FINAL PROJECT REPORT
WTFRC Project Number: PH-04-446 (WSU Project No. 13C-3661-7368)

Project Title: Holistic Approach to Decay Management

PI: Chang-Lin Xiao
Organization: Washington State University Tree Fruit Research and Extension Center
Address: 1100 N. Western Avenue
City: Wenatchee
State/Province: WA
Zip: 98801
Telephone: 509-663-8181 x229
Email: clxiao@wsu.edu

Cooperators: Fruit packinghouses

Budget History:

Item	Year 1: 2004	Year 2: 2005	Year 3: 2006
Salaries	31,000	41,152	42,313
Benefits	12,710	16,486	16,953
Wages	5,000	5,000	5,000
Benefits	800	550	550
Supplies	10,000	10,000	9,000
Travel	2,000	2,000	2,000
Total	61,510	75,188	75,816

Objectives:

1. Evaluate effectiveness and timing of preharvest fungicides in controlling postharvest decay and their effects on fruit finish.
2. Evaluate various pre- and postharvest integrated programs for control of postharvest diseases.
3. Establish baseline sensitivity of major postharvest pathogens to new postharvest fungicides and assess the potential risk of fungicide resistance development in the orchard/storage system.
4. Evaluate new technologies for decay control.

Significant findings:

- One of the significant accomplishments of this study is the discovery of the effectiveness of Pristine used as a preharvest treatment applied within two weeks before harvest for control of postharvest gray mold and blue mold. Pristine was labeled in April 2005 for use on pome fruits. Based on our findings from this study, I have made recommendations to the industry on the use of Pristine as a preharvest strategy for control of postharvest diseases.
- Several other preharvest fungicides were also evaluated as preharvest treatments for control of postharvest gray mold and blue mold. In the trials conducted in the last three years, in the worst scenario (fruit were wounded and inoculated with pathogens) Topsin M applied within one week before harvest reduced gray mold by 41-61% and blue mold by 64-75%. Ziram applied at two weeks before harvest reduced gray mold by 94-97%, but its residue on the fruit was not sufficient to protect wounds from infection by *Penicillium expansum*. Elevate was effective to control gray mold but not blue mold. Registration of Elevate for use on apple is pending.
- Thiram is no longer available. Findings from this study suggest that Pristine, Topsin M and Ziram can be effective alternatives for control of postharvest diseases, particularly gray mold.
- In a trial on Fuji conducted in a commercial operation, fruit that had been drenched with fungicides and DPA tended to have higher levels of lenticel marking compared with non-drenched fruit. The underlying mechanisms for this phenomenon are unknown yet. These observations and the magnitude of this impact on fruit finish justify further research.
- The fruit that were treated with Pristine in the orchard and did not receive any postharvest fungicides at packing had a significantly lower level of decay (47% reduction) compared with the nontreated fruit, indicating that Pristine still had residue protection at five months after harvest. However, the residue protection was diminished when the fruit were moved to room temperature.
- In 2004-06, three postharvest fungicides (Scholar, Penbotec and TBZ) in various combinations as either a drench or an online treatment were tested for control of blue mold. We observed that, when applied as pre-storage drench treatments, Penbotec and Scholar had very good residue protection at packing even after the fruit were stored in CA for five and seven months.
- Bins in commercial orchards at harvest were heavily contaminated by *Penicillium expansum*, with 4,895 to 17,809 spores/cm^2 on the interior sides of the bins; 26-54% of the *P. expansum* recovered from interior sides of the bins were resistant to TBZ, and 14-31% of the *P. expansum* isolates recovered from the underside bottom of the bins were resistant to TBZ. Bins contaminated with TBZ-resistant *P. expansum* were a major source for buildup of inoculum of TBZ-resistant *P. expansum* in the drench-tank water, in which 68-84% of the *P. expansum* isolates were resistant to TBZ. Interestingly, 1-24% of the *P. expansum* isolates recovered from apple fruit on the trees near harvest in the orchards were resistant to TBZ. It appeared that there was great variation in TBZ-resistant *P. expansum* recovered from apple fruit on the trees in the orchards. Orchard practices may have impact on TBZ-resistant populations of *P. expansum* on apple fruit in the orchards.
- Based on three assays (mycelial growth, spore germination and germ-tube elongation), we have established baseline sensitivity patterns of *P. expansum* to the two new postharvest fungicides, Scholar and Penbotec. The information will be used for monitoring sensitivity shifts in populations of the pathogen.

- Fludioxonil-resistant mutants of *P. expansum* were highly resistant to fludioxonil but remained sensitive to pyrimethanil. However, pyrimethanil-resistant mutants also were resistant to fludioxonil. Pyrimethanil-resistant mutants derived from TBZ-S also became resistant to TBZ. Six phenotypes of fungicide resistance in *P. expansum* were detected, and all pyrimethanil-resistant mutants were triple resistant to all three postharvest fungicides. A fitness cost was associated with fludioxonil-resistant mutants in both saprophytic and pathogenic phases.
- None of the three postharvest fungicides was able to provide satisfactory control of pyrimethanil-resistant mutants on apple fruit at both 32ºF and 68ºF.
- Our results indicate that pyrimethanil has a high risk in the development of resistance in *Penicillium expansum*. Multiple resistance to all three postharvest fungicides could become a practical problem if *P. expansum* develops resistance to pyrimethanil. The findings from our study suggest that a program to monitor the shift in sensitivity of *P. expansum* to pyrimethanil and fludioxonil is needed and that strategies of using pre- and postharvest fungicides to avoid or delay the development of resistance to pyrimethanil need to be implemented.
- In the commercial situation, a fungicide treatment applied by thermofogging to the fruit in a storage room may be delayed for 1-3 days after harvest. One experiment was conducted to look at the kick-back activity of pyrimethanil applied by thermofogging. A 1- to 2-day delay of the thermofogging treatment significantly compromised the effectiveness of the treatment, particularly for blue mold control.
- In a trial conducted on commercially harvested fruit, the thermofogging treatment significantly reduced the total decay in storage bins as well as gray mold and blue mold. However, the level of decay resulting from natural infections in that year was low (1.1%).

Methods:

Preharvest fungicides were evaluated for control of postharvest gray mold (*Botrytis cinerea*) and blue mold (*Penicillium expansum*) on Red Delicious and Fuji apples. Fungicides were applied within two weeks before harvest. After harvest, fruit were immediately wounded and inoculated with either *B. cinerea* or *Penicillium expansum*. Fruit were tray packed and stored in cardboard boxes in air at 32ºF. The percentages of fruit that developed gray mold and blue mold were recorded, and lesion diameters were measured after 8-12 weeks of storage.

Three postharvest fungicides alone or in various combinations as either drench or online treatments were evaluated for control of decay before packing as well as after packing.

Isolates of *P. expansum* were collected from various apple-related sources, including fruit in the orchard, bins at harvest, soil or organic debris on the bottom of bins, drench solutions, etc. Isolates were identified to species. Isolates of *P. expansum* from various sources were tested for resistance to thiabendazole. Fludioxonil-resistant and pyrimethanil-resistant mutants of *P. expansum* were generated in the laboratory. These mutants were used to examine potential cross resistance of new postharvest fungicides with other fungicides.

Trials to evaluate the efficacy of thermofogging pyrimethanil for control of postharvest diseases were conducted on Red Delicious. Commercially harvested fruit as well as fruit inoculated with pathogens were included in the study.

Results and discussion:

<u>Preharvest fungicides for control of postharvest gray mold and blue mold</u>

Several trials were conducted during 2004-06 to evaluate preharvest fungicides for control of postharvest gray mold and blue mold of apples. In these trials, several preharvest fungicides were evaluated. The major target disease in these trials was gray mold, but we also evaluated fungicide effects on blue mold. All tests were conducted in the worst scenario, in which the apple fruit were wounded to simulate punctures at harvest and inoculated with pathogens. All fruit were stored in RA

at 32ºF for 8-12 weeks, at which time decay development was evaluated. The results from the last three-year study are summarized as follows:

In the trial conducted on Fuji in 2004, all fungicides were applied at seven days before harvest. Pristine provided excellent control of both gray mold and blue mold from infection of wounds and reduced gray mold and blue mold by 96% and 78%, respectively. Sylgard used as an adjuvant did not improve control. Pristine+Sylgard did not affect fruit quality compared with the nontreated control. Topsin M reduced gray mold and blue mold by 41% and 75%, respectively. Elevate and Captevate (Elevate plus Captan) reduced gray mold infection by 57% and 78%, respectively, in comparison with the nontreated control. Neither fungicide was effective to control blue mold. Elevate and Captevate are not yet labeled for use on pome fruits. Thiram reduced gray mold and blue mold infections by 38% and 22%, respectively.

In the trial conducted on Red Delicious apples in 2005, Pristine applied at 7 and 14 days before harvest reduced gray mold by 68-78% and blue mold by 70% in comparison with the nontreated control. Ziram applied at two weeks before harvest significantly reduced gray mold but not blue mold. Topsin M applied at three and seven days before harvest reduced gray mold by approximately 44% and blue mold by approximately 65%.

In the trial conducted on Fuji apples in 2005, Pristine applied at one and seven days before harvest was equally effective and reduced gray mold by 93-99% and blue mold by 87-95% as compared with the nontreated control. Topsin M reduced gray mold by 61% and blue mold by 64%. Thiram reduced gray mold but not blue mold.

In the trial conducted on Red Delicious in 2006, Pristine applied at 7 and 14 days before harvest reduced gray mold by 83-85% and blue mold by 41-46% in comparison with the nontreated control. Ziram reduced gray mold by 94% but not blue mold. The two-year results on Ziram indicate that Ziram residue on the fruit is able to protect wounds from infection by gray mold but not blue mold and that a higher residue level may required for protecting wounds from infection by blue mold.

One of the significant accomplishments of this study is the discovery of the effectiveness of Pristine used as a preharvest treatment for control of postharvest diseases. Pristine was labeled in April 2005 for use on pome fruits. Based on our findings from this study, I have made recommendations to the industry on the use of Pristine as a preharvest strategy for control of postharvest diseases. One of the active ingredients in Pristine is a strobilurin fungicide. Because other strobilurin fungicides may also be used during the fruit-growing season in the orchard for resistance management, DO NOT make more than four applications of strobilurin fungicides per season, including Pristine applied as a preharvest treatment for control of storage rots.

<u>Pre- and postharvest fungicides for control of postharvest decay – commercial orchard trials</u>

We also evaluated pre- and postharvest fungicides on commercially harvested fruit. On the 2004 crop, the amount of decay resulting from natural infections in the nontreated control was low. There were no significant differences in decay among the treatments except the fruit treated with Elevate in the orchard and drenched with Mertect and DPA, which had a higher level of decay compared with other treatments. Interestingly, the fruit that had been drenched with fungicides and DPA tended to have higher levels of lenticel marking compared with non-drenched fruit (results were presented in the 2005 report).

In a separate trial, three postharvest fungicide-drench treatments significantly reduced the amount of decay. About 3% decay developed on nondrenched, packed fruit, whereas no decay developed on Scholar- or Penbotec-drenched fruit at seven days post-packing at room temperature. This indicates that Scholar and Penbotec might have some residue protection at packing even when they were applied as pre-storage drench treatments. These observations are consistent with our findings from controlled experiments (see “integrated postharvest fungicide programs” below). In this trial the fruit that had been drenched with fungicides and DPA tended to have higher levels of lenticel marking compared with non-drenched fruit. The underlying mechanisms for this

phenomenon are not yet known. The magnitude of this impact on fruit finish needs to be further evaluated.

Pre- and postharvest fungicides integrated programs

We have demonstrated that Pristine applied as a preharvest treatment is effective to control gray mold and blue mold on Red Delicious and Fuji in storage bins prior to packing. A further question we tried to address was how to use Pristine residue protection in combination with fungicides used at packing to control blue mold originating from infections of wounds at packing. In 2005 and 2006, we conducted trials on Fuji. The 2006 experiment is in progress. The results from the 2005-06 experiment are summarized in Table 2.

In this study, Pristine was applied to Fuji apples at seven days before harvest and stored in CA for five months, at which time the fruit were washed and subjected to the packing process. After packing the fruit were stored at 32ºF for eight weeks. The fruit that were treated with Pristine in the orchard and did not receive any postharvest fungicides at packing had a significantly lower level of decay (47% reduction) compared with the nontreated fruit (Table 1), indicating that Pristine still had residue protection at five months after harvest. However, the residue protection was diminished when the fruit were moved to room temperature. Scholar and Penbotec applied at packing provided full protection even against a TBZ-resistant strain of *P. expansum*, whereas TBZ did not control TBZ-resistant *P. expansum*.

Table 1. Integration of preharvest Pristine and postharvest fungicides applied at packing for control of blue mold on Fuji apples caused by TBZ-resistant *Penicillium expansum*, 2005-06 season

Preharvest treatment	Fungicide applied at packing 5 months post drenching	8 weeks at 32ºF post inoculation	1 week at room temp after cold storage
		% infected fruit	% infected fruit
Nontreated	No Fungicide	100	100
	Scholar	0	0
	Penbotec	0	0
	TBZ	100	100
Pristine	No Fungicide	52.5	97.5
	Scholar	0	0
	Penbotec	0	0
	TBZ	68.8	100

Integrated postharvest fungicide programs

In 2004-05, three postharvest fungicides in various combinations as either a drench or an online treatment were tested for control of blue mold. We observed that Penbotec and Scholar had some good residue protection at packing even when they were applied as pre-storage drench treatments. The results were presented in the previous report submitted to Commission in July 2005. Based on these preliminary observations, for the experiments conducted in 2005-06 and 2006-07 seasons we ran the fruit through a research packingline after storage.

The results from the 2005-06 experiment are summarized in Table 2. As we observed previously, when Penbotec and Scholar were applied as drench treatments prior to storage, the residues of these two fungicides seemed to be stable in treated Red Delicious fruit in CA storage conditions. Even after seven months in cold storage, the residues of Penbotec and Scholar in the drenched fruit still protected wounds from infection by *Penicillium expansum*. It appeared that Penbotec had better residue protection than Scholar. TBZ residue in drenched fruit did not provide a satisfactory protection after seven months of CA storage, even against a TBZ-sensitive strain of *Penicillium*

expansum (data not shown). An additional online treatment with either Penbotec or Scholar provided an excellent protection of the fruit from infection by either TBZ-R or TBZ-S strains of *P. expansum*.

This study was repeated on the 2006 crop. The fruit are currently in CA, and various tests will be conducted in spring 2007. Results from this study will be forthcoming.

Table 2. Integration of pre-storage fungicide-drench treatments and online treatments at packing for control of blue mold conducted in 2005-06.

Drench treatment applied prior to storage	Fungicides applied at packing 7 months post drenching	8 weeks at 32ºF post packing	1 week at room temp after cold storage
		% infected fruit	% infected fruit
Nontreated	No fungicide	91.3	93.8
	Scholar 8 oz/100 gal	0	0
	Penbotec 32 fl oz/100 gal	0	0
	TBZ 16 oz/100 gal	98.8	98.8
TBZ 16 oz/100 gal	No fungicide	98.8	98.8
	Scholar 8 oz/100 gal	0	1.3
	Penbotec 32 fl oz/100 gal	0	0
Scholar 8 oz/100 gal	No fungicide	2.5	16.3
	TBZ 16 oz/100 gal	16.3	33.8
	Penbotec 16 fl oz/100 gal	0	1.3
Penbotec 16 fl oz/100 gal	No fungicide	0	0
	TBZ 16 oz/100 gal	0	1.3
	Scholar 8 oz/100 gal	0	0

Management of fungicide resistance in postharvest pathogens

Sources of TBZ-resistant Penicillium expansum. In 2004 and 2005, we collected *Penicillium expansum* isolates from decayed fruit sampled from orchard floors and decayed fruit from a commercial packinghouse. Resistance of these isolates to TBZ was tested (Table 3).

In 2005 and 2006, we collected isolates of *Penicillium* spp. from various apple-related sources, including fruit in the orchard, bins at harvest, soil or debris on the bottom of bins, drench solutions, etc. We have obtained hundreds of isolates of *Penicillium* spp. and identified them to species. Isolates of *P. expansum* were tested for resistance to TBZ. The goal of this study is to understand the sources of TBZ resistance of *P. expansum* in the apple-production process from orchard to storage. This would help us implement strategies to minimize the likelihood of development of resistance to new postharvest fungicides. The results are summarized in Table 4. Bins in commercial orchards at harvest were heavily contaminated by *Penicillium expansum*, with 4,895 to 17,809 spores/cm^2 on the interior sides of the bins; 26-54% of the *P. expansum* recovered from interior sides of the bins was resistant to TBZ, and 14-31% of the *P. expansum* isolates recovered from the underside bottom of the bins was resistant to TBZ. Bins contaminated with TBZ-resistant *P. expansum* were a major source for buildup of inoculum of TBZ-resistant *P. expansum* in the drench-tank water, in which 68-84% of the *P. expansum* isolates was resistant to TBZ. Interestingly, 1-24% of the *P. expansum* isolates recovered from apple fruit on the trees near harvest in the orchards was resistant to TBZ. It appeared that there was great variation in TBZ-resistant *P. expansum* recovered from apple fruit on the trees in the orchards. Orchard practices may have impacts on TBZ-resistant populations of the pathogen on apple fruit in the orchards.

Table 3. Sources of TBZ-resistant strains of *Penicillium expansum* collected in 2004-05

Origin	Pre-storage treatment	Collection year	Total isolates	TBZ-resistant isolates (%)
Orchards		2004	303	2.64
Packinghouses	TBZ-drenched	2004	75	69.3
		2005	45	91.1
	Non-drenched	2004	22	0
		2005	48	2.1

Table 4. Sources of TBZ-resistant *Penicillium expansum* from apple-related sources

Collection year	Source	Spore load	Number of isolates of *Penicillium* spp. sampled	*P. expansum* isolates (%)	TBZ-R isolates of *P. expansum* (%)
2005	Apple fruit at harvest	116/fruit	231	72.7	24.4
	Inside the bin at harvest	4895/cm^2	334	21.9	26.0
	Underside bottom of the bin		219	18.3	31.4
	Drench-tank water	814/ml	239	31	67.7
2006	Apple fruit at harvest	46/fruit	110	80.0	1.4
	Inside the bin at harvest	17809/cm^2	158	29.8	54.4
	Underside bottom of the bin		64	56.3	13.9
	Drench-tank water	498/ml	56	35.7	84.2

Baseline sensitivity of P. expansum to fludioxonil (Scholar) and pyrimethanil (Penbotec). We collected *P. expansum* isolates from apple-related sources across the state, and 120 isolates were selected for baseline sensitivity study. Sensitivities of these 120 isolates to thiabendazole, fludioxonil and pyrimethanil were determined, and the distribution of baseline sensitivity was established. The results were presented in a previous report to the Commission. In summary of the results, the current population of *P. expansum* is sensitive to both new fungicides. Of the 120 isolates, one is much less sensitive to fludioxonil, but it does not cause a practical resistance problem. The baseline sensitivity distribution will be used to monitor the shift in sensitivity of the pathogen to the fungicides.

Risk assessment of resistance to fludioxonil and pyrimethanil. We now have two new postharvest fungicides, Scholar (fludioxonil) and Penbotec (pyrimethanil). Questions we have been trying to address are what is the risk of development of resistance in *P. expansum* to fludioxonil and pyrimethanil and whether there is risk of cross-resistance or multi-drug resistance in *P. expansum* to the postharvest fungicides. This information would help us implement strategies of using postharvest

fungicides. Our goal is to prolong the effectiveness of these fungicides and to avoid or delay the buildup of resistant populations of postharvest pathogens to these new fungicides.

We generated fludioxonil- and pyrimethanil-resistant mutants in the laboratory, used mutants to determine patterns of resistance of *P. expansum* to the three postharvest fungicides, determined fitness parameters of fungicide-resistant mutants, and evaluated whether current fungicides are able to control fungicide-resistant mutants. We made great progress in understanding the risk of resistance to fludioxonil and pyrimethanil. The findings are summarized as follows:

Fludioxonil-resistant mutants of *P. expansum* were highly resistant to fludioxonil but remained sensitive to pyrimethanil. However, pyrimethanil-resistant mutants were also resistant to fludioxonil. More importantly, pyrimethanil-resistant mutants derived from TBZ-S became resistant to TBZ. Six phenotypes of fungicide resistance were detected, and all pyrimethanil-resistant mutants were triple resistant to all three postharvest fungicides (Table 5).

Fludioxonil-resistant mutants were less pathogenic to apple fruit and produced a much smaller amount of spores on inoculated apples, whereas in general there were no significant differences in virulence and sporulation on apple fruit between pyrimethanil-resistant mutants and the wild parental isolates (Fig. 1 and Fig. 2). Fludioxonil-resistant mutants also were sensitive to osmotic stress (data not shown).

None of the three postharvest fungicides were able to provide satisfactory control of pyrimethanil-resistant mutants on apple fruit at both 32 and 68ºF (Fig. 3).

Our results indicated that a fitness cost was associated with fludioxonil-resistant mutants in both saprophytic and pathogenic phases. Pyrimethanil has a high risk in the development of resistance in *Penicillium expansum*. Multiple resistance to all three postharvest fungicides could become a practical problem if *P. expansum* develops resistance to pyrimethanil. The findings from our study suggest that a program to monitor the shift in sensitivity of *P. expansum* to pyrimethanil and fludioxonil is needed and that strategies of using pre- and postharvest fungicides to avoid or delay the development of resistance to pyrimethanil need to be implemented.

Table 5. Phenotypes and resistance patterns of fungicide-resistant mutants of *Penicillium expansum* to the three postharvest fungicides.

Isolate[a]	Origin	Phenotypes[b]		
		Thiabendazole (TBZ)	Fludioxonil (Scholar)	Pyrimethanil (Penbotec)
W1	wild type	S	S	S
W2	wild type	HR	S	S
FR1	W1	S	HR	S
FR2	W1	S	HR	S
FR3	W2	HR	HR	S
FR4	W2	HR	HR	S
PR1	W1	LR	LR	R
PR2	W1	LR	LR	R
PR3	W2	HR	LR	R
PR4	W2	HR	LR	R

[a] FR=fludioxonil-resistant mutants; PR=pyrimethanil-resistant mutants

[b] S=sensitive; LR=lowly resistant; R=resistant; HR=highly resistant

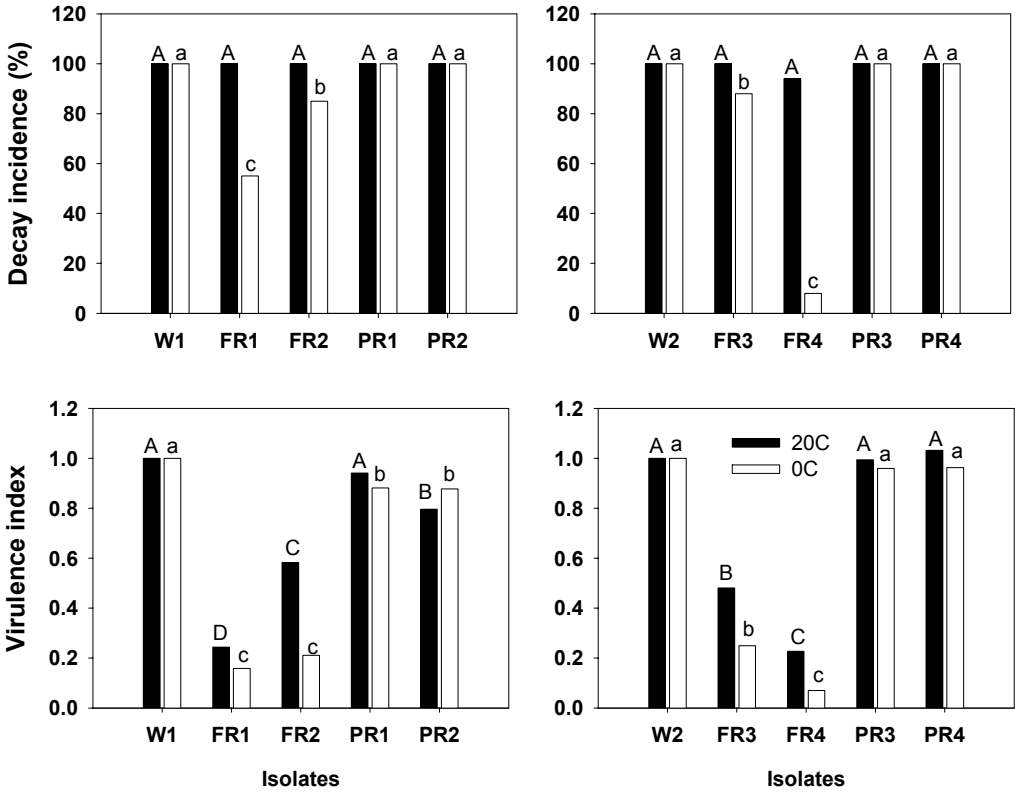

Fig. 1. Pathogenic fitness and virulence of fludioxonil-resistant mutants (FR1 to FR4) and pyrimethanil-resistant mutants (PR1 to PR4) and their wild parental isolates (W1 and W2) of *Penicillium expansum* on apple fruit.

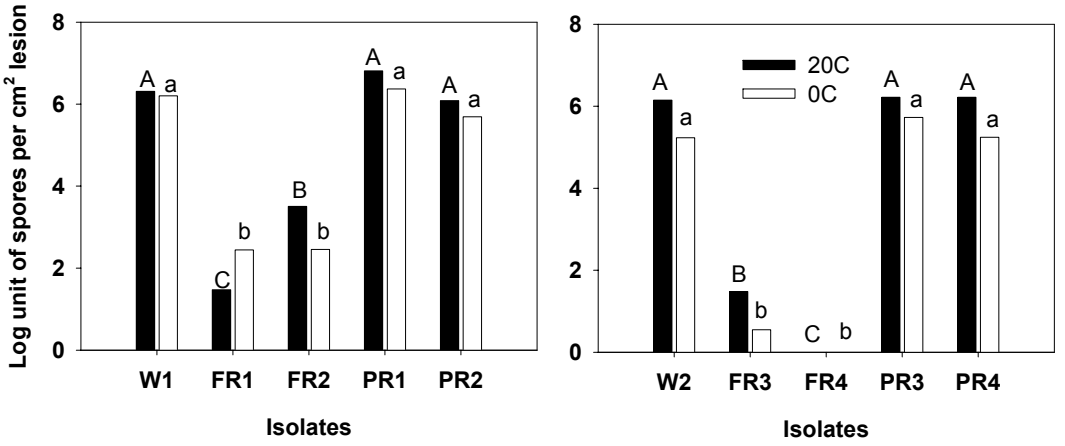

Fig. 2. Sporulation of fludioxonil-resistant mutants (FR1 to FR4) and pyrimethanil-resistant mutants (PR1 to PR4) and their wild parental isolates (W1 and W2) of *Penicillium expansum* on apple fruit.

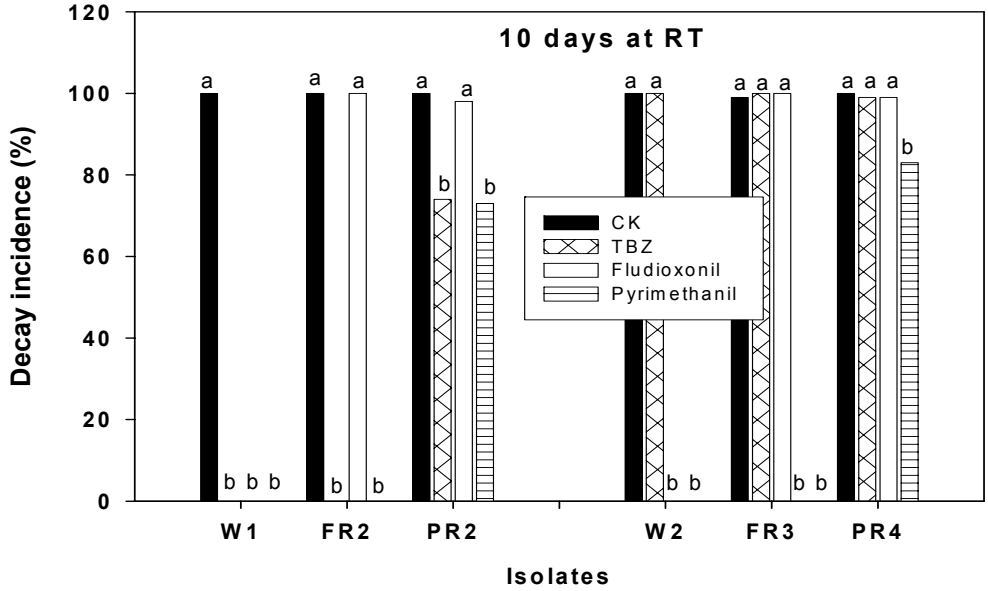

Fig. 3. Effectiveness of thiabendazole (Mertect), fludioxonil (Scholar) and pyrimethanil (Penbotec) for control of fludioxonil-resistant mutants (FR2 and FR3) and pyrimethanil-resistant mutants (PR2 and PR4) and their wild parental isolates (W1 and W2) of *Penicillium expansum* on apple fruit.

New technologies for decay control

Biofumigant fungus Muscodor. In 2004-05, we evaluated biofumigation with the Muscodor fungus for control of postharvest blue mold and gray mold. Results were presented in the 2005 July report. Biofumigation with the Muscodor fungus at both rates significantly reduced gray mold compared with the *Botrytis*-inoculated control. However, fumigation with Muscodor fungus for seven days at 37ºF did not provide satisfactory control of blue mold, though both incidence and severity of blue mold were significantly reduced by the biofumigation in comparison with the *Penicillium*-inoculated control. In preliminary experiments, we observed phytotoxicity problems (lenticel browning) on Gala apples that were fumigated with Muscodor at high rates (46 and 100 g/box) at 37ºF for 10 days. The effort was discontinued because the company claimed that the inoculum of the biocontrol fungus used in 2005 had some problems. The company is trying to improve the formulation of the biofumigant inoculum.

Thermofogging. On 2005 and 2006 crops, we conducted thermofogging trials to evaluate the efficacy of fogging fungicides for control of postharvest diseases. The trials were conducted on organic Red Delicious. The 2006 trial is still in progress. The results from the 2005 trial are summarized here.

In the commercial situation, a fungicide treatment applied to the fruit in a storage room may be delayed for 1-3 days after harvest. In 2005, the first experiment was to look at the kick-back activity of pyrimethanil applied by thermofogging. After harvest, apple fruit were inoculated with either Botrytis or Penicillium, and part of the fruit received the thermofogging treatment with pyrimethanil at 0, 1, 2, and 3 days after inoculation. Delay of the thermofogging treatment significantly compromised the effectiveness of the treatment, particularly for blue mold control (Fig. 4). However, the sizes of decay on treated fruit were much smaller than those on decayed fruit from the nontreated control (data not shown).

The second trial we did in 2005 was to look at the effectiveness of thermofogging pyrimethanil for control of decays on commercially harvested fruit. Eight bins of fruit from a commercial organic orchard were treated and 8 not treated. Fruit were stored in CA. Decay was evaluated at seven

months after harvest. The thermofogging treatment significantly reduced the total decay in storage bins as well as gray mold and blue mold (Table 6). However, the level of decay resulting from natural infections in that year was low (1.1%).

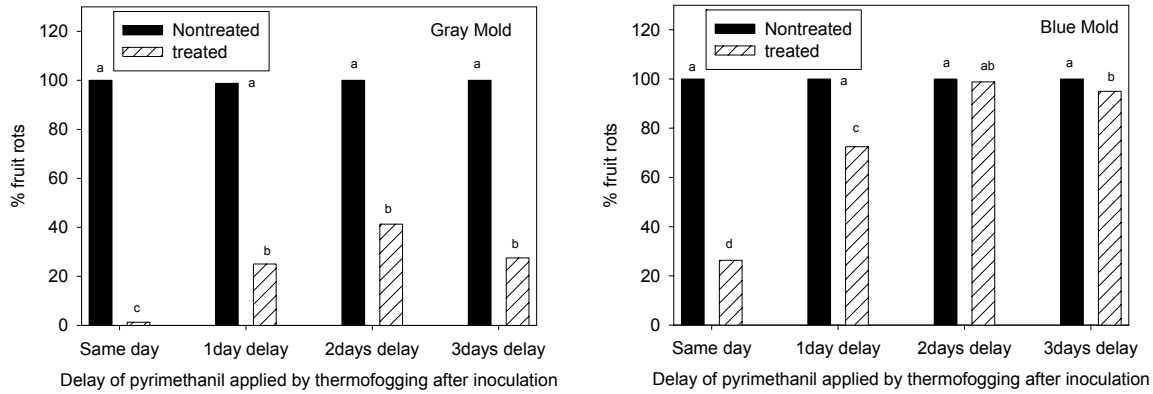

Fig. 4. Effects of delay in application of thermofogging treatment on gray mold and blue mold resulting from infections of wounds. Apple fruit were inoculated with the pathogens at harvest, and part of the fruit was thermofogged with pyrimethanil at 0-3 days after inoculation.

Table 6. Effectiveness of thermofogging pyrimethanil for control of postharvest diseases in Red Delicious apples.

Treatment	Total decay in the bins (%)	Gray mold in the bins (%)	Blue mold in the bins (%)
Nontreated	1.11 a	0.60 a	0.31 a
Thermofogged	0.28 b	0.14 b	0.03 b