FINAL PROJECT REPORT **YEAR**: 3 of 3

Project Title: Pear crop load management and rootstock field testing

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Cooperators: Felipe Castillo, Ines Hanrahan, Jim McFerson, Dave Sugar, Todd Einhorn

Total Project Request: **Year 1:** 24,000 **Year 2:** 26,000 **Year 3:** 16,000

Other funding sources

All chemicals donated by companies
$2000 each from Valent and Fine Americas to support fruit set trials
$2400 from Fine Americas to support thinning trials

Organization Name: WTFRC **Contract Administrator:** Kathy Schmidt
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Item	2009	2010	2011
Salaries	10,500	12,000	6000
Benefits	3300	3800	1900
Wages	5500	5500	5500
Benefits	1500	1500	1500
Equipment			
Supplies			
Travel	3000	3000	1000
Miscellaneous	200	200	100
CLM Subtotal	14,800	15,400	16,000
Rootstock subtotal *	9,200	10,600	See Einhorn report
External funding		(3,000)*	(6,400)*
Grand Total	$24,000	$23,000*	$9,800

Footnotes: 2011 expenses related to Einhorn Horner evaluation project have been removed from this budget
*Note: original budget total for 2011 was $16,000; current figure has been revised to reflect contributions to project from Valent and Fine Americas

Objectives:

1. Continue development of effective crop load management programs for pear to reduce production costs, increase fruit size, and promote return bloom (Schmidt).

2. Provide consulting, logistical, labor, and data management support for Todd Einhorn's project for grower screening of Horner series rootstocks (Auvil).

Significant findings:

- ATS applied during bloom and BA applied at 10 mm fruitlet size effectively thin Bartlett pears; combined programs provide the best results
- Tank mixing of BA with other materials (oil, abamectin, phosphite, carbaryl) did not produce clear benefits
- Split applications of reduced rates of BA showed no benefit over single full rate applications in our studies
- Application of AVG (ReTain), GA_3 (ProGibb, Falgro), GA_4 (Novagib), GA_7, GA_{4+7} (ProVide), and BA + GA_{4+7} (Promalin, Perlan) did not improve fruit set of D'Anjou or Red D'Anjou in 7 trials over 3 seasons
- BA frequently improved harvest fruit size across chemical thinning and fruit set trials
- Budget and details for Horner rootstock evaluation in Einhorn's report

Methods:

Chemical thinning: From 2009-2011, we conducted chemical thinning trials in one D'Anjou and ten commercial Bartlett orchards; three Bartlett trials were applied by grower-cooperators using their own spray equipment, while the rest were applied by WTFRC staff with an AccuTech sprayer. Grower-applied trials were designed as randomized complete blocks with plots comprised of 2-3 whole rows to simplify spraying. WTFRC-applied trials generally featured smaller designs, generally consisting of 5-8 trees per plot, depending on tree size and spacing. Initial bloom counts were recorded on tagged sample branches in each plot. All trials were successfully treated at appropriate timings using 100 gal water/acre; treatments are detailed in Table 1. Fruit set counts were made on sample branches after June drop, but before green fruit hand thinning. Representative fruit from each plot were sampled within a few days of commercial harvest and evaluated in the WTFRC lab for size, firmness, sugar levels, acidity, and fruit finish.

Table 1. Pear chemical thinning programs evaluated. WTFRC 2009-2011.

Material	Concentration	Timing(s)
ATS	5%	20% & 80% bloom
NC99	10%	20% & 80% bloom
BA (MaxCel, Exilis Plus, Genesis 6-BA)	16 - 128 oz/A	8-10 mm, 14-16 mm
BA + carbaryl	128 oz + 64 oz/A	10 mm
BA + Superior oil	128 oz/A + 1%	10 mm
BA + Sysstem-CAL	32 oz + 64 oz/A	10 mm
BA + AgriMek + summer oil	32 oz + 20 oz/A + 1%	10 mm

Fruit set: Seven trials were conducted from 2009-2011 investigating the potential use of various plant growth regulators to increase fruiting in commercial D'Anjou and Red D'Anjou blocks with histories of poor fruit set. Materials were applied by WTFRC staff at 100 gal water/acre with our AccuTech sprayer; application timings and concentrations were determined based on reports of successful programs in Europe and input from the research staff of the respective chemical manufacturers (Table 6). Trials were designed as randomized complete blocks with 6-7 trees per plot. Initial bloom counts were recorded on tagged sample branches in each plot. Fruit set counts were made on sample branches after June drop. Representative fruit from each plot were sampled within a few days of commercial harvest and evaluated in the WTFRC lab for size, firmness, sugar levels, acidity, and fruit finish.

Results and discussion:

Chemical thinning: Starting in 2003, our research program began screening potential bloom thinners of Bartlett pears, including ammonium thiosulfate (ATS), an organic magnesium/calcium brine (NC99), urea, lime sulfur (LS), and combinations of horticultural oils and LS. As is typical of chemical thinning work in other crops, some products performed well in isolated cases, but their effects were unreliable. Over several years of trials, we found ATS to be more consistent in reducing fruit set than other products (Table 5). ATS was also appealing due to its relatively low cost and ease of handling, and became the standard bloom thinning treatment in the course of our investigations.

In contrast to the variability of our chemical bloom thinning results, we have been surprised by the relatively consistent performance of benzyladenine (BA) products like MaxCel (Valent), Exilis Plus (Fine), and Genesis 6-BA (GS Long), especially with respect to increasing fruit size. In fact, the long-term success rate of BA producing statistically significant gains in fruit weight in 53% our studies (Table 5) is unparalleled in our work with any growth regulator in pear, apple, cherry, or soft fruits. Not surprisingly, many of our best trial results in recent years have been from programs featuring the use of ATS during bloom and BA at 10 mm fruitlet size (Tables 2, 3). Chemical thinning programs can often be confounded by poor weather or imprecise application timings and we generally find it advantageous to make multiple applications using different materials to improve chances for success.

The primary focus of our 2011 chemical thinning trials was to explore modifications to use patterns of BA, whether by splitting the applications over time (Monitor, Wapato) or tank-mixing BA with other products which may increase efficacy by improving uptake by plant tissues (Rock Island). Unfortunately, abnormally cold spring weather in 2011 may have compromised the performance of BA products across all three trials. Harvest fruit size was not affected by any treatment in any trial,

and the only reductions in fruit set (Monitor) could be attributed to the use of ATS during bloom in those programs (Table 2).

Nonetheless, our 2011 results (Table 2) corroborate earlier studies which indicated that splitting an equivalent amount of BA over multiple applications does not offer clear advantages over a single high-rate application, although we are aware of anecdotal reports from Northwest pear growers and South American researchers suggesting the contrary. A logical case can be made that split applications may be advantageous when a single application would be made in poor weather (i.e. < 65F) and a second might be applied during warmer temperatures, but our trials may not have experienced the particular weather conditions to properly test that hypothesis.

Even though no treatment in our 2011 trial in Rock Island significantly reduced fruit set or improved fruit size (Table 3), we saw no additional response from adding either oil + abamectin (AgriMek) or phosphite (Sysstem-CAL) to the spray tank with BA. This pattern is consistent with results in 2010, when we observed no benefit from the use of carbaryl with BA. In both 2009 and 2010, we found that using 1% Superior oil with BA slightly increased thinning, but also hurt fruit size, perhaps due to increased photosynthetic stress on the tree (data not shown here). In summary, we have yet to document any benefit to Bartlett growers by deviating from the base program of applying 96-128 oz/A of BA at 8-10 mm fruitlet size during favorable weather conditions.

Table 2. Crop load effects of bloom (ATS) and postbloom (BA) chemical thinners on Bartlett pears. WTFRC 2011.

Trial	Treatment	Fruitlets/100 floral clusters	Blanked spurs	Singled spurs	Harvest fruit weight	Relative box size
			%	%	g	
Bartlett/Seedling	ATS; half rate BA 2x	38 b	69 a	23 ab	240 ns	83
- Monitor	ATS; full rate BA 1x	40 b	68 a	26 ab	241	83
	ATS; FAL 551	38 b	72 a	21 b	251	80
	Control	60 a	58 b	29 a	241	83
Bartlett/Seedling	16 oz BA	85 ns	43 ns	35 a	154 ns	130
- Wapato	32 oz BA	85	49	25 b	143	140
	32 oz BA 2x	92	48	24 b	147	136
	32 oz BA; 16 oz BA	84	48	27 ab	149	134
	64 oz BA	92	44	30 ab	149	134
	Control	83	47	30 ab	149	134

Table 3. Crop load effects of bloom (ATS) and postbloom (BA, oil, AgriMek, Sysstem-CAL) chemical thinning programs on Bartlett pears. WTFRC 2011.

Trial	Treatment	Fruitlets/100 floral clusters	Blanked spurs	Singled spurs	Harvest fruit weight	Relative box size
			%	%	g	
Bartlett/OHxF.97	ATS; BA	56 ns	60 ns	27 ns	215 ns	93
- Rock Island	ATS; BA + AgriMek + oil	76	48	32	214	93
	ATS; BA + Sysstem-CAL	64	55	29	217	92
	Control	73	56	24	226	88

Our lone attempt to chemically thin a pear variety other than Bartlett showed strong treatment effects, but ultimately undesirable results from a grower's perspective. Even with less aggressive chemical rates than in used in Bartlett (Table 1), both BA and the tandem of ATS and BA over-thinned our D'Anjou trial plots in 2010 (Table 4). These results reflect the conundrum of crop load management in D'Anjou (and to a lesser degree, Bosc): while improved fruit size is desirable and achievable, chemical thinning programs typically reduce total yield too much to be considered profitable for growers. As such, we have attempted to identify PGR programs that might allow the use of BA to increase fruit size while still preserving or improving yields of weak-setting pear varieties.

Table 4. Crop load effects of bloom (ATS) and postbloom (BA) chemical thinning programs on D'Anjou pears. WTFRC 2010.

Trial	Treatment	Fruitlets/100 floral clusters	Blanked spurs	Singled spurs	Harvest fruit weight	Relative box size
			%	%	g	
Anjou/OHxF.97	ATS	34 a	73 c	22 a	239 b	84
- Buena	ATS; BA	9 b	92 a	8 b	247 ab	81
	BA	16 b	86 b	11 b	257 a	78
	Control	45 a	70 c	19 a	235 b	85

Due to the inherent variability in chemical thinning research results, we advocate evaluation of trial results across seasons, cultivars, and geographic regions to more accurately assess the efficacy of crop load management programs. Table 5 summarizes all WTFRC pear chemical thinning trials conducted since 2003; entries indicate how often various thinning agents have successfully achieved each of our three basic chemical thinning goals:

1. reduced hand thinning of green fruit (reflected by decreased fruit set)
2. increased fruit harvest fruit size
3. improved return bloom in the season after treatment

In this broader view, it is clear that ATS and BA products are the most consistent materials for reducing fruit set, while BA products most often confer larger fruit size and occasional improvements in return bloom.

Table 5. Incidence and percentage of results significantly superior to untreated control. Pear chemical thinning trials WTFRC 2003-2011.

Treatment	Fruitlets/100 blossom clusters	Harvested fruit size	Return bloom[1,2]
ATS	9 / 31 (29%)	5 / 30 (17%)	3 / 27 (11%)
Urea	1 / 17 (6%)	3 / 17 (18%)	0 / 15 (0%)
Crocker's Fish Oil + lime sulfur	0 / 13 (0%)	1 / 13 (8%)	1 / 12 (8%)
Lime sulfur	1 / 13 (8%)	3 / 13 (23%)	0 / 13 (0%)
BA	4 / 19 (21%)	9 / 17 (53%)	3 / 16 (19%)
NAA	0 / 6	0 / 6	0 / 1

[1]Does not include data from 2011 trials.

[2] (no. blossom clusters year 2/sample area) / (no. blossom clusters year 1/sample area)

Fruit set: As demonstrated by our 2010 chemical thinning trial (Table 4), D'Anjou pears can be highly sensitive to chemical thinners including BA. In fact, many pear growers would benefit from tools to help them increase fruit set, as many D'Anjou and Bosc blocks produce light yields despite apparently ample bloom and good pollination conditions. In 2009 we began screening a range of plant growth regulators for their capacity to increase fruit set in light-bearing pear blocks with the

ultimate goal of developing programs which would allow D'Anjou and Bosc to enjoy the fruit sizing benefits of BA applications without significant losses in yields. The programs we tested were based largely on successful European pear industry practices for mitigating reductions in fruit set following spring frosts.

Unfortunately, no treatment in seven trials over three years provided any significant increase in fruit set and some actually reduced it. Protocols for 2011 trials not only featured more aggressive rates of all materials tested in 2009 and 2010, but alternative formulations of gibberellic acid (GA) not previously assayed. The best result from any treatment in any of the seven trials was a 50% boost in fruit set from GA_7 applied to Dryden D'Anjous in 2011(Table 6), but even that increase was not statistically significant. GA_7 is an isomer of gibberellin which is expensive to formulate and not available in a commercial formulation, rendering further investigation an academic pursuit.

Scientists from Italy and Spain recently reported at a local meeting on European research demonstrating effective use of several plant growth regulators to promote pear set. Their growers utilize specific "cocktails" of materials that are often customized to individual pear blocks and sometimes feature chemistries not registered for use in the US. The researchers were unaware of programs that had been used on D'Anjou or Bosc and suggested these cultivars may behave differently than common European varieties.

In light of our poor results over three seasons with available growth regulators to promote pear fruit set, we have decided to forgo further work in this area until new materials or approaches offer greater prospects for success.

Table 6. Crop load effects of PGR programs to promote fruit set of pears. WTFRC 2011.

PGR material/acre	Application timing(s)	Fruitlets/100 floral clusters	Blanked spurs	Singled spurs	Harvest fruit weight	Relative box size
			%	%	g	
D'Anjou/unknown - Dryden						
12 ppm GA_7	20 & 80% bloom	61 a	58 b	27 ns	208 ns	96
12 ppm GA_4	20 & 80% bloom	43 ab	68 ab	22	205	97
10 ppm GA_3	20 & 80% bloom	51 ab	63 ab	25	215	93
15 ppm GA_3	20 & 80% bloom	51 ab	62 ab	26	203	98
8 oz Promalin	20 & 80% bloom	43 ab	71 ab	19	219	91
12 oz Promalin	20 & 80% bloom	40 ab	70 ab	22	207	97
8 ppm GA_{4+7}	20 & 80% bloom	36 b	72 a	21	205	97
12 ppm GA_{4+7}	20 & 80% bloom	53 ab	65 ab	21	223	90
333 g Retain	Late petal fall	45 ab	67 ab	23	200	100
Control	NA	42 ab	69 ab	21	197	101
Red D'Anjou/OHxF.97 - Cashmere						
12 ppm GA_7	20 & 80% bloom	8 ns	93 ns	7 ns	218 ns	92
12 ppm GA_4	20 & 80% bloom	8	92	7	232	86
8 oz Promalin	20 & 80% bloom	7	93	6	236	85
12 oz Promalin	20 & 80% bloom	6	95	5	235	85
8 ppm GA_{4+7}	20 & 80% bloom	7	93	6	222	90
12 ppm GA_{4+7}	20 & 80% bloom	9	91	8	236	85
333 g Retain	Late petal fall	5	95	5	227	88
Control	NA	7	93	6	225	89
D'Anjou/OHxF.97 - Monitor						
8 oz Promalin	20 & 80% bloom	60 ns	62 ns	22 ns	230 ns	87
12 oz Promalin	20 & 80% bloom	72	59	18	226	88
12 ppm GA_{4+7}	20 & 80% bloom	57	65	19	227	88
333 g AVG	Late petal fall	58	63	21	229	87
Control	NA	63	60	22	229	87

EXECUTIVE SUMMARY

Over three years, chemical thinning trials were conducted on ten Bartlett and one D'Anjou blocks in Washington. Results confirmed the efficacy of ATS applied during bloom for decreasing fruit set and increasing fruit size. BA products applied postbloom consistently increased fruit size and often contributed to additional thinning. Neither split applications of BA nor tank-mixing BA with several other materials demonstrated any clear advantages over a single application of BA by itself. The strongest results were obtained by programs featuring use of ATS at 20% and 80% bloom followed by one application of BA at 8-10 mm. Use of chemical thinners on D'Anjou significantly reduced harvest yields and is unlikely to help improve returns for Northwest growers.

Use of several plant growth regulators to improve fruit set in D'Anjou or Red D'Anjou proved unsuccessful. No treatments in seven trials over three years including several formulations of GA, BA + GA, or AVG were successful despite reports that similar programs are effective for European pear growers. This line of research does not offer sufficient promise to warrant further study at this point.

Horner rootstock evaluation has been divorced from this project and information on those studies may be found in Todd Einhorn's report.