

# Bibliography of Estimated Crop Losses in the United States Due to Plant-parasitic Nematodes<sup>1</sup>

SOCIETY OF NEMATOLOGISTS CROP LOSS ASSESSMENT COMMITTEE<sup>2</sup>

*Abstract:* Recent published estimates of crop losses due to plant-parasitic nematodes are summarized by crop and state. Estimates are systematically reported from major producing states for cotton, peanut, tobacco, and soybean. Only scattered reports were available for nematode losses to other field crops or to vegetables and ornamentals. Among the states, North Carolina and Michigan were most consistent in reporting loss estimates from the widest range of crops.

*Key words:* crop loss assessment, corn, cotton, field crop, ornamental, peanut, soybean, tobacco, vegetables.

Reliable crop loss estimates are important for establishing research, extension, and budget priorities (6). Unfortunately, obtaining such estimates is difficult (5,8). Only one compilation of nematode loss estimates for the United States has been published (7), and since its publication 15 years ago, little or no nematode crop loss information has been compiled at the national level. At the state level, progress has been variable. For example, there are annual updates on nematode losses for all crops in North Carolina (16,17) and a recent update in Michigan (3), but in other states there are only regional annual estimates for groups of nematodes on such major crops as cotton (12), peanut (30,31), soybean (21,22), and tobacco (1). For many states, there is no new information. The original compilation of nematode losses within the United States (7) relied heavily on the opinions of unidentified experts, and the results of a new, similar survey soliciting expert opinion will be published soon (29). The purpose of this bibliography is to document losses more fully using current, publicly available literature on nematode-induced crop loss estimates.

To assemble this bibliography, members

of the Crop Loss Assessment Committee for the Society of Nematologists contacted one or more scientists in all 50 states, with up to 30 contacts made in some states. Because of the extent to which the data sources cited differ, caution is advised in their comparison and interpretation. In many cases, the original literature describes the methods by which estimates were derived; however, methods vary and so does reliability. Origins of the estimates range from educated guesses to expert opinion (3) to detailed surveys (2,26). In one instance, detailed quarantine records are believed to provide a highly accurate estimate (4), and among estimates from North Carolina, a level of reliability is specified for each entry (16,17). The estimates reported here are usually expressed as percentage loss in production for the year of estimation. No consideration is given to costs of chemical control; however, the sources themselves (2,16,17) sometimes do provide information on control costs as an additional component of crop loss. When estimates are provided annually by the same source, only the most recent estimate is usually included; multiple estimates for the same state are included only when they were obtained from different sources. In most instances, figures were published in the original sources using the English system for weights and measurements. These were converted to the metric system using appropriate conversion factors.

Recent loss estimates for cotton, peanut, tobacco, and soybean are summarized (Tables 1-4) and, for the most part, are com-

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The responses of the many scientists who contributed information to this work are gratefully acknowledged.

TABLE 1. Estimated production losses in major cotton-producing states due to nematode damage.

| State          | Production (bales) | Estimated loss (%) | Date of estimate | Reference |
|----------------|--------------------|--------------------|------------------|-----------|
| Alabama        | 549,451            | 2.0                | 1985             | 12        |
| Arizona        | 1,252,222          | Trace              | 1985             | 12        |
| Arkansas       | 708,995            | 0.5                | 1985             | 12        |
| California     | 3,380,589          | 1.3                | 1985             | 12        |
| Georgia        | 456,675            | 3.5                | 1985             | 12        |
| Louisiana      | 947,368            | 5.0                | 1985             | 12        |
| Mississippi    | 1,954,023          | 1.8                | 1985             | 12        |
| Missouri       | 194,942            | Trace              | 1985             | 12        |
| New Mexico     | 94,163             | 3.0                | 1985             | 12        |
| North Carolina | 118,435            | 1.1†               | 1985             | 12,16     |
| Oklahoma       | 273,396            | 0.5                | 1985             | 12        |
| South Carolina | 200,000            | 2.5                | 1985             | 12        |
| Tennessee      | 412,148            | 0.2                | 1985             | 12        |
| Texas          | 4,591,729          | 1.9                | 1985             | 12        |
| Texas‡         | 839,800            | 10.2               | 1984             | 26        |
| Texas§         | 1,800,000          | 9.8                | 1984             | 26        |
| U.S. Total     | 15,981,136         | 1.6                | 1985             | 12        |

† Estimated 1.0% loss due to *Meloidogyne incognita* and 0.1% to *Hoplolaimus columbus* (16).

‡ Survey of six counties in southern high plains of Texas.

§ Projected for region of 16 counties in southern high plains of Texas.

posed of annual estimates from the corresponding commodity groups, mostly from southern states (1,12,22,31). Ranges in estimated losses for nematode and non-nematode scenarios from pesticide impact assessment studies (34–38) are summarized

for corn and soybean (Table 5), although estimates from these studies generally appear somewhat higher than those recently reported by the individual states for soybean (Table 4) and corn (Table 6). Loss estimates for other field crops were available from only a few states (Table 6). Although nematicide trials alone are insufficient to generalize losses on a statewide basis, results from such tests in Kansas (15) and Iowa (25) are included because of the relatively large number of test sites in each state. Estimated nematode losses in vegetables (Table 7) are composed mainly of results from North Carolina and Michigan but are absent from a majority of vegetable-producing states. Information on fruit crops and ornamentals (Table 8) was sparse in most cases.

In addition to the tabular data, losses in terms of dollar value of production have been estimated from Michigan (3) as 5% in bedding flowers, cut flowers, and potted flowers; 2% in vegetable transplants; and 1% in forest trees. Estimated losses in ornamental production from North Carolina (16) are 0.50% in azalea from *Tylenchorhynchus claytoni*, 20.0% in American boxwood from *Pratylenchus vulnus*, 1.0% in Japanese boxwood from *Meloidogyne* spp., 1.0% in rhododendron from *T. claytoni*, and 6.0%

TABLE 2. Estimated production losses in major peanut-producing states for several nematode species.

| State          | Hectares harvested | Production (million kg) | Estimated loss by nematode species (%)† |     |      |      |              | Date of estimate | Reference |
|----------------|--------------------|-------------------------|---|-----|------|------|--------------|------------------|-----------|
|                |                    |                         | BL                                      | MA  | MH   | P    | Combina-tion |                  |           |
| Alabama        | 93,100             | 302.6                   | —                                       | 5.4 | —    | 0.1  | 5.5          | 1984             | 31        |
| Arkansas       | 1,170              | 2.6                     | —                                       | 1.0 | —    | —    | 1.0          | 1984             | 31        |
| Florida        | 22,700             | 72.6                    | —                                       | —   | —    | —    | 5.0          | 1983             | 6,30      |
| Georgia        | 257,000            | 980.9                   | —                                       | 2.7 | 0.3  | —    | 3.0          | 1984             | 31        |
| Louisiana      | 355                | 0.9                     | —                                       | —   | —    | —    | 5.0          | 1983             | 30        |
| North Carolina | 62,700             | 204.1                   | —                                       | —   | 0.25 | 0.5  | 1.25‡        | 1984             | 17,31     |
| North Carolina | 62,300             | 205.0                   | 0.38                                    | —   | 4.70 | 0.25 | 5.58§        | 1985             | 16        |
| Oklahoma       | 34,600             | 77.1                    | 0.25                                    | 0.5 | 2.50 | —    | 3.25         | 1984             | 31        |
| South Carolina | 5,670              | 11.4                    | —                                       | —   | —    | —    | 3.0          | 1984             | 31        |
| Texas          | 90,200             | 154.2                   | —                                       | 3.0 | —    | 2.0  | 5.0          | 1984             | 9,31      |
| Virginia       | 39,000             | 168.3                   | 0.5                                     | —   | 2.5  | Tr   | 3.0          | 1984             | 31        |
| U.S. Total     | 556,000            | 1,494.8                 | —                                       | —   | —    | —    | —            | 1983             | 39        |

† BL = *Belonolaimus longicaudatus*. MA = *Meloidogyne arenaria*. MH = *M. hapla*. P = *Pratylenchus* spp. Dashes (—) indicate no data reported.

‡ Includes estimated 0.5% loss to *Criconebella ornata*.

§ Includes estimated 0.25% loss to *C. ornata*.

TABLE 3. Estimated production losses in major tobacco producing states for several nematode species.

| State          | Tobacco type    | Hectares | Estimated loss by nematode species (%)† |       |       |             | Date of estimate | Reference |
|----------------|-----------------|----------|---|-------|-------|-------------|------------------|-----------|
|                |                 |          | GS/GT                                   | M     | P     | Combination |                  |           |
| Connecticut    | Broadleaf       | 364      | 0.30                                    | —     | 0.10  | 0.40        | 1984             | 1         |
| Connecticut    | Cigar shade     | 380      | 0.30                                    | —     | —     | 0.30        | 1984             | 1         |
| Florida        | Flue-cured      | 3,040    | —                                       | 2.0   | —     | 2.0         | 1984             | 1         |
| Florida        | Flue-cured      | —        | —                                       | 3.0   | —     | 3.0         | 1983             | 6         |
| Georgia        | Flue-cured      | 16,000   | —                                       | —     | —     | 4.5         | 1984             | 1         |
| Georgia        | Flue-cured      | —        | —                                       | 3.5   | 0.04  | 3.54        | 1985             | 13        |
| Maryland       | Maryland        | 9,710    | —                                       | 0.10  | Trace | 0.10        | 1984             | 1         |
| Massachusetts  | Cigar shade     | 111      | 0.30                                    | —     | —     | 0.30        | 1984             | 1         |
| Massachusetts  | Havana seed     | 61       | —                                       | —     | 0.10  | 0.10        | 1984             | 1         |
| North Carolina | Burley          | 4,010    | —                                       | 0.18  | —     | 0.18        | 1984             | 1,17      |
| North Carolina | Burley          | 3,520    | —                                       | 0.10  | —     | 0.10        | 1985             | 16        |
| North Carolina | Flue-cured      | 114,000  | —                                       | 1.0   | —     | 1.03        | 1984             | 1,17      |
| North Carolina | Flue-cured      | 97,900   | —                                       | 0.88  | —     | 0.91        | 1985             | 16        |
| South Carolina | Flue-cured      | 19,800   | —                                       | 1.27  | 0.04  | 1.32        | 1984             | 1         |
| Tennessee      | Burley          | 24,300   | —                                       | 0.05  | 0.05  | 0.10        | 1984             | 1         |
| Virginia       | Dark flue-cured | 2,020    | 0.01                                    | 0.01  | 0.01  | 0.03        | 1984             | 1         |
| Virginia       | Flue-cured      | 15,400   | 0.05                                    | 0.05  | 0.01  | 0.11        | 1984             | 1         |
| West Virginia  | Burley          | 1,300    | —                                       | Trace | Trace | Trace       | 1984             | 1         |
| U.S. Total     | All types       | 319,531  | —                                       | —     | —     | 0.91        | 1984             | 1,39      |

† GS = *Globodera solanacearum*. GT = *G. tabacum*. M = *Meloidogyne* spp. P = *Pratylenchus* spp. Dashes (—) indicate no data reported.

TABLE 4. Estimated production losses for soybean due to nematode damage.

| State                      | Hectares harvested (millions) | Production (million hl) | Estimated loss by nematode species (%)† |       | Date of estimate | Reference |
|----------------------------|-------------------------------|-------------------------|---|-------|------------------|-----------|
|                            |                               |                         | HG                                      | O     |                  |           |
| Alabama                    | 0.54                          | 10.7                    | 4.0                                     | 3.5   | 1985             | 22        |
| Arkansas                   | 1.84                          | 41.6                    | 6.7                                     | 1.5   | 1985             | 22        |
| Delaware                   | 0.11                          | 2.8                     | 3.0                                     | 0.5   | 1985             | 22        |
| Florida                    | 0.17                          | 3.8                     | 5.5                                     | 5.1   | 1985             | 22        |
| Florida                    | —                             | 3.6                     | 1.0                                     | 16.0‡ | 1983             | 6         |
| Georgia                    | 0.79                          | 17.2                    | 1.8                                     | 4.8   | 1985             | 22        |
| Illinois                   | 3.60                          | 2.5§                    | 6.0                                     | —     | 1983             | 24        |
| Illinois                   | —                             | —                       | 5.0                                     | —     | 1983             | 28        |
| Illinois (southern)        | —                             | —                       | 15.0                                    | —     | 1983             | 28        |
| Kentucky                   | 0.60                          | 16.6                    | 2.5                                     | 0.0   | 1985             | 22        |
| Louisiana                  | 1.10                          | 18.2                    | 3.0                                     | 3.0   | 1985             | 22        |
| Maryland                   | 0.17                          | 4.8                     | 2.0                                     | 1.0   | 1985             | 22        |
| Michigan                   | 0.44                          | 11.6                    | —                                       | 4.0   | 1986             | 3         |
| Mississippi                | 1.27                          | 29.4                    | 1.1                                     | 0.3   | 1985             | 22        |
| Missouri (S.E. 8 counties) | 0.41                          | 11.6                    | 4.0                                     | 0.0   | 1985             | 22        |
| North Carolina             | 0.69                          | 13.8                    | 6.0                                     | 2.3   | 1985             | 16,22     |
| Oklahoma                   | 0.07                          | 1.4                     | 0.5                                     | 0.0   | 1985             | 22        |
| South Carolina             | 0.75                          | 15.0                    | 7.0                                     | 8.0   | 1985             | 22        |
| Tennessee                  | 0.68                          | 18.3                    | 2.5                                     | 0.5   | 1985             | 22        |
| Texas                      | 0.16                          | 3.5                     | 0.0                                     | 0.01  | 1985             | 22        |
| Virginia                   | 0.30                          | 7.4                     | 4.0                                     | 1.0   | 1985             | 22        |
| U.S. Total                 | 24.92                         | 739.5                   | 5.8                                     | 2.2   | 1985             | 22        |

† HG = *Heterodera glycines*. O = other nematodes (mostly *Meloidogyne* spp.) or combination of all species (Michigan). Dashes (—) indicate no data reported.

‡ Estimated 15% loss to *Meloidogyne* spp. and 1% to other genera.

§ Metric tons (millions).

|| Estimated 1.5% loss to *Meloidogyne* spp., 0.50% to *Pratylenchus* spp., 0.20% to *Belonolaimus longicaudatus*, and 0.10% to *Hoplotaimus columbus*.

TABLE 5. Estimated nematode losses to field corn and soybeans, with and without current level of nematicide usage.

| State               | Estimated loss in production due to nematodes (%)† |                                       |                                |                                       | Reference |
|---------------------|--|---------------------------------------|--------------------------------|---------------------------------------|-----------|
|                     | Corn   |                                       | Soybeans                       |                                       |           |
|                     | Current, with nematicide usage                     | Anticipated, without nematicide usage | Current, with nematicide usage | Anticipated, without nematicide usage |           |
| Alabama             | 0.2  | 0.5                                   | 9.6                            | 10.9                                  | 35        |
| Arkansas            | 0.5  | 5.0                                   | 6.9                            | 8.0                                   | 38        |
| Georgia             | 7.0  | 7.8                                   | 6.9                            | 11.0                                  | 35        |
| Illinois            | —  | —                                     | 1.7                            | 1.7                                   | 37        |
| Indiana             | 1.1  | 2.3                                   | 8.9                            | 14.0                                  | 37        |
| Iowa                | 4.2  | 5.5                                   | —                              | —                                     | 37        |
| Kentucky            | 1.3  | 10.3                                  | 8.0                            | 8.4                                   | 38        |
| Louisiana           | —  | —                                     | 6.0                            | 15.0                                  | 38        |
| Maryland & Delaware | —  | —                                     | 1.4                            | 1.9                                   | 36        |
| Mississippi         | 2.8  | 3.3                                   | —                              | —                                     | 38        |
| New Jersey          | 0.0  | <0.1                                  | 0.0                            | <0.1                                  | 36        |
| North Carolina      | 5.1  | 7.8                                   | 5.5                            | 12.3                                  | 35        |
| South Carolina      | 7.0  | 22.8                                  | 2.7                            | 7.0                                   | 35        |
| Tennessee           | 0.7  | 3.3                                   | 3.3                            | 4.3                                   | 38        |
| Virginia            | 1.3  | 6.5                                   | 2.1                            | 8.0                                   | 36        |
| Wisconsin           | 1.2  | 1.5                                   | —                              | —                                     | 34        |

† Current estimates represent estimated losses with current (1985) utilization of nematicides; anticipated estimates indicate anticipated losses if management practices were removed. Dashes (—) indicate no data reported.

in Japanese holly (2.0% from *Criconebella xenoplax*, 1.0% from *Meloidogyne* spp., and 3.0% from *T. claytoni*). Losses of 5% due to nematodes are estimated for home gardens in North Carolina (16). Across the southern United States, there are an esti-

mated 3.5 million home gardens; formerly, an estimated 250,000 of these were treated with DBCP (33).

Losses resulting from quarantines for nematodes are probably also considerable and are in addition to those incurred dur-

TABLE 6. Estimated production losses due to nematodes on selected field crops.

| Crop          | State          | Hectares harvested | Production    | Estimated loss (%) | Nema-todes† | Date of estimate | Refer-ence |    |
|---------------|----------------|--------------------|---------------|--------------------|-------------|------------------|------------|----|
| Alfalfa       | California     | 437,000            | 6,370,000 mt  | 2.0–3.0            | —           | 1975             | 18         |    |
|               | North Carolina | 18,200             | 106,000 mt    | 1.0                | M           | 1985             | 16         |    |
|               | Wyoming        | —                  | —             | 2.5–36.3‡          | DD          | 1980             | 14         |    |
| Clover, white | North Carolina | 194,000            | 689,000 mt    | 5.0                | M           | 1985             | 16         |    |
|               | Corn, field    | Kansas             | 608,000       | —                  | 0.0§        | —                | 1980       | 15 |
| Wheat         | Iowa           | —                  | —             | 21.0               | —           | 1973–76          | 25         |    |
|               | Michigan       | 1,010,000          | 79,300,000 hl | 5.0                | —           | 1986             | 3          |    |
|               | North Carolina | 658,000            | 45,200,000 hl | 2.5                | —           | 1985             | 16         |    |
|               | Dry bean       | Michigan           | 202,000       | 272,000 mt         | 8.0         | —                | 1986       | 3  |
|               | Hay            | Michigan           | 708,000       | 4,920,000 mt       | 1.0         | —                | 1986       | 3  |
| Mint          | Michigan       | 1,540              | 55 mt         | 20.0               | —           | 1986             | 3          |    |
| Oats          | Michigan       | 14,200             | 678,000 hl    | 4.0                | —           | 1986             | 3          |    |
| Rye           | Michigan       | 56,600             | 1,430,000 hl  | 3.0                | —           | 1986             | 3          |    |
| Sugarbeet     | Michigan       | 40,500             | 1,720,000 mt  | 5.0                | —           | 1986             | 3          |    |
| Wheat         | Michigan       | 324,000            | 14,100,000 hl | 4.0                | —           | 1986             | 3          |    |

† M = *Meloidogyne* spp. DD = *Ditylenchus dipsaci*. Dashes (—) indicate no data reported or nematode species not given.

‡ Range in % hectareage infested.

§ No losses found in nematicide tests in western Kansas.

|| Average yield increase from 16 nematicide tests in 12 locations.

TABLE 7. Estimated production losses due to nematodes on vegetable crops.

| Crop                | State          | Hectares harvested | Production       | Estimated loss (%) | Nema-todes† | Date of estimate | Refer-ence |
|---------------------|----------------|--------------------|------------------|--------------------|-------------|------------------|------------|
| Asparagus           | Michigan       | 8,090              | 10,200 mt        | 0.0                | —           | 1986             | 3          |
| Bean, lima          | North Carolina | 607                | 63,400 hl        | 7.0                | M           | 1985             | 16         |
| Bean, snap          | Michigan       | 6,070              | 36,300 mt        | 4.0                | —           | 1986             | 3          |
|                     | North Carolina | 2,830              | 9,520 mt         | 7.5                | M           | 1985             | 16         |
|                     | North Carolina | —                  | —                | 0.2                | HG          | 1985             | 16         |
| Cabbage             | North Carolina | 4,710              | 141,000 mt       | 0.05               | —           | 1985             | 16         |
| Cantaloupe          | North Carolina | 1,280              | 6,919,115 melons | 10.5               | M           | 1985             | 16         |
| Carrot              | Michigan       | 2,910              | 81,600 mt        | 15.0               | —           | 1986             | 3          |
|                     | North Carolina | 28                 | 962 mt           | 2.5                | M           | 1985             | 16         |
| Cauliflower         | Michigan       | 607                | 3,860 mt         | 1.0                | —           | 1986             | 3          |
| Celery              | Michigan       | 1,420              | 68,000 mt        | 6.0                | —           | 1986             | 3          |
| Corn, sweet         | Michigan       | 5,260              | 36,300 mt        | 6.0                | —           | 1986             | 3          |
|                     | North Carolina | 4,640              | 2,116,717 crates | 2.0                | PM          | 1985             | 16         |
| Cucumber‡           | Michigan       | 7,280              | 90,700 mt        | 1.0                | —           | 1986             | 3          |
|                     | North Carolina | 14,000             | 2,620,000 hl     | 12.0               | M           | 1985             | 16         |
| Eggplant            | North Carolina | 247                | 64,600 hl        | 3.5                | M           | 1985             | 16         |
| Greens, leafy       | North Carolina | 1,580              | 18,300 mt        | 2.0                | M           | 1985             | 16         |
| Lettuce             | Michigan       | 486                | 11,300 mt        | 10.0               | —           | 1986             | 3          |
| Mushrooms           | Michigan       | 46                 | 9,070 mt         | 5.0                | —           | 1986             | 3          |
| Okra                | North Carolina | 263                | 35,300 hl        | 5.2                | M           | 1985             | 16         |
| Onion               | Michigan       | 3,440              | 113,000 mt       | 5.0                | —           | 1986             | 3          |
|                     | North Carolina | 121                | —                | 0.2                | —           | 1985             | 16         |
| Pea, green          | North Carolina | 40                 | 113 mt           | 0.5                | —           | 1985             | 16         |
| Pea, southern       | North Carolina | 1,170              | 114,000 hl       | 3.5                | M           | 1985             | 16         |
| Pepper, green       | North Carolina | 4,490              | 599,000 hl       | 7.0                | M           | 1985             | 16         |
| Potato              | Michigan       | 22,200             | 624,000 mt       | 12.0               | —           | 1986             | 3          |
|                     | Michigan       | —                  | —                | 4.0                | —           | 1982             | 2          |
|                     | North Carolina | 6,600              | 117,000 mt       | 1.2                | PP          | 1985             | 16         |
| Pumpkin             | North Carolina | 1,210              | 7,500,000 melons | 5.2                | M           | 1985             | 16         |
| Squash              | North Carolina | 1,970              | 381,000 hl       | 3.5                | M           | 1985             | 16         |
| Sweetpotato         | North Carolina | 16,200             | 254,000 mt       | 5.2                | M           | 1985             | 16         |
| Tomato, fresh mkt.  | Michigan       | 1,380              | 18,100 mt        | 2.0                | —           | 1986             | 3          |
|                     | North Carolina | 664                | 2,050,000 ctn    | 2.0                | M           | 1985             | 16         |
| Tomato, greenhouse  | North Carolina | 4                  | 651 mt           | 3.0                | M           | 1985             | 16         |
| Tomato, processing  | Michigan       | 3,440              | 159,000 mt       | 2.0                | —           | 1986             | 3          |
|                     | North Carolina | 202                | 5,220 mt         | 2.0                | M           | 1985             | 16         |
| Tomato, transplants | Georgia        | 1,140              | —                | 2.3                | —           | 1985             | 4          |
| Watermelon          | North Carolina | 4,170              | 6,030,010 melons | 10.0               | M           | 1985             | 16         |

† M = *Meloidogyne* spp. HG = *Heterodera glycines*. PM = *Paratrichodorus minor*. PP = *Pratylenchus penetrans*. Dashes (—) indicate data not reported or nematode species not given.

‡ Fresh market plus processing.

ing production. Losses of tomato transplants in Georgia have been documented (4), and presumably, losses of this kind would occur whenever shipping quarantines are imposed between states. On a national level, substantial losses were incurred by European rejection of shipments of pine wood chips from the United States because of contamination with *Bursaphelenchus xylophilus* (23).

Better loss estimates are needed for most

crops, but good estimates are costly in time and money. Detailed surveys and accurate damage threshold relationships are essential for strengthening expert opinion for generating loss estimates, which is currently the most feasible way to approach this vast and complex topic. Costs of nematode management practices (2,16) and quarantine and regulatory penalties also should be included more often in generating loss information in the future.

TABLE 8. Estimated production losses due to nematodes on fruits, roses, and turf.

| Crop              | State          | Hectares harvested | Production        | Estimated loss (%) | Nematodes† | Date of estimate | Reference |
|-------------------|----------------|--------------------|-------------------|--------------------|------------|------------------|-----------|
| Apples            | Michigan       | 18,200             | 340,000 mt        | 8.0                | —          | 1986             | 3         |
| Cherries          | Michigan       | 15,200             | 90,700 mt         | 10.0               | —          | 1986             | 3         |
| Grapes            | California     | 32,400             | 862,000,000 mt    | 20.0               | —          | 1986             | 27        |
|                   | Michigan       | 5,060              | 45,400 mt         | 12.0               | —          | 1986             | 3         |
| Grapefruit        | Texas          | 17,800             | 406,000 mt        | 54.0               | TS         | 1982             | 10,32     |
| Peaches           | Michigan       | 1,820              | 20,400 mt         | 12.0               | —          | 1986             | 3         |
|                   | North Carolina | 20                 | 7,050 hl          | 0.01               | M          | 1985             | 16        |
|                   | South Carolina | 40,020             | —                 | 5.8                | CX         | 1981–84          | 19,20     |
| Pear              | Michigan       | 648                | 9,070 mt          | 3.0                | —          | 1986             | 3         |
| Plum/prunes       | Michigan       | 1,130              | 10,900 mt         | 10.0               | —          | 1986             | 3         |
| Strawberry        | Michigan       | —                  | —                 | 15.0               | —          | 1986             | 3         |
| Rose bushes       | Texas          | —                  | 14,000,000 plants | 0–10               | —          | 1984             | 11        |
| Turf, golf course | North Carolina | 16,200             | —                 | 1.00               | BL         | 1985             | 16        |
| Turf, lawn        | North Carolina | 115,000            | —                 | 0.50               | BL         | 1985             | 16        |
| Turf, other       | North Carolina | 152,000            | —                 | 0.50               | BL         | 1985             | 16        |

† TS = *Tylenchulus semipenetrans*. M = *Meloidogyne* spp. BL = *Belonolaimus longicaudatus*. CS = *Criconebella xenoplax*. Dashes (—) indicate no data reported or nematode species not given.

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