

**FINAL PROJECT REPORT****WTFRC Project Number:** AP-08-807

(WSU Project 13C-3655-4295)

**Project Title:** Management of vegetative growth in apple trees with bioregulators

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**Other funding sources**

**Agency Name:** BASF  
**Amount requested/awarded:** \$5,000 awarded in 2008

**Agency Name:** NNII  
**Amount requested/awarded:** \$1,000 awarded in 2009

**Total Project Funding:** Year 1: 13,111 Year 2: 14,109

**WTFRC Collaborative expenses:**

Item	2008	2009
Stemilt RCA room rental	0	0
Crew labor	840	550
Shipping	0	0
Supplies	0	0
Travel	520	50
Miscellaneous	0	0
<b>Total</b>	<b>\$1360</b>	<b>\$600</b>

**Budget History:**

Item	2008	2009
Salaries	5,442	5,714
Benefits	1,959	2,057
Wages	1,080	1,134
Benefits	130	204
Equipment	0	0
Supplies	500	800
Travel	4,000	4,200
Miscellaneous	0	0
<b>Total</b>	<b>\$13,111</b>	<b>\$14,109</b>

### **Objectives:**

1. Explore possible methods for improving the efficacy of prohexadione-Ca (Apogee) for control of unwanted vegetative vigor, including application timing, combinations of Apogee with ethephon and/or other bioregulator products, such as abscisic acid (ABA), a bioregulator implicated in the initiation of dormancy.
2. Examine whether ABA can be used either alone or in combination with other bioregulators to force terminal bud set in growing shoots, thus controlling growth.
3. Evaluate the potential benefits for stimulation of latent bud growth on “blind wood” with high concentrations of cytokinins (e.g., chlorfenuron, thidiazuron, 6-benzyladenine) with or without supplemental gibberellic acid (e.g., GA<sub>4+7</sub>).
4. Compare cyclanilide (Tiberon<sup>®</sup>) with cytokinin/gibberellin products (e.g., Promalin) for induction of desired shoots at trellis wires during canopy development in sleeping-eye apple trees.
5. Examine fruiting in cyclanilide treated sleeping-eye trees to determine if this approach results in the development of better quality fruiting wood.

### **Significant findings 2008:**

1. Three treatments, 1) Promalin (PR, 20,000 ppm, pure formulation), 2) thidiazuron (TDZ) + ProVide (GA<sub>4+7</sub>) (5,000 ppm and 2,500 ppm + Pentra-Bark 2% v/v), and 3) thidiazuron (TDZ) + ProVide (GA<sub>4+7</sub>) (both 5,000 ppm + Pentra-Bark 2% v/v) painted on one-year-old vertical leader shoots of ‘Cameo’/M.26 trees at trellis wires doubled the number of new shoots forming at the wire compared to no treatment.
2. The Promalin formulation alone (no surfactant) was concentrated enough to assure a branching response in the absence of bark injury and did not cause phytotoxicity.
3. In apple, cytokinin is as important as gibberellin for inducing shoot formation. This approach can help growers developing apple canopies on trellises, such as for “sleeping-eye” systems.
4. In vigorous, grafted ‘Fuji’/MM.106 trees, four Apogee (prohexadione-Calcium, P-Ca) sprays did not maintain control of shoot growth. Shoot growth on Apogee-treated trees eventually equaled that of untreated control trees.
5. When four Apogee sprays were followed by one or two ethephon applications, two abscisic acid (VBC30051) applications or one or two tank-mix applications of ethephon and VBC, shoot growth was essentially halted after treatment.
6. The various treatment combinations of four Apogee sprays with or without follow-up ethephon and/or ABA applications showed minor effects on fruit quality.
7. In ‘Fuji’/M.26 trees of roughly comparable vigor, untreated shoots grew normally. Four Apogee applications were sufficient to control shoot growth. Curiously, Apogee-treated shoots receiving one or two ethephon treatments grew enough to be the same as controls. Additional treatments with ABA alone or ABA+ethephon were equivalent to four Apogees alone.
8. Pretreating ‘Fuji’/M.26 apple trees later in the growing season with Apogee followed by ethephon and/or ABA resulted in no overall control of growth. Waiting until 24 June to start this program was too late. Nonetheless, shoot growth was less vigorous where ethephon and/or ABA were used.
9. A preliminary trial testing the potential vegetative growth control agent FAL 1210 was carried out on vigorous ‘Fuji’/MM.106 apple trees. FAL 1210 was applied at 125 ppm three times and at 250 ppm only once in early spring, while Apogee (125 ppm) was applied four times. Apogee-treated shoots eventually grew as much as untreated control shoots. A single application of 250 ppm FAL 1210 or 3 applications of 125 ppm were both effective for controlling terminal shoot elongation in this trial. This product shows promise as a vegetative growth control agent for apple. Three applications of the FAL1210 product appeared to

reduce fruit grade-out and resulted in lower titratable acidity. These observations should be considered as preliminary.

10. 'Fuji'/M.26 trees were treated with a single late-June application of Apogee followed one week later by single applications of ethephon and/or ABA. These treatments were applied too late to significantly reduce terminal growth, although combination treatments did have somewhat shorter terminal shoots. There were no effects of any treatment on fruit quality.

#### **Significant findings 2009:**

1. Three or four applications of Apogee at 6 oz/100 gallons (125 mg/liter) to 'BC2 Fuji'/M.7 apple trees provided initial control over terminal shoot extension but later-season regrowth canceled out any differences.
2. Ethephon (900 mg/liter) applied either once or twice after three applications of Apogee had no effect on control of regrowth in response to Apogee applications.
3. ABA (500 mg/liter) applied either once or twice following three applications of Apogee provided good control of shoot regrowth. Two applications were better than one. Combining ethephon with ABA did not improve treatment effectiveness over ABA alone.
4. Neither three nor four applications of Apogee nor supplemental ABA in June had any effect on fruit set or fruit size at harvest.
5. Two applications of Apogee at 12 oz./100 gallons (250 mg/liter) reduced terminal shoot growth in 'BC2 Fuji'/M.7 trees by approximately 50%.
6. A single application of daminozide (1000 mg/liter) at petal-fall slowed initial shoot growth for about 6 weeks in treated trees but did not reduce final shoot growth at the end of the season.
7. Applications of the candidate vegetative growth control agent FAL1210 at from 0 to 1000 mg/liter applied once or three times provided no control of apple shoot growth.
8. None of the growth-control treatments had any effect on either fruit set or fruit size at harvest.
9. Five treatments, 1) Promalin (PR, 20,000 ppm, pure formulation), 2) ProVide (GA<sub>4+7</sub> 5,000 ppm + Pentra-Bark 3% v/v), 3) ProVide (GA<sub>4+7</sub>, 10,000 ppm + Pentra-Bark 3% v/v), 4) thidiazuron (TDZ, 20,000 ppm + Pentra-Bark 3% v/v), and 5) thidiazuron (TDZ) + ProVide (GA<sub>4+7</sub>) (20,000 ppm + 10,000 ppm + Pentra-Bark 3% v/v) painted on one-year-old vertical leader shoots of 'Granny Smith'/M.9 trees at trellis wires nearly doubled or doubled the number of new shoots forming at the wire compared to no treatment.
10. PR and ProVide produced adequate to more-than-adequate lateral branching for training to trellis wires.
11. TDZ consistently caused undesirable tissue proliferation at the bases of induced lateral shoots.
12. Yield in a high-density sleeping-eye apple block ('Fuji'/'Mark') under both Promalin-treated and cyclanilide-treated tree-training regimes reached 46 bins/acre in the third leaf and 91 bins/acre in the fourth leaf.

#### **Results and Discussion:**

In apple, the Promalin formulation alone, undiluted, continues to be effective for stimulation of branch induction on one-year-old leader shoots in the early spring without resort to scoring or notching cuts. Use of strong surfactants (e.g., Pentra-Bark at 3% v/v) helps produce a branch induction response to GA alone. The capacity to place new branches adjacent to trellis wires should facilitate proper canopy development in trellised high-density plantings. This type of tree structure has much to recommend it from the physiological point of view, so facilitating this process without the need for pruning is an important development. Although such a process is labor-intensive, our most successful treatments minimize the labor cost involved. We have now compiled positive results with two very hard-to-branch cultivars, 'Cameo' and 'Granny Smith'.

Apogee programs in commercial apple orchards continue to be plagued by the problem of later-season “regrowth” after a successful initial control response to early-season Apogee applications. The advent of commercially formulated abscisic acid opens a potential new avenue for approaching a resolution to this problem. One or two applications of ABA (500 mg a.i./liter) successfully extended the period of control over shoot growth well beyond that of Apogee alone, with the result that, on average, a single ABA application in late June resulted in terminal shoots about 2/3 the length of untreated shoots, while two applications reduced terminal shoot length by about half. These results are very promising and suggest that ABA should also be tested for growth-control properties on its own. ABA may offer a way to extend the benefits of early-season growth control with Apogee.

Trials in 2009 showed clearly that ethephon has little or no role to play in controlling shoot growth under these conditions. Whether mixed with ABA or applied alone following three previous Apogee applications, ethephon did not produce useful growth-control results. No further work with ethephon for this purpose is planned.

Single or double applications of ABA in early and late June (500 mg/liter) had no effect at all on fruit set or on fruit size at harvest. No observations were made that would suggest a problem with fruit drop. No other fruit-quality parameters were examined in this study. These results support the plan for further studies with this product for control of vegetative growth in apple.

In 2008, Fine Americas introduced a candidate vegetative growth control product (FAL 1210) for testing. After two years of tests, it is clear that this product does not provide any significant control over apple tree shoot growth. No further trials with this product are planned.

Cyclanilide (registered as Tiberon™ in 2009) has proven to be as beneficial as Promalin for branching developing leader shoots at trellis wires on sleeping-eye ‘Fuji’/‘Mark’ apple trees. In this trial, cyclanilide rates below recommended nursery levels (e.g., 50 mg a.i./liter) induced good branching with minimal inhibition of terminal shoot extension. Yields in the 3<sup>rd</sup> and 4<sup>th</sup> years in this trial have been very large (46 and 91 bins/acre on average, respectively), demonstrating the benefit of rapid, early development of a productive canopy through directed growth.

#### **Acknowledgments:**

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#### **Publications 2009:**

- Elfving, D.C. and D.B. Visser. 2009. Stimulation of lateral branch development in young sweet cherry trees in the orchard without bark injury. **Int=I. J. Fruit Sci. 9:166-175.**
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- Schrader, L.E., J.G. Zhang, J.S. Sun, J.Z. Xu, D.C. Elfving and C. Kahn. 2009. Changes in internal fruit quality with sunburn browning. **J. Amer. Soc. Hort. Sci. 134:148-155.**

Schrader, L.E., C. Kahn and D.C. Elfving. 2009. Sunburn browning decreases at-harvest internal fruit quality of apples (*Malus domestica* Borkh.). **Int'l J. Fruit Sci. 9:425-437.**

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## EXECUTIVE SUMMARY

In trellised apple plantings, securing adequate and well-positioned lateral branching is critical for early production success. Lateral branching can be induced on vigorously-growing current-season's shoots in summer or on one-year-old wood in spring. Each approach has its benefits and drawbacks, but either strategy, if properly implemented, will work.

Abscisic acid, a newly-available bioregulator product, may have an important role to play in vegetative growth control. Initial trials indicate that ABA applications can nearly eliminate the undesirable second growth flush ("regrowth") that often follows multiple Apogee applications in the spring and early summer. More work is needed to explore the interactions of dose and timing of ABA treatments, and it also warrants evaluation as a growth-control agent on its own. ABA appears to have no effects on fruit set, fruit size or fruit drop when applied in June, after fruit cell division is completed. Its effects on very early fruit growth are unknown. Ethephon has been discarded as a viable approach in conjunction with Apogee and ABA to control later-season regrowth. Applied alone, or in combination with ABA, ethephon did not produce effective and extended control over vigorous apple shoot elongation in previously Apogee-treated trees.

The candidate growth-control product FAL 1220 (Fine Americas) has been shown to have no potential as a vegetative growth-control material for apple trees. Further work with this product is not planned.