Ohio Fruit ICM News

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Calendar - Newly added in ***Bold***

January 31-February 2, Mid-Atlantic Fruit & Vegetable Convention Hershey Lodge & Convention Center, Hershey PA Contact: Maureen Irvin, 717-677-4184; More information is available at <http://www.pvga.org/conv.htm>

February 11, Fruit Production School - Licking County Extension, Newark, Ohio. The three hour morning session will address "Grape Production -- Table and Wine" and the afternoon program will present information on "Bramble Production -- Raspberries and Domestic Blackberries". Participants may register for one or both of the sessions. Each session is $20.00 for the resources and materials. Dr. Dick Funt, OSU Professor, Emerti is the instructor. Each session will address soil site selection, soil amendments, irrigation, establishment procedures, plant spacings and pest management in the first three years. Additional information and registration may be accomplished by emailing siegrist.1@osu.edu.

February 12-14, Ohio Grape-Wine Short Course, Wilmigton, OH. People can register through the OWPA website http://www.ohiowines.org/

February 15, Southwest Ohio Fruit and Vegetable School. Valley Vineyards and Winery, Morrow, Ohio. For additional information contact Vickie Butler 513-732-7070.

February 15-16, Ontario Fruit & Vegetable Convention at Brock University campus in St. Catharines, Ontario. For more information, call 1-800-387-3276

Feb. 21-22, Ohio River Valley Farm Marketing Conference, Clifty Falls State Park,

Madison, IN. The conference will address: assessing and evaluating new market opportunities, market development, and marketing for value-added agriculture. Registration $40 before 2/6/06. Contact Sharon Ellison 317-290-3100 x 429, e-mail: Sharon.ellison@in.usda.gov or Deb Conley (317) 232-8771 dconley@icdc.coop.

February 22-25, Mid Atlantic Direct Marketing Conference. This year's 4 day event is being hosted near Reading, PA. For those interested - additional info can be found at <www.madmc.com/>

February 26 - March 1, 49th Annual International Fruit Tree Association Educational Conference**,** Hershey, Pennsylvania. Form more information <http://www.idfta.org/ >

Mar. 7-8, Illinois Small Fruit and Strawberry School, Mount Vernon Holiday Inn, Mount Vernon, IL. Contact Elizabeth Wahle. phone: 618-692-9434 or Bronwyn Aly phone: 618-695-2444.

March 30, Lake Erie Grape Growers Convention, Fredonia State University, Fredonia, NY < http://lenewa.netsync.net/public/events03.htm >

Apr. 22, Kentucky Nut Growers' Association Spring Meeting, Elizabethtown Extension office, Elizabethtown. Contact: Kirk Pomper 502-597-5942, e-mail: kpomper@dcr.net

Comments from the Editor

The survey is now active so please take10 minutes to complete it. Also, if you know of an event that I have missed in the calendar or a bad link to a web site or email, please send me the information. I haven't heard anything negative about the time it takes to download the email with the pdf attachment so I will continue doing that unless I hear a lot of complaints. If you need to get the FREE Adobe Reader, click on this link < FREE Adobe Reader > and download the FREE reader. I have included two articles from Dr. Rosenberger and they do contain fungicide recommendations. Remember the pesticide label is a legal document. Registrations that are legal in New York State may not be legal in Ohio.

Survey

The contributors to the Ohio Fruit ICM News are very interested in reader suggestions, comments and thoughts and we strive to provide our readers with unbiased, timely, accurate, and useful information. Therefore, we have developed a web-based survey that will take very little of your time to complete, and will be extremely useful to us. Please take 10 minutes of your time to complete this **anonymous** survey by clicking on the following link

http://www.zoomerang.com/survey.zgi?p=WEB224XNPWWJ78

Thanks for your participation. It is with your input that we can continue to provide a high-quality, useful newsletter.

Fruit Insecticide Update for 2005/2006 Celeste Welty, Extension Entomologist, Ohio State University 10/15/05; revised 1/30/06

New products:

• Venom 20SG: contains dinotefuran, a neonicotinoid. For use on grapes to control leafhoppers, thrips, mealybug, sharpshooter. Made by Valent. Registered Sept. 2005.

• Envidor 2SC: contains spirodiclofen. For use on pome fruit, stone fruit, grapes to control European red mite, two-spotted spider mite, apple rust mite, pear rust mite. Made by Bayer. Registered July 2005.

• Oberon 2SC: contains spiromesifen. For use on strawberry, to control two-spotted spider mite, whiteflies. Made by Bayer. Registered May 2005.

• Clutch 50 WDG: contains clothianidin (same as in Poncho), a neonicotinoid. For use on apples and pears, post-bloom for control of codling moth, Oriental fruit moth, plum curculio, apple maggot, leafminers , aphids, leafhoppers, pear psylla. Made by Arysta (formerly Arvesta). Registered May 2005.

• Admire Pro (4.6F): contains imidacloprid, a neonicotinoid. A higher-strength formulation that replaces Admire 2F. Made by Bayer. Registered May 2005.

• Centaur 70W: contains buprofezin (same as in Courier, Applaud), an insect growth regulator. For use on pome fruit, peaches to kill scale crawlers, leafhoppers, pear psylla. Made by Nichino America. Registered April 2005.

• Rimon 0.83EC: contains novaluron, an insect growth regulator. Ohio special local needs label (24c). For use on apples for codling moth control. Made by Chemtura (formerly Crompton/Uniroyal). Registered Jan. 2005.

Registration expanded to additional crops:

• Baythroid 2E (cyfluthrin): pome fruit, stone fruit, grapes (Nov. 2005). Broad spectrum; controls leafhoppers, caterpillars, bugs, beetles, thrips, leafminers.

• Danitol 2.4EC (fenpropathrin): blueberry (Sept. 2005). Controls caterpillars, maggots, beetles, stink bugs, spider mites, thrips.

• Esteem 35WP (pyriproxyfen): blueberries, strawberries, grape (Sept. 2005). For control of whiteflies, cherry and cranberry fruitworms, lecanium scale, sharpshooter, grape berry moth.

• Zeal 72WP (etoxazole): grapes (Sept. 2005) for mite control.

• Agri-Mek 0.15EC: plum (Mar. 2005), for European red mite and two-spotted spider mite control.

• Actara 25WDG (thiamethoxam): strawberry, blueberry (Dec. 2004), for foliar application for systemic control of aphids, leafhoppers, whiteflies.

• Platinum 2SC (thiamethoxam): strawberry, blueberry (Dec. 2004), for soil application for systemic control of aphids, leafhoppers, whiteflies.

• Intrepid 2F (methoxyfenozide): strawberry (Oct. 2004), for cutworm, armyworm, corn earworm control.

Modifications:
• Capture 2EC (bifenthrin): raspberry crown borer added to caneberry (brambles) label (October 2005).

• Zeal 72WP (etoxazole): pre-harvest interval on apple and pear shortened from 28 to 14 days, and formulation changed from 72WDG to 72WP (Sept. 2005).

• Imidan 70WP: REI lengthened and new limits per year; new label will appear summer 2006 (Jan. 2006).

Cancellations:
• Dimethoate: cancellation has been delayed but likely within a year of May 2005; will be cancelled on apple, grape.

• Guthion 50WP: not allowed for use after 9/30/06 on caneberries (raspberries, blackberries), peaches.

Summary of Fruit Insecticide Changes, 2003-2005 Celeste Welty, Extension Entomologist, Ohio State University 10/15/2005; revised 1/30/06

NEW REGISTRATIONS:

strawberries

Esteem 35WP (9/05)	Oberon 2SC (5/05)
Actara 25WDG (12/04)	Platinum 2SC (12/04)
Intrepid 2F (10/04)	Kanemite 15SC (9/04)
Zeal 72WDG (9/03)	Provado 1.6F (6/03)
Admire 2F (6/03)	

brambles/caneberries

Discipline 2EC (2004) Asana XL 0.66EC (11/03) Brigade 10WP (4/03)

blueberries/bushberries

Danitol 2.4EC (9/05)	Actara 25WDG (12/04)
Platinum 2SC (12/04)	Provado 1.6F (5/04)

Admire 2F (5/04)	Esteem 35WP (5/03; 9/05)

grapes

Zeal 72WP (9/05)	Venom 20SG (9/05)
Esteem 35WP (9/05)	Envidor 2SC (7/05)
FujiMite 5EC (6/04)	Capture 2EC (4/04)

apples & pears

Baythroid 2E (11/05)	Envidor 2SC (7/05)
Clutch 50WDG (5/05)	Centaur 70WP (4/05)
Decis 1.5EC (11/04)	Kanemite 15SC (9/04)
FujiMite 5EC (6/04)	Proaxis 0.5EC (3/04)
Calypso 4F (9/03)	Zeal 72WDG (9/03)
Warrior 1EC (2/03)	Actara 25WDG (5/01; 3/04)

apples

Rimon 0.83EC (1/05)

pears

Discipline 2EC (2004)	Dimilin 25WP & 2L (9/03)
Capture 2EC (7/03)	Brigade 10WSB (4/03)

peach, plum, & cherry

Baythroid 2E (11/05)	Envidor 2SC (7/05)
Proaxis 0.5EC (3/04)	Acramite 50WS (2/02,10/03)
Provado 1.6F (6/03)	Warrior 1EC (2/03)

peach

Centaur 70WP (4/05)	Dimilin 2L (9/03)

plum

Agri-Mek 0.15EC (3/05)_	Dimilin 2L (9/03)

CANCELLATIONS:

apple, grape

dimethoate 4EC, 2.67EC (‘06)

raspberry, blackberry, peach

Guthion 50WP (9/30/2006)

New Options for Decay Control: Fungicides, Sanitation, and the Impact of 1-MCP

David A. Rosenberger and Anne L. Rugh, Cornell University’s Hudson Valley Lab, Highland, NY

Fungicide Options for Decay Control

The best option for minimizing blue mold decay in stored fruit involves using clean bins, avoiding drenches after harvest, and storing apples in sanitized storage rooms. This combination of sanitation practices will minimize exposure of fruit to spores of *Penicillium expansum*, the fungus that causes blue mold. *P. expansum* causes the vast majority of postharvest decays in most years.

In some cases, however, postharvest treatments with diphenylamine (DPA) may be needed to control storage scald and/or carbon dioxide injury. A fungicide should ALWAYS be included in the drench solution when DPA is applied after harvest. Postharvest fungicide treatment may also be desired to control gray mold decay caused by *Botrytis cinerea*, a fungus that may infect fruit calyces in the field and then invades fruit during long-term storage. When fruit are moved into storage without a postharvest treatment, the incidence of blue mold is usually low but the incidence of gray mold is often higher than in fruit that receives a postharvest fungicide treatment. After CA storage, fruit with gray mold are usually firm and light tan with a "baked apple" appearance whereas decays caused by *P. expansum* are soft and watery.

Thiabendazole (trade name: Mertect 340F) and captan are still registered for postharvest treatment of apples. Captan is sometimes used in combination with Mertect 340F, but it should never be used as the sole fungicide in a postharvest treatment. Mertect 340F can be used as the sole fungicide in combination with a DPA treatment, or it can be applied with captan. Many storage operators report that the combination of Mertect 340F plus captan is more effective than Mertect 340F used alone, but we have not been able to verify this in controlled trials. However, in some storages, Mertect 340F is almost worthless because most of the *Penicillium* in these packing houses is resistant to Mertect 340F and the resistant spores cycle from year to year on contaminated field bins.

Two new fungicides will be available for postharvest treatment of apples this fall. Pyrimethanil (trade name: Penbotec) and fludioxonil (trade name: Scholar) are now registered for use in NY. Both of these new products are extremely effective for controlling blue mold and gray mold on apples. Both products are registered for use both in drenches and in packinghouse line sprays. Both Penbotec and Scholar are fully compatible with DPA and calcium chloride. Both products are very stable and hold up well in postharvest drench solutions. There is no reason to include captan or any other fungicide in drenches where Penbotec or Scholar is used.

Warning: *Residue tolerances for these new fungicides have not yet been established in many apple-importing countries. Before applying these fungicides to apples destined for export, packinghouse operators should verify that the importing country will accept product treated with the fungicide in question. A database of approved MRLs (maximum residue levels) for various commodities and countries can be found at the following web site:* http://mrldatabase.com.

Packinghouse operators choosing to use these new fungicides should use Penbotec in one year and Scholar the next year so that *Penicillium* spores that recycle on bins will not be repeatedly exposed to the same fungicide year after year. Penbotec and Scholar have different modes of action, and both of them are distinctly different from Mertect 340F. Alternating annually between Penbotec and Scholar should reduce selection pressure for resistance to both of these new fungicide chemistries. Alternation of chemistries for

fungicides applied in packinghouse line sprays is of less concern because the treated fruit are moved into the retail supply chain before any surviving infections can sporulate, thereby reducing or eliminating selection for fungicide resistance.

Honeycrisp growers may wish to consider a third new possibility for postharvest decay control. The new fungicide Pristine is NOT registered for postharvest treatments, but there is some evidence that field sprays applied several days prior to harvest can reduce the incidence of decays that develop after harvest. Pristine not only controls *P. expansum* and *B. cinerea*, it is also very effective against black rot, white rot, and bitter rot. All three of those diseases can appear after harvest as a result of infections that were initiated in the field. We do not yet know if a single application of Pristine during the week prior to harvest will be sufficient to suppress postharvest appearance of these summer fruit rots, or whether multiple preharvest applications (perhaps at 30 and 7 days before harvest) will be required for complete control of these diseases on Honeycrisp. Effectiveness of field sprays will definitely depend on spray coverage, and field sprays are unlikely to provide protection against blue mold and gray mold infections that are initiated at stem punctures incurred during harvest. Nevertheless, considering the high value of Honeycrisp apples, at least one preharvest application of Pristine would be justified. If Honeycrisp apples are to be stored more than a month or two, the preharvest spray of Pristine should be followed with a postharvest drench of Penbotec or Scholar. The combination of Pristine before harvest and Penbotec or Scholar after harvest should eliminate most of the postharvest decay in Honeycrisp except in cases where chilling injury causes tissue damage. After investing in expensive new fungicides to protect fruit from postharvest decays, special care should be taken to store Honeycrisp at temperatures that will not cause chilling injury.

Sanitation in the packinghouse

Good sanitation is essential both to reduce potential expenses/losses associated with postharvest decays and to eliminate possibilities that apples will become contaminated with human pathogens. Sanitation procedures and methods must be custom-tailored for each packinghouse, but some general principles are outlined below.

Essential practices for all packing operations:

#1: Chlorinate water dump tanks and flumes on apple packing lines.

A survey of 19 apple packinghouses in the Lake Ontario and Hudson Valley regions showed that many packinghouse operators are not using any sanitizer in water flumes. In the surveyed packinghouses, 14 of 25 water flumes had detectable populations of *P. expansum* spores in the water. Five flumes contained more than 5,000 spores/ml, a concentration that frequently results in a high incidence of decay when applied to wounded apples in postharvest fungicide trials. Apples run through these flumes are likely to develop decays on the way to market if any of the apples have stem punctures.

Thirteen of the 25 flumes also contained coliform bacteria, with very high populations (>3,500 cfu/ml) in five flumes. (EPA drinking water standards require <5 coliforms/ml.) The abundance of coliform bacteria was strongly correlated with flume water temperature. Packinghouses that heat flume water to warm apples prior to waxing should be especially careful to maintain effective chlorine concentrations in their flume

water. Improved sanitation of packinghouse water flumes is essential both to eliminate inoculum of decay fungi and because of human health concerns.

#2: Remove all decayed fruit from bins as the bins are emptied.

Decayed fruit do not float and therefore must be manually removed from bins after they come out of water dumps. The only alternative is an automated bin-washing system that inverts the bins while washing them with water jets. Decayed fruit left in the bin will harbor millions of spores that can then be carried into the postharvest drench water and packinghouse water flumes when bins are reused the following year. Leaving decayed fruit in empty bins will create tremendous selection pressure for resistance to the new postharvest fungicides. Complete sanitizing of bins that contained decayed fruit is the best option, but removal of decay fruit is essential even where sanitizing bins may not be feasible.

#3: Sanitize storage rooms at the end of each season.

Walls and floors of all storage rooms should be sanitized at the end of each season using either quaternary ammonium sprays or by applying a foam containing StorOx. Both methods will effectively kill spores and eliminate "storage" odors. Chlorinated water is less effective than quaternary ammonium sanitizers or StorOx foam and is not recommended for cleaning storages.

<u>Recommended practices</u>

#1: Install automated feed pumps to maintain chlorine and pH levels in water flumes, and use filtration to remove particulate matter from recirculating flume water.

The best approach for maintaining consistent chlorine and pH levels in water flumes involves installation of automated feed pumps that continuously monitor chlorine and pH in the water flume and automatically adjust chlorine and pH as needed. Automated systems can be purchased for about $5,000 and require minimal attention and maintenance once they are installed. The advantage of these automated systems is that, because they add chlorine on demand, they can be set to maintain 40-50 ppm free chlorine rather than the 100 ppm free chlorine that is recommended when chlorine is added manually once or twice a day. The lower level of chlorine and the automatic adjustment of pH reduce the likelihood that off gassing will occur due to low pH (i.e., reduces chances of developing a swimming pool odor). It also reduces the likelihood that pH will rise enough to make the chlorine ineffective or that chlorine levels will drop below effective levels.

Hypochlorite, the biologically active molecule in chlorinated water, reacts rapidly with organic matter, so hypochlorite is constantly consumed in flume water that contains organic debris. Centrifugal filters and/or sand filters connected to the water flumes and water dumps can remove organic debris and thereby minimize the need for constant additions of large amounts of chlorine. This is especially critical in presize lines where water is changed relatively infrequently and constant additions of large amounts of chlorine can eventually result in phytotoxic salt levels in the water flumes. However,

filtration is recommended even for smaller water dumps. Water that is filtered and chlorinated appears clean and is drinkable even after many bins of fruit have been processed. Fruit that consumers eat with minimal washing should be handled using clean water!

#2: Sanitize floors and other surfaces in the packinghouses periodically during the winter packing season.

Applying quaternary ammonium sanitizers to packinghouse floors just before the work day begins might prove useful for reducing spore populations apple packinghouses during winter when lack of venting can result in the build-up of huge spore populations in packinghouses. Studies conducted in a 10-ft high plastic greenhouse at the Hudson Valley Lab showed that most airborne spores of *P. expansum* settled to the floor within 4-6 hr in still air. A quaternary ammonium sanitizer (Deccosan 315) applied to the concrete floor after a 12-hr settling period eliminated most of the inoculum that had been released into the greenhouse at the start of the experiment. The sanitizer was mixed in water to provide a 200-ppm concentration and was then applied to the floor with a Solo backpack sprayer at a rate of 1 gal of mixed solution per 350 square feet of floor. This rate of application resulted in even wetting of the untreated concrete surface without puddling of the spray solution. Applying the quaternary ammonium solution to the floor before spores settled was not effective because the solution dried before the spores settled and came into contact with it.

Based on this research, we suggest that packinghouse operators should periodically apply a quaternary ammonium spray to floors and other surface areas within packinghouses. (Electronic equipment and motors should not be sprayed because we do not know how repeated exposures to quaternary ammonium solutions might affect these components.) The quaternary ammonium sanitizer needs to be applied in early morning after spores have settled over night and before morning activities are initiated in the packinghouse because spores on the floor will become airborne again as daytime activities are resumed. One concern about spraying floors in early morning is that the wet floors might be slippery for workers, and the amount of time required for the floors to dry might create scheduling problems. This concern could be avoided by applying the quaternary ammonium sanitizer at weekly intervals on a Saturday or Sunday morning when the packing line will not be operating, thereby allowing plenty of time for the floor to dry before workers re-enter the packinghouse.

Cleaning and sanitizing floors under and around packing line equipment can be difficult if there is not enough clearance between the equipment and concrete floors or if the area beneath the packing line is cluttered with support legs and cross-bracing structures. (Do equipment designers get a bonus for every additional leg they put on their packing line equipment??) When planning for new packing lines, it may be advisable to install the line at a height that allows easy access for cleaning beneath the equipment. At the same time, those purchasing packing line equipment should be asking manufacturers for equipment that is mounted on solid round “pods” that can be bolted to the floor, thereby minimizing the number of legs that create barriers to effective sanitation in the packinghouse.

#3: Sanitize bins, especially bins that are badly contaminated, before re-using them.

As reported in previous years, contaminated bins can harbor hundreds of millions of *Penicillium* spores and carry the spores from the end of the storage season into the next harvest season. Bins that contained large numbers of decayed fruit or bins that have visible blue stains due to contact of decays with bin walls should be sanitized by washing with a high-pressure sprayer. When cleaning bins with a high-pressure sprayer, sanitizing can be accomplished by using steaming water (i.e., heat), quaternary ammonium, a chlorine dioxide foam, StorOx applied in a foam, or perhaps by using chlorinated water. Chlorinated water is probably be less effective than the other options because the bin surfaces may not remain wet long enough for the hypochlorite to kill all of the spores. However, the combination of high-pressure washing plus chlorinated water should still eliminate most of the spores because many spores will be washed away by the high-pressure jets of water even if contact time with the hypochlorite is insufficient for a 100% kill of the spores.

#4: Transition to plastic bins as rapidly as possible.

Plastic bins are easier to sanitize, cause less bruising and fruit injuries where fruit contact the sides of bins, and do not harbor wood-decay fungi that are commonly found in older wooden bins and that may contribute to "storage odors" that sometimes develop when fruit are stored in wood bins. Plastic bins may still need to be cleaned as described above, but thorough cleaning will be much easier than with wooden bins.

Sanitation of plastic bins would be much simpler if the bin manufacturers developed an alternative to the open honeycomb structure on the underside of the bin floor that supplies strength to the bin structure. The open honeycomb structure increases total surface area of the bin dramatically and is difficult to clean. Those making large investments in plastic bins should press the manufacturers to come up with alternative designs that minimize the total surface area that needs to be cleaned each year when bins are sanitized.

<u>Questionable practices</u>

#1: Ozone generators in CA storage rooms have no proven benefits.

Ozone generators are being promoted for apple storage rooms as a means for controlling decays and reducing ethylene levels in apple storage rooms. Ozone generators are commonly used in California lemon storages because ozone limits the ability of spores to form on the surface of fruits that have developed decays caused by *Penicillium* species. Lemons are stored at about 50° F. At that temperature, *Penicillium* can grow rapidly and spores produced by initial decays can spread to other fruit and cause secondary and tertiary cycles of decay. In apples, *P. expansum* grows more slowly due to the colder storage temperature and it generally does not sporulate under CA conditions (although spores can form quickly after CA rooms are opened). In apples we do not have the secondary cycles of spore production and infection that are common in lemons, and the claimed benefits of ozone for decay control are therefore dubious.

Because ozone generators will not affect internal ethylene production of apples that have not been treated with 1-MCP, the value of "burning off" the atmospheric ethylene in

a CA room is also questionable. In the absence of research data showing a clear benefit from ozone in CA rooms, growers might better invest in alternative technologies.

#2: Copper-ion generators and other alternatives to chlorination are usually more expensive and/or less effective than chlorination.

Some of the alternatives to chlorinated water may be effective, but they are rarely cost-effective. Always ask vendors for details of scientific studies that document advantages of their systems compared to chlorinated water, and study carefully the costs required to achieve an effective dose of alternatives for the size of flumes used in your own packing operation.

Effects of 1-MCP on incidence and severity of decay in stored apples:

Multiple studies conducted in NY and in Ontario have provided inconsistent answers to questions about whether treatment with 1-MCP makes apples more susceptible or more resistant to postharvest decays. Studies in NY during the 2003-04 storage season suggested that wounded and inoculated fruit treated with 1-MCP and held in cold air storage decayed more rapidly than similar fruit that had not been treated with 1-MCP. However, there was no effect of 1-MCP treatment when fruit were held in CA storage.

Observations of bagged fruit in grocery stores have shown that the incidence of decay has been much lower since 1-MCP was introduced than it was in the three years prior to that. We have no way of knowing whether the reduction of decay in bagged fruit in grocery stores is attributable to effects of 1-MCP, or whether it has been caused by other factors such as improved attention to sanitation in some of the larger packinghouses. However, we suspect that 1-MCP is at least partially responsible for the reduction in decay at the retail level because fruit treated with 1-MCP is arriving in stores in a less senescent condition and is therefore less prone to decay when inoculum levels are kept reasonably low.

In a very large trial (96 treatments) conducted at the Hudson Valley Lab in fall of 2004, we used wounded Empire apples to investigate the effects of three inoculum concentrations, four different time intervals between wounding and inoculation (to determine if wounds lose susceptibility to decay if inoculum does not reach the wound until 24-72 hr after wounding), and timing of 1-MCP application (to determine if applying 1-MCP before inoculation has a different impact than applying 1-MCP after inoculation). All treatments were stored in cold air storage. At low inoculum levels (500 spores/ml) we found that after 60 days and also after 102 days of storage, incidence of decay was much higher in fruit treated with 1-MCP than in non-treated fruit regardless of whether inoculation occurred before or 1-MCP was applied. At higher inoculum levels (2,500 or 10,000 spores/mil) differences among treatments were less distinct.

The bottom line is that treatment with 1-MCP may cause a slight increase in decay susceptibility for wounded fruit that are not held in CA storage. In long-term CA storage, 1-MCP probably helps to reduce decay by delaying fruit senescence. Finally, either good sanitation (e.g., clean bins, moving fruit to storage without drenching) or application of an effective postharvest fungicide will have a much larger effect on incidence of decays than will presence of absence of 1-MCP.

Inoculum Sources for *Penicillium Expansum* and Implications for Controlling Blue Mold Decay of Apples -

David A. Rosenberger and Anne L. Rugh Cornell University's Hudson Valley Laboratory, Highland, NY 12528

Penicillium expansum causes blue mold decay of apples during postharvest storage and distribution. When first introduced, the benzimidazole fungicides thiabendazole, benomyl, and thiophanate-methyl provided excellent control of *P. expansum* when applied in postharvest drenches. Even though benzimidazole-resistant strains of *P. expansum* emerged soon after these products were introduced in the 1970's, the benzimidazole fungicides continued to provide good control of blue mold decay until the early 1990's because the fungicides were almost always applied with diphenylamine (DPA). DPA suppressed benzimidazole-resistant strains of *P. expansum*. By the mid-1990's, blue mold had become a serious problem in some storages in New York State because *P. expansum* had developed resistance to the benzimidazole-DPA combination.

Epidemiological studies were initiated in the mid-1990's to identify inoculum sources for *P. expansum* and sanitation methods that could be employed to reduce inoculum levels. Contaminated field bins were shown to carry huge quantities of inoculum from one season to the next, with some bins carrying more that 10^9 spores per bin (Table 1). Spores on contaminated bins are washed off of the bins when the filled bins are given postharvest drenches the next fall. Inoculum that accumulates in the drench solution contributes to increased decay which can result in even dirtier bins being returned to the field the next season. Sanitizing bins has been shown to remove 99% of viable conidia, but few packinghouses routinely sanitize bins because of the costs involved in doing so and questions about the economic benefits of bin sanitation.

Although field bins are recognized as a major inoculum source for *P. expansum*, no one knew the relative importance of recycled inoculum from field bins as compared to "new" inoculum originating from the field each year. The effort to sanitize field bins might be wasted if similarly large quantities of inoculum could be brought into the storage each year via contaminated apples or via soil stuck on the runners of field bins. Therefore, we initiated work to quantify populations of *P. expansum* that could be found in orchard soil and on apples at harvest time.

Table 1. Numbers of viable *Penicillium* spores per bin that were released into wash water as determined by washing bins with a portable drencher and dilution-plating sub-samples from the wash water (from Rosenberger, 2001).

Summer 1999	Number of spores per bin recovered in wash water[1]
Group I non-sanitized oak bins	8.35×10^8
Group I following fresh sanitizer wash	1.54×10^6
Group I washed at the end of sanitizer usefulness	7.44×10^6
Group II non-sanitized oak bins from another CA room	4.25×10^8
Summer 2000	

Wooden bins (mixed oak and other wood)	2.23×10^9
Plastic bins from the same storage room	4.82×10^8

[1]Means were derived from washing five replicates of 5 bins each in 1999 and four replicates of five bins each in 2000.

Development of a selective medium for recovering *Penicillium* species: Quantifying *P. expansum* populations in soil is difficult because of the diversity of organisms present in soils. To circumvent this problem, we developed a selective medium that could be used to isolated *P. expansum* from soil and from other environments that harbor a diverse microflora. The selective medium that we developed, DG18-P, is a modified form of DG18 agar (Hocking and Pitt, 1980). It contains 155 g glycerol, 10 g glucose, 5 g peptone, 1 g monobasic potassium phosphate, 0.5 g magnesium sulfate heptahydrate, 2 micrograms dichloran dissolved in 1 ml ethanol, 15 g agar, 0.1 g chloramphenicol, and 1.0 ml tergitol NP-10 nonionic in 1000 ml distilled water. Dichloran is added after autoclaving. This medium suppresses fast growing fungi such as *Trichoderma* and *Mucor* species and eliminates most bacteria, yeasts, and actinomycetes. When plates of DG18-P and acidified potato dextrose agar were similarly inoculated with known numbers of *P. expansum* spores, colony counts were similar on both media. DG18-P does not eliminate other species of soil-inhabiting *Penicillium*, so quantification of *P. expansum* from soil dilution plates must be based on sub-sampling and colony morphology on Czapek yeast extract agar (CYA). *P. expansum* can be readily identified on CYA due to its distinctive colony morphology and growth rate.

Quantification of *P. expansum* in orchard soils: Soils from five different apple orchards near Highland, NY, were sampled at various times in 2004 and 2005. In the four orchards that were being actively managed, soil was collected from the herbicided area beneath the tree canopy. The fifth orchard had been abandoned roughly 20 years ago and was largely overgrown with weeds, brambles and other shrubs. In each orchard, samples were collected from within the drip-line of five different trees that were separated by at least 10 meters. Soil was sampled by removing surface debris and/or cover plants with a shovel and then collecting approximately 50 cc of soil from the upper 8 cm of the soil profile at five different locations beneath each tree. The five sub-samples from each tree were mixed together, but the bulked sub-samples from each tree were evaluated separately to provide five replicate evaluations from each orchard.

Population densities of *Penicillium* species in the soils were quantified by dilution plating on DG18-P agar. One gram of soil was mixed into nine ml of water, and the soil solution was stirred for 5 min on a magnetic stirrer. The solution was allowed to settle for 60 sec, then 100 µL of soil suspension was plated onto each of 10 plates containing DG18-P medium. This process was repeated for each of the five individual samples per orchard, thereby resulting in a total of 50 soil dilution plates for each orchard evaluation. Plates were incubated at 25 °C for seven days after which all visible colonies on the plates were counted. Three arbitrarily selected colonies from each soil-dilution plate were sub-cultured onto CYA plates for species identification. In a few cases where soil dilution plates had low numbers of colonies, more than three subcultures were taken from other plates in the same replicate to bring the total number of subcultures to 30 per replicate, or 150 per orchard. Benzimidazole resistance of all 150 subcultures per orchard was determined by stab-inoculating PDA amended with 5 ppm MBC.

The relationship between the weight of the soil sampled and soil dry weight was determined by drying 4 grams of soil for 24 hr in a drying oven set at 100 °C. The ratio between original sample weight and dry weight was used to adjust counts so that the final concentration of *Penicillium* species in soil could be expressed as the number of colony-forming units (cfu) per g of dry soil.

Density of *P. expansum* in orchard soils ranged from 14 to 218 cfu/g of dry soil in the managed orchards but were roughly 10 times higher than that in the abandoned orchard (Table 2). Spore density in orchard soils were surprisingly consistent from year to year in the four orchards soils that were evaluated in both 2004 and 2005.

We assumed that even in a worst-case scenario involving wet harvest weather with soil occasionally balled into the bin runners, bins would be unlikely to carry more than 1 kg into drench solutions. Given that assumption, the contribution of orchard soils to build-up of *P. expansum* inoculum in postharvest treatment solutions is dwarfed by the inoculum that can originate with badly contaminated bins (Table 1). Contaminated bins can carry 10,000 times more inoculum than a kilogram of soil from the managed

Table 2. Preliminary results from sampling orchard soils in the Hudson Valley to determine populations of *P. expansum* and proportions of the populations that were benzimidazole-resistant.

Orchard	sampling date	cfu *Penicillium* species per g soil: all species	cfu *Penicillium* species per g soil: P. expansum	*P. expansum* as a percent of total *Penicillium* population	% *P. expansum* with benzimidazole resistance	Estimated *P. expansum* spores per bin assuming 1 kg soil/bin
A	23-Jul-04	262	33	12.6	27	33,000
A	17-Jun-05	1008	218	21.6	24	218,000
B	3-Sep-04	3,440	182	5.3	0	182,000
B	17-Jun-05	1626	186	11.4	1	186,000
C	30-Jun-04	298	14	4.7	8	14,000
C	9-Jun-05	698	46	6.5	10	46,000
D	19-Jul-05	310	40	12.9	13	40,000
E	8-Sep-04	15,268	2,137	20.6	0	2,137,000
E	16-May-05	5,447	1610	29.6	0	1,610,000

orchards that we tested and more than 1000 times more inoculum than would be contained in a kilogram of soil from the abandoned orchard we tested.

Quantification of *P. expansum* on apple fruit at harvest**:** To determine how much inoculum may come into storage on the surface of harvested fruit, 10 arbitrarily selected apple fruits were harvested from each of three trees in four different orchards during fall of 2005. One of the orchards was sampled on two different dates. In addition, 10 apples were collected from each of four different replicate Honeycrisp trees in experimental plots that had received three different summer fungicide regimes. In all cases, fruit were brought to the lab where they were individually washed in 500 ml of sterile distilled water containing 0.01% Tween 20. Apples were individually submersed and swirled in the wash solution for 30 sec to dislodge spores from the surfaces of the fruit. A total of 10 fruit were washed in succession, and the wash water was then filtered through a 47-mm diameter Millipore filter made up of mixed cellulose esters and having a pore size of 0.45 µm. The filter was then washed in 5 ml of sterile distilled water containing 0.01% Tween 20 by placing the filters into 25 ml glass test tubes and shaking vigorously for 10 sec. A 100 µl aliquot of the wash solution was then spread onto each of 5 plates of DG18-P agar. Plates were incubated at 25 °C for 7 days, after which all visible colonies on the plates were

counted. Varying numbers of arbitrarily selected colonies from each plate were sub-cultured onto CYA plates for species identification (Table 3). Results were converted to numbers of all *Penicillium* species and numbers of *P. expansum* per fruit. The potential spore load for full field bins was calculated assuming that a field bin would hold approximately 2000 fruit.

The number of *P. expansum* spores recovered ranged from a low of about 9 to a high of 28 in the five samples taken from sprayed orchards (Orchards A-D, Table 1). In orchard A where fruit was collected from the same block of trees on both 21 September and again on 17 October, the significantly reduced population detected in the second sampling was probably attributable to the week of heavy rain that immediately preceded the second sample date. (Empire fruit were still available in this orchard on 17 October because the orchard was not harvested due to hail damage that occurred in early summer.)

The number of *P. expansum* spores detected on Honeycrisp fruit in our fungicide trial was greatly affected by the fungicide treatments (Table 3). Fruit from control trees that received their last fungicide spray (Topsin M 11 oz/A+ Ziram Granuflo 4 lb/A) on 19 July had more than twice as many *P. expansum* spores as fruit that were sprayed with Pristine fungicide (4.8 oz/100 gal) the day prior to harvest. Trees treated with Topsin M 4 oz/100 gal plus Captan 80WDG 10 oz/100 gal on the day prior to harvest had only one-sixth as many *P. expansum* spores as control trees (Table 3). *P. expansum* accounted for nearly 60% of all *Penicillium* spores on apples from control trees but only 21 and 35% of the *Penicillium* spores on fruit from the Topsin M/Captan and Pristine treatments, respectively.

Based on our limited sample in 2005, the numbers of spores that might be brought into storage on fruit surfaces is dwarfed by the inoculum previously measured on field bins.

Although additional sampling should be done in other years and locations, the accumulated evidence from measuring *P. expansum* populations on field bins, in orchard soils, and on apple fruit at harvest suggests that badly contaminated field bins are by far the most important potential source of inoculum for *P. expansum* under conditions prevalent in New York State. In the absence of effective fungicides, sanitizing contaminated field bins should reduce losses to blue mold decay in storages where decay has gradually increased from year to year. Where storage operators choose to use one of the new fungicides (pyrimethanil or fludioxonil) to control *P. expansum*, bin sanitation should still be used reduce selection pressure for fungicide-resistant isolates, thereby extending the useful life of these new fungicides. It may not be cost effective to sanitize all bins every year, but badly contaminated bins (i.e., those showing visible blue stains from fruit that had blue mold decay) should always be sanitized before they are returned to the orchard for refilling.

Table 3. Preliminary results from washing apple fruit collected in Hudson Valley orchards to determine populations of *P. expansum* present on fruit surfaces at harvest.

Orchard	Variety/treatment	Sample date	Mean cfu/apple	No. of sub-cultures evaluated	% of total cfu that were *P. expansum*	Estimated *P. expansum* spores/bin of apples 2000
A	Empire	21-Sep-05	52.0	540	28.3	29,467
A	Empire	**17-Oct-05	3.0	90	10.0	600
B	Rome Beauty	21-Oct-05	15.3	315	14.6	4,478

C	Golden Delicious	21-Sep-05	5.3	180	8.9	948
D	Delicious	21-Oct-05	20.7	315	19.7	8,135
HVL-1*	Honeycrisp-control	8-Sep-05	50.0	84	59.5	59,524
HVL-2	Honeycrisp-Topsin/Capt	8-Sep-05	22.5	84	21.4	9,643
HVL-3	Honeycrisp-Pristine	8-Sep-05	36.3	84	34.5	25,030

*Samples from Hudson Valley Lab research plots left unsprayed during summer (HVL-1) or sprayed with Topsin M + Captan (HVL-2) or Pristine (HVL-3) one day prior to sampling.

** Spore numbers were presumably reduced compared to earlier sampling in the same orchard due to 13.5 inches of rainfall that occurred 7-15 October.

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