2005 Agent Training on Methyl Bromide Alternatives

February 23, 2005

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Alternatives to consider on your Strawberry farm

Telone-C35
Metam Sodium
Telone-C35 + Metam Sodium (heavy weed pressure)
Chloropicrin + Metam Sodium or Herbicides

InLine (=EC formulation of Telone-C35)

(metam sodium = Vapam, Sectagon, Meta-CLR)
DOING AN ON-FARM TRIAL
For example: 3 treatments

Prefer non-fumigated row(s) – do you need to fumigate?

Randomize

Non-randomized

Harvest area
2005 ON-FARM-TRIALS

Site 1: North Carolina (Jones Co.)

Cooperators: Mark Seitz – Agent; Larry Ipock - Grower

Design: 200 foot rows, 30 inch beds, 60 inch row spacing; Randomization with 3 reps.

Treatments: MB, Telone-C35, Chloropicrin 99%
2005 ON-FARM-TRIALS

Site 2: Watkinsville, GA
Cooperators: Dr. Phil Brannen – Plant Pathologist, James Washington - Grower

Design: 500 foot rows, 32 inch beds, 60 inch row spacing; Randomization with 4 reps.

Treatments: MB, Telone–C35 + Vapam HL
Site 3: Virginia Beach, VA

Cooperators: Cal Schiemann-Agent, G.W. (Wink) Henley-Grower

Design: 290 foot rows, 26 inch beds, 60 inch row spacing; Randomization with 4 reps.

Treatments: MB, Telone –C35, Chloropicrin 99%
2004 ON-FARM-TRIALS

Site 3: Virginia Beach

Cooperators: Cal Schieman, Wink Henley

Design: 250 foot rows, 26 inch beds, 60 inch row spacing; Randomization with 4 reps.

Treatments: MB, Telone-C35, Chloropicrin
<table>
<thead>
<tr>
<th>Rep</th>
<th>Trt. #</th>
<th>Plant Source</th>
<th>Bed Width</th>
<th>Crown dry wt (g)</th>
<th>Leaf area</th>
<th>Leaf dry weight (g)</th>
<th>Root dry weight (g)</th>
<th>Root rot severity</th>
<th>Root hair rating</th>
<th>Percent</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>Telone-C35 + Vapam HL</td>
<td>17.0 gal/A + 37.5 gal/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>2</td>
<td>Methyl Bromide 67:33</td>
<td>200.0 lb/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>Telone-C35 + Vapam HL</td>
<td>17.0 gal/A + 37.5 gal/A</td>
<td></td>
<td></td>
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<tr>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>Telone-C35 + Vapam HL</td>
<td>17.0 gal/A + 37.5 gal/A</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>2</td>
<td>Methyl Bromide 67:33</td>
<td>200.0 lb/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>D</td>
<td>1</td>
<td>Telone-C35 + Vapam HL</td>
<td>17.0 gal/A + 37.5 gal/A</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Alternatives to Methyl Bromide: Pest Management Considerations

J.W. Noling
University of Florida, IFAS,
North Carolina State CES Agent Training
Raleigh, North Carolina
February 23, 2005
General IPM Considerations
Principal Pests - Soil

**Disease**
- Bacterial Wilt
- Southern Blight
- Fusarium Wilt
- Verticillium Wilt
- Pythium sp.
- Rhizoctonia sp.
- Fusarium Crown & Root Rot

**Nematode**
- Root-knot
- Sting
- Reniform
- Others

**Arthropod**
- Wireworm
- Mole Crickets
- Cutworms
- Others

**Weeds**
- Nutsedges
- Nightshades
- Many Others
- Others
Summary of the effectiveness of various soil fumigants for nematode, soilborne disease, and weed control

<table>
<thead>
<tr>
<th>FUMIGANT</th>
<th>NEMATODE</th>
<th>DISEASE</th>
<th>WEED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Methyl bromide</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Good to excellent</td>
</tr>
<tr>
<td>2) Chloropicrin</td>
<td>None to Poor</td>
<td>Excellent</td>
<td>None-Poor</td>
</tr>
<tr>
<td>3) Enzone</td>
<td>None - Some</td>
<td>None - Some</td>
<td>None - Some</td>
</tr>
<tr>
<td>4) MetamSodium</td>
<td>Erratic</td>
<td>Erratic</td>
<td>Erratic</td>
</tr>
<tr>
<td>5) Basamid</td>
<td>Erratic</td>
<td>Erratic</td>
<td>Erratic</td>
</tr>
<tr>
<td>6) Telone II</td>
<td>Good to Excellent</td>
<td>None to Poor</td>
<td>Poor</td>
</tr>
<tr>
<td>7) Telone C17</td>
<td>Good to Excellent</td>
<td>Good</td>
<td>Poor</td>
</tr>
<tr>
<td>8) Telone C35</td>
<td>Good to Excellent</td>
<td>Good to excellent</td>
<td>Poor</td>
</tr>
<tr>
<td>9) Potassium N-Methylthiocarbamate (Kpam)</td>
<td>Erratic??</td>
<td>Erratic??</td>
<td>Erratic??</td>
</tr>
</tbody>
</table>

Noling Efficacy Scale—Not to be construed as Gospel
**LEACHING or SOIL RESIDENCE TIME AS A SOURCE OF INCONSISTENCY and as CONTAMINANTS OF GROUNDWATER**

<table>
<thead>
<tr>
<th>ALDICARB</th>
<th>PHENAMIPHOS</th>
<th>ETHOPROP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986-Mi, IND, AR, NC,</td>
<td>1994-Hawaii</td>
<td></td>
</tr>
<tr>
<td>Virg, Wash, Wisc, MA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1988-Florida</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990-New York</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CARBOFURAN</th>
<th>TERBOFOS</th>
<th>1,3-D</th>
<th>MBr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990-Montana</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1994-Maryland</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CHANGES - 1,3-D REGULATORY CONSTRAINTS:

- PERSONAL PROTECTIVE EQUIPMENT for PRE BED Applications w/ Yetter System – “SAFETY GLASSES”
  Otherwise, Chemical Resistant Gloves, Boots, Half-Face Respirator

- TREATMENT BUFFER ZONES
  “100 ft of WELL or OCCUPIED STRUCTURE”
  - 5 Day Re-Entry Period, not areas over Karst, other hydrology...
INTEGRATION of CHEMICALS

TELONE (1,3-D) – nematode
CHLOROPICRIN - disease
and
COMPLIMENTARY HERBICIDE(S)

BOTH TELONE and CHLOROPICRIN in BED

Followed by:

TELONE BROADCAST
Before BEDDING

CHLOROPICRIN in the BED

+ herbicide(s)
Fig. 8. Summary of tomato yields with various alternative chemical and nonchemical treatments relative to yields obtained with methyl bromide (expressed as a proportion) in six USDA sponsored small research plot trials Spring 1998 - Spring 2001.

**TOMATO – SMALL PLOT TRIALS (1998-01)**

**Relative Tomato Yield (0-1)**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield (0-1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MBr</td>
<td>1.0213</td>
</tr>
<tr>
<td>1,3 D + PIC</td>
<td>1.0000</td>
</tr>
<tr>
<td>C17 In-row</td>
<td>0.9407</td>
</tr>
<tr>
<td>C35 In-row</td>
<td>0.969</td>
</tr>
<tr>
<td>C35 BC</td>
<td>0.902</td>
</tr>
<tr>
<td>Vapam</td>
<td>0.847</td>
</tr>
<tr>
<td>Solarization</td>
<td>0.765</td>
</tr>
<tr>
<td>Check</td>
<td>0.567</td>
</tr>
</tbody>
</table>

**METHYL BROMIDE**
Fig. 4. Summary of tomato yields with Telone C17 or Telone C35 fumigant treatment relative to yields obtained with methyl bromide (expressed as a proportion) in six USDA sponsored large scale field demonstration trials conducted Spring 1996 - Spring 2001.


**RELATIVE TOMATO YIELD (0-1)**

```
  1.1
  1
  0.9
  0.8

Mbr 1

Telone C-17
- In-row 0.96
- Broad Cast 0.808

Telone C-35
- In-row 1.004
- Broad Cast 0.938

1,3-D Brdcst + Pic inbed 1.0213
```

Legend:
- mbr
- C17inrow
- C17brdcst
- C35inrow
- C35brdcst
- 1,3-D+PIC
CONSISTENCY IMPROVED
Telone II or C-35 Broadcast w/ Yetter System

Particularly with additional Choropicrin (100-150 lb) at the time of Bedding
Fig. 9. Summary of strawberry yields with various alternative chemical and nonchemical treatments relative to yields obtained with methyl bromide (expressed as a proportion) in eight USDA sponsored small research plot trials Spring 1998 - Spring 2001.

**STRAWBERRY - SMALL PLOT TRIALS (1998-01)**

**RELATIVE STRAWBERRY YIELD (0-1)**
BASIC REPLICATED - 2 row - UNITS - CARL GROOMS FIELD TRIAL - FALL 2004

50 % MeBr 50 % PIC
50 % MeBr 50 % PIC
PIC + GOAL
PIC + GOAL
25% of MeBr (98/2) + VIF
25% of MeBr (98/2) + VIF
50% of MeBr (98/2) + VIF
50% of MeBr (98/2) + VIF
MeBr (98/2) - Grower Standard
MeBr (98/2) - Grower Standard

% Plants < 12" diameter

% of Row w/ Dense Nutsedge
Fig. Influence of fumigant on tomato root gall severity. Spring 2000

- Untreated Control
- Basamid
- Metham Sodium
- Telone II
- Telone C-17
- Telone C-35
- Methyl Bromide

ROOT GALL SEVERITY (0 – 8)

Other studies have documented similar results for weed efficacy.
Figure 5. Effect of fumigant treatment on survival of *Fusarium oxysporum f.sp. lycopersici* Race 3 at three soil depths in field microplots, CREC, Lake Alfred, FL. Spring 2000.

Log\(_{10}(x+1)\) Propagules / gram soil

<table>
<thead>
<tr>
<th>SOIL DEPTH (cm)</th>
<th>Untreated Control</th>
<th>Telone II</th>
<th>Telone C17</th>
<th>Telone C35</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

AOV
- Fumigant: P<0.0001
- Depth: P<0.0001
- Interaction: P<0.006
General Conclusions

TELONE + CHLOROPICRIN

- 1,3-D poorly herbicidal & fungicidal in activity

- Broadspectrum activity synergized by Chloropicrin

- Telone C-35 ‘next best’ Alternative to MBr
INTEGRATION of NEW FUMIGANT APPLICATION TECHNOLOGY

OLD SYSTEM  →  PRESENTLY

Disking & Rolling Required

No Disking & Rolling

Yetter Coulter System

Less in Air, More in SOIL
IMPROVED CONSISTENCY
INTEGRATING NEW PLASTIC MULCH TECHNOLOGY

Fumigant Rate & Emission Reductions with VIF

(mandatory CUE requirement?)

VIF + 100%

VIF + 25%

VIF + 0%

VIF + 0% (75% Less!)

LDPE
18 VIF Trials

- No Major Differences
- Weed Control Observed even when rates reduced as much as 50%
WEED DENSITY / 15 m row

AHF Trial – Fall 2003
P = 0.001

Nutsedge

<table>
<thead>
<tr>
<th>Percent of Standard Dose</th>
<th>0 VIF</th>
<th>25 VIF</th>
<th>50 VIF</th>
<th>100 LBPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>No MBr</td>
<td>50</td>
<td>40</td>
<td>30</td>
<td>20</td>
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</table>

JSF Trial – Fall 2001
P = 0.056

Nutsedge

<table>
<thead>
<tr>
<th>Percent of Standard Dose</th>
<th>37.5 VIF</th>
<th>50 VIF</th>
<th>100 LBPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIF</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

NFF Trial – Fall 2001
P = 0.006

Nutsedge

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<thead>
<tr>
<th>Percent of Standard Dose</th>
<th>60 VIF</th>
<th>80 VIF</th>
<th>100 LBPE</th>
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<tbody>
<tr>
<td>VIF</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

CHF Trial – Fall 2000
P = 0.0001

Nutsedge

<table>
<thead>
<tr>
<th>Percent of Standard Dose</th>
<th>0 VIF</th>
<th>50 VIF</th>
<th>100 LBPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIF</td>
<td>0</td>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>
## INSTALLATION DELAYS:

- 8 of 18 Demonstration sites during 2000-2004 reported plastic laying problems. Tractor speeds reduced to 2-3 mph.

<table>
<thead>
<tr>
<th>Fall Trials</th>
<th>Film</th>
<th>Installation Speed (mph)</th>
<th>Installation Speed (mph)</th>
<th>Grower Film</th>
</tr>
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<tbody>
<tr>
<td>Artesian 2004</td>
<td>IPM</td>
<td>3.6</td>
<td>4.8</td>
<td>Metalized</td>
</tr>
<tr>
<td>Grooms 2004</td>
<td>Greek</td>
<td>1.6</td>
<td>4.9</td>
<td>Pliant 1mil</td>
</tr>
<tr>
<td>Young 2004</td>
<td>IPM</td>
<td>1.2*</td>
<td>4.8</td>
<td>Pliant 1mil</td>
</tr>
<tr>
<td>Herndon 2004</td>
<td>Klerk</td>
<td>2.0</td>
<td>4.3</td>
<td>Pliant 1mil</td>
</tr>
<tr>
<td>Dover 2004</td>
<td>IPM</td>
<td>2.3</td>
<td>5.1</td>
<td>Pliant 1mil</td>
</tr>
</tbody>
</table>

*This site, like unreported others, encountered extreme, unresolved difficulties such as press wheel slippage, curling of the film, defective spooling, and two row machines.*
Some Metalized mulches used for Thrips, Whitefly, and Virus Disease Management have Virtually Impermeable Film Qualities, are cheaper, USA produced, and are easier to lay. HOWEVER......

"ALL METALIZED MULCHES DO NOT APPEAR TO BE CREATED EQUAL"
GENERAL CONCLUSIONS

- VIF maintained treatment efficacy
- Obvious limits to Rate Reductions
- Difficulties remain for speedy installation
- Patience & Problem Solving Attitude
- Metalized Mulches?
**Principal Objective:**

Characterize movement and resultant spatial distribution of a chemigated, water soluble blue dye in soil

**Variables Examined:**

Injection Period, Tube Numbers, Flow Rates, Emitter Spacings, Soil Compaction, Pulsing, Adjuvants, others...
MAXIMIZING CHEMIGATIONAL EFFICACY
GRID EVALUATION METHOD FOR MEASURING WIDTH, DEPTH, AND AREA OF DRIP WATER MOVEMENT

Mapped grid coordinates were then entered into the computer to analyze size of treated or dye stained areas relative to Bed Size, Run Time, Water Volume, Tape Number, and other treatment regimes.
General Result: Much of previous chemigation research evaluated suboptimal irrigation regimes.

Top View

Diam. = 10”

X-section at Emitter
Depth = 8-10”

X-section between Emitters

Longitudinal X-section

Treatment: 2 hr Chemical Injection Period
CHEMIGATION RESEARCH RESULT: SOME SITES CANNOT BE EFFECTIVELY TREATED
INTEGRATING IRRIGATION & PEST MANAGEMENT

144 gal / 100 ft row, 4 hr

288 gal / 100 ft row, 8 hr

432 gal / 100 ft row, 12 hr

% BED TREATED

150-200 gallons per 100 ft of row
Within 16” soil depth

Water Volume (gal/100 ft row)
General Results: “BED WETTING” RESEARCH

• In no treatment did bed shoulders or other substantive areas receive treatment. Max. Bed: 50-60%

“As an Alternative Strategy to Methyl Bromide”

• At least two drip tubes per bed will be required to achieve complete bed coverage of a chemigated compound

• Growers should consider their own on-farm, independent evaluations
SITE S: Metham Sodium (60 gal/a) and Telone EC (12 gal/a) applied continuously in 4 hr run time for post harvest crop destruction/nematode control. Bradenton, FL

**EARLY CROP DESTRUCTION / DOUBLE CROPPING**
Importance of Central Drip Tape Placement and Adequate Line Pressure To Maximize Bed Coverage with Chemigated products

**Drip Tape Distant from Plant**
- Untreated Zone
- Zone of Fumigant Movement
- 5-10 inches

**Drip Tape Central Closer to Plant**
- Plant
- Bed
- Drip Tape Central
- Zone of Fumigant Movement
- Water Phase
Effects of Metam-Sodium Applied by Drip Irrigation

**M-S treatment effective against**

*M. incognita only* when at least 50% of bed width was treated.

*Roberts et al., 1988. Plant Disease 72:213-217*
CROP RESCUE

• Nematode Induced Problems Often Develop during Primary and or Secondary Crops which follow

NONFUMIGANT NEMATICIDES  CROP RESCUE

"THE REALITY: THERE ARE VERY FEW, AND FOR MANY CROPS, NO POST PLANT NEMATODE MANAGEMENT OPTIONS"
Effect of Pulsing on Resultant Dye and Drip Water Distribution

“Bed X-Section on the Emitter”

1x

H₂O

1x

IMPACT of SUBSEQUENT IRRIGATIONS:
NO APPARENT DILUTION / INTERMIXING
Previous applications driven radially outward & Down!
Effect of a 30 min. Line Flush on Resultant Dye and Drip Water Distribution

“Bed X-Sections on the Emitter”

Is it any wonder we have difficulties obtaining Efficacy when Little or no dilution or intermixing occurs, and Water Fronts move radially outward & Down!

Noling et.al., 2001
Understanding Nematostatic Activity: 'the Stupor Effect'

CONCENTRATIONS (ppm) Required to Affect Stages of *Meloidogyne* Life Cycle

<table>
<thead>
<tr>
<th>Product</th>
<th>Hatch</th>
<th>Migration</th>
<th>Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aldicarb</td>
<td>&gt;8</td>
<td>&gt;2</td>
<td>&gt;4</td>
</tr>
<tr>
<td>Fenamiphos</td>
<td>&gt;2</td>
<td>&gt;2</td>
<td>&gt;4</td>
</tr>
<tr>
<td>Ethoprop</td>
<td>&gt;2</td>
<td>&gt;4</td>
<td>&gt;4</td>
</tr>
</tbody>
</table>

*McLeod and Khair, 1974*

Bottom Line:
To be effective as Nematostats: Must Maintain Toxic Concentration.
Most Nonfumigant Nematicides Function:

DELAYING
THE TIME OF ARRIVAL

ALDICARB    OXAMYL
PHENAMIPHOS  ETHOPROP
MOST OTHER NONFUMIGANTS

30 DAYS OF REPRIEVE...is usually enough to achieve desired yield response, HOWEVER, final harvest population levels of nematodes is oftentimes higher in nonfumigant treated areas.
SIMULATING THE IMPACT & DISPERSION of a CHEMIGATIONAL NEMATICIDE USING INDIRECT MEASURES:

Cylindrical Volumes of ‘Steamed’ Soil
Noling, 1993

- Yield response linearly correlated with treated soil volume

Steam Pasteurized Soil

Nematode Infested Soil

16"

12"

9"

6"

3"
**CHEMIGATION**

*What Does the Literature Say:*

- **MOST WATER SOLUBLE NEMATICIDES LOSE THEIR EFFECTIVENESS BETWEEN 2\(^{\text{nd}}\) AND 4\(^{\text{th}}\) WEEK AFTER APPLICATION**

- **SPLIT better than SINGLE APPLICATIONS**
  - i.e., 6X better than 3X, 3X better than 1X
Time of Discovery / Postplant Treatment Initiation

"Is it ever too late to initiate treatment"

ROOT GALL SEVERITY (0-8)

AOV Time  P=0.0001

Started 3 weeks post plant

OXAMYL TREATMENT INITIATION
(weeks prior to harvest)

Noling, 1998  "Sooner weekly treatments initiated the better"
Integration of New CULTURAL PRACTICES

Influence of Soil Compaction On Diffusion of Fumigants
Soil Compaction Layer as Barrier to Water Infiltration

Cross Sectional Views (inches)

On the Emitter

- bed
- 250.3 in² (80%)
- 80.8% of Bed

Between the Emitter

- 155.3 in² (88%)
- 50.1% of Bed

Compacted traffic layer

The dye hit the compacted traffic layer and then flooded into middles
EXPERIMENTAL DESIGN

LAND PREPARATION:

+ With CHISEL PLOW
- WITHOUT CHISEL PLOW

CHEMICAL TREATMENTS

In-Row Methyl Bromide (350 lb/a)
In-Row Telone II (18 gal/a)
Broadcast Telone II (18 gal/a)

MEASURED SOIL GAS CONC. (6 & 18"")
6 Reps / Trtmt
MEASURED GAS CONCENTRATIONS – 2 SOIL DEPTHS

Gas Concentrations Measured with GasTek Model GV-100 Vacuum Pump using either No. 132 HA (1,3-D) No. 136H (MBr) Detector Tubes

- Fumigant Plume
Soil Compaction Layer in Fields Everywhere
SEVERELY RESTRICTED FUMIGANT MOVEMENT

possible Cause of Treatment Inconsistency!

Soil Traffic - Compaction Layer

Restricted Fumigant Penetration into deeper soil

Fumigant Knife & plume
"in or above compacted zone"

6-8"

6-18"

Soil surface

Travel
Unless destroyed by CHISEL PLOWING before injection, the presence of a soil compaction layer RESTRICTED downward diffusion of Telone (1,3-d) (and possibly MBr).

To Maximize Distribution, Efficacy, & Consistency, MUST Chisel Plow Soil before Telone injection, particularly BROADCAST APPLICATIONS.
The Importance and Interaction of Weeds for Nematode Management
Working Hypothesis:
Weed density and diversity to increase in the Post Methyl Bromide Era
OBJECTIVES:
Characterize weed host status to species of *Meloidogyne* and field impacts to population growth

Eight Locations:
- Plant City
- Baum
- LaBelle
- Boynton Beach
- Naples
- Immokalee
PROCEDURE

- Nematode Infested Fields Identified
- Plant Roots Carefully Excavated & Returned to Lab (nonrandom sampling)
- Roots Stained to Locate Egg masses
- Egg Masses per gram root indexed
**Florida Weed / Nematode Host Survey**

**Egg Mass Index / g root**

<table>
<thead>
<tr>
<th>Egg Mass</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-0</td>
<td>None</td>
</tr>
<tr>
<td>1-10</td>
<td>Light</td>
</tr>
<tr>
<td>2-50</td>
<td>Moderate</td>
</tr>
<tr>
<td>3-100</td>
<td>Heavy</td>
</tr>
<tr>
<td>4-100+</td>
<td>Very Heavy</td>
</tr>
</tbody>
</table>
Figure 1. Heavy galling of pigweed roots by root knot nematode, Melodigyne spp.
Fig. 2. Heavy galling of black nightshade by root knot nematode, *Melodigyne* spp.
Figure 3. Heavy galling of purslane roots by root knot nematode, *Melodigyne* spp.

“Egg masses Stained in Red”
### Table 2. Results of Field Survey Demonstrating the Capacity of Different Weeds to Support Root-Knot Nematode Reproduction

<table>
<thead>
<tr>
<th>Weed Species</th>
<th>Reproductive Index (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pigweed</td>
<td>Heavy – Very Heavy</td>
</tr>
<tr>
<td>Purslane</td>
<td>Very Heavy</td>
</tr>
<tr>
<td>Nightshade</td>
<td>Few – Very Heavy</td>
</tr>
<tr>
<td>Eclipta</td>
<td>Moderate - Heavy</td>
</tr>
<tr>
<td>Ragweed</td>
<td>None - Few</td>
</tr>
<tr>
<td>Clover</td>
<td>Very Heavy</td>
</tr>
<tr>
<td>Sesbania</td>
<td>Very Heavy</td>
</tr>
<tr>
<td>Sand Vetch</td>
<td>Very Heavy</td>
</tr>
<tr>
<td>Goosegrass</td>
<td>Few - Very Heavy</td>
</tr>
<tr>
<td>Crabgrass</td>
<td>None - Few</td>
</tr>
<tr>
<td>Carolina Geranium</td>
<td>Very Heavy</td>
</tr>
<tr>
<td>Cutleaf Primrose</td>
<td>Moderate</td>
</tr>
<tr>
<td>Gnaphalium</td>
<td>Moderate</td>
</tr>
<tr>
<td>Cudweed</td>
<td>None - Few</td>
</tr>
<tr>
<td>Yellow Nutsedge</td>
<td>Few</td>
</tr>
</tbody>
</table>

- Key Florida Species (Weed Density x Index)
Figure 4. WEED MANAGEMENT-ROW MIDDLES-

- Periodic Herbicide
- Ground Cloth
- Rotovation

Early Season  Final Harvest
Fig. 5. Number of root-knot nematodes from row middles, raised plant beds, or below ground cloth cover in nonfumigated (check) or soil fumigated locations. Weed / Middles ManagementGround Cloth Trial – Fall 2002

Numbers J2 Meloidogyne / 100 cc Soil

After 1st pepper crop
Fig. 6. Number of root-knot nematodes from row middles, raised plant beds, or below ground cloth cover in nonfumigated (check) or soil fumigated locations. Weed / Middles Management Ground Cloth Trial – Spring 2003

Numbers J2 *Meloidogyne* / 100 cc Soil

<table>
<thead>
<tr>
<th>Treatment</th>
<th>J2 Nematodes per 100 cc Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fumigant</td>
<td>Mbr Bed (0.0)</td>
</tr>
<tr>
<td></td>
<td>C35 Bed (0.0)</td>
</tr>
<tr>
<td></td>
<td>Ground Cloth Middle (0.0)</td>
</tr>
<tr>
<td>Untreated Middles</td>
<td>P = 0.019</td>
</tr>
</tbody>
</table>

Final Harvest 1st crop tomato F&F Farms, Spring 2003
GENERAL CONCLUSIONS

- Host range is wide, with few nonhosts

- Nematode population growth can be extensive, and is functionally related to weed density and root biomass

- Nematodes cannot be effectively managed without simultaneous consideration of weed management
GENERAL CONCLUSIONS

DOES LONG TERM NEED FOR SOIL FUMIGATION
ARISE FROM WEED GROWTH IN MIDDLES?

Population
Doubling-Tripling
Effect?
### Herbicide Selection MATRIX to simultaneously consider PRIORITY weeds for nematode control

**INTEGRATED PEST MANAGEMENT - TOMATO**

<table>
<thead>
<tr>
<th>Weed Species</th>
<th>Post Emergence</th>
<th>Pre Emergence</th>
<th>Nematode Priority Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dacthal</td>
<td>Sencor</td>
<td>Poast</td>
</tr>
<tr>
<td>Sedges</td>
<td>Poor</td>
<td>Poor</td>
<td>?</td>
</tr>
<tr>
<td>Grasses</td>
<td>F-G</td>
<td>P-F</td>
<td>G-E</td>
</tr>
<tr>
<td>Pigweed</td>
<td>F-G</td>
<td>G</td>
<td>NONE</td>
</tr>
<tr>
<td>Primrose</td>
<td>F-G</td>
<td>E</td>
<td>NONE</td>
</tr>
<tr>
<td>Eclipta</td>
<td>?</td>
<td>F-G</td>
<td>NONE</td>
</tr>
<tr>
<td>Pusley</td>
<td>F</td>
<td>G</td>
<td>F-G</td>
</tr>
<tr>
<td>Purslane</td>
<td>G</td>
<td>G</td>
<td>NONE</td>
</tr>
<tr>
<td>Nightshade</td>
<td>F</td>
<td>Poor</td>
<td>NONE</td>
</tr>
<tr>
<td>Ragweed</td>
<td>?</td>
<td>G</td>
<td>NONE</td>
</tr>
</tbody>
</table>

**NONE** Poor **P-F** Fair **F-G** Good **G-E** Excellent
Need for Integrated System

With MBr: SAMPLING NOT REQUIRED!

After MBr: More Complex Decision Making Process regarding Selection & Integration of Alternatives

New IPM Requirements:
- ECONOMICALLY ACCEPTIBLE
- PEST MONITORING PROGRAMS !!!
Grower Conducted Surveys for Field Diagnosis and Sampling for Root-Knot Nematode Based on Root Gall Indices.
PATTERN OF PLANT REMOVAL

FIGURE 1.

The basic sampling unit: A grower defined spray block or land

Sites for removal and gall indexing of a crop plant based on 50 ft increments of plant row.
Rating scheme for evaluation of root-knot infestation

VISUAL ACUITY OF GROWER ROOT GALL = 5.0
Designed Computer Simulation to Randomly & Repeatedly Subsample Each Dataset by SPRAY BLOCK 250 times:

(6 row)

"Randomly Selected" within
WHOLE BLOCKS

2 plants

4 plants

24 plants

"Randomly Selected" only from MIDDLES

- VS -
The sampling scheme must exhibit:

**PRECISION**
Frequency in which Sample Mean is Less than or Greater than defined level of Accuracy

(20 or 25%)
Figure 11. Spatial distribution of root knot nematode galling on roots of eggplant in a commercial field.
Figure 12. Spatial distribution of root knot nematode galling on roots of zucchini in a commercial field.
No. PLANT SAMPLES REQUIRED FOR RISK TAKERS WHO CONSIDER ONLY UNDERESTIMATES - WITH MORE RISK AVERSE PEOPLE WHO CANNOT ACCEPT EITHER UNDERESTIMATES OR OVERESTIMATES OF THE TRUE MEAN MORE THAN 25% OF THE TIME.

TYPES OF RISK TAKERS:

More Risk Averse (Coward)
'Under + Overestimates'

Less Risk Averse (Cowboy)
'Only Underestimates'

10 Plants

4 Plants

The less risk you accept the more the sample requirement.

25% Precision (1 in 4)
Plant Sample Requirements for estimates within 25% of mean; 80% of time

- Fewer samples required from field centers than from whole field.
- Fewer samples required as nematode field severity and distribution increases.
GENERAL CONCLUSIONS

- Numbers of Plant Samples per Spray Block Dependent upon Overall FIELD Infestation Level

- Higher the Overall FIELD Infestation level The Fewer the Plant Samples Required

- The Less Risk a Person is Willing to Accept, The More Samples Required
GENERAL CONCLUSIONS (cont’)

In-Field ROOT GALL Bioassay Technique
Accurate / Reliable System for:
Nematode Population / Disease Assessment

WITH AS FEW AS:

4 - 5 Plants / 6 row Spray Block
(8 Plants / acre)
GENERAL CONCLUSIONS

POST METHYL BROMIDE ERA

Requirements:

INTEGRATED STRATEGIES

- Chemical Combinations
- New Land Preparation Requirements
- Chemigation Considerations
- Coupling Weed Management Tactics
- Nematode Monitoring Systems
Even with Integrated Systems: “RESPONSE INCONSISTENCY”

CONTRIBUTING FACTORS: (controllable / uncontrollable)

- CHEMICAL
- PHYSICAL
- BIOLOGICAL
- ENVIRONMENTAL
- HUMAN

Bottom line: With Alternatives: SOME INCONSISTENCY IS UNAVOIDABLE
Tactic Transferability:

Physical, Chemical, Cultural, Biological Approaches:

EDAPHIC

CLIMATIC

BIOTIC

TACTICS CAN’T GO EVERYWHERE, ENFORCING INDEPENDENT DEVELOPMENT & EVALUATION
LONG TERM IMPACTS & DOUBLE CROPPING

A Biorational

Methyl Bromide

Pickles following fumigated Pepper
Definition of Rate:

One Acre
43,560 sq ft

Broadcast Rate:

<table>
<thead>
<tr>
<th>Form.</th>
<th>Rate</th>
<th>Metric Ai Eq</th>
</tr>
</thead>
<tbody>
<tr>
<td>98/2</td>
<td>400 lb/a</td>
<td>43.9 g ai / m²</td>
</tr>
<tr>
<td>67/33</td>
<td>350 lb/a</td>
<td>26.3 g ai / m²</td>
</tr>
</tbody>
</table>

Per Treated Acre:

14,520 Linear Feet of Treated Row is one acre (43,560 ft²)

Form. Rate Metric Ai Eq

<table>
<thead>
<tr>
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</tr>
<tr>
<td>67/33</td>
<td>350 lb/a</td>
<td>26.3 g ai / m²</td>
</tr>
</tbody>
</table>

Plastic covered 3ft wide beds with row spacings of 6 feet
Black Root Rot of Strawberry and Phytophthora crown rot
Strawberry healthy roots (A) as compared with those of Black Root Rot (B). Close up of diseased root (C,D). Observe fungal mycelia in D.
Procedure

RHIZOCTONIA SPP., FUSARIUM SPP., OTHER FUNGI

ALKALINE WATER AGAR (AWA)

PYTHIUM SPP., OTHER FUNGI

CORN MEAL AGAR + ANTIBIOTICS (PARP)

PDA 30

CMA

GRASS-LEAF-WATER
Monilioid cells of *R. fragariae* = A, B, C, and *R. solani* = D
Anamorph stage (A), Sporangium (S), vesicle (V) and teleomorph (T), Antheridium (A), Oogonium (Og), and Oospore (O) of *Pythium* spp.
Fig. 3 . Colony morphology of *R. fragariae* = A, B, C, and *R. solani* = D in PDA 30
Pathogens to Control

- *Rhizoctonia fragariae*: AG-G, AG-A, AG-I
- *Pythium irregulare*, *Pythium spinosum*, *Pythium artotrogus*, *Pythium HS*
- *Fusarium solani* and *Fusarium oxysporum*
Table 1. Distribution of organisms isolated from strawberries affected with Black root rot disease in North Carolina. Year 1998

<table>
<thead>
<tr>
<th>FUNGI</th>
<th>LOCALITIES</th>
<th>FLETCHER</th>
<th>VOLLMER</th>
<th>PLYMOUTH</th>
<th>CLAYTON</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhizoctonia spp.</td>
<td></td>
<td>50</td>
<td>15</td>
<td>9</td>
<td>2</td>
<td>76</td>
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<tr>
<td>R. fragariae</td>
<td></td>
<td>30</td>
<td>15</td>
<td>6</td>
<td>2</td>
<td>53</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td>11</td>
<td>7</td>
<td>3</td>
<td></td>
<td>21</td>
</tr>
<tr>
<td>I</td>
<td></td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>G</td>
<td></td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>unknown</td>
<td></td>
<td>9</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>18</td>
</tr>
<tr>
<td>R. solani AG4-HGIII</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Rhizoctonia sp.</td>
<td></td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td>23</td>
</tr>
<tr>
<td>Pythium spp.</td>
<td></td>
<td>12</td>
<td>9</td>
<td>21</td>
<td>47</td>
<td>89</td>
</tr>
<tr>
<td>P. artotrogus</td>
<td></td>
<td>4</td>
<td></td>
<td>4</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>P. irregulare</td>
<td></td>
<td>1</td>
<td>6</td>
<td>23</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>P. paroecandrum</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>P. ultimum</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Pythium “F”</td>
<td></td>
<td>10</td>
<td></td>
<td>10</td>
<td>23</td>
<td>43</td>
</tr>
<tr>
<td>Pythium “HS”</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>Pythium sp.</td>
<td></td>
<td>10</td>
<td></td>
<td>10</td>
<td>23</td>
<td>43</td>
</tr>
<tr>
<td>Fusarium spp.</td>
<td></td>
<td>7</td>
<td>4</td>
<td>13</td>
<td>9</td>
<td>33</td>
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<td>F. oxysporum</td>
<td></td>
<td>1</td>
<td></td>
<td>2</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>F. solani</td>
<td></td>
<td>2</td>
<td>6</td>
<td>1</td>
<td>9</td>
<td></td>
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<tr>
<td>Fusarium sp.</td>
<td></td>
<td>4</td>
<td>2</td>
<td>7</td>
<td>8</td>
<td>21</td>
</tr>
<tr>
<td>OTHERS</td>
<td></td>
<td>10</td>
<td>7</td>
<td>8</td>
<td>21</td>
<td>46</td>
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<tr>
<td>Alternaria sp.</td>
<td></td>
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<td>2</td>
<td>2</td>
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<tr>
<td>Aspergillus sp.</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Cephalosporium sp</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Cylindrocarpon sp</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Cylindrosorium sp</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Epicoccum sp.</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Mucor sp.</td>
<td></td>
<td>7</td>
<td>2</td>
<td>1</td>
<td>6</td>
<td>16</td>
</tr>
<tr>
<td>Penicilium sp.</td>
<td></td>
<td>1</td>
<td>3</td>
<td></td>
<td>7</td>
<td>11</td>
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<tr>
<td>Trichoderma sp.</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>1</td>
<td>4</td>
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<tr>
<td><strong>TOTAL OF ISOLATES</strong></td>
<td></td>
<td><strong>50</strong></td>
<td><strong>15</strong></td>
<td><strong>9</strong></td>
<td><strong>2</strong></td>
<td><strong>76</strong></td>
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</tbody>
</table>
Phytophthora Crown Rot:
Tomato Diseases
<table>
<thead>
<tr>
<th>Tomato Disease</th>
<th>Resistance</th>
<th>Avoidance</th>
<th>Cultural practices</th>
<th>Funigate</th>
<th>Chemical</th>
<th>Other</th>
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<tbody>
<tr>
<td>Verticillium race 1</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verticillium wilt race 2</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>Southern bacterial wilt</td>
<td>?</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fusarium race 1</td>
<td></td>
<td></td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fusarium wilt race 3</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Southern stem blight</td>
<td></td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Root knot nematodes</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Phytophthora</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Pith necrosis</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pythium root rot</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>
PRIMARY SOILBORNE DISEASES

Verticillium wilt    race 2
Southern bacterial wilt
Fusarium wilt race 3
Southern Stem Blight
DAMPING OFF
Figure 1. Symptoms of pith necrosis:

A. Four-week-old “Mountain Pride” tomato plants. Note stunting of the diseased plant.

B. Internal appearance of the main stem of the diseased plant shown in (A). Note discoloration, hollowing, and adventitious root initials in the pith.

C. Pith necrosis in a ten-week-old “Mountain Delight” tomato plant. Note browning of the stem and collapse of several leaf petioles. Even with severe pith necrosis, this plant is still bearing fruit.

D. Internal appearance of the main stem of the diseased plant shown in (C). Note dark brown discoloration and disking in the pith.

E. Severe pith necrosis. Note adventitious roots in affected area.
Tomato Root Knot Nematode
Mature Female
38x 97-5196
PEPPER PHYTOPHTHORA CROWN & ROOT ROT
SYMPTOMS: FOLIAR BLIGHT/FRUIT ROT
SYMPTOMS: PROCESSING/FRESH
## Fumigants and Methods of Application

<table>
<thead>
<tr>
<th>Fumigant</th>
<th>Plant Back</th>
<th>DRIP</th>
<th>SHANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telone-C35</td>
<td>21 days</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>InLine</td>
<td>21 days</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Chloropic</td>
<td>14-21 days</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Vapam / K-Pam</td>
<td>14-21 days</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Midas (iodomethane)</td>
<td>7-14 days</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>SEP-100 (sodium azide)</td>
<td>14 days</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Propozone (propylene oxide)</td>
<td>14-21 days</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
30 inch beds on 5 foot centers
= 2.5 ft wide beds and 2.5 ft wide alleys

43560 sq ft per acre/2.5 feet bed width
= 17,424 but only half is under plastic
= 8,712 linear feet under plastic/physical acre
= 21,780 sq ft is treated

Telone C35 Broadcast application Rate
35 gallons/acre

Thus, we would apply T-C35 at a rate of 35 gallons/treated acre (43560 sq. ft; 17,424 linear feet with 2.5 foot beds). In this case, this one acre block with 21,780 sq. ft under plastic will receive 17.5 gallons of product. Treated acre means the actually land area treated.

Q: How much product would be dispensed if the grower treated 2178 linear feet?
Injection of Chemicals into Drip Irrigation Systems

Garry L. Grabow, PhD, PE
Overview

- Principles of Chemical Injection
- Injector Types
- Operation
- Example
Potential Benefits

• Better than shank injection (Guo, et al.¹)
• Can use prior to plant and post plant (herbicide)
• No additional equipment if already have a drip system with injection unit

Injection Considerations

• Better to inject over whole duration of irrigation rather than in a “slug” of chemicals introduced at first of cycle-leave enough time to flush chemicals out of system

• May want to use multiple cycles
Injection Considerations

- Limit injection time to prevent over-application of water that will leach chemicals
Dispersion

From Water Supply

Chemical Tank

Filter

Flow Meter

Main Line

Manifold

Valve/Pressure Regulator

Drip Lines

Injector

Concentration vs. Time

Head of System

Concentration vs. Time

Distal End of System

Concentration vs. Time

NC STATE UNIVERSITY
Each concentric circle is 2-hour irrigation cycle

1 Nematode Management in Commercial Vegetable Production
J.W. Noling, 2002
Water distribution along drip line

4-inch emitter spacing

12-inch emitter spacing
Wetting Patterns
Application rates

- Actual wetted area may not be full bed width
- Application rates may have to be adjusted from broadcast rates

\[
DripRate = \frac{\text{wetted width}}{\text{row spacing}} \times \text{broadcast rate}
\]
Venturi Injector
Venturi Injector

- Cheap
- Injection proportions 6:1 to 50:1
- Will need a bigger stock tank, unless on bypass system
- Best to calibrate these injector types
Dosatron

- Water pump – no electricity required
- Proportional injector 1:64-1:500
- Models designed for flow rates of .1 to 500 gpm
- Don’t allow for acid injection normally
Dosatron
Metering Pump

- Positive displacement
- Flow does not vary with system pressure
- Some units are variable speed and interlinked with system to vary injection rate
- Can do low rates (acid)
California

Drip Application Equipment

Nitrogen pressurized cylinder with fumigant

Flow meter

Nitrogen cylinder

Injection port

Static mixer

Water meter
CHEMIGATION & FERTIGATION:

ANTI-POLLUTION DEVICES FOR

IRRIGATION SYSTEMS

Chemigation: The application of pesticides
through an irrigation system to
land, crops, and/or plants
indoors or outdoors.
NC Regulations
Proportional Injector

Discharge Filter Backwash water a recommended 30’ min. distance from surface waters
NC Regulations
Venturi

Supply Tank
Screen

Vacuum Relief Valve

Check Valve

Venturi Ball Valve

Gate Valve

Automatic Low Pressure Drain

Check Valve

Foot Valve

Discharge Filter Backwash
water a recommended 30’ min.
distance from surface waters

To Irrigation System

To Filtration Unit

NC STATE UNIVERSITY
J.A. Desaeger, A.S. Csinos, J.E. Laska
Coastal Plain Experiment Station, Dept. of Plant
Pathology, University of Georgia, Tifton, GA, 31793

DRIP-APPLIED SOIL
PESTICIDES FOR NEMATODE
CONTROL IN DOUBLE-
CROPPED VEGETABLE
SYSTEMS
Tifton Georgia
TIFTON SANDY LOAM

- 88% sand
- 9% silt
- <1% OM

- Poor water holding capacity
- Difficult to apply water / chemical entire bed
Injecting the proper amount

• Target may be
  • Mass per area (e.g. lbs/acre)
  • Concentration (more typical for chlorine)
Injecting the proper amount

- Sources of dilution
  - Stock solution (diluted raw chemical)
- Injection ratio
- Bypass flow
Injecting the Proper Amount

• Convert pounds of formulated material to pounds of active ingredient
• Dissolve material required into stock solution, e.g. lbs/acre x acres to be treated (gal/acre=lbs/acre / lbs/gal)
• Adjust volume of stock solution (dilution) and/or injection ratio to obtain adjust application duration
Injecting the Proper Amount Calibration

- May be easier (and better) especially if you have bypass flow to calibrate
- Measure volume of solution injected and volume of total flow over set period of time
Example

Given: a 3-hour injection period to apply 0.4 inches of water (total area basis). You wish to inject for 2.5 hours.

What is the injection rate (gallons per hour) required to apply 200 l/ha (21.4 g/acre) to 10.0 acres?

What if the rate were 200 lbs/acre?
<table>
<thead>
<tr>
<th><strong>Midas™, (Iodomethane, TM-425)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chemical Name:</strong></td>
</tr>
<tr>
<td><strong>Product Type:</strong></td>
</tr>
<tr>
<td><strong>Family of Chemistry:</strong></td>
</tr>
<tr>
<td><strong>Geography:</strong></td>
</tr>
<tr>
<td><strong>Signal Word:</strong></td>
</tr>
<tr>
<td><strong>Toxicity Class:</strong></td>
</tr>
</tbody>
</table>
| **Formulations:** | 98:2  Iodomethane:Chloropicrin  
other |
| **Target Pests:** | Weed seeds, plant parasitic nematodes, soil-born fungi and bacteria |
| **Crops:** | Strawberries, fresh market tomatoes, peppers, cut flowers and bulbs, trees, conifer nurseries, vines, turf, and other |
| **Comments:** | Toxicology and efficacy studies are ongoing.  
Earliest plant back 7 days  
REI 36 hours |
Application Information

- Factors to consider...
  - Pest identification and incidence
    - Disease, weed seeds, nematodes and insects
  - Soil type
    - Heavy to light texture
  - Ground preparation
    - Tilth, presence of plant / weed trash
  - Environmental
    - Temperature, moisture content

- Soil Pathogens 120 – 175 lbs/A
- Nematodes 100 – 150 lbs/A
- Weed Seeds 100 – 150 lbs/A
- Insects 100 – 150 lbs/A
Application Methods

Flat Fume / Broadcast

Bed Shank

Drip Injection

Tarp:
Standard or VIF
Shallow to 12” – required
Deep +18” - Optional
Iodomethane Efficacy Comparison

Data listed on the following slides represents efficacy trials conducted by University, USDA-ARS and Private Contractors. The rating system is compiled to show the technical feasibility between Iodomethane and Methyl Bromide

(+) = Comparable: Iodomethane control is lower than Methyl Bromide’s but not statistically different

(+++) = Equal: Iodomethane control is at least equal to but not statistically different from Methyl Bromide’s

(++++) = Better: Iodomethane control is statistically greater than Methyl Bromide’s
**MIDAS Nematode Control**

<table>
<thead>
<tr>
<th>Nematode Type</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pratylenchus sp.</td>
<td>++</td>
</tr>
<tr>
<td>Lesion nematode ++</td>
<td></td>
</tr>
<tr>
<td>Belonolaimus sp.</td>
<td>++</td>
</tr>
<tr>
<td>Sting nematode ++</td>
<td></td>
</tr>
<tr>
<td>Meloidogyne incognita</td>
<td></td>
</tr>
<tr>
<td>Root knot nematode ++</td>
<td></td>
</tr>
<tr>
<td>Heterodera schachtii</td>
<td>+++</td>
</tr>
<tr>
<td>Cyst nematode +++</td>
<td></td>
</tr>
<tr>
<td>Xiphenema americanum</td>
<td></td>
</tr>
<tr>
<td>Dagger nematode ++</td>
<td></td>
</tr>
<tr>
<td>Tylenchulus semipenetrans</td>
<td>++</td>
</tr>
<tr>
<td>Citrus nematode ++</td>
<td></td>
</tr>
<tr>
<td>Paratylenchulus spp.</td>
<td>++</td>
</tr>
<tr>
<td>Pin nematode ++</td>
<td></td>
</tr>
<tr>
<td>Aphelenchoides spp.</td>
<td></td>
</tr>
<tr>
<td>Bud and Leaf ++</td>
<td></td>
</tr>
</tbody>
</table>

**Overall Rating = ++**

(+)=Comparable  (++)=Equal  (+++)=Better
MIDAS Disease Control

Verticillium dahliae +++
Phytophthora cactorum +++
Phytophthora cinnamomi +
Phytophthora citrophthora ++
Fusarium oxysporum ++
Rhizoctonia solani +++
Pythium ultimum ++
Pythium aphanidermatum ++
Gliocladium virens ++
Colletotrichium gloeosporioides ++
Cylindrocladium spp. ++
Sclerotinia spp. ++

Overall Rating = ++

(+) = Comparable   (++) = Equal   (+++ = Better
MIDAS Weed Seed Control

Mallow ++
Nutsedge ++
Bluegrass ++
Rye ++
Sowthistle +++
Bermuda ++
Purslane ++
Vetch +
Filaree +
Groundsel +
Lambsquarters ++
Pigweed ++
Crabgrass +
Carpetweed +++

Bindweed +++
Knotweed ++
Chickweed ++
Mustard ++
Spurge +
Nettle +
Clover ++
Hairy Nightshade ++
London Rocket ++
Pineapple Weed ++
Shepherds Purse ++
Skunk Weed ++
Volunteers ++

Overall Rating = ++

(+) = Comparable  (++) = Equal  (+++) = Better
IR-4 Support Request

• EPA has agreed to consider an “All Crops” registration based on a reduced site and crop residue program for Iodomethane
  – CHEMSAC has approved this protocol
  – No parent residues present in Tomato and Strawberry
All Crops Rationale

- D. Thompson proposed a 1X and 3X use rate on wheat and radish
- Radish is a root crop, short season, maximum opportunity to accumulate residues
- Wheat is a crop that often picks up residues when other crops do not
- 5 locations proposed, major geographic regions (FL, CA, MI/OH, OR/WA, NY/NJ)
Registration Timeline

- **EPA**
  - EPA is committed to give a registration decision by the end of 2003.

- **STATES**
  - Florida – Awaiting US EPA decision.
    - No delay in registration expected.
Moving California East
an analysis of the plasticulture system for vegetable production
Doug Sanders
Horticultural Science
NC State University
### Agroenvironmental Differences

**physical**

<table>
<thead>
<tr>
<th>California</th>
<th>Back East</th>
</tr>
</thead>
<tbody>
<tr>
<td>▲ Soil moisture - steady</td>
<td>▼ Soil moisture - erratic</td>
</tr>
<tr>
<td>▲ Temperature - more diurnal change</td>
<td>▼ Temperature - less differential</td>
</tr>
<tr>
<td>▲ Soil nutrients - more CEC = 10 - 45</td>
<td>▼ Soil nutrients - less CEC = 2 - 30</td>
</tr>
</tbody>
</table>
PLANTS RESPOND QUICKLY

TOMATO

WATERMELON
PLASTICULTURE → CROP GROWTH
How Plasticulture Changes the Agroenvironment

- Warmer soils
- Less evaporation
- Greater carbon dioxide
- Cleaner fruit
- More consistent soil moisture
- Nutrients on demand
- Warmer air
- Altered light quality
- Pest populations
How Plasticulture Changes the Agroenvironment

- Warmer soils
Warmer soils
Soil temperature C @ 50 mm
How Plasticulture Changes the Agroenvironment

- Warmer soils
- Less evaporation
How Plasticulture Changes the Agroenvironment

- Warmer soils
- Less evaporation
- Greater carbon dioxide
- Cleaner fruit
Cleaner fruit
How Plasticulture Changes the Agroenvironment

- Warmer soils
- Less evaporation
- Greater carbon dioxide
- Cleaner fruit
- More consistent soil moisture
BEFORE DRIP
IMPROVEMENT WITH DRIP
More consistent soil moisture
How Plasticulture Changes the Agroenvironment

- Warmer soils
- Less evaporation
- Greater carbon dioxide
- Cleaner fruit
- More consistent soil moisture
- Nutrients on demand
Fertilizer injectors

Water drive

Piston injector
## Fertilizer Sources for Drip

<table>
<thead>
<tr>
<th>Material</th>
<th>Solubility</th>
</tr>
</thead>
<tbody>
<tr>
<td>calcium nitrate (15.5-0-0)</td>
<td>8.51</td>
</tr>
<tr>
<td>potassium nitrate (13-0-44 or 46)</td>
<td>1.08</td>
</tr>
<tr>
<td>ammonium nitrate (34-0-0)</td>
<td>9.84</td>
</tr>
<tr>
<td>sodium nitrate (16-0-0)</td>
<td>6.08</td>
</tr>
<tr>
<td>urea (29.9-0-0)</td>
<td>6.51</td>
</tr>
<tr>
<td>diammonium phosphate (6-17-0)</td>
<td>3.58</td>
</tr>
<tr>
<td>nitrate of soda potash (15-0-14)</td>
<td>9.80</td>
</tr>
<tr>
<td>potassium thiosulfate (0-0-25)</td>
<td>11.00</td>
</tr>
</tbody>
</table>
EXCESSIVE GROWTH
TOO MUCH NUTRIENT
How Plasticulture Changes the Agroenvironment

- Warmer soils
- Less evaporation
- Greater carbon dioxide
- Cleaner fruit
- More consistent soil moisture
- Nutrients on demand
- Warmer air
ADD WHITE WHEN AIR TEMP > 30

PAINT WORKS ALSO
Air temperature
Mulch and row cover
How Plasticulture Changes the Agroenvironment

- Warmer soils
- Less evaporation
- Greater carbon dioxide
- Cleaner fruit
- More consistent soil moisture
- Nutrients on demand
- Warmer air
- Altered light quality
LIGHT QUALITY
Altered light quality

- RED PLASTIC
- RED PLASTIC
PAINT ALTERNATIVE
How Plasticulture Changes the Agroenvironment

- Warmer soils
- Less evaporation
- Greater carbon dioxide
- Cleaner fruit
- More consistent soil moisture
- Nutrients on demand
- Warmer air
- Altered light quality
- Pest populations
Pest populations

Weeds
Pest populations

*Weeds*

- NEARLY CLEAN
- HERBICIDES PRIOR TO CROP
WEED SPRAYERS
Pest populations

Diseases
Pest populations

Diseases

SOUTHERN BAC.  RHIZOCTONIA
Pest populations

Diseases

NEMATODES

NEMATODES
tomatoes
PLANTS RESPOND QUICKLY

TOMATO

WATERMELON
COMMERCIAL TOMATO FIELDS

NC/TN FIELD

FLORIDA
Average Yield Response to Plasticulture (per acre)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Plasticult. Inc.of NC</th>
<th>NET inc</th>
</tr>
</thead>
<tbody>
<tr>
<td>E cantaloupe</td>
<td>6000 fruits 4X</td>
<td>$1500</td>
</tr>
<tr>
<td>W cantaloupe</td>
<td>15000 fruits 5X</td>
<td>2400</td>
</tr>
<tr>
<td>Cucumbers</td>
<td>1200 bu 5X</td>
<td>4000</td>
</tr>
<tr>
<td>Pepper</td>
<td>2000 bu 4-6X</td>
<td>4000</td>
</tr>
<tr>
<td>Squash</td>
<td>800 bu 4X</td>
<td>2400</td>
</tr>
<tr>
<td>Tomato</td>
<td>25-3500 Ct 3X</td>
<td>6000</td>
</tr>
<tr>
<td>Watermelon</td>
<td>3000 fruits 4X</td>
<td>1200</td>
</tr>
</tbody>
</table>
NONE vs PLASTIC vs DRIP
Total season mkt tomato yield from drip and black plastic mulch

<table>
<thead>
<tr>
<th>Year</th>
<th>Bare ground - Irr.</th>
<th>Bare ground + Irr.</th>
<th>Black plastic - Irr.</th>
<th>Black plastic + Irr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>normal</td>
<td>70.1</td>
<td>76.6</td>
<td>80.3</td>
<td>77.8</td>
</tr>
<tr>
<td>early dry</td>
<td>58.8</td>
<td>66.4</td>
<td>58.6</td>
<td>97.0*</td>
</tr>
<tr>
<td>late dry</td>
<td>51.8</td>
<td>97.6*</td>
<td>56.2</td>
<td>107.3*</td>
</tr>
</tbody>
</table>

LSD(0.05) plastic=8.5; irrigation=14.7

T/A x 80=25 lb ct/A
# Tomato net returns from drip and black plastic

<table>
<thead>
<tr>
<th>Year</th>
<th>Bare ground</th>
<th>Black plastic</th>
<th>($1,000/A)</th>
<th>$1,000/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>normal</td>
<td>13.2</td>
<td>13.8</td>
<td>14.5</td>
<td>13.9</td>
</tr>
<tr>
<td>dry early</td>
<td>7.9</td>
<td>9.2</td>
<td>7.4</td>
<td>14.2</td>
</tr>
<tr>
<td>dry late</td>
<td>7.3</td>
<td>15.1</td>
<td>7.7</td>
<td>16.4</td>
</tr>
<tr>
<td><strong>LSD(0.05)</strong> ir. = 3.1</td>
<td><strong>LSD(0.05)</strong> plastic = NS</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Plastic-no drip
Plastic & drip influence pepper early total yield (box/A)

<table>
<thead>
<tr>
<th>Plastic</th>
<th>Drip centibar</th>
<th>Not dry YR 1</th>
<th>Dry early YR 2</th>
<th>Dry late YR 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>No</td>
<td>212c</td>
<td>572e</td>
<td>249c</td>
</tr>
<tr>
<td>No</td>
<td>-0.3</td>
<td>314bc</td>
<td>847cd</td>
<td>886b</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>515a</td>
<td>772de</td>
<td>165c</td>
</tr>
<tr>
<td>Yes</td>
<td>-0.3</td>
<td>575a</td>
<td>1176ab</td>
<td>1219a</td>
</tr>
</tbody>
</table>
Plastic & drip influence pepper early return ($/A)

<table>
<thead>
<tr>
<th>Plastic</th>
<th>Drip centibar</th>
<th>Not dry YR 1</th>
<th>Dry early YR 2</th>
<th>Dry late YR 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>No</td>
<td>2195c</td>
<td>6288d</td>
<td>2689d</td>
</tr>
<tr>
<td>No</td>
<td>-0.3</td>
<td>3184bc</td>
<td>9260cd</td>
<td>9025a</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>5804a</td>
<td>8225de</td>
<td>1982c</td>
</tr>
<tr>
<td>Yes</td>
<td>-0.3</td>
<td>5782a</td>
<td>12398ab</td>
<td>10831a</td>
</tr>
</tbody>
</table>
## Muskmelon K and N sources

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mkt No.</th>
<th>Avg Wt</th>
<th>S S</th>
</tr>
</thead>
<tbody>
<tr>
<td>KNO3 + Ca(NO₃)</td>
<td>6045</td>
<td>4.9</td>
<td>9.3</td>
</tr>
<tr>
<td>KNO3 + NaNO₃</td>
<td>6536</td>
<td>4.1</td>
<td>9.5</td>
</tr>
<tr>
<td>KNO3 + Trisert CB</td>
<td>6095</td>
<td>4.2</td>
<td>8.6</td>
</tr>
<tr>
<td>KTS + Ca(NO₃)₂</td>
<td>6435</td>
<td>4.5</td>
<td>8.7</td>
</tr>
<tr>
<td>KTS + NaNO₃</td>
<td>5990</td>
<td>4.4</td>
<td>8.4</td>
</tr>
<tr>
<td>KTS + Trisert CB</td>
<td>5614</td>
<td>4.0</td>
<td>9.3</td>
</tr>
<tr>
<td>LSD</td>
<td>1385</td>
<td>ns0.7</td>
<td>ns</td>
</tr>
</tbody>
</table>
?PLASTIC QUALITY?
OTHER CROPS

- STRAWBERRIES
- STAKED EGGPLANT
OTHER CROPS

SEEDED BEANS

BEAN SEEDER
Second crops
SPECIAL STUFF
SPECIAL STUFF
Fertilizer injectors

TMB injector

Small venturi
Fertilizer injectors

Water drive

Piston injector
FERTIGATION EQUIPMENT

Water drive  Backflow
TECHNOLOGY/EQUIPMENT
PLASTIC EQUIPMENT
FILTRATION FOR DRIP
FILTRATION FOR DRIP
DRIP PRESSURE REGULATORS
SPECIALIZED EQUIPMENT
SPECIAL CULTURAL NEEDS

Drain ends

Lateral drains needed
How Plasticulture Changes the Agroenvironment

- Warmer soils
- Less evaporation
- Greater carbon dioxide
- Cleaner fruit
- More consistent soil moisture
- Nutrients on demand
- Warmer air
- Altered light quality
- Pest populations
SUMMER SQUASH OR CUCUMBERS

- BROCCOLI
- COLLARDS
- CABBAGE

- LETTUCE
- ONIONS
- LETTUCE +ONIONS

- SNAP BEANS
- G. PEAS
- CUCUMBER*
- S. SQUASH*
BEGINNING AND END SUCCESSFUL PLASTICULTURE
ON FARM RESEARCH
Generation 1 – finding non-ozone depleting fumigant alternatives (tactic substitution)

Generation 2 – finding non-fumigants and focus on IPM tactics (tactic diversification)

Generation 3 – focussing on the pathogens and pests and reduce their presence (avoidance/suppression)

Generation 4 – mutual vision
STRENGTHENING EXTENSION THROUGH ON-FARM RESEARCH

Adapted from: Roger Crickenberger for: Alternative Research Strategies for Sustainable Farming Systems SARE PDP training. September 21, 2000

1. What are the essential elements or tenets of on-farm research?
2. Strengthening the professional extension worker
3. Strengthening the program foundation
4. Strengthening farmer capacities and information
5. Challenges and limitations
6. Application of on-farm generated research


How to Conduct Research on Your Farm or Ranch. 1999. Sustainable Agriculture Network.
Strawberry Flower Power & Troubleshooting

Expo Workshop
Nov. 3, 2004
Welcome to High Point

- A busy year!
- Still lots of things “to do” on the farm
- Introduce speakers
Taking a different approach today…
Strawberry “Flower Power”
Introduce some new concepts …

We can gain better control of our crop if we understand some important ideas related to Vegetative & Reproductive Balance of the Plant.
Vegetative Phase (the nursery)
Reproductive Phase (our farm)
Getting from there to here…

The nursery

My farm
Takes us on an interesting journey...

- A journey that is influenced by a number of factors we don’t understand!
- Perhaps, if we understand these unseen “forces” better, we can achieve a more desirable outcome!
So, when did I get started on this?
It really started in St. Louis (1980)
Professor Dana’s Talk…

The Strawberry Plant and Its Environment
This part I understood (anatomy)
The Plant & Its Environment – how they interact, is where I needed help...

- Environmental factors
  - That control vegetative growth
    - Stolons (runners)
    - Leaves
    - Branch crowns
  - That control reproductive growth
    - Flowering
    - Fruiting
  - Can we bring about a better balance?
Why this is so important...

• A fruit grower is interested in not just total yield
• But, is it a “quality crop”
  – Fruit size and appearance
• Is the crop “concentrated”?
  – Can you keep up with the harvest
• Are there “ways” to influence the above by having greater knowledge of these environmental factors?
Why is daylength so important?
Exaggerated view of crown…
Comparison of Three Methods for Determining the Floral or Vegetative Status of Strawberry Plants

Edward F. Durner¹ and E. Barclay Poling²

¹Department of Horticulture and Science, North Carolina State University, Raleigh, NC 27695-7600
²University of Massachusetts, Amherst, MA 01003-3393

What is “critical” photoperiod?
First stage – vegetative apex
Second stage - transitioning
Reproductive (looks like a “molar”)
Research – when does it happen?

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Method of detection</th>
<th>September</th>
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*Number in parenthesis is the number of weeks under greenhouse conditions before the emergence of the first cluster. Some samples did not produce clusters after 22 weeks.

*Indicates missing data.
Research: floral initiation Chandler

- Requires 2 weeks of inductive conditions...
  - Daylength less than 12 ½ hours
  - Or, uninterrupted night of 11 ½ hours
- Temperature is less important to “triggering” floral initiation
- Temperature has more influence “Afterwards”
Back to St. Louis...
Exaggerated view of a new inflorescence at terminal position
What else is happening?

• When critical photoperiod is met
• How are other processes affected?
  – Like branch crown development
  – Like runnering
• How is temperature involved?
Runnerning…

- **Apical Meristem**
- **Embryonic Leaves**
- **Blade**
- **Petiole**
- **Axillary Bud**
- **Stipule**
- **Elongate Stem (Normal 1 Inch)**
- **Roots**

- **Daughter Plant**
- **1st Node**
- **Parent Crown**
- **Roots**
Branch crown formation

- Apical meristem
- Embryonic leaves
- Blade
- Petiole
- Axillary bud
- Stipule
- Elongate stem (normal 1 inch)
- Roots
- Terminal inflorescence
- Vegetative extension crown
- Branch crown & inflorescence
- Leaf petiole
- Stipule
What terminates at each crown?
Here is how it looks in November
Late fall and spring...
Putting this all together...
Stem berry
Balance
Strawberry production, plant-back trials, and implications of fumigant trials/work

Barclay Poling
Professor & Extension Specialist
Part 1 – Strawberry production (taking an integrated approach)

Part 2 – Plant-back trials (10:35 – 10:50)

Part 3 – Nursery fume trials (10:50 – 10:55)
Big changes over the last 20 years in Mid-South

Strawberry Production Systems...

- **Matted row** – traditional growing system in Mid-South
  - Bare-root, dormant plants in spring
  - 1 year waiting period for crop
  - Renovation for 2\(^{\text{nd}}\) and 3\(^{\text{rd}}\) year
  - Very susceptible to rains and botrytis (and red stele)

- **Strawberry plasticulture** – started in 1980’s in NC
  - Raised beds, plastic film, and MeBr fumigation (in-row)
  - Annual planting system (carryover discouraged)
    - Crop in 7 months for 5 to 7 weeks
    - Earlier and larger berries (for faster picking)
    - Mainly California cultivars (e.g. Chandler, Camarosa)
    - Plug plants became available in the early 1990’s
Goal Today: Put Pre-plant Fumigation w/MeBr in Context

- **Strawberry plasticulture** (1,800 acres)
  - Methyl bromide:chloropicrin
    - 98:2 formulation (1 week plant-back)
    - 67:33 formulation (2 week plant-back)

- **Nursery fumigation** (200 acres)
  - Methyl bromide:chloropicrin
    - 67:33 formulation
Strawberry Plasticulture

- **Highly intensive management system** (vs. MR)
  - It is a “collection” of practices and technologies that require careful/timely execution (even the best farmers have a hard time with plasticulture)
  - Very knowledge-intensive enterprise that requires an understanding of how things “work together”
    - e.g. the plant’s vegetative & reproductive development
    - e.g. how fumigation interacts with planting date to influence ultimate plant size, yield and fruit quality

- With such a “complex system” extension plays a crucial support role!
On-farm tests in over 30 counties introduced Strawberry Plasticulture to North Carolina

Extension Support

Interpretation of:

- Plant tissue reports (deciding on fertility program)
- PDIC reports
- Berry-mg advisories
- Digital photographs from the field to specialists
- On-farm trials with alternative fumigants
- Beneficial site visits to plasticulture operations
  - e.g. recent January ’05 freezes ~ assessing injury
Pre-plant Meetings for Growers – 7/22/04 Nash-Franklin Counties

Sharing lots of information/experiences – good and bad!
It was a Meeting like this in Orangeburg, SC, led to CUE in 2005
Investigating Recent Freeze Effects Led to An Interesting MeBr Story
Fresh dugs planted 9/25/04; plugs 10/03/04
Organic and conventional (methyl bromide) plantings
Row covers first applied December 15th
December 20, 2004 – Minimum 11°F
Warm-up first 2 weeks Jan. ’05
  - 10 to 20 F warmer than usual
  - Chandler broke dormancy (2-3 new leaves)
Row covers re-applied on January 15th
January 17th – Minimum temperature 13 F
January 18th – Minimum temperature 12 F
Covers off February 5-7
February 15th – Site visit
  - Issue #1 – cold injury?
  - Issue #2 – plant size, earliness
Organic field

Plug
Set 10/3/04

Fresh Dug
Set 9/25/04
Organic FD Camarosa (8” dia.)

Knife 8 ¾ inches
Organic Fresh dugs – slightly larger size than plugs

Notice all of the winter blossoms → source of botrytis crown rot
Methyl Bromide Fumigated – Camarosa (same source)

Planted 9/25/04; row cover 2nd half Dec; no row cover in first 2 weeks of Jan.; re-apply Jan 15
Camarosa – Lewis Nursery
Fresh Dugs (9/25/04)

Organic

Methyl bromide

Photograph – 2/15/05
5 Branch Crowns + Main Crown
Virtually NO INJURY (11 F Dec, 12 F Jan 18)
Organic FD Camarosa (8” dia.)

Knife 8 ¾ inches
Only 1 branch crown on Camarosa Fresh Dug on Organic Ground
Camarosa planted same date

Organic

Methyl Bromide

1 branch crown

5 branch crowns
Is this too large?

February 15, 2005
Jan. 8, 2002

Bad memory!
Spring 2002

Crop load - excessive
2 branch crowns

NC – Feb 16

3 crowns

NC – March 9

Late April – Clayton

Main crown

Set Oct 6

4-5 crowns
35 Successful Blossoms/Plant
= 1.5 lbs/plant
= 26,250 lbs/acre
What Plant Back Studies Have Taught Us About Crown Number

- 2003-2004 Trial Clayton Central Crops
- Iodomethane 98:2 formulation (2 rates) vs. Telone C-35, plus control
- Three planting dates for Chandler plugs
  - 25 Sep
  - 2 Oct
  - 9 Oct
- Very good growing season overall (vs. 2002-2003 season...cold fall season)
Why is plant-back important?
Early August

**MeBr:pic In-row (2 weeks)**

End August

Wait 2-3 weeks (3rd wk Sept)
Part 2. Plant-back trials

- Actual scenario for 2003-2004 crop
  - September 17, 2003 – Isabel on track for landfall
    - Fortunately stayed east and impacted VA Beach
  - Heavy rains!
  - Research team fumigated at Clayton on Sept. 19th
    - 1 week plant-back fumigant required for first plant date
      - Sept. 25, 2003 (no registered materials to do this)
      - October 2, 2003 (o.k. for MeBr:Pic 67:33 – 2 week plant-back)
      - October 9, 2003 (o.k. for Alternatives requiring 3 weeks)
What was the outcome?

<table>
<thead>
<tr>
<th>Plant-back (Date)</th>
<th>Market Yield (lb/A)</th>
<th>Ave. Size (g/berry)</th>
<th>Ave. Crown (# plant)</th>
<th>Ave. Flower (# plant)</th>
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</thead>
<tbody>
<tr>
<td>1 week (9/25)</td>
<td>24,447 a</td>
<td>14.4 31/clam</td>
<td>6.6</td>
<td>44.4</td>
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<tr>
<td>2 week (10/2)</td>
<td>24,416 a</td>
<td>15.21 29/clam</td>
<td>6.4</td>
<td>41.8</td>
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<tr>
<td>3 week (10/9)</td>
<td>23,421 a</td>
<td>17.05 26/clam</td>
<td>5.8</td>
<td>35.7</td>
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What about in 2002-2003?

<table>
<thead>
<tr>
<th>Plant-back (Date)</th>
<th>Market Yield (lb/A)</th>
<th>Ave. Size (g/berry)</th>
<th>Ave. Crown (# plant)</th>
<th>Ave. Flower (# plant)</th>
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<td>1 week (9/27)</td>
<td>20,487 a (24,447)</td>
<td>16.4</td>
<td>5.25 (6.6)</td>
<td>24.7</td>
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<tr>
<td>2 week (10/4)</td>
<td>16,666 b (24,416)</td>
<td>18.4</td>
<td>4.70 (6.4)</td>
<td>23.0</td>
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<tr>
<td>3 week (10/11)</td>
<td>9,449 c (23,421)</td>
<td>20.4</td>
<td>4.20 (5.8)</td>
<td>20.9</td>
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What does this mean?

- Planting date in 2002 had huge effect
  - Earlier was better

- Planting date in 2003 was not important
  - Earlier was very undesirable from “quality” standpoint with smaller berries (31.5/clamshell) with 9/25/03
  - Later was best from quality standpoint (23,421 lb/A, and 26 berries per clamshell (16 oz)

- Planting date is not consistent!

- Why regional growers have gone to “staggering”
<table>
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<th>2003 Mkt Yield (lb/A)</th>
<th>2004 Mkt Yield (lb/A)</th>
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<td>IM98 (75 #)</td>
<td>16,378 a</td>
<td>25,461 a</td>
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<td>IM (60#)</td>
<td>16,072 a</td>
<td>25,073 a</td>
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<td>Telone C35</td>
<td>14,152 b</td>
<td>24,491 a</td>
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<tr>
<td>Control</td>
<td>NA</td>
<td>21,257 b</td>
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Can the fumigation effect be more important?

Sticking with our theme of strawberry plasticulture being so unpredictable!
Fresh dugs planted 9/25/04; **plugs 10/03/04**

- **Organic** and conventional (methyl bromide) plantings

- Row covers first applied December 15th

- December 20, 2004 – Minimum 11°F

- Warm-up first 2 weeks Jan. ’05
  - 10 to 20°F warmer than usual
  - Chandler broke dormancy (2-3 new leaves)

- Row covers re-applied on January 15th

- January 17th – Minimum temperature 13°F

- January 18th – Minimum temperature 12°F

- Covers off February 5-7

- February 15th – Site visit
  - Issue #1 – cold injury?
  - Issue #2 – plant size, earliness
# Branch Crowns

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<tr>
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<th>Methyl Bromide</th>
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<tr>
<td>Fresh dug (9/25)</td>
<td>1</td>
<td>5</td>
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<tr>
<td>Plug (10/3)</td>
<td>3</td>
<td>NA</td>
</tr>
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</table>
Let’s review this...

- Looking for plants about 8-9” dia
  - Mid-February
- 3 nice branch crowns
- Producing about 1.5 lb/plant of high quality fruit
Let’s keep thinking about this…

- Feb. 15, 2005 on-site visit
- Camarosa plugs on organic soil had 3 br. crowns
- Camarosa fresh dug on organic had 1 br. crown
- Camarosa fresh dug on MeBr had 5 br. crown

Evaluation

- Just right
- Too little
- Too many

No Methyl Bromide
When you meet with a farmer...

- Look beyond methyl bromide issue...
- Plant type factor
- Plant date factor
- Soil prep factor
- Nursery plant quality
- Plant N and irrigation

Agents need to know there are multiple ways to over-invigorate plants and exceed desired size...
2 branch crowns
NC – Feb 16

3 crowns
NC – March 9

Late April - Clayton

Main crown
Set Oct 6

4-5 crowns
Let’s Summarize

- Important ways to “invigorate” strawberry plant
  - 1. Planting date – greatest influence of all factors
    - Early planting – get excess branch crowns (>5)
    - Late planting – too few branch crowns (<2)
  - 2. Plant type – can be very important
    - Plugs – establish more quickly than fd (about 5 days)
    - Bare-root fresh dugs
  - 3. Fumigant & Plastic Mulch Bed (can be very sign.)
  - 4. Mild fall and winter (can be very significant)
  - 5. Application of row covers
Thanks
Weed Management

David Monks
Dept. of Horticultural Science
Methyl Bromide Phase-Out

U.S. Methyl Bromide Consumption and Phaseout Schedule

Source: U.S. EPA and Steve Toth
Plasticulture production system
Nutsedge Control Measures

- Hand removal/cultivation/tillage  P
- Chloropicrin/Telone/Vapam  P
- Methyl bromide  F to E
- Rotation with effective herbicides  F to E
- Herbicides  P to E
Without Nutsedge Control

• One nutsedge can infest an 8.5 by 10 feet area by the end of the growing season.
• Densities often can be as high as 200 to 300 plants per m$^2$
Methyl Bromide CUE

- Based on methyl bromide control of nutsedge consistently
- Alternatives often give unacceptable control
Without Methyl Bromide

- Nutsedge (yellow and purple) densities will increase (nutsedge from hole and growing through plastic).
- Broadleaf weeds from hole will increase
- Thus, overall weed densities will increase greatly.
- Farmers will be faced with a high population of weeds that will grow at a fast rate.
Supplement Weed Control by Alternative Fumigants??

• Increase use of hand removal of weeds.
  – 2 to 4 times per season
  – $ per 1000

• Use of herbicides applied to bed under plastic.

• Use of herbicide over the top of crop and plastic.
Problems Faced

- Lack of herbicides that will control nutsedge.
- Lack of crop safety.
- Relatively few herbicides that are registered for use in the row in plasticulture.
Crops

Nutsedge control (herbicides)
  Tomato, cucumber, cantaloupe

No nutsedge control (herbicides)
  Strawberry, pepper, squash, watermelon