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

Project Title: Crop load and canopy management of apple

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Budget 1:
Organization Name: WTFRC **Contract Administrator:** Kathy Coffey
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Year	**2015**	**2016**	**2017**
Salaries	3000	2000	2000
Benefits	900	600	600
Wages	35,000	26,000	26,000
Benefits	12,000	8,600	8,600
Equipment			
Supplies	500	500	500
Travel	2,500	2,000	2,000
Stemilt lab fees	1,500	500	500
WSU plot fees		6,400	0
Total gross costs	55,400	46,600	40,200
Reimbursements	(87,000)	(70,000)	(43,200)
Total net costs	(31,600)	(23,400)	(3000)

Footnotes:

- Salary and benefits reflect contributions from exempt WTFRC staff other than project managers
- Supply costs primarily covered by private industry cooperators
- Travel includes fuel costs for driving to trial sites
- Stemilt lab fees for use of single lane Aweta color grader
- 2017 WSU plot fees waived due to donation of ag chemicals to WSU by WTFRC cooperators

NOTE: Budget for informational purposes only; research is funded through WTFRC internal program

OBJECTIVES:

1) Continue screening PGRs and chemical thinners for apple
2) Refine practical PGR programs to manipulate floral initiation and promote annual bearing
3) Expand collaborative efforts with other research programs working on crop load and canopy management

2015-2017 CONCLUSIONS:

K-Pax, an alternative lime sulfur formulation, performed similarly to Rex Lime Sulfur in two years of thinning studies (Table 2)

The most efficacious options for chemical bloom thinning of apple continue to be spray oil + lime sulfur programs (Table 3)

Metamitron can effectively reduce fruit set and boost fruit size in WA conditions (Tables 4, 5)

Metamitron efficacy can be promoted by tank mixing with non-ionic surfactants or lightweight summer petroleum oils (Table 4)

Aggressive metamitron programs can induce phytotoxicity in apple trees when applied in temperatures above 85F; leaf burn can sometimes occur during cooler temperatures, but effects are largely temporary

Warm temperatures combined with low light conditions following applications of postbloom thinners can amplify treatment effects, potentially resulting in over-thinning (Table 4)

Thinning efficacy of BA can be improved with use of surfactants (Table 4)

BA + NAA programs are as effective as any postbloom thinning program featuring carbaryl (Table 5)

Multiple applications of 100 ppm GA_3 have effectively reduced return bloom in apple over several years of study, including a 2016 trial (Table 6)

New formulation of GA shows promise for reducing flowering in apple (Table 6)

Multiple formulations of prohexadione-calcium were effective at reducing Fuji shoot extension in a 2015 trial; efficacy was increased by acidifying spray tanks with ammonium sulfate (data not shown)

Collaborative research efforts continue to help develop new models, information, and technologies to improve crop load management of WA apples

BACKGROUND:

After years of robust efforts to evaluate various aspects of bloom and postbloom chemical thinning programs, our current focus is to screen new chemistries and provide collaborative support for external research programs working on crop load and canopy management. Most of our current trials are funded in part or wholly by third party companies that contract our services to independently evaluate their products alongside industry standard programs. We continue to evaluate the relative success of thinning programs through three measurable targets which are directly tied to a grower's economic bottom line:

1. Reduction of green fruitlet hand-thinning
2. Improved fruit size and quality
3. Increased return bloom/annual bearing

The degrees to which our chemical thinning programs achieve each of these goals are reflected in our data labeled fruitlets/100 floral clusters, harvest fruit size, and percent return bloom, respectively.

Chemical thinning programs evaluated over the last 3 years are listed in Table 1. Due to the potentially risky nature of many of our treatments, we conducted most of our trials at WSU's Sunrise Research Orchard, which also allowed us to ensure no other thinning applications were superimposed on our plots. Historically, however, additional bloom or postbloom chemical thinning applications have been left to the discretion of individual commercial grower-cooperators, provided that each experimental plot received the same programs.

Table 1. Chemical thinning programs evaluated (applied in 100 gal water/acre). WTFRC 2015-2017.

BLOOM THINNERS
4-10% Rex Lime Sulfur (LS)
6% K-Pax
4-8% K-Pax II
2% Crocker's Fish Oil (CFO) + 1.5-3% K-Pax II
2% Crocker's Fish Oil (CFO) + 3% Rex Lime Sulfur (LS)
4% ATS
2% WES + 10% Rex Lime Sulfur (LS)
48 oz Carbaryl
48 oz Carbaryl + 5 oz Fruitone L
400-800 ppm Brevis
POSTBLOOM THINNERS
300-800 ppm Brevis (metamitron)
400-800 ppm Brevis + 1% Wilbur Ellis 440 summer oil (WES)
300-800 ppm Brevis + 16-32 oz Regulaid
400-600 ppm Brevis + 4-6 oz Fruitone L
400-800 ppm Brevis + 6 oz Sylgard
400-800 ppm Brevis + 64 oz IAP dormant oil
400 ppm Brevis + 122 oz Exilis Plus
400 ppm Brevis + 48 oz carbaryl 4L/4F
600-800 ppm ADA 46342
400-600 ppm ADA 46342 + 16 oz Regulaid
24 oz Exilis 9.5SC + 4 oz Fruitone L
122 oz Exilis Plus + 4-6 oz Fruitone L
48 oz Carbaryl 4L + 4-6 oz Fruitone L
128 oz MaxCel + 4-5 oz Fruitone L
24 oz FAL-551 + 4 oz Fruitone L
25.6 oz FAL-551
25.6 oz FAL-551 + 64 oz Surfactant A
25.6 oz FAL-551 + 64 oz Surfactant B
25.6 oz FAL-551 + 64 oz Surfactant C

2-3.3 lb ADA 46343
2-3.3 lb ADA 46343 + 32 oz Regulaid
2-3.3 lb ADA 46343 + 1% WES
36-48 oz Sevin 4F + 3-5 oz Fruitone L

BLOOM THINNING:

The focus of our chemical bloom thinning work in recent years has been to screen new products that could potentially become commercially viable materials used by industry. The main new candidates in that arena have been alternative formulations of lime sulfur developed by Orcal Inc. known as K-Pax and K-Pax II. These products handle and perform much the same as Orcal's standard Rex Lime Sulfur product. The new formulations include potassium and potentially produce a higher yield of hydrogen sulfide, one of the active byproducts of lime sulfur.

In three years of testing as chemical thinners, we saw no obvious differences between Rex and K-Pax products in terms of handling, thinning efficacy, or side effects on tree health or fruit finish; in short, the products seemed relatively indistinguishable from a chemical thinning perspective. Results from the fullest test of K-Pax II in 2016 are detailed in Table 3 below; even though no thinning treatments produced significant results in that trial, earlier studies with the products did demonstrate reductions in fruit set (data not shown). According to the company, Orcal will not market K-Pax nor K-Pax II as distinct products, but plan to modify the formulation of Rex Lime Sulfur to include more potassium under its current label.

Table 2. Crop load and fruit quality effects of bloom chemical thinning programs. WTFRC 2016.

Treatment	Fruitlets/100 floral clusters	Blanked spurs	Singled spurs	Harvest fruit weight	Relative box size	Russet free fruit	Return bloom
		%	*%*	*g*		*%*	*%*
Gala / M.9 Nic.29 – Rock Island							
2 gal CFO + 1.5 gal K-Pax II	93 a	44 ns	32 ns	152 ns	119	93 ns	13 ns
2 gal CFO + 3 gal K-Pax II	88 ab	49	29	152	119	97	22
2 gal CFO + 3 gal Rex LS	61 b	57	29	164	111	93	7
4 gal K-Pax II	65 ab	56	28	160	114	87	14
8 gal K-Pax II	72 ab	49	34	151	120	95	12
4 gal Rex LS	73 ab	52	31	154	118	100	11
8 gal Rex LS	62 b	57	29	158	115	85	10
Control	67 ab	55	28	153	119	98	10

Table 3 reflects the cumulative success rates of our most frequently tested chemical bloom thinners over time at achieving our three main criteria for effective thinning and demonstrates the overall superiority of programs featuring lime sulfur.

Table 3. Incidence and percentage of results significantly superior to untreated control. Apple chemical bloom thinning trials. WTFRC 1999-2017.

Treatment	Fruitlets/100 blossom clusters	Harvested fruit size	Return bloom[1,2]
ATS	15 / 60 (25%)	10 / 63 (16%)	4 / 55 (7%)
NC99	15 / 32 (47%)	7 / 34 (21%)	2 / 28 (7%)
Lime sulfur	26 / 58 (45%)	12 / 52 (23%)	9 / 52 (17%)
CFO + LS	62 / 115 (54%)	27 / 106 (25%)	22 / 105 (21%)
JMS + LS	14 / 24 (58%)	8 / 23 (35%)	4 / 22 (18%)
WES + LS	15 / 30 (50%)	5 / 29 (17%)	4 / 29 (14%)
ThinRite	7 / 22 (32%)	0 / 23 (0%)	0 / 12 (0%)

[1]Does not include data from 2017 trials.

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

POSTBLOOM THINNING:

The cornerstone of postbloom chemical thinning in Washington for decades has been carbaryl, which has delivered generally efficacious results at a relatively low price point for apple growers. The US EPA is currently reviewing the registration of carbaryl products and could eventually recommend restrictions in its usage or even complete deregistration. TKI NovaSource, the current registrant of carbaryl, is confident they will be able to successfully preserve its labeled use as a postbloom thinner of apple, but even if carbaryl survives the review process relatively unscathed, some major retailers have already announced they will no longer purchase produce which has been treated with carbaryl, a trend that is likely to expand in the future. As such, our program has focused for several years on identifying and developing thinning programs which do not rely on the use of carbaryl.

Historically, we have not found 6-BA products to be adequate as stand-alone chemical thinners, but that they partner well with other thinning chemistries such as carbaryl or NAA (Table 5). This year, however, we had better results in trials on Honeycrisp and Fuji with FAL-551, a formulation of BA analogous to Exilis 9.5SC. When applied by itself, FAL-551 provided modest thinning but no clear increase in fruit size; its performance was improved in both categories by the addition of a range of proprietary surfactants (Table 4). These preliminary results are encouraging and merit further investigation.

One promising new chemistry is metamitron, a sugar beet herbicide that has been recently registered by Adama under the trade name “Brevis” as a postbloom thinning agent in several countries including Italy, France, Spain, and South Africa. We have worked with small quantities of metamitron since 2011, finding it to be a promising chemistry when used aggressively in our relatively low plant stress environment. While trials in Europe and the Eastern US have found single applications of 200-400 ppm metamitron to be efficacious, our results indicate that two applications of 600-800 ppm are often necessary to produce similar effects in Washington conditions. With these aggressive use patterns, we continue to produce trial results which indicate metamitron can be a viable thinning chemistry for our industry, particularly if carbaryl use becomes more restricted.

For the second consecutive year, our trials at WSU’s Sunrise Research Orchard near Rock Island were confounded by unusual weather patterns which contributed to significant overthinning in nearly all treatments (Table 4). Both Granny Smith and Jonagold trial blocks experienced several days of cloudy, dark weather after application, followed several days of high temperatures in the 90s and nighttime lows in the 60s. These types of weather conditions add stress to fruit trees, limit their capacity to generate carbohydrates via photosynthesis, and generally amplify the effects of most postbloom chemical thinners. Even though we have now observed multiple instances of overthinning from metamitron, it is encouraging that industry standard thinning programs such as carbaryl + NAA have overthinned at least as much if not often more significantly, suggesting that thinning results from metamitron may be somewhat more predictable and perhaps less subject to weather-related volatility. More typical Central Washington weather conditions bracketed the spray applications in commercial trials on Fuji near Wapato and Honeycrisp near Bridgeport, and the thinning responses at those sites were more modest (Table 4).

This year, we evaluated Brevis, the commercial formulation of metamitron used in Europe, alongside a numbered formulation (ADA 46343) from Adama which contains a different package of inert ingredients, but comparable loading of metamitron, the active ingredient. As in we have seen in the past, our 2017 metamitron treatments were generally equal to or better than industry standards like carbaryl and BA in terms of reducing fruit set and/or promoting fruit size across sites and cultivars (Table 4). Generally speaking, we have found that metamitron can pair well in tank mixes with a non-ionic surfactant (Regulaid), a summer oil (Wilbur Ellis Superior Oil), or NAA (Fruitone L); in most instances, a reduced concentration of metamitron in a tank mix with one of those partner chemistries has produced similar results to those of higher rates of metamitron alone. Previous WTFRC studies found that adding silicone-based surfactants or heavier-weight dormant oil to metamitron produced significant levels of phytotoxicity without clear improvements in thinning.

Table 4. Crop load and fruit quality effects of postbloom thinning programs. WTFRC 2017.

Treatment	Fruitlets/100 floral clusters	Blanked spurs	Singled spurs	Harvest fruit weight	Relative box size	Russet free fruit
		%	*%*	*g*		*%*
Honeycrisp/sdlg with Cameo interstem - Bridgeport						
ADA 46343	75 a	45 de	38 a	252 b	72	0 ns
ADA 46343 + Reg	52 bc	57 bcd	35 ab	233 b	78	3
FAL-551	69 ab	48 cde	39 a	227 b	80	4
FAL-551 + Surfactant A	40 cd	67 ab	28 bc	235 b	77	0
FAL-551 + Surfactant B	52 bc	58 bc	34 ab	230 b	79	0
FAL-551 + Surfactant C	44 cd	62 b	33 abc	242 b	75	0
Sevin 4F + Fruitone L	31 d	73 a	23 c	298 a	61	0
Control	86 a	43 e	35 ab	234 b	78	0
Fuji / M.9 – Wapato						
ADA 46343	23 cde	81 b	16 cd	245 ab	74	45 ns
ADA 46343 + Reg	12 e	91 a	7 e	256 a	71	78
FAL-551	40 b	68 de	26 ab	223 bc	81	61
FAL-551 + Surfactant A	18 de	84 b	14 de	248 ab	73	61
FAL-551 + Surfactant B	36 bc	71 cd	23 abc	237 abc	77	60
FAL-551 + Surfactant C	30 bcd	77 bc	17 bcd	246 ab	74	68
Sevin 4F + Fruitone L	23 cde	80 bc	18 bcd	253 a	72	68
Control	56 a	58 e	31 a	213 c	85	66
Granny Smith / M.9 – Rock Island						
ADA 46343 2lb	25 b	78 cd	18 b	232 a	78	90 ns
ADA 46343 2lb + Reg	13 bcd	89 bc	9 c	237 a	77	85

ADA 46343 2lb + WES	13 bcd	88 bc	10 c	214 a	85	75
ADA 46343 3.3lb	11 d	91 bc	8 c	240 a	79	81
ADA 46343 3.3lb + Reg	6 d	95 ab	4 c	239 a	76	88
ADA 46343 3.3lb + WES	4 d	97 a	3 c	224 a	81	90
Brevis	11 d	91 bc	8 c	229 a	79	78
Brevis + Reg	9 d	92 ab	7 c	228 a	80	79
Brevis + WES	7 d	94 ab	4 c	213 a	85	74
Exilis Plus + Fruitone L	23 bc	78 d	21 b	232 a	78	84
Sevin 4F + Fruitone L	12 cd	89 b	10 c	246 a	74	78
Control	87 a	32 e	52 a	155 b	117	90
Jonagold / M.26 – Rock Island						
ADA 46343 8-10 & 12-14mm	45 b	62 d	31 b	274 bc	66	80 ns
ADA 46343 12-14 & 16-18mm	9 cd	92 c	8 cd	318 ab	57	68
ADA 46343 16-18 & 20-22mm	13 c	87 c	12 c	308 ab	59	83
ADA 46343 + Reg 8-10 & 12-14mm	7 cd	93 bc	6 cd	307 ab	59	81
ADA 46343 + Reg 12-14 & 16-18mm	2 d	98 ab	2 d	305 ab	60	80
ADA 46343 + Reg 16-18 & 20-22mm	1 d	99 a	1 d	281 ab	65	91
Sevin 4F + Fruitone L	0 d	100 a	0 d	338 a	54	90
Control	64 a	46 e	45 a	218 c	83	76

One positive outcome of the unusual weather at our Rock Island trials was the opportunity to observe the consequences of applying metamitron during hot weather. While overthinning was observed across most treatments and application timings, the incidence of leaf phytotoxicity was most pronounced in treatments which were sprayed at 16mm fruitlet size on May 22; the high temperature that day was 88F, followed by 93F the next day. Leaf damage similar to that depicted in Figure 1 was far more common in our Rock Island trials than those in Wapato or Bridgeport, which were sprayed in cooler conditions (data not shown). In 20 total trials, we have yet to observe any deleterious effect of metamitron on fruit finish, regardless of cultivar, spray conditions, or incidence of leaf phytotoxicity.

Figure 1. Phytotoxicity in untreated control (L) and metamitron + Regulaid treated (R) leaves. Jonagold/M.26, Rock Island, WA. WTFRC 2017.

Our confidence in the potential of metamitron as a thinner in WA conditions continues to grow as we gain more experience with this chemistry. Table 5 demonstrates that after several years of testing, our success rates for producing satisfactory results from metamitron thinning treatments are comparable or superior to any standard industry programs; when metamitron is partnered with materials like a non-ionic surfactant, a summer oil, or another thinner such as NAA, our results have consistently improved. Even though metamitron is unlikely to complete registration with the EPA within the next few years, WA growers should be able to achieve satisfactory results with currently available products. We continue to find good results in postbloom thinning programs that feature tank mixes of carbaryl, BA, and/or NAA (Table 5).

Table 5. Incidence and percentage of results significantly superior to untreated control. Apple chemical postbloom thinning trials. WTFRC 2002-2017.

Treatment	Fruitlets/100 blossom clusters	Harvested fruit size	Return bloom[1,2]
BA	4 / 25 (16%)	0 / 26 (0%)	0 / 22 (0%)
Carb + BA	33 / 91 (36%)	10 / 89 (11%)	13 / 86 (15%)
Carb + NAA	22 / 69 (32%)	16 / 69 (23%)	7 / 63 (11%)
BA + NAA	18 / 40 (45%)	9 / 39 (23%)	7 / 35 (20%)
Metamitron	10 / 20 (50%)	6 / 19 (32%)	3 / 16 (19%)

[1]Does not include data from 2017 trials.

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

GIBBERELLIC ACID FOR BLOOM INHIBITION:

Despite the annual cropping tendencies of modern dwarfing rootstocks and improved chemical thinning programs, biennial bearing continues to present a major challenge to many apple growers, especially in organic production systems which have limited options for postbloom thinning and plant growth regulators (PGRs). Over the years, we have investigated a number of PGR programs to promote bloom, but had very poor results with industry standards such as summer applications of ethephon and/or NAA. Consequently, we shifted our focus to investigate cost-effective PGRs, namely gibberellic acids (GAs), which could help excessive cropping in an “on” year of an alternate bearing cycle by inhibiting flower formation after a season of light bloom (i.e. the “off” year). Our work showed that several isomers of GA can reduce return bloom in WA conditions, but our primary focus was on GA_3 due to its potential for use in organic orchards and effective rates of that isomer would potentially be less expensive to growers than effective rates of more potent isomers.

After many years of studying product rates and timings, we determined that 2-4 applications of 100-200 ppm of GA_3 in the month after petal fall yielded the most consistent reductions in return bloom across numerous sites and cultivars. Single applications of higher concentrations of product were also sometimes effective, but not as reliably as multiple applications at 7-14 day intervals. Table 6 reports results from GA trials launched in 2016 which featured Falgro 2XLV, a commercial formulation of GA_3 registered for use on cherry to promote size and delay maturity.

As in the past, our recent trials demonstrate the inherent challenge of generating statistically significant results due to pronounced variability within return bloom data; even though a grower would consider trees with either 2 or 20 flower clusters to have insufficient bloom, results like those still reflect a 10X degree of variability, which can thoroughly confound an analysis of variance. Despite these mathematical challenges, roughly half of our GA_3 trials through the years have produced statistically significant reductions in return bloom. Further, another 20-30% of our studies have yielded results where apparent numeric reductions in return bloom were observed without statistical significance.

The fundamental question remaining for these programs is not their efficacy, but whether registrants of GA_3 products will decide to amend their labels to accommodate this use pattern on apple. Several companies manufacture GA_3 for use in tree fruit, and we have lobbied the key PGR suppliers for the Pacific Northwest tree fruit market for years to consider relevant label expansions. Unfortunately, these companies find little financial incentive to assume the costs and potential liabilities for doing so given the availability of several other analogous competitor products in the market.

Given the well-established track record of our GA_3 programs, it seems of little marginal value to continue demonstrating their efficacy in ongoing trials, so our current focus in this arena is to evaluate new GA formulations to inhibit flowering. We initiated two trials in 2016 that featured just such a product with a unique blend of GA isomers, comparing it to our "standard" GA_3 program of 4 applications of 100ppm Falgro 2XLV at weekly intervals. The single application of the new product was not quite as potent as the Falgro program on Honeycrisp in Othello, but showed some ability to reduce flowering (Table 6); no treatments were effective on Honeycrisp in Naches, which were nearly devoid of any flowering spurs at the time of application and may have been alternating too severely to be impacted by our treatments. Nonetheless, this new formulation of GA has produced good results in other trials and could potentially be brought to market with a label for inhibition of apple bloom within a few years. We currently have another trial in the field featuring this product that will be evaluated this spring.

Table 6. Effects on tree vigor, fruit size, and return bloom of GA applications. WTFRC 2016.

Treatment	**2016 shoot length**	**2016 harvest fruit weight**	**2016 relative box size**	**2017 return bloom**	**2017 return bloom per CSA**
	cm	*g*		*%*	*clusters/cm²*
Honeycrisp / M.9 337 - Othello					
New GA product 25ppm	28.7 ns	249 ns	73	1239 ns	2.1 ab
New GA product 100ppm	30.4	243	75	804	1.9 ab
Falgro 2XLV (4 x 100 ppm)	30.4	232	78	639	1.4 b
Control	30.2	223	81	1270	2.4 a
Honeycrisp / M.106 on Red Delicious interstem - Naches					
New GA product 25ppm	11.4 b	262 ns	69	2376 ns	12.9 ns
New GA product 100ppm	13.8 ab	260	70	2582	11.7
Falgro 2XLV (4 x 100 ppm)	14.7 a	263	69	2019	12.3
Control	12.5 ab	244	74	2394	13.2

COLLABORATIVE CROP LOAD MANAGEMENT RESEARCH:

"Effects of physiology of apple under photoselective anti-hail nets" (AP-15-104; PI: Kalcsits) – support for labor intensive data collection, harvest sampling, and postharvest fruit quality analysis; also support for project leadership team including sharing of relevant WTFRC projects and protocols, as well as editing of project manuscripts

“Pollen tube growth model validation & utilization for flower thinning” (AP-15-105; PI: Yoder) – local support for coordination with WSU-AgWeatherNet, beta testers, and flower sample collection for shipment to VTU for microscopic analysis; leadership of extension/education efforts regarding industry adoption of models

“Validation of Honeycrisp and Granny Smith pollen tube growth models” (AP-15-103; PI: Yoder) – local support for coordination of beta testers and flower sample collection for shipment to VTU for microscopic analysis

“Validation of the Red Delicious pollen tube growth model” (AP-16-108; PI: Yoder) – local support for coordination of beta testers and flower sample collection for shipment to VTU for microscopic analysis

“Development and validation of a precision pollination model” (TR-16-102; PI: DeGrandi-Hoffman) – coordination of local data collection for bee foraging, bloom phenology, and fruit sampling activity at sites near Yakima and Chelan; active member of project leadership team (project funded through WTFRC technology committee)

“Developing and validating models for tree fruit” (TR-17-102; PI: Jones) – coordination of data collection for fruit growth at 39 blocks throughout Central Washington (primarily Golden Delicious, Fuji, and Honeycrisp); help with outreach activities for new horticultural models (project funded through WTFRC technology committee)

EXECUTIVE SUMMARY

- Efficacious programs for chemical bloom and postbloom thinning of Washington apples are well established in industry. Ongoing WTFRC thinning trials focus on identifying new chemistries to expand and enhance current options.
- New formulations of Rex **Lime Sulfur** handled and thinned much the same as the original product in three trials, but may have more potency as a fungicide.
- Efficacy of **BA** products may be improved with use of some surfactants; further study is warranted to corroborate preliminary results.
- **Metamitron** products have established a strong record of successfully thinning multiple apple varieties in WTFRC trials. Effective application rates and timings have been established, but effects of tank mixes with other products on results would benefit from more investigation to further develop best practices for use of this product prior to its registration and use by commercial growers.
- **Metamitron** has the potential to overthin during high stress periods for apple trees (prolonged periods of low light with warm temperatures), but seemingly no more so than current standard postbloom thinning programs. Application of metamitron in high temperatures (85F +) can cause significant leaf phytotoxicity, especially when tank mixed with an oil or surfactant. These observations would be strengthened by further study of metamitron programs in variable weather conditions.
- Many formulations of **gibberellic acid (GA)** can help inhibit floral initiation in apple; when applied in the "off" year of a biennial bearing cycle, this strategy can help pull trees out of alternation and promote annual cropping. After several years of study, we found that 2-4 weekly applications of 100ppm GA_3 starting at petal fall were most effective at reducing return bloom. While GA_3 products are unlikely to be labeled for this use pattern in the near future, at least one other GA material is in commercial development which may provide similar results. We will need to work further with this formulation to help determine practical recommendations for its usage.
- Acidification of spray tanks with ammonium sulfate improved the performance of **prohexadione-calcium** products at inhibiting shoot growth in Fuji apple trees.
- WTFRC collaboration with other scientists has significantly aided the development of several **models** with implications for crop load management including the pollen tube growth model, bee foraging model, bloom phenology model, and fruit growth model. We have also helped assist research partners to study horticultural impacts of **protective overhead netting** and hope to help further refine its practical use by evaluating the impacts of various net shade factors and the deployment of reflective ground cloth underneath netting to help offset the reduction of ambient light.