FINAL REPORT
Project No.: AH-03-307

Project title:	**Evaluation of the Carbohydrate Balance Modeling of Carbohydrate Production and Distribution to Predict Chemical Thinning Responses in Apples**
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Project Objectives:

The long-term goal of this research is to understand why current thinning practices give such variable results, focus on the key factors that cause this variability, and provide a real-time model on which can provide objective information to the grower for thinning decisions. The specific objectives for 2003 were:

(1) To conduct a series of chemical thinning tests, with unthinned controls, in different locations (NY and Massachusetts) comparing fruit growth responses and natural and thinner-induced drop patterns over time after bloom using the same thinner concentrations and application procedures.

(2) To collect data on environment and tree growth and initial cropping status that are required inputs for previously-developed apple tree carbohydrate balance model to simulate the experiments done in the field. This data was used to test the carbohydrate balance model to explain the apparent baseline variability of apple trees to the environment and chemical thinners

Significant Findings:

• Detailed sequential monitoring of fruit drop patterns revealed that response to thinners may be obscured if only mid-late season observations of set are taken. Trees that are not thinned have heavier crops later which makes them more sensitive to natural thinning by low light or high temperatures. Eventually, the later natural thinning may give a final crop load similar to the thinned trees, thus obscuring the chemical thinning effect.

• The carbohydrate supply demand balance model showed the same general seasonal pattern of tree sensitivity as shown in thinner response although the thinner response tended to be more extreme. This is likely due to the great variation in conditions when the thinners were applied. The model does not now estimate weather effects on thinner uptake although that component is planned. The general results are very promising as until now we have not had a quantitative way to estimate tree sensitivity, but the model will need more development to be ready for field use.

Methods:

We conducted field trials in Gala and Delicious apple orchards in NY and, Massachusetts using the same chemical thinning treatments (7.5 ppm NAA + 1 Pt Carbaryl Sevin XLR) at 7 stages of fruit development after apple bloom, approximately 4 day intervals. The fruit diameters at those times varied from about 5-6mm up to about 22 mm. We tagged and monitored drop on many representative spurs on several branches/tree in each trial at short intervals of 2-5 days by monitoring fruit growth and following the waves of fruit drop after treatment. These were done to more precisely differentiate the thinner effects from natural variations in drop that make conclusions difficult if only the final fruit set is measured.

Additionally, we gathered data on the weather (temperatures and sunlight), tree vegetative growth status and initial cropping. This data was then be incorporated into our model of apple tree carbohydrate status and fruit development. The model was used to estimate tree sensitivity to thinning based on the carbohydrate supply and demands. These estimates were compared to the variations in thinning and fruit development that were documented in the thinning trials. These tests and many other studies, were used to test the model predictions and to identify modifications in the model that will improve the explanations and predictions of fruit thinning by chemical thinners.

Results and Discussion:

Weather Effects. The weather postbloom in 2003 was extremely cool and cloudy which gave few consistent days on which to apply thinners. So the applications in the timing study were made under quite variable conditions. This was good for testing our model although a major concern was extremely variable thinner uptake with the variable weather. Thinner uptake is not currently modeled although we are planning to include this in the model.

Patterns of Drop. The patterns of natural and thinner-caused drop were followed with detailed monitoring every few days. An example is shown in Figure 1. When examined closely, the fruit drop patterns revealed that response to thinners may be obscured if only mid-late season observations of set are taken. An example can be seen in Figure 2 where there was a clear thinner effect around June 1. However, the trees that were not thinned had heavier crops after that time which makes them more sensitive to natural thinning by poor weather conditions like low light or high temperatures. The thinned trees had a better balance of crop demand to the tree's supply, and so it responded less to later poor conditions. Eventually, the later natural thinning of the untreated trees gave a final crop load similar to the thinned trees. So, if we only looked at the final results in July, the true chemical thinning effect of the treatment would not be seen.

The significance of this is that we must be careful about judging thinner effectiveness only by the final fruit set or fruit numbers late in the season. For the example in Figure 2, the final fruit numbers were not that different, yet the final fruit size of the Gala fruit from these treatments were 119 g for the controls and 150 g for the Petal Fall thinning. If the final fruit size is very good for that crop load, it likely reflects an early thinning that improved early fruit development although the final crop was similar to the unthinned. Conversely, as with the control poor fruit size even though the crop was moderate probably was due to late drop related to enhanced tree sensitivity by heavy early cropping.

Seasonal Patterns of Thinner Effect and Model Predictions. To see if we could explain quantitatively the variations in tree response to NAA/Sevin treatments at different timings after bloom, we collected needed data for our carbohydrate supply/demand model and made estimates of tree sensitivity based on the weather, tree development, crop load, etc. The general pattern predicted by the model was similar to that seen in the tree responses to NAA/Sevin in the timing study (Figure 3). The main trend was that thinning was less during when the fruit were about 5-6 mm, then most sensitive at around 10 mm, then less sensitive again.

The model suggests that this is mostly due to the low growth demand per fruit shortly after bloom as the fruit is only growing slowly. Also this year, the very cool temperatures also limited demand early. Later, the fruit start growing rapidly and there are still many young fruitlets, so the total crop demand rises very rapidly. At about 10 mm there are still many fruit but with much higher demand. At this point the tree could not supply all carbohydrates needed, so sensitivity to thinners increased. Many fruits then dropped which overall reduced the crop demand. Also the canopy was growing and so the supply was increased. Finally, at around 20 mm the supply was sufficient to support the fruit and so the tree was not very sensitive anymore.

This pattern was similar to the actual thinning. The primary difference was that the actual effect was more severe than the model suggested. The greater thinning at about 10 mm was likely to due to both maximal tree sensitivity and warmest weather for thinning as that was the only thinning day over 72˚F and it was humid (i.e good thinner uptake conditions). We will be adding a thinner uptake sub model to our model to take into account these factors.

The model also estimated the pattern of drop over time and this is shown in Figure 4. The pattern and final values look very realistic. The reason the model shows earlier drop is that the model considers a fruit physiologically "dropped" when it cannot growth further. In practice, visible fruit fall takes 7-14 days after fruit stop growing. So this time to finally drop off the tree is the difference.

In conclusion, the model gave promising results in this year, and we hope that with further development it can be a robust tool that can help growers know the general status of their trees before thinning. Then in combination with our work on rapid estimations of the effectiveness of thinners with fruit growth monitoring, we hope to have some tools to help growers select the right postbloom thinnner concentrations, and then respond to thinner behavior with any needed followup.

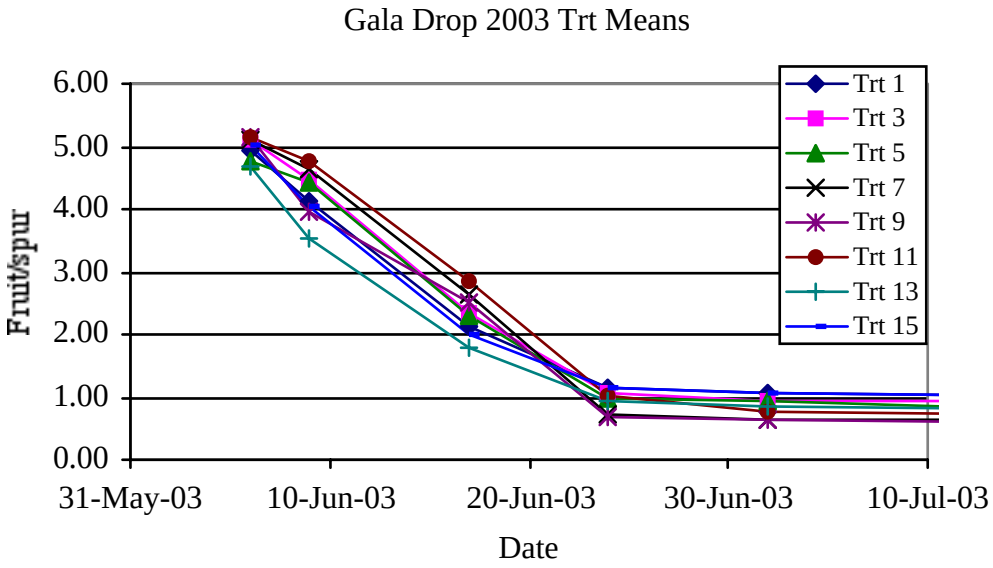

Figure 1. Gala fruit drop patterns in 2003 in NY of many timings of NAA/Sevin treatments

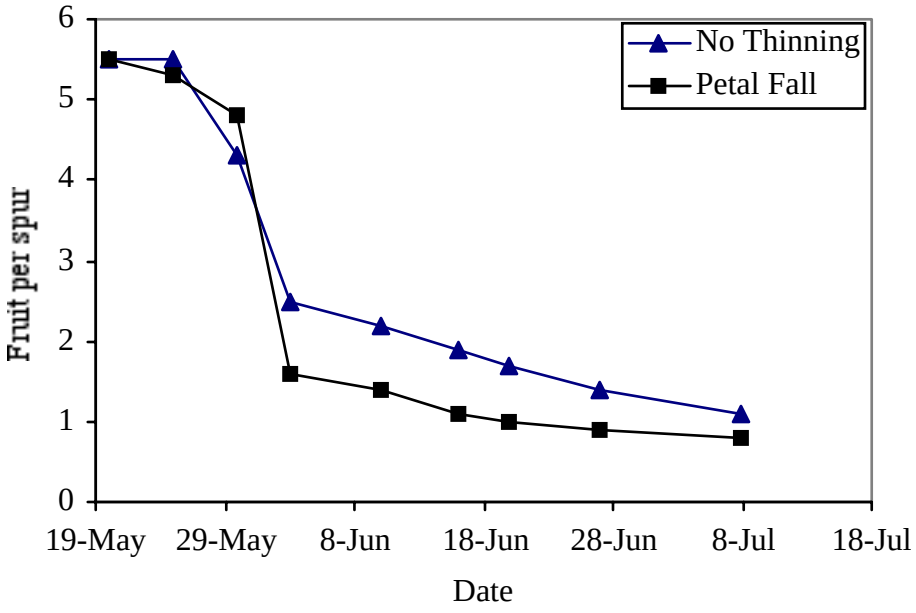

Figure 2. Fruit Drop patterns of a petal fall NAA/Sevin thinner applied 19 May versus unthinned control to demonstrate the need to monitor drop patterns to determine thinner effect. Note that by early June the thinner had about a 35% thinning effect, but by July the difference was hard to see.

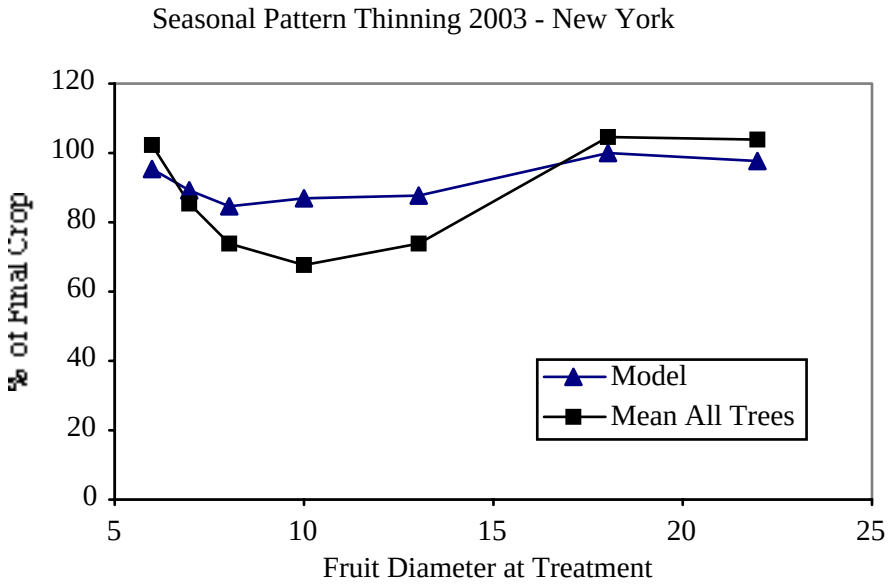

Figure 3. Pattern of response of all Delicious and Gala trees to 7.5 ppm NAA/ 1 pt Sevin XLR thinner applied at several timings in Geneva NY. Also shown is the predicted pattern of tree sensitivity to thinning from the carbohydrate supply/demand model showing similar pattern.

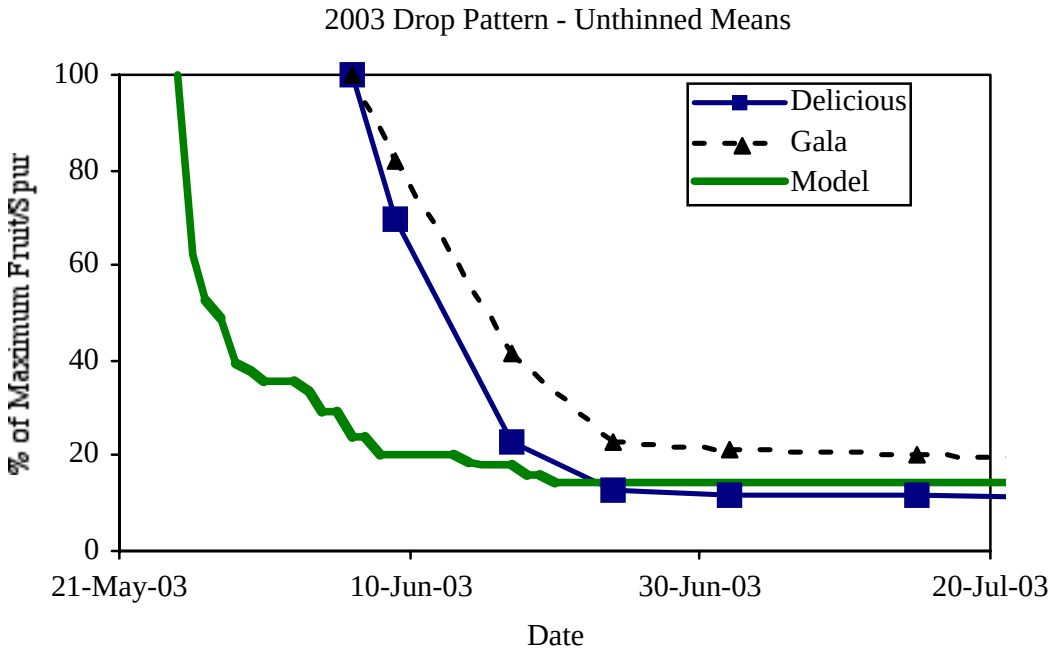

Figure 4. Pattern of actual and model estimates of fruit drop over the post bloom periodfor unthinned trees. The offset in time is due to the model that assumes a rapid loss of physiological activity of fruit. In the tree it takes 7-14 days to eventually fall off after becoming physiologically inactive.

2003 Budget

Note – The budget and scope for this project and the coordinated project on fruit growth led by Duane Greene (AH-03-313) were reduced. Since both NY and Massachusetts were cooperating on both projects, for simplicity the budget of this project was used for the Cornell research while the budget of the fruit growth project was used for the MA research.

Item	Totals
Salaries	0
Benefits	0
Wages	7,500
Benefits	2,873
Equipment	0
Supplies	1,627
Travel	0
Miscellaneous	0
Total	**$12,000**