Potato Soil Fumigation

A Field Guide to Fumigant Management Plans:
With Special Reference to Potato Early-Die in Michigan
Appendix A.
Table of Contents

Field Guide Overview..................................3

Potato Early-Die.......................................4

Early-Die Management History....................5

Biofumigation and Compost.........................8

Fumigant Management Plan.........................9

Post Application Report.......................... 15

Buffer Zones (Proposed for Phase II Labels)....18

Good Agriculture Practices.......................22

Soil Moisture Determination Process............24

*********

Potato Soil Fumigation was developed at Michigan State University through a USDA Specialty Crop Block Grant to the Michigan Potato Industry Commission from the Michigan Department of Agriculture.
Potato Soil Fumigation

Loren G. Wernette$^1$ and George W. Bird$^2$

Edited by Lesley Schumacher-Lott$^2$

Soil fumigants are commonly used in MI potato production to decrease yield losses caused by Potato Early-Die (PED). In 2010, the Environmental Protection Agency (EPA) completed re-registering the soil fumigants, metam sodium and chloropicrin, as mandated by the Federal Insecticide, Fungicide and Rodenticide Act. Labels for these fumigants mandate a Fumigant Management Plan (FMP), Post Application Report (PAR) and Buffer Zone (BZ) for every site. This Field Guide describes the specifications of these requirements for label compliance. It also reviews the nature of PED and associated Good Agricultural Practices (GAP). Additional information can be obtained by going to the EPA Soil Fumigation Tool Box at http://www.epa.gov/pesticides/reregistration/soil_fumigants/

$^1$Crop Consultant, Agri-Business Consultants, Inc. Remus, MI
Lwernette@agribusinessconsultants.com

$^2$Department of Entomology, Michigan State Univ., East Lansing, MI
Potato Early-Die: In MI, Potato Early-Die (PED) is caused by an interaction between the penetrans root-lesion nematode (*Pratylenchus penetrans*) and Verticillium-wilt fungus (*Verticillium dahliae*). It is a problem in about 50% of MI’s potato acreage. If not managed, it causes tuber yield losses as high as 50%. The MI PED Risk Matrix Tables are presented on pages 6-7. The penetrans root-lesion nematode is the most common plant-parasitic nematode in MI. It thrives in cultivated soil. It is a Good Agricultural Practice (GAP) to attach a copy of the nematode and *Verticillium* report to the Fumigant Management Plan (FMP).

*Figure (1) Nematode head, (2) Stylet, (3) Females and eggs in red stained root tissue.*
**PED Management History:** MI potato growers became aware of PED in the 1970s. Soon after beginning to use 1,3-D (Telone), aldicarb (Temik) was registered for potatoes. It was used extensively and provided excellent root-lesion nematode and Colorado Potato Beetle control. When the MI registration for aldicarb was withdrawn, oxamyl (Vydate), ethoprop (Mocap) and metam sodium (Vapam, Busan 1020, Sectagon 42) were substituted. Initially, metam was applied through center pivot irrigation systems. This changed to shank injection with the product diluted with large volumes of water. Today, metam sodium is applied in the fall at rates between 38 and 50 gal/A acre using modern shank injection technology. In some cases it is applied at a soil depth of 12 inches. In other cases, it is injected at both 6 and 12 inch depth. Some operators dilute the metam with water and others do not.
Table 1. Potato Early-Die Risk Matrix (1 = Low, 5 = High)

<table>
<thead>
<tr>
<th>Lesion Nematode Risk</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2. Population densities of penetrans lesion nematodes and dahliae *Verticillium* fungi in fall samples for designation of risk indices.

<table>
<thead>
<tr>
<th>Risk Rating</th>
<th>Penetrans root-lesion nematodes*</th>
<th><em>Verticillium dahliae</em> Colonies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dilution-plating/g soil</td>
<td>Wet-sieving/10g soil</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1-25</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>26-75</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>76-150</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>151-300</td>
<td>8-16</td>
</tr>
<tr>
<td>5</td>
<td>&gt;300</td>
<td>&gt;16</td>
</tr>
</tbody>
</table>

*combined counts of nematodes found per 1.0g root tissue and 100 cm$^3$ soil Risk index ratings are slightly different for nematode samples collected in the spring (i.e. 101-200 lesion nematodes represents risk index 4 for spring-collected samples).
**Biofumigation:** Biofumigation is the process of incorporating living green tissue from certain plant families, most commonly Brassicas (yellow mustard, rapeseed, oilseed radish) into soil. The process must cut the plant tissue to release glucosinolates, which are then transformed into isothiocyanate in soil. The results from biofumigation in MI has been mixed. It has, however, been used successfully and has potential to be effective in combined with other GAP for PED management.

**Compost:** In MI, composts are frequently broadcast the fall before potato planting for overall soil quality enhancement. It is a GAP to attach compost records to the FMP.
Fumigant Management Plan (FMP)

The following information is mandated by the label to be included in the FMP and available at the fumigation site. In MI, the 2011 FMPs were prepared by growers, private consultants or fumigant distributors.

- Application Supervisor (Certified Applicator)
  - Name
  - Phone Number
  - Applicator License/Certificate Number
  - Commercial or Private

- Employer Name
  - Employer Address
  - Employer Phone Number
  - Applicator License/Certificate Number
  - Commercial or Private

- Site Information
  - County
  - Township
  - Section
  - Address w/ Zip Code
  - GPS Coordinates

- Owner/Operator of Application Site
  - Name
  - Address
  - Telephone number
Fumigant Management Plan Continued...

- Management Plan Record
  - The owner/operator has been informed that he/she, as well as the certified applicator, must keep a signed copy of the site-specific FMP and the Post-Application Report (PAR) for two years from the date of application.

- Application Details
  - Target Application Date
  - EPA Product Registration Number
  - Fumigant Product Name
  - Application Method
  - Injection Depth
  - Acres Treated
  - Buffer Zone (BZ) Size

- Buffer Zones
  - A BZ must be established for every fumigation site. See the Buffer Zone Section (Tables 3-5 on pages 18-21) for calculation instructions. The BZ size must be included in the FMP. A site map illustrating the BZ should be attached to the FMP.
Fumigant Management Plan Continued...

- **Weather**
  - Forecast for the day of application (a printed copy should be attached to the FMP). The information should include:
    - *Wind Speed*
    - *Inversion Conditions*
    - *Air-Stagnation Advisories*
    - *Other*

- **Soil**
  - *Texture/Clay Content*
  - *Organic Matter (record as)*
    - <1%,
    - ≥1-2%,
    - ≥2-3%, or
    - >3%
  - *Temperature.* Has the air temperature been above 100°F in any of the 3 days prior to application? If yes, record the temperature.
  - *Moisture (use one of the following)*
    - *USDA Feel/Appearance Method*
      - (process described on page 24)
    - *Instrument*
    - *Other*
Fumigant Management Plan Continued...

- Communications
  - Pesticide product labels and material safety data sheets must be at the application site and available for employees to review.
  - Will the certified applicator be at the application site during all handler activities that take place from the beginning of the application until the entry restricted period expires? If not, describe how the certified applicator will share the label requirements with owner/operator and/or handlers who will be present at the application site after the application is complete until the entry restricted period expires.

- Handler Information
  - Information for all handlers must be attached to the FMP.

- Emergency Response Plan
  - A description of evacuation routes (photo, diagram or drawing must be attached to the FMP)
  - Locations of telephones
  - Contact information for first responders
  - Other contacts (see page 13)
Fumigant Management Plan Continued…

- Emergency Response Contacts (continued)
  - Michigan DEQ, 1-800-292-4706
  - National Pesticide Center, 1-800-858-7378
  - National Response Center, 1-800-424-8802
  - Michigan DARD, 1-800-405-0101

- Emergency Procedures/Responsibilities in case of an incident, equipment/tarp/seal failure, complaints or elevated air concentration levels suggesting potential problems, or other emergencies.

- Air Monitoring Plan
  - If monitoring indicates air concentrations greater than or equal to 6000 ppb for methyl isothiocyanate (MITC), handlers must stop work and leave the application block.
  - If sensory irritation is experienced, check which of the following procedures will be followed:
    - Intend to cease operations
    - Intend to continue operations with respiratory protection
    - Handler tasks to be monitored
    - Monitoring equipment (see page 14)
    - Timing
Fumigant Management Plan Continued...

- Full Face Respirator Response Plan if: (1) a handler experiences any sensory irritation when wearing a full-face air-purifying respirator, or (2) a MITC air sample is greater than or equal to 6000 ppb, all handler activities must cease and handlers must be removed from the application block and the emergency plan implemented.

- Signs: Two types of signs are required (Treated Area and Buffer Zones). The BZ requirements are described on page 19. The treated area signs must be in place for five days after fumigation. The following must be recorded: (1) Name of person responsible for Treated Area Signs, (2) sign posting date and (3) sign removal date

- Signature & Date

- All FMPs must be signed, dated, and retained for two years!
Post-Application Report (PAR)

A PAR must be completed, signed, dated and retained for two years. The PAR describes any deviation from the FMP. It includes application issues not in the FMP, occurrence of fumigant irritation or any complaint. The PAR documentation structure should be the same as used for the FMP. If no deviations from the original plan occurred, there should be check boxes that indicate this lack of difference. The following topics need to be covered:

1. General Application Information: This section must include information about the application site and process (e.g. applicator, date, rates and equipment).

2. Handler Changes: Any changes in the handler information should be included or attached to the PAR.

3. Weather: Any weather conditions not included in the original forecast must be included in the Post-Application Report.

4. Incidents: Any incident that happened during fumigation should be described, including why the incident happened, what emergency procedures were followed, date and time of the incident, and if a state agency was notified.
5. **Complaints:** This section records complaints from individuals on-site or off-site. If off-site, include his/her name, address, and telephone number. It should also include comments on what additional control measures and emergency procedures were performed following the complaints, and any additional information that are applicable to the report.

6. **Communications:** This is a follow-up to the communication section of the Fumigant Management Plan regarding the presence of the applicator at the application site during all handler activities that took place from the beginning of fumigation to the end of the 48 hour restricted entry period. If the certified applicator was not on-site for all handler activities, the names and phone numbers of the persons contacted should be listed.

7. **Treated and Buffer Zone Area Postings:** Dates of treated area and buffer zone sign removals must be recorded in the PAR.

8. **Other Deviations:** Other deviations not accounted for in the original FMP need to be recorded.

9. **The PAR must be signed, dated and retained for two years!**
Soil fumigation Process, Equipment and FMP
Buffer Zones (BZ)

A buffer zones (BZ) must be established for every fumigation site. Final buffer zone information will be available as part of Phase II labels. While these were to be published before the end of 2011, it appears that they will not be available until the spring of 2012. The following tentative BZ information is designed for use of metam sodium in MI potato production systems.

BZ are areas around the fumigated area that are not treated. BZ must be unoccupied during a required no-entry period or 48 hours (5 days for the treated area).
The size of the BZ is based on: (1) the size of the area to be treated, (2) the nature of the application process (e.g. shank injection, water seal), and (3) the rate of fumigant applied. The Phase II EPA label will most likely include seven BZ Tables. Some of these may contain more than 750 data cells. The probable BZ for MI potato production systems are presented below and on page 20. The probable BZ for a broadcast metam shank injection with a water seal is 25 feet for a 38-75 gal/acre application for sites from 1-160 acres. Probable BZ for broadcast metam shank injections without a water seal vary from 25 to 188 feet (see page 20).
| gal/A | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 100 | 105 | 110 | 115 | 120 | 125 | 130 | 135 | 140 | 145 | 150 | 155 | 160 | 165 |
|-------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 38    | 25 | 25 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 |
| 40    | 25 | 25 | 27 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 |
| 45    | 25 | 25 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 |
| 50    | 25 | 27 | 34 | 36 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 46 | 48 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 |
| 55    | 25 | 29 | 37 | 40 | 41 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 |
| 60    | 27 | 32 | 40 | 43 | 45 | 46 | 48 | 50 | 52 | 53 | 54 | 56 | 58 | 60 | 61 | 62 | 63 | 65 | 66 | 67 | 68 | 69 | 70 | 72 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 |

Metam Shank Injection Application Broadcast without Water Seal

Proposed EPA Phase II Buffer Zone (feet)
It is believed that Phase II labels will allow for BZ reduction credits based on various Good Agricultural Practices (GAP) and site characteristics as indicated below. In no case will a BZ of less than 25 feet be allowed. Proposed BZ reduction credits can not be used to reduce the size of a BZ more than 80%.

<table>
<thead>
<tr>
<th>Situation</th>
<th>Amount</th>
<th>Reduction %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Organic Matter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;1&lt;2%</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>&gt;2&lt;3%</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>&gt;3%</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>Clay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;27%</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Soil Temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;60 F</td>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>
Good Agricultural Practices
Three types of Good Agricultural Practices (GAP) are associated with MI potato production.
1. GAP used for individual potato enterprise (farm) certification,
2. GAP used for soil fumigation BZ size reduction credits, and
3. GAP recommended for superior soil fumigation results under MI conditions.

Wind Speed: Wind speed must be at least 2 mph or forecasted to reach 5 mph during application. The wind speed forecast for the day of the application and 48 hours following application should be monitored. If weather conditions are not optimal, fumigation should not proceed. The application should not take place if a temperature inversion is forecasted to persist for more than 18 consecutive hours for the 48 hour period after application.
Soil Temperature: If soil temperature is not in the ideal range, the fumigant will lose efficacy. Soil temperature at the beginning of an application should not be above 90°F. In MI, soil temperature of <60°F is recommended. If air temperature has been above 100°F in any of the three days prior to application, soil temperature must be measured and recorded in FMA.

Soil Moisture: Soil moisture in the top six inches must be between 60-80% of field capacity prior to application. If soil moisture measuring equipment is not used, the USDA Feel Method is may be used (see page 24). If there is insufficient moisture in the top six inches immediately prior to the application, soil moisture can be adjusted with pre-treatment irrigation. If there is adequate soil moisture below six inches, tillage can be used during or immediately prior to application.

### Michigan Good Agricultural Practices Checklist

<table>
<thead>
<tr>
<th>Checkbox</th>
<th>Topic</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>( )</td>
<td>Equipment</td>
<td>Modern Pump-Driven Shank Injection</td>
</tr>
<tr>
<td>( )</td>
<td>Site Preparation</td>
<td>Seed Bed</td>
</tr>
<tr>
<td>( )</td>
<td>Soil Temperature</td>
<td>&lt;60°F</td>
</tr>
<tr>
<td>( )</td>
<td>Soil Moisture</td>
<td>60-80% Field Capacity</td>
</tr>
<tr>
<td>( )</td>
<td>Rate</td>
<td>57.5 gal/A {Nematodes}; 75 gal/A {Fungi}</td>
</tr>
<tr>
<td>( )</td>
<td>Depth of Injection</td>
<td>6 inches _____ 12 inches _____</td>
</tr>
<tr>
<td>( )</td>
<td>Physical Seal</td>
<td>Soil Drag</td>
</tr>
<tr>
<td>( )</td>
<td>Water Seal</td>
<td>Irrigation (0.25-0.33 inches)</td>
</tr>
</tbody>
</table>
### Soil Moisture Determination Procedure

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>Soil ball structure at 60-80% moisture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse</td>
<td>Weak ball with loose and clustered sand grains on fingers darkened color moderate water staining on fingers will not ribbon.</td>
</tr>
<tr>
<td>Moderately Coarse</td>
<td>Ball with defined finger marks very light soil water staining on fingers darkened color will not stick.</td>
</tr>
<tr>
<td>Medium</td>
<td>Ball and will leave a very light staining on fingers and will form a weak ribbon between the thumb and forefingers.</td>
</tr>
<tr>
<td>Fine</td>
<td>Ball with defined finger marks light soil water staining on fingers ribbons between thumb and forefinger.</td>
</tr>
<tr>
<td>Multiple Textures</td>
<td>Soil texture should be considered the lightest for it to comply with the moisture requirements. The field can be divided into areas of similar soil texture, and soil moisture of each area should be adjusted as needed.</td>
</tr>
</tbody>
</table>