FINAL PROJECT REPORT

Project Title: Ripening capacity and decay control in Winter Pears

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Other funding sources: None

Total Project Funding:

Item	**2010**	**2011**
Salaries	19,500	19,500
Benefits	12,090	12,090
Wages		
Benefits		
Equipment		
Supplies	2,000	2,000
Travel		
Miscellaneous		
Total	33,590	33,590

OBJECTIVES

This project had two overall objectives:

1. Characterize appropriate conditioning regimes for 'Anjou' and 'Comice' pears based on fruit maturity at harvest, ethylene conditioning, and intermediate temperature conditioning. Appropriate conditioning regimes will result in fruit with (1) early capacity to ripen to good quality, (2) adequate shipping firmness, and (3) a useful post-conditioning storage life before shipping.

2. Advance the development of orchard-based programs for postharvest decay control, integrating new materials, timings, and modes of application with effective techniques identified previously.

SIGNIFICANT FINDINGS

Objective 1 (Ripening Capacity):

1. The most efficient temperature for inducing ripening capacity in 'Anjou' and 'Comice' pears was 50 °F.
2. The duration of temperature conditioning needed by 'Anjou' and 'Comice' pears to develop ripening capacity, at all temperatures tested, decreased linearly with advancing harvest maturity. Conditioning time can be calculated based on the harvest date relative to the orchard block reaching the top of the firmness range for maturity.
3. 'Anjou' pears did not have the capacity to ripen after 24 or 48 hours in ethylene, unless given further temperature conditioning. Temperature conditioning after ethylene exposure can be completed faster at 50 °F than at 31 °F. Little or no further conditioning was needed after 72 hours in ethylene.
4. Identifying useful ethylene-temperature combinations to induce ripening capacity involves balancing eating quality (increases with longer conditioning) and shipping firmness (decreases with longer conditioning).
5. The storage potential at 31 °F of 'Anjou' and 'Comice' pears after conditioning decreases with increasing time in ethylene, warmer post-ethylene conditioning temperatures, and later harvest.
6. Smaller pears softened faster in response to ethylene treatment than did larger pears, but this effect was most pronounced with extreme size differences and marginal ethylene exposure.

Objective 2 (Postharvest Decay):

1. Decay control efficacy was compromised when application of Bio-Save 10 as a postharvest line-spray was delayed until 3 or more weeks after harvest, and of Scholar fungicide when delayed until 6 weeks or more after harvest.
2. Calcium chloride summer sprays resulted in strong reduction in decays caused by *Cladosporium* and *Alternaria* fungi, but not in decay caused by *Botrytis* (gray mold).
3. Pristine fungicide applied one week pre-harvest reduced all types of natural infection in these experiments, while Luna Sensation was effective in reducing *Botrytis* infection but not *Cladosporium* / *Alternaria* infections.
4. Potential organic decay control programs with yeast orchard sprays followed by a Bio-Save 10 line spray was did not provide significant decay reduction.
5. A single-bin drench with Scholar applied in the orchard reduced decay at a level similar to applying Scholar as a packinghouse line-spray between 3 and 6 weeks after harvest.

METHODS

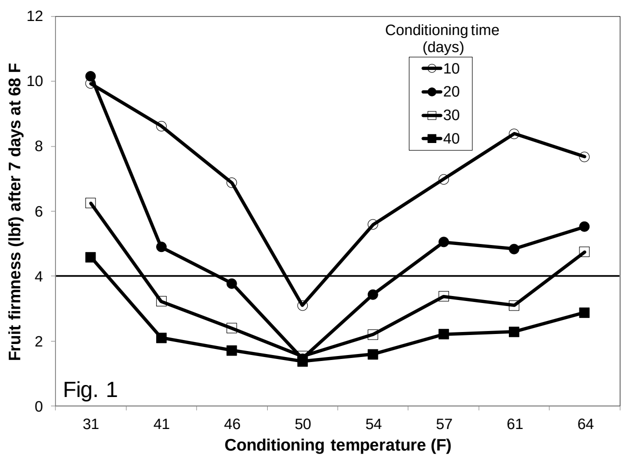
This project uses the series of research-size CA-style rooms at the Southern Oregon Research and Extension Center for controlled temperature and ethylene treatments. All experiments are replicated four times, with replication based in the orchard; that is, replicate lots of fruit will come from distinct areas in the orchard to account for variability among orchard locations. Fruit firmness for maturity, shipping firmness, and storage quality measurements are determined using a Fruit Texture Analyzer. Ethylene is introduced from a compressed ethylene cylinder and concentrations verified using a gas chromatograph.

Studies of the interaction of fruit maturity, ethylene exposure, and temperature conditioning, including follow-up factors of shipping firmness and storage life require detailed scheduling of the movement of fruit and the measuring of firmness and evaluation of quality. A technician supported by this project has daily responsibilities for fruit tracking and firmness measurements. The Principal Investigator is responsible for application of ethylene treatments, temperature management, weekend fruit movement and measurements, and quality evaluations.

RESULTS & DISCUSSION

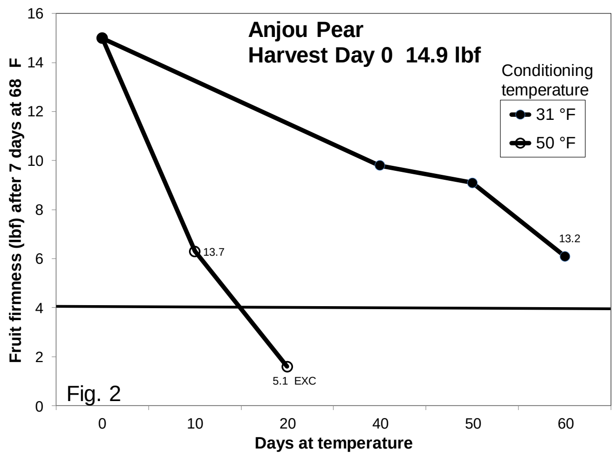
Objective 1 (Ripening Capacity):

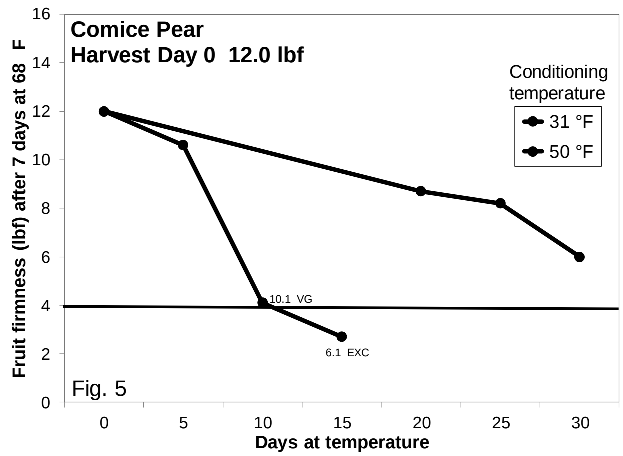
1. Surprisingly, the most efficient temperature for inducing ripening capacity ("satisfying the chill requirement") among the temperatures studied was 50 °F. A range of potential conditioning temperatures for 'Anjou' pear were studied in 2009 and 2010; combined results shown in Fig. 1. Similar results were found for 'Comice' pear. This confirms the potential of using exposure to 50 °F as a tool for conditioning winter pears much faster than at 31 °F. Preliminary results from colleagues at UC Davis show that ripened 'Comice' pears that had been conditioned at 50 °F had more intense sweet pear aroma than those that had been conditioned at 31 °F or in ethylene for 72 hours. Because peak conditioning efficiency occurs at 50 °F, detailed work on integrating harvest maturity, temperature conditioning, and ethylene conditioning in 2011 focused on 50 °F.

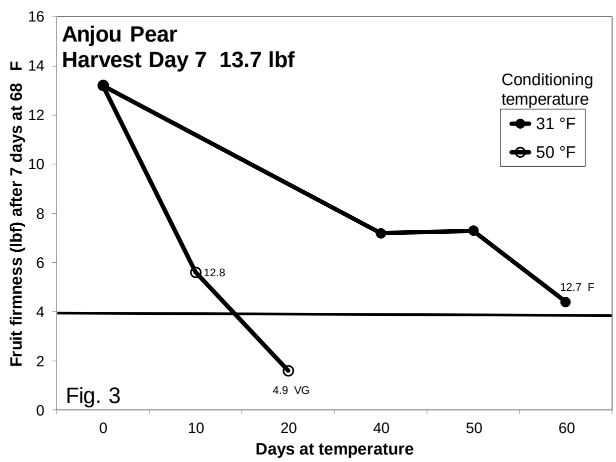


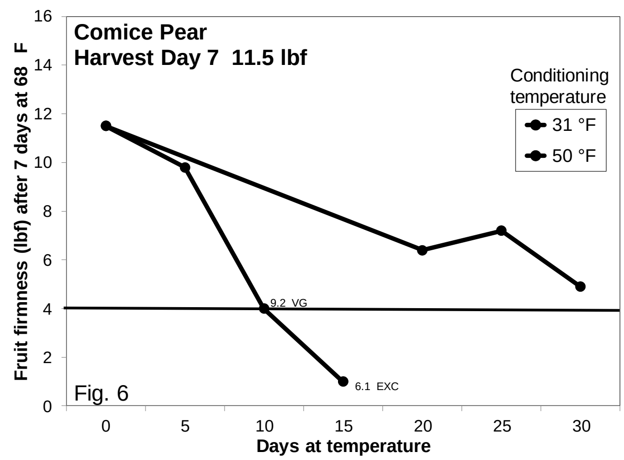
2. Experiments concluded in 2010 found a linear decrease in conditioning time with advancing harvest maturity, regardless of conditioning temperature. The conditioning time at any temperature can be calculated from the equation for the line describing the relationship. Experiments in 2011 for 'Anjou' and 'Comice' included three harvest dates: 0, 7, and 14 days after the average fruit firmness in the orchard reached the top of the maturity range. The efficiency of both temperature and ethylene conditioning will always reflect interaction with the fruit harvest maturity. The duration of conditioning at 31 °F and 50 °F from the three harvest dates is shown in Figs. 2-4 for 'Anjou' and Figs. 5-7 for 'Comice'. In these and other charts in this report, the data points reflect fruit firmness after 7 days of ripening time at 68 °F. Values falling below the horizontal line at 4 lbf are considered "ripe" in being at the onset of a buttery-juicy texture. Numbers next to data points indicate the fruit firmness at the end of conditioning, before ripening. Letters next to data points below 4 lbf indicate overall eating quality of the ripe fruit.

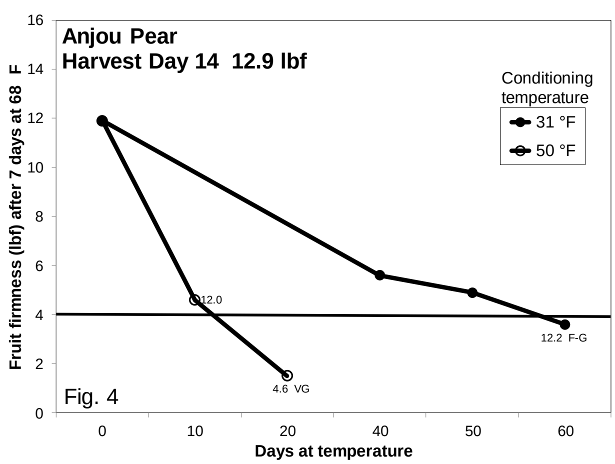
3. ‘Anjou’ pears did not have the capacity to ripen after 24 or 48 hours in ethylene, unless given

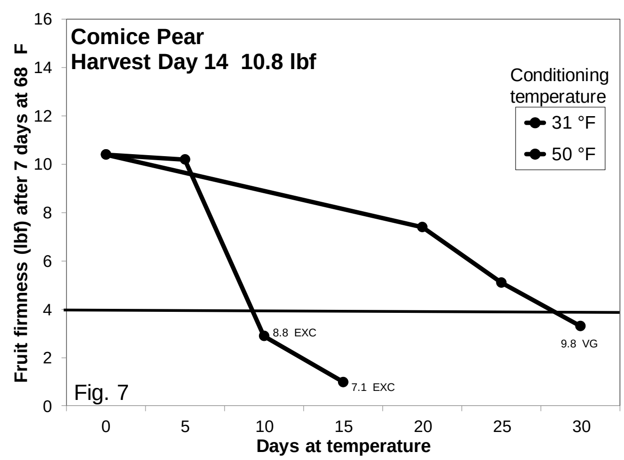


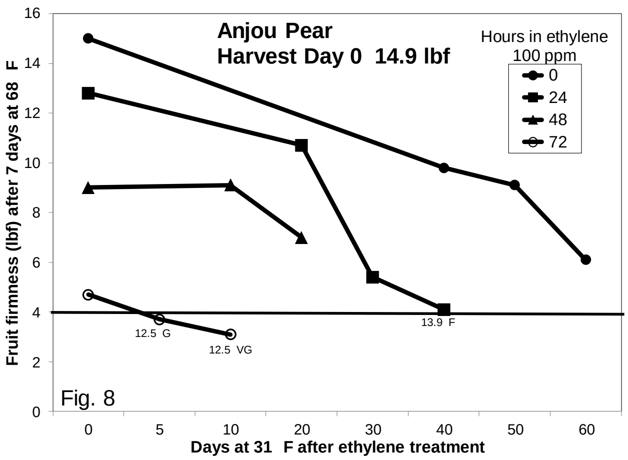


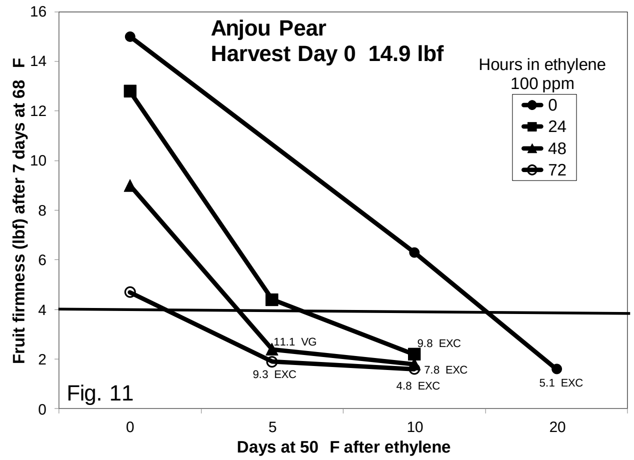


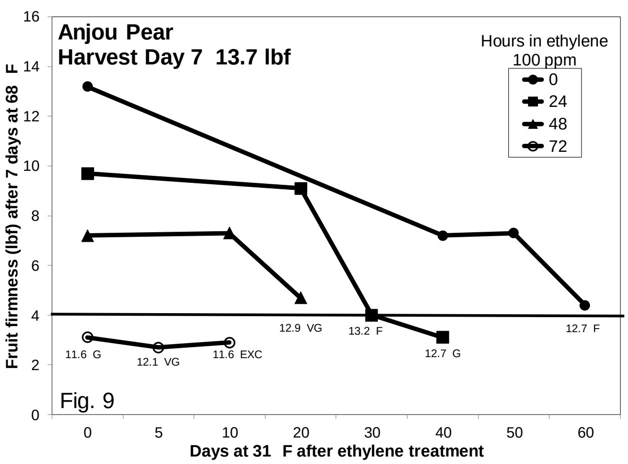


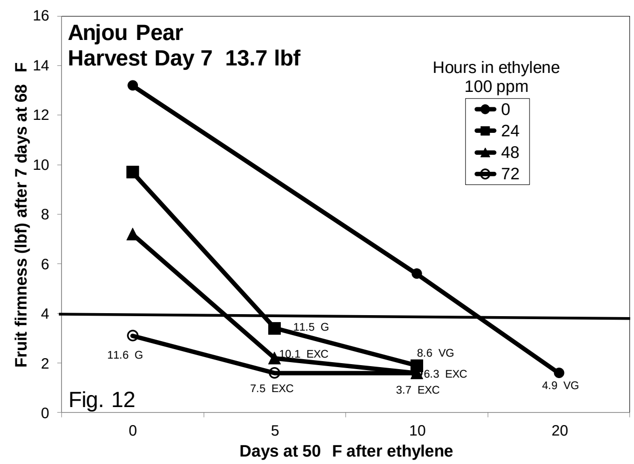


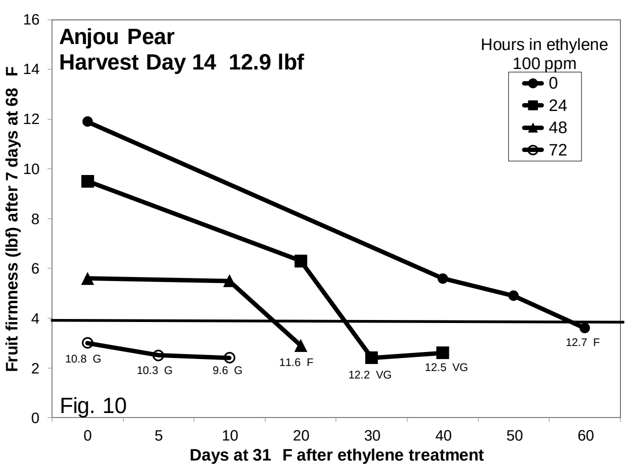


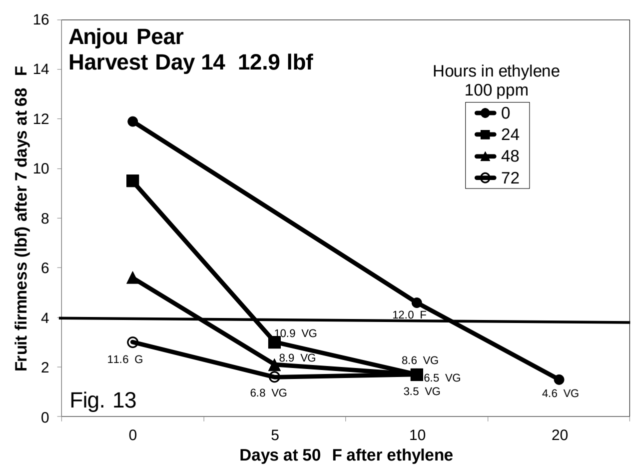




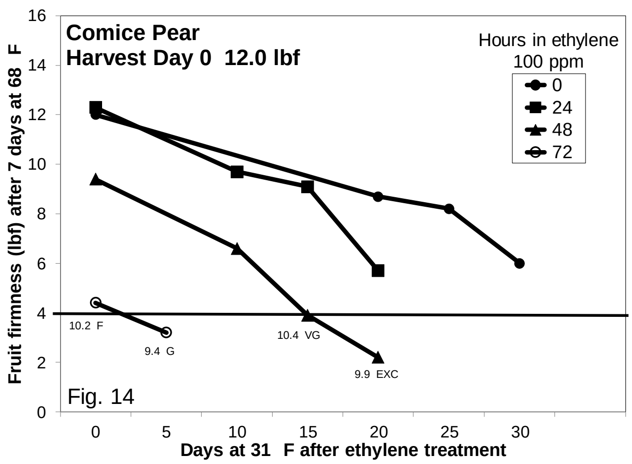


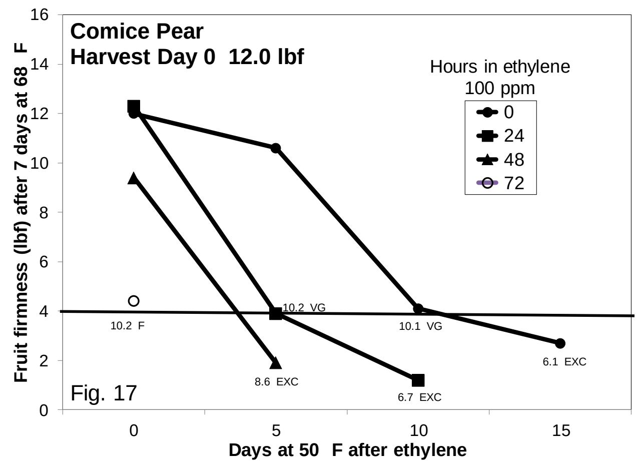


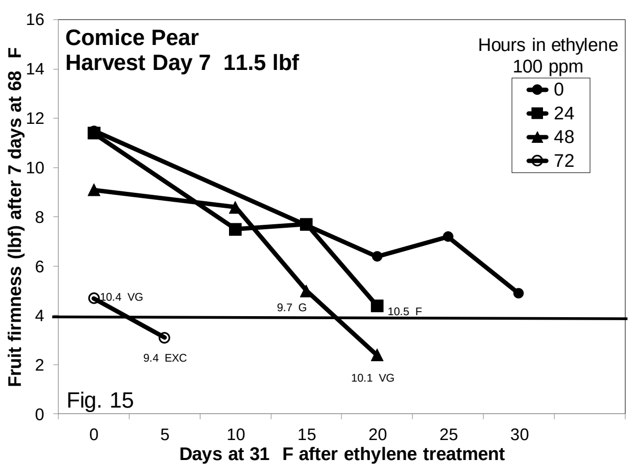


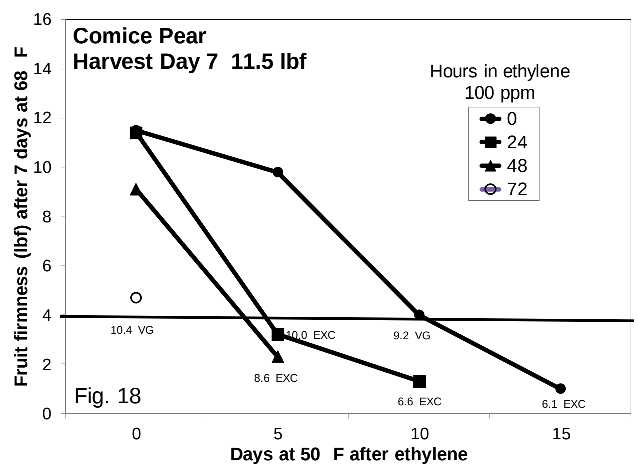


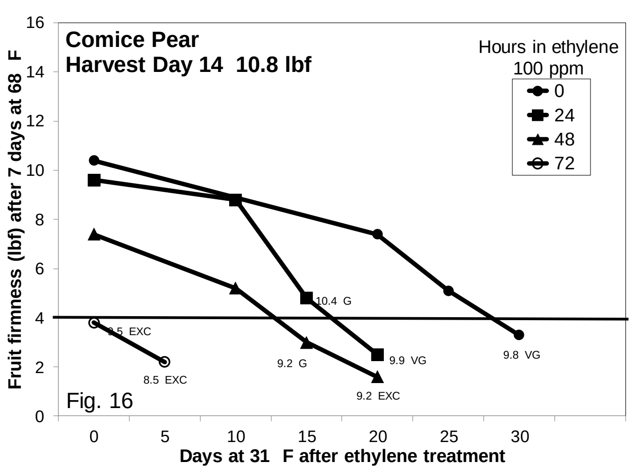
further temperature conditioning. After 24 hours in ethylene, 'Anjou' pears needed an additional 25-40 days at 31 °F to develop ripening capacity, depending on maturity at harvest (Figs. 8-10). After 48 hours in ethylene, 'Anjou' needed 15-30 days at 31 °F (Figs. 8-10). After 72 hours in ethylene, 'Anjou' pears softened to nearly 4 lbf without further temperature conditioning (Figs. 8-10). When the post-ethylene conditioning temperature was 50 °F, induction of ripening capacity proceeded significantly faster. Typically, 5 days at 50 °F following 24 or 48 hours in ethylene was sufficient to complete induction of ripening capacity (Figs. 11-13). For all three harvest dates of 'Anjou', the fruit firmness at the end of 10 days conditioning at 50 °F was equivalent to the fruit firmness at the end of 60 days conditioning at 31 °F. Similar response patterns, although on a shorter time scale, were found for ‘Comice’ pears when ethylene conditioning was followed by temperature conditioning at 31 °F (Figs. 14-16) or at 50 °F (Figs. 17-19). An element of this project that was lacking was to re-cool the fruit after conditioning and before ripening, which would have better simulated industry practices. Thus treatments which came close to softening to 4 lbf firmness within 7 days at 68°F might have actually done so if given further conditioning time through the re-cooling and shipping process.

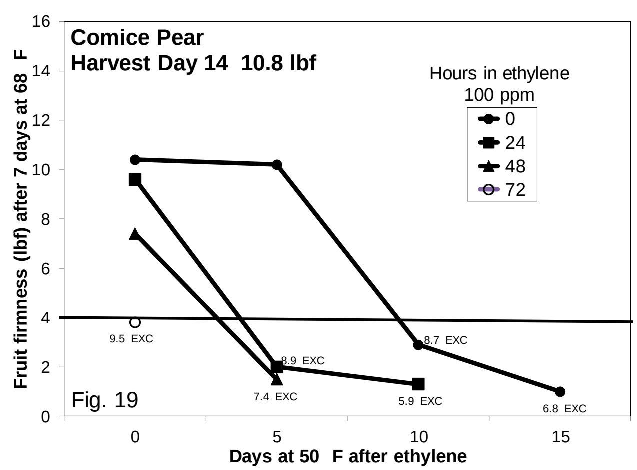








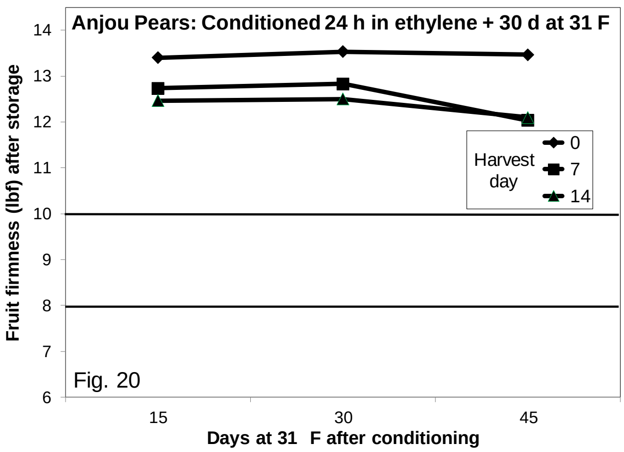


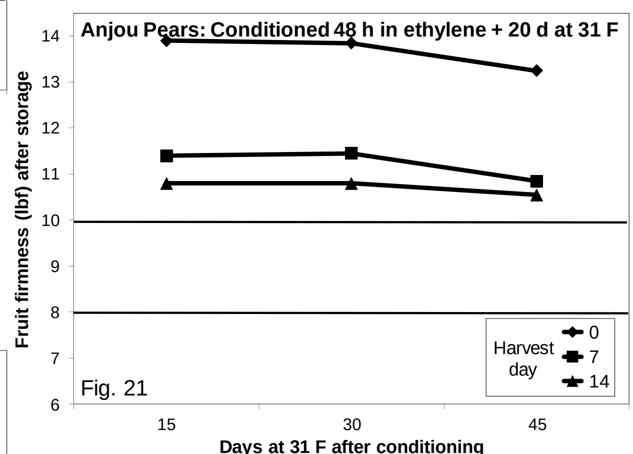


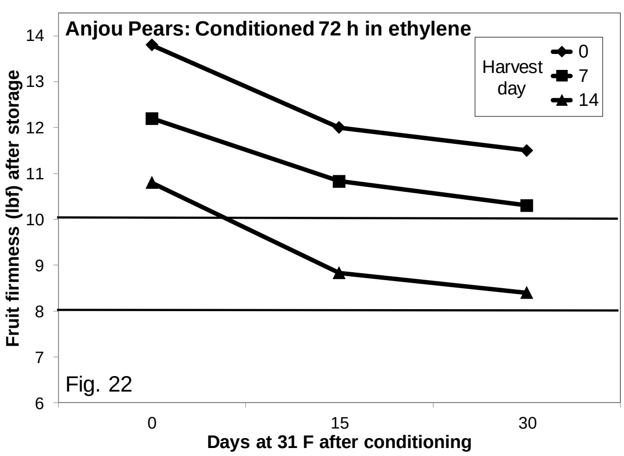
4. With 5 days at 50 °F following 24 or 48 hours in ethylene, fruit firmness at the end of conditioning (shipping firmness) varied from around 9 to 11.5 lbf, depending on harvest maturity and length of

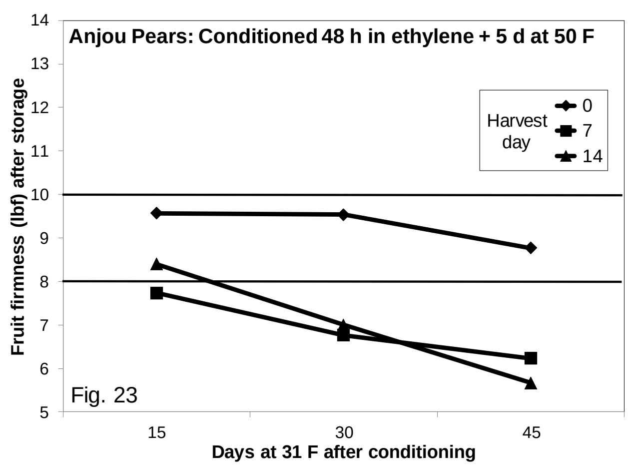
ethylene exposure (Figs. 8-19). From informal discussions with pear shippers, it appears that a lower threshold for shipping firmness may be between 8 and 10 lbf. Following some conditioning treatments in this project, fruit firmness was too soft for the fruit to be expected to ship without injury. Post-ethylene temperature conditioning, especially at 50 °F, needs to be managed to avoid excess fruit softening while gaining the ripening and eating quality benefits. In general, eating quality of ripe fruit improved with longer ethylene exposure and longer post-ethylene temperature conditioning time.

5. The firmness of ‘Anjou’ and ‘Comice’ pears after a range of durations of ethylene treatments and post-ethylene conditioning temperatures also indicates the potential storage life after the fruit have experienced various conditioning strategies. While the storage potential at 31 °F of ‘Anjou’ and ‘Comice’ pears after conditioning decreases with increasing time in ethylene, warmer post-ethylene conditioning temperatures, and later harvest, fruit from several conditioning regimes and harvest dates could be stored at 31 °F for 15-45 days while retaining suitable shipping firmness (Figs. 20-23). In general, ‘Anjou’ and ‘Comice’ pears conditioned in ethylene only maintained high shipping firmness during post-conditioning storage, although ‘Anjou’ pears conditioned for 72 hours in ethylene from the latest harvest were close to 8 lbf after 30 days of post-conditioning storage at 31 °F (Fig. 22). Harvest date was a critical factor in the post-conditioning storage potential of fruit conditioned for 48 hours in ethylene followed by 5 days at 50 °F (Fig. 23).









6. ‘Comice’ pears of three size categories (larger than 90, 90-120, and smaller than 120) were harvested and fruit firmness was measured after the fruit were exposed to ethylene for 24, 48, and 72 hours. When very small fruit were selected and compared to medium and large-sized fruit, they indeed responded to ethylene more quickly than the larger fruit (Fig. 24). Using a natural range of fruit sizes exposed to ethylene for 24 hours, there was a slight trend for smaller fruit to ripen more fully than larger fruit (Fig. 25). However, with longer ethylene exposure (48 hours), there was no relation between fruit size and ability to soften (Fig. 26). Thus fruit size may have a role in the variability of some lots of varying fruit size exposed to ethylene, but this is not expected to have a significant role in determining ethylene-based conditioning practices. In all cases, there was a high degree of variability in fruit response to ethylene that was not accounted for by differences in fruit size.

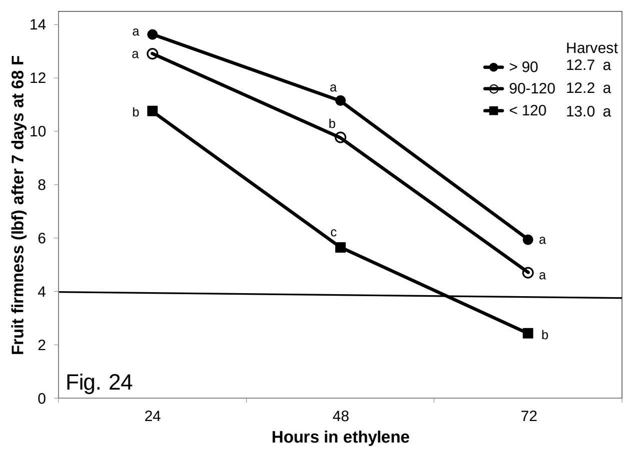


Fig. 24

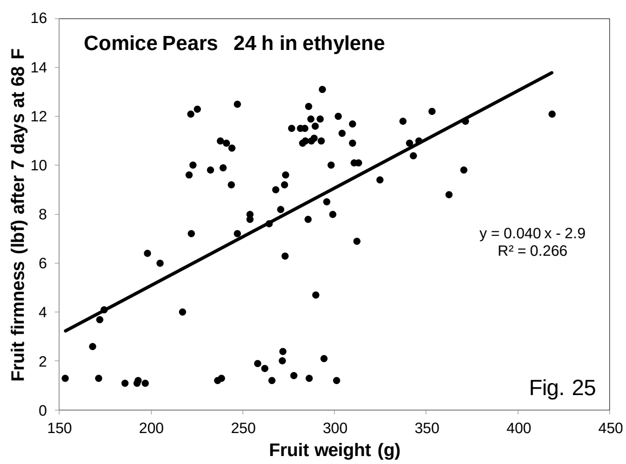


Fig. 25

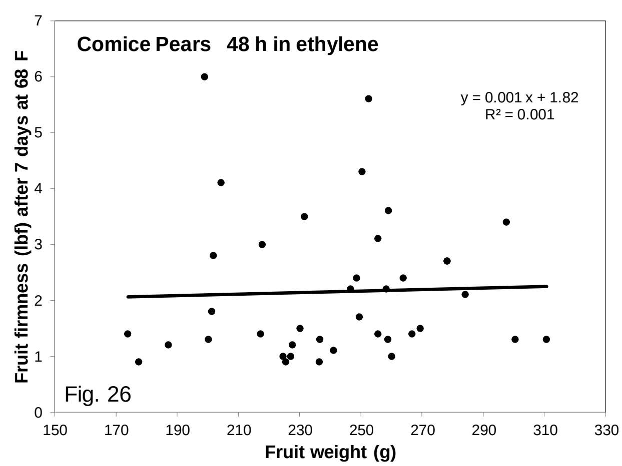
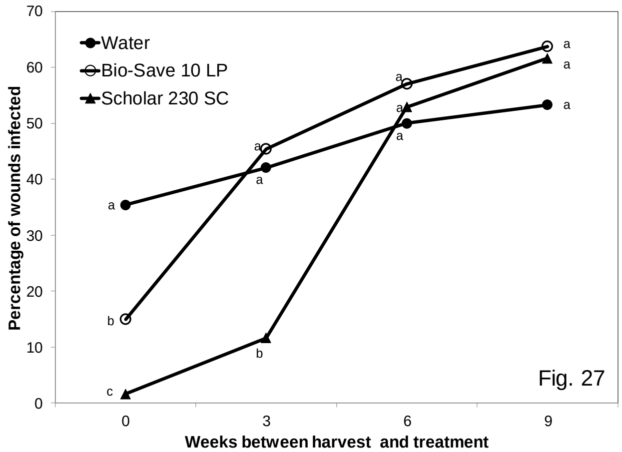
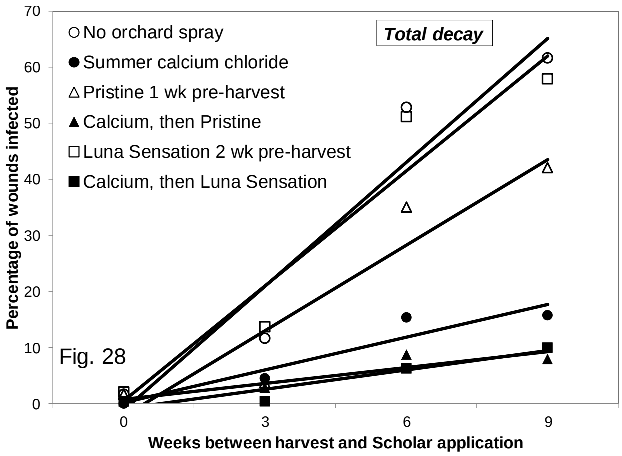


Fig. 26

Objective 2 (Postharvest Decay):

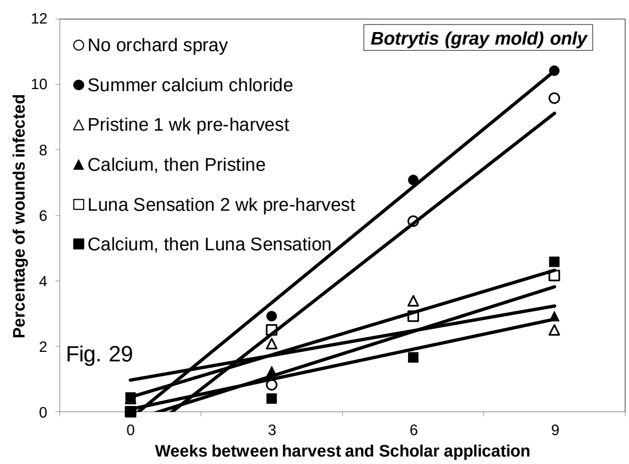




1. This research addressed the common industry situation in which a large portion of the winter pear crop intended for mid-to-long-term storage may not receive postharvest fungicide treatment promptly after harvest, and thus postharvest fungicide treatment may be inadequate. Relying solely on postharvest treatments, the ability to control infections by decay fungi at wounds made at harvest was largely lost when postharvest treatment with Scholar fungicide was delayed until 6 weeks or more after harvest, and when postharvest treatment with Bio-Save 10 biocontrol agent was delayed until 3 weeks or more after harvest (Fig. 27). Treatment materials that may be effective when applied promptly after harvest may be of little value for decay control if applied a few weeks later, even if the fruit are kept cold between harvest and treatment. Thus integration of orchard treatments with postharvest treatments as key elements of a comprehensive decay control strategy may be critical to reducing economic losses due to postharvest decay.

2. Calcium chloride summer treatments can serve as a backbone for subsequent pre- and postharvest fungicide treatments. In our experiments, calcium chloride sprays were most effective in reducing "side rot" types of wound infections, caused by fungi such as *Cladosporium* and *Alternaria* (Fig. 28). Calcium chloride sprays were not effective in controlling gray mold (*Botrytis cinerea*) (Fig. 29).

3. Pristine fungicide applied one week pre-harvest was effective in reducing total decay incidence, while Luna Sensation applied two weeks pre-harvest did not appear to be effective (Fig. 28). However, when only the *Botrytis* infections were considered, Luna Sensation treatments reduced decay (Fig. 29). Experiments on pre-harvest fungicide and other orchard-based decay control options performed during in 2011 growing season will be evaluated in February, 2012.



4. Potential organic decay control strategies were evaluated, involving two yeast-based products applied before harvest and the bacterial-based biocontrol product Bio-Save 10 applied as a postharvest line. In general, the biocontrol programs based on either yeast followed by Bio-Save performed similarly to the check in decay control (Fig. 30), while the most effective fungicide program (Pristine followed by Scholar) was highly effective when applied promptly after harvest.

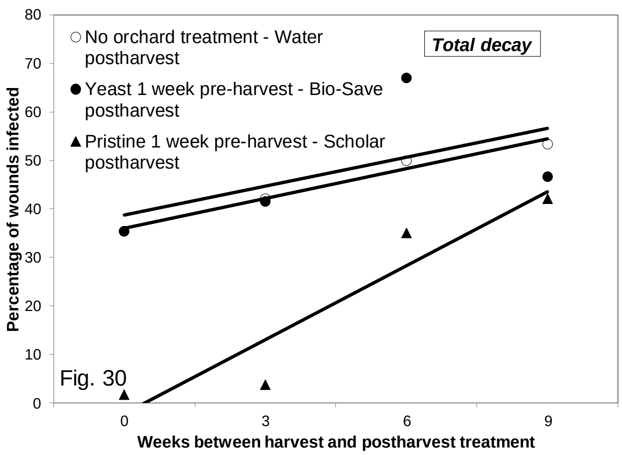


Fig. 30

5. As an alternative or additional to pre-harvest fungicide treatments, a single-bin drench system for applying fungicide or biocontrol agents to harvested bins of fruit is being evaluated. Scholar fungicide applied through the single-bin drench system further reduced decay in fruit that had been treated in orchard with calcium and/or Pristine (Fig. 31). Overall, applying Scholar through this system appears to provide decay control at a level similar to applying Scholar as a packinghouse line-spray between 3 and 6 weeks after harvest (Fig. 32). Biocontrol agents applied through the single-bin drench system in 2011 will be evaluated in February, 2012.

EXECUTIVE SUMMARY

The most efficient temperature for satisfying the chill requirement (inducing ripening capacity) in winter pears appears to be 50 °F. A range of potential conditioning temperatures for ‘Anjou’ and ‘Comice’ were compared, confirming the potential of using 50 °F as a tool for conditioning winter pears much faster than at 31 °F. In addition to speed of conditioning, preliminary results from UC Davis show that ripened ‘Comice’ pears that had been conditioned at 50 °F had more intense sweet pear aroma than those that had been conditioned at 31 °F or in ethylene for 72 hours.

‘Anjou’ pears did not have the capacity to ripen after 24 or 48 hours in ethylene, unless given further temperature conditioning. After 24 hours in ethylene, ‘Anjou’ pears needed an additional 25-40 days at 31 °F to develop ripening capacity, depending on maturity at harvest. After 48 hours in ethylene, ‘Anjou’ needed 15-30 days at 31 °F. After 72 hours in ethylene, ‘Anjou’ pears softened to nearly 4 lbf within 7 days at 68 °F without further temperature conditioning. When the post-ethylene conditioning temperature was 50 °F, induction of ripening capacity proceeded significantly faster. Typically, 5 days at 50 °F following 24 or 48 hours in ethylene was sufficient to complete induction of ripening capacity. For three weekly harvest dates of ‘Anjou’, the fruit firmness at the end of 10 days conditioning at 50 °F was equivalent to the fruit firmness at the end of 60 days conditioning at 31 °F. The same response patterns, on a shorter time scale, were found for ‘Comice’.

After 24 or 48 hours in ethylene followed by 5 days at 50 °F, fruit firmness at the end of conditioning (shipping firmness) varied from around 9 to 11.5 lbf, depending on harvest maturity and length of ethylene exposure. Following longer post-ethylene conditioning at 50 °F, fruit were too soft to ship without risk of injury. Post-ethylene temperature conditioning, especially at 50 °F, needs to be managed to avoid excess fruit softening while gaining the ripening and eating quality benefits. In general, the eating quality of ripe fruit improved with longer ethylene exposure and longer post-ethylene temperature conditioning time.

How long can conditioned pears be stored before shipping? While the storage potential at 31 °F of ‘Anjou’ and ‘Comice’ pears after conditioning decreases with increasing time in ethylene, warmer post-ethylene conditioning temperatures, and later harvest, fruit from several conditioning regimes and harvest dates could be stored at 31 °F for 15-45 days while retaining suitable shipping firmness. ‘Anjou’ and ‘Comice’ pears conditioned in ethylene generally maintained high shipping firmness during post-conditioning storage. ‘Anjou’ pears conditioned for 72 hours in ethylene from the latest harvest were close to 8 lbf after 30 days of post-conditioning storage at 31 °F. The post-conditioning storage potential of fruit conditioned for 48 hours in ethylene followed by 5 days at 50 °F was highly dependent on harvest date; earlier harvest provided the best storage potential.

The ability to control postharvest infections by decay fungi at wounds made at harvest was largely lost when postharvest treatment with Scholar fungicide was delayed until 6 weeks or more after harvest, and when postharvest treatment with Bio-Save 10 biocontrol agent was delayed until 3 weeks or more after harvest. Summer calcium chloride and pre-harvest Pristine were effective treatments for postharvest decay reduction. As an alternative or addition to pre-harvest fungicide treatments, Scholar fungicide applied to harvested bins in the orchard through a single-bin drench system further reduced decay in fruit that had been treated in the orchard with calcium and/or Pristine. Overall, applying Scholar through this system appears to provide decay control at a level similar to applying Scholar as a packinghouse line-spray between 3 and 6 weeks after harvest.