Growing Healthy Crops and Healthy Profits
December 6-8, 2005
Grand Rapids, Michigan

Great Lakes EXPO
FRUIT, VEGETABLE & FARM MARKET

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

Phytophthora in Pepper Production: How to Minimize the Losses

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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 irrigations 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 1. Products available for *Phytophthora capsici* control in peppers.

Product	Active ingredient(s)
Ridomil Gold/Ultra Flourish	mefenoxam
Ridomil Gold Copper	mefenoxam/copper hydroxide
ProPhyt/Phostrol	phosphorous acid equivalents
Kocide, Champ/Cuprofix Disperss	copper hydroxide/copper sulfate
Manex	maneb
Tanos	famoxadone + cymoxanil
Acrobat/Forum	dimethomorph

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 CO_2 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 1and 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.

Treatment and application technique	Plant Loss (%)	Yield (lb/40 ft)
Untreated..	42.1	19.2
Ridomil Gold 4SL 1 pt drip applied Ridomil Gold Copper 65WP 2.5 lb foliar application	5.4	53.1
ProPhyt 4.2SC 2.5 pt drip applied Ridomil Gold Copper 65WP 2.5 lb foliar application	14.6	43.2
Ridomil Gold 4SL 1 pt + ProPhyt 4.2SC 2.5 pt drip applied Ridomil Gold Copper 65WP 2.5 lb foliar application	10.8	44.9
Ridomil Gold 4SL 1 pt drip applied Ridomil Gold Copper 65WP 2.5 lb + ProPhyt 4.2SC 6 pt foliar application	14.3	36.8
Ridomil Gold 4SL 1 pt + ProPhyt 4.2SC 2.5 pt drip applied Ridomil Gold Copper 65WP 2.5 lb + ProPhyt 4.2SC 6 pt foliar application	10.7	43.5
ProPhyt 4.2SC 2.5 pt drip applied ProPhyt 4.2SC 6 pt foliar application	13.1	43.8
Ridomil Gold 4SL 1 pt + ProPhyt 4.2SC 2.5 pt drip applied A12946 2.08SC 5.5 fl oz foliar application	11.3	42.0
Ridomil Gold 4SL 1 pt drip applied Tanos 50DF 10 oz +Kocide 2000 54DF 1.5 lb alternate with Manex 4FL 2 qt +Kocide 2000 54DF 1.5 lb foliar application	13.6	40.9

The untreated plots had higher plant and yield loss compared to the chemical treatments. Because of variability within the plot, here 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 (Table3).

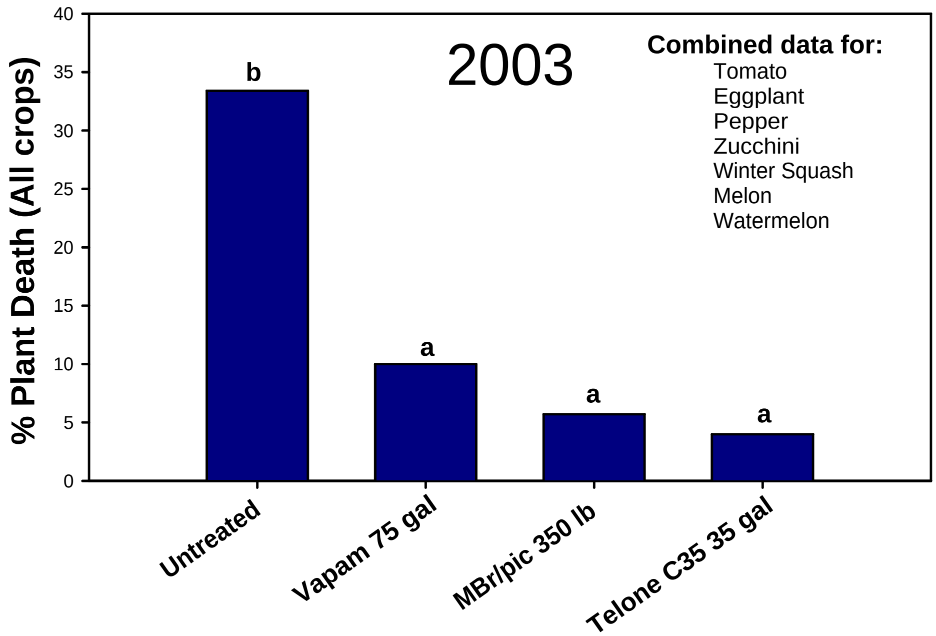
Table 3. Evaluations of fumigants for Phytophthora crown and fruit rot of pepper, 2004.

Treatment	Rate/acre	Application method[z]	Plant death (%)[y] Hot pepper	Plant death (%)[y] Green pepper
Untreated	–	–	18.0	25.0
Methyl bromide/Chloropicrin (67/33)	350 lb	Shank	0.0	3.0
Telone C35	35 gal	Shank	10.0	8.0
Chloropicrin K-Pam	25 gal 30 gal	Shank Drip	0.0	5.0
Chloropicrin K-Pam	25 gal 60 gal	Shank Drip	0.0	0.0
Chloropicrin	25 gal	Shank	3.0	5.0
K-Pam	60 gal	Drip	0.0	0.0
K-Pam	30 gal	Drip	0.0	0.0

[z]Materials were applied either at time of bed formation using swept back knives or pre-plant through drip tape.
[y]Percentage of plants killed by disease out of ten original plants.

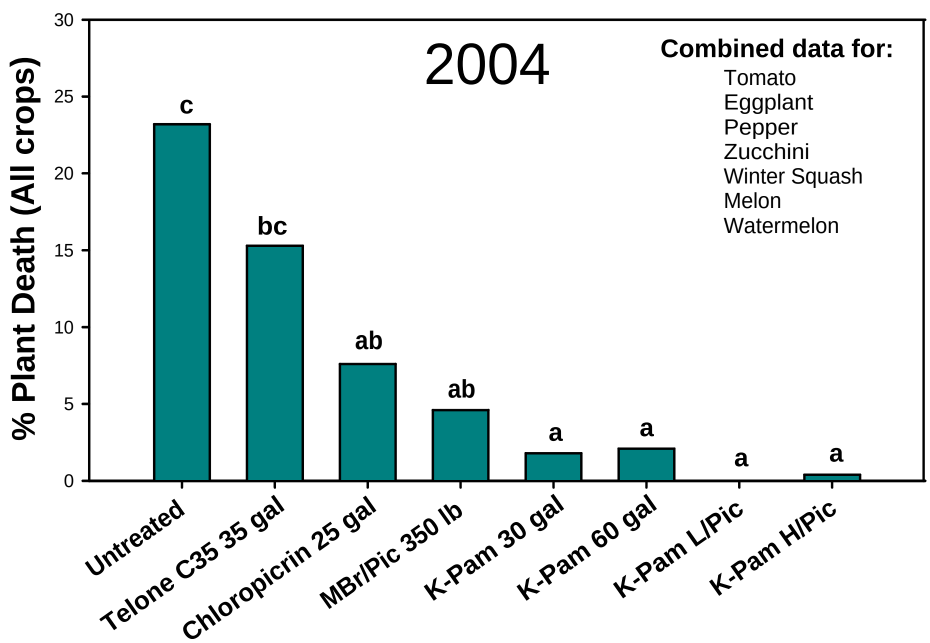
All treatments applied in 2003 (Fig. 1) resulted in significant disease control when combining the percentage of plants killed by *P. capsici* for all crops. In 2004, both rates of K-Pam™ applied alone or in combination with chloropicrin were very effective in limiting *P. capsici* in all crops (Fig. 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).

Fig. 2. Fumigant evaluation for Phytophthora, 2004.



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

Cucumber Mosaic Virus: Symptoms and Management

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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.

snap bean	pepper	pumpkin	tomato
yellow wax bean	jalapeno pepper	butternut squash	zucchini
cucumber	pickle	summer squash	

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).