FINAL REPORT

Project Title: Decay risk prediction models and novel decay control methodology
PI: Robert A. Spotts
CoPI: Chang-Lin Xiao
CoPI: David Sugar
Organization: OSU Mid-Columbia Ag Research and Extension Center
Telephone/email: 541-386-2030 ext. 15/robert.spotts@oregonstate.edu

Cooperators: Ag Canada (Peter Sholberg, Dan O'Gorman)

Total project funding: 43,822

Budget: 2008: 43,822

Significant findings:

- Two years of validation of the gray mold risk prediction model showed that decay risk was accurately predicted for field run fruit, but decay levels were too low in fruit that had been run over the packing line and treated with disinfectants and fungicides for accurate risk prediction.
- The factors that are important for gray mold prediction did not affect blue mold similarly. Blue mold is more closely related to contamination of packinghouse surfaces and water.
- Resistance of pear fruit to decay changes yearly and can be quantified.
- The relationship between decay and spore load is important for establishing action thresholds for packinghouse water systems. Results emphasize the importance of good sanitation.
- Topsin, Pristine, and Ziram reduced gray mold, while Topsin reduced blue mold.

Results and discussion:

1. Validate gray mold decay risk prediction model

The first complete year of validation was in 2007-2008 and included pear fruit from 34 orchards in OR and WA (Table 1). The second year of validation was in 2008-2009 and used fruit from 37 orchards (Table 2).

Pear fruit from 9 and 6 orchards in 2007-8 and 2008-9, respectively, were stored field-run. Gray mold in this fruit ranged from 0.4 to 8.9% in 2007-8 and 4.5 to 21.3% in 2008-9 (Table 3). The model predictions matched well with the levels of gray mold in both years.

Fruit from commercial storages had 0.07 to 0.32% gray mold in 2007-8 and 0.03 to 2.68% in 2008-9 (Table 4). Percent gray mold was reduced from 90 to 99% when run over the packing line and placed in commercial storage when compared with field run fruit from the same orchards without any postharvest treatments. Postharvest treatments and cold storage conditions varied considerably among packinghouses, and the model predictions were not useful with the low levels of decay that are typical of commercial conditions.

It is important to note that **orchard rating** was the most significant predictor of gray mold risk. Problem orchards often had old trees with dead limbs and poor weed control. Fruit on lower limbs often were intermingled with various weeds and grasses. **Preharvest fungicide** application was the second most important predictor of gray mold risk.

Table 1. Gray mold risk model validation orchards 2007-8

Packer	Orchard	2007 Harvest Date	DNA	Preharvest fungicide	Rain	Orchard Rating	Time stored (mo)	Predicted Risk	Total %Bot
A	1	9/15	L	Yes	Yes	1	ND	L	ND
A	2	9/12	L	Yes	Yes	2	ND	M	ND
A	3	9/24	L	Yes	No	1	ND	L	ND
A	4	9/6	L	Yes	Yes	2	ND	M	ND
A	5	9/4	L	No	Yes	2	6*	H	2.85*
A	6	9/7	L	No	Yes	2	6*	H	3.29*
A	7	9/18	L	Yes	Yes	1	ND	L	ND
B	1	9/20	L	Ziram	Yes	2	7	M	0.33
B	2	9/24	L	Ziram	No	2	6	L	0.51
B	3	9/8	L	Ziram	Yes	2	8	M	0.29
B	4	9/8	L	Ziram	Yes	2	8	M	1.39
B	5	9/8	L	Ziram	Yes	2	7.75	M	0.22
B	6	9/19	L	Ziram	Yes	2	6*	M	0.88*
B	7	9/20	L	Ziram	Yes	2	7.75	M	0.37
C	1	9/8	L	Yes	Yes	2	4.5	M	0.22
C	2	9/10	L	Yes	Yes	3	5.25	H	0.39
C	3	9/8	L	Yes	Yes	2	4.5	M	0.08
C	4	9/15	L	Yes	Yes	1	7.5	L	0.04
C	5	ND	L	Yes	Yes	2	ND	M	ND
C	6	ND	L	Yes	Yes	3	4.5	H	0
C	7	9/11	L	Yes	Yes	1	4.5	L	0
C	8	9/13	L	Yes	Yes	3	4.5	H	0.28
D	1	9/17	L	Topsin	Yes	2	ND	M	ND
D	2	9/17	L	Topsin	Yes	2	6.25	M	0.01
D	3	9/21	L	Topsin	Yes	2	ND	M	ND
D	4	9/10	L	Topsin	Yes	2	6.5	M	0.24
D	5	9/14	L	Topsin	Yes	3	6*	H	3.48*
D	6	9/19	L	Yes	Yes	2	6.5	M	0.21
D	7	9/14	L	No	Yes	3	6*	E	9.9*
D	8	9/14	L	No	Yes	3	6*	E	7.8*
E	1	9/6	L	No	No	2	4	M	0.54
E	2	9/6	L	Ziram	No	2	4	L	0.18
E	3	9/6	L	No	No	2	4	M	0.18
F	1	8/30	L	Yes	Yes	2	6*	M	0.15*
F	2	9/17	L	No	No	2	6*	M	0.07*
F	3	9/17	L	Yes	No	2	6*	L	1.3*

*=fruit not in commercial storage but field run in MCAREC or SOREC room. ND=Not determined.

Table 2. Gray mold risk model validation orchards 2008-9

Packer	Orchard	2008 Harvest Date	DNA	Preharvest fungicide	Rain	Orchard Rating	Time stored (mo)	Predicted Risk	Total %Bot
A	1	9/27	L	Topsin	Yes	2	8(4.5)	M	0.23
A	2	9/17	L	Yes	No	2	8	L	0.11
A	3	9/28	H	Topsin	Yes	2	8.7	H	1.02
A	4	9/22	L	Topsin	Yes	2.5	8	M+	0.51
A	5	9/27	L	Topsin	Yes	1	8.75	L	1.07
A	6	9/20	L	Topsin	Yes	2	8(4.5)	M	0.07
A	7	9/19	H	Topsin	Yes	2	5	H-	0.48
A	8	9/29	L	Topsin	Yes	1.5	4.5	L+	0.17
A	9	9/28	L	Topsin	Yes	2	8.75	M	0.16
B	1	9/5	L	Yes	No	2	6	L	1.75
B	2	9/15	L	No	No	2	6	M	0.25
B	3	9/12	L	No	No	2	6	M	0.67
B	4	9/16	L	No	No	2	6	M	2.4
B	5	9/15	L	No	No	2	6	M	2.68
B	6	9/12	L	Yes	No	2	6	L	0.12
C	1	9/29	L	Topsin	Yes	2	5.5	M	1.79
C	2	9/16	L	Topsin	No	1	7	L	1.19
C	3	10/7	L	Topsin	Yes	2	5	M	2.36
C	4	9/15	L	Topsin	No	2	6	L	0.03
C	5	17-Sep	L	Topsin	No	2	7	L	0.12
D	1	7-Oct	L	Yes?	Yes	2	6.5	M	0.56
D	2	10/9	L	Yes	Yes	2	5.5	M	0.1
D	3	10/8	L	ziram	Yes	2	5	M	0.24
D	4	10/8	L	Yes	Yes	2	5	M	0.1
D	5	9/23	L	Topsin	Yes	3	6.75	H	0.14
E	1	9/23	L	No+	No	2	5.25	M-	1.06
E	2	9/15	L	No+	No	2	5	M-	0.5
E	3	9/15	L	No+	No	2	5	M-	0.38
E	4	9/15	L	Topsin	No	2	5	L	1.2
E	5	9/23	L	Ziram	No	2	5.25	L	1.02
E	6	9/15	H	No	No	2	5	H	0.42
F	1	9/11	L	No	No	2	8	M	5.1*
F	2	9/17	L	No	No	2	8	M	4.6*
F	3	9/19	L	Organic-No	No	3	8	H	13.2*
F	4	9/23	L	Topsin	Yes	2	8	M	4*
F	5	9/19	H	Organic-No	No	3	8	E	21.*3
F	6	10/2	L	Yes	Yes	2	8	M	4.2*

*=fruit not in commercial storage but field run in MCAREC room.

Table 3. Anjou pears stored field-run at MCAREC and SOREC for gray mold risk model validation 2007-8 and 2008-9

	2007-8		2008-9	
Predicted risk level	Avg. gray mold (%)[z]	No. orchards	Avg. gray mold (%)[z]	No. orchards
Low	1.3a	1	-	-
Moderate	0.3a	3	4.5a	4
High	3.2b	3	13.2b	1
Extreme	8.9c	2	21.3c	1

[z]Fruit stored six months; different letters indicate statistical differences at $P = 0.05$.

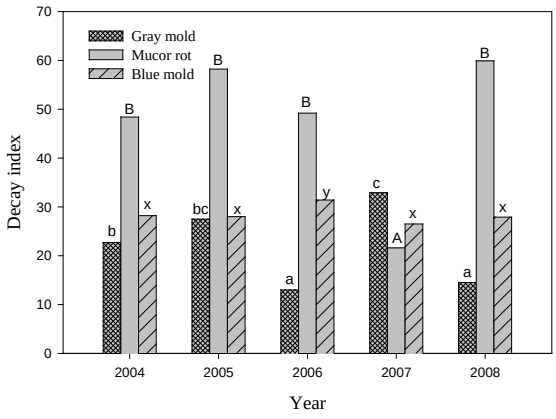
Table 4. Pears run over commercial packing lines and stored in commercial cold rooms for gray mold risk model validation 2007-8 and 2008-9

	2007-8		2008-9	
Predicted risk level	Avg. gray mold (%)[z]	No. orchards	Avg. gray mold (%)[z]	No. orchards
Low	0.46a	4	0.68a	10
Moderate	0.35a	12	0.83a	17
High	0.44a	4	0.51a	4

[z]Fruit stored 4 to 8.75 months; different letters indicate statistical differences at $P = 0.05$.

2. Develop blue mold decay risk prediction model

Blue mold decay levels were low in fruit from orchards used for the gray mold model. The factors that are important for gray mold prediction did not affect blue mold similarly. It appears that blue mold is more closely related to contamination of packinghouse surfaces and water systems (drenchers, dump tanks, flumes) than to orchard factors.

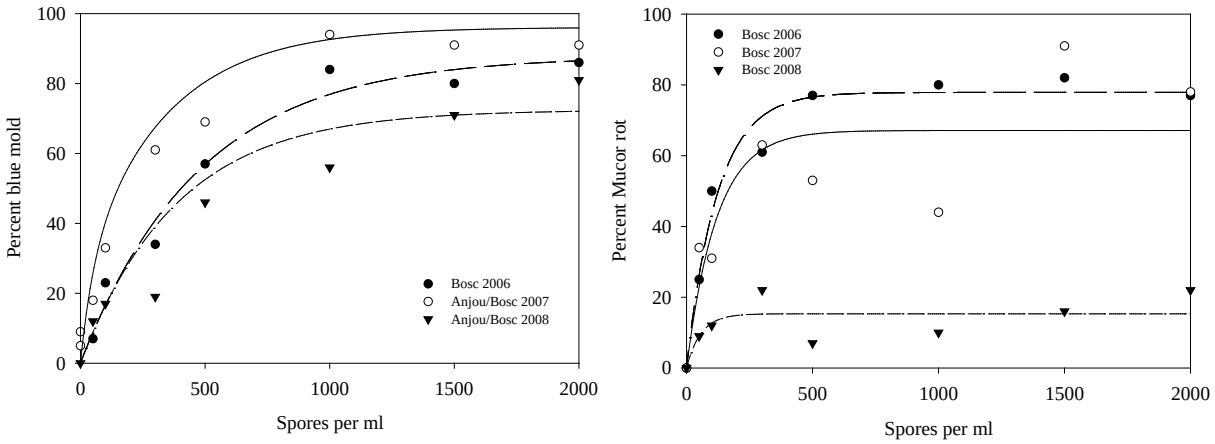


Resistance of pear fruit to decay changes yearly. We developed a test to measure this at the beginning of each packing season. Fruit resistance eventually needs to be incorporated into gray mold and blue mold risk prediction models.

3. Implement real time DNA techniques for rapid detection of decay spores in packinghouse water systems

Spore concentration, DNA extraction, and real time PCR protocols that have been successful for *Botrytis* are inadequate for *Penicillium.* Considerable effort has been focused on developing a protocol for detection of *Penicillium* spore numbers considered in the threshold range (100 to 300 per ml or less) for blue mold problems in packinghouses. Because of the lack of efficient and specific primers for *P. expansum*, the protocol remains under development.

The relationship between decay and spore load is important for establishing action thresholds for packinghouse water systems. For blue mold and Mucor rot, the steep curve between 0 and 500 spores per ml indicates that reduction of spore numbers in this part of the curve will result in significant reductions in decay. These results emphasize the importance of good sanitation.



4. Evaluate new fungicides and biological control agents in preharvest and postharvest integrated systems

In 2007-8, all tested preharvest fungicides reduced gray mold. In both years, Topsin was the most effective preharvest fungicide for control of blue mold (Table 5).

Table 5. Preharvest fungicides for control of postharvest decay of d'Anjou pear fruit

	2007-8		2008-9
Fungicide and rate/A	Gray mold (%)	Blue mold (%)	Blue mold (%)
Topsin 70WP 1/0 lb	2.2a	6.2a	15.5a
Pristine 38WG 14.5 oz	3.1a	21.3b	25.2ab
Ziram 76DF 8.0 lb	2.9a	19.4b	---
Yucca Ag Aide 2%	---	---	24.6ab
Silmatrix 2%	---	---	46.9c
Unsprayed	7.5b	26.0b	33.7bc

In 2007, all fungicides contained Nutraphos 24. In 2008, Pristine used at 18.5 oz with Silgard 4.0 oz. Fungicides applied 2 wks before harvest and evaluated after 3, 6, and 8 months at 30ºF. Numbers followed by the same letter within columns are not significantly different at $P = 0.05$ according to protected LDS.

5. Develop pre- and post-storage integrated programs for decay control (Xiao: coordinator and d'Anjou pears in WA; Spotts: d'Anjou pears in Hood River; Sugar: Bosc pears in Medford)

Dr. Xiao will report the results for this objective.

Executive Summary:

Gray mold is one of the most serious decay problems of pear fruit in the Pacific Northwest and is estimated to cost the pear industry about $6 million per year. The main thrust of this project was to develop a model to predict, at harvest, the risk of gray mold for pear fruit in long-term cold storage. The model is driven by four factors that include: i) preharvest fungicide application, ii) preharvest rainfall, iii) an orchard management rating, and iv) amount of DNA of Botrytis on the fruit surface. A simplified version without the DNA factor also was developed. The model classifies gray mold risk as low, moderate, high, or extreme. It is important to note that **orchard rating** (orchard condition) was the most significant predictor of gray mold risk. Problem orchards often had old trees with dead limbs and poor weed control. Fruit on lower limbs often were intermingled with various weeds and grasses. **Preharvest fungicide** application was the second most important predictor of gray mold risk. This project has identified effective preharvest fungicides for gray mold. The model works best for field run fruit rather than for fruit run over the packing line that has been subjected to various postharvest treatments. Gray mold risk prediction at harvest is a valuable tool for packinghouse managers to determine which fruit is most suitable for long-term storage. The prediction also is useful to growers to help understand the factors that cause fruit to be at risk of decay and to make the necessary changes in horticultural and pest management practices to lower the risk of gray mold.