An Integrated Approach to Manage Phytophthora Blight on Michigan's Vine Crops

GREEEN Project #: GR99-020

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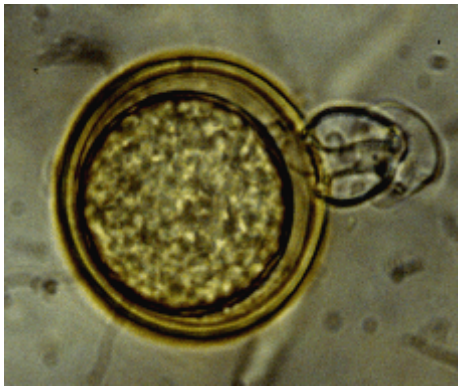
Objectives

1. Determine the role of sporangia and oospores of *Phytophthora capsici* in disease epidemics.
2. Characterize the intraspecific variation of *P. capsici* residing in Michigan soils with respect to mating type, fungicide resistance, and genotype.
3. Investigate the use of cultural control of *P. capsici* via soil amendments, protective mulches, cropping schemes, and water management.
4. Evaluate commercial cultivars of cucumber, summer squash, and pumpkin for genetic resistance to *P. capsici*.
5. Evaluate currently labeled fungicides, fungicides labeled on other crops for *Phytophthora* spp., biocontrol agents, and new chemistry in reducing disease.



Oospore of *Phytophthora capsici*.

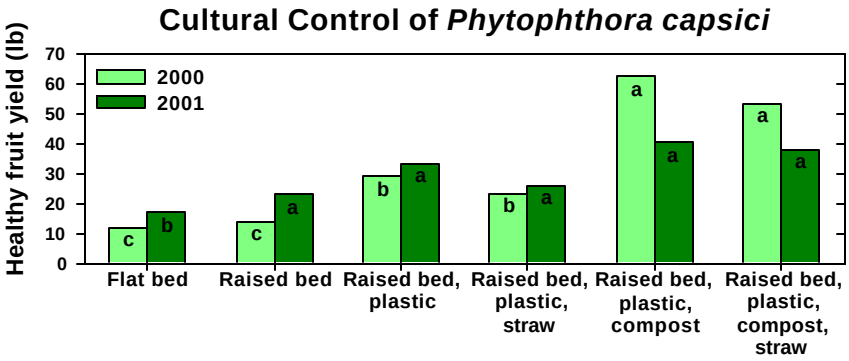
Results

1. Determine the role of sporangia and oospores of *Phytophthora capsici* in disease epidemics.

Isolates of *P. capsici* collected throughout the course of this project were evaluated on the basis of mating type (A1 or A2) and sensitivity to the fungicide mefenoxam (sensitive, intermediately sensitive or resistant). *Phytophthora capsici* can form sporangia which produce swimming asexual spores upon immersion in water; the isolate that grows once the asexual spore germinates and infects a host would be genetically identical to the isolate that produced the sporangia. Oospores are thick-walled survival structures which result from sexual recombination between an A1 and A2 mating type. Infected fruit sampled from many locations in Michigan had oospores present, and isolates grown from these oospores and tested for mating type and fungicide sensitivity showed genetic segregation for these traits (all six possible combinations of mating and sensitivity types were present). A single population of *P. capsici* was sampled through an entire growing season, and many of the isolates proved to be genetically identical (clones). Isolates that were collected from the same fields over consecutive years did not yield populations that were mainly clones, and indicated that oospores are likely the way that this organism overwinters.

2. Characterize the intraspecific variation of *P. capsici* residing in Michigan soils with respect

to mating type, fungicide resistance, and genotype. Approximately 3,500 *Phytophthora* isolates were collected from infected crops at various sites in Michigan. Mating type (production of oospores indicates different types) and fungicide resistance (sensitive, intermediately sensitive or resistant) was determined. Testing the oospore progeny resulting from sexual crosses of isolates of opposite mating and known fungicide sensitivity types demonstrated that fungicide sensitivity is inherited as a single incompletely dominant gene unlinked to mating type.



About 800 *Phytophthora* isolates originating from seven different farms were analyzed using an advanced laboratory technique (AFLP), and genetic diversity was found to be uniformly high in every population sampled and it remained stable over time. Geographically separated sites had different pools of genetic diversity which demonstrated that long distance dispersal of *P. capsici* is rare, and that in many cases *P. capsici* survives long periods of time (more than 2 years) as dormant inoculum (thick-walled oospores) in the soil.

3. Investigate the use of cultural control of *P. capsici* via soil amendments, protective mulches, cropping schemes, and water management. Controlled, replicated field trials investigating the use of drip irrigation and cultural methods and their influence on disease incidence were conducted in 2000 and 2001 with a commercial grower. The effect of different cultural methods on the occurrence of disease compared raised beds, flat beds, and raised beds with black plastic + 1" straw and/or 2 ton/A compost. Significant differences occurred each year the trial was conducted. The treatment with raised beds, plastic, straw and compost was significantly better than flat beds for stand count, numbers and weight of healthy fruit both years.

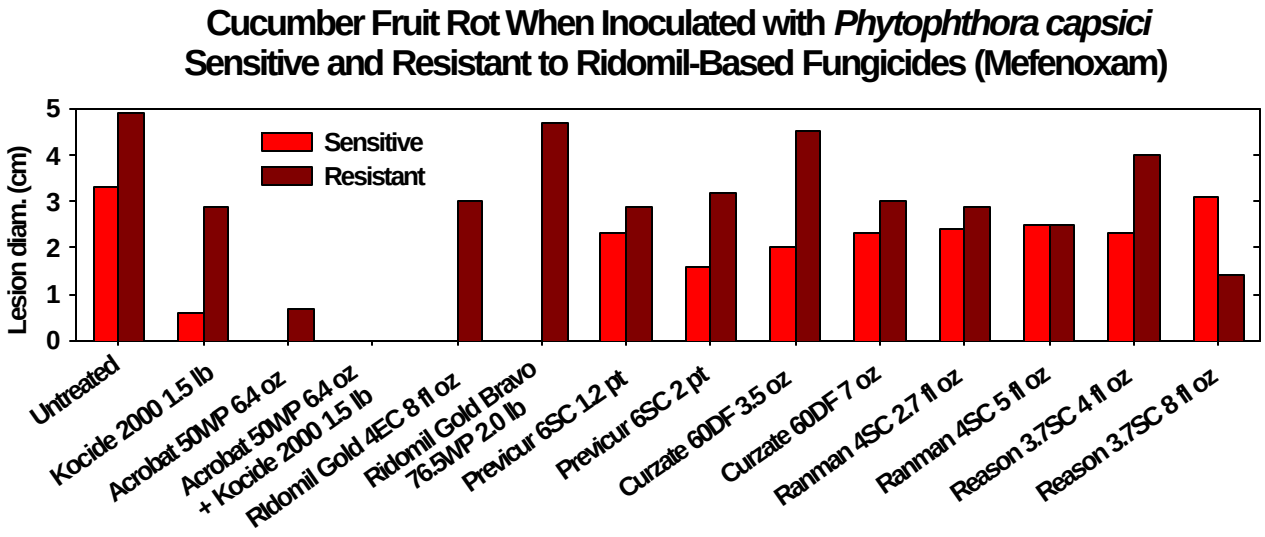
Cucumber germ plasm were screened for resistance.

Fungicides applied through the drip irrigation included Ultra Flourish (mefenoxam), Deny (*Burkholderia cepacia*), RootGuard Plus (capsaicin + garlic + humic acid + seaweed [*Ascophyllum nodosum*]); Telone C-35 (1,3-dichloropropene + chloropicrin) was applied at bed formation; however, no differences between treatments were noted for any trial.

4. Evaluate commercial cultivars of cucumber, summer squash, and pumpkin for genetic resistance to *P. capsici*.

Over the course of this project, 198 cucurbit varieties have been screened for resistance to *P. capsici*: 11 pumpkin, 40 zucchini, 14 slicing cucumber, 51 pickling cucumber, 24 numbered cucumber and 58

plant introduction cucumber varieties. Notable differences in disease resistance were not observed.



5. Evaluate currently labeled fungicides, fungicides labeled on other crops for *Phytophthora* spp., biocontrol agents, and new chemistry in reducing disease.

Over the course of this project, there were 8 field trials with grower cooperators testing 23 products for the control of Phytophthora blight.

One field trial tested fungicides applied conventionally and with new spray technology; reductions in Phytophthora-infected fruit were noted for all treatments of Acrobat + Kocide 2000, and Acrobat + Kocide 2000 + Ridomil Gold Bravo (4.5 and 3.5 infected fruit per sample, respectively, for new technology; 15.0 and 19.0 infected fruit, respectively, for conventional technology) compared to standard grower treatments (59.5 infected fruit).

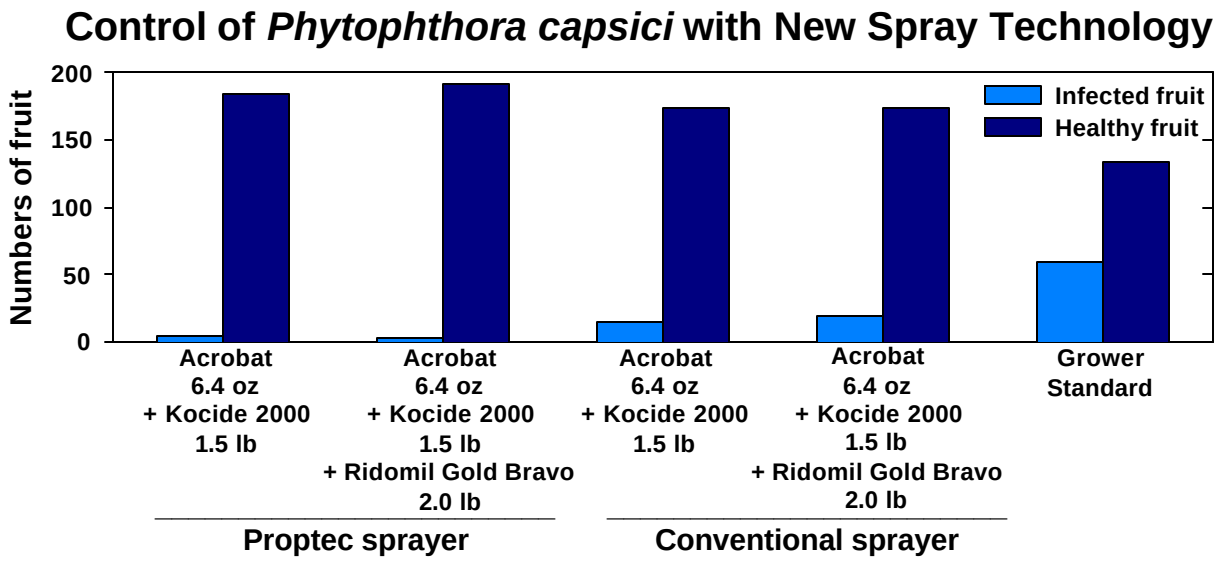
Nine laboratory screens were conducted to determine which fungicides prevent fruit rot. In every trial, the fungicide combination of Acrobat + Kocide 2000 completely prevented fruit rot on cucumber or zucchini, even when the *Phytophthora* was resistant to the commonly used fungicide, mefenoxam.

Conclusions

Phytophthora blight is a complex disease and is the limiting factor in the production of vine crops (cucumber, zucchini, squash, melon, and pumpkin) in Michigan. Cucumbers alone are an important fresh market and processing industry in Michigan with a value of $64 million in 2000. This disease also affects tomatoes, eggplant, and peppers. Michigan growers raise 54,450 acres of vegetable crops valued at $137 million that are susceptible to foliar blight, crown, root, and fruit rot caused by the soilborne fungus *Phytophthora capsici*. Many growers report major crop losses despite following recommended control strategies.

- The sexual stage of *P. capsici* plays a significant role in survival as well as maintaining both genic and genotypic diversity, and has likely played a key role in the evolution of mefenoxam insensitivity. Tracking populations over consecutive years suggests that oospores are the primary means of survival.

- The presence of all combinations of sensitivity and mating type found in infected fruit from many locations in Michigan strongly supports the hypothesis that sexual reproduction is occurring in the field, and that sexual recombination may directly generate progeny fully insensitive to mefenoxam.
- *Phytophthora capsici* has successfully colonized a number of geographical locations in Michigan. Statistical analyses suggest that long distance dispersal of inoculum is not common.
- Fruits from a total of 187 cucurbit varieties were tested for resistance to Phytophthora blight, but all proved susceptible to direct inoculation with the fungus.
- Fungicide trials, whether with plants in field with a history of Phytophthora blight, or with inoculated fruits, consistently showed Acrobat (dimethomorph), alone or in combination with other products, to be effective at limiting disease.
- Reliable disease management practices are needed to maintain profitability in vine crops, and other *Phytophthora*-susceptible crops. Managing Phytophthora blight on vine crops requires a multi-faceted approach that includes resistant varieties, cultural control, and fungicides.
- Insensitivity to Ridomil-based fungicides (mefenoxam) appears to be selected for rapidly within *P. capsici*, and is unlikely to decrease when the fungicide selection pressure is removed.
- Fields with Phytophthora blight epidemics are likely to harbor oospores for an extended amount of time (at least five years). This must be considered before replanting to susceptible crops.
- Drainage ditches, irrigation ponds and dumping of culls, factors which may contribute to the introduction of *P. capsici* into uninfested fields should be avoided, because once an epidemic is established, it is unlikely to disappear.
- Cultural strategies such as raised beds decreased fruit rot and plant death. Combining raised beds, black plastic, and composted chicken manure enhanced yields.



Impacts

- Resistance of *Phytophthora* to a commonly-used fungicide was identified in Michigan for the first time, and explained, in part, why crown and fruit rot is becoming more prevalent.
- The fungicide trials funded by this project have supported a Section 18 Specific Exemption label for

Michigan growers to use Acrobat (dimethomorph) to manage *P. capsici* on cucurbits. Currently, this is the only effective alternative for growers managing *Phytophthora* that is resistant to the Ridomil Gold-based fungicides (mefenoxam). Several states have followed Michigan's lead in requesting a Section 18 label for the use of the Acrobat fungicide.

- Approximately 10,000 acres are estimated to be infested with *Phytophthora* that is resistant to Ridomil Gold-based fungicides (mefenoxam). Since these traditionally-used fungicides are no longer effective in some fields, they can be discontinued on this acreage at a savings of $16 million.
- Over 4,000 Michigan *Phytophthora* isolates have been collected and tested for fungicide sensitivity and mating type. This information has been used to make disease management recommendations to growers that have problems with this disease.
- Growers utilizing a raised bed with black plastic and compost can yield two to three times more healthy fruit from an infested field than using a conventional flat bed.

Publications

Lamour, K.H., and M.K. Hausbeck. 2002. The spatiotemporal genetic structure of *Phytophthora capsici* in Michigan and implications for disease management. Phytopathology 92:681-684.

Lamour, K.H., and M.K. Hausbeck. 2001. Investigating the spatiotemporal genetic structure of *Phytophthora capsici* in Michigan. Phytopathology 91:973-980.

Lamour, K.H., and M.K. Hausbeck. 2001. The dynamics of mefenoxam insensitivity in a recombining population of *Phytophthora capsici* characterized with amplified fragment length polymorphism markers. Phytopathology 91:553-557.

Hausbeck, M.K. 2001. Phytophthora management in vine crops. Proceedings of Great Lakes Fruit, Vegetable and Farm Market Expo, Grand Rapids, MI, pp. 35-37.

Lamour, K.H., and M.K. Hausbeck. 2001. The spatiotemporal genetic structure of *Phytophthora capsici* in Michigan and implications for disease management. Phytopathology 91:S166 (Abstract).

Lamour, K.H. and M.K. Hausbeck. 2001. The dynamics of mefenoxam insensitivity in a recombining population of *Phytophthora capsici* characterized with AFLP markers. Phytopathology On-Line Publication no. P-2001-0021-NEA (Abstract).

Lamour, K.H., and M.K. Hausbeck. 2000. Mefenoxam insensitivity and the sexual stage of *Phytophthora capsici* in Michigan cucurbit fields. Phytopathology 90:396-400.

Lamour, K.H., and M.K. Hausbeck. 2000. *Phytophthora* root, crown, and fruit rot of vine crops. On-line publication/Michigan State University/MSU Extension/Area of Expertise Teams/Vegetable/Disease Control/Phytophthora Root, Crown, and Fruit Rot of Vine Crops.

Hausbeck, M.K., W.R. Quackenbush, and S.D. Linderman. 2000. Evaluation of fungicides for managing Phytophthora crown and fruit rot of zucchini, 1999. Fungicide and Nematicide Tests 55:293.

Hausbeck, M.K., W.R. Quackenbush, and S.D. Linderman. 2000. Evaluation of fungicides for managing Phytophthora crown and fruit rot of zucchini, 1999. Fungicide and Nematicide Tests 55:294.

Goldy, R., M.K. Hausbeck, and V. Vickery. 1999. Summer squash and cucumber *Phytophthora* observation trial. Southwest Michigan Research and Extension Center 1999 Annual Report, MSUE, Ag Expt Sta:128-131.

Lamour, K.H., and M.K. Hausbeck. 1999. Characterization of *Phytophthora capsici* populations in

Michigan. Phytopathology 89:S43 (Abstract).

Workshops

February 22, 2001: Phytophthora Workshop. Provided a 1 day session for growers and agents (66 participants). Southwest Michigan Research and Extension Center, Benton Harbor, MI. The overall grower rating for the workshop was 1.3 on a 1 (valuable) to 5 (not valuable) scale.

Presentations

"*Phytophthora capsici* on vegetable crops in Michigan," K.H. Lamour and M.K. Hausbeck. 15th Annual Tomato Disease Workshop, Detroit, MI, 1999.

"*Phytophthora* management in vine crops," M.K. Hausbeck, Great Lakes Fruit, Vegetable and Farm Markets Expo, Grand Rapids, MI, 2001.

"Phytophthora root and fruit rot in pickles and slicing cucumber," M.K. Hausbeck, MSU Extension, Hamilton, MI, 2001.

"Phytophthora management in vine crops," M.K. Hausbeck, Southwest Horticulture Days Vegetable Programs, Benton Harbor, MI, 2001.

"Dealing with Phytophthora blight in pickling cucumber fields," M.K. Hausbeck, Great Lakes Vegetable Convention, Grand Rapids, MI, 2001.

"Cucumber cultivar screening for *Phytophthora*," M.K. Hausbeck, Great Lakes Vegetable Convention, Grand Rapids, MI, 2000.

"Phytophthora and other vegetable fruit rots," M.K. Hausbeck, Michigan Food Processors Association, 1999 Winter Conference Program, Grand Rapids, MI, 1999.

"Disease control," M.K. Hausbeck, Pickle Packers International, Inc. 1999 Spring Program, E. Lansing, MI, 1999.

Funding Partnerships

Over the course of this project, this research was supported by Pickle Packers International, $22,000 for "Managing Phytophthora fruit rot on pickling cucumbers using fungicides;" Pickle Seed Research Fund, $57,900 for "Characterization of *Phytophthora capsici* populations and screening for genetic resistance to fruit rot in pickles;" MSU SWMREC, $2,600 in 1999 for "Screening for genetic resistance to *Phytophthora capsici* in vine crops;" and various chemical companies, $6,800 for evaluation of fungicides for the control of Phytophthora blight.