

Soybean Disease Loss Estimates for the Southern United States, 1974 to 1994

J. A. Wrather, University of Missouri-Delta Center, P.O. Box 160, Portageville 63873; A. Y. Chambers, University of Tennessee, 605 Airways Blvd., Jackson 38301; J. A. Fox, Mississippi State University, P.O. Box 157, Decatur 39327; W. F. Moore, Mississippi State University (Retired), P.O. Box 5446, Mississippi State 39736; and G. L. Sciubato, Mississippi State University, P.O. Box 197, Stoneville 38776

Soybean has been and continues to be a very valuable crop in the southern United States, including Alabama, Arkansas, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Missouri, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia. Estimated soybean production in these 16 states was 12.71 million metric tons from 8.60 million hectares (467 million bu from 21.25 million acres) in 1974 (5) and 16.18 million metric tons from 7.11 million hectares (595 million bu from 17.57 million acres) in 1994 (7). At \$221 per metric ton (\$6/bu), the estimated value of the 1994 crop was \$3.58 billion.

Unfortunately, soybean yields in the South are reduced each year by disease. Consequently, income derived from the crop is lower than it would be otherwise. For example, the estimated loss due to diseases, including nematodes, in the South during 1994 was \$266 million (1.204 million metric tons \times \$221 per metric ton) (7). This financial loss is important to rural economies and to the economy 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 objectives and budgets.

The Southern Soybean Disease Workers (SSDW) began reporting estimated soybean losses due to disease in the southern United States in 1974. The objective was to provide information on the significance of soybean diseases in the South. The disease loss estimate report was developed from estimates of losses in individual states. The report was distributed at the annual SSDW meetings from 1974 to

1978 and was included with other reports in a proceedings from 1979 to the present. Copies of the proceedings were distributed to about 70 university libraries around the United States. Summaries of the results from 1977 (6), 1985 and 1986 (2), 1987 (3), 1988 to 1991 (4), and 1992 to 1993 (8) have been published. Summaries of the percent loss (Tables 1 and 2) and yield loss (Tables 3 and 4) estimates from 1974 to 1994 are presented here. These are estimates and should not be construed as actual losses.

Methods used to estimate disease losses were field surveys, plant disease diagnostic clinic samples, variety trial data, questionnaires to extension staff, research plots, grower demonstrations, and private crop consultant reports. Most individuals who reported estimates used several of these methods. Actual production figures for each state were supplied by the state crop reporting service. Production losses were based on estimates of yield in the absence of disease. Sixteen states have submitted estimates since 1983. Prior to 1983, some of the 16 states were not included every year. Delaware was omitted in 1974 to 1980, Maryland in 1974 to 1982, Florida in 1976 to 1977 and 1979, Georgia in 1974, Alabama in 1975, and Virginia in 1977. Loss estimates due to stem canker, sudden death syndrome, and charcoal rot were collected beginning when these diseases were recognized as serious problems across the South: stem canker from 1983 to the present, and sudden death syndrome and charcoal rot from 1988 to the present.

Estimates of percent loss and yield loss due to a particular disease varied over years. For example, the percent loss due to root and stem rots, primarily *Phytophthora* root rot, varied from 2.99 to 4.66% during 1974 to 1983 (Table 1) and then declined to 1.08% in 1994 (Table 2). Yield loss due to charcoal rot also varied greatly from year to year. The variation in percent loss and yield loss between years was probably due to yearly environment differences.

Yield losses due to most diseases declined from 1974 to 1994 (Tables 3 and 4). For example, soybean cyst nematode, *Heterodera glycines* Ichinohe, was responsible for losses of 1.034 million metric tons in

1974 and 0.377 million metric tons in 1994. Similarly, the loss due to root and stem rots, root-knot nematodes, stem canker, and some bacterial diseases declined over 21 years. These declines were probably due to the release and planting of high-yielding disease resistant cultivars as well as to advances in disease management technologies. Yield loss due to brown spot, anthracnose, and purple seed stain also declined over the 21 years, although no cultivars resistant to these diseases were purposefully released. The decline in these diseases may be due to inadvertent selection for horizontal resistance to the diseases when lines that looked odd or yielded poorly were discarded. Poor appearance and yield of some lines may have been due to disease. The decline in losses may also be due to farmers adopting cultural practices that impede disease development.

Total yield losses caused by soybean cyst nematode were greater than those caused by any other disease during 1974 to 1994 (Fig. 1). Root and stem rots caused the second greatest yield reduction over the years. The importance of some diseases relative to others, based on yield reduction, changed over the years (Table 5). Soybean cyst nematode caused the greatest yield reduction over most of the years, ranking number 1 in 1974 to 1979, 2 in 1980 to 1984, and 1 in 1985 to 1989 and 1990 to 1994. The rank of root-knot and ectoparasitic nematodes jumped from number 5 in 1974 to 1979 to 3 in 1990 to 1994. The rank of charcoal rot jumped dramatically over the years. Although losses attributable to this disease were unrecorded until 1988, it ranked 2 in 1990 to 1994. The rank of root and stem rots and anthracnose fell over the years. Root and stem rots ranked 2 in 1974 to 1979 and 4 in 1990 to 1994, and anthracnose fell from 3 in 1974 to 1979, to 7 in 1990 to 1994.

Clearly, diseases caused extensive reductions in soybean yield in the southern United States over the last 21 years. They also caused significant yield reductions in the northern United States (1). The reductions in yield declined over the last 21 years in the South. These declines are due

Published as Journal Series 12,295 of the University of Missouri Agriculture Experiment Station.

Corresponding author: J. A. Wrather
E-mail: plantaw@mizzou1.missouri.edu

Accepted for publication 13 June 1995.

Table 1. Estimated percent loss of soybean yields in 16 southern states from 1974 to 1983^a

Diseases	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Anthracnose	3.30	3.68	3.29	2.46	3.23	2.60	3.15	3.08	2.96	1.70
Bacterial diseases	1.13	0.67	0.62	0.45	0.26	0.16	0.06	0.14	0.07	0.63
Brown leaf spot	...	1.33	1.03	0.86	0.90	0.90	0.97	1.40	0.89	0.60
Cercospora purple seed stain	1.90	1.82	1.14	0.94	1.81	1.20	0.87	1.01	0.96	0.76
Charcoal rot	... ^b	...	...	...	...	...	...	...	...	...
Diaporthe pod and stem blight	3.40	3.32	2.27	2.79	1.98	1.68	1.70	1.60	1.91	1.71
Downy mildew	...	0.81	0.60	0.47	0.36	0.21	0.16	0.21	0.18	0.06
Foliar diseases (other)	2.70	0.64	1.03	0.70	1.34	1.15	0.56	0.64	0.31	0.41
Root and stem rots	2.99	2.69	2.61	2.95	3.16	2.50	3.75	3.55	3.75	4.66
Root-knot nematodes and ectoparasites	5.20	3.75	3.61	3.07	1.63	2.79	3.35	2.73	2.11	2.81
Seedling diseases	2.52	1.30	1.83	1.47	1.29	1.66	2.21	1.76	1.10	1.12
Soybean cyst nematode	5.20	3.76	4.85	3.66	3.52	3.70	3.38	2.86	2.29	2.65
Stem canker	...	...	...	...	...	...	...	...	...	1.44
Sudden death syndrome	...	...	...	...	...	...	...	...	...	...
Virus diseases	1.60	0.80	1.56	0.94	0.65	0.43	0.33	0.56	0.48	0.21
Total percent loss ^c	29.94	24.57	24.44	20.76	20.13	18.98	20.49	19.55	17.01	18.16

^a States represented are Alabama, Arkansas, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Missouri, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia. Delaware was omitted in 1974 to 1980, Maryland in 1974 to 1982, Florida in 1976 to 1977 and 1979, Georgia in 1974, Alabama in 1975, and Virginia in 1977.

^b ... = no estimate available.

^c Rounding errors present.

Table 2. Estimated percent loss of soybean yields in 16 southern states from 1984 to 1994^a

Diseases	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Anthracnose	1.12	1.35	1.22	0.91	1.04	1.33	0.88	0.99	0.84	0.79	0.80
Bacterial diseases	0.07	0.02	0.02	0.04	0.04	0.05	0.01	0.05	0.14	0.03	0.03
Brown leaf spot	0.47	0.50	0.36	0.31	0.21	0.32	0.32	0.23	0.33	0.23	0.15
Cercospora purple seed stain	0.51	1.09	0.92	0.38	0.47	0.41	0.24	0.49	0.74	0.35	0.38
Charcoal rot	... ^b	...	...	...	0.98	0.52	0.96	1.12	0.57	1.03	0.65
Diaporthe pod and stem blight	2.00	2.62	2.48	1.33	1.16	1.13	0.54	0.94	0.79	0.59	0.67
Downy mildew	0.07	0.05	0.02	0.01	0.02	0.07	0.05	0.04	0.09	0.52	0.03
Foliar diseases (other)	0.32	0.17	0.24	0.50	0.73	1.57	0.23	0.50	0.41	0.34	0.37
Root and stem rots	4.04	1.92	1.97	2.82	1.82	1.74	1.09	1.18	1.04	1.27	1.08
Root-knot nematodes and ectoparasites	2.35	2.25	1.72	1.91	1.41	2.12	1.81	2.16	1.92	1.77	1.64
Seedling diseases	0.96	0.86	0.75	1.08	1.03	1.09	0.85	0.73	0.43	0.36	0.46
Soybean cyst nematode	2.48	5.77	2.51	2.61	2.68	2.70	2.59	3.08	2.50	2.50	2.34
Stem canker	0.11	0.03	0.88	0.63	0.12	2.02	0.11	0.09	0.11	0.12	0.12
Sudden death syndrome	...	...	...	...	0.15	0.02	0.007	0.17	0.15	0.07	0.11
Virus diseases	0.14	0.17	0.16	0.16	0.22	0.09	0.16	0.26	0.29	0.18	0.26
Total percent loss ^c	14.64	17.61	13.25	12.71	12.09	15.17	9.85	12.10	10.35	9.68	9.05

^a States represented are Alabama, Arkansas, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Missouri, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia. Delaware was omitted in 1974 to 1980, Maryland in 1974 to 1982, Florida in 1976 to 1977 and 1979, Georgia in 1974, Alabama in 1975, and Virginia in 1977.

^b ... = no estimate available.

^c Rounding errors present.

Table 3. Estimated reduction of soybean yields (metric tons × 10⁵) for 16 southern states^a from 1974 to 1983^b

Diseases	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Anthracnose	3.75	3.97	3.40	9.17	6.31	7.64	5.85	6.28	6.85	2.72
Bacterial diseases	0.76	0.70	0.62	0.21	0.51	0.76	0.19	0.29	0.08	0.02
Brown leaf spot	...	1.33	1.19	1.74	1.76	2.91	1.41	2.85	2.77	0.89
Cercospora purple seed stain	2.55	2.20	1.30	4.68	3.56	5.00	1.49	2.06	2.42	1.79
Charcoal rot	... ^c	...	...	...	...	...	...	...	...	...
Diaporthe pod and stem blight	2.80	2.63	3.89	5.71	3.86	4.89	3.45	3.26	4.73	2.82
Downy mildew	...	0.97	0.65	0.46	0.70	0.81	0.27	0.43	0.40	0.14
Foliar diseases (other)	1.76	0.43	0.97	1.44	2.61	4.38	1.79	1.30	0.76	1.08
Root and stem rots	7.72	8.46	4.08	5.76	6.17	8.38	7.51	7.26	6.23	9.93
Root-knot nematodes and ectoparasites	3.34	3.29	4.27	3.83	3.18	4.84	5.06	5.57	4.43	4.57
Seedling diseases	3.23	3.10	2.04	1.65	2.53	4.43	3.18	3.61	2.20	2.06
Soybean cyst nematode	10.34	9.79	5.08	8.68	6.88	10.72	6.47	5.85	5.11	4.10
Stem canker	...	...	...	...	...	...	...	...	...	2.01
Sudden death syndrome	...	...	...	...	...	...	...	...	...	...
Virus diseases	0.89	0.68	1.30	0.92	1.27	1.38	0.59	1.14	1.33	0.46
Total metric tons × 10 ⁵ ^d	37.14	37.55	28.79	44.25	39.34	56.14	37.26	39.90	37.31	32.59

^a States represented are Alabama, Arkansas, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Missouri, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia. Delaware was omitted in 1974 to 1980, Maryland in 1974 to 1982, Florida in 1976 to 1977 and 1979, Georgia in 1974, Alabama in 1975, and Virginia in 1977.

^b The metric ton loss is based on the percent loss of yield had no disease occurred.

^c ... = no estimate available.

^d Rounding errors present.

Table 4. Estimated reduction of soybean yields (metric tons × 10⁵) for 16 southern states^a from 1974 to 1994^b

Diseases	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Anthraxnose	3.48	2.34	1.60	1.68	1.38	1.25	0.78	0.87	0.65	0.62	0.63
Bacterial diseases	0.13	0.05	0.02	0.40	0.10	0.02	0.02	0.19	0.57	0.08	0.04
Brown leaf spot	1.25	1.25	0.76	0.54	0.27	0.65	0.73	0.27	0.57	0.24	0.18
Cercospora purple seed stain	1.46	1.25	0.48	0.54	0.76	0.48	0.24	0.84	0.76	0.27	0.42
Charcoal rot	...	...	...	...	2.47	0.84	1.98	2.88	1.22	2.44	1.84
Diaporthe pod and stem blight	6.53	4.68	5.41	2.42	1.57	0.95	0.76	1.19	0.70	0.54	0.64
Downy mildew	0.19	0.16	0.02	0.01	0.02	0.21	0.02	0.08	0.29	0.05	0.04
Foliar diseases (other)	0.87	0.38	0.40	1.44	1.87	4.13	0.21	1.08	0.54	0.32	0.46
Root and stem rots	6.85	2.88	4.54	4.48	1.33	0.92	1.00	1.14	0.48	1.65	1.08
Root-knot nematodes and ectoparasites	3.53	3.45	3.18	1.52	1.63	2.01	1.08	1.30	1.25	0.92	1.15
Seedling diseases	2.14	1.82	2.01	1.11	0.95	1.22	1.52	0.92	0.48	0.40	0.78
Soybean cyst nematode	6.09	6.55	5.63	4.97	4.38	5.19	3.99	5.46	4.62	3.34	3.77
Stem canker	0.27	0.05	0.43	0.92	0.27	4.59	0.19	0.16	0.21	0.24	0.30
Sudden death syndrome	...	...	...	...	0.57	0.05	0.02	0.62	0.32	0.08	0.30
Virus diseases	0.29	0.32	0.27	0.62	0.57	0.16	0.48	0.21	0.62	0.19	0.41
Total metric tons × 10 ⁵ ^d	33.08	25.18	24.75	20.65	18.14	22.67	13.02	17.21	13.28	11.38	12.04

^a States represented are Alabama, Arkansas, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Missouri, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia. Delaware was omitted in 1974 to 1980, Maryland in 1974 to 1982, Florida in 1976 to 1977 and 1979, Georgia in 1974, Alabama in 1975, and Virginia in 1977.

^b The metric ton loss is based on the percent loss of yield had no disease occurred.

^c ... = no estimate available.

^d Rounding errors present.

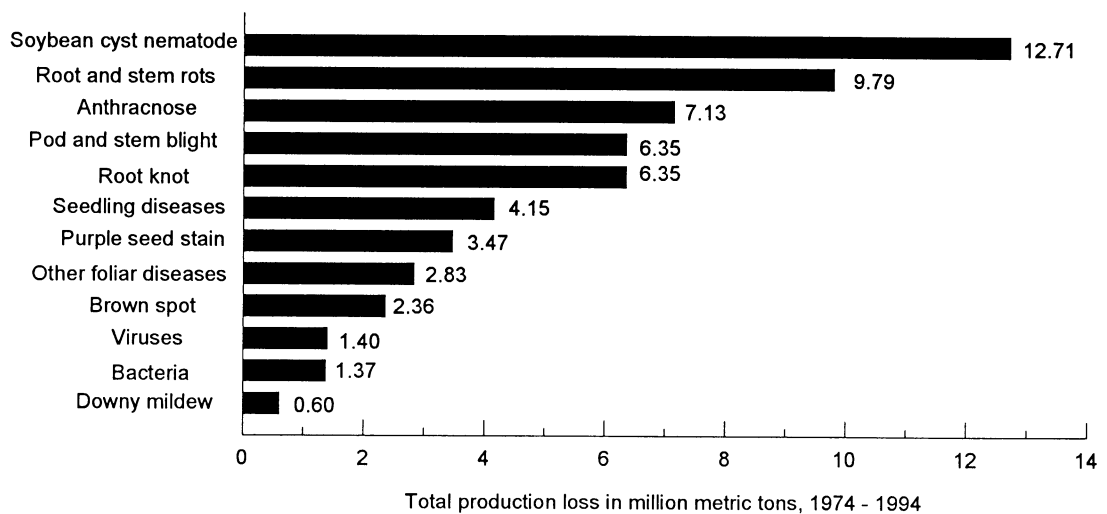


Fig. 1. Summary of southern region soybean disease loss estimates by disease (1990 to 1994). Values are the total production loss for each disease in million metric tons. The states represented are Alabama, Arkansas, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Missouri, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia.

Table 5. Estimated total reduction of soybean yields in metric tons × 10⁵ for 16 southern states from 1974 to 1979, 1980 to 1984, 1985 to 1989, and 1990 to 1994^a

Disease	1974-1979	Ave.	1980-1984	Ave.	1985-1989	Ave.	1990-1994	Ave.
Anthraxnose	34.24	5.71	25.18	5.04	8.25	1.65	3.56	0.71
Bacterial diseases	3.56	0.59	0.71	0.14	0.59	0.12	0.93	0.19
Brown leaf spot	8.93	1.79	9.17	1.83	3.47	0.69	2.01	0.40
Cercospora Purple seed stain	19.29	3.22	9.22	1.84	3.51	0.70	2.56	0.51
Charcoal rot	...	...	...	...	3.31 ^c	1.66	8.54	1.71
Diaporthe pod and stem blight	23.78	3.96	20.79	4.16	15.03	3.01	3.86	0.77
Downy mildew	3.59	0.72	1.43	0.29	0.42	0.08	0.52	0.10
Foliar diseases (other)	11.59	1.93	5.80	1.16	8.22	1.64	2.64	0.53
Root and stem rots	41.02	6.84	37.78	7.56	14.15	2.83	5.39	1.08
Root-knot nematodes and ectoparasites	22.75	3.79	23.16	4.63	11.79	2.36	5.74	1.15
Seedling diseases	16.98	2.83	13.19	2.64	7.11	1.42	4.14	0.83
Soybean cyst nematode	51.49	8.58	27.62	5.52	26.72	5.34	21.20	4.24
Stem canker	...	...	2.28 ^c	1.14	6.26	1.25	1.11	0.22
Sudden death syndrome	...	...	...	...	0.62 ^c	0.31	1.36	0.27
Virus diseases	6.44	1.07	3.81	0.76	1.94	0.39	1.93	0.39
Total metric tons × 10 ⁵ ^d	243.66		180.14		111.39		65.49	

^a States represented are Alabama, Arkansas, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Missouri, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia. Delaware was omitted in 1974 to 1980, Maryland in 1974 to 1982, Florida in 1976 to 1977 and 1979, Georgia in 1974, Alabama in 1975, and Virginia in 1977.

^b ... = no estimate available.

^c Represents 2 years of data only, loss estimates for stem canker for 1983 to 1984, estimates for sudden death syndrome and charcoal rot for 1988 to 1989.

^d Rounding errors present.

largely to the success of land-grant university agriculture research and extension programs. Plant pathologists and agronomists at these universities developed most of the disease resistant cultivars and alternative disease management strategies. Farmer knowledge of these advances is due in great part to university extension programs. The benefit of agriculture research and extension is clearly evident. Yet even with the advances made to control disease through research, the value of the yield reduction due to disease was \$266.1 million in 1995. Soybean diseases will continue to be a problem unless research and extension efforts are expanded to provide more effective preventive and

therapeutic disease management strategies and systems to producers.

ACKNOWLEDGMENT

We gratefully acknowledge the efforts of Joyce Elrod, senior research technician, on this project.

LITERATURE CITED

1. Doupnik, B., Jr. 1993. Soybean production and disease loss estimates for north central United States from 1989 to 1991. *Plant Dis.* 77:1170-1171.
2. Mulrooney, R. P. 1988. Soybean disease loss estimate for southern United States in 1985 and 1986. *Plant Dis.* 72:364-365.
3. Mulrooney, R. P. 1988. Soybean disease loss estimate for southern United States in 1987. *Plant Dis.* 72:915.
4. Sciumbato, G. L. 1993. Soybean disease loss

estimates for the southern United States during 1988-1991. *Plant Dis.* 77:954-956.

5. United States Department of Agriculture Economics and Statistics Service Crop Reporting Board. 1979. Field crops: Estimates by states, 1974-78 acreage yield production. U.S. Dep. Agric. Econ. Stat. Serv. Crop Rep. Board. Stat. Bull. 646.
6. Whitney, G. 1978. Southern states soybean disease loss estimates-1977. *Plant Dis. Rep.* 62:1078-1079.
7. Wrather, J. A. 1995. Soybean disease loss estimate for the southern United States during 1994. *Proc. South. Soybean Dis. Workers* 1995:1-6.
8. Wrather, J. A., and Sciumbato, G. L. 1995. Soybean disease loss estimates for the southern United States during 1992 and 1993. *Plant Dis.* 79:84-85.