FINAL REPORT
WTFRC Project # AH-03-313

Project title:	**Development and Testing of a model to Rapidly Predict Apple Thinner Response**
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Recapping of Objectives:

Chemical thinning of apples is one of the most important activities an orchardist is required to do since it can significantly influences the value of the crop the year of application and flower bud formation for the following year. One approach orchardist are increasingly relying upon is to make more than one thinner application. However, there are no guidelines available to aid orchardists in determining if thinning is necessary or evaluation of thinner response early enough so that remedial action can be taken.

Following pollination there is a period of time where fruit grow very slowly. Between 6 to 8 days (5 to 6 mm fruit size) after pollination a logarithmic stage of fruit growth starts where fruit growth is most rapid and fruit are most vulnerable to hormone-type thinners. Many physiological and environmental factors that can influence if a fruit will abscise or not but all express themselves the same way; through fruit growth rate.

The goal of Objective 1 was to follow fruit growth rate following thinner application to determine if a reduction in fruit growth rate was an appropriate, timely, and accurate predictor of thinner response and final fruit set. The premise for this was based upon the observations made over several years that fruit that are destined to abscise, slow and stop growth well in advance of the time that they actually abscise. Figure 1 illustrates growth of a fruit in a previous study that was caused to abscise by NAA application and one that continued to grow and persist to harvest. Detection of the reduction in growth rate, even if small, appears to be a powerful tool for early detection of fruit that will ultimately abscise. Cultivars can be characterized as king fruit dominant, non king fruit dominant, or intermediate between the two. Varieties were selected for this study that represented the three spur characteristic types: king flower dominant (Delicious), intermediate (Gala and Golden Delicious) and non king flower dominant (McIntosh).

The goal of Objective 2 was to develop a procedure that would be effective and user-friendly yet simple enough that would encourage growers to use it or at least try it. This procedure would allow growers to determine the response to a thinner early enough to make a followup thinner application while fruit were physiologically susceptible to the abscission promoting effects of a thinner. There were 2 key components in developing this procedure. First, marking and following the growth of individual fruit when 7-8 mm. Secondly, and identifying fruit that would persist to harvest so that a growth rate of viable fruit could be used a meter for reduction in fruit growth rate.

Significant Findings:

Growth rate of fruit was determined to be a very good and highly reliable indicator of which fruit and how many fruit that would abscise as a result of thinner application.

The time of detection of the reduction in growth rate appeared to be

somewhat determined by the weather. This was an unusually cold chemical thinning season thus detection of reduction in growth took between 7 to 11 days rather than 5 to 7 in a more normal year (Figure 1).

Based upon application of thinners in support of the Modeling project, thinners were very effective when applied after the 7 to 11 days required to detect growth reduction.

It appears that it will require the measurement of relatively few untreated control fruit to determine a growth rate of fruit that are projected to persist.

Fruit on 70 to 80 spurs per thinning treatment were measured in this investigation. Half of that number appeared to be sufficient to get an accurate assessment of fruit abscission, but this is based only upon one year of data collection and onlly on the spurs that were measured.

It appears that the detection of fruit that will abscise is equally appropriate on king flower dominant , non king flower dominant and intermediate dominant cultivars.

Methods:

Twenty one mature trees each of McIntosh and Ace Delicious on M.26 rootstock were selected in Massachusetts and blocked into 7 blocks (replications) of 3 trees each. Ten spurs were randomly selected, tagged and all fruit in each cluster were numbered with a Magic Marker when fruit were 8 to 9 mm in size. All fruit were individually measured using a digital caliper. The caliper was placed on the fruit where it was marked and subsequent measurements were taken in the same place. This increases the precision of subsequent measurements. One tree in each block was not sprayed and served as the control. One tree was sprayed with a commercial air blast sprayer at tree row volume dilute 7 ppm NAA plus 0.5 lb of Sevin. Similarly, the third group of 7 McIntosh trees was similar sprayed with Sevin while the Delicious received 100 ppm MaxCel. Eighteen Golden Delicious trees on M.7 in Massachusetts were blocked into 3 groups of six trees each. When fruit were about 8 mm 15 spurs per tree were tagged, numbered and measured as previously described. Fruit measurements were taken at 2 to 3 day intervals for 2 weeks. Final fruit set was determined at the end of June drop in July. Four single tree replications per treatment of Gala and Delicious on M.9 rootstock were selected in Geneva, New York. Trees were blocked into 4 group of 2 trees each. Twenty two to 25 spurs were randomly selected on each tree and marked and measured as previously described. One groups of each cultivars was sprayed with a commercial airblast sprayer with 7.5 ppm NAA plus 0.5 lb/100 of Sevin. The second group of 4 trees received no spray and served and the untreated control. Fruit were measured regularly as previously described.

Determination of growth rate of fruit that persist to harvest was established using fruit on untreated control trees. On each measurement date the fastest growing 3 to 5 fruit per tree were selected from all spurs measured to give a total of 20 fruit per treatment. Growth rate of the fastest growing fruit were similar, thus variance in growth rates were quite small. Growth rate was determined by averaging the growth of all fruit. This exercise was repeated except selection of the fastest growing fruit was done from only half of the spurs. Results were very similar using the full number or half the number of spurs indicating that it may not be necessary to measure fruit from a large number of spurs on untreated control spurs to get a reliable indication of growth rate of fruit that will persist to harvest. Over 99% of the fruit selected based upon rapid growth rate persisted to harvest.

We suggested in our original proposal that fruit that grow at 50% or less during time of measuring would ultimately abscise. Therefore, half of the growth rate of fruit that were predicted to

persist was the figure used to determine if a fruit would persist (grow faster than 50%) or abscise (less than 50%). Because weather conditions were quite different, a growth rate for persisting fruit had to be established for each time interval and cultivar and this figure applied to fruit growing during that period of time.

Weather conditions during the time these data were being taken was cool and cloudy with frequent periods of rain. It can be characterized and very unfavorable for thinning because of a lack of stress. Shorting out of the calipers due to rain occurred even when calipers were protected from the elements with a plastic bag.

Results and Discussion:

A summary of the prediction of fruit set in all trials is summarized in Table 1. The number of spurs involved, the number individual fruit measured and the initial set (fruit per spur) are listed. If a fruit grew 50% percent or more of the growth rate of fruit that were projected to persist to harvest it would considered set. For example, between 0 and 3 days after thinner application on Golden Delicious-MA the fastest growing control fruit grew 2.9 mm (data not shown). Half of that growth rate was 1.45 mm. Any fruit that grew 1.45 mm or more during that time period was considered set. For the NAA 2.5 ppm + Sevin treatment 0-3 days after application 304 of the 413 fruit grew more than 1.45 mm and were considered set. Similar calculations were done at the other time intervals: 5, 7, 10 and 14 days after application. At 10 days after application 64 of the fruit were projected to set based upon fruit growth, even though most had not abscised. In the middle of July the number of fruit that actually set was determined (final set) and on these spurs 62 fruit actually set. Similar calculations were made for the other thinning treatments. For Massachusetts prediction of final set could be made with between 90 and 100% accuracy between 7 and 11 days after application. This was well within the time where an effective thinner application could have been made if necessary. Weather in New York was considered more inclement so slightly less precision was achieved under these circumstances.

Prediction of fruit set based upon growth rate of half of the number of fruit is shown in Table 2. Nearly same precision in predicting final set was achieved by measuring fruit growth rate on 35 to 40 spurs. Calculation of set were similar to those described in Table 1. It is somewhat labor intensive to tag spurs, label fruit and measure fruit. Therefore, getting reliable results by using fewer spurs would make this a useful activity that may be well within the reach of all orchardists. Accurate prediction measuring fewer fruit is dependent upon fruit and spurs being selected that are representative of the tree.

Significance to the Industry:

The results of chemical thinner application have frequently been variable from year to year and block to block within a year. There has been no way up to this point to determine the effectiveness of a thinner until near the end of June drop when chemical thinners are no longer effective. We believe that measuring fruit growth and early realization of the results of a thinner application will result in orchardists being able to identify blocks that require additional thinner and to take remedial action with a followup thinner. Hand thinning is expensive and frequently it is difficult to find labor to do this in a timely fashion. While doing a better job of chemical thinning may not totally eliminate the need for hand thinning, it certainly would cut down both on the amount and the cost. The time and labor invested in fruit measuring should pay for itself many time over and also result in the production of a better product.

A component of this system that must be developed is extrapolation of results obtained from measuring fruit on spurs to results on the whole tree. Selection of spur to measure must reflect a population of spurs on the tree. In this investigation relatively low numbers of measured spurs

appeared to give good results. However, it may be necessary to measure more spurs just to get a population that is representative of the whole tree. The link between results from measured spurs and the whole tree results will be a component of the proposal that will be submitted. One objective of a proposal that will be submitted it to evaluate sampling of spur to measure to assure that those selected are representative of the population on the tree.

We have long recognized that weather following thinner application can have a profound effect on thinner efficacy. This year the weather following thinner application influenced the time interval between application and the time required for a fruit growth reduction to be noticed. Under most circumstances thinner response can be noted within 4 days of application and an accurate prediction made by 7 days after application. Because of the cool damp weather 11 or more days was required in some instances. This circumstance does not negate the value of using fruit growth to predict thinning response, since it is well documented that fruit remain susceptible to thinners for a longer period of time when cool temperatures follow bloom.

In previous studies with more normal weather conditions following thinner application, 7 days after application was sufficient to measure thinner response to make a reasonably accurate prediction of thinner response. With the exception of Golden Delicious, that time was insufficient. Modeling or following growing degree days following application may should be addressed to determine the best time after application to make measurements from which decisions will be made.

Table 1. Predicted fruit set based upon fruit growth rate of measured fruit on 70-80 spurs/chemical thinning treatments.

Cultivar	Thinning	No. measured		Fruit	Projected number of fruit set							Final set-July	
	treatment	Spurs	Fruit	per spur	Days after thinner application							Per spur	No.
					3	5	7	9	10	11	14		
Golden Delicious	NAA 2.5 ppm +	75	413	5.5	304	189	83	---	64	---	62	0.83	62
Golden Delicious	NAA 10 ppm +	75	420	5.6	255	90	54	---	57	---	54	0.71	54
Delicious MA	BA 100	70	282	4.0	162	114	46	26	---	20	19	0.33	23
Delicious MA	NAA 7 ppm +	70	286	4.1	157	110	73	26	---	25	24	0.33	23
McIntosh MA	Sevin	70	222	3.2	194	110	79	67	---	46	48	0.70	49
McIntosh MA	NAA 7 ppm +	70	225	3.2	167	79	33	47	---	44	43	0.61	43
Gala NY	NAA 7.5 ppm +	80	249	3.1	230	211	172	125	---	---	99	0.99	79
Delicious NY	NAA 7.5 ppm +	80	240	3.0	187	136	50	37	---	---	33	0.31	25

Table 2. Predicted fruit set based upon fruit growth rate of measured fruit on 35-40 spurs/treatments.

Cultivar	Thinning	No. measured		Fruit	Projected number of fruit set							Final set-July	
	treatment	Spurs	Fruit	per spur	Days after thinner application							Per spur	No.
					3	5	7	9	10	11	14		
Golden Delicious	NAA 2.5 ppm +	42	188	4.5	126	80	30	---	20	---	21	0.50	21
Golden Delicious	NAA 10 ppm +	42	196	4.7	131	57	29	---	26	---	29	0.67	28
Delicious MA	BA 100	35	141	4.0	92	81	20	19	---	11	10	0.29	10
Delicious MA	NAA 7 ppm +	35	146	4.2	78	49	15	11	---	10	10	0.29	10
McIntosh MA	Sevin	35	105	3.0	80	65	43	33	---	26	26	0.74	26
McIntosh MA	NAA 7 ppm +	35	114	3.3	89	48	17	22	---	20	20	0.57	20
Gala NY	NAA 7.5 ppm +	40	117	2.9	103	96	65	39	---	---	36	0.70	28
Delicious NY	NAA 7.5 ppm +	40	120	3.0	97	63	22	11	---	---	10	0.20	8

Table 3. Summary of table showing predicted set 7-11 days after thinner application, actual fruit set taken at the end of June drop, and percent accuracy of the prediction.

Cultivar	Thinning treatment	Predicted set 7-11 days after thinner application (Fruit no.)	Final set in July (Fruit no.)	Accuracy of prediction (%)
Golden Delicious MA	NAA 2.5 ppm + Sevin	64	62	97
Golden Delicious MA	NAA 10 ppm + Sevin	54	54	100
Delicious MA	BA 100	20	23	87
Delicious MA	NAA 7 ppm + Sevin	25	23	92
McIntosh MA	Sevin	46	49	94
McIntosh MA	NAA 7 ppm + Sevin	44	43	98
Gala NY	NAA 7.5 ppm + Sevin	125	99	79
Delicious NY	NAA 7.5 ppm + Sevin	37	25	68

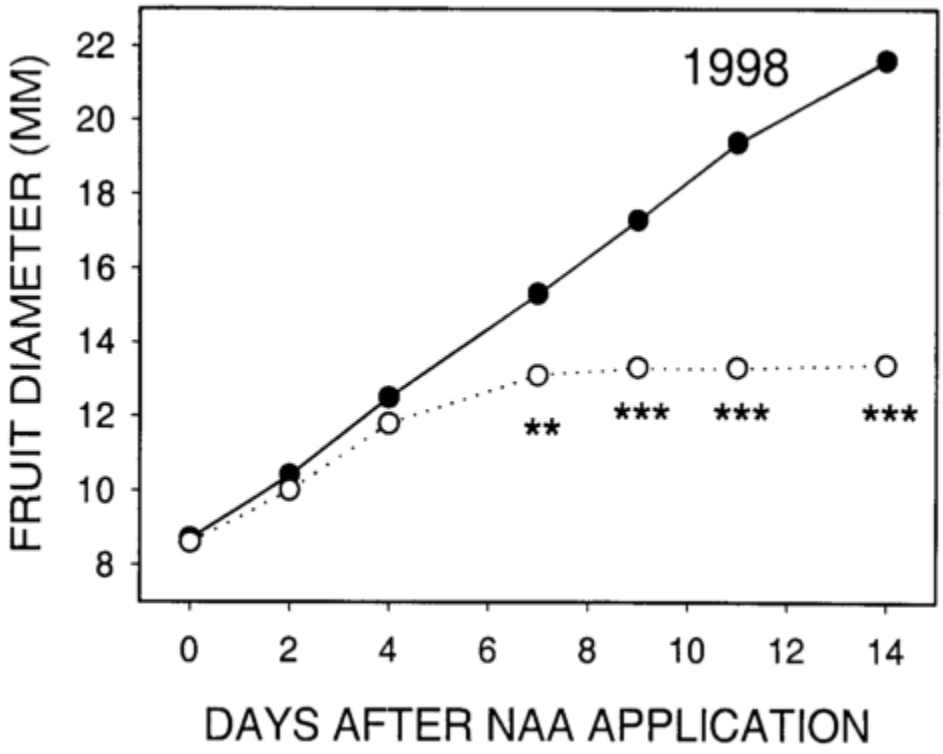

Figure 1. Growth of abscising fruit and those that persist to harvest.

Budget that was used in support of the Predicting Thinning proposal that I served as PI on and the Apple Abscission Modeling Project where Alan Lakso served as PI.	
Item	Amount
Wages	$ 6,200.
Benefits (35%)	$ 2,170.
Plot maintenance	$ 800.
Crop loss	$ 600.
Supplies	$ 270.
Total	$10,000.