Pepper

Tuesday afternoon 2:00 pm

**Moderator:** Hannah Stevens, Macomb Co. MSU Extension

2:00 p.m.  Weed Control Strategies for Pepper Production

Doug Doohan, Horticulture & Crop Science Dept., Ohio State Univ.

2:20 p.m.  Pepper Response to Irrigation

Mathieu Ngouajio, Horticulture Dept., MSU

2:40 p.m.  Calculating Your Break-Even Price

Barbara Dartt, Salisbury Management Services, Portage, MI

3:05 p.m.  Phytophthora in Pepper Production: How to Minimize the Losses

Brian Cortright, Plant Pathology Dept., MSU

3:40 p.m.  Cucumber Mosaic Virus: Symptoms and Management

Mary Hausbeck, Plant Pathology Dept., MSU
A wisely planned weed control program starts with selection of the best possible site. Crops growing in good soil with adequate nutrients and moisture will compete with weeds. Weak crops are not competitive and are more likely to be injured by herbicides. Eliminating perennial weeds before planting vegetables is also a must. Accomplishing this task has never been easier, given the opportunities to rotate vegetables with glyphosate tolerant crops such as corn and soybean. Peppers are sensitive to soil-residues of herbicides used in previous crops, particularly triazine herbicide and phenyl urea herbicides. Check rotational crop guidelines provided with the product label before planting. Be especially on guard for potential herbicide carry-over problems with newly acquired and/ or rented land. Use bare-ground fallow to minimize weed problems before transplanting. The germination cycle of many summer weeds is largely over by late May when peppers are planted; cycles of shallow tillage in April and early May will kill emerged weed seedlings and stimulate germination of still more that will be killed by the next round of tillage.

<table>
<thead>
<tr>
<th>Table 1. Herbicides registered for weed control in peppers.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-Plant</strong></td>
</tr>
<tr>
<td>trfluralin</td>
</tr>
<tr>
<td>Devrinol</td>
</tr>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

* Sandea is only registered for use on weeds growing between rows of pepper planted in plastic mulch. ** Roundup (many formulations/ brands available) and Gramoxone will severely injure or kill peppers contacted by spray.

Most of the herbicides in Table 1 are exclusively or primarily for grass control. Poast and Select, may be applied one or more times during the growing season, up to 20 days before harvest, and control only grass weeds. Trifluralin (many brands available) and Devrinol control mainly annual grasses. Some broadleaf weeds are controlled but too few to provide truly effective weed control. Both herbicides need to be incorporated into the soil before transplanting. Roundup and Gramoxone can be used before planting in a combination tillage/ herbicide fallow intended to reduce weed seed numbers in the soil or as directed-post treatments after planting. Annual and perennial broadleaf and grass weeds are controlled. Peppers that are contacted by Gramoxone or Roundup spray will be severely damaged or killed. Sandea is effective on a range of broadleaf weeds and on yellow nutsedge but is only registered for use between the rows of peppers planted in plastic mulch.
Command 3ME and Dual Magnum are the primary herbicides used by Ohio growers because they are relatively gentle to peppers and control both grasses and broadleaf weeds. Applied as a tank-mix before transplanting these herbicides provide fairly good complementary control of weeds that neither controls alone. Dual is good on pigweeds, carpetweed and Eastern black nightshade. Command controls lambsquarters, velvetleaf, and improves purslane control over Dual. Command also suppresses common ragweed and smartweed when applied at the upper range of the rates registered on pepper (2.67 pt/A). Another approach is to apply Command Pre-Transplant and follow this with Dual soon after transplanting (within 48 hours). This may extend weed control slightly over that obtained when both are applied before transplanting but this has not been confirmed by research. Dual can be used on all pepper types and Command is registered for all but banana peppers.

In Ohio there is a lot of interest in expanding the Command 3ME label to include banana peppers and the Dual Magnum label to allow use later than within 48 hours of transplanting (as currently labeled). We have conducted trials starting in 2002 to look at the safety of these uses. Briefly, we have not detected serious injury on bell, banana, cherry or jalepeno peppers treated with Command 3 ME Pre-Transplant at rates up to 4 pt/A. Likewise Dual applied up to a week after transplanting did not cause injury on these pepper types. Tank-mixes and sequential treatments have not been tested. Yield data is reported in Table 2. Even though control plots in our trials were hoed and cultivated several times to minimize weed competition, we have consistently observed a trend (sometimes statistically significant) to higher yield in herbicide treated plots. We have also observed a trend, not always significant, for higher yield in Command treated plots relative to those treated with Dual Magnum.

<table>
<thead>
<tr>
<th>Yield T/A</th>
<th>Bell  ‘02</th>
<th>Cherry ‘02</th>
<th>Jalepeno ‘03</th>
<th>Banana ‘03</th>
<th>Jalepeno ‘05</th>
<th>Banana ‘05</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pt/A</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand-weeded</td>
<td>10.5b</td>
<td>4.7</td>
<td>1.6</td>
<td>1.4b</td>
<td>7.8</td>
<td>10b</td>
</tr>
<tr>
<td>Dual Magnum 1</td>
<td>11.8b</td>
<td>7.6</td>
<td>2.1</td>
<td>2.1ab</td>
<td>9.7</td>
<td>11.4ab</td>
</tr>
<tr>
<td>Dual Magnum 2</td>
<td>12.3b</td>
<td>7.6</td>
<td>1.9</td>
<td>1.9ab</td>
<td>7.4</td>
<td>9.6b</td>
</tr>
<tr>
<td>Command 2</td>
<td>14.6ab*</td>
<td>7.1</td>
<td>1.8</td>
<td>2.1ab</td>
<td>9.1</td>
<td>13.8a</td>
</tr>
<tr>
<td>Command 4</td>
<td>13.7ab</td>
<td>7.5</td>
<td>2.2</td>
<td>2.5ab</td>
<td>9.3</td>
<td>13.8a</td>
</tr>
</tbody>
</table>

*Command at 0.5 pt/A had significantly higher yield (17 T/A) than hand weeded control and Dual Magnum plots.

Further research is needed to expand the uses of Dual and Command to meet the weed management needs of growers in the Midwest. Also there is a need to investigate tank-mixes and sequential applications of these herbicides as we move towards improved weed control recommendations.
Pepper Response to Irrigation
Mathieu Ngouajio, Ronald Goldy, and Guangyao Wang
Michigan State University
E-mails: ngouajio@msu.edu, ngoldy@msu.edu, and wanggy@msu.edu

Background
About 1,800 acres of bell peppers are produced annually in Michigan. In 2004, the total production was 522 cwt with a corresponding value of about $13.6 million. Irrigation is critical for pepper production. Unfortunately, the amount and distribution of precipitation in Michigan, and the Midwest, are uneven and vary greatly from year to year. Therefore, most growers use supplemental irrigation to reduce the risks associated with natural rainfall patterns. Drip irrigation is a commonly used irrigation method that helps reduce water inputs and the incidence of foliar diseases. Water use in agriculture is being increasingly regulated in Michigan, thereby putting more pressure on growers to reduce amounts used. It is well known that water deficiencies during blossom, fruit formation, and fruit maturation are detrimental to pepper yield and quality. During the early stages of plant development, it may be possible to reduce the amount of irrigation water without a significant effect on yield. This might be more feasible under plasticulture systems where plastic mulches prevent large amounts of water loss through evaporation. In fact, some plasticulture vegetable growers have withheld irrigation for some time after crop transplant. This practice may reduce irrigation input and nutrient leaching, and promote deeper rooting. Pepper has a shallow root system, and too much water during the transplant establishment and vegetative growth stages could further reduce root depth. Plants with shallow root systems are more vulnerable to drought events and soil borne diseases. This work was carried out to answer the following questions for pepper produced under drip irrigation in a sandy soil on raised beds covered with black plastic: Does withholding (minimizing) irrigation after planting enhance water use efficiency? If yes, how long after planting should a grower wait before initiating full irrigation? Does natural rainfall affect the timing of irrigation initiation?

Research objectives
Field studies were conducted in 2003 and 2004 to determine effects of withholding (minimizing) irrigation on pepper plant height, leaf chlorophyll content, yield, and irrigation water use efficiency (IWUE).

Methodology
Bell pepper “Camelot” was grown using recommended practices for plasticulture fresh market pepper production in southwest Michigan. Pepper plants were transplanted on June 4 in 2003 and May 20 in 2004 into raised beds covered with black plastic that had been previously fumigated. Plots were drip irrigated and fertigated. Irrigation treatments were initiated either at planting, after transplant establishment, at first flower, at first fruit, or at fruit ripening. A sixth treatment received only enough water to apply fertigation for the entire growing season. All treatments were fertigated weekly with 4-0-8-2 (N-P-K-Ca). The total volume of water applied to each treatment was measured using flow meters. Fruits weight and number, by grade (Jumbo, Extra large, Large, Medium, No 2, and Cull), were recorded. Leaf chlorophyll content was measured during flower formation. Total marketable yield was calculated as the sum of yield of all grades except the cull. Irrigation water use efficiency was calculated as (yield in each irrigated treatment minus yield in the fertigated only
treatment)/(total volume of water in each irrigated treatment minus total volume of water in the fertigated only treatment) and expressed in kg/ha/inch of water.

Results

Natural rainfall
Natural rainfall varied greatly between 2003 and 2004 seasons (Figure 1). Total rainfall during the season was 6.5 inches in 2003 and 16 inches in 2004. In addition to greater rainfall in 2004, we also observed a better distribution of rain events compared to 2003. Therefore, 2003 was considered a dry year and 2004 a more normal year in terms of rainfall. The variability between years was ideal to test how rainfall can affect pepper response to irrigation.

![Figure 1. Cumulative rainfall during pepper growing season in 2003 and 2004](image)

Volume of water applied in each treatment
In 2003, the volume of water applied varied from 44 inches for treatments where irrigation started immediately after planting to 4 inches in the treatment where irrigation was used only during fertigation (Figure 2). In 2004 a similar volume of water was used, but slightly reduced due to more rainfall. Our results show that a significant amount of water can be saved by delaying irrigation after planting with no yield penalty. For example, delaying irrigation until the vegetative stage in 2003 saved about 15 inches of water, representing 34% less water. In 2004, 20% less water was used by delaying irrigation until the vegetative stage.

![Figure 2. Volume of water applied in 2003 and 2004](image)
Pepper leaf chlorophyll content

Leaf chlorophyll content increased as the duration of irrigation withholding increased. The SPAD values ranged from 55 (for plots irrigated from planting to harvest) to 68 (for plots that were only fertigated). This is an indication the too much water inputs especially early in the growing season may contribute to nutrient, leaching, especially nitrogen. Leaves were the most yellow when irrigation was initiated before first flower, suggesting possible N deficiency.

Pepper Yield

Yield in all treatments was smaller in 2004 compared to 2003 (Figure 3). Planting in 2003 was followed by about 30 days of dry conditions. In 2004, however, planting was followed by frequent and heavy rains. Although water stress is detrimental to pepper growth, excessive soil moisture has been shown to slow down growth. In extreme situations, pepper plants have been shown to die after 48 hours of flooding.

Plots that received water only for fertigation (FT) produced the smallest yield in both years. The yield reduction due to lack of water was more severe in 2003 (42% yield reduction) than in 2004 (27% yield reduction) when compared with the system that was irrigated from transplanting to harvest.

Pepper yield responded significantly to the different timings of irrigation initiation after planting. In both years, withholding irrigation following pepper transplanting showed a positive response in the form of yield increase. Up to 5-6% yield increase was observed while reducing water use by delaying irrigation in 2003 and 2004. However, water deficits after first flower resulted in excessive yield loss.

This study shows that after transplanting, it was possible to withhold irrigation until 48 days in 2003 (dry year) and 67 days in 2004 (wet year) without yield losses. It is important to note that all plots were well irrigated prior to transplanting and that pepper was grown on raised beds covered with black plastic mulch.
**Figure 4.** Effect of delaying full irrigation after planting on pepper yield. Irrigation started at S0 (transplanting), S1 (after transplant establishment), S2 (at first flower), S3 (at first fruit set), S4 (at fruit ripening), or FT (plot receive only water for fertigation)

![Irrigation Water Use Efficiency (IWUE)](image)

**Figure 5.** Effect of delaying irrigation after planting on Irrigation Water Use Efficiency (IWUE). Irrigation started at S0 (transplanting), S1 (after transplant establishment), S2 (at first flower), S3 (at first fruit set), S4 (at fruit ripening), or FT (plot receive only water for fertigation)

**Irrigation water use efficiency**

Irrigation water use efficiency (IWUE) is one way of looking at the effect of irrigation on crop yield. This parameter eliminates the effects of natural rainfall in order to estimate the contribution of irrigation to total yield. This is a measure the amount of pepper obtained for every inch of water applied. IWUE was optimum when irrigation was delayed until fruit ripening in 2003 and first fruit set in 2004 (Figure 5). The selling price of pepper fruit, the cost of irrigation, as well as the effect of water on fruit quality, should be considered to maximize the profit of irrigation.

**Conclusion**

Over two years of study, our results were very consistent even though the two growing seasons (2003 and 2004) were quite different in terms of rainfall and heat unit accumulation. Our results suggest that a grower could save up to 40% irrigation water input without pepper yield reduction simply by withholding (or limiting) irrigation for a few weeks after transplanting. The exact duration of this period of limited irrigation would depend on the weather conditions. Limiting irrigation water inputs early in the season could help reduce nutrient leaching and enhance deeper and more extensive root systems. However, it is critical to have moist soil at planting. Also, such a practice requires monitoring soil moisture status, especially during excessively dry seasons. Finally any water deficit after first flower set should be avoided.

**Acknowledgements**

This work was supported in part by GREEEN Project (Generating Research and Extension to meet Environmental and Economic Needs), SWMREC (Southwest Michigan Research and Extension Center), and the Michigan Vegetable Council. Thanks to all growers in Southwest Michigan who contributed to the design of this experiment by sharing their ideas and experience, and Trevor Meachum for providing pepper transplants in 2003.
Calculating Your Break-Even Price

Barbara Dartt, DVM, MS
Business Consultant
Salisbury Management Services, Inc.

1416 W. Milham Avenue
Portage, MI 49024
bdartt@salisbury-management.com
269-382-0539 office
517-896-3608 cell

This presentation aims to fulfill two objectives:
1. Illustrate a tool that can assist in economic decision-making; and
2. Raise awareness of cost of production resources.

Using a partial budgeting framework, we will determine the net benefit or cost of a proposed management change. The partial budgeting framework is not appropriate for capital decisions (TVM) and evaluates profitability, not cash flow.

To demonstrate this tool, data from Michigan green pepper operations will be utilized. In addition, a worksheet will be provided so that growers can do the analysis using their own data.

Short discussions of enterprise accounting and other financial analysis topics will also be covered.

Resources:

Phytophthora in Pepper Production:
How to Minimize the Losses

Dr. M.K. Hausbeck (517-355-4534, email: hausbec1@msu.edu)
B. Cortright (Research Technician)
Michigan State University, Department of Plant Pathology

Michigan has over 79,000 acres of vegetables that are vulnerable to root, crown, and fruit rot caused by the soilborne fungus, *Phytophthora capsici*. *P. capsici* has two mating types that allow for the production of long term survival spores (oospores) and development of genetic adaptations that foster fungicide resistance. The oospores can survive in soil up to ten years without a susceptible crop, and both mating types needed for oospore production have been found in every field sampled in Michigan. *P. capsici* is favored by rain and warm temperatures that occur during the Michigan growing season and has recently been found in irrigation ponds and other surface water sources. The most effective control measures are to avoid planting in infested soil and limit the spread of the pathogen to clean fields. Crop rotation is difficult as infested acreage and urban pressure is increasing across the major growing areas of the state. Properly constructed raised beds can be helpful as they keep vulnerable plants from saturated soil conditions. Foliar applications of preventive fungicides can be effective if proper coverage and timing of applications can be achieved. Certain fumigants are also available that can help lower crop losses. A combined approach of all available control techniques is more effective than using just one control measure.

Fungicide Trials

Research conducted at Michigan State University has identified fungicides that can be used to limit plant loss and fruit infection of peppers. At one time, the standard systemic fungicide mefenoxam (Ridomil Gold, Ultra Flourish) was very effective in protecting the plants and fruit from infection. However, the repeated use of this fungicide and the genetic adaptation capability of *P. capsici* resulted in resistant populations of the pathogen in many of Michigan vegetable fields. In these cases, using Ridomil Gold or Ultra Flourish does not offer any control and alternative fungicides should be used (Table 1). Recent registrations of Acrobat (dimethomorph), and Tanos 50DF (famoxadone + cymoxanil) give growers alternatives to Ridomil Gold or Ultra Flourish and are helpful as rotational products for growers interested in using Ridomil Gold or Ultra Flourish.

<table>
<thead>
<tr>
<th>Product</th>
<th>Active ingredient(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ridomil Gold/Ultra Flourish</td>
<td>mefenoxam</td>
</tr>
<tr>
<td>Ridomil Gold Copper</td>
<td>mefenoxam/copper hydroxide</td>
</tr>
<tr>
<td>ProPhyt/Phostrol</td>
<td>phosphorous acid equivalents</td>
</tr>
<tr>
<td>Kocide, Champ/Cuprofix Disperss</td>
<td>copper hydroxide/copper sulfate</td>
</tr>
<tr>
<td>Manex</td>
<td>mane b</td>
</tr>
<tr>
<td>Tanos</td>
<td>famoxadone + cymoxanil</td>
</tr>
<tr>
<td>Acrobat/Forum</td>
<td>dimethomorph</td>
</tr>
</tbody>
</table>
During the summer of 2005 a study was conducted at a grower cooperator’s farm in Oceana County with a history of *P. capsici*. The field used in the experiment was previously planted to cucurbit and solanaceous crops. Plots were established into raised beds that were covered with plastic mulch and drip irrigation. A single drip tape was installed under the black plastic mulch and was used to apply soil applied products. Six-week old pepper transplants (‘Camelot’) were planted into plots that were 40 ft long and had a 12 in. spacing between plants in the row. Treatments were replicated four times in a random order. Treatments applied at planting were made via injection into the drip tape. Irrigation occurred for approximately 45 minutes during the injection period and created a 12 in. wide treatment band surrounding the transplants. Foliar applications started 14 days after planting and were applied with a CO₂ backpack sprayer calibrated to deliver 50 GPA using three XR8003 nozzles. The nozzles were spaced 18 in. apart and configured for a directed spray application to the foliage and crown area. The center nozzle was positioned directly over the plants and the side nozzles had a 45° angle orientation to the plants. Foliar treatments were applied eight times on a 7-day spray schedule. The plot had a slight slope that increased from south to north. This slope resulted in severe disease pressure in the two replicates located at the low side (Reps 1 and 3) and light and scattered pressure in the remaining two replicates that were on the upper side of the field (Reps 1 and 4). Information on average plant loss and yields for the plot are presented in Table 2.

Table 2. Efficacy of fungicides for Phytophthora crown, root, and fruit rot of peppers.

<table>
<thead>
<tr>
<th>Treatment and application technique</th>
<th>Plant Loss (%)</th>
<th>Yield (lb/40 ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated..........................................................</td>
<td>42.1</td>
<td>19.2</td>
</tr>
<tr>
<td>Ridomil Gold 4SL 1 pt drip applied</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ridomil Gold Copper 65WP 2.5 lb foliar application .......</td>
<td>5.4</td>
<td>53.1</td>
</tr>
<tr>
<td>ProPhyt 4.2SC 2.5 pt drip applied</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ridomil Gold Copper 65WP 2.5 lb foliar application .......</td>
<td>14.6</td>
<td>43.2</td>
</tr>
<tr>
<td>Ridomil Gold 4SL 1 pt + ProPhyt 4.2SC 2.5 pt drip applied</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ridomil Gold Copper 65WP 2.5 lb foliar application .......</td>
<td>10.8</td>
<td>44.9</td>
</tr>
<tr>
<td>Ridomil Gold 4SL 1 pt drip applied</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ridomil Gold Copper 65WP 2.5 lb + ProPhyt 4.2SC 6 pt foliar application</td>
<td>14.3</td>
<td>36.8</td>
</tr>
<tr>
<td>ProPhyt 4.2SC 2.5 pt drip applied</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ProPhyt 4.2SC 6 pt foliar application.............................</td>
<td>13.1</td>
<td>43.8</td>
</tr>
<tr>
<td>Ridomil Gold 4SL 1 pt + ProPhyt 4.2SC 2.5 pt drip applied</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ridomil Gold Copper 65WP 2.5 lb + ProPhyt 4.2SC 6 pt foliar application</td>
<td>10.7</td>
<td>43.5</td>
</tr>
<tr>
<td>ProPhyt 4.2SC 2.5 pt foliar application.........................</td>
<td>11.3</td>
<td>42.0</td>
</tr>
<tr>
<td>A12946 2.08SC 5.5 fl oz foliar application .........................</td>
<td>13.6</td>
<td>40.9</td>
</tr>
<tr>
<td>Tanos 50DF 10 oz +Kocide 2000 54DF 1.5 lb alternate with Manex 4FL 2 qt +Kocide 2000 54DF 1.5 lb foliar application</td>
<td>13.6</td>
<td>40.9</td>
</tr>
</tbody>
</table>
The untreated plots had higher plant and yield loss compared to the chemical treatments. Because of variability within the plot, there were no significant differences among the different chemical programs tested. All treatment programs were helpful in limiting *P. capsici* although no program completely prevented plant loss. The mefenoxam based-treatments seemed to be effective as these fungicides have not been used frequently at this site and the *P. capsici* is still sensitive to this product in this area.

**Fumigation Trials**

Studies conducted on vegetable crops (tomato, eggplant, pepper, zucchini, winters squash, melon, and watermelon) in 2003 and 2004 compared the efficacy of currently registered fumigants for the control of *P. capsici* and their possible use as a replacement product for methyl bromide. Each year, trials were conducted on grower cooperator farms in fields with severe *P. capsici* disease pressure. Treatments of methyl bromide/chloropicrin, chloropicrin alone (100%), and Telone C-35(dichloropropene/chloropicrin) were applied using standard gas-injection knives 10-12 in. below the soil and then covered with plastic mulch. Applications of Vapam™ (metam sodium) and K-Pam™ (metam potassium) were made via drip tapes installed under the plastic mulch. In 2003, each product was applied alone at the rates used by growers. For 2004, K-Pam™ was tested alone and in combination with chloropicrin at both the high and low labeled rates. Each crop was planted after the appropriate off-gassing period had expired for each treatment. Plots were rated for plant death from *P. capsici* each year.

The data from the 2004 trial indicate that applications of both rates of K-Pam™ applied either alone or in combination with chloropicrin were effective in controlling *P. capsici* in hot and green peppers (Table 3).

### Table 3. Evaluations of fumigants for Phytophthora crown and fruit rot of pepper, 2004.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate/acre</th>
<th>Application method</th>
<th>Plant death (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>–</td>
<td>–</td>
<td>18.0 25.0</td>
</tr>
<tr>
<td>Methyl bromide/Chloropicrin (67/33)</td>
<td>350 lb Shank</td>
<td>0.0 3.0</td>
<td></td>
</tr>
<tr>
<td>Telone C35</td>
<td>35 gal</td>
<td>Shank</td>
<td>10.0 8.0</td>
</tr>
<tr>
<td>Chloropicrin</td>
<td>25 gal</td>
<td>Shank</td>
<td>0.0 5.0</td>
</tr>
<tr>
<td>K-Pam</td>
<td>30 gal</td>
<td>Drip</td>
<td>0.0 0.0</td>
</tr>
<tr>
<td>Chloropicrin</td>
<td>25 gal</td>
<td>Shank</td>
<td>3.0 5.0</td>
</tr>
<tr>
<td>K-Pam</td>
<td>60 gal</td>
<td>Drip</td>
<td>0.0 0.0</td>
</tr>
<tr>
<td>K-Pam</td>
<td>30 gal</td>
<td>Drip</td>
<td>0.0 0.0</td>
</tr>
</tbody>
</table>

*Materials were applied either at time of bed formation using swept back knives or pre-plant through drip tape.

All treatments applied in 2003 (Fig. 1) resulted in significant disease control when combining the percentage of plants killed by *P. capsici* for all crops. In 2004, both rates of K-Pam™ applied alone or in combination with chloropicrin were very effective in limiting *P. capsici* in all crops (Fig. 2). Applications of methyl bromide/chloropicrin and chloropicrin alone were also significantly better than the untreated control. The treatment of Telone C-35™ was not as effective in 2004 as it was in the 2003 study. Methyl bromide is a critical component of fresh market vegetable production in MI as its broad use range allows for applications in the early growing season. The continued use of methyl bromide as a critical use exemption (CUE) is under consideration by the Montreal Protocol Technical Use Committee.
Fig. 1. Fumigant evaluation for Phytophthora, 2003.

*Data bars with a letter in common are not significantly different, Fisher LSD \((P=0.05)\).

![Graph 2003](image)

\begin{itemize}
  \item Untreated
  \item Vapam 75 gal
  \item MBr/pic 350 lb
  \item Telone C35 35 gal
\end{itemize}

Combined data for:
- Tomato
- Eggplant
- Pepper
- Zucchini
- Winter Squash
- Melon
- Watermelon

Fig. 2. Fumigant evaluation for Phytophthora, 2004.

*Data bars with a letter in common are not significantly different, Fisher LSD \((P=0.05)\).

![Graph 2004](image)

\begin{itemize}
  \item Untreated
  \item Telone C35 35 gal
  \item Chloropicrin 25 gal
  \item MBr/Pic 350 lb
  \item K-Pam 30 gal
  \item K-Pam 60 gal
  \item K-Pam L/Pic
  \item K-Pam H/Pic
\end{itemize}

Combined data for:
- Tomato
- Eggplant
- Pepper
- Zucchini
- Winter Squash
- Melon
- Watermelon
Cucumber Mosaic Virus: Symptoms and Management
Mary K. Hausbeck, Professor
Michigan State University, Department of Plant Pathology
(517) 355-4534

The importance of virus diseases in pepper has been recognized for many years in Michigan. There are six different viruses that are known to occur in pepper in our region. In Michigan, three viruses are more prevalent and cause the most severe damage on pepper: cucumber mosaic virus (CMV), potato virus Y (PVY), and tobacco etch virus (TEV). CMV causes severe mosaic on foliage and older leaves exhibit large dead rings. Infected fruit has blotchy discoloration and spotting. PVY and TEV cause similar leaf mottling, foliar distortion and misshapen fruit. All three viruses are brought into and spread in pepper fields by aphids. Only a short feeding time (as short as 15 seconds) is necessary for an aphid to pick up the virus from an infected plant. Once the aphid has picked up the virus, it can transmit it immediately to a healthy plant. Aphids retain the virus for a short time and may lose the ability to transmit it within 4 hours. Pepper plants in different geographical areas and under different management treatments may become infected with the viruses at different stages of growth.

Numerous weeds can harbor these viruses. The solanaceous relatives are the most common. In a survey of weed hosts in Michigan, horsenettle, bitter nightshade, ground cherry, crabgrass, green amaranth and bouncing bet were found to be infected with one or more of these viruses. Crop plants like tomato, potato, and cucumber can also be sources of inoculum. Weeds that may harbor CMV include ragweed, Carolina geranium, pokeweed, cowpea, clover, milkweed, white cockle, common motherwort, carpetweed, groundcherry and flowering spurge. In addition, CMV may be seed-borne on chickweed, deadnettle and spurry, and can overwinter in perennial weeds. CMV is at its highest concentration within the plant two weeks after infection.

Table 1. Vegetable crops testing positive for CMV in 2005.

<table>
<thead>
<tr>
<th>snap bean</th>
<th>pepper</th>
<th>pumpkin</th>
<th>tomato</th>
</tr>
</thead>
<tbody>
<tr>
<td>yellow wax bean</td>
<td>jalapeno pepper</td>
<td>butternut squash</td>
<td>zucchini</td>
</tr>
<tr>
<td>cucumber</td>
<td>pickle</td>
<td>summer squash</td>
<td></td>
</tr>
</tbody>
</table>

Control of virus problems in pepper requires a combination of methods. Cultivars resistant to some virus strains are available but may only be useful in certain areas. Major virus host plants should be eradicated from ditch banks, hedge rows, and roadways. Isolate peppers, if possible, away from crops like potatoes, tomatoes, and cucurbits. Remove infected plants within the field if possible.

Applying insecticides to control these viruses has not been effective. However, growers should be aware of surrounding crops and weeds that may serve as aphid sources. Insecticide applications to surrounding crops that are serving as aphid sources may be helpful. Reflective mulches, plastic coverings, and oil sprays when used experimentally have delayed and reduced infections, but have not been used commercially because of cost and disposal problems of mulches and covering materials. Weed control in and around plantings may help reduce infections, but will likely be inadequate by itself.

Planting a border crop that is attractive to aphids but not a host to the viruses around a susceptible pepper crop has not been evaluated in Michigan. In theory, the aphids would feed first on the border crop greatly diluting any virus that the aphid might be carrying before feeding on the susceptible vine crop. Although this practice may be helpful, it would not eliminate occurrence of the virus. Currently, use of
resistant varieties, where available, is the most effective approach in managing these virus diseases and should be coupled with weed control.

Fig. 1. CMV symptoms on pepper foliage (left, center) and japeno fruit (below).