Reducing Root Rot, Bulb Rot and Vascular Wilt Disease Losses in Floral Crops by Improvements in Pathogen Tracking and Management

PRINCIPAL INVESTIGATORS:
Margery Daughtrey, CDR and PI, Cornell University, Department of Plant Pathology; and William Miller, Co-PI, Cornell University, Department of Horticulture.

PROJECT OBJECTIVES:
Objectives related to Pythium management: Collect isolates of *Pythium* spp. from greenhouses; extract and store DNA from representative isolates. Develop a database of DNA fingerprints for strains of *Pythium* spp. from greenhouse floral crops. Characterize the seasonal population fluctuations in species of *Pythium* in selected crop production areas in individual greenhouses. Elucidate the importance of fungus gnats and shore flies as vectors or contributors to symptoms.

Objectives related to Phytophthora management: Identify and report new diseases of ornamental crops caused by *Phytophthora* spp. Collect isolates of *Phytophthora* spp. associated with floriculture crops and store representative isolates in a permanent collection for future studies and reference. Identify isolates and explore taxonomic diversity using morphological, biochemical, and/or molecular methods. Characterize variation among groups of isolates based on economically and biologically important traits—including pathogenicity, host range, and fungicide resistance.

Objectives related to helping growers to make good cultivar choices: Elucidate the physiological basis for differential susceptibility of tulips to *Fusarium* spp. Compare cultivars of poinsettia, geranium, cyclamen, calibrachoa, tulip and possibly other crops for susceptibility to the major root rot, bulb rot, and vascular wilt pathogens. Determine the role of biological and cultural factors in pathogenicity of *Phytophthora* spp. to selected ornamental crops.

Objectives related to overall root and wilt disease management: Evaluate new reduced-risk and alternative chemical and biological controls for effectiveness against diseases caused by species of *Pythium*, *Phytophthora*, *Thielaviopsis*, *Fusarium*, and *Rhizoctonia*. Present information on performance of products under development to product manufacturers, researchers, and growers at local, state, and national meetings. Develop guidelines for the most effective use of labeled products, describe these guidelines in university pest management publications, present them at local, state, and national meetings, and report them in refereed and non-refereed publications.

ACCOMPLISHMENTS:
1. Pythium Management:
*Pythium* sp. isolates have been collected year-round in greenhouses in NY and PA and their DNA has been stored; changes in individual greenhouses over seasons have been observed. Pythium species causing diseases in greenhouses were found not to be harbored over time. In a 3-year study in Pennsylvania greenhouses, G. Moorman found that species recovery was
scattered in time and space. The major disease-causing species did not appear to be residents of
the facilities and irrigation water did not appear to be a major source of Pythium. Results
indicated that growers’ sanitation efforts between crops are effective, and that disease-causing
species are perhaps primarily reintroduced with planting material.

In the past several years, 225 Pythium isolates from flower crops, growing media or floor debris
have been collected from Long Island greenhouses or clinic samples and tested for pathogenicity
in M. Daughtrey’s lab. These were identified by morphology as belonging to 24 different
species, only 9 of which are non-pathogens (these included Pythium orthogonon, P. rostratum,
P. rostratifingens and P. segnition). Pythium irregulare was the most common species (38
percent of isolates) followed by P. aphanidermatum (15 percent), P. ultimum (8 percent), P.
vexans (5 percent), and P. myriotylum (3 percent). Chrysanthemum, geranium, poinsettia,
sidalcea, New Guinea impatiens, calibrachoa, snapdragon and xanthosoma were all found to be
hosts of P. aphanidermatum; P. irregulare (or the morphologically indistinguishable P.
cryptoirregulare) was found on coleus, coreopsis, geranium, osteospermum, phlox, poinsettia,
primula, rudbeckia, sempervivum and verbena; Pythium ultimum was found on alstroemeria,
amaranthus, geranium, poinsettia and New Guinea impatiens; Pythium vexans was found on
geranium, and Pythium myriotylum was found on chrysanthemum, delphinium, geranium,
gerbera, New Guinea impatiens, and poinsettia.

A new Pythium species of significance to the greenhouse industry was reported: Pythium
cryptoirregulare, which was previously hidden within what had been called Pythium irregulare,
was brought to light by Dr. Moorman’s DNA sequencing and fingerprinting studies. He was
able to separate two species that were morphologically identical. The new species is important
to growers because while none of the P. irregulare isolates are resistant to mefenoxam (active
ingredient in the fungicide SubdueMAXX), most P. cryptoirregulare isolates are resistant (G.
Moorman and M. Daughtrey data).

DNA sequence, location, and fungicide resistance data on all the isolates obtained and examined
during this study to date have been transferred to Dr. Seogchan Kang (Associate Professor of
Plant Pathology, Penn State) who is developing a comprehensive Pythium database to share via
the World Wide Web with the scientific community.

In 2007, Dr. Moorman developed molecular markers (simple sequence repeat markers) to help in
tracking Pythium aphanidermatum, P. irregular, and P. cryptoirregulare within greenhouses.
Fourteen markers are now available for the destructive poinsettia and chrysanthemum pathogen,
P. aphanidermatum, and 21 and 22 are available for the other two species, respectively. This
technique will be a very helpful tool. If, for example, the DNA fingerprint of an isolate from
irrigation water matches that of an isolate found infecting plants, it will be possible to learn that
the pathogen was likely introduced to the crop via the irrigation water. Laboratories assisting
growers will be able to use this technique to tell the difference between lapses in greenhouse
sanitation and newly-introduced pathogens.

Malachite green, rose bengal, sodium chloride, copper sulfate, dimethomorph, fenamidone, and
zinc sulfate were tested and found to differentially influence the growth of isolates within
Pythium species. The resulting growth characteristics were tested by Dr. Moorman for their ability to supplement the above-described molecular marker information, to better distinguish isolates and trace them to their harbors.

(Please Note: Additional accomplishments related to Pythium vectoring are reported by John Sanderson and Steve Wraight in a separate report)

2. Phytophthora Management:

Phytophthora species identified on ornamentals in New York over the past 3 years were P. capsici, P. cinnamomi, P. citricola, P. citrophthora, P. cryptogea, P. drechsleri, P. nicotianae, and P. palmivora. The species encountered most frequently on diseased greenhouse crops that were submitted for diagnosis has been P. nicotianae, followed by P. citricola and P. drechsleri.

An important new Phytophthora root and bulb rot on tulip caused by P. citricola was found on plants growing in a landscape bed in Baltimore, Maryland, by M. Daughtrey and S. Jeffers. The pathogen was identified by morphological and molecular means in the Jeffers lab. Proof of pathogenicity was shown by M. Daughtrey on cultivars Red President, Yellow President, and Garden Princess—with P. citricola reisolated from wounded inoculated stems that developed rot; cv. Passionale did not develop symptoms. Phytophthora cryptogea also was found associated with rotting tulip bulbs; this pathogen has been reported only from Australia and the United Kingdom previously. Both P. citricola and P. cryptogea were recovered from soil in the landscape bed where the problem occurred. Growers have been alerted to the presence of this new Phytophthora threat and know to make precautionary treatments.

In M. Daughtrey’s lab, P. capsici was found to be the cause of a new crown rot on calibrachoa. The isolates were identified by molecular and morphological characters and were found to be insensitive to the fungicide mefenoxam in the S. Jeffers lab. In the greenhouse, mefenoxam did not provide adequate management, but the development of cankers on the bases of stems was reduced with drench treatments of fosetyl-Al, phosphorous acid, pyraclostrobin, cyazofamid, dimethomorph, etridiazole, and two experimental products (EXP 01623B and V-10161). Growers encountering this new Phytophthora disease on calibrachoa will now know which treatments to use to protect their crops.

Important facts have been learned in S. Jeffers’ lab about host specialization of P. nicotianae. Petunia isolates are surprisingly only able to cause mortality on petunia; other known hosts such as Catharanthus species remained symptom-free after inoculation. Several heat-tolerant bedding plants have demonstrated strong resistance or immunity to P. nicotianae. Results will help home gardeners, commercial growers, and landscape gardeners to choose more resistant cultivars for use in areas contaminated with this destructive pathogen, eliminating the need for protective fungicide applications.

A study in the S. Jeffers lab using isolates of Phytophthora spp. collected over 13 years from diseased herbaceous ornamental (primarily perennial) plants from five states (SC—primarily, NY, NC, VA, and MD) detected 58 new Phytophthora diseases (new host-pathogen combinations). Isolates came from 62 host plants in 46 genera and 24 families. Twelve species of Phytophthora, including two that were undescribed previously, were identified using
morphological traits as well as RFLP fingerprinting and ITS sequencing. *P. nicotianae* was the most common species found, but other common species identified were: *P. cinnamomi, P. palmivora, P. cryptogea, P. drechsleri,* and *P. citrophthora.* All but two of the 87 isolates examined were sensitive to the fungicide mefenoxam.

3. **Cultivar Comparisons:**
Dr. William B. Miller at Cornell University has confirmed preliminary studies indicating a wide variation in the ethylene production of different tulip cultivars diseased with *Fusarium,* as well as an effect of fungus strain. Approximately half of the assayed cultivars produced more than the published baseline levels of ethylene, and half produced less. About 20 per cent of the tulip cultivars give off very low levels of ethylene when infected by *Fusarium.* Learning more about ethylene production by *Fusarium* in diseased bulbs will ultimately lead to improved handling and storage of tulips.

The effect of temperature on ethylene production by *Fusarium*-infected tulips was determined. Studies by W. Miller and G. Suazo at Cornell University have shown that temperature has no effect on ethylene evolution from a resistant cultivar, but that a susceptible cultivar produces two and four times as much ethylene at 17°C and 21°C, respectively, as it does at 5°C. From this research, shippers and growers of bulb crops have learned the importance of keeping bulbs properly cooled in order to reduce disease losses.

A new Fusarium wilt disease was identified on *Coreopsis verticillata* ‘Moonbeam’, a popular landscape ornamental, in 2006. In 2008, W. Elmer (University of Connecticut), M. Daughtrey of Cornell, and M. Jimenez-Gasco of Penn State proposed the name *F. oxysporum* f. sp. *coreopsii* for this pathogen, on the basis of molecular and host range studies. Aster, chrysanthemum, echinacea, ageratum, basil, eggplant, gomphrena, scabiosa, and snapdragon were not susceptible, whereas both *C. verticillata* and *C. lanceolata* developed wilt symptoms in pathogenicity trials. Knowledge of the host range will be helpful to greenhouse growers and landscapers, who can safely plant many other kinds of flowers to replace diseased coreopsis, now that it is shown that this is a host-specialized strain.

A new experimental technique was developed for studying Fusarium disease of tulips. Studying cultivar effects on *Fusarium* disease in tulips has previously required whole-plant studies. Dr. Miller and coworkers at Cornell University have developed an *in vitro* system utilizing freeze-dried tulip bulb powders as the sole carbon source for *Fusarium* growth. This system will allow researchers to study specific differences in tulip cultivars’ ability to support ethylene production by *Fusarium.*

Also at Cornell, the efficacy of an anti-ethylene product, 1-methylcyclopropene (MCP), has been studied, in both fully controlled and commercial-scale overseas tulip bulb shipments. Results indicate the length of protection from ethylene varies in a number of ways including by cultivar and by seasonal timing of application. In commercial shipments in the fall of 2008 (forced in spring 2009), improvements in plant quality were seen even in the absence of a prolonged, intentional ethylene exposure *per se.* Studies on cultivar susceptibility to ethylene injury and
protection by 1-MCP are currently underway using a large scale high air-flow system for gassing bulbs with appropriate ethylene concentrations.

Dr. Gary Chastagner of Washington State University developed IGS (intergenic spacer) sequences for *Fusarium* pathogens specific to various bulb crops. This will help growers to assess inoculum levels of specific *Fusarium* pathogens that cause basal rot on bulbs. (Traditional agar culture of soil samples does not allow researchers to distinguish among the various host-specialized forms of *F. oxysporum*).

*P. aphanidermatum* susceptibility was found to be common in popular red poinsettias when 15 cultivars from three poinsettia breeders were trialed by M. Daughtrey. Most plants were stunted or killed when inoculated; only cv. Silent Night showed no mortality and cv. Enduring Red showed only 12.5 percent mortality. In contrast, the highly susceptible and widely grown cultivar Prestige Red showed 75 percent mortality. Breeders have been provided with this information to guide them in selecting away from high root rot disease susceptibility in this important floral crop.

**4. Root and Bulb Disease Control:**
Flutolanil and fludioxonil treatments were as effective as PCNB in controlling gray bulb rot on 3 tulip cultivars in tests by G. Chastagner. The optimal in-furrow application rate of Moncut (flutolanil) was found to be 4-8 oz per 1,000 feet of row, while the optimum for Medallion (fludioxonil) was found to be 4 oz per 1,000 feet of row. These rates are significantly lower than application rates of PCNB, which has been the grower standard. Also, bulb dips in pyraclostrobin, pyraclostrobin plus boscalid, or azoxystrobin provided better control of blue mold on irises and tulips than the industry standard. This information will be incorporated into product labels and will be adopted by growers in the future.

M. Daughtrey tested the biofumigant Muscodor at 3.5 and 7.5 g/L of growing mix as well as Rhapsody (*Bacillus subtilis*) at 2 and 3 percent for control of *Pythium irregulare* in geranium cv. Orbit White. Only plants drenched with the registered fungicide Terrazole had good root ratings and dry weights similar to non-inoculated controls. Muscodor and Rhapsody treatment at the rates tested appeared to predispose plants to root rot and stunting; lower rates should be tested in future to find levels that are not phytotoxic.

An experimental fungicide, V-10161, was found to have good potential as a Pythium control when it was tested at 2, 4, 8 and 16 fl oz per 100 gal for protection of snapdragons against *P. aphanidermatum* by M. Daughtrey. All rates of V-10161 improved plant growth and reduced symptoms; dry weight data indicated that geraniums grew better at 2 oz than 16 oz.

The effectiveness of the new fungicide Palladium, and the relatively new materials Medallion and Heritage, was compared for Rhizoctonia stem rot control in a trial conducted at Cornell by M. Daughtrey. Although symptoms developed in over 50 percent of the inoculated controls, all of the fungicides protected plants well. Results will be used to streamline control recommendations for greenhouse flower growers.
Phytotoxicity of Actigard (acibenzolar–s-methyl) to daffodils in bulb dip applications and failure of Medallion to control Penicillium bulb rot on iris and tulips were reported by G. Chastagner. The information developed on performance of active ingredients will be used by chemical companies to develop safe and effective label guidelines for plant health products for use on bulbs.

The fungicide Pageant was identified by M. Daughtrey as an effective rotational partner for thiophanate-methyl fungicides used for black root rot (Thielaviopsis basicola) control. Stunting of treated calibrachoas indicated possible phytotoxicity from the higher rates of Pageant tested, but an 8 oz/100 gal rate was safe for the plants. Pageant was not effective at protecting vinca from T. basicola in a separate study.

Biocontrols applied as drenches or incorporated were found by M. Daughtrey to reduce incidence of root rot in young geraniums inoculated with P. aphanidermatum. Although a Banrot drench at 6 and 10 oz/100 gal was the only treatment to give plant quality similar to non-inoculated plants, drenches with BW240 and RootShield G incorporation gave uneven but significant protection against the pathogen.

Evidence was obtained by M. Daughtrey and Dr. Wade Elmer, University of Connecticut, for overwintering of the Fusarium wilt pathogen of chrysanthemums outdoors in the Northeast. Chrysanthemum growers need to know of the possibility of over-winter survival of pathogens that cause serious diseases because this affects their choice of sanitation practices and their decisions of what garden mum cultivars to grow.

Reduced risk fungicides were tested for bulb disease control, and found lacking. Six field, three bulb dip, and two commercial greenhouse forcing trials of bulb dips were conducted by G. Chastagner. Preplant iris bulb dips in Heritage, Medallion, Pageant or Mertect alone had no effect on Fusarium basal rot. Disease pressure was high: only 38 percent of the untreated check bulbs produced marketable flowers. The current industry standards of Captan alone, or Mertect plus Captan, were the only treatments that statistically increased the production of marketable iris flowers. In a gray bulb rot trial, the “reduced-risk” strobilurin treatments tested were not as effective as Terraclor, Moncut or Medallion.

**TECHNOLOGY TRANSFER/IMPACT:**
A number of the experimental fungicides that we have tested for plant safety and performance have been commercialized or soon will be.

Refereed journal articles have extended findings to the research community on markers for Pythium identification; new Fusarium wilt on coreopsis; basal sensitivity of Phytophthora cactorum to strobilurins; Phytophthora cinnamomi diversity in ornamentals; and the discovery of Pythium cryptoirregulare.

Articles including our research findings have appeared in extension newsletters, such as NE Greenhouse IPM Notes, and greenhouse trade journals, including GPN and GrowerTalks.
Presentations of research findings have been made to growers and scientists at various meetings, including the Perennial Plant Association Conference, the Mid-Atlantic Fruit and Vegetable conference, the New England Greenhouse Conference, the NE, SE, and Pacific NW Divisions of the American Phytopathological Society, the American Phytopathological Society and the International Symposium of Flowering Bulbs and Herbaceous Perennials, as well as at numerous regional extension meetings.


Web sites are used to present technical reports and aid growers in diagnosis: [www.hort.cals.cornell.edu/department/facilities/lihrec](http://www.hort.cals.cornell.edu/department/facilities/lihrec) and [www.greenhouse.cornell.edu](http://www.greenhouse.cornell.edu)


**COLLABORATORS:**
Gary Chastagner, Collaborator PI, Washington State University; Steven Jeffers, Collaborator PI, Clemson University; Gary Moorman, Collaborator PI, The Pennsylvania State University; and Stephen P. Wraight, ADODR and USDA-ARS PI, Plant Protection Research Unit.

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