DECAY CONTROL WITH NEW TOOLS

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This presentation focuses primarily on recent developments in new technologies that have impacts on decay control. These technologies include 1-methylcyclopropene (1-MCP) and new pre- and postharvest fungicides. With the increasing use of 1-MCP in the apple industry, depending on varieties, many apples do not have to be drenched with diphenylamine (DPA) prior to storage. Because use of 1-MCP has been changing the traditional way the industry used to handle apples, non-drench-based measures for decay control are needed for the MCP-based fruit handling system. In 2004, two new postharvest fungicides, Penbotec (pyrimethanil) and Scholar (fludioxonil), were registered for use on pome fruits. Some preharvest fungicides that have the potential to control postharvest diseases are becoming available. This presentation is organized as three parts: first, the major postharvest diseases we are dealing with; second, strategies for decay control; and third, updates on the use of pre- and postharvest fungicides for decay control.

KNOWING THE PROBLEM

Gray mold, blue mold, Sphaeropsis rot and Bull's eye rot are common postharvest diseases on apples, and the first three are the major postharvest diseases on apples in Washington State (Table 1), based on the survey of postharvest diseases of apple we conducted in 2003 and 2004. In 2004 we sampled 72 grower lots including Red Delicious, Fuji and Golden Delicious. Gray mold, blue mold, Sphaeropsis rot and Bull's eye rot accounted for 23%, 44%, 18% and 4% of the total decay on thiabendazole (TBZ) drenched fruit, respectively, and 35%, 25%, 20% and 14% of the total decay on non-drenched fruit, respectively (Figure 1). On TBZ-drenched fruit, blue mold was dominant, whereas gray mold dominated on non-drenched fruit. Sphaeropsis rot, caused by *Sphaeropsis pyriputrescens*, is a newly reported postharvest disease of apple and pear. This disease is an important component of storage rots of apple. We have seen instances of significant economic losses of Red Delicious and Fuji caused by Sphaeropsis rot. In the 2004 survey, Bull's eye rot was more commonly seen on Golden Delicious. It appears that a postharvest drench with Mertect TBZ reduced Bull's eye rot.

Table 1. Major target postharvest pathogens on apple and pear.

Apple	Pear
Gray mold (*Botrytis cinerea*)	Gray mold (*Botrytis cinerea*)
Blue mold (*Penicillium* spp., mainly *P. expansum*)	Blue mold (*Penicillium* spp., mainly *P. expansum*)
Sphaeropsis rot (*Sphaeropsis pyriputrescens*)	Phacidiopycnis rot (*Phacidiopycnis piri*)
Bull's eye rot (*Neofabraea* spp.)	Bull's eye rot (*Neofabraea* spp.)

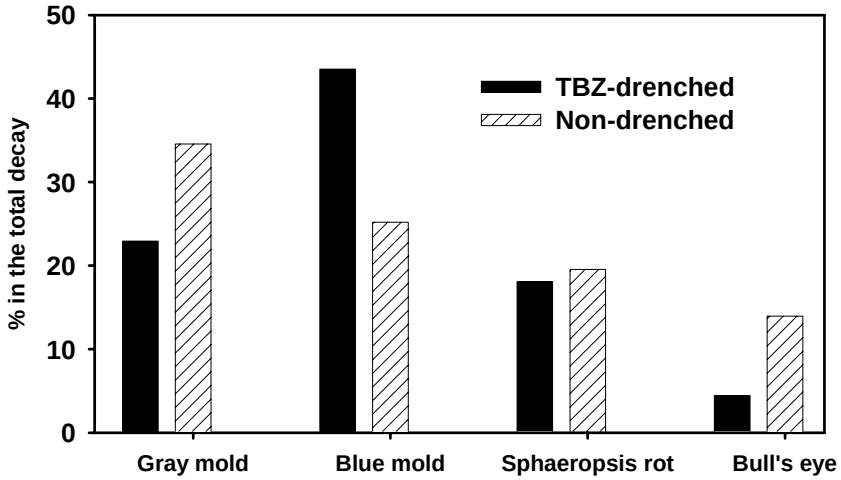

Figure 1. Occurrence of common postharvest diseases on apple in 2004. A total of 78 grower lots either drenched with TBZ or not drenched were sampled from late March to early August.

In Washington State, d'Anjou pears are usually packed shortly after harvest and stored in cardboard boxes. Decay on packed fruits in the boxes is a major concern. There also are three major postharvest diseases on d'Anjou pears in the region (Table 1). In addition to gray mold and blue mold, Phacidiopycnis rot caused by *Potebniamyces pyri* (anamorph *Phacidiopycnis piri*) is an important component of storage rots of d'Anjou pears.

Based on their origins, the common postharvest diseases of pome fruits can be divided into two categories (Figure 2). Diseases in the first category originate from fungal latent infection of fruit in the orchard, whereas those in the second category originate primarily from infection of wounds that occur at harvest and during postharvest handling processes. Sphaeropsis rot, Phacidiopycnis rot and Bull's eye rot belong to the former category, and they are orchard-related postharvest diseases. In the past, little research has been done to address such a group of postharvest diseases. In order to reduce overall losses due to postharvest diseases, decay control should target all major postharvest diseases in both categories.

STRATEGIES FOR DECAY CONTROL

The production of apple and pear is a complex process involving orchard, storage and marketing phases. Control of postharvest diseases should involve all phases of fruit production, starting in the orchard and completing when fruit is consumed. Decay control is not the responsibility of fruit packers alone. Growers and packers need to work together to implement relevant, effective measures to reduce losses due to decay. Decay control should be implemented in the context of a holistic approach, which considers the production from orchard to storage a whole system and integrates pre- and postharvest practices to reduce overall losses due to postharvest diseases (Figure 3). As illustrated in Figure 3, there are several things that growers can do in the orchard and packers can do in the packing facility. In today's session of this meeting, Dr. Peter Sholberg will talk about bin and storage room sanitation (http://postharvest.tfrec.wsu.edu/PC2004F.pdf) and Dr. Doug Kelly will talk about chlorine and ORP technology (http://postharvest.tfrec.wsu.edu/PC2004B.pdf). I will give updates on the use of pre- and postharvest fungicides for decay control.

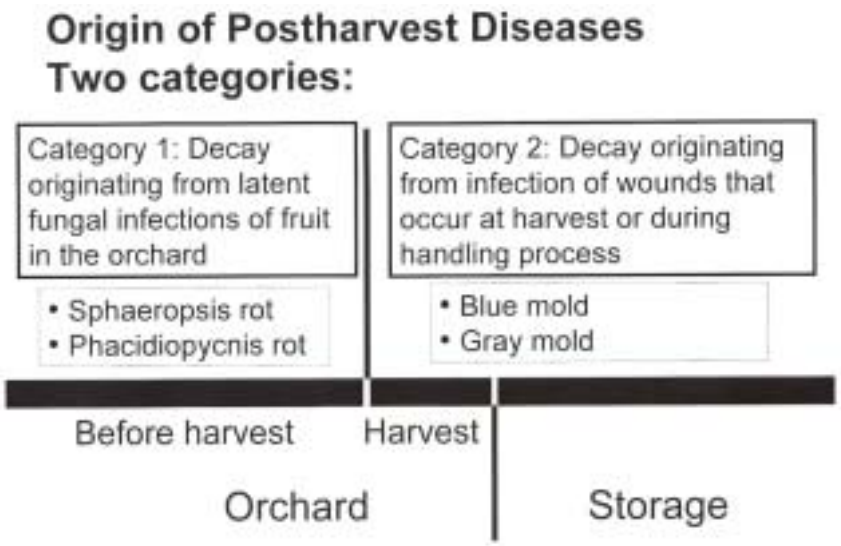

Figure 2. Origin of postharvest diseases of pome fruits. Diseases in category 1 are orchard-related postharvest diseases. Diseases in the category 2 essentially originate from infection of wounds, though calyx-end gray mold may also originate from infection of calyx tissues before harvest.

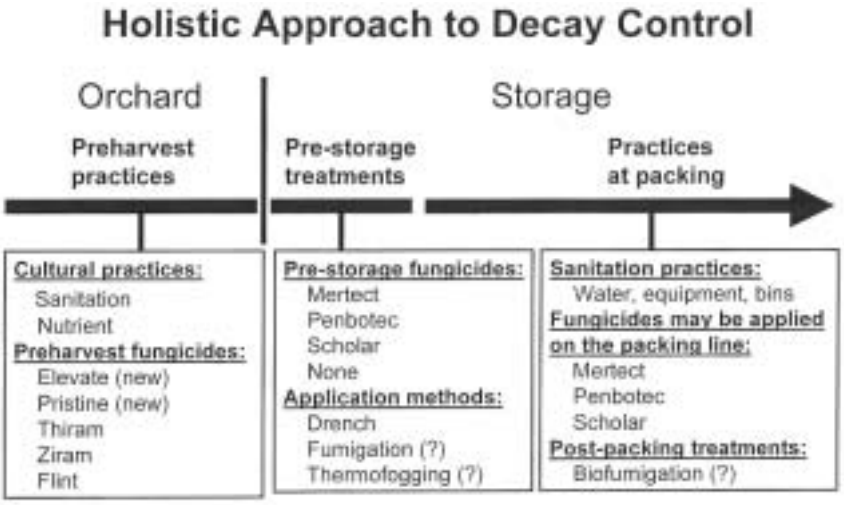

Figure 3. Illustration of a holistic approach to decay control (note: registrations of Elevate and Pristine are still pending at the time of writing this publication).

USE OF PRE- AND POSTHARVEST FUNGICIDES

Thiabendazole (TBZ, Mertect) has been the only postharvest fungicide commonly used as either drench treatments or online sprays in pome fruits since it was introduced in 1968. A postharvest drench with TBZ has been a common practice to treat apples before they are put into the storage room. Thiabendazole is still effective to control gray mold, but resistance to TBZ in *Penicillium expansum* populations has been a problem on drenched fruit. In 2004, two new postharvest fungicides, Penbotec (pyrimethanil) from Janssen Pharmaceutica and Scholar (fludioxonil) from

Syngenta, were registered for use on pome fruits. Today we have representatives from both companies at the meeting, and they will give updates on these two products. I will provide updates on preharvest fungicides.

Use of preharvest fungicides is needed to reduce amount of decay, particularly on long-term stored fruits in field bins that have not been treated with postharvest fungicides prior to storage. The benefits from preharvest fungicide applications are (1) to reduce or control latent infections, (2) to reduce spore load on the surfaces of the fruit, and (3) to protect wounds that occur at harvest and during the handling process from infection by decay-causing pathogens. Control of blue mold and gray mold originating from infection of wounds is particularly important. Broad-spectrum fungicides such as thiram and ziram are effective to reduce spore inoculum on fruit surfaces, but their residual activity to protect wounds that occur at harvest from infection by decay-causing pathogens is limited compared with some newer fungicides we have tested. A thorough coverage achieved through a high-volume ground application is essential to the success of a preharvest application of fungicides for decay control.

I will particularly mention two new fungicides, Elevate (fenhexamid) and Pristine (pyraclostrobin plus boscalid). Registration of Elevate for use on pome fruits is still pending. The proposed label of Elevate includes use as a either preharvest treatment or postharvest treatment. Because Elevate is not effective to control *Penicillium expansum*, I do not recommend it as a postharvest treatment. Our field studies indicated that Elevate applied shortly before harvest was effective to control gray mold originating from wound infections. It appears that the closer to harvest the fungicide was applied, the better the control it provided (Figure 4).

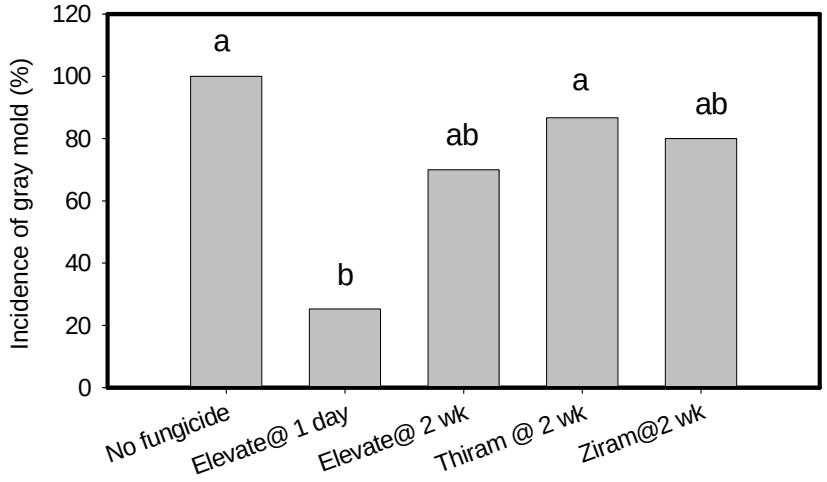

Figure 4. Effects of preharvest fungicides on gray mold on Gala apples. Elevate was applied at either 1 day or 2 weeks before harvest, and thiram and ziram were applied at 2 weeks before harvest. Fruit were wounded and inoculated shortly after harvest with spore suspensions of *Botrytis cinerea*. Fruit were then stored in air at 32 ºF for 10 weeks.

Captevate is a premixed formulation of Captan and Elevate. It appears that Captevate provided a better control of gray mold than Elevate alone (Figure 5). Captevate is not yet registered for use on apples.

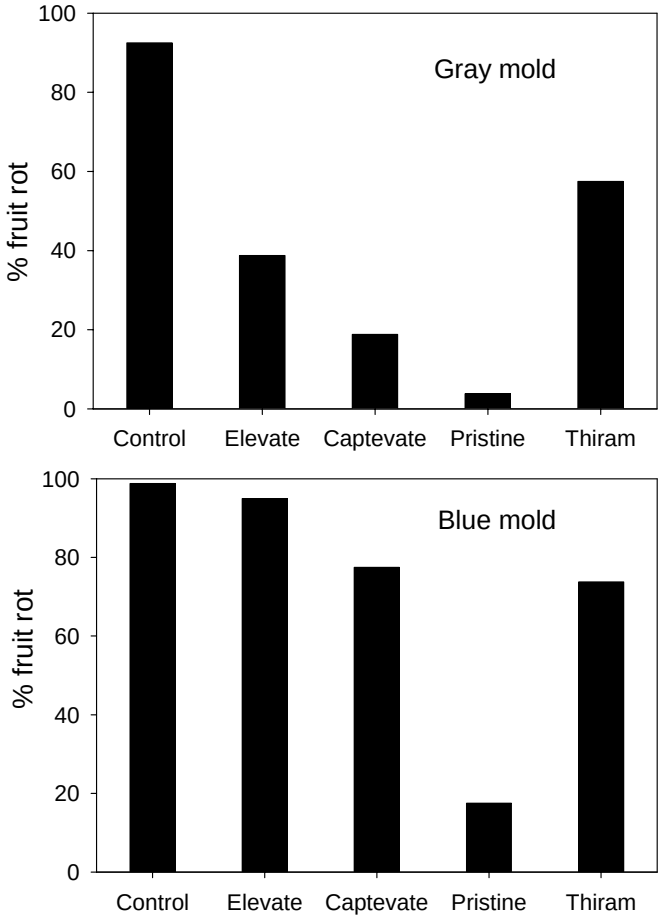

Figure 5. Preharvest applications of fungicides for control of gray mold and blue mold originating from wound infections. Fungicides were applied at 7 days before harvest. Fruit were wounded and inoculated with conidial suspensions of either *B. cinerea* or *P. expansum*. Fruit were stored in air at 32 ºF for two months, at which time decay was assessed.

Pristine is a new fungicide that has two active ingredients belonging to two different classes of fungicides. It has been labeled for use on sweet cherry. Registration for use on pome fruits is expected in 2005. Pristine applied at 7 days before harvest was effective to control both gray mold and blue mold originating from infection of wounds (Figure 5).

In collaboration with a packer in Yakima, we conducted a trial in a commercial Fuji orchard to evaluate pre- and postharvest fungicide treatments for decay control (Figures 6 and 7). The decay level after 6 months of storage was not high in that particular year. Fruit treated only with preharvest Flint has a significantly lower percent decay compared with other treatments, but fruit from the three treatments consisting of postharvest drench with Mertect TBZ and DPA had

higher percentages of decay as compared with the three non-drench treatments (Figure 6). This is likely due to the resistance of *Penicillium expansum* to TBZ. Blue mold dominated on drenched fruit, whereas gray mold dominated on non-drenched fruit (Figure 7).

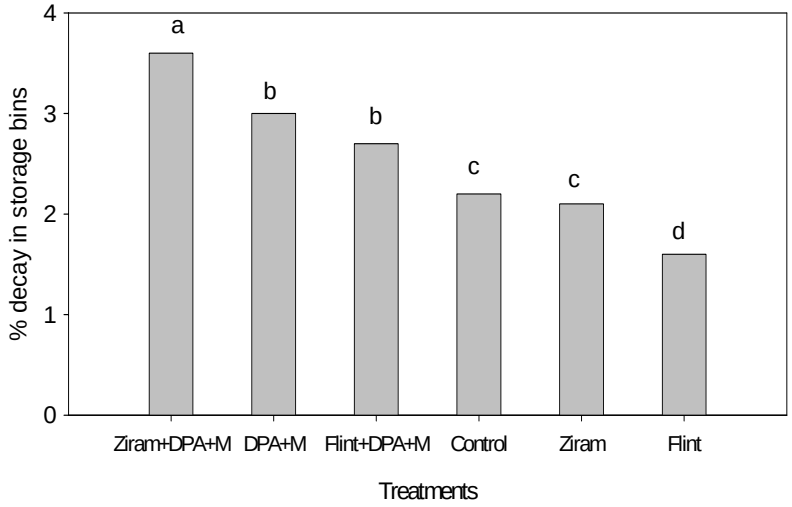

Figure 6. Control of postharvest decay on Fuji apples with pre- and postharvest fungicides in a trial conducted in a commercial orchard. Flint and ziram were applied at 14 days before harvest. After harvest, part of fungicide-treated fruit and non-treated fruit was drenched with DPA plus Mertect TBZ (M). Fruit were treated with 1-MCP and stored in RA for six months, at which time decay was assessed.

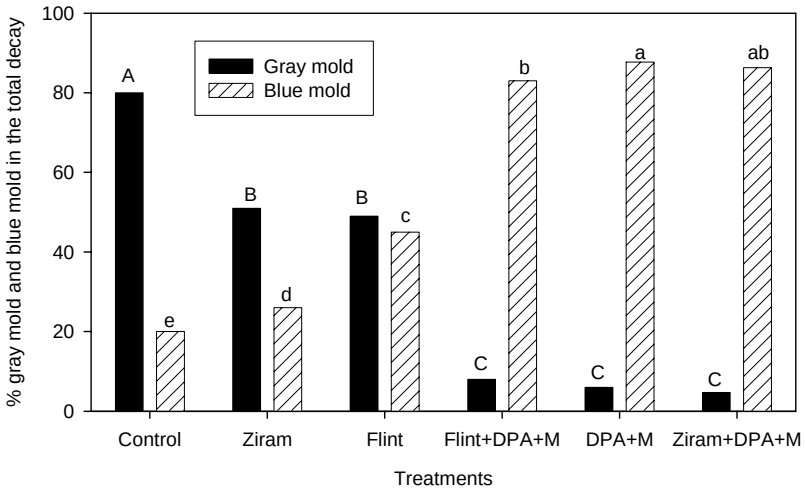

Figure 7. Control of postharvest decay on Fuji apples with pre- and postharvest fungicides in a trial conducted in a commercial orchard. Flint and ziram were applied at 14 days before harvest. After harvest, part of fungicide-treated fruit and non-treated fruit was drenched with DPA plus Mertect TBZ (M). Fruit were treated with 1-MCP and stored in RA for six months, at which time decay was assessed. Percentages of gray mold and blue mold in the total decay in each treatment were determined.

In summary, we have two new postharvest fungicides available now. New preharvest fungicides are likely becoming available. We have more tools in the tool box for decay control. But again, decay-control measures should be implemented in the context of a holistic approach as illustrated in Figure 3. Grower and packers should work together and implement orchard-specific programs for decay control.

ACKNOWLEDGMENTS

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