Northern NY Agricultural Development Program
2019 Final Report

Precision Crop Load Management to Optimize Profitability of the NNY Apples Growers

Project Leader:

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Cooperating Producers:

- Jay Toohill, Chazy Orchards, Chazy, NY
- Mason, Seth and Mac Forrence, Forrence Orchards, Peru, NY
- Tom Everett, Everett Orchards, Peru, NY

Background:

Management of apple crop load is a balancing act between reducing crop load (yield) sufficiently to achieve optimum fruit size and adequate return bloom without reducing yield excessively. Managing crop load is one of most important management tasks faced by apple growers. For each variety and orchard there is an optimum number of fruits per tree where yield, fruit size, and fruit quality are optimized. Optimized crop loads for a given cultivar and production system in a particular environment can clearly give enhanced financial returns to growers. This NNYADP precision apple project was designed to help apple growers to optimize yield and fruit size of the most important varieties recently grown in Northern NY by implementing a suite of management practices we have named "precision orchard management."

Producing fruit of the appropriate size and high quality is one of the most important task apple growers must accomplish in order to ensure profitability. In the Northeastern US, almost all apple orchards are chemically thinned early in the season each year using a combination of either naphthaleneacetic acid (NAA, a synthetic auxin plant growth regulator) plus carbaryl (a carbamate insecticide), naphthalene acetamide (NAD) plus carbaryl or benzyl adenine (BA, a synthetic cytokinin plant growth regulator) plus carbaryl. Carbaryl causes some thinning by itself but also enhances the thinning efficacy of either NAA, NAD or BA. However, results are quite variable and difficult to predict. In addition we have discovered that the severity of pruning affects chemical thinning results. Through this project we have developed more precise pruning methods and chemical thinning strategies.

Carbaryl has been an essential component of chemical thinning programs for more than 40 years. However, there is concern that carbaryl will be removed from the market by regulatory action either in the US or in Europe. In the last couple of years, one retailer in the U.S. — Whole Foods Markets — prohibited carbaryl's use on produce sold in stores, creating several obstacles for growers to remain competitive in the apple industry. While growers have been using their own experience to devise thinning strategies without carbaryl, there is still a need to develop new carbaryl-free thinning strategies for all of our commercial varieties of apples and various weather conditions. Therefore, in 2019, we evaluated several carbaryl-free thinning strategies.

Lastly, but equally important, fruit size is often reduced by drought. Irrigation in dry years helps to improve fruit size. Through this project we sought to implement practical guidelines for irrigation of apples in NNY to optimize fruit size.

This project involved NNY regional growers through the use of on-farm research plots. These grower-based plots are resulting in broad grower involvement and more rapid adoption of beneficial practices.

Methods:

1. Precision Pruning

In 2019 we conducted a precision pruning study with Honeycrisp apple trees at Chazy Orchards in Chazy, N.Y. At pink bud stage, we pruned trees to 5 different bud loads by first calculating the number of fruits per tree desired at harvest, then counting the flower buds on the tree at the beginning of the season, and then reducing the initial number to one of five flower bud targets (1 bud per final fruit, 1.5 buds per final fruit, 2 buds per final fruit, 3 buds per final fruit and 4 buds per final fruit).

After the pruning, we thinned half of the trees with the precision chemical thinning program with a sprays at bloom, petal fall, 12 mm and 18mm fruit size; the other half of the trees we thinned by hand to one flower per cluster at full bloom.

At harvest we measured yield, fruit size, and fruit number, and calculated crop value from a projected packout based on fruit size.

2. Precision Thinning

In 2019 we conducted two on-farm field precision crop load experiments at Everett Orchards in Peru, NY, as a part of a statewide effort on precision thinning that involved

24 farms. On each farm we first established a target fruit number and then implemented the precision chemical thinning protocol (Figure 1). We used the Pollen Tube Growth Model (PTGM) to guide bloom thinning and the Cornell MaluSim model to guide post bloom thinning.

After the postboom sprays we assessed the progress toward achieving the target fruit number using the fruit growth rate model. At each location the cooperating grower counted the number of flower buds on 5 representative trees at pink and calculated the target number of fruits per tree needed to achieve a desired high yield. The cooperators then targeted 15 representative spurs per tree on the 5 test trees. After the petal fall spray, the fruit diameter of each fruit in the 15 tagged clusters on each of the 5 trees (375 fruits) was measured 3 days after spraying and again 7-8 days after spraying to clearly differentiate abscising versus retained fruit.

The diameter data were sent electronically to the Cornell University Horticulture Department for analysis by Terence Robinson using the Fruit Growth Rate (FGR) model. Within 24 hours the results were sent to growers with the recommendation for the next spray.

Michael Basedow with the Cornell Cooperative Extension Eastern NY Commercial Horticulture Program assisted the NNY growers on how to set up the protocol on their farm, how to use the models, how to take the measurements, and how to interpret the results.

In 2019, we deployed a smartphone app to help growers take the data more efficiently and more accurately. This phone app was introduced to all the growers in the Champlain region at the Fruit Thinning workshop held in early June 2019.

When we determined that the proper crop load had been achieved we stopped further applications of chemical thinners. One month after the end of thinning we counted the actual number of fruits on the trees and calculated the percentage of the target crop load achieved with precision chemical thinning.

3. Precision Irrigation

In 2019 we continued our irrigation management trial that started in 2015 on Forrence Orchards in Clinton County (NNY) using the Cornell Apple Irrigation Model. The orchards was planted with the new variety NY1 (Snapdragon) on B.9 rootstock. The trees were planted in 2010 at 1,037 trees/acre. We managed soil water level according to the irrigation model to minimize water stress while other trees were left unirrigated. We assessed tree growth and tree stress, and crop yield, fruit size, and fruit quality (flesh firmness and sugars) with irrigation and with no irrigation.

4. Carbaryl-free Thinning Strategies

In 2019, we evaluated two carbaryl-free thinning strategies. The trial was done at Forrence Orchards and included the evaluation of either the combination of benzyl adenine (BA) + either naphthalene acetic acid (NAA) or naphthalene acetamide (NAD), at bloom, petal fall and 12 mm and 18 mm fruit size on thinning efficacy of Honeycrisp apple. In order to find the best program that provides growers the best crop value, we evaluated fruit number per tree, yield, fruit size, color, and fruit quality.

Results:

1. Precision Pruning

Pruning severity had a large impact on final fruit number and yield per tree of Honeycrisp (Table 1) in 2019. When trees were pruned very lightly (bud load ratio of 4 buds:1 final fruit number), the final fruit number per tree was significantly higher than the target fruit number of 60 fruits per tree despite the hand or chemical thinning used (Figure 1). Yield was also increased significantly higher with less aggressive pruning (Figure 2).

However, fruit size was reduced linearly with less aggressive pruning (Figure 3). With the most aggressive pruning (1 bud:1 final fruit number), the final fruit number was less than the target number and fruit size was large (64 count), while with the least aggressive pruning, final fruit number was twice the target number and fruit size was small (100 count).

Pruning severity also had large impact on fruit set (Table 1). The higher the initial flower number per tree (less aggressive pruning) the lower the fruit set.

Pruning severity also had a significant impact on total crop value (Figure 4). Crop value was maximized under chemical thinning when the optimum level of pruning severity for Honeycrisp was about 2.7 buds:final fruit number. However, such a high crop load will almost certainly result in too little bloom the next year. With hand thinning the optimum level of crop value was achieved at about 1.6 buds:final fruit number. This level of cropping combined with early hand thinning should result in good return bloom the next year. Additionally, these results indicate that optimum crop value was achieved when average fruit size was about 250 g.

Method of thinning (chemical vs hand thinning) also affected yield and crop value. Early hand thinning resulted in greater yield and crop value at any given pruning severity than chemical thinning. However, hand thinning at bloom is very costly and not likely to be adopted by growers due to lack of sufficient labor. Thus, more precise control of chemical thinning using first bloom thinning and petal fall thinning to adjust crop load very early in the season should improve the results of chemical thinning and more closely approximate the positive effects of hand thinning at bloom.

An important result of this study is the reduction in fruit set with greater flower bud numbers after pruning. Similar results were found by Francescatto et al., (2019) and Schupp et al. (2017), where fruit set of 'Gala' as a percentage of initial blossom clusters tended to increase in a quadratic pattern with increasing pruning severity. We theorize that with greater number of initial flower buds (light pruning), the spring uptake of nutrients from the root system and the flux of plant hormones from the root system distributed into many more buds provided a smaller amount of nitrogen and growth promoting hormones to each flower, thus resulting in lower fruit set from weak flowers and smaller fruit size from those that do set a fruit. This result suggests growers should reduce flower bud numbers through pruning to improve fruit set and ultimately fruit size.

A second important result of this study is that crop value was maximize at a high bud number which resulted in too high of a crop load for good return bloom the next year. Thus, with Honeycrisp, if a grower maximizes crop value in year 1 there is likely to be little return bloom and low crop value the second year. A more sustainable approach is to manage Honeycrisp at a crop load that results in a slightly lower crop value but that results in repeat bloom and high crop value the second year.

Table 1. Effect of pruning severity and thinning method on fruit set, fruit number, yield, fruit size, and crop value of Honeycrisp apples at Chazy, NY, 2019; NNYADP Precision Apple Management project.

Thinning Method	Pruning Severity (Ratio of floral buds to final fruit number)	Fruit Set (%)	Final Fruit number per tree	Yield/tree (kg)	Yield /acre (bu)	Fruit Size (g)	% Fruit drop	Crop Value ($/acre)
	1	14	43.1	11.4	787.4	274.2	25.39	21262
	1.5	13	57.5	14.8	1025	256.1	17.38	28568
	2	11	63.2	15.1	1048	243.5	12.34	28696
	3	10	86.9	19.9	1377	230.9	13.91	37171
	4	10	113.9	20.6	1424	177.7	8.857	32127
	Significance of Pruning Severity	**	**	**	**	**	**	**
	LSD P≤0.5	2.8	14.9	3.6	251	23.7	7.9	7760
Chemical	.	10	62.2	13.5	931.8	227.1	17.22	23932
Hand	.	13	84.9	19.3	1337	243.6	13.99	35082
Significance of Thinning Method		NS	NS	*	*	NS	NS	*
LSD P≤0.5		4.7	26.7	5.7	397	31.7	7.8	11356
Chemical	1	14	43.2	10.7	741.4	251.3	26.51	20238
Chemical	1.5	9	41.3	9.9	686.4	242.2	21.14	19096
Chemical	2	10	57	14.3	989.6	254.8	13.67	27359
Chemical	3	8	69.4	15.6	1077	226.8	17.02	29138
Chemical	4	8	91.8	15.4	1066	166.3	9.324	21893
Hand	1	14	43	12	833.3	297	24.27	22286
Hand	1.5	15	67.2	17.8	1229	264.4	15.13	34251
Hand	2	12	71	16.2	1122	229.4	10.68	30366
Hand	3	12	104.4	24.2	1676	235.1	10.8	45204
Hand	4	11	136	25.7	1782	189.2	8.389	42361
Significance of Interaction		NS	*	NS	NS	*	NS	NS

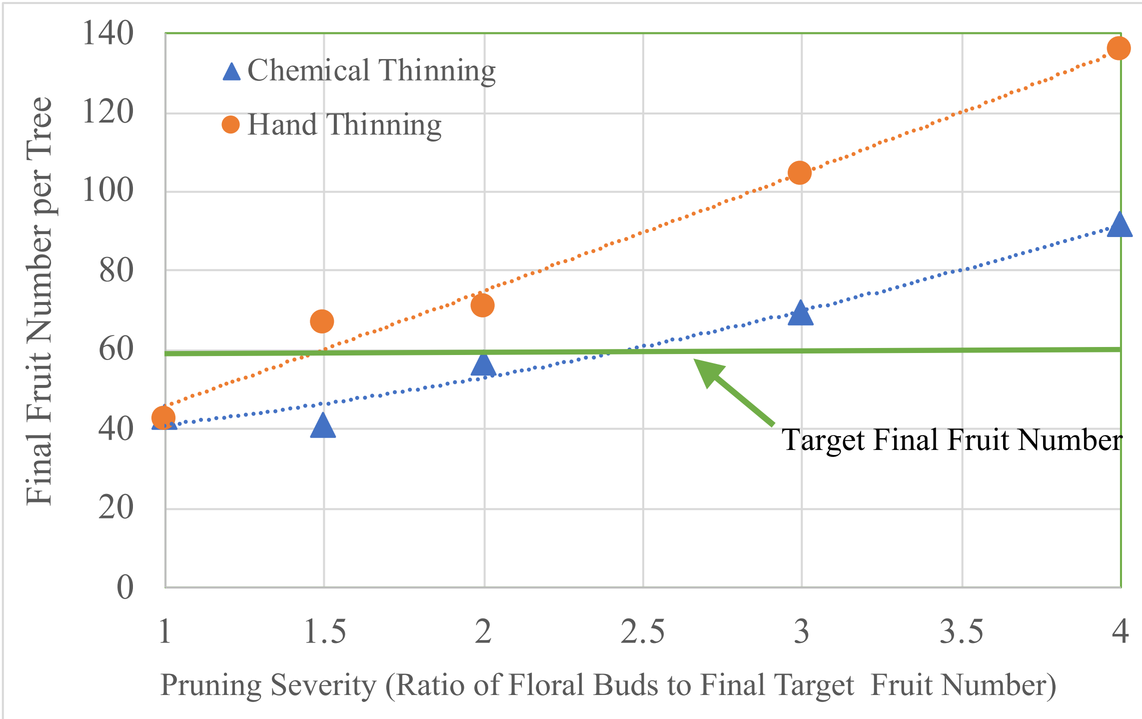

Figure 1. Relationship of pruning severity and thinning method on final fruit number of Honeycrisp apples when either chemically-thinned or hand-thinned at Chazy, NY, 2019; NNYADP Precision Apple Management project.

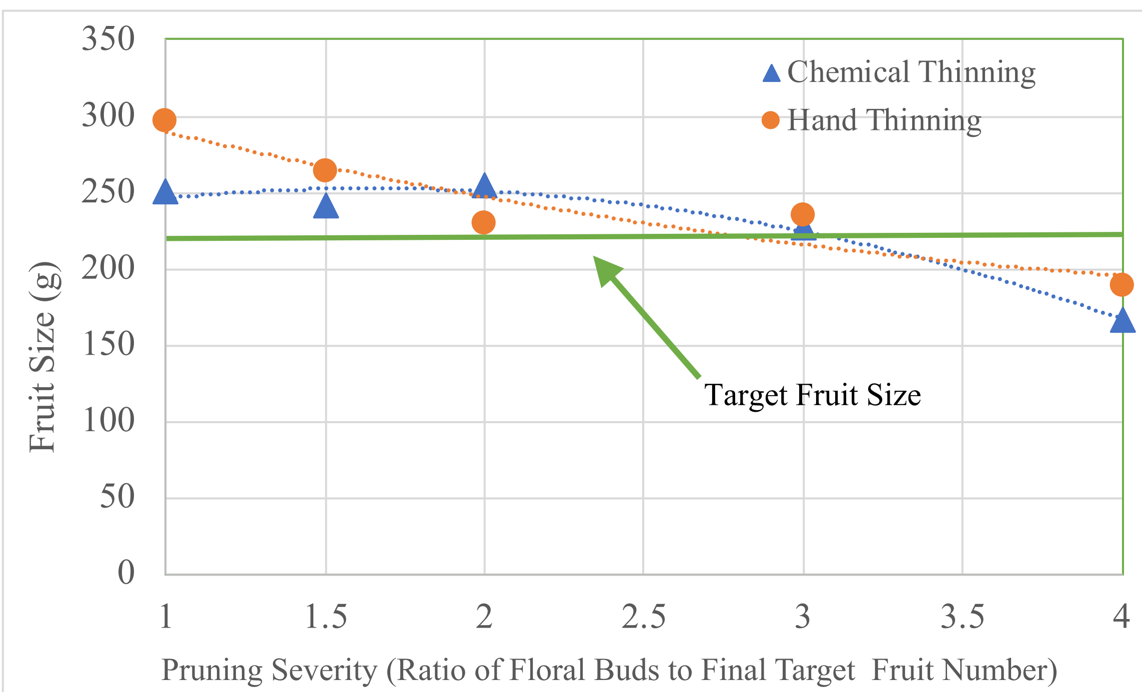

Figure 2. Relationship of pruning severity and thinning method on fruit size of Honeycrisp apples when either chemically-thinned or hand-thinned at Chazy, NY, 2019; NNYADP Precision Apple Management project.

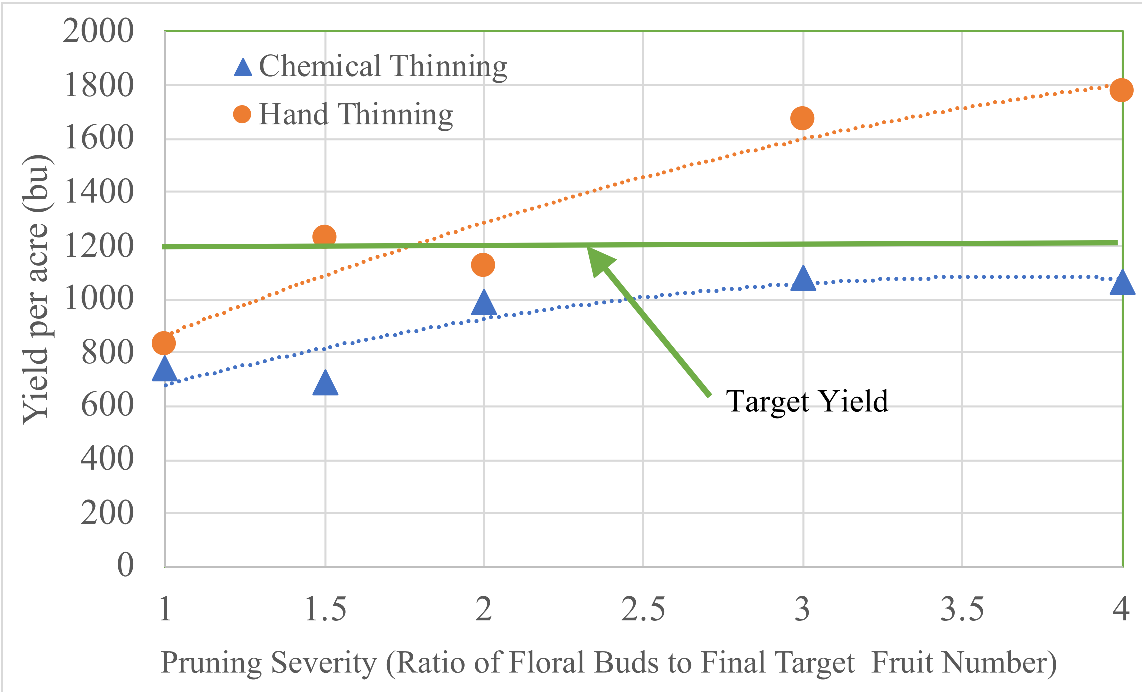

Figure 3. Relationship of pruning severity and thinning method on yield of Honeycrisp apples when either chemically-thinned or hand-thinned at Chazy, NY, 2019; NNYADP Precision Apple Management project.

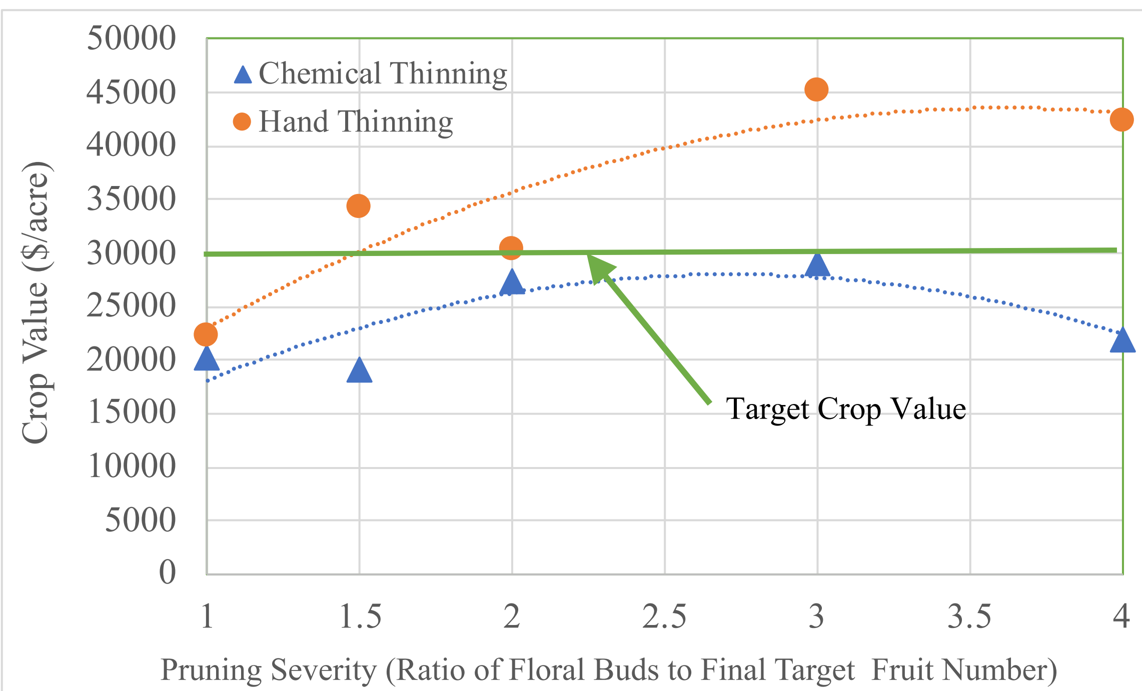

Figure 4. Relationship of pruning severity and thinning method on crop value of Honeycrisp apples when either chemically-thinned or hand-thinned at Chazy, NY, 2019; NNYADP Precision Apple Management project.

2. Precision Thinning

The 24 orchards across NY State differed significantly in the ratio of floral buds to final target fruit number indicating very different pruning severities (Table 1). The ranking of orchards in Table 2 is by increasing ratio of floral buds to target fruit number. The orchard pruned most severely had a ratio of only 0.6 which is more severe than we recommend (1.5-1.8) while the orchard with the highest ratio was 5.0 which had a bud load of more than 3 times the number of buds we recommend.

The success of the precision chemical thinning protocol was related to the initial bud load (Figure 5). A high initial bud load in almost all cases resulted in less than adequate thinning with a poorer result with higher initial floral bud load. There were two exceptions to this general trend which were the two orchards in the Champlain Valley (NNY). In Figure 6 the two triangle-shaped points that had high initial bud load but achieved close to the target number of fruits (~100%) were the only two orchards to receive the full 4-spray program of the precision thinning protocol shown in Figure 6.

The precision chemical thinning protocol resulted in different numbers of chemical thinning sprays for each orchard. At only one of the 24 total orchards a good thinning result was achieved with only 2 sprays of ATS at bloom and a single carbaryl spray at petal fall. All of the other orchards required more sprays to achieve the target crop load. Only two orchards received the full 4 sprays (bloom, petal fall, 12mm and 18mm) of the precision thinning protocol. These orchards (triangles in Figure 2) began with a high floral bud load but achieved close to the target number of fruits.

The precision chemical thinning protocol worked well in orchards that were pruned to a bud load within our recommended range of 1.5-1.8 floral buds:final target fruit number. The precision protocol prevented overthinning in Orchard 1 by stopping chemical application after the petal fall spray. In all of the other orchards the protocol called for additional sprays, resulting in a good crop load for most but not all orchards. However, in several orchards although 3 sprays were applied the final crop load remained too high. This was related to the pruning severity of the respective orchards. In orchards where bud load was above 2, inadequate thinning was achieved with the precision thinning protocol. In these orchards a 4th spray could have improved the thinning situation but the fruit grower was unwilling to apply the 4th spray.

These results confirm the general rule reported by Francescatto et al. (2019) that leaving too many flower buds on a tree results in too many final fruits despite repeated attempts to reduce the number through chemical thinning. **These results indicate the importance of combining precision pruning with precision chemical thinning to achieve a target fruit number.**

Currently, few growers are willing to do the tedious manual counting of buds to implement precision pruning. Our future work will be to automate the counting of fruit buds with computer vision which will greatly assist and stimulate the adoption of precision pruning.

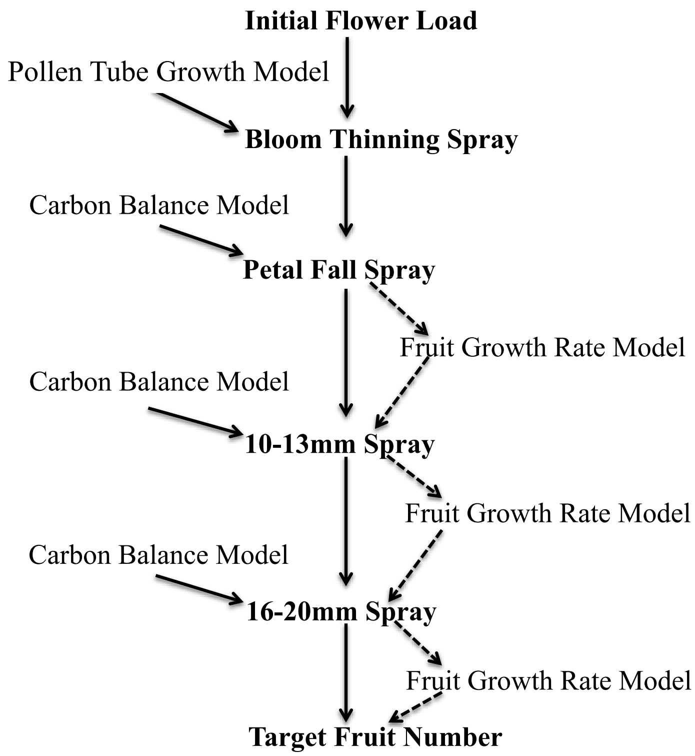

Figure 5. Precision chemical thinning protocol used in 2019 field trials; NNYADP Precision Apple Management project.

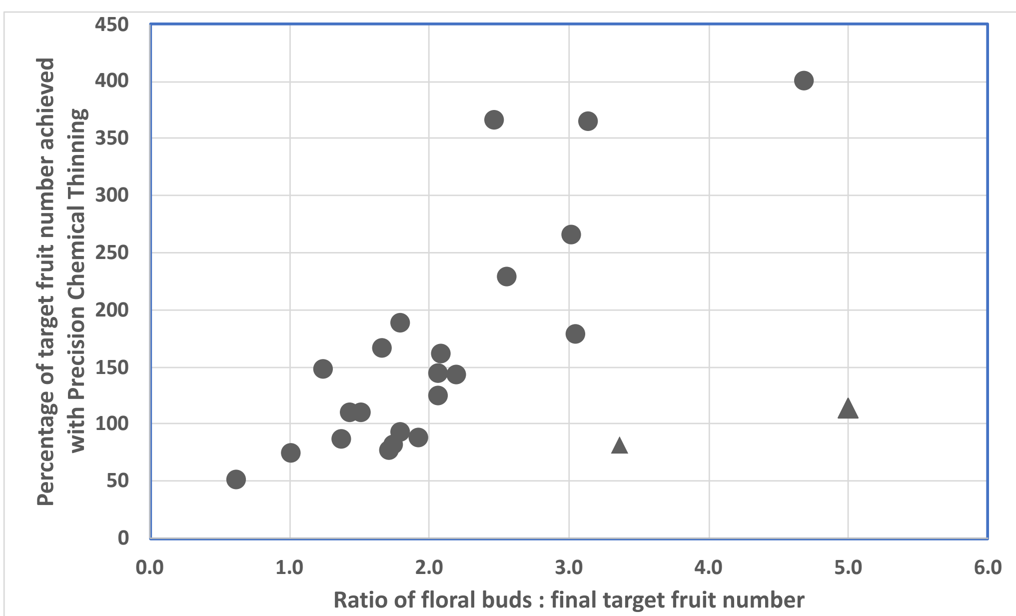

Figure 6. Relationship between pruning severity (initial flower bud load=X axis) and success of precision chemical thinning with 24 orchards in New York State in 2019. The 2 triangles are the Champlain Valley (NNY) orchards; Precision Apple Management project. (100% on Y axis=perfect thinning while numbers below 100% indicate over-thinning and numbers above 100% indicate under-thinning).

Table 2. Response of 24 orchards to precision chemical thinning in 2019 in New York State. Yellow highlighted rows are data from the Champlain Valley orchards; NNYADP Precision Apple Management project.

Orchard No.	Variety	Target final fruit number	Initial floral bud load	Ratio of floral buds : final target fruit number	Final Fruit Number	Percentage of target fruit number achieved with Precision Chemical Thinning
1	Honeycrisp	110	68	0.6	56	51
2	Honeycrisp	123	125	1.0	90	73
3	Gala	130	162	1.2	191	147
4	Gala	120	165	1.4	103	86
5	Gala	150	215	1.4	163	109
6	NY1	45	68	1.5	49	109
7	Honeycrisp	100	167	1.7	165	165
8	Minnieska	90	154	1.7	68	76
9	Honeycrisp	110	192	1.7	89	81
10	Honeycrisp	35	63	1.8	32	91
11	Honeycrisp	85	153	1.8	159	187
12	Gala	126	243	1.9	110	87
13	Honeycrisp	75	155	2.1	93	124
14	NY2	100	207	2.1	143	143
15	Gala	120	250	2.1	192	160
16	NY1	80	176	2.2	114	143
17	Gala	140	346	2.5	512	366
18	Gala	65	166	2.6	148	228
19	Honeycrisp	115	347	3.0	305	265
20	Gala	100	305	3.1	178	178
21	Gala90	120	377	3.1	437	364
22	Honeycrisp	175	588	3.4	143	82
23	Honeycrisp	32	150	4.7	128	400
24	NY1	75	375	5.0	86	115

3. <u>Precision Irrigation</u>

Irrigation did not significantly improve fruit size, yield, or crop value of NY1 apples in 2019 (Table 3). However, there was a trend for increased yield (p=0.07) and increased crop value (p=0.17) due to irrigation. This was likely due to the relatively wet season in 2019. Water balance estimates from the Cornell apple irrigation model showed excess balance until August 2 and no significant water stress until August 12. Despite the relative abundance of rainwater in 2019, the numeric difference in crop value with irrigation suggests a trend for a positive economic impact of the irrigation even in a wet season.

Table 3. Effect of precision irrigation on fruit number, yield fruit size, and crop value of NY1 (Snapdragon) apple in Peru, NY, 2019; NNYADP Precision Apple Management project.

Irrigation Treatment	Fruit Number/ tree	Yield/ tree (kg)	Yield/ acre (bu)	Fruit Size (g)	% Fruit Drop	Crop Value ($/acre)
Precision Irrigation	162.3	24.5	1694	151.6	3.976	29503
Unirrigated	141.1	19.1	1325	136.3	3.615	18465
Significance	NS	NS	NS	NS	NS	NS
LSD P≤0.05	38.5	5.8	403	37.1	2.33	17306

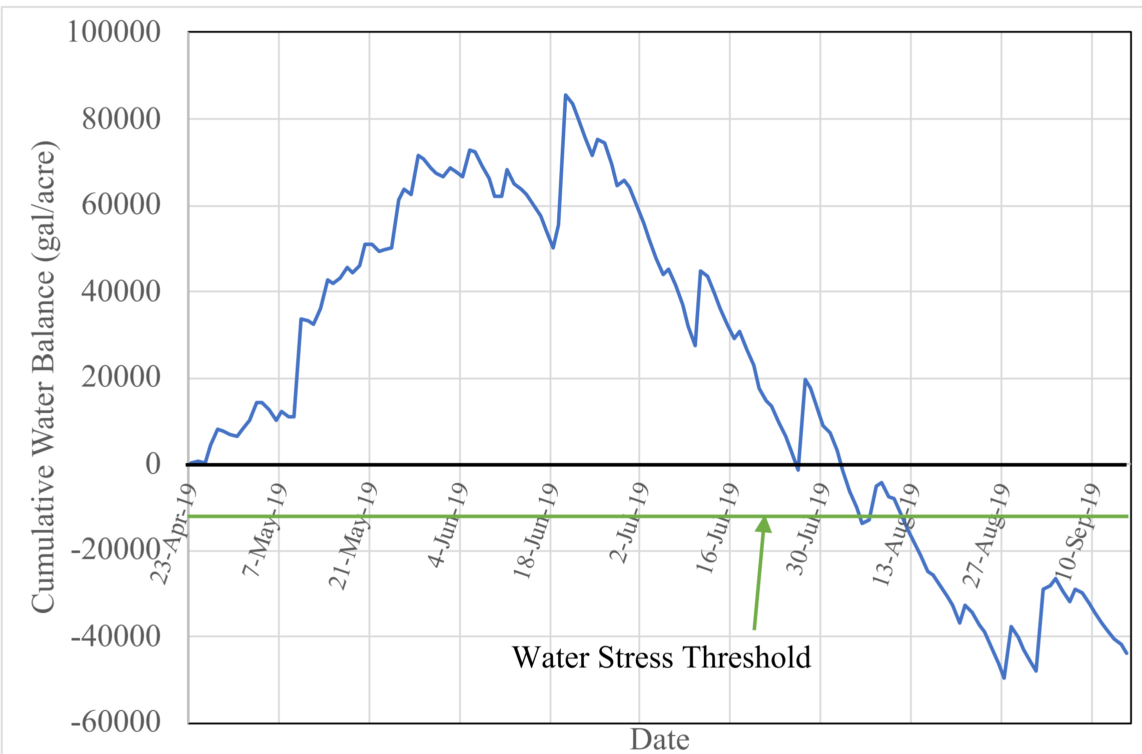

Figure 7. Water Balance for NY1/B.9 apple orchard at Peru, NY 2019; NNYADP Precision Apple Management project. (Water stress is possible when water balance is below -10,000gal/acre.)

4. <u>Carbaryl-free Thinning Strategies</u>

All three thinning treatments caused fruit thinning compared to the unthinned control (Table 1 and Figure 1). **The two non-carbaryl treatments had similar thinning as the commercial standard treatment using carbaryl.** The most effective treatment was the 3-spray program with NAA at bloom and BA+NAA at petal fall and at the 12 mm stage. This treatment slightly overthinned with only 72 fruits per tree compared to the target fruit number of 100. The commercial standard treatment with carbaryl had 101 fruits per tree and the NAD-based treatment had 87 fruits per tree.

Fruit size was increased by all three thinning treatments with no difference between treatments.

Crop value was highest for the commercial standard treatment (NAA+carbaryl), but the two treatments with NAD+BA and with NAA+BA were not significantly lower.

Table 4. Effects of two non-carbaryl thinning strategies compared to the standard program with carbaryl on fruit number per tree, yield, fruit size, and crop value of Honeycrisp apples at Forrence Orchards, Peru, NY, 2019; NNYADP Precision Apple Management project.

Treatment	Final Fruit Number	Yield/tree (kg)	Yield/acre (bu)	Fruit Size (g)	% Fruit Drop	Crop Value ($/acre)
Untreated Control	164.1	24.2	1673	147.7	10.8	27766
NAD at bloom and PF, NAD + 6BA at 12mm	87.4	16.6	1148	192.1	8.1	27415
NAA at bloom, NAA + Sevin at PF and 12mm	101.6	20.4	1409	205	6.8	35183
NAA at bloom, 6BA + NAA at PF and 12mm	71.9	14.5	1005	210.8	7.7	25119
LSD P≤0.05	43.1	6.2	432	31.1	3.8	7689

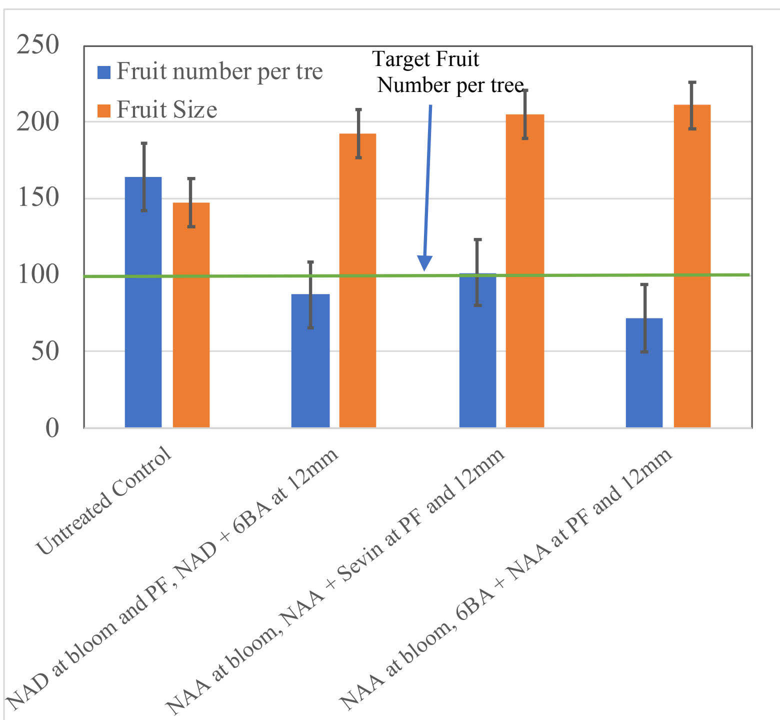

Figure 8. Effects of two non-carbaryl thinning strategies compared to the standard program with carbaryl on fruit number per tree, and fruit size of Honeycrisp apples at Forrence Orchards, Peru, NY, 2019; NNYADP Precision Apple Management project.

The results in 2019 were similar to the results in 2018, indicating that either non-carbaryl program successfully thinned Honeycrisp and is a viable alternative to

using carbaryl. This should allow NNY apple growers to respond to markets that require carbaryl-free fruit.

5. **Smartphone App-Assisted Orchard Management**
In 2019, we introduced the new smartphone app we recently developed. We worked with several growers in NNY's Champlain Valley to use the app during the thinning season. The app worked well and allowed participating growers to take the data more efficiently and view the results more easily in the field rather than going to their office to run the models.

Conclusions/Outcomes/Impacts:

The precision pruning results of this research in Northern NY will guide NNY apple growers on the proper level of pruning of Honeycrisp, however, we will evaluate the full impact of precision pruning on return bloom on the test trees until May 2020. We expect this process of precision pruning will help growers consistently produce a large crop of Honeycrisp and avoid biennial bearing to maximizing grower income each year.

The precision thinning protocol was very successful in achieving near perfect thinning in the Champlain Valley (NNY) orchards when 4 sprays were applied. However, if only the first 2 sprays were applied, then too little thinning was achieved, resulting in a large hand thinning job. The impact of applying this precision orchard management technology is that apple growers in the Champlain Valley will be able to more consistently achieve the optimum crop load, resulting in greater crop value ($2,000-5,000 more per acre) with less hand thinning, resulting in time saving and less labor cost.

The quest to develop carbaryl-free thinning programs was a success. We were successful in achieving good thinning without using carbaryl, but crop value was not as high as when we used carbaryl. Also, we will not be able to evaluate the impact on return bloom on the test trees until May 2020.

Irrigation was not necessary in 2019 but there was a trend for greater yield with irrigation. The full benefits of precision irrigation will be more apparent during a dry year.

Outreach:

The results of this project were reported at the Eastern NY Fruit and Vegetable School in February 2020. An article on precision pruning was published in the Fruit Quarterly in April 2019. An article on improvements to the carbohydrate model was published in the Fruit Quarterly in April 2020.

Next Steps:

We will further evaluate the precision crop load management strategy with precision pruning and precision thinning trials in the Champlain Valley in 2020, and continue carbaryl-free thinning evaluation under the new project led by Mike Basedow.

Reports and/or articles in which results of this project have been published:

Refereed

Lordan, J., G.H. Reginato, A.N. Lakso, P. Francescatto, T.L. Robinson. 2019. Natural fruitlet abscission as related to apple tree carbon balance estimated with the MaluSim model. *Scientia Horticulturae.* 247:296-306.

Lordan, J., G.H. Reginato, A.N. Lakso, P. Francescatto, T.L. Robinson. 2019. Correlations of chemical thinning responses to apple tree carbon balance estimated with the MaluSim model. *J. of Hort. and Biotechnology.* (in press).

Francescatto, P., J. Lordan and T.L. Robinson. 2019. Efficacy of metamitron as a postbloom thinner – the American Northeast experience. *Acta Hort.* (in press). Francescatto, P., Lordan, J. and Robinson, T.L. 2019. Precision crop load management in apples. *Acta Hort.* (in press).

Robinson, T.L., J. Lordan and P. Francescatto. 2020. Irrigation of apples in a humid climate in wet and dry years. *Acta Hortic.* (in press).

Robinson, T.L., P. Francescatto and J. Lordan. 2020. Precision crop load management of apple. *Acta Hortic.* (in press).

Non-Refereed Technical

Robinson, T.L., P. Francescatto and J. Lordan. 2019. Precision pruning of Gala apples. *Fruit Quarterly* 27:(1):5-8.

Robinson, T.L., P. Francescatto, J. Lordan, A.N. Lakso and G.H. Reginato. 2020. Improvements to the Cornell Apple Carbohydrate Thinning Model – MaluSim. *Fruit Quarterly* 28:(1):27-35.

Abstracts of papers presented at professional meetings:

Robinson T., P. Francescatto and J. Lordan. 2019. Precision crop load management of apple. *International Symposium on Precision Management of Orchards and Vineyards* October 7-11. Palermo, Italy. Book of abstracts.

Robinson, T.L., J. Lordan and P. Francescatto. 2019. Irrigation of apples in a humid climate in wet and dry years. *International Symposium on Irrigation* June 20-23. Matera, Italy. Book of abstracts.

Francescatto, P., B. Carra, G. Fontanella and T. Robinson. 2019. Ethylene evolution of different apple cultivars varies in timing and intensity. *ASHS Annual Conference.* Las Vegas, NV, USA. Abstracts.

Extension Publications:

Agnello, A.M., A. Landers, D.A. Rosenberger, T.L. Robinson, J.E. Carroll, L. Cheng, P.D. Curtis, D.I. Breth, and S. Hoying. 2019. Pest management guidelines for commercial tree-fruit production 2019, p. 252. Cornell University, Ithaca, NY, USA.

Robinson, T.L. 2019. Precision Crop load Management for Apples. Proceedings of the 2019 Cornell Indepth Fruit School. Syracuse, NY March 25-27, 2019. 70 pages Cornell University, Geneva, NY, USA.

Robinson, T.L. and M. Miranda Sazo. 2019. Precision Chemical Thinning in 2019 for Gala and Honeycrisp. *Lake Ontario Fruit Newsletter* 2019(13):1-2.

Robinson, T.L. 2019. Precision Pruning with Bud Load Targets. *Lake Ontario Fruit Newsletter* 2019(13):1-2.

Robinson, T.L. and M. Miranda Sazo. 2019 Blossom Thinning in 2019. *Lake Ontario Fruit Newsletter* 2019(13):1-2.
Robinson, T.L. and M. Miranda Sazo. 2019 Blossom Thinning Wednesday-Friday. *Lake Ontario Fruit Newsletter* 2019(13):1-2.
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