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POTENTIAL MARKET IMPACTS OF SOYBEAN RUST

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Introduction
Asian soybean rust, a plant disease caused by *Phakopsora pachyrhizi*, has lowered yields and raised production costs in many parts of the world including Asia, Australia, India, Africa, and South America (Caldwell and Laing; Yorinori et al.). *P. pachyrhizi* can infect over 95 species of plants, including soybeans, other cultivated legumes such as peas and beans, and wild hosts including kudzu, which is widespread in the U.S. (Office of Technology Assessment; APHIS 2004a, 2004b).

P. pachyrhizi spores have the potential to disperse naturally over long distances and, under suitable climatic conditions, rapidly infect large production regions. Recent introductions of the pathogen into Uganda in 1996, Kenya, Nigeria, Rwanda, Zambia, and Zimbabwe in 1998, South Africa, Paraguay, and Brazil in 2001, northern Argentina in 2002, and Bolivia in 2004 have led to heightened concerns regarding the threat this pest poses to U.S. agriculture (Caldwell and Laing; Yorinori et al.). As a result, USDA established a soybean rust surveillance, information, and education program to enhance the ability of domestic producers to respond effectively to rust establishment (APHIS, 2004a).

The extent of economic impacts depends on the timing, location, spread, and severity of rust establishment and outbreaks, and on how soybean and crop producers, livestock producers, and consumers of agricultural commodities respond. In addition, the arrival of a new pest of a major U.S. crop has implications for numerous public policies, including those concerned with invasive species, agricultural trade, pest control research, commodity programs, extension, pesticide regulation, and crop insurance.

Study Objectives
Periodic soybean rust outbreaks in the U.S. would be expected to induce a series of adjustments by agricultural producers, especially soybean growers, including, for example, using fungicides to treat the disease or altering their crop mix. Management options may increase over time, as producers gain new information (e.g., rust spread advisories) and/or as new technologies (e.g., more efficacious fungicides or resistant varieties) become available. Because some regions are more susceptible to rust establishment than others, impacts will likely vary considerably by region.

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In April 2004, the Economic Research Service (ERS) released a study which examined the potential economic implications of soybean rust establishment in the U.S. (Livingston et al, 2004). [Note: Asian soybean rust was first confirmed on the U.S. mainland last November.] The analysis was designed to account for:

- varying regional susceptibilities to rust establishment;
- uncertainties surrounding yield and production cost impacts;
- commodity price changes; and
- economic adjustments of soybean and crop producers, livestock producers, and consumers of agricultural commodities.

Ranges for potential economic impacts are presented because uncertainties exist regarding the suitability of different regional climates for the establishment and severity of rust outbreaks, potential yield and production cost impacts, and producer responses.

Assumptions of the Analysis

The ERS economic analysis of potential soybean rust establishment and subsequent periodic outbreaks is based on the assumption that soybean rust arrives in 2005 and that producers adjust to the establishment of soybean rust within 3 years (i.e., by 2008). During the 3-year period after establishment, crop producers are assumed to have responded to soybean rust by adjusting the mix of crops they plant or increasing the use of soybean fungicides. Impacts are based on comparisons of a rust scenario relative to 2008 projections reported in, or consistent with, the 2001 USDA baseline. The susceptibility of regions to annual periodic outbreaks varies according to climatic characteristics and, for this analysis, selected geographic scenarios of rust outbreak extent are analyzed, and yield loss and fungicide cost estimates are adjusted by regional climate suitability indices.

Estimating Yield and Cost Impacts

Assumptions about potential yield and production cost impacts of rust establishment are critical to the analysis. Since no data on potential yield losses for the U.S. are available, the analysis considers a range of yield losses based on estimates of rust-free and treated yields in Brazil and Paraguay during 2001–2003 (BASF; Bayer 2003a, 2003b; Sierk et al.). These data suggest that treated soybean yields average 4.3 percent lower than estimated, rust-free yields, but with a range between 9.5 percent lower to 0.9 percent higher than rust-free yields. Consequently, we examine the economic consequences of the following yield impacts: -9.5 percent, -4.3 percent and +0.9 percent.

The yield increase possibility arises from the fact that fungicides used to manage rust outbreaks, especially for a relatively mild rust infestation, also manage other diseases (e.g., anthracnose, stem canker, Diaporthe pod and stem blight, frogeye leaf spot, Cercospora blight, purple seed stain, and Septoria brown spot), which may reduce yield but are not profitable to manage individually (Hartman, et al.).

Information on the likely cost of fungicide treatments was partially drawn from data submitted to the EPA in a request for a quarantine exemption for fungicides to treat soybean rust (Sierk et al.). Fungicide material and application (ground and air) costs are assumed to average roughly $19

per treated acre, but exhibit considerable variation depending on the type of fungicide and number of treatments. A test of the analytical model's sensitivity to assumptions about fungicide treatment costs showed that economic outcomes are relatively insensitive to the cost of treatment compared to yield changes. This analysis assumed a higher figure of $25 per treated acre, assuring some conservatism in the analytical assumptions with the knowledge that overall outcomes were not unduly affected.

The Economic Model
Potential impacts of soybean rust establishment in the U.S. are simulated using a spatial equilibrium, mathematical-programming model (USMP) of the U.S. agriculture sector. USMP includes 45 geographic sub-regions based on the intersection of 10 USDA Farm Production Regions and 25 USDA Land Resource Regions. Twenty-three inputs are included, as are the production and consumption of 44 agricultural commodities and processed products. The model accounts for more than 5,000 crop production enterprises at the sub-regional level—according to cropping rotations, tillage practices, and fertilizer rates—and more than 90 livestock and poultry production enterprises at the regional level by species. Agricultural markets for inputs such as land (crop and pasture), labor (family and hired), and irrigation water are specified at the regional level, and the demand for roughly 23 other inputs (e.g., fertilizer and seed) is subject to fixed, national prices. Nearly 1,000 primary commodity and 70 processing activities (e.g., producer input demand) and consumer demand activities in 44 competitive crop, livestock, and processed product markets are chosen to maximize net returns to all agricultural producers and consumers, subject to market-clearing constraints.

USMP simulates likely adjustments made by crop, feed, and livestock producers and consumers after soybean rust is introduced into the U.S.. More specifically, USMP simulates the impacts of soybean yield changes and increased production costs (i.e., fungicide treatments) for a number of scenarios exploring different geographic assumptions about potential soybean rust establishment.

Impacts of Soybean Rust Establishment
Several scenarios are simulated to provide ranges for impacts of soybean rust outbreaks. These scenarios consider varying geographic extent and yield impact assumptions but assume fungicide costs are fixed. Results are presented for three of these scenarios: a "Low Spread" scenario with limited geographic infestation (in the Appalachia, Southeast, and Delta regions), a yield increase of 0.9 percent on treated acres, and $25-per-acre treatment cost; a "Medium Spread" scenario with moderate geographic infestation (in the Appalachia, Southeast, Delta, Corn Belt, and Northeast regions), a 4.3-percent yield decrease on infected acres, and a $25-per-acre treatment cost; and a "High Spread" scenario with extensive geographic infestation (in all soybean production regions), a 9.5-percent yield decrease on infected acres, and a $25-per-acre treatment cost. These impacts are summarized in tables 1 and 2.

To incorporate data on the relative propensity of regions to host soybean rust, yield shocks and fungicide treatment costs were assumed to affect that portion of the regional soybean acres reflected by the regional suitability indices shown in the first row of table 2. For example, the 9.5-percent yield loss shock and $25-per-acre fungicide cost is applied to 70 percent of the Corn Belt acres, as a way of representing the relative propensities for rust-related economic impacts.

Consequently, the study assumes that different rust-affected regions will have different geographic and yield loss shocks based on the assumed suitability for soybean rust.

Once soybean rust becomes established in the U.S., producers are assumed to adjust their crop mix in response to the likelihood of periodic soybean rust outbreaks. In the years following the arrival of soybean rust, producers would be faced with the prospect of changed soybean yields and increased production costs in regions subject to outbreaks. In regions prone to experience annual soybean rust outbreaks, producers would examine alternative uses of their cropland, and if soybean production appeared relatively less profitable, they would choose to plant alternative crops.

The analysis indicates that across the different scenarios, acreage planted to soybeans would fall between 1.9 percent and 5.5 percent from 2008 baseline levels (table 1). With fewer soybean acres, in aggregate, production would fall (between 1.1 and 10.2 percent) and soybean prices would rise (from 0.7 percent to 6.0 percent). Increased prices would likely lead to reduced exports of between 0.6 percent to 5.6 percent from baseline levels.

The soybean sector, under a severe infestation ("High Spread" scenario), would be expected to see a 21-percent decrease in returns due to acreage and production declines and production cost increases. Aggregate returns to soybean production would fall by nearly 3 percent even when yields increase (under a "Low Spread" case) due to increased production costs associated with fungicide treatments and fewer planted acres. Furthermore, higher soybean prices would lead to increased feed costs and lower livestock and poultry sector profits. On the other hand, returns would increase for other crops as producers shift from soybeans to alternative crops, mainly corn, sorghum, rice, and cotton. Many of these producers also grow soybeans and could offset reduced soybean net returns by producing other crops. Overall, total net producer plus consumer effects under these scenarios would drop only 0.5 to 0.06 percent ($2 billion to $240 million) from the 2008 base.

Because producers in different regions have different cropping alternatives, the impacts of rust establishment are not evenly distributed across all soybean-growing areas (table 2). For regions in which rust is less likely to occur, soybean producers would benefit from higher soybean prices and therefore would plant more acres to soybeans. Consider the "Low Spread" scenario, where a soybean rust outbreak occurs in the Appalachia, Delta, and Southeast regions. Crop producers in infested regions would reduce acres planted to soybeans and shift to alternative crops; in the Delta region, much of the soybean acreage would shift into corn, sorghum, rice, and cotton. Conversely, in all other regions soybean acres would increase as producers respond to higher soybean prices and net returns relative to other cropping opportunities.

Conclusions
Several implications can be drawn from this analysis. First, the U.S. agricultural sector as a whole exhibits a tremendous amount of resilience, even when it is buffeted by large yield or production cost shocks affecting a key agricultural commodity like soybeans. This conclusion follows from the observation that, after market adjustments take place, the aggregate impact of soybean rust establishment in the U.S. represents less than 1 percent of the value of agricultural economic activity. Factors explaining the U.S. agricultural sector's resilience include the

availability of substitute crops in regions where soybean rust is anticipated to be most severe; the availability of alternatives to soybeans and its derivative products for consumption as soybean prices increase; and the availability of inputs and technologies to limit economic losses.
In South America, where conditions are far more conducive for rust and rust infestations have been widespread and costly, the soybean sector has not been overwhelmed due primarily to the adaptability of growers and responsiveness of the pest control industry. The resilience predicted by the analysis is consistent with the observed response of the U.S. agricultural sector to past pest infestations, such as the recent shock to the soybean sector caused by soybean aphids. Over time, technological innovations spurred by the new soybean production environment can be expected to further soften the impact of soybean rust infestation.

Another general conclusion is that, because soybean rust affects each production region differently, there will be both winners and losers—even among soybean producers. The adverse effects of soybean rust will be most pronounced in U.S. production regions with agro-climatic conditions favorable for the pathogen. And in some of those vulnerable regions, soybean farmers may have few alternative planting choices that are as profitable as rust-free soybeans. The analysis also suggests that crop producers in regions that are unaffected by soybean rust will gain from an infestation elsewhere. Further, given time to adjust, the national economic impact of a soybean rust infestation on producers of other crops is positive, which partially offsets the losses from reduced soybean production.

This analysis assumes that an effective soybean rust public surveillance and monitoring capability is in place, that cost-effective fungicides are available to treat soybean crops in amounts that are needed by farmers, and that public programs are available to provide farmers with the expertise needed to respond to a soybean rust infestation.

Any analysis of the biological and economic impacts of this pest on domestic soybean producers and the agricultural sector is subject to great uncertainty. These uncertainties include: when and where soybean rust might strike different soybean growing regions in the U.S.; variation in the suitability of regional climates for the establishment and severity of rust establishment; potential yield and production cost impacts; availability and efficacy of soybean rust control alternatives; and the short- and long-term domestic producer responses to a new pest. This analysis required numerous assumptions regarding these uncertainties, and the reported results should be interpreted in this context. As additional scientific research is undertaken to refine or narrow these uncertainties, both the biological and economic impacts can be better measured.

NOTE: The entire report, from which this paper was derived, can be accessed at:
http://www.ers.usda.gov/publications/OCS/APR04/OCS04D02/

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Table 1—Economic impacts of soybean rust on the soybean sector, as changes from baseline projections

	Additional Fungicide Costs ($million)	Price[a] ($ per bu)	Production (million bu)	Exports (million bu)	Acres (million)	Net Returns[a] ($million)
2008 baseline[b]	$0.00	$4.99	3,150	1,055	74.20	$5,776
		Percent Change				
Scenario[c]						
High Spread	$961	6.0	-10.2	-5.6	-5.5	-21.0
Medium Spread	$779	2.8	-4.7	-2.6	-3.2	-14.3
Low Spread	$246	0.7	-1.1	-0.6	-1.9	-2.8

a/Discounted to 2004 dollars.

b/Economic impacts are compared to 2008 levels derived from baseline projections (USDA, 2001).

c/High Spread = All Soybean Regions; -9.5% yield shock and $25/ac treatment on a portion of the regional acreage that reflects the regional suitability index; Medium Spread = AP, SE, DL, CB, and NE Regions; -4.3% yield shock and $25/ac treatment on a portion of the regional acreage that reflects the regional suitability index; and Low Spread = AP, SE, and DL Regions; positive 0.9% yield shock and $25/ac treatment on a portion of the regional acreage that reflects the regional suitability index; where NE (Northeast) = CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VT; LS (Lake) = MI, MN, WI; CB (Corn Belt) = IA, IL, IN, MO, OH; NP (Northern Plains) = KS, ND, NE, SD; AP (Appalachia) = KY, NC, TN, VA, WV; SE (Southeast) = AL, FL, GA, SC; DL (Delta) = AR, LA, MS; SP (Southern Plains) = OK, TX.

Source: Livingston, M., R. Johansson, S. Daberkow, M. Roberts, M. Ash, and V. Breneman, "*Economic and Policy Implications of Wind-borne Entry of Asian Soybean Rust into the U.S.,*" e-Outlook, OCS-04D-02, April 2004.

Table 2—Baseline soybean acres, soybean rust suitability index, and percent changes in soybean acres by region

Regions	NE	LA	CB	NP	AP	SE	DL	SP	US
Regional suitability index	0.76	0.59	0.70	0.54	0.78	0.83	0.66	0.38	na
Baseline soybean acres (million)	1.10	8.60	37.60	8.50	5.50	3.30	9.40	0.30	74.2[a]
Scenario[b]	Percent change								
High Spread	-7.4	-5.8	-2	-6.9	-12.4	-14.9	-10.5	-1	-5.5
Medium Spread	-6.6	2.3	-1.9	2.1	-11.3	-13.3	-10	1.2	-3.2
Low Spread	0.4	0.5	0.2	0.5	-9.4	-8.7	-8.6	0.3	-1.9

a/Soybean acres are compared to 2008 levels derived from baseline projections (USDA, 2001).
b/High Spread = All Soybean Regions; -9.5% yield shock and $25/acre treatment on a portion of the regional acreage that reflects the regional suitability index; Medium Spread = AP, SE, DL, CB, and NE Regions; -4.3% yield shock and $25/acre treatment on a portion of the regional acreage that reflects the regional suitability index; and
Low Spread = AP, SE, and DL Regions; positive 0.9% yield shock and $25/acre treatment on a portion of the regional acreage that reflects the regional suitability index; where
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NP (Northern Plains) = KS, ND, NE, SD; AP (Appalachia) = KY, NC, TN, VA, WV; SE (Southeast) = AL, FL, GA, SC;
DL (Delta) = AR, LA, MS; SP (Southern Plains) = OK, TX; US (United States).

Source: Livingston, M., R. Johansson, S. Daberkow, M. Roberts, M. Ash, and V. Breneman, "*Economic and Policy Implications of Wind-borne Entry of Asian Soybean Rust into the U.S.,*" e-Outlook, OCS-04D-02, April 2004.

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Report

- **Potential Economic and Policy Implications of the Wind-Borne Entry of Asian Soybean Rust into the United States**

  - Outlook Report No. (OCS04D02)
    April 2004
    http://www.ers.usda.gov/publications

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Presentation Outline

- Study Objectives

- Study Assumptions

- Results

- Discussion

Study Objectives

- Examine economic implications of soybean rust (SBR) outbreaks:
  - Soybean sector
  - Other crops
  - Livestock sector
  - Consumers
- Policy implications

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Study Assumptions

- Farmer's annual decision of which crops to plant is based on:
  - Expected market price
  - Expected yield
  - Expected cost of production
  - Crop rotation considerations
- Adequate pest control information

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Study Assumptions

Share of acres planted to the same crop for 2 and 3 years, 1996-2003
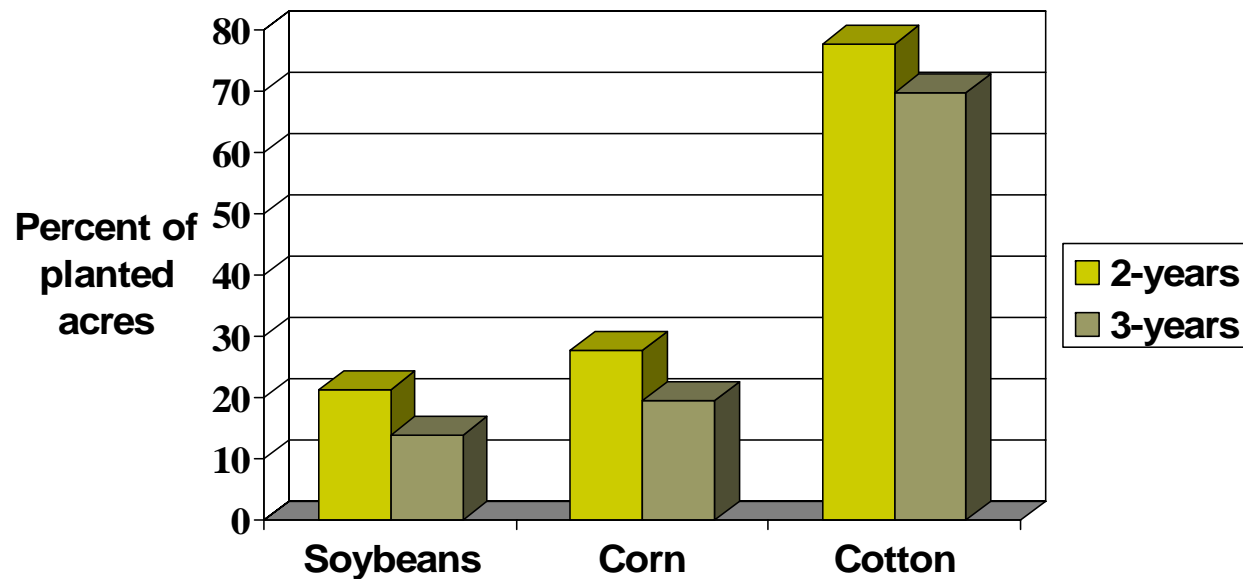
Study Assumptions

- SBR arrives in 2005

- 2-3 year adjustment period

- SBR impacts relative to USDA baseline published in 2001

- Incorporated regional SBR susceptibility

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Study Assumptions

- **SBR scenarios**
  - Yield impact
  - Regions affected
  - Cost of fungicide treatment

- **Fungicide cost per treated acre**
  - $19/acre material cost
  - $6/acre application cost
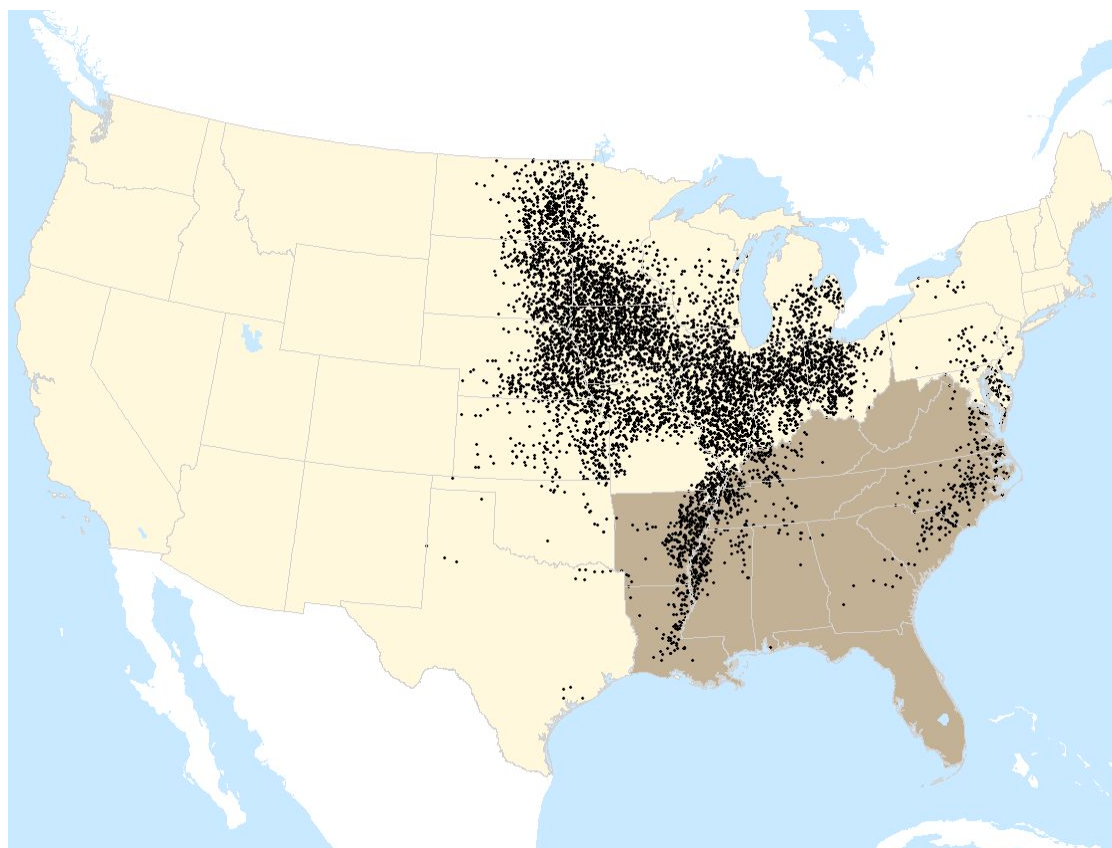 - $25/acre total cost
  - No fungicide shortage

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Study Assumptions

- Three SBR yield impact scenarios
- Yield change with fungicide treatment
  - 1% yield increase
  - 4% yield decline
  - 10% yield decline
- Three regional SBR infestation scenarios:
  - Southeast, Delta and Appalachia States
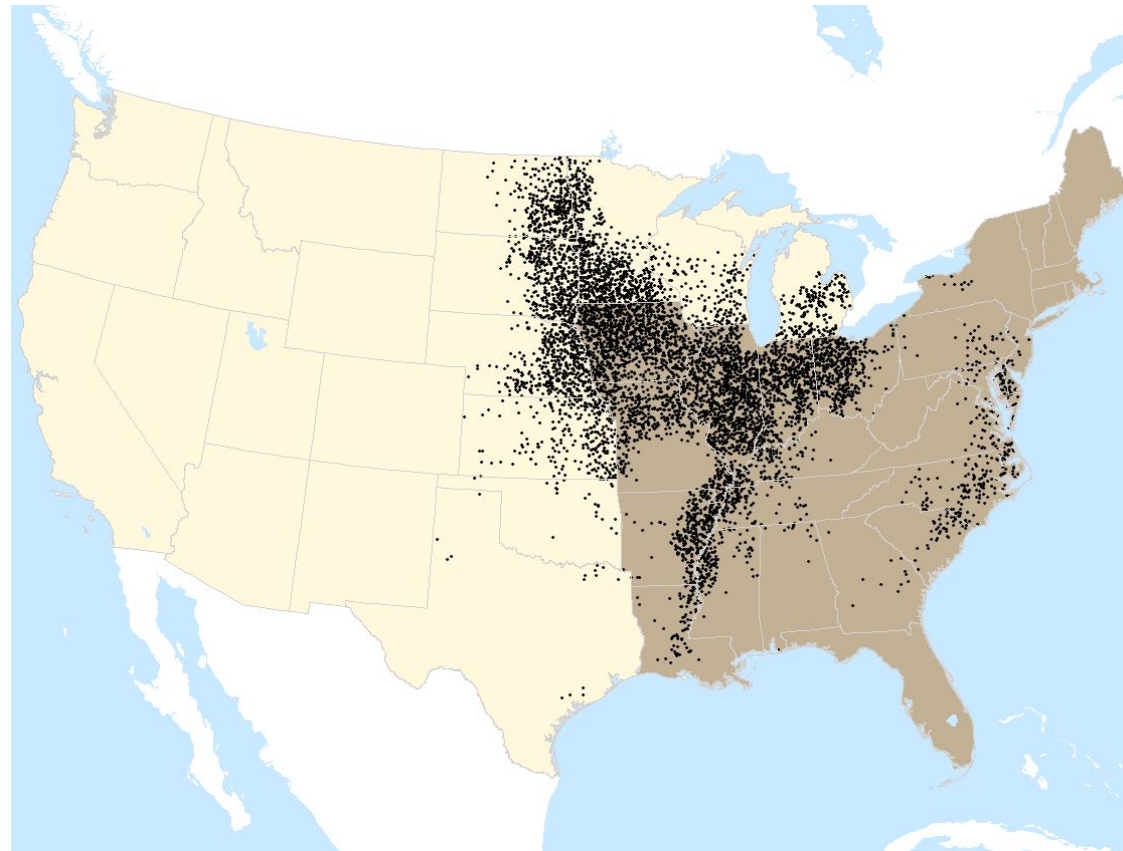 - Cornbelt and Northeast States (plus above)
  - All soybean States

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U.S. Soybean Production Regions

Source: NASS
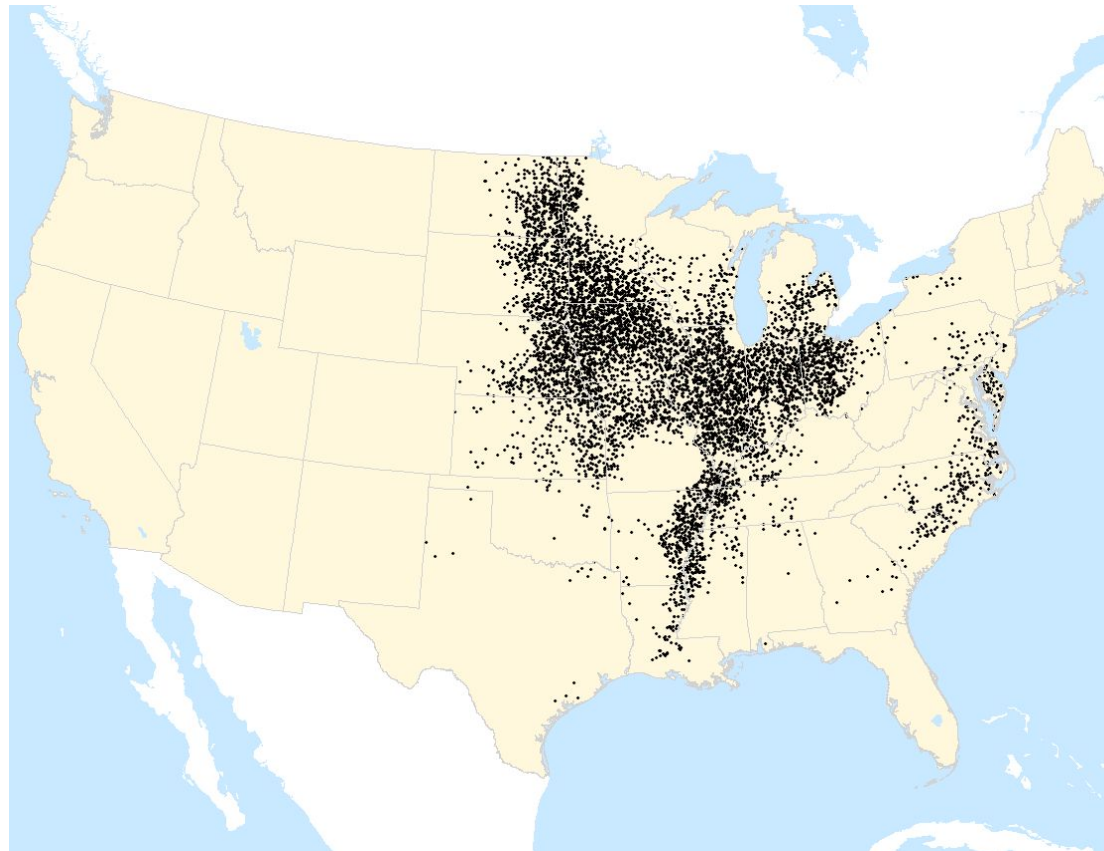
Low Spread Scenario
18 mil. soybean acres (25%)

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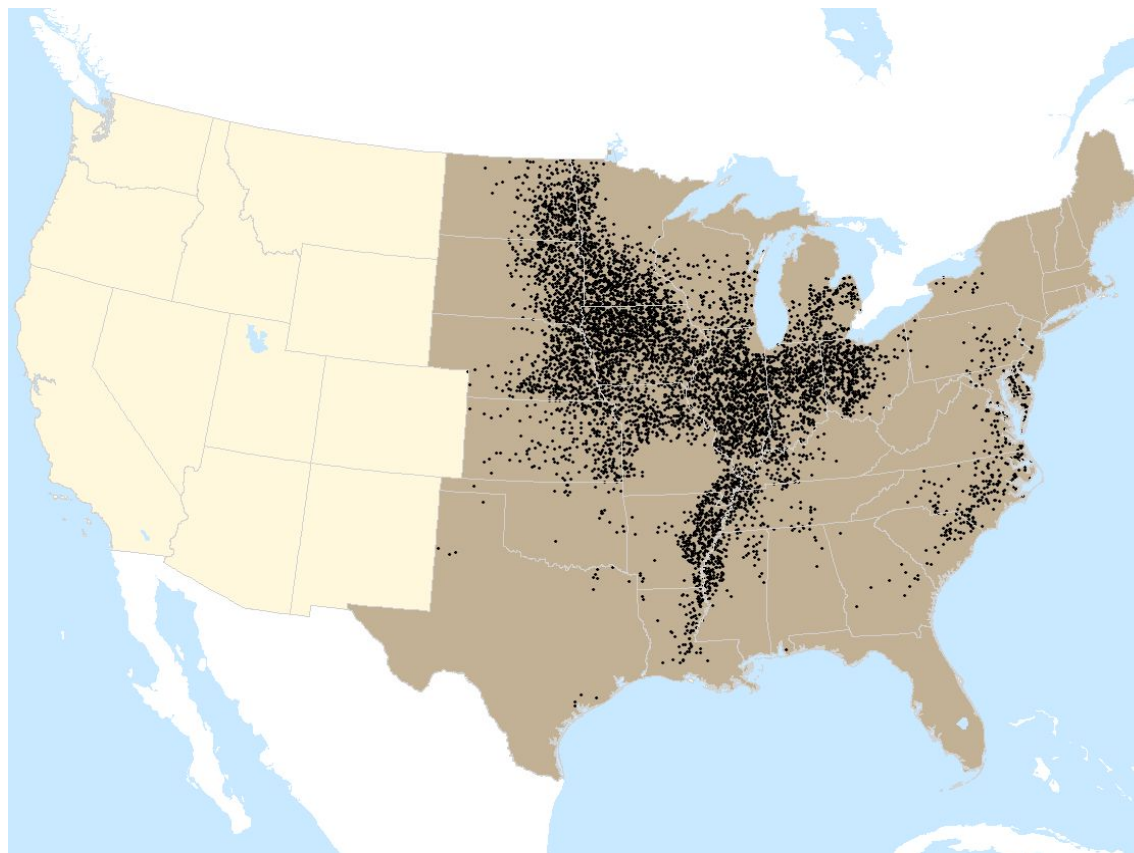ECONOMIC RESEARCH SERVICE
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Medium Spread Scenario
57 mil. soybean acres (77%)

High Spread Scenario
74 mil. soybean acres (baseline)

SBR Scenarios

Yield Impact	Regional Infestation		
	Delta, AP, & SE States	Cornbelt & NE States	All other States
1 % Increase	LOW SPREAD		
4 % Decrease	MEDIUM SPREAD		
10 % Decrease	HIGH SPREAD		

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Results

**Soybean acres and production response
under different SBR scenarios**

Percent change from baseline, with bars for Acres and Production across Low spread, Medium spread, and High spread scenarios.

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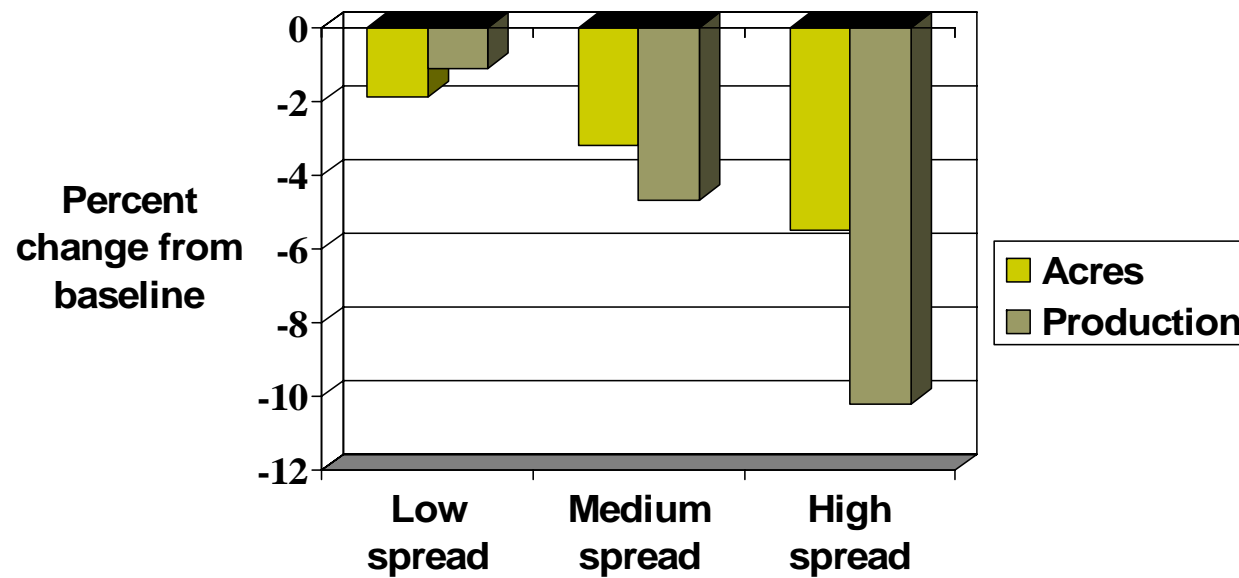
Results

Soybean price response under different SBR scenarios

Percent change from baseline
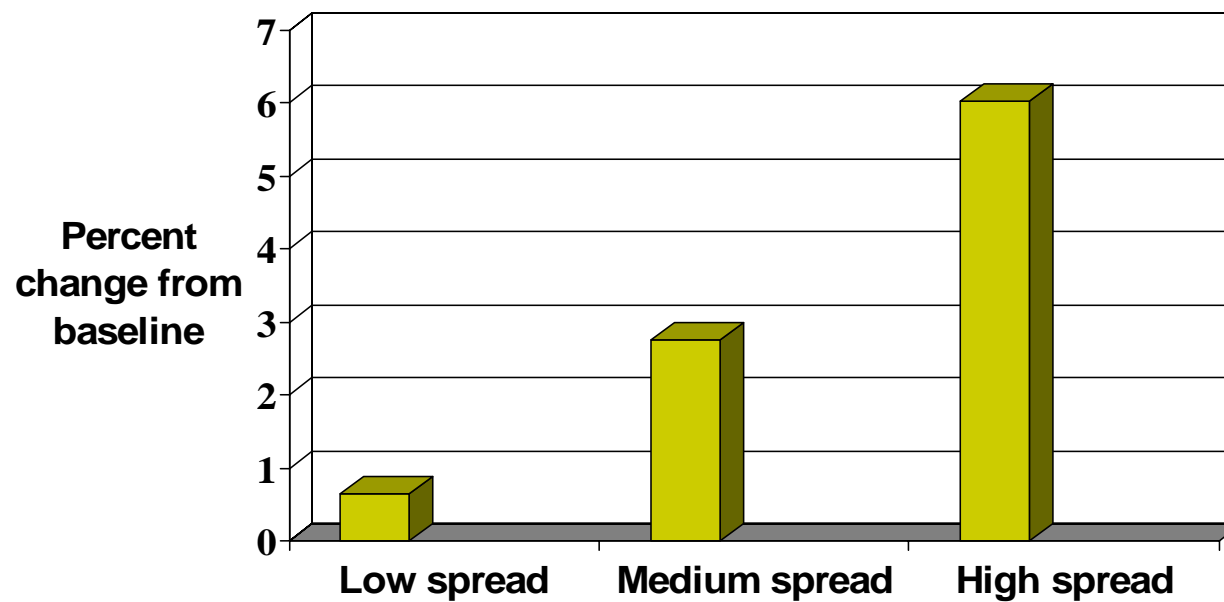
Results

Regional soybean acreage changes under different SBR scenarios
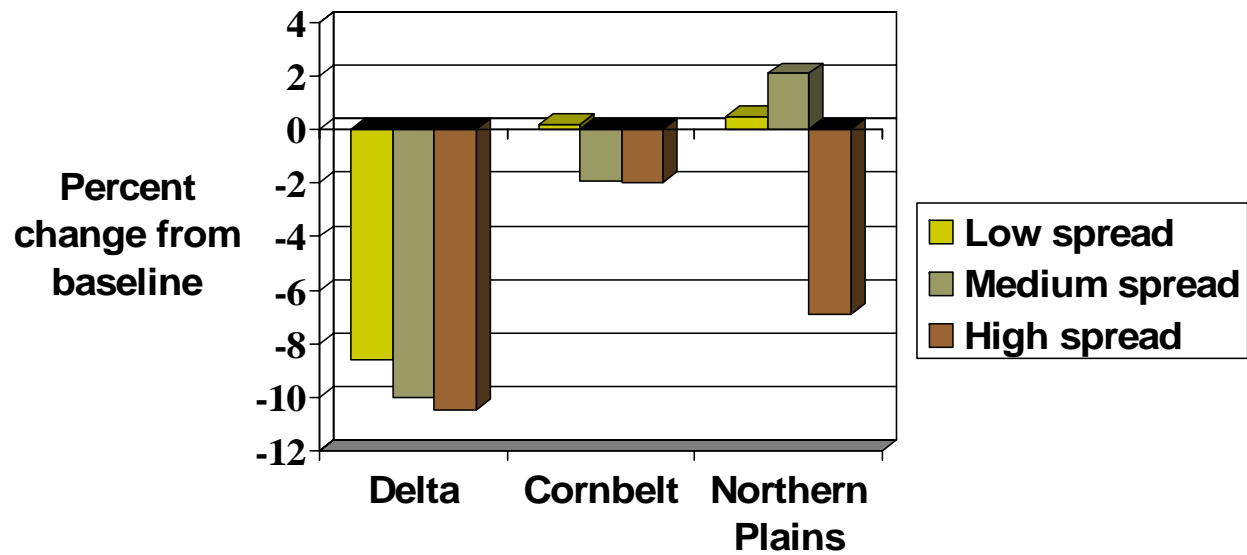
Discussion

- Fungicide availability and cost
- Well informed producers
  - Active Extension and crop advisor network
  - SBR monitoring and scouting
- Adaptability of U.S. agriculture mitigates impact
  - Changing crop mix or crop rotations?
  - South American experience
  - Soybean aphid experience
  - Safety net programs

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