and will probably delay need for subsequent applications.

If the soybean crop is insured, producers are required to follow good farming practices, and to document their actions to deal with rust. Good farming practices are considered to be the recommendations of Agricultural Experts, including employees of Cooperative Extension System, of state and university agricultural departments, Certified Crop Advisers (CCAs), Certified Professional Agronomists (CPAs), and Certified Professional Crop Consultants (CPCCs). If a producer chooses not to spray for economic reasons, and the crop is insured, notice of damage or loss should be given to the crop insurance agent, and the amount of damage associated with uninsured causes of loss assessed against the insurance guarantee. In some cases, no indemnity may be payable to the insured.

Not all producers or advisers will want to assume the same risks, treatment capabilities, and fungicide performance as these recommendations assume, and may thus want to modify these recommendations. That's OK with us. They now have the benefit of our thinking on which to base their own recommendations.

Jim Dunphy & Steve Koenning, NCSU (May, 2007)

Management of Asian Soybean Rust

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Patrick Phipps, ***Professor of Plant Pathology, Virginia Tech, Suffolk***

Extensive research is showing that resistance to Asian soybean rust is a real possibility in the not too distant future. Until resistance is available we will need to rely on other management strategies. Although soybean is known to be susceptible to rust at all growth stages it has not been detected in commercial production fields in the Mid-Atlantic region prior to flowering in a given field. This observation over the last three years indicates that the fungicide usage prior to flowering is normally not justified and that management of planting dates may allow individual fields to escape rust. A combination of early planting dates and applications of fungicides only when needed appears to offer the best management approach for rust in much of this region.

Avoiding Rust: The use of early planting dates to allow plants to flower and produce pods and mature seed before rust becomes a threat has been very effective in South Carolina and areas farther north. In the last three years rust has not appeared in southern South Carolina prior to August 15. The normal planting window of April 15 to May 20 will allow many maturity group IV, V, and even some group VI soybean cultivars to be well past R-3 before rust becomes a problem in the area. These planting dates still allow optimal yields in the absence of rust in many locations. Growers still have the option to spray fungicides if rust appears at an earlier than normal date or if a wet year and high market prices make controlling late season pod and stem diseases desirable.

Spraying Fungicides: Deciding when you should spray fungicides is one of the most critical decisions you will make in controlling rust. When weather conditions are right, rust can move rapidly within and between fields. Applying a fungicide before rust becomes prevalent in a field is necessary if yield losses are to be avoided. The rule of thumb is to spray when less than 5% of the leaves have three to five pustules present. If spraying is delayed then yield losses can be substantial. Most fungicides will control rust for only two to three weeks. So, an early spray may not be the safest decision. In the last three years rust has not been detected in a commercial production field prior to R1 and in many cases was not detected until R3/R4. So spraying prior to flowering is probably not cost effective and may lead to the need for a second spray.

When Should You Spray for Rust: Predicting when rust will be arriving in your field is critical to making spray decisions. Your accuracy in predicting the arrival of rust in your area can be enhanced by utilizing the following resources:

Disease Tracking Reports

As rust begins to move northward you should monitor disease progress reports on the USDA website, *http://www.usda.gov/soybeanrust/*, on at least a weekly basis. This site records the incidence of rust on both kudzu and soybean. Reports for soybean include both commercial production fields and sentinel plots. When rust reaches within 100 miles of your location you should be ready to spray. *Table 1, pg. 29* outlines the different scenarios that you might encounter. Growers in Georgia and Florida may want to decrease the 100-mile alert radius to 25 or 50 miles depending upon the severity of rust in their state.

Sentinel Plot Data

Multiple locations in each state are planted in one acre or smaller plots of usually three maturity groups (early to standard in a locality) up to three weeks prior commercial planting. This provides an extended period of favorable conditions for infection by soybean rust and early detection of the disease as it spreads northward from state to state. The greatest risk of crop infection is when plants in each maturity group begin flowering and proceed through the stages of pod and seed development. As a result, sentinel plots are expected to be the first to exhibit disease, which can provide an early warning before commercial fields show the disease. Once disease appears in sentinel plots, they should be sprayed with a triazole fungicide or mixture of triazole/strobilurin fungicides in order to minimize opportunities for secondary spread of disease to neighboring fields. The USDA rust website, *http://www.usda.gov/soybeanrust/*, contains data for all the sentinel plots.

Scouting Your Fields

Commercial fields need to be scouted once a week from the start of flowering (R1) up to full seed (R6). The intensity of scouting should be increased as rust moves closer to your region. Scout fields in a zigzag pattern and use different entry and exit points on each visit. Priority should be given to areas likely to have extended periods of leaf wetness due to poor air drainage as in low lying areas, and locations with heavy plant growth and a dense canopy. Scouting for rust should be done by checking the leaves that are midway or lower on plants.This is where the disease is most likely to develop first.

Plant Growth Stage

Until research justifies otherwise, sprays of fungicides will be recommended for control of soybean rust only during the period from flowering (R1) until the beginning of full seed (R6). Overall, it seems likely that fungicides may be the most profitable when applied in the period from flowering (R2) to beginning seed (R4). Spraying earlier or later is likely to reduce the profitability of fungicide use. No fungicide sprays are expected to be profitable if applied prior to flowering (R1) and labels do not allow spraying after the start of full seed (R6).

Stay informed on the status of soybean rust by checking the Soybean Rust Home Page in your state and/or the USDA web page *http://www.usda.gov/soybeanrust/*. Many states have electronic newsletters either posted on web sites or emailed directly to growers. Collectively, the above information should be used in the decision to apply a fungicide. Other factors may also be considered depending upon field conditions such as weather, plant growth, canopy development, yield potential, and the presence of other diseases.

Newsletters by State

Clemson University has a weekly “Soybean Rust Newsletter” during the rust season. To signup for this newsletter email John Mueller at *jmllr@clemson.edu*.

North Carolina State University issues updates on an as-needed basis. To receive these updates contact your local North Carolina extension agent.

The University of Georgia has a website containing an archive of their soybean newsletters and current meeting info at *http://www.griffin.peachnet.edu/caes/soybeans/*.

Information on rust in Virginia is available in the “Virginia Soybean Update”. To sign up for this monthly newsletter, email David Holshouser at *dholshou@vt.edu*.

Types of Fungicides and Rates of Application: The primary classes of fungicides that will be used for rust are the strobilurin and triazole fungicides. Chlorothalonil (a nitrile fungicide) is also effective in protecting against rust but has less residual activity and may require more frequent applications than strobilurin or triazole fungicides. Also, chlorothalonil cannot be applied within 42 days of soybean harvest. The triazole type fungicides have curative and preventative activity, whereas strobilurin fungicides and chorothalonil are preventative only. If a soybean field has already been exposed to the rust fungus and especially if active sporulation is observed, a triazole type fungicide is preferred since it may eradicate some infections. If infection has occurred, higher rates of a triazole or a combination material may be needed. This may reduce the necessity of a second spray since higher rates in general will give longer residual activity. All triazole fungicides have some limited systemic activity (move through the plant, especially to newly developed leaves) and are thus somewhat forgiving if application is less than perfect. Strobilurin fungicides may have some local systemic activity and will move into the leaf and stem within an hour or two of application. Both strobilurin and triazole fungicides will provide protection for two to three weeks depending on the rate at which they are applied. Chlorothalonil type products may persist for several weeks if there is no rainfall, but will not move to newly developed plant tissues. Some data suggest that strobilurin type fungicides may provide better protection from many of our typical late season diseases (anthracnose, cercospora blight, brown spot, frogeye leaf spot, and target spot) whereas the triazoles work best on powdery mildew and rust. This may explain the popularity of combination products in Brazil.

Method of Application: Coverage is the key! In general, higher spray pressure and higher water volume than are normally used for insecticides or herbicides will be needed to obtain optimal disease control from fungicides.

Yield Boost from Fungicides?: Will the strobilurin fungicides Headline or Quadris provide a yield boost in the absence of disease? We have relatively little data in the Atlantic coast states on the effects of these materials on soybean yield. They are certainly excellent products for managing several serious foliar diseases in soybean, such as frogeye leaf spot (on susceptible varieties) and several other common diseases. Some areas where large yield increases occur also have an environment more conducive for disease, including some diseases that have not been identified or are rarely a problem in Atlantic coast states. A yield boost from a strobilurin fungicide is most common in high yield (often irrigated) environments.

Types of Fungicide Labels: There are two basic types of fungicide labels. A Section 3 label is for general use on multiple diseases in multiple states and is not contingent on emergency conditions. A Section 18 label is temporary, specifically for one or more states and diseases and requires the presence of emergency conditions to be activated each growing season. A Section 18 label can be replaced by a Section 3 label. With the arrival of soybean rust in the United States in 2004 it was deemed necessary to issue initial emergency registrations of additional fungicides (Section 18 labels) to several fungicides. These labels are on a state by state basis. Many of these labels expired in the late fall of 2007. Some of these original Section 18 fungicides such as Bumper, Domark 230 ME, Laredo EC, PropiMax, Quilt, Stratego, and Tilt, were granted Section 3 labels in the fall of 2007. In the fall of 2007 other new fungicides such as Alto, Caramba, Punch, and Topguard were granted new Section 18 labels.

One of the original 2004 Section 18 fungicides whose Section 18 label expired in the Fall of 2007 without a Section 3 being granted is tebuconazole. Tebuconazole is the active ingredient in Folicur, Uppercut and Orius as well as several other generic products. Efforts are currently underway to get a renewal of the Section 18 label for this product.

See Table 2 for the status of most fungicides as of January 1, 2008.
For Current Labels on Asian Soybean Rust See:
http://www.greenbook.net/FocusOn/SoybeanRust/
http://www.epa.gov/oppfead1/cb/csb_page/updates/soybean_rust.htm#section3

Table 2. Fungicides for managment of soybean rust

Brand Name	Common Name	Rate (fl oz/a)[b]	Number of Applications/year and Maximum (fl/oz/a)/year	Fungicide Class and (FRAC Code)[a]	Label[c]
Bravos, Echo, Equus	Chorothalonil	24-32	3 (96)	Nitrile (M4)	Section 3
Quadris	Azoxystrobin	6.2-15.4	2 (90.0)	Strobilurin (11)	Section 3
Headline	Pyraclostrobin	6.0-12.0	2 (24)	Strobilurin (11)	Section 3
Tilt, PropiMax, Bumper	Propiconazole	4.0-8.0	2 (12)	Triazole (3)	Section 3
Folicur, Uppercut, Orius	Tebuconazole	3.0-4.0	2 (8)	Triazole (3)	Expired/Pending Renewal
Laredo EC	Myclobutanil	4.0-8.0	2 (16)	Triazole (3)	Section 3
Domark	Tetraconazole	4.0-6.0	1 (6.0)	Triazole (3)	Section 3
Stratego	Propiconazole + Trifloxystrobin	5.5-10.0	2 (20)	Strobilurin + Triazole (3 & 11)	Section 3
Quilt	Azoxystrobin + Propiconazole	14-20	2 (40.0)	Strobilurin + Triazole (3 & 11)	Section 3
Alto	Cypraconazole	2.75-4.0	2 (8.0)	Triazole (3)	Section 18
Quadris Xtra	Azoxystrobin + Cypraconazole	4.0	2 (8.0)	Strobilurin + Triazole (3 & 11)	Section 18
Caramba	Metconazole	8.2-9.6	2 (19.2)	Triazole (3)	Section 18
Punch	Fluzilazole	4.0	2 (8.0)	Triazole (3)	Section 18
Charisma	Fluzilazole + Famoxodone	9.0	2 (18.0)	Triazole (3)	Pending
Topguard	Flutriafol	7.0	2 (14.0)	Triazole (3)	Section 18

[a] Combinations of a strobilurin and a triazole may provide increased control and residual activity.

[b] Higher rates provide greater residual activity and may reduce the need for later sprays.

[c] Section 3 labels are for general use and not contingent on emergency conditions. Section 18 labels are temporary and expire on various dates unless renewed or replaced by Section 3 labels. Pending indicates that these materials may be labeled as Section 3 or Section 18 materials. Fungicides labeled as Section 18 materials are restricted use pesticides when used on soybean, regardless of what the accompanying label material may say and you must have the Section 18 label in your possession if using these materials. Read label for plant back restrictions on all materials used, some are very restrictive.

Fungicide Spray Test Results

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Numerous tests have been conducted to measure the ability of fungicides to control Asian soybean rust and reduce yield losses. Fungicides have been tested throughout Asia, South Africa, South America and in the past three years the Southeastern United States. There are many facets of a test to consider when applying those results to your farm. Naturally the closer the test was geographically to your farm the more similar will be soil types and environmental conditions. Therefore the growth habit of the soybeans will also be closer to what you normally encounter. A second factor to look for is the level of disease present in the test. If no disease is present then the fungicides obviously cannot be adequately challenged. Attached are fungicide tests from 2005, 2006, and 2007 conducted in Georgia by the Soybean Pathology Team.

2005 Test (*see pg. 36*): This was a very simple test comparing the activity of various combinations of two fungicides that were commonly used for rust in 2005, Folicur and Headline. Disease severity was high with over 70% of the leaf area affected by rust in the check. Disease severity in the treatments was less than 20%. This level of disease control resulted in an increase in yield from 38 bu/acre to a yield of approximately 55 bushels per acre. Obviously the fungicide application in this case was well warranted and more than cost effective.

2006 Test (*see pg. 37*): This test was slightly more complicated and examined multiple rates and variable application timings primarily for one fungicide, Domark 230 ME. It also includes ratings for another foliar disease commonly observed with rust, Frogeye leaf spot. Domark was effective in reducing the levels of rust and subsequently increasing yields. This was especially true for the R1 and R3 sprays compared to the later R5 treatment which provided very little rust control. Yield increases of 10+ bushels were common in the early Domark treatments making this treatment very cost effective. Control of Frogeye leaf spot appeared to be greater by Domark applied at R3 than R5 or R1.

2007 Test (*see pg. 39*): This test is much more complicated and compares various rates and spray adjuvents for several fungicides. Disease incidence and severity were rated on two dates. In the 12 day interval between ratings both rust incidence and severity significantly increased demonstrating the breakdown of the fungicide activity over time. However, severity for most treatments was still lower than for the Check even at the second date. Yield increases were not as dramatic as for the first two tests but a yield increase of 5 bushels per acre was not uncommon.

These tests demonstrate that in areas such as South Georgia where rust appears during early reproductive growth stages the rust is capable of causing significant yield losses if left untreated. The tests also show that numerous fungicides can provide very good control of rust and that proper timing of the sprays to the R3/R4 growth stages appears to be beneficial. At the levels of Asian rust control exhibited in these tests application of an appropriate fungicide when rust is present during the reproductive growth stages can be economically viable.

Evaluation of Fungicides for Control of Asian Soybean Rust in Attapulgus, Georgia, 2005

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A trial was conducted at the Attapuglus Research Center to compare the effectiveness of various fungicides to control Asian soybean rust. The plot area was planted to 'DP 7870RR' on 17 May 2005. Plots were irrigated to maintain optimal growth. Each plot was 2 rows wide (36-in. spacing) by 40 ft in length. Plots were separated by 2 border rows that were not sprayed with fungicides during the season. Each treatment was replicated 4 times in a randomized complete block design. Fungicide applications were made once with a CO2 backpack sprayer and once with a boom-mounted sprayer. Fungicides were applied at 50 psi, spray volume of 20 gal/A, with 8002 flat fan tips. Fungicides were applied on 18 Jul (1) at the R1 growth stage and 9 Aug (2) at the R3 growth stage. Plots were rated for Asian soybean rust on 22 Sep and 6 Oct. Soybeans were harvested on 3 Nov.

Rainfall was abundant at Attapulgus through the middle of the season but turned very dry in the latter part of the season. Asian soybean rust was first detected in the sentinel plots adjacent to this fungicide trial on July 21st. On September 22nd combinations of Headline + Folicur (sprayed on both application dates) significantly reduced leaflet infection when compared to untreated plots. Rust severity was significantly less for all treatments when compared to untreated plots. Compared to untreated plots, severity was significantly less for all plots treated twice with fungicides. Severity was lowest (1.9) in plots treated with 2 applications of Headline + Folicur + non-ionic surfactant. Yields were significantly greater in plots treated with two fungicide applications over those treated once or not at all. Plants treated with the strobilurin fungicide Headline remained greener longer and natural defoliation was delayed as compared to plots not treated with this fungicide. Foliage in plots treated with Folicur developed a distinctive interveinal chlorosis.

Treatment, rate/acre	Application timing [y] on October 6th	Average severity/leaflet [z]	Yield (bu/acre)
Untreated	----	5.0 a	38.0 f
Headline, 4.71 fl oz, + Folicur, 3.16 fl oz, + Induce, 0.25%	1,2	2.0 g	55.2 ab
Headline, 3.56 fl oz, + Folicur 3.6F, 2.38 fl oz, + Induce, 0.25%	1,2	2.6 fg	52.5 abc
Folicur 3.6F, 3.56 fl oz, + Induce, 0.25%	1,2	2.3 fg	56.8 a
Headline, 6.14 fl oz, + Induce, 0.25%	1		
Headline, 4.71 fl oz, + Folicur 3.6F, 3.16 fl oz, + Induce, 0.25%	2	2.8 efg	54.6 ab
Headline, 6 fl oz, + Induce, 0.25%	1	5.0 a	48.7 cd

[y] The dates for the fungicide applications were July 18 for 1and August 9 for 2.
[z] Soybean rust infection was assessed for 20 terminal leaflets from lower canopy of each plot based on a visual estimation of percentage of each leaflet infected and rated on a scale of 0 to 5, where 0=no disease, 1=trace to 5% infection, 2=5 to 15%, 3=15 to 35%, 4=35 to 67.5%, 5=67.5 to 100%.
Means within a column with a letter in common are not significantly different (FLSD, P=0.05).

Evaluation of Fungicides for Control of Asian Soybean Rust in Attapulgus, Georgia, 2006

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A trial was conducted at the Attapuglus Research Center to compare the effectiveness of various fungicides to control Asian soybean rust. The plot area was planted to 'AgSouth Genetics 758RR'on May 31. Plots were irrigated to maintain optimal growth. Each plot was 2 rows wide (36-in. spacing) by 40 ft in length. Plots were separated by 2 border rows that were not sprayed with fungicides during the season. Each treatment was replicated 4 times in a randomized complete block design. Fungicide applications were made with a Spider Spray Trac boom-mounted sprayer. Fungicides were applied at 50 psi, spray volume of 15 gal/A, with 8002 flat fan tips. All fungicides were applied on July 28 (R1), August 14 (R3), and August 28 (R5). Plots were rated for Asian soybean rust and frogeye leaf spot on October 16. Soybeans were harvested on November 5.

Soybean rust was detected in the plots on September 1, and by September 15 rust was severe, with 100% of untreated control leaflets infected. Frogeye leaf spot was also severe in this study and approached 100% incidence by the first rating date in some treatments.

Treatment rate/acre, application timing	Rust Severity [x] (October 16)	Frogeye Severity [x] (October 16)	% Defoliation [z] (October 20)	Yield (bu/A)
Untreated controls	7.7 a [y]	4.7 abc	---	49.3 e
Domark 4 fl oz, R1	4.0 cd	3.2 de	95.0 abc	63.6 ab
Domark 5 fl oz, R1	4.4 bc	3.7 bcde	96.5 abc	59.8 abc
Domark 6 fl oz, R1	3.8 cd	2.8 efg	97.2 ab	56.0 bcde
Folicur 4 fl oz, R1	7.1 a	5.1 ab	98.2 a	56.2 bcde
Headline SBR (3.16 fl oz tebuconazole + 4.7 fl oz Headline), R1	3.3 de	2.9 ef	85.0 d	66.4 a
Domark 4 fl oz, R3	2.7 ef	1.7 fgh	93.2 bc	65.6 a
Domark 5 fl oz, R3	2.6 ef	1.5 gh	92.0 c	59.3 abcd
Domark 6 fl oz, R3	2.3 f	1.6 gh	93.0 bc	62.9 abc
Folicur 4 fl oz, R3	5.4 b	3.4 cde	97.7 ab	54.4 cde
Headline SBR (3.16 fl oz tebuconazole + 4.7 fl oz Headline), R3	1.8 f	1.3 b	83.7 d	63.9 ab
Domark 4 fl oz, R5	7.0 a	4.5 abcd	98.7 a	58.6 abcd
Domark 5 fl oz, R5	6.9 a	4.9 ab	99.5 a	51.1 de
Domark 6 fl oz, R5	7.1 a	4.4 abcd	99.7 a	55.4 bcde
Folicur 4 fl oz, R5	7.5 a	5.2 a	99.5 a	47.8 e
Headline SBR (3.16 fl oz tebuconazole + 4.7 fl oz Headline), R5	6.8 a	4.4 abcd	97.7 ab	55.8 bcde

[x] Based on a visual estimation of percentage of each leaflet infected and rated on a scale of 0 to 8, where 0=no disease, 1=trace to 2.5% infection, 2=2.5 to 5%, 3=5 to 10%, 4=10 to 15%, 5=15 to 25%, 6=25 to 35%, 7=35 to 67.5%, and 8=67.5 to 100%.
[y] Column means with a letter in common are not significantly different (Fisher's least significant difference t-test; P=0.05).
[z] Percentage of plot with defoliation caused by soybean rust, rated on 20 Oct 2006.

Evaluation of Fungicides For Control of Asian Soybean Rust in Moultrie (Kemsoy-1), Georgia, 2007

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A trial was conducted at the Sunbelt Ag Expo Research Farm in Moultrie to compare the effectiveness of various fungicides to control Asian soybean rust. The plot area was planted to 'DPL 7870RR' on May 9, 2007 with a seeding rate of 6 seed/ft. Plots were irrigated to maintain optimal growth. Each plot was 2 rows wide (36-in. spacing) by 40 ft in length. Plots were separated by 2 border rows that were not sprayed with fungicides during the season. Each treatment was replicated 4 times in a randomized complete block design. Fungicide applications were made with a Spider Spray Trac boom-mounted sprayer. Fungicides were applied at 40 psi, spray volume of 15.5 gal/A, with 8002 flat fan tips. Fungicides were applied on August 29 (1) at the R3 stage and on September 11 (2) at the R4-R5 stage. Plots were rated for Asian soybean rust on September 26 and October 8. Soybeans were harvested on November 9 with a Massey Ferguson 2-row combine with an on-board yield computer.

Rainfall was recorded at a nearby automated weather station as 0.06 in., 5.92 in., 8.18 in., 6.34 in., 3.68 in., and 4.77 in. for May, Jun, Jul, Aug, Sep, and Oct, respectively. By the end of this trial, rust was severe, with 100% of all collected untreated plot leaflets infected.

Treatment, rate/A	App. timing [w]	Leaflet incidence [x]		Average severity/ leaflet [y]		Yield (bu/A)
		26 Sep	08 Oct	26 Sep	08 Oct	09 Nov
Untreated	--	37.5 a [z]	100.0 a	0.26 a	13.7 a	43.3 c-f
Echo, 32 fl oz	1					
Folicur, 3.6F 4.0 fl oz	2	0.0 d	42.5 def	0.0 c	0.7 c	45.8 a-e
Quilt, 14 oz	1					
Crop oil, 0.1 % v	1					
Folicur 3.6F, 4.0 fl oz	2	0.0 d	52.5 cde	0.0 bc	0.7 c	47.5 abc
Headline, 6.2 fl oz	1					
Non-ionic surfactant, 0.25 % v	1					
Folicur 3.6F, 4.0 fl oz	2	10.0 bcd	42.5 def	0.04 bc	0.3 c	46.7 a-d
Stratego, 10.0 fl oz	1					
Folicur, 3.6F, 4.0 fl oz	2	7.5 bcd	45.0 def	0.05 bc	2.2 c	44.9 b-e
Quadris, 6.2 fl oz	1					
Crop oil, 0.1 % v	1					
Folicur 3.6F, 4.0 fl oz	2	2.5 cd	67.5 bc	0.01 bc	1.7 c	50.5 a
Folicur 3.6F, 4.0 fl oz	2	2.5 cd	62.5 bcd	0.003 bc	1.7 c	46.3 a-e
Quadris, 6.2 fl oz	1					
Crop oil, 0.1 % v	1					
Laredo, 6 fl oz	2	35.0 a	92.5 a	0.20 a	8.1 b	49.4 ab
Quadris, 6.2 fl oz	1					
Crop oil, 0.1 % v	1					
Domark, 5.0 fl oz	2	0.0 d	40.0 ef	0.0 bc	0.9 c	48.0 abc
Quadris, 6.2 fl oz	1					
Crop oil, 0.1 % v	2					
Headline, 4.71 fl oz	2					
Folicur, 3.16 fl oz	2	20.0 b	80.0 ab	0.09 bc	4.5 bc	47.6 abc
Quadris, 6.2 fl oz	1					
Crop oil, 0.1 % v	1					
TOPGUARD, 7.0 fl oz	2	0.0 d	25.6 fg	0.0 bc	0.1 c	47.4 abc
Folicur, 4.0 fl oz	1					
Folicur 3.6F, 4.0 fl oz	2	10.0 bcd	32.5 efg	0.05 bc	0.4 c	41.1 ef
Domark, 5.0 fl oz	2	0.0 d	27.5 fg	0.00 bc	0.1 c	41.4 def
TOPGUARD, 7.0 fl oz	2	5.0 cd	17.5 g	0.02 bc	0.3 c	38.8 f
Folicur, 4.0 fl oz	2	15.0 bc	30.0 fg	0.10 b	1.4 c	41.7 def

[w] Fungicides were applied on August 29 (1) at the R3 stage and on September 11 (2) at the R4-R5 stage.
[x] Soybean rust incidence was assessed as number of infected leaves out of 10 terminal leaflets collected arbitrarily from the lower canopy of each plot and multiplied by 100.
[y] Based on a visual estimation of percentage of each leaflet infected and rated on a scale of 0 to 100% of leaf affected
[z] Column means with a letter in common are not significantly different (Fisher's least significant difference t-test; P=0.05).

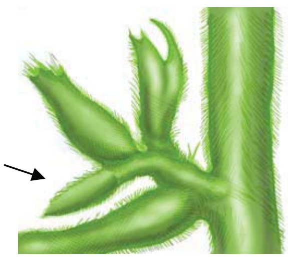
Identifying soybean growth stages –

Begin scouting for soybean rust by the reproductive (R) stages. The growth stages can overlap; consider that a growth stage begins when 50% or more of the plants are in or beyond that stage. A node is a part of the stem where a leaf is attached.

Pod development- R3 and R4

R3- Beginning pod- pods are 3/16 inch at one of the four uppermost nodes with a fully developed leaf

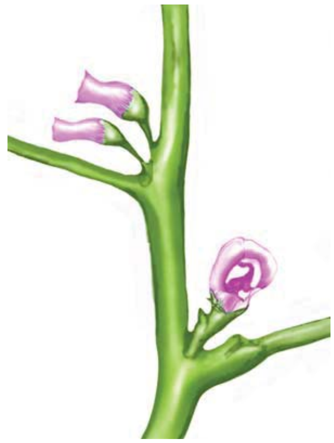
3/16 inch



R4-Full pod– pods are 3/4 inch at one of the four uppermost nodes on a main stem with a fully developed leaf. This stage is the most critical for soybean yield.

Bloom stages- R1 and R2

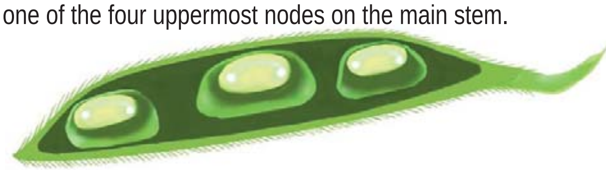
R1-Beginning bloom– plants have at least one open flower at any node



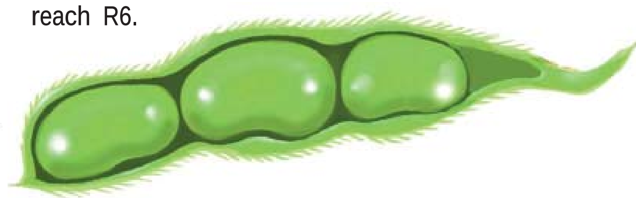
R2-Full bloom- an open flower at one of the two uppermost nodes of the main stem

Seed development- R5-R6

R5-Beginning seed- seed is 1/8 inch long in the pod at one of the four uppermost nodes on the main stem.



R6-Full seed- pod containing a green seed that fills the pod capacity at one of the four uppermost nodes on the main stem –**stop scouting when soybeans reach R6.**



Maturity R7-R8

R7-Beginning maturity- One normal pod on the main stem has reached it's mature pod color.

R-8 Full maturity-95% of pods have turned their mature color (tan or brown).

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Prepared by Diane Brown-Rytlewski, Michigan State University. Drawings adapted from photos at: Soybean Extension and Research Program, Department of Agronomy, Iowa State University. (www.soybeanmanagement.info). References for growth stage information: "How a Soybean Plant Develops" Special Report 53- Iowa State University and "Reproductive Soybean Development Stage and Soybean Aphid Thresholds" -University of Wisconsin Extension. Artwork by: Steven Brown

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Table 2. Fungicides for managment of soybean rust

Brand Name	Common Name	Rate (fl oz/a)[b]	Number of Applications/year and Maximum (fl/oz/a)/year	Fungicide Class and (FRAC Code)[a]	Label[c]
Bravos, Echo, Equus	Chorothalonil	24-32	3 (96)	Nitrile (M4)	Section 3
Quadris	Azoxystrobin	6.2-15.4	2 (90.0)	Strobilurin (11)	Section 3
Headline	Pyraclostrobin	6.0-12.0	2 (24)	Strobilurin (11)	Section 3
Tilt, PropiMax, Bumper	Propiconazole	4.0-8.0	2 (12)	Triazole (3)	Section 3
Folicur, Uppercut, Orius	Tebuconazole	3.0-4.0	2 (8)	Triazole (3)	Expired/Pending Renewal
Laredo EC	Myclobutanil	4.0-8.0	2 (16)	Triazole (3)	Section 3
Domark	Tetraconazole	4.0-6.0	1 (6.0)	Triazole (3)	Section 3
Stratego	Propiconazole + Trifloxystrobin	5.5-10.0	2 (20)	Strobilurin + Triazole (3 & 11)	Section 3
Quilt	Azoxystrobin + Propiconazole	14-20	2 (40.0)	Strobilurin + Triazole (3 & 11)	Section 3
Alto	Cypraconazole	2.75-4.0	2 (8.0)	Triazole (3)	Section 18
Quadris Xtra	Azoxystrobin + Cypraconazole	4.0	2 (8.0)	Strobilurin + Triazole (3 & 11)	Section 18
Caramba	Metconazole	8.2-9.6	2 (19.2)	Triazole (3)	Section 18
Punch	Fluzilazole	4.0	2 (8.0)	Triazole (3)	Section 18
Charisma	Fluzilazole + Famoxodone	9.0	2 (18.0)	Triazole (3)	Pending
Topguard	Flutriafol	7.0	2 (14.0)	Triazole (3)	Section 18

[a] Combinations of a strobilurin and a triazole may provide increased control and residual activity.

[b] Higher rates provide greater residual activity and may reduce the need for later sprays.

[c] Section 3 labels are for general use and not contingent on emergency conditions. Section 18 labels are temporary and expire on various dates unless renewed or replaced by Section 3 labels. Pending indicates that these materials may be labeled as Section 3 or Section 18 materials. Fungicides labeled as Section 18 materials are restricted use pesticides when used on soybean, regardless of what the accompanying label material may say and you must have the Section 18 label in your possession if using these materials. Read label for plant back restrictions on all materials used, some are very restrictive.