FINAL PROJECT REPORT

Project Title: Pear fruit quality improvement

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Total Project Funding: **Year 1:** 28,997 **Year 2:** 28,997 **Year 3:** 28,997

Budget History:

Item	2007	2008	2009
Salaries	18,238	18,238	18,238
Benefits	10,759	10,759	10,759
Wages			
Benefits			
Equipment			
Supplies			
Travel			
Miscellaneous			
Total	$28,997	$28,997	$28,997

Significant Findings:

1. **Developing early ripening capacity in winter pears**.

- 50°F was the most efficient temperature for conditioning (or "satisfaction of the chill requirement") for Comice and Anjou pears among a range of temperatures tested between 31 and 65°F. Both colder and warmer temperatures required longer times for chilling satisfaction.
- As fruit maturity advances through the harvest season, the minimum conditioning time decreases. Relatively short periods at 41°F may be used to condition later-harvested Anjou pears while maintaining adequate firmness for shipping.
- Combinations of ethylene conditioning and intermediate temperature conditioning can substantially reduce the time between harvest and development of ripening capacity in winter pears.

2. **Postharvest decay control programs**.

- Orchard-based decay management programs using summer calcium chloride sprays followed at 1 week pre-harvest with fungicides Pristine, Flint, or Topsin M can both reduce overall postharvest decay levels and reduce the impact of a significant delay in application of postharvest fungicides due to storage of field-run fruit.
- A single-bin drench system for applying postharvest fungicide to fruit in bins prior to truck loading in the orchard may contribute to an orchard-based decay management program.

3. **Fruit size enhancement**. Over six years of study, urea treatments applied as 5% solutions at full bloom to Bartlett pears increased average fruit weight and the tons per acre of fruit size 90 and larger. Applications at 7-7.5% concentration were more consistent than 5% solutions. Over three years of study, MaxCel applied at 125 ppm 6-benzyladenine enhanced fruit size in Bartlett pears when applied 10 days after petal-fall. Fruit size distribution for untreated, unthinned trees peaked at size 100, while fruit size distribution from trees treated with MaxCel 125 ppm at 10 days after petal-fall peaked at size 80.

4. **Russet management**. Long-term correlations between russet and weather factors point to the period 2-3 weeks after petal-fall as the critical period for russet susceptibility. Spray mixtures consisting of any two of the three products Pristine, mancozeb, or Surround during this period were more effective in reducing Comice russet than either material alone.

Results and Discussion:

1. **Developing early ripening capacity in winter pears**. New knowledge about the responsiveness of Anjou and Comice pears to intermediate conditioning temperatures should be useful in getting fruit to market sooner after harvest. The combination of ethylene conditioning and temperature conditioning can significantly reduce total conditioning time. Some treatment combinations that speed conditioning may result in fruit that are too soft for long-distance shipping after treatment, but many treatment options result in the fruit maintaining good shipping firmness.

a. **Conditioning with intermediate storage temperatures.** This project identified the most efficient temperature for fastest satisfaction of the chill requirement for Comice and Anjou pears as 50 °F among a range of temperatures tested between 31 and 65 °F. Both colder and warmer temperatures required longer times for chilling satisfaction.

Table 1. Effects of different conditioning temperatures and exposure durations on the ripening capacity of Anjou pears. Firmness values below 3.0 typically reflect a buttery-juicy texture.

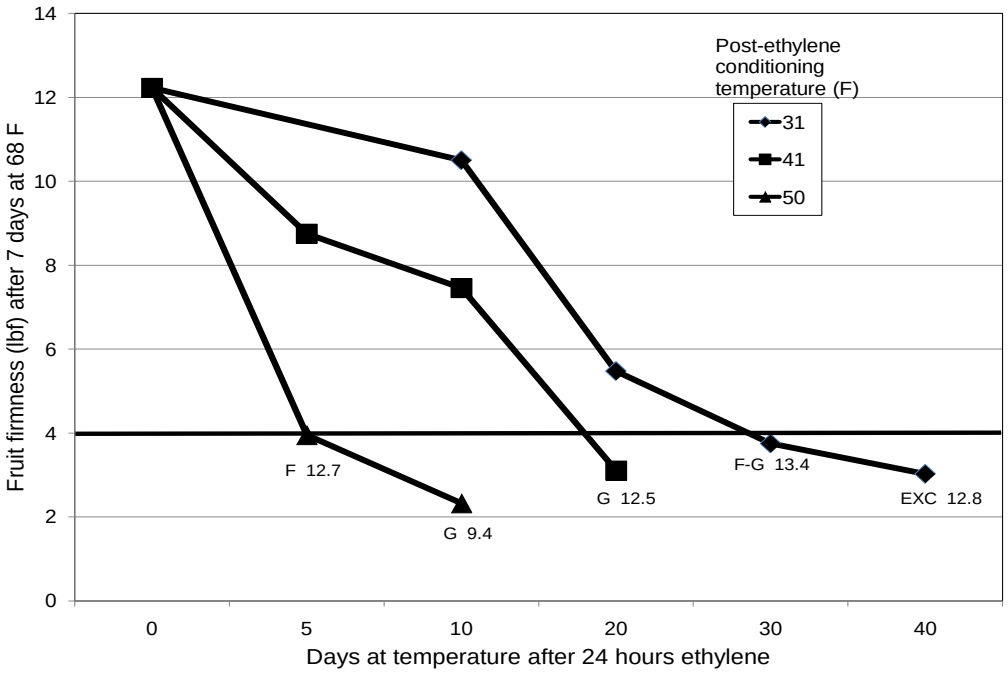
Conditioning Time (days)	Average firmness (lbf) of Anjou pears after conditioning at different temperatures followed by 7 days of ripening at 68 °F.							
	Conditioning temperature							
	31	**41**	**46**	**50**	**54**	**57**	**61**	**64**
10	13.6	12.8	9.6	4.8	7.9	8.2	7.5	7.7
20	12.1	7.2	5.8	1.7	4.7	5.4	5.3	5.5
30	7.8	5.2	3.6	1.7	2.8	4.1	3.7	4.8
40	5.3	2.7	2.0	1.6	1.8	2.7	2.5	2.9

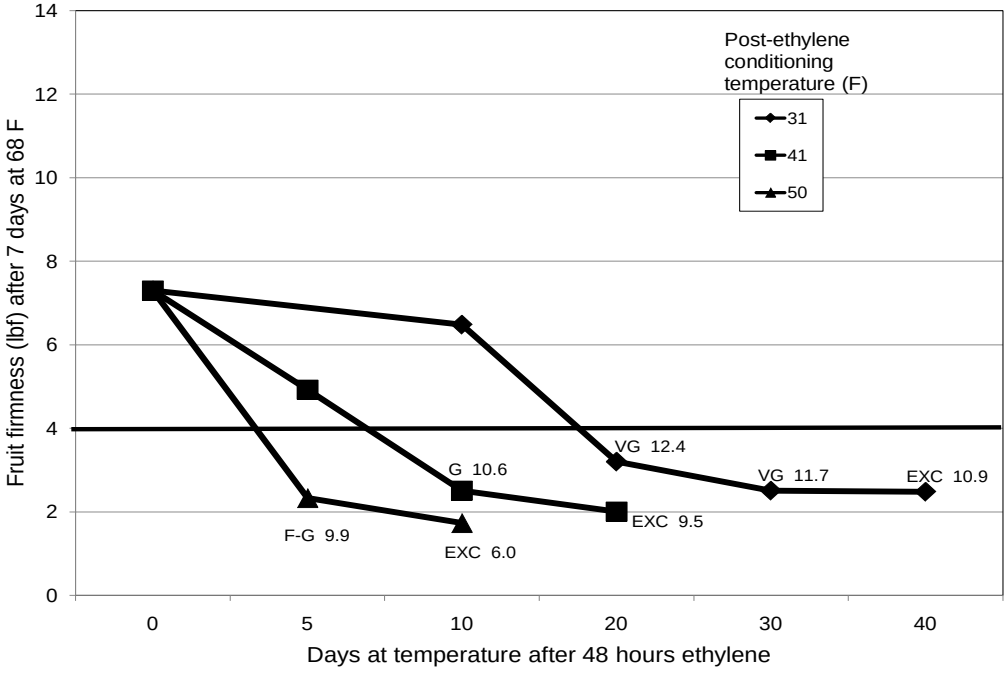
b. **Interaction of fruit maturity at harvest with temperature and duration of postharvest conditioning.** Later- harvested fruit required less conditioning time at all conditioning temperatures. Anjou pears harvested at 12 lbf or less needed only 10 days at 50°F to develop the capacity to ripen to acceptable quality, while retaining shipping firmness $\geq$ 8 lbf. Earlier harvested fruit required 20 days conditioning at 50°F, and consequently were too soft for shipping at the end of temperature conditioning. Shipping firmness was well-retained by conditioning at 41°F.

Table 2. Effects of harvest maturity and conditioning temperature on development of ripening capacity in Anjou pears.

Anjou 2009 Harvest			Minimum conditioning days needed to allow ripening to acceptable quality			Fruit firmness after conditioning (lbf) (shipping firmness)		
Day	Date	Firmness	**31°F**	**41°F**	**50°F**	**31°F**	**41°F**	**50°F**
0	Sept 14	14.1	> 60	40	20	-	13.0	4.8
7	Sept 21	13.2	> 60	40	20	-	12.3	3.9
14	Sept 28	12.0	> 60	30	20	-	11.1	4.5
21	Oct 5	11.9	60	20	10	11.8	11.2	9.1
28	Oct 12	10.8	30	20	10	10.2	9.7	8.0

c. **Interaction of ethylene conditioning and temperature conditioning to induce ripening capacity in Anjou pears**. Anjou pears harvested at 14.1 lbf average and exposed to ethylene 100 ppm at 68°F for 24 hours still needed an additional 30 days at 31°F in order to ripen to acceptable quality in 7 days at 68°F. However, fruit from the same 24 hour ethylene treatment needed only 20 additional days at 41°F, or 5-10 days at 50°F. If ethylene treatment was increased to 48 hours at 68°F, an additional 20 days were necessary at 31°F, 10 days at 41°F, and 5 days at 50°F.
In the figures below, treatments that resulted in successful ripening are accompanied by quality ratings (fair, good, very good, excellent) and the average fruit firmness at the end of the conditioning period (ethylene conditioning + further temperature conditioning), which approximates the shipping firmness.





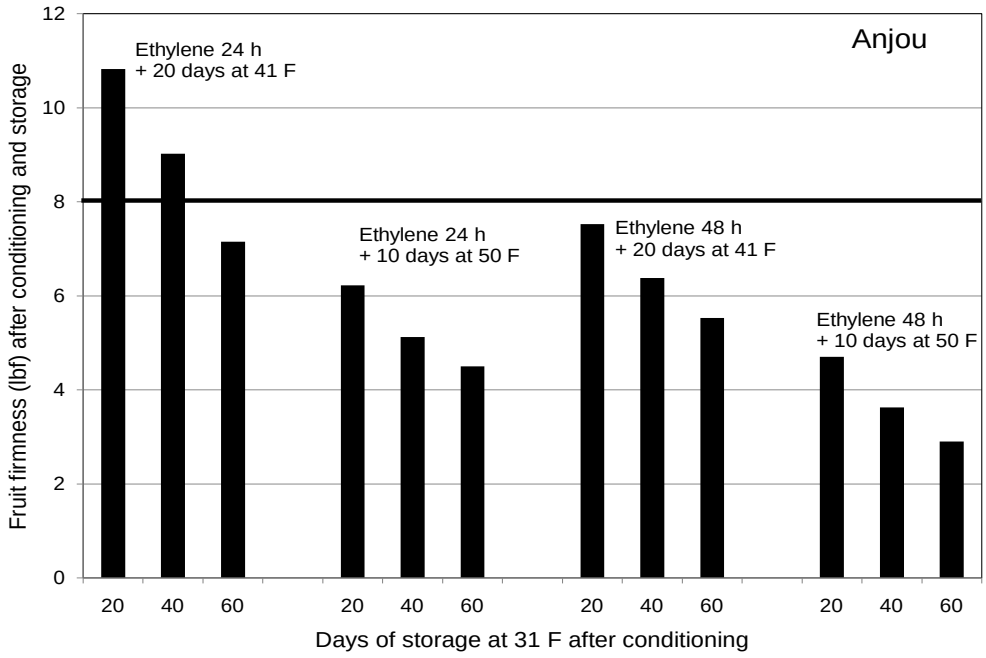
d. **Ethylene conditioning + temperature conditioning summary.** Experiments with Anjou, Bosc, and Comice pears in the course of this project have generated sufficient information to estimate the

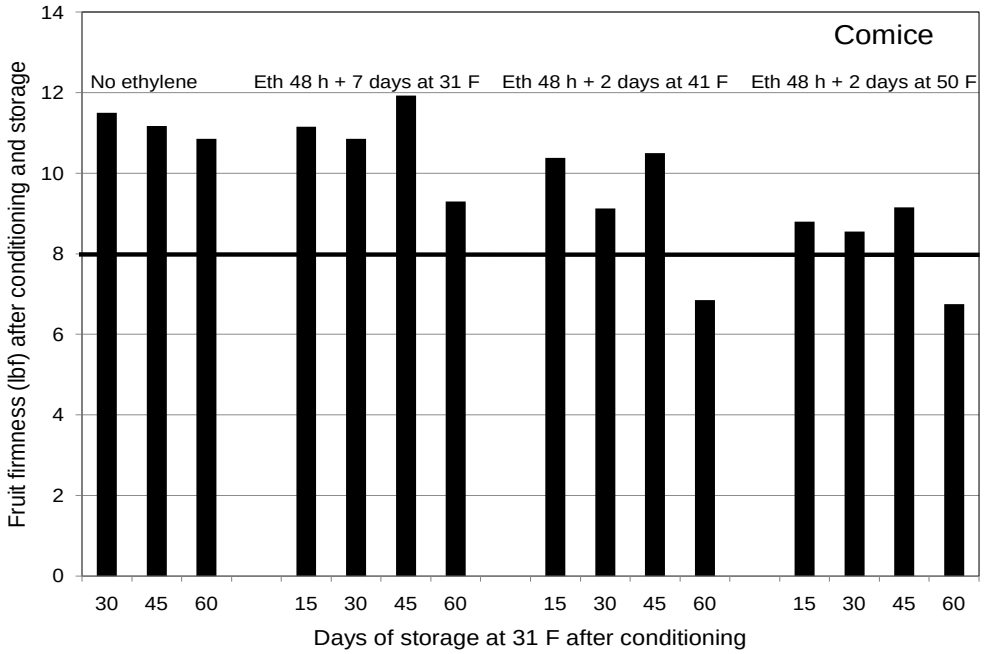
amount of time necessary to condition pears harvested near the top of the maturity range, using various combinations of ethylene and temperature conditioning.

Table 3. Summary of minimum conditioning times for winter pear varieties using both ethylene conditioning and temperature conditioning.

	Approximate number of conditioning days needed to induce ripening capacity (Fruit harvested at beginning of maturity range)								
	No ethylene			**24 h ethylene at 68°F**			**48 h ethylene at 68°F**		
	31°F	**41°F**	**50°F**	**31°F**	**41°F**	**50°F**	**31°F**	**41°F**	**50°F**
Bosc	15	10	5	0	0	0	0	0	0
Comice	30	20	12	15	10	5	10	5	4
Anjou	>60	40	20	40	20	10	20	10	5

d. **Post-conditioning storage life**. Anjou pears harvested at 14.1 lbf and treated with ethylene for 24 hours followed by 20 days at 41°F had a shipping firmness near 11 lbf after 20 days further storage at 31°F, and over 8 lbf after 40 days further storage at 31°F. However, shipping firmness values were below 8 lbf following 24 hour ethylene treatment plus 10 days at 50°F, or 48 hours ethylene treatment plus 10 days at 50°F or 20 days at 41°F.





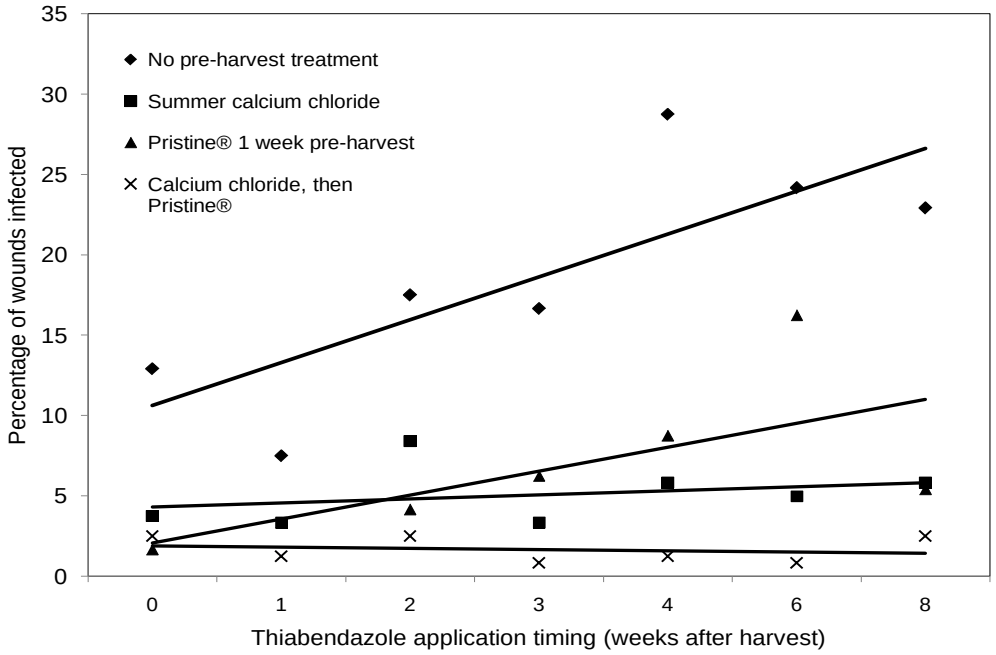
2. **Postharvest decay control programs**. Two conflicting facts drove the design of these decay studies: (1) postharvest fungicide and biocontrol treatments lose effectiveness in controlling decay if they are applied more than 3 weeks after harvest; and (2) there is a trend in the pear industry to delay postharvest line-spray fungicide treatments due to prolonged storage in field bins prior to packing. The research results demonstrated the high value of a programmatic approach in which summer calcium treatments are followed by application of appropriate fungicides approximately one week before harvest in reducing decay incidence when postharvest fungicide treatment is delayed. A single-bin drench system for applying postharvest fungicide to fruit in bins prior to truck loading in the orchard may also contribute to an orchard-based decay management program.

a. **Individual bin field drenching**. A powered hand-operated single-bin drencher was tested for field application of Scholar fungicide at 4 fl oz per 100 gallons but varying treatment volumes, without recirculation. Wound-inoculated fruit were buried near the top and bottom of each bin before treatment. Treatments reduced decay, and increasing treatment volume generally improved control. (In cooperation with Syngenta, Wilbur-Ellis, and Dr. Jim Adaskaveg, UC Riverside).

Table 4. Decay in wounded, inoculated Bosc pears buried in standard bins and treated Scholar fungicide using a hand-operated single-bin drenching system at varying gallonage.

	Percentage of wounds infected			
	Botrytis (gray mold)		*Penicillium* (blue mold)	
	Top	Bottom	Top	Bottom
Scholar dip	0.0 c	0.0 d	2.1 c	2.1 c
Water check	100.0 a	100.0 a	95.8 a	89.8 a
Scholar 4 oz in 2 gal water per bin	27.8 b	61.4 b	31.5 b	60.7 b
Scholar 4 oz in 4 gal water per bin	40.3 b	51.8 bc	37.5 b	59.3 b
Scholar 4 oz in 8 gal water per bin	13.0 c	35.4 c	21.5 c	19.9 c

b. **Orchard-based decay management programs**. The figure below shows the response of Bosc pears from different orchard decay management programs to postharvest line-spray fungicide treatment applied from 0 to 8 weeks after harvest. Fruit were wounded immediately after harvest, then stored at 31°F before and after line-spray treatment. Both summer calcium chloride sprays (3 sprays of 3 lb actual calcium per 100 gallons, 2 weeks apart during July and August) and fungicide applied one week before harvest were very effective in compensating for the delay in application of postharvest line-spray. Results show with Pristine were similar to those found with Flint or Topsin-M as the pre-harvest fungicide.



3. **Fruit Size Enhancement**. Urea treatments at full (80%) bloom resulted in increased average fruit weight and in increased yield of fruit size 90 and larger over the six years of evaluation in Bartlett pear (Table 1). The treatment was dosage-dependent; although 5% urea treatments were highly effective over the course of the study, 5% urea only enhanced Bartlett average fruit weight significantly in two of the six individual years, while 7-7.5% urea treatment enhance Bartlett average fruit weight every year. The overall reduction in fruit set and yield was compensated for by the increase in fruit size, resulting in a net gain of large-sized fruit. We suspect that a nitrogen boost to developing fruitlets may have worked in tandem with thinning to produce the size-enhancement effect. The plant growth regulator MaxCel, applied at 125 ppm 6-benzyladenine 10 days after petal-fall (8-10 mm average fruit diameter) was also highly effective in enhancing Bartlett pear fruit size and tons per acre of fruit size 90 and larger, despite reducing fruit size and total yield (Table 2).

Table 5. Effects of urea treatments applied at 80% bloom to Bartlett pear trees on production characteristics averaged over six years of study (2004-2009).

Treatment	Fruit set /100 clusters	Total yield (tons/acre)	Avg. fruit weight (g)	% of fruit size 90 & larger	Tons/acre size 90 & larger
Untreated	66.2 a	18.8 a	192 c	30.7 c	5.5 b
Urea 5%	56.8 b	17.5 ab	210 b	45.4 b	7.8 a
Urea 7-7.5%	45.0 c	16.1 b	223 a	56.1 a	8.9 a

Table 6. Effect of MaxCel 125 ppm treatment timing on fruit and production performance in Bartlett pear. Results averaged over 2008 and 2009 trials.

Treatment	Timing	Fruit diam. at treatment	Fruit set /100 clusters	Total yield (tons/acre)	Avg. fruit weight (g)	% of fruit size 90 & larger	Tons/acre size 90 & larger
Untreated			89.3 a	17.2 a	202 c	38.2 c	6.6 b
MaxCel 125 ppm	Petal-fall + 5 days	5-7 mm	82.7 ab	14.1 ab	223 b	56.3 b	7.7 ab
MaxCel 125 ppm	Petal-fall + 10 days	8-10 mm	68.5 b	13.1 b	246 a	72.0 a	9.5 a
MaxCel 125 ppm	Petal-fall + 15 days	12-14 mm	75.7 ab	13.3 b	239 a	67.8 a	8.7 ab

4. **Russet Management**. Experiments bagging Comice pear fruit weekly after petal-fall in 2008 and 2009 demonstrated that fruit are most susceptible to developing russet when wet during any of the first three weeks after petal-fall. Greatest susceptibility appears to occur during the first two weeks after petal-fall. Application of mancozeb, Pristine, or Surround during this period has been effective in reducing russet, and combinations (tank-mixes) of any two of the three products during this period appears to reduce russet to a greater extent than either product alone. Correlation studies comparing various weather factors to incidence of russet in Comice pears over the past 11 years showed that the strongest predictors of russet incidence were cool temperatures and low evapotranspiration during the second and third weeks after petal-fall.

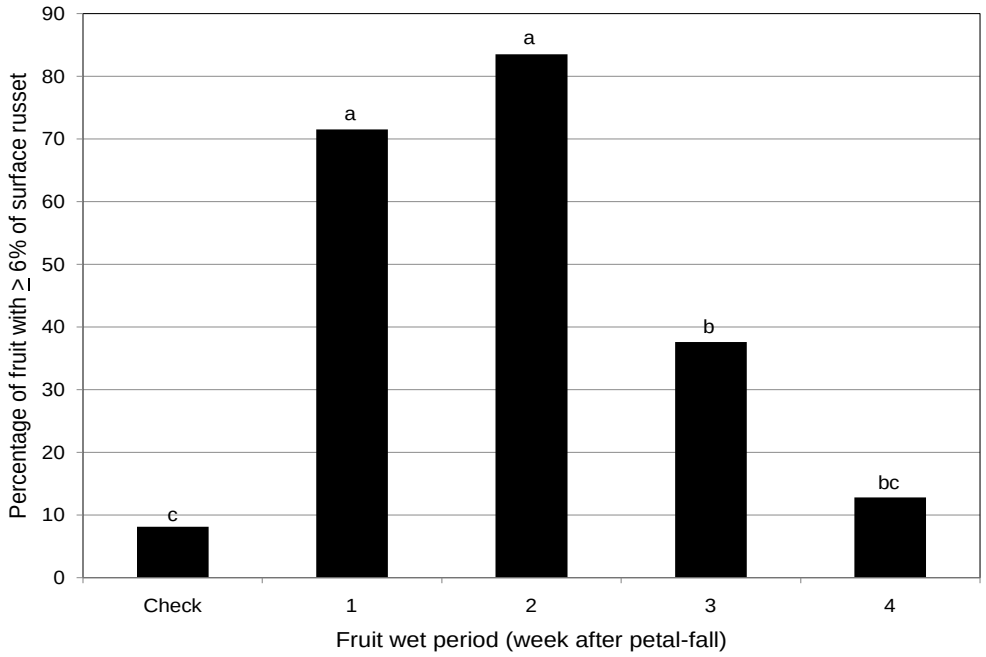


Table 7. Control of russet in Comice pears with treatment programs applied at petal-fall and 2 and 4 weeks after petal-fall (Mancozeb is active ingredient in products Dithane and Manzate).

Treatment	**Rate**	**% of fruit with ≥ 6 % russet**
Untreated		11.6 a
Pristine	14.5 oz/acre	5.5 b
Pristine + Mancozeb	14.5 oz + 3 lb/acre	2.2 b
Pristine + Mancozeb + Surround	14.5 oz + 3 lb + 25 lb/acre	1.5 b

Untreated		11.6 a
Mancozeb	3 lb/acre	9.8 ab
Mancozeb + Procure	3 lb + 12 fl oz /acre	8.6 ab
Mancozeb + Pristine	3 lb + 14.5 oz /acre	2.2 bc
Mancozeb + Surround	3 lb + 25 lb/acre	1.3 c
Mancozeb + Pristine + Surround	3 lb + 14.5 oz + 25 lb/acre	1.5 c

Untreated		11.6 a
Surround	25 lb/acre	6.5 b
Surround + Mancozeb	25 lb + 3 lb/acre	1.3 c
Surround + Mancozeb + Pristine	25 lb + 3 lb/acre + 14.5 oz	1.5 c

Executive Summary:

The most efficient temperature for fastest satisfaction of the chill requirement for Comice and Anjou pears was 50 °F among a range of temperatures tested between 31 and 65 °F. Both colder and warmer temperatures required longer times for chilling satisfaction. Anjou pears harvested at 14.1 lbf average and exposed to ethylene 100 ppm at 68°F for 24 hours still needed an additional 30 days at 31°F in order to ripen to acceptable quality in 7 days at 68°F. However, fruit from the same 24 hour ethylene treatment needed only 20 additional days at 41°F, or 5-10 days at 50°F. If ethylene treatment was increased to 48 hours at 68°F, an additional 20 days were necessary at 31°F, 10 days at 41°F, and 5 days at 50°F. Conditioning requires less time as pear harvest maturity advances, as ethylene exposure time increases, and as post-ethylene temperature increases up to 50°F. These findings need to be followed up with studies of ethylene-temperature conditioning regimes at different fruit maturities, and predictions of the shipping firmness and storage potential of pears following various conditioning regimes.

Bartlett pear fruit size was enhanced by either urea at full bloom or MaxCel at 125 ppm applied 10 days after petal-fall. Urea was more effective and more consistent in improving fruit size when applied at a 7.5% concentration than at 5%. Fruit size enhancement was similar with 7.5% urea or with MaxCel 125 ppm. Fruit russet was most affected by weather conditions during the 2-3 weeks after petal-fall. Combinations of any two materials among mancozeb, Pristine, or Surround beginning at petal-fall were more effective in reducing russet than any product alone.