## Estimated Losses Due to Nematodes in California:

<table>
<thead>
<tr>
<th>Crop</th>
<th>Estimated Acres</th>
<th>Farm $ Value</th>
<th>$ Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citrus</td>
<td>15</td>
<td>326,660</td>
<td>1,181,597,142</td>
</tr>
<tr>
<td>Cotton</td>
<td>5</td>
<td>1,280,071</td>
<td>1,008,713,000</td>
</tr>
<tr>
<td>Potatoes</td>
<td>10</td>
<td>51,977</td>
<td>157,981,100</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>15</td>
<td>252,968</td>
<td>477,111,728</td>
</tr>
</tbody>
</table>

(Note: % Loss estimates are from the USDA for U.S. as a whole)

## Estimated Losses Due to Nematodes in California:

<table>
<thead>
<tr>
<th>Crop</th>
<th>Acres</th>
<th>Farm $ Value</th>
<th>$ Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Crops</td>
<td>6</td>
<td>1,091,166</td>
<td>2,791,345,185</td>
</tr>
<tr>
<td>Fruits &amp; Nuts</td>
<td>12</td>
<td>1,883,204</td>
<td>4,026,765,267</td>
</tr>
<tr>
<td>Vegetables</td>
<td>11</td>
<td>6,402,613</td>
<td>2,947,240,705</td>
</tr>
<tr>
<td>Ornamentals</td>
<td>10</td>
<td>1,185,876,000</td>
<td>118,587,800</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>1,085,682,045</td>
</tr>
</tbody>
</table>

Total California Cash Farm Value = $16,838,870,235

(Note: % Loss estimates are from the society of nematologists for U.S. as a whole)

## In 1991, 18.7 Million Pounds of Methyl Bromide Were Used in California:

<table>
<thead>
<tr>
<th>Use</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strawberry Fields</td>
<td>24</td>
</tr>
<tr>
<td>Structural Fumigation</td>
<td>18</td>
</tr>
<tr>
<td>Greenhouse Soil - Nursery Crops</td>
<td>11</td>
</tr>
<tr>
<td>Grapes - Preplant &amp; Postharvest</td>
<td>10</td>
</tr>
<tr>
<td>Stone Fruits - Preplant &amp; Postharvest</td>
<td>8</td>
</tr>
<tr>
<td>Carrots</td>
<td>7</td>
</tr>
</tbody>
</table>

In 1991, 18.7 million pounds of methyl bromide were used in California:

Use

Percent
1991 California growers' economic losses from nematode damage on the nine crops with greatest historic usage of 1,3-D = $106.8 million (Landels, 1992)

Millions of Dollars Lost
ROOT-KNOT NEMATODE (RKN)
Tomatoes 13.4
Cotton 9.8
Sweet potatoes 7.5
Potatoes 0.4
Carrots 15.1
SUGARBEET CYST & (RKN)
Broccoli 15.7
Cauliflower 7.9
Sugar beets 6.1
Brussel sprouts 0.7

THE MOST COMMON GENERA OF PLANT PARASITIC NEMATODES IN CALIFORNIA:

<table>
<thead>
<tr>
<th>ECTOPARASITES</th>
<th>MIGRATORY ENDOPARASITES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trichodorus - Stubby Root*</td>
<td>Pratylenchus - Lesion</td>
</tr>
<tr>
<td>Xiphinema - Dagger*</td>
<td>Ditylenchus - Stem &amp; Bulb</td>
</tr>
<tr>
<td>Longidorus - Needle*</td>
<td>Aphelenchoides - Foliar</td>
</tr>
<tr>
<td>Helicotylenchus - Spiral</td>
<td></td>
</tr>
<tr>
<td>Mesocricnema - Ring</td>
<td></td>
</tr>
<tr>
<td>Paratylenchus - Pin</td>
<td></td>
</tr>
<tr>
<td>Hemicyclophora - Sheath</td>
<td></td>
</tr>
</tbody>
</table>

SOME GENERA CONTAIN SEVERAL IMPORTANT SPECIES
*Vectors of plant viruses

SYMPTOMS & SIGNS OF NEMATODE DAMAGE:

VISIBLE ABOVE GROUND -
Stunting
Chlorosis
Mid-day Wilting
Leaf Drop
Small Fruit
Yellowing
Curling and Twisting of Leaves and Stems
Patches of Poor Growth in Field
Lack of Response to Treatment
Premature Maturity
Delayed Maturity
Reduced Yield
"Unthriftiness"

ROOT SYMPTOMS -
Galls or Swellings
Stubby Roots
Lesions or Dark Spots
Stunting
"Dirty Roots"

TRICHODORUS OR PARATRICHODORUS (STUBBY ROOT NEMATODE) ON ONIONS AND CHIVES
DAGGER NEMATODE (XIPHIINEMA INDEX) ON ROSE

DAGGER NEMATODE (X. DIVERSICAUDATUM) ON ROSE

DAGGER NEMATODE (XIPHIINEMA INDEX) ROOT GALLS

VECTORS GRAPEVINE FANLEAF VIRUS

VIRUS SYMPTOMS:
LEAF MALFORMATIONS
YELLOW MOSAIC OF LEAVES
VEINBANDING
DAGGER NEMATODE (XIPHINEMA INDEX) ON GRAPE

VIRUS SYMPTOMS:
- SMALL BUNCHES
- POOR FRUIT SET
- IRREGULAR RIPENING

XIPHINEMA INDEX - VECTORS
GRAPEVINE FANLEAF VIRUS

THE VIRUS IS:
- BOUND TO ESOPHAGEAL LINING
- LOST AT MOLT
- DOES NOT PASS THRU EGG STAGE
- DOES NOT REPLICATE IN NEMATODE

LONGIDORUS AFRICANUS (NEEDLE NEMATODE) ON LETTUCE
RING NEMATODE (MESOCRICONEMA XENOPLAX)

RING NEMATODE - BACTERIAL CANKER COMPLEX
Susceptible - almond, apricot, cherry, kiwi, nectarine, peach, pear, plum, prune.
Bacteria (*Pseudomonas syringae*) is usually present in orchards.
Ring nematode stresses trees.
Stress predisposes trees to bacterial canker.
Usually associated with younger trees.
Usually associated with sandy soils.

TURFGRASS NURSERY

SHEATH NEMATODE (HEMICYCLIOPHORA ARENARIA)

RING NEMATODE (MESOCRICONEMA XENOPLAX) ON GRAPE

LESION NEMATODE (PRATYLENCHUS VULNUS)
LESION NEMATODE (PRATYLENCHUS PENETRANS)
EASTER LILY
BEGONIA
BEFORE FUMIGATION
AFTER FUMIGATION

STEM AND BULB NEMATODE (DITYLENCHUS DIPSACI)

STEM AND BULB NEMATODE (DITYLENCHUS DIPSACI) ON ALFALFA
STEM AND BULB NEMATODE
(DITYLENCHUS DIPSACI)
ON DAFFODIL

DITYLENCHUS DIPSACI
(STEM AND BULB NEMATODE)
ON GARLIC

DITYLENCHUS DESTRUCTOR
(STEM AND BULB NEMATODE)
ON POTATO

FOLLIAR NEMATODE
(APHELENCHOIDES FRAGARIAE)
AFRICAN VIOLET
(HEALTHY IN CENTER)
FOLIAR NEMATODE (APHELENCHOIDES FRAGARIAE) on CHrysanthemum and Strawberry

ROOT-KNOT NEMATODE (MELOIDOGYNE SP.) on Carrots and Sweet Potatoes
ROOT-KNOT NEMATODE (MELOIDOGYNE SP.) ON GRAPE
CHECK ON LEFT, NEMACUR TREATMENT ON RIGHT

SEED AND LEAF GALL NEMATODE (ANGUINA TRITICI)

SEED AND LEAF GALL NEMATODE (ANGUINA PACIFICA) ON TURF
HETERODERA SCHACHTII (SUGARBEET CYST NEMATODE)
HOW NEMATODES INJURE PLANTS:
1. Mechanical injury - penetration and movement through tissues
2. Cellular changes
   A. Death of cells (necrosis)
   B. Changes in growth of cells
3. Physiological changes in host
   A. Interruption in uptake and flow of water and nutrients from roots
   B. Interaction in flow of food from leaves to roots
4. Create openings for entry of other microorganisms
5. Interaction with other disease producing agents
6. Transmission of other disease producing agents
7. Increase susceptibility to environmental stress
SAMPLING FOR NEMATODES:

- Sample in root zone where moisture is present
- Place soil and roots into plastic bag
- Soil from several places can be combined
- Collect about 1 quart of soil and roots
- Sample healthy areas also and place in separate bag
- Seal bags and keep cool (do not freeze)
- Label bags - name, address, sample location, date, site history
- Notify laboratory that is to receive samples

EXTRACTION EQUIPMENT & PROCEDURES:

- Sieving
- Fenwick Can
- Elutriator
- Baermann Funnel
- Mist
- Sugar Flotation
- Sugar Centrifugation
- Staining Roots
- Greenhouse Bioassay

Select appropriate procedure for nematode species of interest.

RING: ELUTRIATION - SUGAR FLOTATION OR CENTRIFUGATION
DAGGER: BAERMANN FUNNEL LINED WITH CHEESE CLOTH
<table>
<thead>
<tr>
<th>NEMATODE</th>
<th>ELUTRIATOR-SUGAR CENTRIFUGATION (NUMBER/LITER SOIL)</th>
<th>BAERMANN FUNNEL (NUMBER/LITER SOIL)</th>
<th>CHEESE CLOTH LINED FUNNEL (NUMBER/LITER SOIL)</th>
<th>ROOTS ON MIST (NUMBER/GRAM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LESION</td>
<td>2,750</td>
<td>7,200</td>
<td>280</td>
<td>1.6</td>
</tr>
<tr>
<td>RING</td>
<td>1,000</td>
<td>28</td>
<td>150</td>
<td>0</td>
</tr>
<tr>
<td>DAGGER</td>
<td>150</td>
<td>280</td>
<td>350</td>
<td>0</td>
</tr>
</tbody>
</table>

**MIST CHAMBER EXTRACTION - FOLIAR NEMATODE**

MIST CHAMBER VARIABILITY

FENWICK CAN EXTRACTION
NEMABASE Nematode-Host Association Database
Nematode Common-Scientific Name Database
Plant Common-Scientific Name Database
Lownsbery Nematode-Host Association Database
Radewald California Ornamental Nematode-Host Association Database
Nematode Primer Database
Knowledge Planning Database

**SURVEY OF WALNUT ORCHARDS:**
Compiled by B. F. Lownsbery from CDFA and UC records.

- **MIGRATORY ECTOPARASITES** -
  - Ring (*Mesocricetonus* sp.) 19%
  - Dagger (*Xiphinema americanum*) 17%
  - Pin (*Paratylenchus* sp.) 6%
  - Spiral (*Helicotylenchus* sp.) 2%

- **MIGRATORY ENDOPARASITE** -
  - Lesion (*Pratylenchus* sp.) 51%

- **SEDENTARY ENDOPARASITE** -
  - Root knot (*Meloidogyne* sp.) 15%

*LIKELY TO CAUSE DAMAGE

**SURVEY OF PRUNE ORCHARDS:**
97 orchards sampled.
Pin (*Paratylenchus* sp.) 67%
Dagger (*Xiphinema americanum*) 62%
Ring (*Mesocricetonus* sp.) 38%
Lesion (*Pratylenchus vulnus*) 7%

---

![Carrot, Sugarbeet, Tomato bar chart](chart.png)
1998 SOUTH COAST FIELD STATION - ROOT-KNOT NEMATODE

1998 SOUTH COAST FIELD STATION - SUGARBEET CYST NEMATODE

ROOT KNOT NEMATODE ON PROCESSING TOMATOES - SAN JOAQUIN VALLEY

NUMBER OF LARVAE/GRAM OF SOIL

FALL PERCENT SPRING INCREASE FALL % OF NORMAL YIELD

<table>
<thead>
<tr>
<th></th>
<th>0.01</th>
<th>1000 X</th>
<th>10.0</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.31</td>
<td>85</td>
<td>500 X</td>
<td>23.8</td>
</tr>
<tr>
<td></td>
<td>1.56</td>
<td>85</td>
<td>150 X</td>
<td>37.3</td>
</tr>
<tr>
<td></td>
<td>4.06</td>
<td>85</td>
<td>75 X</td>
<td>48.0</td>
</tr>
<tr>
<td></td>
<td>6.25</td>
<td>85</td>
<td>55 X</td>
<td>54.8</td>
</tr>
</tbody>
</table>

THE USE OF NEMATODE DAMAGE/ECONOMIC THRESHOLDS IS OFTEN LIMITED BY THE METHODS AVAILABLE TO DETECT NEMATODES.
SUGARBEET DAMAGE TRIAL

AVERAGE OF THREE YEARS DATA FROM ONE ORCHARD IN EACH OF FIVE COUNTIES

TWO POINTS AT THE SAME DEPTH WHICH ARE NOT IDENTIFIED BY THE SAME LETTER ARE SIGNIFICANTLY DIFFERENT FROM EACH OTHER ACCORDING TO FISHER'S LSD TEST AT P = 0.05.

LOWNSBERY, 1959
ROOT GROWTH

NUMBER OF RING NEMATODE PER QUART OF SOIL

MONTHS

NUMBER OF RING NEMATODE PER QUART OF SOIL

MONTHS

LOWNSBERY, 1959
ROOT GROWTH

NUMBER OF RING NEMATODE PER QUART OF SOIL

MONTHS

LOWNSBERY, 1959
ROOT GROWTH
LESION NEMATODE / LITER OF SOIL
AVERAGE OF THREE YEARS DATA FROM THREE ORCHARDS

TWO POINTS WHICH ARE NOT IDENTIFIED BY THE SAME LETTER ARE SIGNIFICANTLY DIFFERENT FROM EACH OTHER ACCORDING TO FISHER’S PROTECTED LSD TEST AT P = 0.05.

LESION NEMATODE / GRAM OF ROOT
AVERAGE OF THREE YEARS DATA FROM THREE ORCHARDS

TWO POINTS WHICH ARE NOT IDENTIFIED BY THE SAME LETTER ARE SIGNIFICANTLY DIFFERENT FROM EACH OTHER ACCORDING TO FISHER’S PROTECTED LSD TEST AT P = 0.05.

RING NEMATODE / LITER OF SOIL
AVERAGE OF THREE YEARS DATA FROM THREE ORCHARDS

TWO POINTS WHICH ARE NOT IDENTIFIED BY THE SAME LETTER ARE SIGNIFICANTLY DIFFERENT FROM EACH OTHER ACCORDING TO FISHER’S PROTECTED LSD TEST AT P = 0.05.

COMPARISON OF RING NEMATODE IN WALNUT AND PRUNE ORCHARDS
GRAPE GROWING REGIONS:
NORTH & CENTRAL COAST - DEWEY RASKI
SAN JOAQUIN VALLEY - MIKE MCKENRY
SOUTHERN CALIFORNIA - JOHN RADEWALD

XIPHEINEMA INDEX ON GRAPES

CITRUS NEMATODE ON GRAPES IN THE COACHELLA VALLEY

<table>
<thead>
<tr>
<th>NEMATODE</th>
<th>NORTH</th>
<th>SAN JOAQ</th>
<th>S CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAGGER</td>
<td>X</td>
<td>X</td>
<td>0</td>
</tr>
<tr>
<td>RING</td>
<td>X</td>
<td>X</td>
<td>0</td>
</tr>
<tr>
<td>LESION</td>
<td>X</td>
<td>X</td>
<td>0</td>
</tr>
<tr>
<td>STUBBY ROOT</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>ROOT KNOT</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>CITRUS</td>
<td>0</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>NEEDLE</td>
<td>0</td>
<td>0</td>
<td>X</td>
</tr>
</tbody>
</table>