MAPPING YOUR ROUTE TO THE FUTURE

Great Lakes Fruit, Vegetable & Farm Market EXPO
DeVos Place Convention Center
Grand Rapids, MI
December 7-9, 2004

Phytophthora

Wednesday morning 9:00 am

Where: Grand Gallery Room E-F (lower level)

Recertification credits: 1 (Private, 1B, 1C)

CCA Credits: IPM(2)

Moderator: Bruce MacKellar, St. Joseph Co. MSU Extension

9:00 a.m. Wisconsin Experience with Phytophthora Fruit Rot of Cucumbers

- Walter R. Stevenson, Plant Pathology Dept., Univ. of

9:15 a.m. Are all Susceptible Crops Equally Susceptible to Phytophthora Blight?

- Gerald J. Holmes, Plant Pathology Dept., NC State Univ.

10:15 a.m. Planning Your Strategy: New Tips

- Mary Hausbeck, Plant Pathology Dept., MSU

The Wisconsin Experience with Phytophthora Fruit Rot of Cucumbers

Walter R. Stevenson
University of Wisconsin, Department of Plant Pathology
Tel. No. 608-262-6291
Email: wrs@plantpath.wisc.edu

Cucumber and pumpkin growers throughout the East and Midwest have confronted the most recent outbreak of Phytophthora fruit rot for close to a decade with significant losses in years with above normal rainfall. There are recurrent reports of this disease in the literature since the first description in 1922, but the outbreaks during the past decade have been particularly devastating to growers across multiple growing areas. Growers in Wisconsin have been a bit more fortunate than some since we didn't observe this disease until the summer of 1995 on cucumbers. Since the 1995, the disease has appeared on cucumbers, pumpkin and peppers, although Wisconsin losses have been minimal due to effective use of fungicide controls, rotation and less than favorable weather.

As many growers can attest, this disease, caused by the soilborne pathogen *Phytophthora capsici*, can become a serious problem, particularly when wet and warm weather conditions persist for long periods during the flowering and fruit-bearing stages of the growing season. Symptoms of Phytophthora blight include the rapid wilting of individual plants accompanied by a browning of the vascular elements in the stem, the appearance of watersoaked areas on infected fruit, a rapid enlargement of fruit lesions that become covered by a dense coating of white growth consisting of sporangia, sporangiophores and mycelium, and the rapid collapse of affected fruit. It is not uncommon for infected fruit to be entirely enveloped in a white fungal growth and to resemble the appearance of a powdered doughnut. During the season, the pathogen is spread by rain splash, insects, workers, and equipment. The disease progresses rapidly in production fields killing individual plants and rotting fruit. At the end of the season, the pathogen can successfully overwinter in crop debris and soil.

Cucumber acreage in Wisconsin is not normally treated with fungicide since the most common diseases are controlled by the planting of resistant cultivars. However, when the disease was observed in Wisconsin pickling cucumber acreage during 1995, research efforts focused on the efficacy of fungicides available for use on this crop. While the use of mefenoxam fungicide at planting or as a surface application soon after planting was shown to provide good control, depending on a single fungicide with a single site of activity runs a high risk of selecting strains of the pathogen that are resistant to this fungicide. In our screening studies we observed that dimethomorph (Acrobat) in combination with copper hydroxide (Kocide) provided a level of control similar to the use of mefenoxam. Data from our trial as well as trials in Michigan and other states contributed to Section 18 registrations of Acrobat for multiple states. Subsequently cucumbers and other cucurbit crops were added to the full Acrobat label. Later, cucurbit crops received supplemental labeling that allowed the use of Gavel fungicide (a mixture of zoxamide and mancozeb). Thus we now have multiple chemical tools available for controlling Phytophthora blight that include Ridomil Gold EC, Acrobat 50W plus Kocide and Gavel 75DF. At this point, all of the products appear to be effective and we have not yet observed the control failures with mefenoxam that are being reported in other production areas. Having multiple control options reduces the pressure on any single product and seems to be a workable resistance management strategy. A slight wrinkle in chemical control occurred during the past season when late season rainfall increased the need for the application of chemical controls. Because of the lack of potato late blight in Wisconsin and significant late blight outbreaks in several other states, chemical manufacturers and dealers moved all of the Acrobat and Gavel supplies to areas in the country needing these materials for late blight management. The Wisconsin growers wishing to treat late season cucumbers with one of these materials were unable to find product. While losses to Phytophthora blight were minimal, this could have turned into a significant problem if disease pressure had appeared somewhat earlier in the season.

Control measures that are currently recommended and used by the Wisconsin cucumber industry include the following:

Plant pathogen-free seed - It is possible for the pathogen to be seed-borne, but the planting of seed from reputable sources helps to avoid this problem.

Rotation - Use a minimum of 3 years between susceptible crops that include cucurbits, pepper, snap beans and lima beans.

Plant in well-drained sites - The pathogen is favored by wet soil conditions and can be carried between sites by running water, thus concentrating inoculum in low-lying areas.

Soil applied fungicide - Consider the application mefenoxam (Ridomil Gold) at the time of planting or as a surface application soon after planting.

Avoid over-irrigation - Excessive irrigation keeps fruit and foliage wet for extended periods, thus favoring disease development. Careful irrigation to match crop needs with the amount of applied water can be critical to the production of a healthy crop.

Avoid entering wet fields - Do not enter fields with workers or equipment while foliage and fruit are wet from rain, dew, or irrigation since the pathogen can be easily moved from area to area within and between fields.

Apply fungicides if needed – Monitor weather and crop conditions for each field and apply fungicides if conditions warrant. Often Phytophthora blight appears near the time of harvest, but any later planted and maturing crops are certainly candidates for fungicide applications. Materials of choice for broadcast foliar sprays include 1) Acrobat plus Kocide or 2) Gavel

Field sanitation - At the conclusion of the growing season, promptly till under all plant debris. This will reduce in-field spread and reduce the risk of late season infection of plants and fruit not intended for harvest.

Resistant cultivars when available – At the present time, all cultivars being grown commercially appear to be susceptible. However, extensive field studies are continuing to evaluate potential sources of resistance. Once a useful source of resistance is identified, resistance breeding is key to long term control.

Are All Susceptible Crops Equally Susceptible to Phytophthora Blight?

Gerald J. Holmes, Assoc. Professor & Extension Specialist
Dept. Plant Pathology, North Carolina State University
Box 7616, Raleigh, NC 27695-7616
Email: gerald_holmes@ncsu.edu; Ph. 919-515-9779

Phytophthora blight is one of the most important and devastating diseases of vegetable crops in the southeastern U.S. The pathogen, *Phytophthora capsici*, has a wide host range and is known to cause disease in cucurbits as well as several solanaceous crops (e.g., pepper, tomato and eggplant). Field observations indicate that these crops are not equally susceptible.

In 2000 and 2001, we tested the susceptibility of ten crops (summer squash, pumpkin, zucchini, cucumber, muskmelon, watermelon, pepper, eggplant, tomato and cherry tomato) to Phytophthora blight under field conditions on a commercial vegetable farm in Henderson Co. in western North Carolina. Two additional treatments consisted of pepper and squash inoculated at the germling stage with a non-pathogenic isolate of *Colletotrichum magna* which is known for its ability to protect certain plants from root diseases. While all crops tested were susceptible to *P. capsici*, each differed in the degree of susceptibility, the specific host tissue affected and the symptoms produced. Summer squash, pumpkin and zucchini were the most susceptible crops (100% plant mortality) and were affected similarly by the disease (i.e., crown rot, fruit rot and leaf blight). The other cucurbits tested were susceptible to fruit rot, but we did not detect evidence of disease in other plant tissues (e.g., leaf, stem, crown, root). High plant mortality also occurred in pepper (near 100% mortality), but lagged several weeks behind squash, pumpkin and zucchini. In tomatoes and eggplant, infection was confined to fruit and stems resulting in occasional plant death in eggplant but not in tomato (Table 1). In 2000, inoculation of squash and pepper with *C. magna* provided significant disease control over the non-inoculated control until frequent rains increased disease pressure. In 2001, *C. magna* had no effect.

These results are of practical importance to growers who are often faced with the difficult decision of choosing rotational crops. All the crops tested were susceptible to the disease and their cultivation should be avoided in fields where Phytophthora blight has been a problem. However, in the event that a susceptible crop is grown where the disease has been a problem, the likelihood of producing a successful crop will depend greatly on the particular susceptible crop grown.

Table 1. Susceptibility of host tissue to Phytophthora blight under field conditions

	Host tissue				
Host (cultivar)	**Root**	**Crown**	**Stem & petiole**	**Foliage**	**Fruit**
Cucurbitaceae					
Cantaloupe (Vienna)	0	0	0	1	3
cucumber (Dasher II)	0	0	0	0.5	4
pumpkin (Oz)	0	4	4	2	4
squash, yellow summer (Multipik)	0	5	4	2	5
squash, zucchini (Elite)	0	4	3	2	5
watermelon (Crimson sweet)	0	0	0	0	3
Solanaceae					
eggplant (Classic)	0	1	1	0.5	3
tomato (Mountain Fresh)	0	1	1	0	2
tomato, cherry (Cherry Grande)	0	1	1	0	2
pepper, bell (Camelot XR-3)	1	2	3	2	3

Rating scale = 0 to 5; 0 = not observed; 0.5 = very rare (<5 lesions observed); 1 = rare (<1%); 2 = uncommon (<10%); 3 = somewhat common (10-25%); 4 = common (25-50%); 5 = very common (>50%).

Phytophthora – Planning Your Strategy: New Tips

Dr. M.K. Hausbeck (517-355-4534, hausbec1@msu.edu)
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*. *Phytophthora capsici* has two mating types that allow 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 sampled field in Michigan. *Phytophthora* 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 measure that growers have available is to avoid planting in infested soil and limit the spread of the disease 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. 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 fruit infection of pickling cucumbers. At one time, the standard systemic fungicide mefenoxam (Ridomil, Ultra Flourish) was very effective in protecting the fruit from infection. However, the repeated use of this fungicide and the genetic adaptation capability of *Phytophthora 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), Gavel (mancozeb + zoxamide), 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 used in 2004 pickle trials.

Product	Active ingredient	Company	Crops on label
Acrobat 50WP	dimethomorph	BASF	cucurbits
Forum 4.16SC	dimethomorph	BASF	no
Gavel 75DF	mancozeb + zoxamide	Dow	cucumber, melon, summer squash
Kocide 2000 54DF	copper hydroxide	Griffin	cucurbits
Maestro 80DF	captan	Arvesta	no
ManKocide 61DF	mancozeb + copper hydroxide	Griffin	cucumber, melon, summer squash
Manzate 75DF	mancozeb	Griffin	cucumber, melon, summer squash
Ridomil Gold MZ	mefenoxam + mancozeb	Syngenta	cucumber, melon, summer/winter squash
Tanos 50DF	famoxadone + cymoxanil	duPont	cucurbits

A study was conducted at a grower cooperator's farm in Van Buren County, MI on a sandy loam soil with a history of *Phytophthora*, and previously planted to cucumber. Plots were 600 ft long with 9 rows per plot, 30 in between rows and 3 in between plants. Treatments were replicated twice in a random order. Fungicide treatments were applied with a conventional boom sprayer with XR8003 nozzles spaced 20 in. apart, operating at 60 psi and delivering 30 gal/A. Sprays were applied when the oldest fruits on the vine were 1, 3, and 5 in. in size. Numbers of infected fruit that came across the transfer belt of the harvester were recorded for a pass of 3 rows by 600 ft (4,500 ft^2). Samples of fruit were taken on 30 August from each treatment strip and stored five days under ambient conditions, and evaluated for *Phytophthora* infection on 3 September.

Rainy conditions (5 in. total) occurred during the 12 days between the first and final applications. The soil remained wet throughout the trial and disease developed uniformly across all untreated plots. All treatments significantly reduced the amount of infected pickles at the time of harvest (Table 2).

Table 2. Efficacy of fungicides for Phytophthora crown, root, and fruit rot of pickles, trial 1.

Treatment and rate/A (fruit size when treated)	Infected fruit	
	At harvest (number)	After 5 days storage (%)
Untreated	1,092.5 b*	33.0
Forum 4.16SC 6.2 fl oz + Kocide 2000 54DF 1.5 lb (1", 3", 5") . .	6.5 a	11.5
Forum 4.16SC 6.2 fl oz + Kocide 2000 54DF 1.5 lb + Manzate 75DF 2 lb (1", 3", 5")	12.5 a	11.5
Gavel 75DF 2 lb + Kocide 2000 54DF 1.5 lb (1") Acrobat 50WP 6.4 oz + Kocide 2000 54DF 1.5 lb (3", 5")	10.5 a	24.0
Gavel 75DF 2 lb + Kocide 2000 54DF 1.5 lb (1", 3") Acrobat 50WP 6.4 oz + Kocide 2000 54DF 1.5 lb (5")	11.5 a	17.0
Tanos 50DF 8 oz + Kocide 2000 54DF 1.5 lb + Manzate 75DF 2 lb (1") Gavel 75DF 2 lb + Kocide 2000 54DF 1.5 lb (3") Acrobat 50WP 6.4 oz + Kocide 2000 54DF 1.5 lb (5")	1.0 a	10.0
Tanos 50DF 10 oz + Kocide 2000 54DF 1.5 lb + Manzate 75DF 2 lb (1") Gavel 75DF 2 lb + Kocide 2000 54DF 1.5 lb (3") Acrobat 50WP 6.4 oz + Kocide 2000 54DF 1.5 lb (5")	66.0 a	36.0
Tanos 50DF 12 oz + Kocide 2000 54DF 1.5 lb + Manzate 75DF 2 lb (1") Gavel 75DF 2 lb + Kocide 2000 54DF 1.5 lb (3") Acrobat 50WP 6.4 oz (5")	2.0 a	3.5
Tanos 50DF 10 oz + ManKocide 61DF 2 lb (1") Gavel 75DF 2 lb + Kocide 2000 54DF 1.5 lb (3") Acrobat 50WP 6.4 oz + Kocide 2000 54DF 1.5 lb (5")	10.0 a	7.5
Ridomil Gold MZ 2.5 lb + Kocide 2000 54DF 1.5 lb (1", 3", 5") . .	10.0 a	31.0
Maestro 80DF 6 lb + Kocide 2000 54DF 1.5 lb (1", 3", 5")	37.0 a	5.5

*Column means with a letter in common or no letter are not significantly different (Student-Newman-Keuls; *P*=0.05).

A study was conducted at a grower cooperator's farm in Van Buren County, MI on a sandy loam soil with a history of *Phytophthora*, and previously planted to cucumber. Plots were 600 ft long with 9 rows per plot, 30 in between rows and 3 in between plants. Treatments were replicated twice in a random order. Fungicide treatments were applied with a conventional boom sprayer with XR8003 nozzles spaced 20 in apart, operating at 60 psi and delivering 30 gal/A. Sprays were applied four different times, when the oldest fruits on the vine were 1, 3, and 5 in. (12, 16, and 20 September) in size and again on 23 September. Numbers of infected fruit that came across the transfer belt of the harvester were recorded for a pass of 3 rows by 600 ft (4,500 ft^2). Samples of fruit were taken on 25 September from each treatment strip and stored five days under ambient conditions, and evaluated for *Phytophthora* infection on 30 September.

A driving rainstorm between the second and third applications provided 1 in. of rain in a 15 minute period. This event left substantial amounts of soil on the fruit that remained until harvest. No other precipitation occurred during the trial. All treatments significantly reduced the amount of infected pickles at the time of harvest (Table 3). All treatments of Maestro 80DF (both rates) + Kocide 2000 54DF applied either alone or in rotation with Acrobat 50WP + Kocide 2000 54DF were very effective in limiting *P. capsici* infection to under 16 fruit per harvest pass. There were no significant differences among the treatments for amount of infected pickles evaluated after five days of storage.

Table 3. Efficacy of fungicides for Phytophthora crown, root, and fruit rot of pickles, trial 2.

Treatment and rate/A (fruit size when treated)	Infected fruit	
	At harvest (number)	After 5 days storage (%)
Untreated	83.3 b*	4.4
Acrobat 50WP 6.4 oz + Kocide 2000 54DF 1.5 lb (1", 3", 5") . .	29.3 a	0.2
Maestro 80DF 4 lb + Kocide 2000 54DF 1.5 lb (1", 3", 5")	15.7 a	0.8
Maestro 80DF 6 lb + Kocide 2000 54DF 1.5 lb (1", 3", 5")	5.0 a	0.0
Tanos 50DF 12 oz + Kocide 2000 54DF 1.5 lb (1", 3", 5")	30.3 a	2.3
Gavel 75DF 2 lb + Kocide 2000 54DF 1.5 lb (1", 3", 5")	20.0 a	0.2
Gavel 75DF 2 lb + Kocide 2000 54DF 1.5 lb (1") Tanos 50DF 12 oz + Kocide 2000 54DF 1.5 lb (3") Acrobat 50WP 6.4 oz + Kocide 2000 54DF 1.5 lb (5")	28.0 a	0.0
Maestro 80DF 6 lb + Kocide 2000 54DF 1.5 lb (1", 5") Acrobat 50WP 6.4 oz + Kocide 2000 54DF 1.5 lb (3")	7.7 a	0.0

*Column means with a letter in common or no letter are not significantly different (Student-Newman-Keuls; *P*=0.05).

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 *Phytophthora 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 *Phytophthora* disease pressure. Treatments of Methyl bromide/chloropicrin, chloropicrin alone (100 %), and Telone C-35™ (1,3-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 upper rates used by growers. For 2004, K-Pam™ was tested alone and in combination with chloropicrin at both the upper and lower labeled rates. Each crop was planted after the appropriate period of off-gassing had expired for each treatment.

Plots were rated for amount of plants killed by *P. capsici* each year and the plantings of melon and watermelon were especially vulnerable to disease (Table 4). Data from the 2004 trial shows that applications of both rates of K-Pam™ applied either alone or in combination with chloropicrin were very effective in controlling *P. capsici* in both the melon and watermelon plantings. Applications of Methyl bromide/chloropicrin and chloropicrin alone also significantly limited disease in the highly susceptible crops in 2004.

Table 4. Evaluations of fumigants for Phytophthora crown and fruit rot of cucurbit crops.

Treatment	Rate/acre	Application method[z]	Plant death (%)[y]	
			Melon	Watermelon
Untreated	–	–	97.8 b[x]	37.7 b
Methyl bromide/Chloropicrin (67/33)	350 lb	Shank	22.2 a	11.1 ab
Telone C35	35 gal	Shank	66.7 b	36.7 b
Chloropicrin K-Pam	25 gal 30 gal	Shank Drip	0.0 a	0.0 a
Chloropicrin K-Pam	25 gal 60 gal	Shank Drip	0.0 a	0.0 a
Chloropicrin	25 gal	Shank	20.0 a	33.3 b
K-Pam	60 gal	Drip	3.3 a	8.8 a
K-Pam	30 gal	Drip	8.8 a	0.0 a

[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 nine original plants.
[x]Column means with no letter or a letter in common are not significantly different, SNK, *P*=0.05.

Combining the percentage of plants killed by *P. capsici* for all crops resulted in significant disease control for all treatments applied in 2003 (Fig. 1). 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.