FINAL PROJECT REPORT **YEAR**: 1 of 1

Project Title: Advancing Metamitron as a chemical thinner for Bartlett pear

PI: Todd Einhorn
Organization: OSU-MCAREC
Telephone/email: (541) 386-2030 todd.einhorn@oregonstate.edu
Address: 3005 Experiment Station Drive
City: Hood River
State/Zip: OR 97031

Cooperators: Drew Hubbard

Total Project Request: Year 1: $11,779 **Year 2:** $0 **Year 3:** $0

Other funding sources: Adama- chemical product for all trials and crop destruct for additional on-farm trials.

Budget 1: Todd Einhorn
Organization Name: OSU-MCAREC **Contract Administrator:** Russell Karow
Telephone: 541-737-3228 **Email address:** Russell.Karow@oregonstate.edu

Item	2016	2017	2018
Salaries[1]	4,357	0	0
Benefits[2]	3,006	0	0
Wages[3]	1,040	0	0
Benefits[4]	87	0	0
Equipment	0	0	0
Supplies	0	0	0
Travel	0	0	0
Miscellaneous[5]	3,289	0	0
Total	11,779	0	0

Footnotes: [1]Estimated salaries are for: 0.096 FTE for full-time technician to apply thinning compounds, conduct all measurements (fruit set, hand thinning, yield, fruit size and fruit quality attributes), hand thin and enter/collate data. [2]Actual OPE rate is 69%. [3]Wages are to cover 80 hours of part-time labor ($13/hr) to assist with harvest and data collection. [4]Benefits for part-time employees is 8.34%. [5]Miscellaneous includes per acre research plot fees: $3,104/acre and 2 months cold storage room fee (monthly fee of $0.94 per square foot for a 98.6 sq. ft. cold storage room).

Objectives

1. Evaluate the efficacy of metamitron to thin 'Bartlett' pears and inform commercialization decision.

Significant Findings, 2016

- Four trials were conducted in three different locations to evaluate the thinning efficacy of metamitron on Bartlett pear.
- Metamitron effectively thinned Bartlett pears at two locations, but not at the third where two trials were established. Incidentally, 6-BA (MaxCel) also did not thin fruits at this site. Thinning was rate-dependent. The most efficacious rates (250 to 300 ppm) reduced fruit set to 75% and 50% of untreated controls.
- Metamitron reduced photosynthesis by 70% the first four days after application. The effect diminished but was still evident 10 days after application. The response was dose dependent but saturated near 300 ppm. A strong reduction of photosynthesis was associated with fruit abscission. 6-BA did not significantly affect photosynthesis.
- Metamitron-treated trees tended to have larger fruit size compared to controls. Fruit quality at harvest and after storage/ripening was unaffected by metamitron.

Results and Discussion

2015 Results (A brief background and synopsis of significant findings): In 2015, we were funded by the pear research subcommittee to evaluate the thinning efficacy of metamitron on 'Bartlett' pear trees (please refer to the 2016 Final Report, 'Improving fruit set, production efficiency, and profitability of pears'). In that study we selected several rates of metamitron (150, 300, 600 ppm) based on a previously published trial using 'Conference' pear in The Netherlands. For each rate, we also evaluated two application timings (~6 mm and 11 mm), alone and combined. We demonstrated that metamitron reduced photosynthesis by ~50% to 90% depending on rate; an effect that lasted ~ two weeks (Fig. 1).

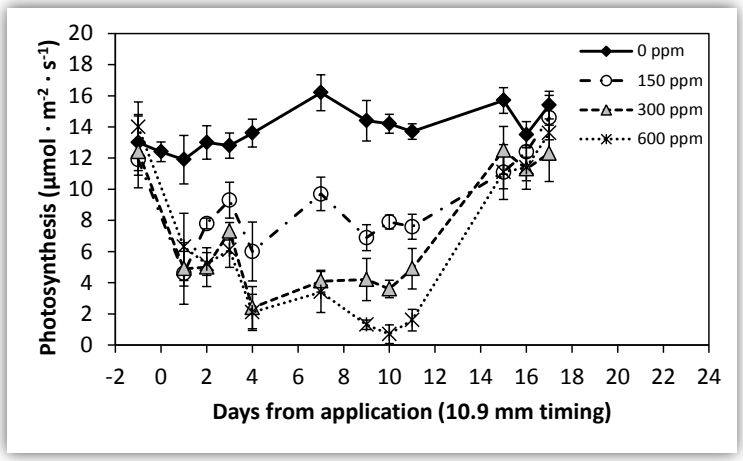

Figure 1. Effect of metamitron rates on photosynthesis of 'Bartlett' pear leaves. Applications were made at 11 mm diameter. Data points represent the mean of 4 single-tree replicates (4 leaves per replicate) and are bracketed by standard error bars.

Importantly, fruit abscission was strongly associated with the measured decrease in photosynthesis. Rates of 150 and 300 ppm reduced the crop load of untreated control trees by ~25% to 40%. The highest rate (600 ppm) did not result in significantly greater thinning than that achieved with 300 ppm. The early, 6 mm timing had relatively no thinning efficacy; therefore, the combination of early

and late timings differed little from the later, 11 mm, timing. Yields reflected the relative number of fruits removed by chemical and follow-up hand thinning and fruit size improved for all 11 mm application rates as was clearly a function of crop load.

We proposed to further fine-tune metamitron rates and application timings in a new, 2016 proposal using a range of 'Bartlett' plantings (varying primarily in age and location but also in canopy architecture). Given the 2015 results, we timed our sprays for 10-12 mm fruit size, weather permitting.

2016 Results:

Trial 1. Bartlett/OH x F 97; 12-year-old commercial orchard (G. Blaine); 222 trees/acre. Application timing 11.5 mm fruit size.

Table 1.

Treatment		Fruit set	Before Hand Thinning	Hand Thinned	Yield		Avg. Fruit wt.	FF	SSC	TA
Product	ppm	(fruits/cluster)	(no. fruit/tree)	(no. fruit/tree)	(lbs/tree)	bins/acre	(g)	(lb f)	(%)	(%)
Control	0	1.06 a	732 a	227 a	202 a	41	189 c	19.8	11	0.3
Metamitron	100	0.66 b	703 a	219 a	201 a	41	196 bc	19.8	11.2	0.31
Metamitron	200	0.65 b	550 ab	162 ab	168 ab	34	206 ab	19.8	11.4	0.31
Metamitron	300	0.55 b	387 b	100 b	126 b	26	197 abc	20.4	11.2	0.34
Metamitron	400	0.59 b	424 b	101 b	146 ab	29	214 a	20.1	11.3	0.32
6-BA	100	0.44 b	415 b	115 b	136 b	27	213 ab	20.5	11.1	0.32
Pr>F		*0.0002*	*0.011*	*0.0007*	*0.05*		*0.027*	*0.3*	*0.6*	*0.5*

The above data (Table 1) show the effect of Metamitron (Adama formulation) and 6-BA (MaxCel) on fruit set, yield and fruit quality of Bartlett pear trees in Parkdale, OR. Applications were made on 7-May, 2016 to whole canopies. Data are means of 6 single-tree reps. Fruit set was based on the number of fruits per flower cluster. A minimum of 150 flower clusters were counted per rep by selecting three limbs (each containing ~50 clusters) at low, mid and high positions in the canopies. All thinning treatments significantly reduced fruit set. The number of fruits remaining after natural fruit set but prior to hand thinning, better reflected the fruit set status of entire trees compared to the flower cluster data and showed, importantly, that the thinning effect of metamitron saturated at 300 ppm. Moreover, these results agree with our 2015 findings.

Yield was projected as bins per acre based on the yield per tree and the tree density of the orchard. Yield was reduced by the higher rates of metamitron and 6-BA. While thinning reduced fruit set by roughly half, hand thinning was still required; however, hand-thinning data comprise fruits from the tops of trees which were not treated as thoroughly as the canopy below 10 feet height in an effort to mitigate potential spray drift to adjacent rows accommodating other treatments. A minimum of one guard tree and typically three, separated treatments within replications. Individual fruit weights of chemical thinning treatments were increased proportionately to whole tree crop loads. The average fruit weight for control fruit was 189 g - corresponding to a box size of 110 - compared with an average box size of 100 for thinning treatments. A shift to larger size classes was commensurate with an increase in the average fruit size for high rates of metamitron and 6-BA (Fig. 2).

Thinning agents did not affect fruit maturation (evident by similar firmness values at harvest) or fruit soluble solids concentration (SSC) and titratable acidity (TA). Further, fruit finish (russet) was not affected by any of the treatments (data not shown). Ripening was also unaffected by thinning agents and all fruit ripened to acceptable firmness and eating quality (data not shown).

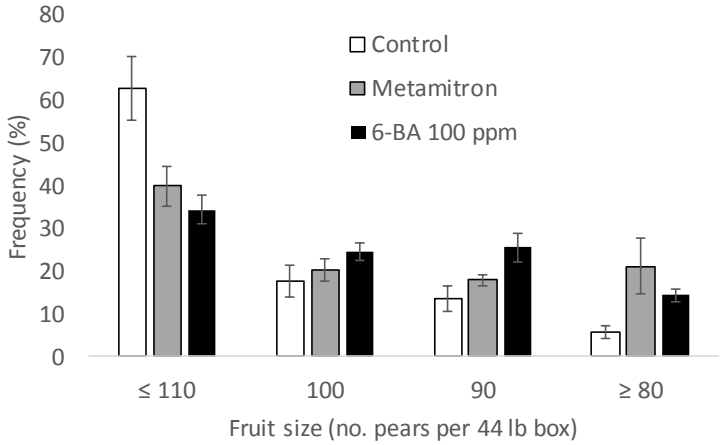

Figure 2. Distribution of fruits at harvest comprising four size classes from whole tree applications of thinning agents to Bartlett/OH x F 97, 12-year-old trees (Trial 1). Data are means of 6 reps with SE bars.

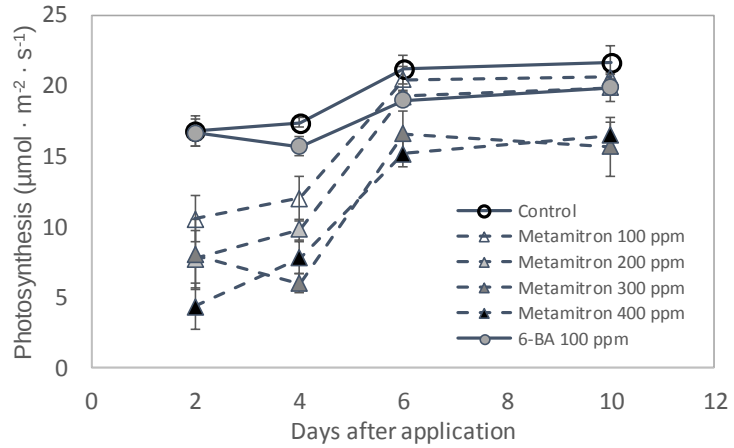

Figure 3. Photosynthesis measurements of single leaves (n=4) taken periodically after application of thinning compounds to entire Bartlett/OH x F 97, 12-year-old trees (Trial 1). Data are means of 4 replicates. Bars are ± SE.

Photosynthesis was reduced by metamitron according to rate (Fig. 3). The maximum effect was achieved at 300 ppm, as similarly observed for thinning. MaxCel had no measurable effects on photosynthesis. Metamitron had a slightly greater and longer-lasting effect in 2015; though, differences in tree age, rootstock, environmental and site factors could all have contributed to the difference. Clearly, metamitron thins by inducing carbon deficit as opposed to the hormonal regulation elicited by 6-BA.

Trial 2.

Site 1, 'Daum Block' - Bartlett/OH x F 97, 12-year-old orchard (MCAREC) 272 trees/acre. Application timing 12.3 mm fruit size.

The effect of two formulations of Metamitron (Brevis and Adama) and MaxCel (6-BA) on fruit set and production attributes of Bartlett/OH x F 97 was evaluated at OSU's MCAREC, Hood River, OR. Applications were made on April 21, 2016 to whole canopies. Table 2 data are means of four, single-tree reps. Fruit set was not significantly reduced by any of the thinning treatments. Adama and Brevis at 500 ppm had fewer fruits per tree at harvest than other treatments, albeit nonsignifiantly (*P*, 0.088; Table 2). Trees were not hand thinned as natural fruit set was deemed appropriate to achieve commercial fruit size.

Average fruit weights of 200 to 250 g equate to box sizes between 100 and 90. Numerically higher fruit weights were observed for some thinning agents but were not consistently related to formulation or rate. We observed some solubility issues with the Brevis formulation while preparing solutions, but this may not have factored into the poor thinning response since the Adama formulation and 6-BA were both ineffective at thinning.

Table 2.

Treatment		Fruit set	Yield		Avg. Fruit wt.	FF	SSC	TA
Product	ppm	(%)	(no./tree)	(lbs/tree)	(g)	(lb f)	(%)	(%)
Control	0	44.5	263.7	134.7	213.4	17.9	10.8	0.29
Brevis	125	39.6	235.5	113.4	240.3	17.5	11.3	0.29
Brevis	250	43.4	279	143.3	240	17.8	11.2	0.29
Brevis	500	33.7	150.8	82.3	238.4	18.2	11.3	0.29
Adama	125	50.7	284.3	137.6	204.5	18	11.4	0.29
Adama	250	45.7	220.5	111.1	241.4	17.8	11.4	0.3
Adama	500	36.2	205.5	114.4	253.9	18.3	11.6	0.31
Maxcel	100	53.4	231.3	107.4	244.3	17.4	11.4	0.29
Pr>F		0.748	0.088	0.061	0.055	*0.289*	*0.375*	*0.701*

Fire blight infection compromised data from trees in the fourth replicate (experimental design was a randomized complete block) following the removal of several primary scaffold limbs mid-season. Maturity and fruit quality were not affected by thinning treatments. Maximum daytime temperatures were around 60°F for a period of 10 days after applications. Nighttime low temperatures were typically between 40°F and 50°F, though on several occasions temperatures reached lows of 38°F. Collectively, fruit demand for carbon would not have been high during this period rendering thinning more difficult. On the day of application, maximum daytime temperatures were 75°F, which would have been acceptable for uptake and activity of 6-BA. Absorption of 6-BA has been shown to require temperatures >60°F and, ideally, between 65 to 75°F. The argument that temperatures for the 10-day period following applications may have increased the difficulty to thin is strengthened with photosynthesis data. Both metamitron formulations reduced photosynthesis by ~ 50% when measured one week after application (Fig. 4). These results agree with data collected from other trials and indicate that the products were in fact absorbed. 6-BA had no effect on photosynthesis. While light supplies the carbon necessary to support fruit growth, when fruit demand for carbon is low, as would be the case for the temperatures observed, thinning becomes markedly more difficult.

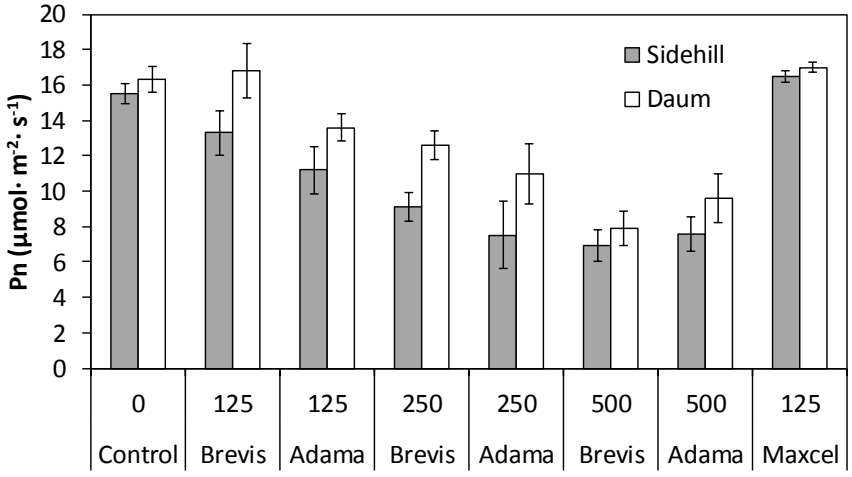

Fig 4. Photosynthesis (Pn) measurements of single leaves (n=4) on days 6 and 7 from application of thinning compounds for Sidehill and Daum trials, respectively. Both trials were performed at the OSU

Mid-Columbia Agricultural Research and Extension Center in Hood River OR. Data are means of 4 replicates and indicate a persistent, rate response of Metamitron formulations on Pn. Bars are ± SE.

Site 2, 'Sidehill'- Bartlett/OH x F 87, 22-year-old orchard (MCAREC) 303 trees/acre. Application timing 12.5 mm fruit size.

Table 3.

Treatment		Fruit set	Yield		Avg. Fruit wt.	FF	SSC	TA
Product	ppm	(%)	(no./tree)	(lbs/tree)	(g)	(lb f)	(%)	(%)
Control	0	97.1	270.8	122.3	204.4	17.7	11.9	0.36
Brevis	125	68.7	267.3	122.7	207.7	18.1	11.7	0.36
Brevis	250	82.7	296.8	136.3	207.8	17.5	11.2	0.35
Brevis	500	66	234.8	116.7	224.9	18.1	11.4	0.37
Adama	125	91.2	308.8	141.9	207.9	18.1	11.8	0.35
Adama	250	98.5	254.3	120.2	213.9	17.7	11.6	0.36
Adama	500	81	271.5	122	203.4	17.9	11.5	0.36
Maxcel	100	109.4	290.3	136.1	212.2	17.7	11.5	0.35
Pr>F		*0.247*	*0.769*	*0.761*	*0.599*	*0.729*	*0.553*	*0.979*

The effect of two formulations of Metamitron (Brevis and Adama) and MaxCel (6-BA) were evaluated on fruit set and production attributes of Bartlett/OH x F 87 at OSU's MCAREC, Hood River, OR. Applications were made on April 21, 2016 to whole canopies. Table 3 data are means of four, single-tree reps. Fruit set, yield, fruit size and quality were unaffected by treatments as similarly observed at Site 1 (i.e., 'Daum'). Crop loads were nearly identical at both sites. Photosynthesis was similarly affected by high rates of metamitron at both sites (Fig. 4). Despite differences in biological and horticultural factors between sites (trees age, different rootstocks, training systems, etc.) similar responses support an overriding effect of environment on thinning as described above.

Trial 3. Bartlett/OH x F 87 4-year-old orchard (G. Blaine; 726 trees/acre). Application timing 12.7 mm fruit size.

Table 4.

Treatment		Fruit set	Yield		Avg. Fruit wt.	FF	SSC	TA	3 months PH Storage + Ripening		
									FF	SSC	TA
Product	ppm	(%)	(no./tree)	(lbs/tree)	(g)	(lb f)	(%)	(%)	(lb f)	(%)	(%)
Control	0	24.2 a	111.7 a	50.2 a	204.1 b	19.4	12.5	0.4	2.6	13.3	0.34
Metamitron	250	5.6 b	26.7 b	14.7 b	248.1 a	20.9	12.4	0.46	2.7	13.9	0.38
Metamitron	500	7.1 b	33.3 b	17.5 b	236.5 a	20.6	11.9	0.44	2.6	14	0.37
Pr>F		<0.0001	<0.0001	<0.0001	<0.0001	*0.11*	*0.18*	*0.17*	*0.63*	*0.09*	*0.29*

An additional trial was performed on a young, high-density block of 'Bartlett' trees in an expansive commercial orchard in Wamic, OR. Given that fruit were near the maximum size for thinning efficacy when we visited the site, we only applied two rates of metamitron. Treatments were selected to represent an ideal (250 ppm) and an excessive (500 ppm) rate. Applications were made to whole canopies. Table 4 data are means of 5 reps. Each replication comprised three contiguous trees. Fruit set was reduced roughly 4-fold by metamitron. The rate response was similar to our previous results (Trial 1 herein, and 2015 data). The higher fruit drop was likely associated with tree age and/or the relatively high temperatures following applications (>70°F). In fact, fruit set of control trees was relatively low when compared to Trials 1 and 2. Hand thinning was not performed since the fruits from these trees were designated as 'processing' pears. Average fruit weight was significantly increased by metamitron. Metamitron-treated fruit were slightly less mature at harvest, although not significantly. Fruit quality and ripening were not affected by treatments (Table 4).

Executive Summary:

- Five trials over two years were conducted to evaluate the thinning efficacy of metamitron on Bartlett pear. Applications coincided with 10-12 mm fruitlet diameter.
- Metamitron effectively thinned Bartlett pears in three of five trials. The two trials where thinning was not observed were established in 2016 at the same location (OSU- MCAREC). A 10-day period of low temperatures following treatments likely contributed to the poor thinning response observed at that site. Incidentally, 6-BA (MaxCel) did not thin fruits at this site either. At other sites where thinning was observed, the response was rate-dependent. The most efficacious rates (250 to 300 ppm) reduced fruit set to 75% and 50% of untreated controls.
- Depending on the year and site, metamitron significantly reduced single-leaf photosynthesis 50% to 70% within the first few days from application. The effect diminished over time but was still evident 10 to 14 days after applications. The photosynthetic response to metamitron was dose dependent but saturated near 300 ppm. The strong reduction in photosynthesis was associated with fruit abscission. 6-BA did not significantly affect single-leaf photosynthesis in trials where it was evaluated.
- Metamitron-treated trees tended to have larger fruit sizes than controls but similar to 6-BA. The effect was crop load dependent. Fruit maturity and quality at harvest was unaffected by thinning treatments and all fruit ripened to good eating quality after postharvest storage.
- Metamitron is a promising thinner for Bartlett pear. Future work could address absorption characteristics through pear leaves as influenced by temperature, humidity and surfactants.