

Estimates of Disease Effects on Soybean Yields in the United States 2003 to 2005

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Abstract: Research must focus on management of diseases that cause extensive losses, especially when funds for research are limited. Knowledge of the losses caused by various soybean diseases is essential when prioritizing research budgets. The objective of this project was to compile estimates of soybean yields suppressed due to diseases for each soybean-producing state in the US from 2003 to 2005. The goal was to provide this information to help funding agencies and scientists prioritize research objectives and budgets. Yield suppression due to individual diseases varied among regions in the US, and the total of soybean yields suppressed due to diseases in the US varied among years. Soybean cyst nematode suppressed US soybean yield more during 2003 to 2005 than any other disease. Phytophthora root and stem rot, sudden death syndrome, and seedling diseases ranked in the top four on the list of diseases that suppressed soybean yield during these years. This is the first report of soybean yield suppression due to Asian soybean rust in the United States.

Key words: detection, *Heterodera glycines*, *Glycine max*, Phytophthora root and stem rot, rust, soybean, soybean cyst nematode, yield suppression.

High yields are critical to US soybean producer profit margins, especially during periods of low prices for soybean. Unfortunately, soybean yields in the US have been suppressed by diseases in the past (Wrather et al., 2001a), and income derived from this crop has been less than optimal. This financial loss is important to rural economies and to the economies of allied industries in urban areas.

Research must focus on management of diseases that cause extensive losses, especially when funds for research are limited. Clearly, knowledge of the losses caused by various soybean diseases is essential when prioritizing research budgets.

The Southern Soybean Disease Workers (SSDW) began reporting estimated soybean losses due to diseases in the southern US in 1974, and a summary of these data from 1974 to 1994 has been published (Wrather et al., 1995). Estimates of soybean yield suppression due to diseases for the US from 1996 to 1998 (Wrather et al., 2001b) and 1999 to 2002 (Wrather et al., 2003) have been published.

The objective of this project was to compile estimates of soybean yields suppressed due to diseases for each soybean-producing state in the US from 2003 to 2005. The goal was to provide this information to help fund-

ing agencies and scientists prioritize research objectives and budgets.

This report was prepared through a joint effort of North Central Regional Committee on soybean pathology (NCR-137) and the Southern Soybean Disease Workers. A common objective of these two groups has been to monitor and publicize the development of new or recurring diseases of soybean in North America.

METHODS AND MATERIALS

Scientists from each soybean-producing state in the US were asked to estimate the percent yield each soybean disease suppressed in their state from 2003 to 2005. These scientists developed their estimates from field surveys, research plot data, and questionnaires given to field workers and extension staff. Most individuals used several of these methods and consulted with their colleagues to develop a percent loss estimate. Production losses for all areas were based on estimates of yield in the absence of disease (Wrather et al., 2001b).

RESULTS AND DISCUSSION

During 2003, 62.3 million tonnes (t) of soybean (2.45 billion bushels [bu]) was produced in the US from 29.4 million ha (72.5 million acres), 68.3 million t (2.69 billion bu) were produced from 29.1 million ha (71.80 million acres) in 2004, and 77.3 million t (3.04 billion bu) were produced from 28.8 million ha (71.3 million acres) in 2005.

Disease suppressed soybean production in the US in 2003 to 2005 (Tables 1–7). Yield suppression due to individual diseases varied among regions in the US, and

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TABLE 1 (Part I). Estimated reduction of soybean yields in tonnes due to diseases for 15 southern states during 2003.^a

Diseases	AL	AR	DE	FL	GA	KY	LA	MD
Anthraxnose	762	27,937	762	NA	254	508	7,873	4,063
Bacterial diseases	0	0	0	NA	0	254	0	0
Brown spot	0	254	0	NA	0	3,556	0	254
Brown stem rot	0	0	0	NA	0	0	0	0
Charcoal rot	0	61,968	0	NA	254	7,111	7,873	0
Downy mildew	0	0	0	NA	0	254	0	0
Frogeye leaf spot	2,286	15,492	0	NA	1,778	2,286	1,524	0
Fusarium root rot	0	0	0	NA	0	254	0	0
Other diseases ^b	0	0	0	NA	762	0	0	0
Phomopsis seed rot	762	9,397	0	NA	508	14,476	0	0
Phytophthora rot	0	254	0	NA	0	254	1,524	0
Pod and stem blight	1,524	17,270	0	NA	254	4,317	15,746	0
Purple stain	254	3,048	0	NA	254	1,524	46,984	254
Rhizoctonia aerial blight	0	13,968	0	NA	0	0	7,873	0
Root-knot nematodes & other nematodes ^c	1,016	62,222	0	NA	6,349	0	24,889	0
Sclerotinia stem rot	0	0	0	NA	0	0	0	0
Seed diseases	0	0	0	NA	0	0	0	0
Seedling diseases	1,524	1,524	762	NA	254	7,111	7,873	0
Southern blight	254	1,016	0	NA	254	254	0	0
Soybean cyst nematode	254	123,683	5,333	NA	5,079	36,063	1,524	8,381
Stem canker	3,048	7,619	0	NA	762	254	0	0
Sudden death syndrome	0	4,063	0	NA	0	254	0	0
Virus	1,524	508	0	NA	0	254	1,524	0

^a Rounding errors may occur, Tr = trace.^b Other diseases were red crown rot caused by *Cylindrocladium parasiticum* in NC, GA, and VA, target spot in LA, and Phymatotrichum root rot in TX.^c Other nematodes were stubby root in VA, Columbia lance in NC and GA, lance in LA and Reniform in AL, AR, and NC.

the total amount of soybean yields suppressed due to diseases in the US varied among years (Table 7).

Soybean cyst nematode (*Heterodera glycines* Ichinohe) (SCN) suppressed US soybean yield more during 2003 to 2005 than any other disease. Phytophthora root and stem rot (*Phytophthora sojae* (Kaufman & Gerdemann)),

sudden death syndrome (*Fusarium solani* f. sp. *glycines* (Roy)), and seedling diseases caused by several pathogens ranked from second to fourth on the list of diseases that suppressed soybean yield during 2003 to 2005, but not in this order each year. Soybean yield suppression due to charcoal root rot (*Macrophomina phaseolina*

TABLE 1 (Part II). Estimated reduction of soybean yields in tonnes due to diseases for 15 southern states during 2003.^a

Diseases	MS	NC	OK	SC	TN	TX	Other ^b	TOTAL
Anthraxnose	15,492	5,079	0	2,540	58,667	4,063	9,651	137,651
Bacterial diseases	0	1,270	0	762	0	254	0	2,540
Brown spot	7,619	2,540	0	762	43,937	254	508	59,683
Brown stem rot	0	0	0	0	0	0	0	0
Charcoal rot	15,492	508	2,540	254	29,460	4,825	5,587	135,873
Downy mildew	0	3,048	0	254	254	254	0	4,063
Frogeye leaf spot	76,952	8,635	0	16,508	117,333	1,270	6,349	250,413
Fusarium root rot	0	0	0	0	0	254	0	508
Other diseases ^b	0	56,127	0	0	0	0	0	56,889
Phomopsis seed rot	30,730	2,540	762	254	14,730	2,032	1,270	77,460
Phytophthora rot	0	3,810	0	0	0	254	0	6,095
Pod and stem blight	30,730	5,079	762	254	0	2,032	0	77,968
Purple stain	30,730	1,270	254	254	14,730	2,032	1,270	102,857
Rhizoctonia aerial blight	7,619	0	0	0	0	254	0	29,714
Root-knot nematodes & other nematodes ^c	0	22,349	254	16,508	254	508	0	134,349
Sclerotinia stem rot	0	0	0	0	0	254	0	254
Seed diseases	0	0	0	0	0	0	0	0
Seedling diseases	23,111	508	762	0	29,460	762	762	74,413
Southern blight	0	2,540	0	1,778	0	254	0	6,349
Soybean cyst nematode	3,048	62,476	1,270	6,603	66,032	0	0	319,746
Stem canker	3,048	0	0	0	1,524	254	0	16,508
Sudden death syndrome	1,524	0	0	0	29,460	254	254	35,810
Virus	0	2,540	0	3,302	0	0	0	9,651

^a Rounding errors may occur, Tr = trace.^b Other diseases were red crown rot caused by *Cylindrocladium parasiticum* in NC, GA, and VA, target spot in LA, and Phymatotrichum root rot in TX.^c Other nematodes were stubby root in VA, Columbia lance in NC and GA, lance in LA and Reniform in AL, AR, and NC.

TABLE 2 (Part I). Estimated reduction of soybean yields in tonnes due to diseases for 13 northern states during 2003.^a

Diseases	IA	IL	IN	KS	MI	MN	MO
Anthraxnose	0	124,216	574	0	0	12,698	Tr
Bacterial diseases	0	0	574	0	0	3,810	0
Brown spot	0	0	5,737	0	0	0	0
Brown stem rot	0	248,432	5,737	0	0	6,349	0
Charcoal rot	818,260	621,054	20,079	226,006	0	7,619	96,000
Downy mildew	0	0	0	0	0	0	0
Frogeye leaf spot	0	0	574	0	0	0	Tr
Fusarium root rot	0	62,095	1,147	0	0	12,698	Tr
Other diseases ^b	0	0	0	0	0	0	0
Phomopsis seed rot	0	0	2,868	0	0	0	0
Phytophthora rot	109,105	372,648	177,843	9,422	Tr	12,698	38,425
Pod and stem blight	0	62,095	2,295	940	0	0	0
Purple stain	0	0	574	0	0	0	0
Root-knot nematodes & other nematodes	0	0	Tr	0	0	0	Tr
Sclerotinia stem rot	Tr	24,838	1,147	0	Tr	5,079	0
Seed diseases	0	0	2,868	0	0	0	0
Seedling diseases	0	186,311	28,684	160,076	0	12,698	3,835
Southern blight	0	0	0	0	0	0	0
Soybean cyst nematode	872,787	621,054	229,474	18,844	102,705	126,984	57,651
Stem canker	0	124,216	574	5,638	0	0	0
Sudden death syndrome	Tr	186,311	86,053	178	0	0	Tr
Virus	0	62,095	6,884	1,879	0	0	Tr

^a Rounding errors may occur, Tr = trace, data from MN were not available.

^b Other diseases were Rhizoctonia root and stem rot in WI and Ontario, and green stem in IL.

(Tassi) Goidanich) and Sclerotinia stem rot (*Sclerotinia sclerotiorum* (Lib.) deBary) varied dramatically among years.

Charcoal root rot was second on the list of diseases that suppressed soybean yield during 2003, but it was not among the top 10 during 2004 or 2005. Sclerotinia stem rot was second on the list of diseases that suppressed soybean yield during 2004, but it was not among the top 10 during 2003 or 2005.

Yield suppression due to SCN seemed to decline slightly in the US, from 2.9 million t in 2003 to 1.9 million t in 2005. However, these estimates of soybean yield suppression due to diseases in the US during 2005 do not include data for Iowa. In 2005, the Iowa soybean crop was damaged by SCN, brown spot, frogeye leaf spot, sudden death syndrome, and Sclerotinia stem rot (white mold), but estimates of yields suppressed due to each disease are not available.

TABLE 2 (Part II). Estimated reduction of soybean yields in tonnes due to diseases for 13 northern states during 2003.^a

Diseases	ND	NE	OH	PA	SD	WI	TOTAL
Anthraxnose	0	0	0	2,108	Tr	1,422	141,018
Bacterial diseases	0	457	0	0	1,727	0	6,567
Brown spot	0	0	0	2,108	3,454	1,422	12,721
Brown stem rot	0	2,286	0	0	1,727	28,444	292,975
Charcoal rot	0	2,286	0	0	34,540	14,222	1,840,067
Downy mildew	0	51	0	2,108	1,727	0	3,886
Frogeye leaf spot	0	0	0	0	0	0	574
Fusarium root rot	11,530	4,571	55,035	0	1,727	1,422	150,227
Other diseases ^b	0	0	0	0	0	0	0
Phomopsis seed rot	0	457	0	8,432	17,270	7,111	36,138
Phytophthora rot	46,171	4,571	550,375	0	69,054	14,222	1,404,535
Pod and stem blight	0	457	0	0	1,727	7,111	74,625
Purple stain	0	914	0	12,648	Tr	0	14,136
Root-knot nematodes & other nematodes	0	0	0	0	Tr	1,422	1,422
Sclerotinia stem rot	0	51	Tr	12,648	1,727	7,111	52,601
Seed diseases	0	0	0	8,432	356	1,422	13,078
Seedling diseases	46,171	45,790	110,070	2,108	34,540	14,222	644,507
Southern blight	0	0	0	0	0	0	0
Soybean cyst nematode	0	22,883	385,270	0	120,838	28,444	2,586,935
Stem canker	0	0	0	0	34,540	42,667	207,634
Sudden death syndrome	0	0	Tr	0	0	7,111	279,653
Virus	0	36,622	0	0	34,540	28,444	170,465

^a Rounding errors may occur, Tr = trace, data from MN were not available.

^b Other diseases were Rhizoctonia root and stem rot in WI and Ontario, and green stem in IL.

TABLE 3 (Part I). Estimated reduction of soybean yields in tonnes due to diseases for 15 southern states during 2004.^a

Diseases	AL	AR	DE	FL	GA	KY	LA	MD
Anthracnose	0	18,540	1,016	508	508	762	9,905	0
Bacterial diseases	0	0	0	0	0	254	0	0
Brown spot	0	254	1,016	0	0	2,794	0	0
Brown stem rot	0	0	0	0	0	0	0	0
Charcoal rot	0	58,413	0	254	254	14,476	4,825	0
Downy mildew	0	0	0	0	508	254	0	0
Frogeye leaf spot	6,095	26,667	0	0	4,571	1,524	4,825	0
Fusarium root rot	0	0	0	0	0	254	0	0
Other diseases ^b	0	0	0	0	0	0	0	0
Phomopsis seed rot	2,032	18,286	0	508	762	10,921	19,556	1,270
Phytophthora rot	0	0	0	0	0	254	4,825	0
Pod and stem blight	0	18,540	0	0	508	4,317	0	0
Purple stain	2,032	1,778	0	254	254	254	58,921	4,063
Rhizoctonia aerial blight	0	8,381	0	0	0	0	19,556	0
Root-knot nematodes & other nematodes ^c	2,032	33,524	0	254	9,905	0	17,778	2,794
Rust	0	0	0	0	0	0	0	0
Sclerotinia stem rot	0	0	0	0	0	0	0	0
Seed diseases	0	0	0	0	0	0	0	0
Seedling diseases	2,032	1,778	4,317	254	254	2,794	4,825	0
Southern blight	0	762	0	0	508	254	0	0
Soybean cyst nematode	0	66,540	0	0	1,270	28,952	2,032	10,921
Stem canker	4,063	141,714	0	0	1,270	254	4,825	0
Sudden death syndrome	0	61,206	0	0	0	762	0	0
Virus	2,032	254	0	0	0	762	2,032	0

^a Rounding errors may occur.^b Other diseases were: red crown rot caused by *Cylindrocladium parasiticum* in NC and GA, ozone in NC, green bean syndrome in AR and LA, target spot in LA, and Phymatotrichum root rot in TX.^c Other nematodes were stubby root in VA, Columbia lance in NC and GA, lance in LA, lesion in AL, and Reniform in AL, AR, and NC.

Phytophthora root and stem rot caused yield suppression of soybean in most regions in the US during 2003 to 2005. This disease was not a problem in Iowa during

2005. The estimated yield suppression in the US due to this disease declined from 1.4 million t in 2004 to 1.1 million t in 2005. This decline occurred in all regions of

TABLE 3 (Part II). Estimated reduction of soybean yields in tonnes due to diseases for 15 southern states during 2004.^a

Diseases	MS	NC	OK	SC	TN	TX	VA	TOTAL
Anthracnose	39,619	4,571	0	2,032	66,540	5,079	5,333	154,413
Bacterial diseases	0	4,571	0	1,016	0	1,295	1,524	8,660
Brown spot	19,810	3,048	0	1,016	33,270	508	2,794	64,508
Brown stem rot	0	0	0	0	0	0	2,794	2,794
Charcoal rot	19,810	762	2,286	0	16,508	3,810	1,016	122,413
Downy mildew	0	4,571	0	0	0	254	0	5,587
Frogeye leaf spot	59,429	22,857	0	10,667	99,556	7,721	10,921	254,832
Fusarium root rot	0	0	0	0	0	508	0	762
Other diseases ^b	0	70,349	0	1,016	0	0	2,794	74,159
Phomopsis seed rot	59,429	4,571	0	8,381	49,778	3,810	0	179,302
Phytophthora rot	39,619	8,381	2,286	0	0	254	0	55,619
Pod and stem blight	39,619	6,095	0	4,317	1,778	3,810	5,333	84,318
Purple stain	1,016	3,048	0	508	16,508	6,349	508	95,492
Rhizoctonia aerial blight	0	0	0	0	0	508	0	28,444
Root-knot nematodes & other nematodes ^c	0	27,429	254	34,032	3,556	762	5,333	137,651
Rust	0	0	0	Tr	0	0	0	0
Sclerotinia stem rot	0	0	0	0	0	0	0	0
Seed diseases	0	0	0	0	0	0	0	0
Seedling diseases	39,619	762	2,286	0	33,270	1,270	2,794	96,254
Southern blight	0	3,048	0	2,032	0	254	508	7,365
Soybean cyst nematode	0	76,444	2,286	8,381	66,286	0	10,921	274,032
Stem canker	79,238	0	0	0	33,270	254	0	264,889
Sudden death syndrome	0	0	0	0	41,397	254	0	103,619
Virus	0	3,048	0	4,317	0	508	0	12,952

^a Rounding errors may occur.^b Other diseases were: red crown rot caused by *Cylindrocladium parasiticum* in NC and GA, ozone in NC, green bean syndrome in AR and LA, target spot in LA, and Phymatotrichum root rot in TX.^c Other nematodes were stubby root in VA, Columbia lance in NC and GA, lance in LA, lesion in AL, and Reniform in AL, AR, and NC.

TABLE 4 (Part I). Estimated reduction of soybean yields in tonnes due to diseases for 13 northern states during 2004.^a

Diseases	IA	IL	IN	KS	MI	MN	MO
Anthracnose	0	149,181	813	14,933	0	70,781	5,892
Bacterial diseases	0	Tr	813	0	0	0	Tr
Brown spot	305,676	223,797	8,025	2,997	0	0	Tr
Brown stem rot	0	149,181	16,025	Tr	0	141,562	0
Charcoal rot	0	74,590	16,025	29,892	0	0	29,460
Downy mildew	0	Tr	Tr	0	0	0	Tr
Frogeye leaf spot	Tr0	Tr	Tr	0	0	0	29,460
Fusarium root rot	152,838	0	813	0	0	212,343	Tr
Other diseases ^b	0	0	0	0	0	0	0
Phomopsis seed rot	0	74,590	2,413	0	0	0	5,892
Phytophthora rot	0	372,978	240,559	2,997	Tr	141,562	29,460
Pod and stem blight	0	74,590	2,413	2,997	0	0	5,892
Purple stain	0	Tr	813	Tr	0	0	0
Root-knot nematodes & other nematodes	0	Tr	Tr	0	0	0	Tr
Rust	0	0	0	0	0	0	0
Sclerotinia stem rot	1,069,867	223,797	20,038	Tr	Tr	70,781	Tr
Seed diseases	0	0	2,413	0	0	0	0
Seedling diseases	0	223,797	20,038	80,686	0	353,879	5,892
Southern blight	0	0	0	0	0	0	0
Soybean cyst nematode	1,222,680	745,956	280,660	29,892	100,317	212,343	88,356
Stem canker	0	74,591	Tr	5,968	0	0	0
Sudden death syndrome	458,514	223,797	180,419	305	0	70,781	29,460
Virus	0	Tr	9,625	5,968	0	0	Tr

^a Rounding errors may occur, Tr = trace, losses in MN were not available.

^b Other diseases were Rhizoctonia root and stem rot in WI and Alternaria leaf spot in KS.

the US and was probably due to changes in weather, but may have been due to changes in the pathogen. The yield suppression due to this disease in the US during 2005 was valued at \$251.6 million (\$236/t).

Yield suppression due to Sclerotinia stem rot was greater in the US for 2004 than 2003 or 2005. This disease has been a problem only for North Dakota,

South Dakota, Wisconsin, Iowa, Illinois, Minnesota, and Indiana. The differences in yield suppression due to the disease in the US during 2003 to 2005 were probably due to changes in weather patterns among years.

Charcoal root rot suppressed soybean yield in the US more during 2003 than 2004 or 2005. The reasons for these differences are not clear. Resistant cultivars were

TABLE 4 (Part II). Estimated reduction of soybean yields in tonnes due to diseases for 13 northern states during 2004.^a

Diseases	ND	NE	OH	PA	SD	WI	TOTAL
Anthracnose	0	0	0	10,819	Tr	1,625	250,044
Bacterial diseases	0	5,740	0	0	3,860	0	10,413
Brown spot	0	4,597	0	5,410	19,200	4,851	574,552
Brown stem rot	0	1,143	Tr	0	38,527	48,483	394,921
Charcoal rot	0	1,143	0	0	381	1,625	153,117
Downy mildew	0	584	Tr	5,410	381	1,625	8,000
Frogeye leaf spot	0	0	0	5,410	Tr	0	34,870
Fusarium root rot	10,997	1,143	Tr	5,410	3,860	4,851	239,416
Other diseases ^b	0	1,143	0	0	0	0	153,981
Phomopsis seed rot	0	2,870	Tr	5,410	1,930	1,625	94,730
Phytophthora rot	44,013	11,479	489,600	Tr	38,527	16,152	1,394,946
Pod and stem blight	0	1,143	0	0	1,930	8,076	97,041
Purple stain	0	51	0	Tr	Tr	1,625	2,489
Root-knot nematodes & other nematodes	0	0	0	0	Tr	1,625	1,625
Rust	0	0	0	0	0	0	0
Sclerotinia stem rot	0	28,698	Tr	10,819	19,200	80,813	1,524,013
Seed diseases	0	0	Tr	0	381	1,625	4,419
Seedling diseases	66,006	45,943	183,594	0	19,200	24,254	1,023,289
Southern blight	0	0	0	0	0	0	0
Soybean cyst nematode	0	28,698	306,006	0	134,883	48,483	3,198,274
Stem canker	0	0	Tr	0	19,200	16,152	115,911
Sudden death syndrome	0	51	Tr	0	Tr	8,076	971,403
Virus	0	1,143	Tr	0	19,200	8,076	44,013

^a Rounding errors may occur, Tr = trace, losses in MN were not available.

^b Other diseases were Rhizoctonia root and stem rot in WI and Alternaria leaf spot in KS.

TABLE 5 (Part I). Estimated reduction of soybean yields in tonnes due to diseases for 15 southern states during 2005.^a

Diseases	AL	AR	DE	FL	GA	KY	LA	MD
Anthraxnose	0	1,016	762	0	0	254	4,063	0
Bacterial diseases	762	0	0	0	0	254	0	0
Brown spot	0	254	0	0	0	2,286	0	0
Brown stem rot	0	0	0	0	0	0	0	0
Charcoal rot	0	68,825	0	0	0	29,206	8,127	0
Downy mildew	0	0	0	508	762	254	0	0
Frogeye leaf spot	2,794	254	0	508	1,270	762	0	0
Fusarium root rot	0	0	0	0	0	254	0	0
Other diseases ^b	2,794	0	0	0	254	0	0	0
Phomopsis seed rot	5,587	762	1,270	0	1,270	21,841	4,063	0
Phytophthora rot	0	0	0	0	0	254	4,063	0
Pod and stem blight	0	1,524	0	0	0	4,317	8,127	508
Purple stain	2,794	0	0	0	0	1,524	16,000	2,032
Rhizoctonia aerial blight	762	0	0	0	0	0	8,127	0
Root-knot nematodes & other nematodes	1,524	33,270	1,270	254	4,825	0	16,254	2,032
Rust	0	0	0	0	9,397	0	0	0
Sclerotinia stem rot	0	0	0	0	0	0	0	0
Seed diseases	0	0	0	0	0	0	0	0
Seedling diseases	1,524	1,270	0	0	1,270	2,794	0	0
Southern blight	0	0	0	0	254	254	0	0
Soybean cyst nematode	0	52,317	3,810	0	0	21,841	0	8,381
Stem canker	0	2,032	0	0	0	762	0	0
Sudden death syndrome	0	4,063	0	0	0	1,524	0	0
Virus	0	0	0	0	0	2,794	0	0

^a Rounding errors may occur.^b Other diseases were: ozone in NC, red crown rot caused by *Cylindrocladium parasiticum* in NC, SC, and VA, and green stem in AR.

not available for planting, so these differences were probably due to yearly variation in weather patterns.

Sudden death syndrome (SDS) suppressed soybean yield more in Arkansas, Iowa, Illinois, Indiana, Minnesota, and Tennessee during 2003 to 2005 than in any other state. Losses to this disease were especially severe

in Illinois and Indiana each year. Scherm and Yang (1999) determined that weather patterns were more conducive for this disease for the central than any other area of the US, and these data confirm their observation. The yield suppression due to SDS in the US during 2005 was valued at \$118.9 million (\$236/t).

TABLE 5 (Part II). Estimated reduction of soybean yields in tonnes due to diseases for 15 southern states during 2005.^a

Diseases	MS	NC	OK	SC	TN	TX	VA	TOTAL
Anthraxnose	34,032	1,016	254	1,270	42,921	2,540	4,317	92,445
Bacterial diseases	0	0	0	254	0	254	762	2,286
Brown spot	25,397	1,016	2,286	508	42,921	254	2,286	77,208
Brown stem rot	0	0	0	0	0	0	1,270	1,270
Charcoal rot	17,016	508	6,603	508	28,698	5,079	0	164,570
Downy mildew	0	4,571	0	1,778	0	254	0	8,127
Frogeye leaf spot	17,016	11,429	0	1,778	71,619	3,556	6,603	117,589
Fusarium root rot	0	0	0	0	0	254	0	508
Other diseases ^b	0	5,587	0	508	0	0	3,556	12,699
Phomopsis seed rot	25,397	5,587	0	508	28,698	1,778	0	96,761
Phytophthora rot	0	6,095	254	0	0	0	0	10,666
Pod and stem blight	17,016	4,571	254	508	1,524	762	2,286	41,397
Purple stain	34,032	5,587	1,016	254	7,111	3,556	2,286	76,192
Rhizoctonia aerial blight	0	0	0	0	0	762	0	9,651
Root-knot nematodes & other nematodes	0	21,333	254	12,698	1,524	508	8,381	104,127
Rust	0	0	0	3,810	0	0	0	13,207
Sclerotinia stem rot	0	0	0	0	0	254	0	254
Seed diseases	0	0	0	0	0	0	0	0
Seedling diseases	25,397	508	1,524	254	28,698	762	2,286	66,287
Southern blight	0	2,286	254	1,270	0	254	762	5,334
Soybean cyst nematode	0	56,635	3,302	5,079	57,143	0	8,635	217,143
Stem canker	8,381	0	0	0	28,698	254	508	40,635
Sudden death syndrome	0	0	0	0	28,698	254	0	34,539
Virus	0	2,286	0	2,540	1,524	254	0	9,398

^a Rounding errors may occur.^b Other diseases were: ozone in NC, red crown rot caused by *Cylindrocladium parasiticum* in NC, SC, and VA, and green stem in AR.

TABLE 6 (Part I). Estimated reduction of soybean yields in tonnes due to diseases for 13 northern states during 2005.^a

Diseases	IA	IL	IN	KS	MI	MN	MO
Anthracnose	NA	187,759	7,289	13,968	0	84,902	4,698
Bacterial diseases	NA	12,521	737	0	0	0	Tr
Brown spot	NA	25,041	7,289	33,498	0	0	Tr
Brown stem rot	NA	25,041	7,289	0	0	84,902	0
Charcoal rot	NA	62,578	18,235	27,911	0	0	47,086
Downy mildew	NA	0	737	Tr	0	0	0
Frogeye leaf spot	NA	12,521	18,235	0	0	0	23,543
Fusarium root rot	NA	0	737	6,984	0	84,902	0
Other diseases ^b	NA	0	0	0	0	0	0
Phomopsis seed rot	NA	0	2,184	0	0	0	0
Phytophthora rot	NA	187,759	218,743	13,968	21,206	42,463	23,543
Pod and stem blight	NA	12,521	2,921	2,794	0	0	4,698
Purple stain	NA	12,521	737	Tr	0	0	0
Root-knot nematodes & other nematodes	NA	0	Tr	0	0	0	Tr
Rust	NA	0	0	0	0	0	0
Sclerotinia stem rot	NA	25,041	10,946	Tr	21,206	42,463	0
Seed diseases	NA	0	3,657	0	0	0	0
Seedling diseases	NA	187,759	18,235	41,879	0	254,705	4,698
Southern blight	NA	0	0	0	0	0	0
Soybean cyst nematode	NA	500,673	255,213	19,530	105,981	254,705	70,629
Stem canker	NA	25,041	737	Tr	0	0	0
Sudden death syndrome	NA	187,759	164,064	0	0	0	0
Virus	NA	12,521	7,289	Tr	0	0	0

^a Rounding errors may occur, Tr = trace.^b Other diseases were: Rhizoctonia root and stem rot in WI.

Seedling diseases suppressed soybean yields in both the northern and southern regions of the US during 2003 to 2005. The greatest yield suppression due to seedling diseases in the US occurred in Illinois, Kansas, Minnesota, North Dakota, and Ohio. These maladies caused more problems during 2004 than 2003 or 2005, and the weather was probably an important factor.

Rust (*Phakopsora pachyrhizi* (Syd & P. Syd.)) was first confirmed on soybean in nine states in the continental US during November and December of 2004: Alabama, Arkansas, Florida, Georgia, Louisiana, Missouri, Mississippi, Tennessee, and South Carolina. Rust did not suppress soybean yields during 2004, but did suppress soybean yield in Georgia and South Carolina during 2005.

TABLE 6 (Part II). Estimated reduction of soybean yields in tonnes due to diseases for 13 northern states during 2005.^a

Diseases	ND	NE	OH	PA	SD	WI	TOTAL
Anthracnose	0	0	0	5,613	Tr	10,260	324,749
Bacterial diseases	0	8,889	0	0	3,860	203	26,210
Brown spot	0	4,749	Tr	11,251	9,651	15,390	106,869
Brown stem rot	0	2,971	0	0	38,552	41,041	199,797
Charcoal rot	0	1,194	0	5,613	1,930	2,057	166,603
Downy mildew	0	584	Tr	2,819	Tr	2,057	6,197
Frogeye leaf spot	0	0	584	5,613	0	0	60,495
Fusarium root rot	14,679	1,194	0	16,863	3,860	10,260	139,479
Other diseases ^b	0	1,194	0	0	0	10,260	11,454
Phomopsis seed rot	0	2,971	0	22,502	1,930	2,057	31,644
Phytophthora rot	58,667	17,752	406,629	5,613	38,552	20,521	1,055,416
Pod and stem blight	0	1,194	0	0	1,930	20,521	46,578
Purple stain	0	51	Tr	2,819	Tr	2,057	18,184
Root-knot nematodes & other nematodes	0	0	0	0	Tr	2,057	2,057
Rust	0	0	0	0	0	0	0
Sclerotinia stem rot	0	1,194	0	11,251	19,276	20,521	151,898
Seed diseases	0	0	58,083	0	1,930	2,057	65,727
Seedling diseases	88,000	47,365	58,083	2,819	138,552	20,521	762,616
Southern blight	0	0	0	0	0	0	0
Soybean cyst nematode	305	41,448	232,356	0	134,933	102,578	1,718,350
Stem canker	0	0	0	0	138,552	61,562	125,892
Sudden death syndrome	0	305	58,083	0	1,930	10,260	469,562
Virus	0	1,194	0	0	Tr	10,260	31,263

^a Rounding errors may occur, Tr = trace.^b Other diseases were: Rhizoctonia root and stem rot in WI.

TABLE 7. Estimated reduction of US soybean yields in tonnes due to diseases during 2003, 2004, and 2005.

Diseases	2003	2004	2005
Anthraxnose	278,669	408,457	417,194
Bacterial diseases	9,107	19,073	30,782
Brown spot	72,404	639,060	184,077
Brown stem rot	292,975	397,714	201,067
Charcoal rot	1,975,940	275,530	495,743
Downy mildew	7,949	13,587	14,324
Frogeye leaf spot	250,986	289,702	178,084
Fusarium root rot	150,735	240,178	139,987
Other diseases	56,889	228,140	24,153
Phomopsis seed rot	113,599	274,032	128,405
Phytophthora rot	1,410,630	1,450,565	1,066,082
Pod and stem blight	152,593	181,359	87,975
Purple stain	116,993	97,981	94,376
Rhizoctonia aerial blight	29,714	28,444	9,651
Root-knot nematodes & other nematodes	135,771	139,276	106,184
Rust	0	0	13,207
Sclerotinia stem rot	52,855	1,524,013	152,152
Seed diseases	13,078	4,419	65,727
Seedling diseases	718,919	1,119,543	828,903
Southern blight	6,349	7,365	5,334
Soybean cyst nematode	2,906,681	3,472,306	1,935,493
Stem canker	224,142	380,800	166,527
Sudden death syndrome	315,462	1,075,022	504,101
Virus	180,116	56,965	40,661
Total	9,472,556	12,323,531	6,930,850

Reliable estimates of crop losses to diseases based on precise methodology using crop surveys and crop loss models have been very useful for defining the severity of various diseases (James et al., 1991). It is hoped that estimates of soybean yield losses to diseases based on precise methodology will be available in the future.

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