**NEMATICIDES THAT HAVE ACHIEVED CALIFORNIA REGISTRATION:**

No longer available or in danger of going away soon  | Non-fumigants

<table>
<thead>
<tr>
<th>NEMACUR (FENAMIPHOS) (WITHDRAWN)</th>
<th>FUMIGANTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CARBON DISULFIDE (CS2)</td>
<td></td>
</tr>
<tr>
<td>MOCAP (ETHOPROP)</td>
<td></td>
</tr>
<tr>
<td>*TELONE II (1,3-D)</td>
<td></td>
</tr>
<tr>
<td>DASANIT (WITHDRAWN)</td>
<td></td>
</tr>
<tr>
<td>*TEMIK (ALDICARB)</td>
<td></td>
</tr>
<tr>
<td>DYDATE (OXAMYL)</td>
<td></td>
</tr>
<tr>
<td>ENZONE (GY-81) SODIUM</td>
<td></td>
</tr>
<tr>
<td><strong>DITERA (MYROTHECIUM VERRUCARIA TOXIN)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>ADMIRE PRO (IMIDACLOPRID)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>NEMA-Q (QUILLAJA, SOAPBARK TREE)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>ABAMECTIN SEED TREATMENTS</strong></td>
<td></td>
</tr>
<tr>
<td><strong>MELOCON (PAECILOMYCES LILACINUS)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>MOVENTO (SPIROTETRAMAT)</strong></td>
<td></td>
</tr>
</tbody>
</table>

**FUMIGANTS:**

<table>
<thead>
<tr>
<th>YEAR</th>
<th>TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1869</td>
<td>CS2</td>
</tr>
<tr>
<td>1936</td>
<td>CS2</td>
</tr>
<tr>
<td>1940'S</td>
<td>CS2</td>
</tr>
<tr>
<td>1950'S</td>
<td>CS2</td>
</tr>
</tbody>
</table>

**GENERALIZATIONS FOR CHOOSING A NEMATICIDE:**

**REGISTRATION STATUS**

**FUMIGANTS**

Typically registered on many crops
Low potential for residues

**ORGANOPHOSPHATES AND CARBAMATES**

Typically registered on a few crops
Potential for residues limits number of crops

**NEWER CATEGORIES**

Product dependent
GENERALIZATIONS FOR CHOOSING A NEMATICIDE:

ANNUAL CROPS
PREPLANT - CONTROL NEEDED TO A 2 TO 3 FOOT DEPTH
POSTPLANT - COST EFFECTIVENESS IS QUESTIONABLE

PERENNIAL CROPS
PREPLANT - CONTROL NEEDED TO 5 FOOT DEPTH
POSTPLANT - 50% NEMATODE REDUCTION TYPICALLY IMPROVES YIELDS WITH 2 YEARS OF USE

CALIFORNIA LEGISLATION AFFECTING NEMATICIDES:

PROPOSITION 65 - SAFE DRINKING WATER AND TOXIC ENFORCEMENT ACT OF 1986
AB 2021 - PESTICIDE CONTAMINATION PREVENTION ACT (1985 - GROUNDWATER PROTECTION)
SB 950 - THE BIRTH DEFECT PREVENTION ACT OF 1984
AB 1807 - AIR TOXICS (1983 - THE TOXIC AIR CONTAMINANT IDENTIFICATION AND CONTROL ACT)

LIFE CYCLE OF A TYPICAL PLANT PARASITIC NEMATODE:

EFFECTIVENESS MAY DEPEND ON LIFE CYCLE STAGE

COMMON PLANT PARASITIC NEMATODES IN CALIFORNIA:

ECTOPARASITES
Trichodorus - Stubby Root*
Xiphinema - Dagger*
Longidorus - Needle*
Helicotylenchus - Spiral
Criconemella - Ring
Paratylenchus - Pin
Hemicycliophora - Sheath

MIGRATORY ENDOPARASITES
Pratylenchus - Lesion
Ditylenchus - Stem & Bulb
Aphelenchoides - Foliar

SEDENTARY ENDOPARASITES
Meloidogyne - Root Knot
Anguina - Seed & Leaf Gall
Tylenchulus - Citrus
Heterodera - Cyst

SOME GENERA CONTAIN SEVERAL IMPORTANT SPECIES
*Vectors of plant viruses
### Compound Volatility

<table>
<thead>
<tr>
<th>Compound</th>
<th>Volatility</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fumigants</strong></td>
<td></td>
</tr>
<tr>
<td>Methyl Bromide - Tarped</td>
<td>5</td>
</tr>
<tr>
<td>- Nontarped</td>
<td>5</td>
</tr>
<tr>
<td>Chloropicrin</td>
<td>7</td>
</tr>
<tr>
<td>1,3-Dichloropropene (1,3-D.Telonell)</td>
<td>30</td>
</tr>
<tr>
<td>Methyl isothiocyanate</td>
<td>500</td>
</tr>
<tr>
<td>(Metam Sodium, Vapam, Basamid)</td>
<td></td>
</tr>
<tr>
<td><strong>Organophosphates &amp; Carbamates</strong></td>
<td></td>
</tr>
<tr>
<td>Ethoprop (Mocap)</td>
<td>100,000</td>
</tr>
<tr>
<td>Carbofuran (Furadan)</td>
<td>1,000,000</td>
</tr>
<tr>
<td>Aldicarb (Temik)</td>
<td>1,500,000</td>
</tr>
<tr>
<td>Fenamiphos (Nemacur)</td>
<td>10,000,000</td>
</tr>
<tr>
<td>Oxamyl (Vydate)</td>
<td>100,000,000</td>
</tr>
</tbody>
</table>

### Generalizations About Soil Type:

Nematicides move further through coarser than through finer textured soils.

### Generalizations About Water Solubility:

The more water soluble a product is, the further it will move through soil, and the greater the chance it will reach groundwater.

### Non-Fumigant Products

Non-fumigant products may not always kill nematodes:

- Nematistat vs Nematicide
- Products may promote plant growth but not reduce nematode numbers
- Or they may result in an increase in nematodes because a healthier root system can support more nematodes.
EFFECTS OF NEMACUR ON MOBILITY OF
PRATYLENCHUS PENETRANS & DITYLENCHUS DIPSACI
TIME FOR PARALYSIS TO OCCUR (HOURS):

<table>
<thead>
<tr>
<th>CONCENTRATION (PPM)</th>
<th>P. PENETRANS</th>
<th>D. DIPSACI</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>0.1</td>
<td>48</td>
<td>504</td>
</tr>
</tbody>
</table>

INHIBITION OF MOBILITY IS REVERSIBLE IF NEMATODES ARE TRANSFERRED TO WATER

TIME FOR MORTALITY TO OCCUR (DAYS):

<table>
<thead>
<tr>
<th>CONCENTRATION (PPM)</th>
<th>P. PENETRANS</th>
<th>D. DIPSACI</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>5</td>
<td>21</td>
</tr>
<tr>
<td>10</td>
<td>12</td>
<td>41</td>
</tr>
<tr>
<td>1</td>
<td>27</td>
<td>65</td>
</tr>
<tr>
<td>0.1</td>
<td>57</td>
<td>105</td>
</tr>
</tbody>
</table>

Fumigant Costs

<table>
<thead>
<tr>
<th>Product</th>
<th>$/lb. AI</th>
<th>Per acre, applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methyl Bromide</td>
<td>$3.50</td>
<td>$2100 (350 lb/acre, broadcast shank, tarped)</td>
</tr>
<tr>
<td>Chloropicrin</td>
<td>$2.40</td>
<td>$1200 (200 lb/acre, broadcast shank, tarped)</td>
</tr>
<tr>
<td>Telone (1,3-D)</td>
<td>$1.40</td>
<td>$550 (35 gal/acre, broadcast shank)</td>
</tr>
<tr>
<td>InLine</td>
<td>$2.00</td>
<td>$640 (25 gal/acre, drip application)</td>
</tr>
<tr>
<td>Metam Sodium (MITC)</td>
<td>$1.00</td>
<td>$400 (75 gal/acre, shanked, water seal)</td>
</tr>
</tbody>
</table>

NEMATODES ARE AQUATIC ORGANISMS

FUMIGANTS MOVE THEMSELVES THROUGH AIR IN SOIL PORES AND THEN DISSOLVE IN WATER TO KILL NEMATODES

WHAT MAKES A FUMIGANT WORK, ALSO MAKES IT A VOC

NON-FUMIGANTS NEED TO BE MOVED WITH WATER OR TILLAGE
IS IT ORGANIC?

ALTERNATIVE AGRICULTURE (1989) - NATIONAL RESEARCH COUNCIL
CASE STUDY 8 - Fresh Grapes in California and Arizona: Stephen Pavich & Sons

"Nematodes are controlled by fumigation and a 2- to 3-year fallow period." (page 351)

"The bare field is then fumigated with chloropicrin and methyl bromide..." (page 360)

MATERIAL SAFETY DATA SHEET - HEALTH HAZARD INFORMATION:
Inhalation - Early symptoms of overexposure are dizziness, headache, nausea and vomiting, weakness and collapse. Lung edema may develop in 2 to 48 hours after exposure, accompanied by cardiac irregularities. Repeated overexposure can result in blurred vision, staggering gait, and mental imbalance, with probable recovery; after a period of no exposure. In extreme cases of overexposure, unconsciousness and death can occur. Liquid can cause severe burns to eyes and skin.

Inhalation causes intense burning of the mucous membranes, throat and respiratory tract; overexposure to vapors can lead to bronchopneumonia. Inhalation of high concentration can cause fatal pulmonary edema. Repeated or prolonged skin exposure causes dermatitis. Can cause blistering of skin due to its defatting properties. Exposure to eyes can cause hyperemia of the conjunctiva. Ingestion or excessive vapors can cause inebriation, drowsiness, blurred vision, vertigo, confusion, vomiting and cyanosis. Aspiration after ingestion causes bronchitis, pneumonia, or edema which can be fatal.

Ingestion can cause corrosion of mucous membranes, perforation of esophagus and stomach, and laryngeal edema; may lead to convulsion, coma, death. Inhalation of mist or fumes can cause bronchial irritation, cough, difficult breathing, stomatitis, nausea, and pulmonary edema. Additional effects have included circulatory collapse and delirium. Liquid contact can produce irritation of the eyes or skin with blistering and eczema.
MULTIPLE MODES OF ACTION OF NATURAL PRODUCTS:

- **Addition of Beneficial Microbials**
- **Stimulation of Nematophagous Fungi**
- **Competition for Root Surface**
- **Reduce Stress on Nematode Infested Plants (via Improved Soil Structure, Soil Water Retention, Plant Nutrition)**
- **Produce Nematicidal Breakdown Products**

**PRODUCT X Soil Conditioner - COMPANY X**

"PRODUCT X contains a micro-organism capable of combating most of the known soil fungi that can be harmful to crops. PRODUCT X is the best tool to combat nematodes and fungi that prey on cotton fields."

*(PRODUCT X BULLETIN)*

"There was an outbreak of nematodes in the spring of 1981... whereupon we added 200 pounds quickly. We found nematodes at crop pullout, but nevertheless did not sterilize. At crop pullout on July 1, 1982, we found no nematodes."

*(Letter from GROWER X)*

GROWER X gave his nematodes something else to chew on - **PRODUCT X**

- We have been especially concerned about the high cost of nematicides and the problems handling them.
- COMPANY X introduced a product to us about three years ago called **PRODUCT X**.
- They suggested that we use it in place of nematicides, as a natural solution to the nematode problem.
- We have been using **PRODUCT X** for the past three years on carrots and melons and are very pleased with the results.
- We had as good or better crops without using any chemical nematicide."

*(Source: PRODUCT X AD)*
"It has no toxic materials, it is not a nematocide, and it does not kill nematodes. ... encourage and enhance those natural processes already present in the soil which could control non-beneficial nematodes. Practical field experience is showing that when used as a part of the integrated Company X system, Product X is a highly cost-effective tool in the management of nematode infestations in agricultural situations."

(source: Agricultural Trade Journal, Summer 1990)
ANNUAL CROPS: 
MILLIONS OF DOLLARS LOST 
IN 1992 FOLLOWING SUSPENSION 
OF USE OF TELONE II IN 1991

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

GENERALIZATIONS
ABOUT CROPS MOST 
IN NEED OF PROTECTION

PERENNIALS TREATED 
AT REPLANT 
EVERY 10 TO 50 YEARS

ROOT-KNOT NEMATODE 
ON TOMATO

HEALTHY INFESTED

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APPLICATION OF FUMIGANTS 
INJECTION FOLLOWED BY LAYING AND GLUING TARP

METHYL BROMIDE (98 % A.I.):
SOIL TEXTURE:
Coarse Texture (high % sand)
- has large pore spaces
- dries out more quickly.
Fine Texture (high % silt & clay)
- small pore size
- dries out more slowly
The finer the soil texture, the higher the rate of fumigant needed.

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The finer the soil texture, the higher the rate of fumigant needed.
SOIL TEMPERATURE:
If temperatures are too high, fumigant will volatilize and degrade too quickly.
If temperatures are too low, fumigant will volatilize but not move through pore space as rapidly or as far.

SOIL MOISTURE:
Too low - fumigant becomes adsorbed to soil particles.
Too high - water in soil pore spaces hinders movement.

WHAT IS THE TARP FOR?
REMOVE ROOTS

SHANK SPACING AND DEPTH OF INJECTION
FLOOD APPLICATIONS OF ENZONE

ENZONE
SODIUM TETRATHIOCARBONATE
RELEASES CS$_2$ IN SOIL
NEEDS TO BE APPLIED IN IRRIGATION WATER
CA REGISTRATION ON CITRUS, GRAPES, ALMONDS, PRUNES, PEACHES, PLUMS
EQUIPMENT USED FOR INCORPORATION OF NONFUMIGANTS CAN EFFECT EFFICACY

LILLISTON ROLLING CULTIVATOR

ROTERA CULTIVATOR

ROTOTILLER

POTATO

HEALTHY INFESTED

EFFECT OF DEPTH OF INCORPORATION ON EFFICACY BLEMISH CONTROL WITH PREPLANT SOIL INCORPORATED MOCAP

MOCAP 6 LB/ACRE

MOCAP 12 LB/ACRE

UNTREATED

% TUBER BLEMISH

60
50
40
30
20
10
0

1-2 INCHES

3-4 INCHES

6-8 INCHES

LILLISTON

ROTERA

ROTOTILLER

GRANULAR APPLICATOR

SPRINKLER APPLICATION OF METAM SODIUM

TRACTOR MOUNTED SPRAYER

Drip IRRIGATION

GANDY GRANULAR APPLICATOR
EASTER LILY BULB PRODUCTION:
ORIGINAL PLANTING STOCK FROM JAPAN
GROWN IN HUMBOLDT COUNTY SINCE 1940’S
600 ACRES ROTATED WITH PASTURE
65,000 BOXES OF BULBS/YEAR
6.5 MILLION YEARLY FARM GATE VALUE
AREAS LARGEST EMPLOYER

NEMATODE MANAGEMENT:
LEASE NEMATODE (PRATYLENCHUS PENETRANS)
STANDARD TREATMENT -
DD PLUS TEMIK (ALDICARB)
(1,3-DICHLOROPROPENE+1,2-DICHCLROPROPANE)
1982 1,2-D AND TEMIK FOUND IN GROUNDWATER
SWITCHED TO TELONE II AND NEMACUR
(FENAMIPHOS)
1986 REGISTRATION FOR NEMACUR WITHDRAWN
SWITCHED TO THIMET (PHORATE)
1990 REGISTRATION FOR TELONE II SUSPENDED
SWITCHED TO VAPAM OR METHYL BROMIDE
1996 USE OF TELONE II REINSTATED (TOWNSHIP CAP)
RIGHT NOW: DANGER OF LOSING THIMET
AND METHYL BROMIDE

CURRENTLY, THE COST OF CHEMICAL CONTROL IS
FREQUENTLY LESS THAN THE COST OF
ALTERNATIVES.

WHY?
COST FIGURES EASILY AVAILABLE:
FOR CHEMICAL PRODUCT PLUS APPLICATION
(PAIRED BY GROWER)
COST FIGURES NOT AVAILABLE:
FOR ACTUAL OR PERCEIVED ENVIRONMENTAL
DAMAGE
(COST IS CURRENTLY SUBSIDIZED BY SOCIETY

WHAT'S MISSING FROM COST FIGURES?:
OZONE DEPLETION
CARCINOGENICITY
MUTAGENICITY
GROUND WATER POLLUTION
AIR POLLUTION
ACUTE TOXICITY (WORKERS, ENDANGERED
SPECIES)