

WHAT NEMATICIDES ARE AVAILABLE?

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

HISTORICAL DEVELOPMENT OF NEMATICIDES

	YEAR	TYPE
CARBON DISULFIDE (CS ₂)	1869	FUMIGANT
*CHLOROPICRIN	1936	FUMIGANT
METHYL BROMIDE	1940'S	FUMIGANT
EDB (ETHYLENE DIBROMIDE)	"	FUMIGANT
DD (1,3-D+1,2-D) (1,2-DICHLOROPROPANE)	"	FUMIGANT
DBCP (DIBROMOCHLOROPROPANE)	"	FUMIGANT
*TELONE II (1,3-D) (1,3-DICHLOROPROPENE)	"	FUMIGANT
FORMALDEHYDE	"	FUMIGANT
*MIT>>METAM-SODIUM	1950'S	FUMIGANT
*BASAMID	"	FUMIGANT
NEMACUR (FENAMIPHOS)	LATE	ORGANOPHOSPHATE
*FURADAN (CARBOFURAN)	50'S &	CARBAMATE
*MOCAP (ETHOPROP)	1960'S	ORGANOPHOSPHATE
DASANIT	"	ORGANOPHOSPHATE
*TEMIK (ALDICARB)	"	CARBAMATE
*VYDATE (OXAMYL)	1970'S	CARB (SYSTEMIC)
ENZONE (GY-81) SODIUM	1990'S	FUMIGANT
TETRATHIOCARBONATE>>CS ₂		
*DITERA (<i>MYROTHECIUM VERRUCARIA</i> TOXIN)	"	NATURAL
*TELONE EC, INLINE	"	FUMIGANT
*ADMIRE PRO (IMIDACLOPRID)	2000'S	NEONICITYNOID
*NEEM (AZADIRACHTIN)	"	"
*NEMA-Q (QUILLAJA, SOAPBARK TREE)	"	NATURAL
*ABAMECTIN SEED TREATMENTS	"	NATURAL
MIDAS (IODOMETHANE)	"	FUMIGANT
*MELOCON (<i>PAECILOMYCES LILACINUS</i>)	"	NATURAL
*NIMITZ	"	FLUENSULFONE

*Currently available for use on some crops in California

FUMIGANTS:

	YEAR
CARBON DISULFIDE (CS ₂) (WITHDRAWN)	1869
*CHLOROPICRIN (TEAR GAS)	1936
*METHYL BROMIDE (OZONE DEPLETER)	1940'S
EDB (ETHYLENE DIBROMIDE) (CARC / GW) (1983)	"
DD (1,3-D+1,2-D) (1,2-DICHLOROPROPANE) (CARC / GW) (1989)	"
DBCP (DIBROMOCHLOROPROPANE) (CARC / GW) (1985)	"
*TELONE II (1,3-D) (1,3-DICHLOROPROPENE) (PROP65 / AIR)	"
FORMALDEHYDE (CARCINOGEN)	"
*MIT>>METAM-SODIUM (ISOTHIOCYANATE)	1950'S
*BASAMID (GRANULE, ISOTHIOCYANATE)	"
*ENZONE (GY-81) SODIUM	1990'S
TETRATHIOCARBONATE>>CS ₂	
*INLINE (TELONE + CHLOROPICRIN) (PROP65 / AIR)	"
MIDAS (IODOMETHANE) (WITHDRAWN)	2012
*DOMINUS (ALLYL ISOTHIOCANATE, AITC)	In Progress

NO LONGER AVAILABLE
ON ITS WAY OUT
 CARC = CARCINOGEN
 PROP65 = CARCINOGEN AS DEFINED BY PROPOSITION 65
 GW = FOUND IN GROUNDWATER IN CA
 *CURRENTLY AVAILABLE FOR USE ON SOME CROPS IN CALIFORNIA

NONFUMIGANTS

	YEAR	TYPE
NEMACUR (FENAMIPHOS) (WITHDRAWN)	LATE	OP
FURADAN (CARBOFURAN)	50'S &	CARB
*MOCAP (ETHOPROP)	1960'S	OP
DASANIT (WITHDRAWN)	"	OP
*THIMET (PHORATE)	"	OP
*TEMIK (ALDICARB)	"	CARB
*VYDATE (OXAMYL) (SYSTEMIC)	1970'S	CARB
*DITERA (<i>MYROTHECIUM VERRUCARIA</i> TOXIN)	1990'S	NATURAL
*NEEM (AZADIRACHTIN)	"	NATURAL
*ADMIRE PRO (IMIDACLOPRID)	2000'S	NEONICITYNOID
*NEMA-Q (QUILLAJA, SOAPBARK TREE)	"	NATURAL
*ABAMECTIN SEED TREATMENTS, TURF	"	NATURAL
*MELOCON (<i>PAECILOMYCES LILACINUS</i>)	"	NATURAL
*MOVENTO (SPIROTETRAMAT)	"	TETRAMIC ACID
*NIMITZ (FLUENSULFONE, MCW-2)	"	FLUENSULFONE

OP=ORGANOPHOSPHATE,
 CARB=CARBAMATE

NO LONGER AVAILABLE

*CURRENTLY AVAILABLE FOR USE ON SOME CROPS IN CALIFORNIA

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

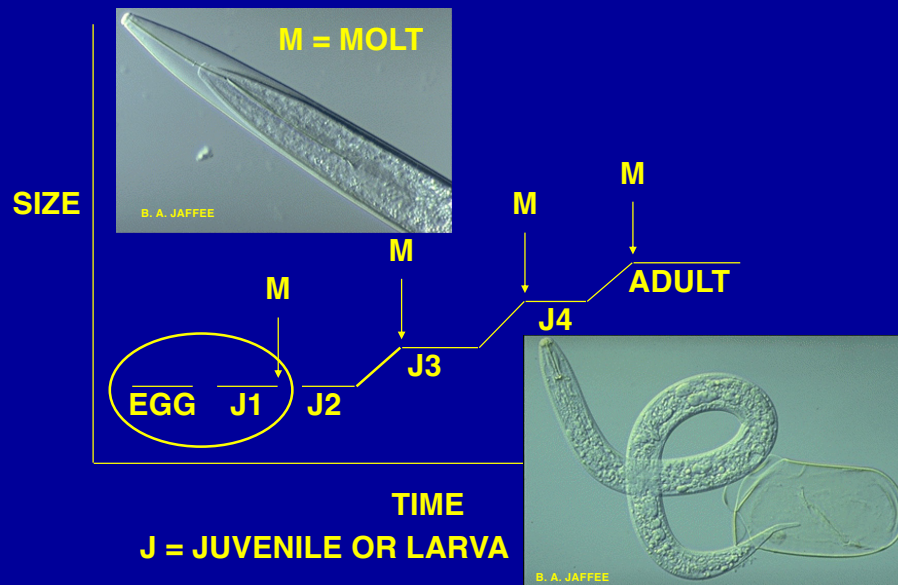
AB 2021 - PESTICIDE CONTAMINATION PREVENTION ACT (1985 - GROUNDWATER PROTECTION)

SB 950 - THE BIRTH DEFECT PREVENTION ACT OF 1984

AB 1807 - AIR TOXICS (1983 - THE TOXIC AIR CONTAMINANT IDENTIFICATION AND CONTROL ACT)

EFFECTIVENESS MAY DEPEND ON LIFE CYCLE STAGE

LIFE CYCLE OF A TYPICAL PLANT PARASITIC NEMATODE:



EFFECTIVENESS MAY VARY DEPENDING ON THE TARGET

COMMON PLANT PARASITIC NEMATODES IN CALIFORNIA:

**ECTOPARASITES
 ENDOPARASITES**

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

MIGRATORY

- 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**

**THE MORE VOLATILE THE PRODUCT THE BETTER
IT MOVES THROUGH SOIL:**

<u>COMPOUND</u>	<u>VOLATILITY</u> HIGH
FUMIGANTS	
Methyl Bromide - Tarped	5
- Nontarped	5
Chloropicrin	7
1,3-Dichloropropene(1,3-D.Telonell)	30
<hr/>	
Methyl isothiocyanate (Metam Sodium, Vapam, Basamid)	500
ORGANOPHOSPHATES & CARBAMATES	
Ethoprop(Mocap)	100,000
Carbofuran(Furadan)	1,000,000
Aldicarb(Temik)	1,500,000
Fenamiphos(Nemacur)	10,000,000
Oxamyl(Vydate)	100,000,000
	LOW

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**

**INCREASING
WATER
SOLUBILITY**

↓

THIMET (PHORATE)
MOCAP (ETHOPROP)
NEMACUR (FENAMIPHOS)
TEMIK (ALDICARB)
VYDATE (OXAMYL)

**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 INCREASES 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):**

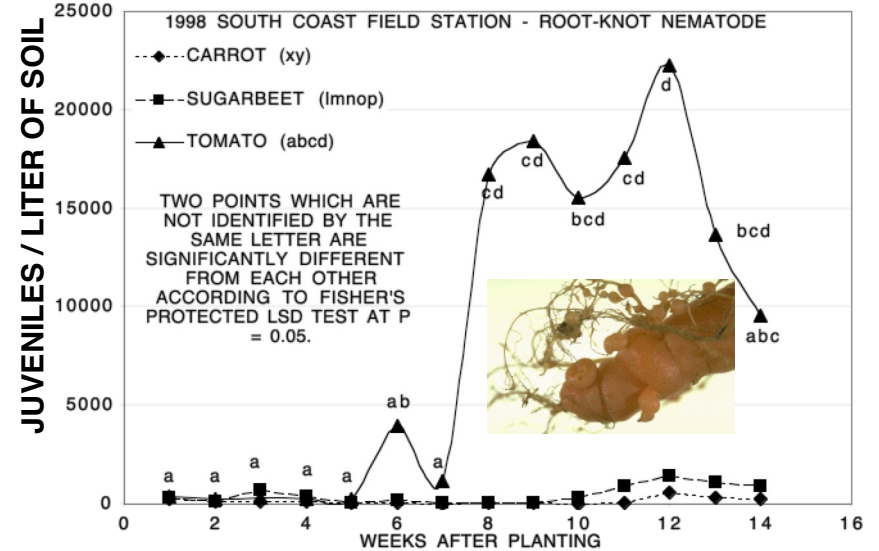
CONCENTRATION (PPM)	P. PENETRANS	D. DIPSACI
100	1	1
10	1	5
1	5	1
0.1	48	504

INHIBITION OF MOBILITY IS REVERSIBLE IF NEMATODES ARE TRANSFERRED TO WATER

TIME FOR MORTALITY TO OCCUR (DAYS):

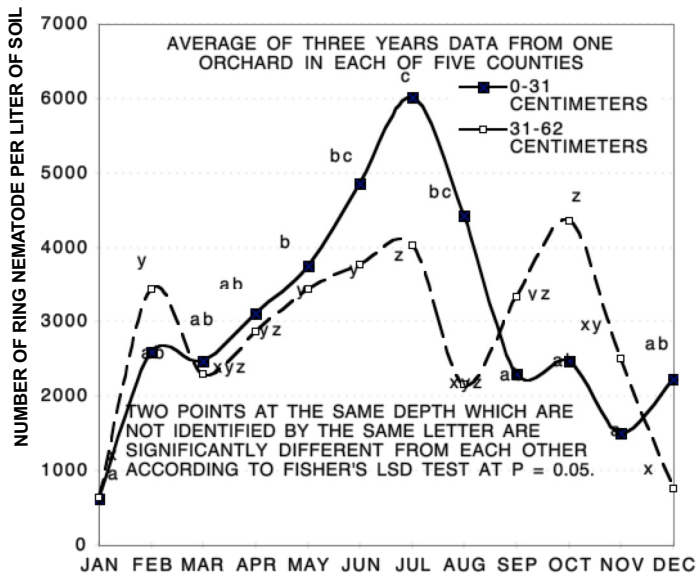
CONCENTRATION (PPM)	P. PENETRANS	D. DIPSACI
100	5	21
10	12	41
1	27	65
0.1	57	105

ANNUAL CROPS ONLY NEED PROTECTION FOR SIX WEEKS AFTER PLANTING?



YES, BUT ONLY IF YOU CONTROL THEM PREPLANT

POPULATION CYCLING IN PERENNIAL CROPS



WHEN IS THE BEST TIME TO APPLY A NEMATICIDE?

GENERALIZATIONS ABOUT CROPS MOST IN NEED OF PROTECTION

PERENNIALS TREATED AT REPLANT EVERY 10 TO 50 YEARS

ROOT-KNOT NEMATODE ON TOMATO



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

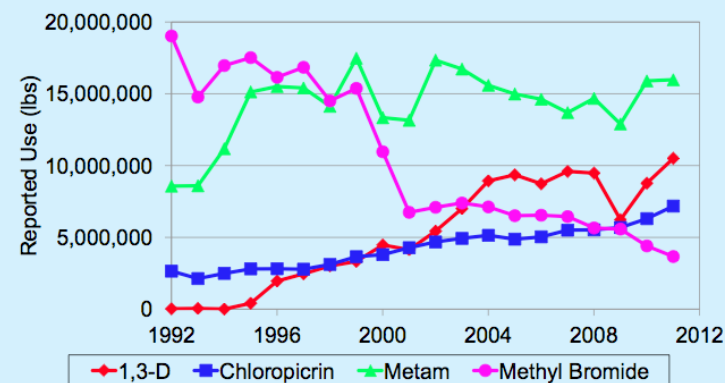
SUGARBEET CYST(SBCN)& (RKN)

Broccoli	15.7
Cauliflower	7.9
Sugar beets	6.1
Brussel sprouts	0.7

Fumigant Costs

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

Fumigant use in California by chemical, 1992-2011



dpr

Randy Segawa (CDPR)²



Conventional Fumigation (Acres, California 2007):

Methyl Bromide/Chloropicrin:	40,000
Telone/Chloropicrin:	17,000
Telone II:	37,000
Chloropicrin alone:	6,000
Metam sodium:	77,000

TOTAL: ~ 180,000 acres annually



Husein Ajwa (UC Davis)

Significant Regulatory Pressure:

- Buffer zones
- VOCs regulations
- Application rates

Resulted in development of new film (tarp) technology:

- "Virtually impermeable (VIF)"
- "Totally impermeable (TIF)"

Need for Emission Reduction Research

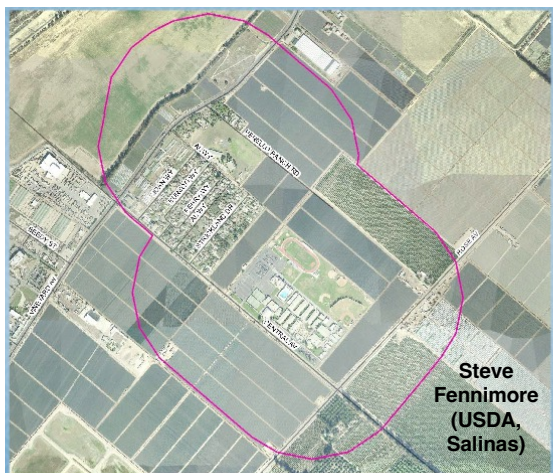
- Recent US-EPA regulations imposed larger buffer zones and lower application rates of fumigants.
- In California, many townships exceeded the "Township Cap" of 90,250 lbs of Telone per township (36 square miles).
- In California, volatile organic compounds regulations limit fumigants use in certain areas in California due to high emissions.

Husein Ajwa (UC Davis)



David Sullivan
(Consultant)

Emissions from field applications are monitored and models are developed to establish buffer zones for sensitive areas.



Types of Mulch Film

PE	PE	PE + Adhesive	PE	PE	PE
LDPE	HDPE	Nylon	Adhesive Nylon Adhesive	Adhesive EVAL™ Adhesive	PE Adhesive EVAL™ Adhesive PE
PE	PE	PE + Adhesive	PE	PE	PE
STD	SIF	VIF	VIF	TIF	TIF
FUMIGANT BARRIER					
Poor	Poor	Medium	Medium	High	High
MECHANICAL PROPERTY					
Excellent	Excellent	Poor	Good	Good	Excellent

STD = Standard PE film
SIF = semi-impermeable film
VIF = virtually impermeable film
TIF = "totally" impermeable film



Benefit to the Grower

Buffer Zone Distances in Feet
Assuming 350 lbs/A of MB/PIC 67:33 on 10 acres

Block size in Acres	USEPA Table: Broadcast Equivalent Application Rate (lbs ai/acre)														
	43	75	108	134	161	188	215	242	269	296	323	350	377	403	430
1	25	25	25	25	25	25	25	25	25	25	25	50	75	100	125
5	25	25	25	60	90	120	150	210	265	320	375	450	525	600	675
10	25	25	25	95	165	235	300	385	465	545	625	700	775	850	925
20	25	25	25	145	265	385	500	625	750	875	1000	1115	1225	1340	1450
30	25	38	50	210	365	520	675	835	980	1145	1300	1440	1575	1715	1850
40	25	75	125	310	490	770	1035	1215	1395	1575	1760	1940	2120	2300	2480
60	25	115	200	425	650	875	1100	1350	1595	1840	2085	2330	2570	2810	3050
80	25	165	300	565	825	1090	1350	1660	1965	2270	2575	2885	3150	3440	3725
100	25	200	375	690	1000	1315	1625	1985	2340	2695	3050	3375	3700	4025	4350

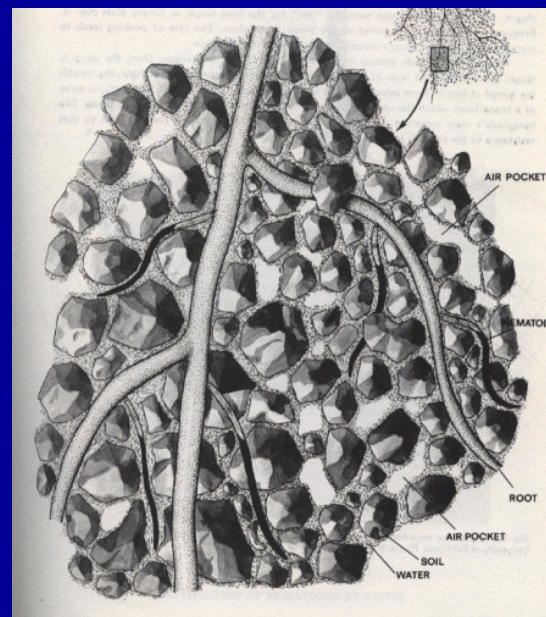
TIF
50% Dose
60% BZC
34 ft BZ

TIF
60% BZC

USEPA
STD film
350 lb/a dose



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

Schedule D, Chart V. Protection for a 14-month crop. Telone II™, not flipped, followed by 1 pound active ingredient NemaCur (Fenamiphos) or Vydate (Oxamyl) monthly through emitter tubing with 12 inch or less emitter spacings (drip irrigation). Do not use Chart V if pencil-sized or larger viable roots are present in the top 12 inches of soil. **CHECK WITH COUNTY PESTICIDE USE ENFORCEMENT OFFICIALS PRIOR TO TREATMENT TO ENSURE COMPLIANCE WITH CURRENT STATE / COUNTY PESTICIDE USE RESTRICTIONS.**

Temperature	5 to 25° C		10 TO 25° C		15 to 20° C	
Soil Moisture	Sand	Loamy Sand	Sandy Loam	Loam	Clay Loam	Clay
2 to 6%	190 lbs. a.i.					
3 to 8%		190 lbs. a.i.				
4 to 9%			190 lbs. a.i.			
9 to 12%			285 lbs. a.i.			
6 to 9%				190 lbs. a.i.		
9 to 14%				285 lbs. a.i.		
14 to 18%						
8 to 12%					285 lbs. a.i.	
12 to 18%						
18 to 22%						
15 to 35%						

TOO DRY

TOO WET

➤ Numbers indicate the pounds of actual ingredient of Telone II™ (94% or 97.5% 1,3-dichloropropene) to apply per acre at a minimum depth of 16 inches and a chisel spacing of 30 inches (76 cm) or less. Treatment followed by ring roller or compaction device. Highest soil moisture percent in the top five feet of soil shall be considered. It is not necessary to apply monthly applications of NemaCur and Vydate until the crop is planted and the soil temperature exceeds 14°C at a depth of 12 inches.

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.

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



MATERIAL SAFETY DATA SHEET -HEALTH HAZARD INFORMATION (METHYL BROMIDE):

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.

GASOLINE:

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.

BLEACH:

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.

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)

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.

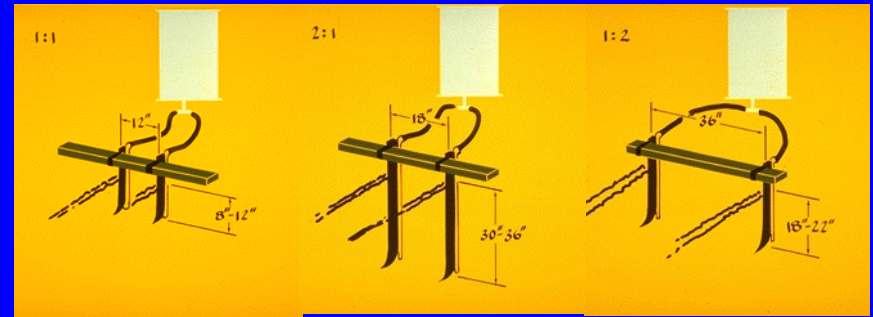
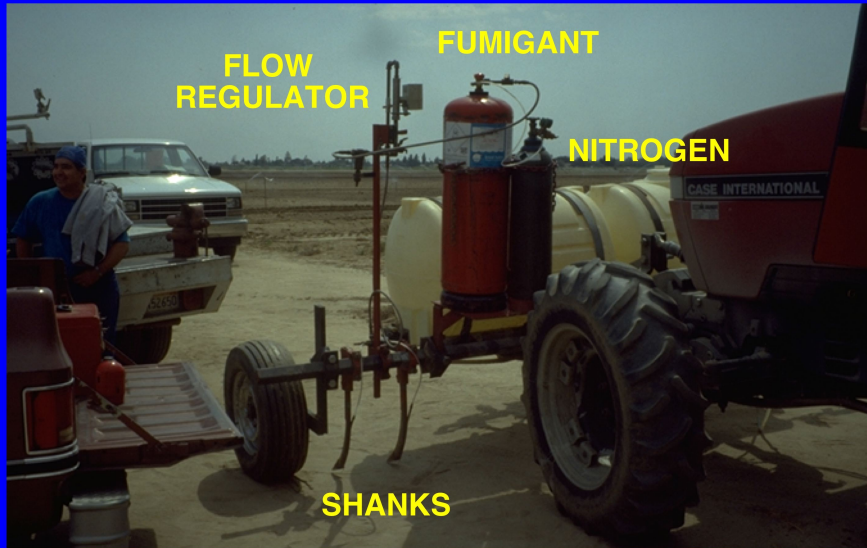
We have been using PRODUCT X for the past three years on carrots and melons and are very pleased with the results.

We had as good or better crops without using any chemical nematicide. " (Source: PRODUCT X AD)

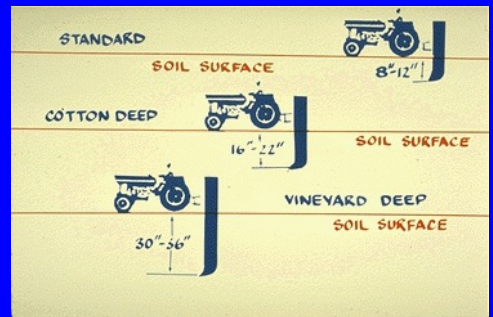
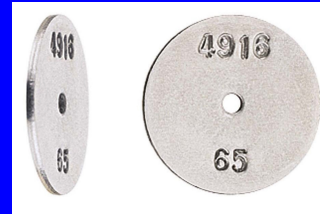
"It has no toxic materials, it is not a nematocide, and it does not kill nematodes. ... encourage and enhance those natural processes already present in the soil which could control non-beneficial nematodes. Practical field experience is showing that when used as a part of the integrated Company X system,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

(source: Agricultural Trade Journal, Summer 1990)

METHODS USED TO APPLY PRODUCTS TO SOIL



SHANK SPACING AND DEPTH OF INJECTION



SOIL SEALING AFTER INJECTION



PUMP DRIVEN APPLICATOR



PUMP DRIVEN APPLICATOR



NITROGEN PRESSURIZED APPLICATOR



WINGED SHANKS WITH SPRAY NOZZLES



SHANKS WITH SPRAY NOZZLES



SPRAY NOZZLES FOR MULTIPLE DEPTHS OF INJECTION



TURF GRASS INJECTION WITH COULTER CUTTERS



FLOOD APPLICATIONS OF ENZONE



ENZONE

SODIUM TETRATHIOCARBONATE

**RELEASES CS₂ IN SOIL
NEEDS TO BE APPLIED IN
IRRIGATION WATER**

**CA REGISTRATION ON
CITRUS, GRAPES,
ALMONDS, PRUNES,
PEACHES, PLUMS**

**REGISTRATION
WITHDRAWN**

**EQUIPMENT USED FOR INCORPORATION OF
NONFUMIGANTS CAN EFFECT EFFICACY**

LILLISTON ROLLING CULTIVATOR



ROTERA CULTIVATOR



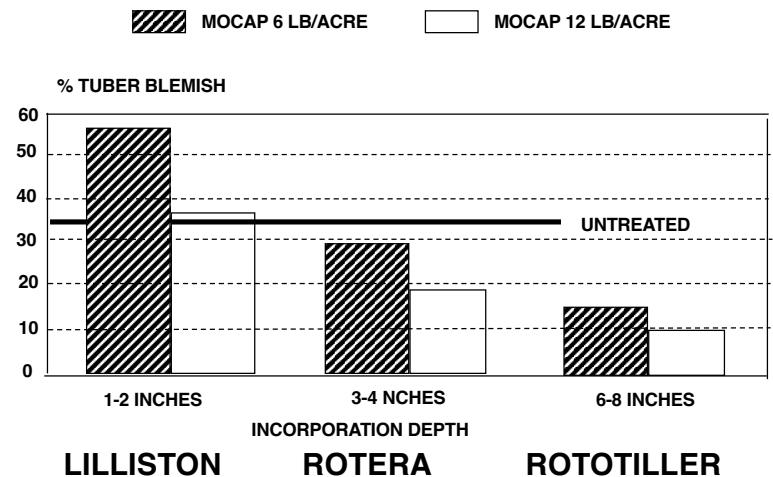
ROTOTILLER



POTATO



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



GRANULAR APPLICATOR



SPRINKLER APPLICATION OF METAM SODIUM



TRACTOR MOUNTED SPRAYER



DRIP IRRIGATION



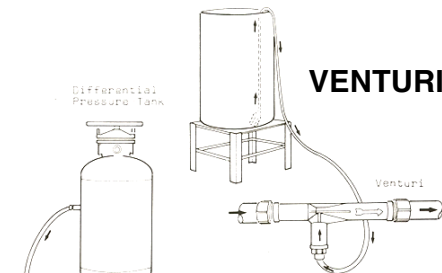
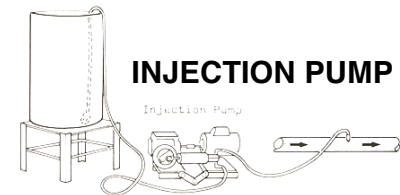
GANDY GRANULAR APPLICATOR



TRACTOR MOUNTED SPRAYER



TYPES OF APPLICATORS USED FOR DRIP IRRIGATION



TYPES OF APPLICATORS USED FOR DRIP IRRIGATION

INJECTION PUMP

VENTURI

DIFFERENTIAL PRESSURE TANK

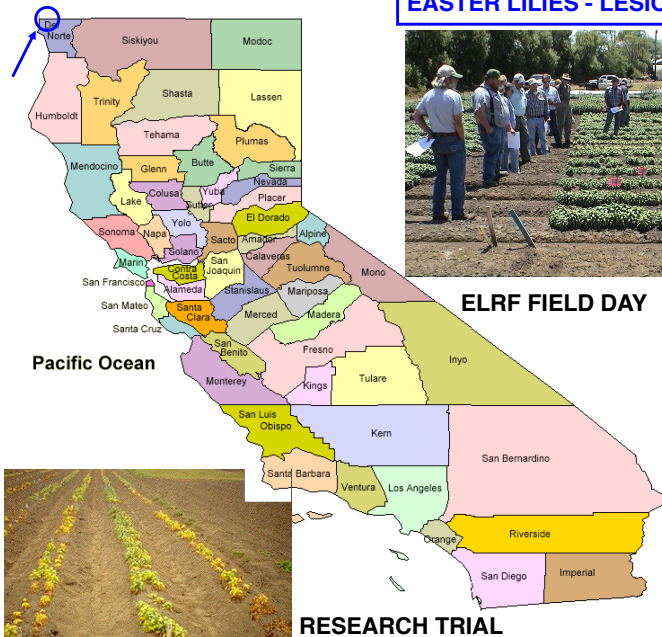


Drip Fumigation Equipment



EASTER LILIES - LESION (*P. PENETRANS*)

**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:

LESION NEMATODE (PRATYLENCHUS PENETRANS)

STANDARD TREATMENT -

DD PLUS TEMIK (ALDICARB)

(1,3-DICHLOROPROPENE+1,2-DICHLOROPROPANE)

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

(PAID 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)