

FINAL REPORT

WTFRC Project #CH-01-20

WSU Project #13C-3655-3298

Project title: Bioregulator uses for controlling vegetative growth, stimulating precocity and managing fruit quality in sweet cherry

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Reporting period: 2001-2003

Objectives of original project:

1. Evaluate effects of Apogee and ethephon alone and in combination on vegetative growth, flowering, fruiting and fruit quality in young sweet cherry trees. Include the cultivars 'Bing,' 'Lapins,' 'Rainier,' and others as appropriate in trials.
2. Compare single vs. multiple application strategies of Apogee and ethephon for effectiveness in control of vegetative growth under southern Washington and north-central Washington environmental conditions. Develop application combinations and timing strategies that produce effective growth control in different cherry growing environments.
3. Determine the propensity for treatment with Apogee and/or ethephon to induce regrowth and application methods that minimize regrowth.
4. Examine effects of growth-control applications to non-fruiting cherry trees on stimulation of precocity in flowering and fruiting.
5. Evaluate Apogee effects on cherry fruit size, color, firmness, solids content and quality. Determine the potential for use of Apogee in management of growth and cropping in fruiting cherry trees.
6. Examine canopy structure in relation to whole-tree photosynthesis of young sweet cherry trees treated with Apogee and/or ethephon. Characterize the changes in canopy structure and document tree photosynthetic behavior through the growing season. Assess the relationship, if any, of whole-tree carbon-fixing capacity to flowering, fruiting and crop quality.

Significant findings:

Over the three-year period of this project, 23 separate trials were undertaken to assess various aspects of bioregulator use for management of vegetative growth, flowering, fruiting and fruit quality in sweet cherry trees. Some of the trials were established to assess the potential for prohexadione-Ca (Apogee[®], BASF Corp.) and ethephon (Ethrel[®], Bayer CropScience) for control of vigor and induction of flowering in young, non-fruiting sweet cherry trees on Mazzard seedling rootstock. Other trials examined the effects of ethephon on loosening of 'Bing' cherries for mechanical harvest and the potential for either aminoethoxyvinylglycine (ReTain[®], Valent BioSciences) or 1-methylcyclopropene (MCP, SmartFresh[®], AgroFresh, Inc.) to reverse or offset some of the negative side effects of ethephon on cherry fruit quality. One trial in 2003 explored the potential of three chemicals showing promise in the citrus mechanical harvesting project in Florida for possible

loosening of sweet cherries. Another trial in 2003 initiated a new phase of research into the potential for using gibberellic acid on size-controlled sweet cherry trees for both fruit quality improvement and reduction in flowering, with the goal of producing another grower tool to facilitate the management of such trees for improved fruit quality. This GA program is planned for expansion in 2004 and for continuation for several years to allow the proper assessment of efficacy on cropping and crop quality in subsequent years from GA applications.

Results:

During the course of this project, all objectives have been met except for the evaluation of effects of bioregulators on canopy photosynthesis. This objective was of significantly lower priority and was not addressed. Early on in the project it became obvious that control of vegetative growth was not nearly as important a priority as control of flowering. Both stimulation of flowering and reduction of flowering became more important priorities in the later phases of the project. The following results and conclusions have been obtained during the three years of this project:

A. Vegetative growth

1. Apogee can be successfully used to control vegetative growth in sweet cherry under Washington conditions, but the cost effectiveness of this approach has not been demonstrated.
2. No benefit in growth control has been observed when Apogee doses in excess of 6 oz./100 gallons (dilute basis) have been used, even under high vigor conditions.
3. Reduced vegetative vigor is a prerequisite for improved flowering in young cherry trees, but reduction in vegetative vigor alone is NOT sufficient to encourage flower bud initiation. Apogee reduces vegetative growth but does not supply whatever else is needed to increase flowering.

B. Flowering and fruiting

1. Sweet cherry cultivars differ in their growth responses to Apogee, Ethrel and tank mixes of these products, but only ethephon improves flowering. The cause(s) for variable flowering responses to ethephon is (are) unknown at this time.
2. Apogee has no beneficial effect on induction of flowering in young, non-fruiting sweet cherry trees, either when applied alone or in combination with ethephon.
3. During the course of this project, ethephon increased flowering in 'Rainier'/Mazzard trees, increased bloom and yield in 'Bing'/Mazzard and slightly increased flowering and fruiting in 'Tieton' trees, but at concentrations used ethephon did not improve flowering of 'Lapins' sweet cherry.
4. Trees of 'Attika'/Mazzard planted on the same date in the same orchard and sprayed with Apogee and/or Ethrel on the same dates as the two other cultivars listed below showed increased flowering and yield in response to ethephon, 'Bing'/Mazzard trees showed a small increase in bloom that did not translate into improved yield, and 'Regina'/Mazzard trees did not respond to either Apogee or Ethrel with any improvement in flowering or yield.
5. Ethephon increased the number of flower buds per spur and number of flower buds borne on previous season's shoots in 'Bing'/Mazzard trees.
6. The flowers induced by ethephon treatment are capable of producing fruits of normal quality.
7. Ethephon at concentrations up to 200 ppm produced up to threefold improvement in 'Bing' yield in the year following application. Unfortunately, this response was not observed in all trials.
8. Where yield was increased by ethephon, fruit size was not reduced.
9. Three applications of ethephon did not appear to be superior to two applications of a higher concentration. Substituting concentration for number of applications can improve the cost effectiveness if the gain in flowering and fruiting is sufficient and injury to the tree can be avoided. The relation between ethephon concentration and number of applications still needs further exploration.

10. Gummosis severity was proportional to ethephon concentration in most trials. Where little or no flower-bud formation occurred as a result of ethephon application, little gummosis was observed as well.
11. Ethephon-induced gummosis has not been associated with any negative effects on cherry tree or fruiting behavior. Gummosis may in fact be another sign of a successful ethephon treatment.
12. In one trial, ethephon treatment resulted in increased flowering for two years following treatment. This observation has not been confirmed in other trials to this point.
13. Ethephon treatment of young sweet cherry trees increases flowering by increasing flower-bud density on spurs and on previous season's shoots.
14. Where ethephon has been effective for increasing flowering, the trees have been at least in their third leaf. Treatment of second-leaf trees had no beneficial effect on flowering. A body of spurs needs to be produced before ethephon treatment can be maximally effective because the largest effect of ethephon is on increasing spur flower buds.

C. *Fruit loosening and fruit quality*

1. Ethephon-based loosening of sweet cherries depends on amount of active ingredient per acre; the amount of water applied per acre appears relatively unimportant as long as good coverage is achieved.
2. Similarly, ethephon-induced gummosis depends primarily on quantity of product per acre and only to a small extent on concentration in the spray solution.
3. Ethephon is highly buffered; only extremely poor quality water is likely to increase the pH of the spray solution. Ethephon was equally effective in loosening cherries at spray solution pH values of 3.2, 6.0 or 8.2 as long as the mixture was sprayed immediately after preparation. Alkaline pH can degrade ethephon performance but only after enough time has elapsed for significant hydrolysis to occur.
4. Ethephon application preharvest reduces the force required to remove the cherry from its pedicel but also increases fruit flesh softening. Ethrel has less effect on soluble solids, acids, fruit size, fruit color and incidence of pitting and tears, but there appear to be important effects of season, which are likely related to temperature after Ethrel treatment.
5. Half rates of Ethrel applied twice are equally effective as twice the amount of Ethrel applied once for fruit loosening and for flesh softening.
6. Applying Ethrel when fruit are more mature (closer to harvest) does not result in greater reduction in fruit removal force. The amount of Ethrel per acre, environmental conditions and time after application are the principal factors that influence the amount of loosening from an Ethrel application.
7. Preharvest ReTain application to sweet cherry trees near harvest has no noticeable effects on fruit removal force, fruit flesh firmness or any other quality parameter. ReTain applied before or at the same time as Ethrel does not alter the Ethrel effects on fruit loosening, softening and other quality parameters. This outcome might be expected, since an ethylene biosynthesis inhibitor would not be expected to have much effect in a system in which ethylene is not being synthesized.
8. MCP is an inhibitor of ethylene action. MCP sprayed on sweet cherry trees near harvest had no discernible effect on fruit removal force, but MCP-treated fruit was firmer than untreated fruit at harvest.
9. When MCP was applied to the same trees at the same time as Ethrel, the ethephon loosened the cherries as normal, but MCP inhibited the flesh softening otherwise normally associated with ethephon treatment. This exciting observation definitely deserves further research attention.
10. Delaying the MCP application 3 to 5 days after the ethephon treatment eliminated the MCP-based control over fruit softening.
11. Three candidate products that loosen citrus for mechanical harvesting were tested for the capability to loosen sweet cherries. The chemicals were Release, LA-139 and Atrimmec

(dikegulac). The same concentrations that are effective in citrus were used. None of these candidate products produced any loosening effect on 'Bing' sweet cherry.

D. Control of flowering and fruit quality with gibberellic acid

1. Gibberellic acid appeared to retard color development and maintain higher flesh firmness in relation to concentration and to number of applications. Double applications were firmer and less red-colored in general than single applications at either the end of stage I or stage II of development.
2. Effects on flowering will be assessed in spring, 2004.

Summary:

Flowering in young cherry trees was improved, sometimes substantially, by treatment with Ethrel, but the results varied from year to year. Cherry cultivars show surprisingly different responses to both Apogee and Ethrel. It appears likely that growers interested in improving flowering in specific cultivars will have to evaluate recommended procedures to be sure they are effective under their specific conditions and cultivars. Apogee does NOT improve flowering in sweet cherry, even though it can reduce vegetative vigor. Without an improvement in flowering, Apogee treatment of sweet cherry does not appear to be cost effective in young trees. Ethrel may produce an improvement in flowering for two seasons after treatment, but this observation needs confirmation.

Perhaps the most exciting observation in the mechanical harvesting project was made in 2003. Combining preharvest Ethrel with an application of MCP at the same time resulted in the normal loosening typically produced by Ethrel but without the loss of flesh firmness that otherwise always accompanies Ethrel application. If this observation can be confirmed with more study, it may pave the way toward being able to use Ethrel effectively for fruit loosening for mechanical harvest while better preserving fruit quality, both during and possibly after the harvest process.

The newest project involves the potential use of gibberellic acid in cherry to reduce the excessive flowering induced by size-controlling rootstocks, such as the Gisela series rootstocks. Size-controlling rootstocks will become much more popular for commercial cherry growing if the problems of excessive flowering and fruit set can be effectively managed. Chemical blossom thinning techniques may be developed but are not available at present. Using the tree's own physiology to control flowering by controlling the initiation of flower buds offers an exciting possibility for a new tool for growers of dwarf cherry trees. This project is only in the beginning stages and requires further study to verify its potential benefit as a tool for cherry growers to manage fruit quality on small trees.

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Publications 2001-2003:

Drake, S.R. and D.C. Elfving. 2001. Fruit quality of spur-type and nonspur-type 'Delicious' apple strains. J. Amer. Pomol. Soc. 55(4):209-215.

- Drake, S.R., D.C. Elfving and R.D. Gix. 2001. The influence of paper wraps on the quality of 'd'Anjou' pears after controlled atmosphere storage. *HortTechnology* 11(4):10-14.
- Mazzola, M., D.M. Granatstein, D.C. Elfving and K. Mullinix. 2001. Suppression of specific apple root pathogens by *Brassica napus* seed meal amendment regardless of glucosinolate content. *Phytopathology* 91(7):673-679.
- Drake, S.R. and D.C. Elfving. 2002. Influence of prestorage carbon dioxide treatments on the quality of 'd'Anjou' and 'Bartlett' pears. *J. Food Processing Preservation* 26(2):143-151.
- S.R. Drake and D.C. Elfving. 2002. Indicators of maturity and storage quality of 'Lapins' sweet cherry. *HortTechnology* 12(4):9-12.
- S.R. Drake, D.C. Elfving and T.A. Eisele. 2002. Harvest maturity and storage of 'Cripps Pink' (Pink Lady™) apples. *HortTechnology* 12(3):388-391.
- Mazzola, M., D.M. Granatstein, D.C. Elfving, K. Mullinix and Y.H. Gu. 2002. Cultural management of microbial community structure to enhance growth of apple in replant soils. *Phytopathology* 92:1363-1366.
- Elfving, D.C., G. A. Lang and D. B. Visser. 2003. Prohexadione-Ca and ethephon reduce shoot growth and increase flowering in young, vigorous sweet cherry trees. *HortScience* 38:293-298.
- Elfving, D.C., L. Lombardini, J.R. McFerson, S.R. Drake, D.F. Faubion, T.D. Auvil, G. Van Ee and D.B. Visser. 2003. Effects of directed applications of prohexadione-Calcium to tops of mature pear trees on shoot growth, light penetration, pruning and fruit quality. *J. Amer. Pomol. Soc.* 57:45-57.
- Elfving, D.C., D. Sugar and D. Faubion. 2003. Pear tree shoot growth patterns in relation to chemical control of vegetative growth with prohexadione-Calcium (Apogee™). *Acta Hort.* 596:711-716.
- Drake, S.R. and D.C. Elfving. 2003. Short-term controlled atmosphere storage for storage-life extension of white-fleshed peaches and nectarines. *J. Food Quality* 26:135-147.
- Sugar, D., D.C. Elfving and E.A. Mielke. 2003. Effects of prohexadione-calcium on blossoming, production and fruit quality in pear. *Acta Hort.* 596:757-760.
- Mazzola, M., D.M. Granatstein, D.C. Elfving and M.K. Mullinix. 2002. Field evaluation of non-fumigant measures for the control of apple replant disease. In: G.L. Obenauf (ed). 2002 Annual International Research Conference on Methyl Bromide Alternatives and Emission Reductions, USDA-USEPA, pp. 90.1-90.4.
- Elfving, D.C. 2001. Apogee™ effects on apple and sweet cherry in Washington. *Proc. MI State Hort. Soc.* 130:14-18.
- Elfving, D.C. 2001. Factors affecting productivity in apple. *Proc. MI State Hort Soc.* 130:28-31.
- Elfving, D.C. and D.B. Visser. 2002. Bioregulators to control vigor and stimulate precocity in sweet cherry. *Proc. Wash. State Hort. Assoc.* 97:102-106.
- Elfving, D.C. 2002. Growth regulator sprays. p. 62-71. In: T.J. Smith (coord.), 2002 Crop Protection Guide for Tree Fruits in Washington. EB 0419.
- Elfving, D.C. 2003. GA improves fruit quality. *Good Fruit Grower* 54(10):27.
- Elfving, D.C. 2003. Ethephon loosens cherries for mechanical harvest. *Good Fruit Grower* 54(11):31-32.
- Elfving, D.C. and E.A. Curry 2003. Bioregulator applications in nursery tree-fruit production. *PGRSA Quarterly* 31(1):126.
- Drake, S.R., D.C. Elfving, T.A. Eisele, M.A. Drake, S.L. Drake and D.B. Visser. 2003. Effects of ethephon and aminoethoxyvinylglycine on the carbohydrate and acid contents of 'Scarletspur Delicious' apples (*Malus domestica*). *Proc. Inst. Food Technol.*, July 12-13, Chicago, IL, pg. 115.
- Elfving, D.C., D.B. Visser, M.D. Whiting and J.R. McFerson. 2001. Apogee™ and Ethrel™ effects on sweet cherry: Growth, flowering and cropping. Poster, Wash. State Hort. Assoc. Annual Meeting, Wenatchee.
- Auvil, T., D.C. Elfving, J.R. McFerson, T. Schmidt and R. Corral R. 2001. Low volume spraying and efficacy. Poster, Wash. State Hort. Assoc. Annual Meeting, Wenatchee.

- Beers, E.H., L. Lombardini, F.J. Peryea, J. Dunley, D.C. Elfving, L. Schrader, S. Welter and J.R. McFerson. 2001. Whole canopy photosynthesis measurements of apple trees affected by herbivory and water stress. Poster, Wash. State Hort. Assoc. Annual Meeting, Wenatchee.
- Drake, S.R., D.C. Elfving, M.A. Drake and T.A. Eisele. 2001. Use of bioregulators to enhance 'Delicious' fruit quality and maintain fruit condition. Poster, Wash. State Hort. Assoc. Annual Meeting, Wenatchee.
- Elfving, D.C. and D.B. Visser. 2002. Bioregulator effects on growth and flowering in apple and pear trees. Poster, Wash. State Hort. Assoc. Annual Meeting, Yakima.
- Elfving, D.C., D.B. Visser, M.D. Whiting and G.A. Lang. 2002. Growth and flowering responses of sweet cherry cultivars to prohexadione-calcium and ethephon. Poster and Abstract (2409), 26th International Horticultural Congress, Toronto, Ontario, Canada.
- Drake, M.A., S.R. Drake, D.C. Elfving and T.A. Eisele. 2002. Influence of bioregulators on apple fruit quality. Poster and Abstract (76C-8), Institute of Food Technologists Annual Meeting, Anaheim, CA.
- Visser, D.B. and D.C. Elfving. 2002. Lateral branch induction in sweet cherry trees with bioregulators. Poster, Wash. State Hort. Assoc. Annual Meeting, Yakima.
- Elfving, D.C. and D.B. Visser. 2003. Bioregulator effects on growth and flowering in apple and pear trees. Poster, Wash. State Hort. Assoc. Annual Meeting, Wenatchee.
- Drake, S.R., D.C. Elfving, T.A. Eisele, M.A. Drake, S.L. Drake and D.B. Visser. 2003. Effects of ethephon and aminoethoxyvinylglycine on the carbohydrate and acid contents of 'Scarletspur Delicious' apples (*Malus domestica* Borkh.). Poster, Proc. Inst. Food Technol. Annual Meeting, July 12-13, Chicago, IL.

Summary of total project costs:

Project duration: three years
Total project costs: \$40,520