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) plus carbaryl or benzyl adenine (BA, a synthetic cytokinin) plus carbaryl. Carbaryl, which is a carbamate insecticide, causes some thinning but also enhances the thinning efficacy of either NAA or BA. 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 in the US. In Europe, the European Commission prohibited the use of carbaryl in 2007, and in 2008 its use was no longer allowed. If carbaryl were removed from the market, apple growers in the Northeastern US would not achieve adequate thinning with NAA or BA alone. Since 2014, one US-based supermarket chain (Whole Foods Markets) has prohibited the use of carbaryl on apples they have purchased, even though it is still a legal product. In 2014, we began recommending 5 thinning strategies for growers who needed to thin without carbaryl as a result of Whole Foods Markets’ action (Robinson and Hoyer 2014). In addition, the Cornell crop load management program is currently researching the use of ACC (1-aminoacyclopropane carboxylic acid, a naturally occurring amino acid/precursor to ethylene, tested for late thinning at the 18–20-mm fruit stage), Metamitron (a photosynthesis inhibitor that creates a photosynthetic deficit in the tree), and ABA (abscisic acid), with promising results as thinners in apples.

Strategies for chemical thinning without carbaryl

1. Multiple thinning sprays: Probably the best approach to thinning without carbaryl is to use multiple thinning sprays beginning at bloom, and then use the precision thinning protocol to measure progress toward the target fruit number after each spray. Thus, a spray program for a hard to thin variety like Gala could begin at bloom with a 2% spray of ammonium thiosulfate (ATS) or a 10 ppm spray of NAA followed by a petal fall spray of NAA+Maxcel, followed by a 10–12-mm spray of NAA+Maxcel. A spray program for an easy to thin variety like McIntosh could begin at petal fall with a NAA+BA spray followed by a second spray of NAA+Maxcel at 10–12 mm. With good assessments after each spray using the fruit growth rate model followed by the carbohydrate model, growers could adjust rates to achieve the target fruit number.

2. Higher rates of NAA: Thinning with NAA alone requires higher rates than when thinning with combination sprays of NAA+carbaryl. A good rule of thumb is to increase the rate of NAA by 50% over the rate you have used when combined with carbaryl. For example, if in the past you used 5 ppm NAA+carbaryl on McIntosh, now you should use 7.5 ppm NAA alone. Likewise, if you used 7.5 ppm NAA+carbaryl on Empire in the past, you should now use 10 ppm NAA alone. However, very high rates of NAA can cause a temporary fruit growth stunting, and a negative effect on final fruit size. Thus, we recommend not exceeding 10 ppm, even though up to 20 ppm will give more thinning.

3. Mixtures of BA and NAA: BA alone is a weak thinner and requires very high rates for effective thinning. However, high rates (above 150 ppm) can cause lateral bud break, which we don’t want. Thus, a high rate of BA alone is not a good solution. Carbaryl gives a synergistic effect with BA, which is the reason the mixture of BA and carbaryl is so useful. We have had very good success mixing BA and NAA for several varieties. In one study (Robinson 2006) we evaluated the mixture of BA and NAA on 12 varieties (Braeburn, Cortland, Delicious, Empire, Fuji, Gala, Gingergold, Jonagold, Jonamac, Liberty, McIntosh and Sansa). We had very successful thinning on 10 of the 12, but with Delicious and Fuji, we ended up with numerous pygmy fruits from this mixture. For small fruited varieties like Gala, Empire, Jonamac, etc., growers can use the combination of BA+NAA. Our studies indicated that 7.5 ppm of NAA could substitute for the carbaryl. Thus, if in the past a grower thinned Gala with 75 ppm BA+1 pt Sevin, now he/she could spray 75 ppm BA+7.5 ppm NAA.

4. Additions of oil to BA: Small amounts of spray oil (1 pt/100 gallons) added to a spray of BA can increase thinning efficacy, since the oil acts as a penetrant. With most BA sprays, only a small fraction of the spray deposited on the leaf or fruit is
absorbed into the plant, where it can act as a thinner. Commercial BA formulations come with a surfactant already added to improve uptake, but more uptake can be achieved with oil. However, the use of oil carries its own risks of inducing russetting if Captan is applied shortly before or shortly after the BA+oil spray. This is especially true if the BA+oil spray is applied from petal fall to 15 mm or following a frost. We have given the following urgent caution since 2014: Do not use oil as a surfactant with BA if you are using a Captan program from petal fall to 15 mm. The situation where BA+oil is most useful is with Delicious and Fuji where NAA causes pygmies. For these two varieties, we suggest a thinning program that does not use NAA, but rather BA. However, to get enough thinning response from the BA, growers must use some oil to get greater uptake. If in the past on your Red Delicious or Fuji you used 100 ppm BA+1pt of carbaryl, now growers can use 100 ppm BA+1 pt of oil.

5. Additions of Regulaid to NAA: The use of regulaid (1pt/100) with NAA can significantly increase the thinning efficacy of NAA. The Regulaid increases uptake of NAA in a similar manner to oil's effect on BA uptake. The use of Regulaid is very common in WA state, but not so common in NY because of the risk of overthinning in some years, and the risk of russetting due to increased Captan uptake when Captan is used shortly before or after a NAA spray that contains Regulaid. Thus, we have given the same caution as with BA+oil: Do not use Regulaid as a surfactant with NAA if you are using a Captan program from petal fall to 15 mm. If Regulaid is used, it can essentially substitute for the carbaryl. For example, if in the past a grower used 5 ppm NAA+carbaryl on McIntosh, now he/she can use 5 ppm NAA+1pt/100 of Regulaid. Likewise, if in the past you used 7.5 ppm NAA+carbaryl on Empire, now you could use 7.5 ppm NAA+1pt/100 of Regulaid.

A cooperative effort to develop a long-term mechanical blossom thinning strategy in Western NY

The first mechanical blossom thinning trials were conducted in apples in North America in Pennsylvania (2007), Washington (2009), and Canada (2010). In Europe (mainly in Italy, Germany, Catalonia, and Switzerland), there has been a significant amount of research with mechanical blossom thinning conducted since 1996. Even though fire blight is also a concern, the rise in organic production and the lack of registered thinners has also increased the implementation of mechanical thinning during the last years. There are approximately 600 string thinner machines being utilized for pome and stone fruits in Europe at this moment. In the US, we first knew about the successful use of a string thinner in 2013 by a Quebec apple grower (Louis Cournoyer), who spoke at the 56th IFTA Annual Conference intensive workshop, “Insights into Innovative Orchard Technology”, in Boston on 23 February 2013. A few Western New York growers who attended the workshop (Kevin Bittner, Mark Russell, and Jill McKenzie) were interested in Louis’s mechanical thinning experience and offered a string thinner and trees for preliminary on-farm non-replicated trials in 2013 (data not shown in this article). In the spring of 2014, Adolf Beltz (a German apple grower and manufacturer of the Darwin string thinner machine) travelled to New York, assisted by Matt Peters (Bartlett Company, Ontario, Canada) and showed Jason Woodworth (apple grower, Lamont Fruit Farm, Inc.) how to use the Darwin machine in Super Spindle apple trees. From this cooperative effort we learned: (1) the optimal and safe application timing during apple bloom, (2) how to maneuver, calibrate, and select the tractor speed and the thinning severity of the Darwin machine for light, medium, and heavy bloom conditions, and more importantly, (3) how to position the string thinner regarding the tree canopy structure to minimize damage to the spur leaves, reproductive and vegetative structures (Figures 1–3).

In 2014, there was significant interest in economical and safe nonchemical thinning strategies for use in high-density apple orchards as a result of Whole Foods Markets’ action. The main objective of this study was to evaluate the use of a single spindle string thinner on two high-value apple cultivars in the Western NY fruit region for three consecutive years. The specific goals were (1) determine the proper thinning severity for Honeycrisp and Gala, (2) verify the potential spread of fire blight under the more humid NY weather climate compared with other regions in Europe, (3) supplement the mechanical thinning with other chemical treatment to enhance fruit size, and (4) measure return bloom and potential yields.

Materials and Methods

We conducted two string thinner studies (2.5 acres total) on mature Gala and Honeycrisp apple trees on B.9 rootstock at 2 ft x 11 ft spacing over a period of three years (2014, 2015, and 2016). The Gala and Honeycrisp trees were 7 and 9 years old.
at the beginning of this study, respectively. Both were trained to a Super Spindle apple system at Lamont Fruit Farm Inc., Waterport, New York. The shape of the canopy was a narrow tree wall. The string thinner (Darwin machine) consisted of a tractor-mounted frame with a 10-ft tall vertical spindle in the center of the frame. Attached to the spindle were 54 steel plates securing a total of 216 plastic cords, each measuring 2 ft in length. Speed of the clockwise rotating spindle was adjusted with a hydraulic motor. The string thinner spindle was operated at 220 or 240 rpm in 2014, 200 or 220 rpm in 2015, and 180 or 200 rpm in 2016. Each year, the mechanical thinner was driven through the orchard rows at the same speed of 5 miles/hour. All treatments were applied at 70–80% bloom stage for the king flower, and balloon stage for the laterals for Gala and Honeycrisp, on 17 May 2014; for Gala on 10 May 2015, for Honeycrisp on 11 May 2015, for Gala on 13 May 2016, and for Honeycrisp on 18 May 2016.

The specific treatments for Gala were: Control apple trees that received the grower standard chemical thinning program; 2% ATS at bloom, 2 pt/A Sevin XLR at petal fall, 1 gal/A Maxcel + 2 pt/A Sevin XLR at the 8–10 mm fruit stage, and 1 gal/A Maxcel + 2 pt/A Sevin XLR at the 12–14 mm fruit stage (without the use of the string thinner). The grower standard program was compared against 4 string thinning treatments in 2014 (2 treatments were followed with 1 Maxcel application @ 16 oz/A), 4 string thinning treatments in 2015 (2 treatments were followed with 1 Maxcel application @ 32 oz/A), and 6 string thinning treatments in 2016 (4 treatments were followed with 1 or 2 Maxcel applications @ 64 oz/A) (Table 1).

The specific treatments for “Honeycrisp/B.9” were: Control apple trees that received the grower standard chemical thinning program; 2% ATS at bloom, 2 pt/A Sevin XLR at petal fall, and Fruitone L 4.25 oz/A + 2 pt/A Sevin XLR at the 8–10 mm fruit stage (without the use of the string thinner). The grower standard program was compared against the same number of string thinning treatments as used for Gala. Maxcel rates were not the same for both cultivars in year 3 (see rates and results in Table 1). A streptomycin application was made after the string thinner treatments were applied in 2014, 2015, and 2016. Minimal hand thinning was conducted in order to break clusters of fruit each year.

The two field experiments were designed as randomized complete blocks, with five replications consisting of 50 trees per plot. Each year, Gala or Honeycrisp trees received consistent...
<table>
<thead>
<tr>
<th>Variety/rootstock</th>
<th>Darwin Rotational Speed (rpm)</th>
<th>Chemical</th>
<th>Fruit Number (N’fruit/tree)</th>
<th>Yield/tree (kg)</th>
<th>Yield/acre (bu)</th>
<th>Yield/ha (t)</th>
<th>Fruit size (g)</th>
<th>Adjusted Fruit Size (g)</th>
<th>Crop Value ($/acre)</th>
<th>Fruit Color (%)</th>
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</thead>
<tbody>
<tr>
<td>Gala/B.9</td>
<td>220</td>
<td>No Maxcel</td>
<td>55.8 b</td>
<td>8.6 bc</td>
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### 2015 Results

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<th>Variety/rootstock</th>
<th>Darwin Rotational Speed (rpm)</th>
<th>Chemical</th>
<th>Fruit Number (N’fruit/tree)</th>
<th>Yield/tree (kg)</th>
<th>Yield/acre (bu)</th>
<th>Yield/ha (t)</th>
<th>Fruit size (g)</th>
<th>Adjusted Fruit Size (g)</th>
<th>Crop Value ($/acre)</th>
<th>Fruit Color (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gala/B.9</td>
<td>220</td>
<td>No Maxcel</td>
<td>51.9 ab</td>
<td>12.3 ab</td>
<td>1342 ab</td>
<td>60.1 ab</td>
<td>215.0 a</td>
<td>-</td>
<td>23,633 ab</td>
<td>-</td>
</tr>
<tr>
<td>Gala/B.9</td>
<td>220</td>
<td>Maxcel</td>
<td>41.3 bc</td>
<td>10.1 bc</td>
<td>1107 bc</td>
<td>49.6 bc</td>
<td>244.6 a</td>
<td>-</td>
<td>19,961 b</td>
<td>-</td>
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<tr>
<td>Honeycrisp/B.9</td>
<td>220</td>
<td>No Maxcel</td>
<td>33.7 c</td>
<td>9.0 bc</td>
<td>978 bc</td>
<td>43.8 bc</td>
<td>268.7 a</td>
<td>-</td>
<td>18,693 b</td>
<td>-</td>
</tr>
<tr>
<td>Honeycrisp/B.9</td>
<td>220</td>
<td>Maxcel</td>
<td>33.1 c</td>
<td>8.7 c</td>
<td>953 c</td>
<td>42.7 c</td>
<td>273.9 a</td>
<td>-</td>
<td>17,985 b</td>
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**Contrast Maxcel vs. No Maxcel**

**LSD P=0.05**

### 2016 Results

<table>
<thead>
<tr>
<th>Variety/rootstock</th>
<th>Darwin Rotational Speed (rpm)</th>
<th>Chemical</th>
<th>Fruit Number (N’fruit/tree)</th>
<th>Yield/tree (kg)</th>
<th>Yield/acre (bu)</th>
<th>Yield/ha (t)</th>
<th>Fruit size (g)</th>
<th>Adjusted Fruit Size (g)</th>
<th>Crop Value ($/acre)</th>
<th>Fruit Color (%)</th>
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</thead>
<tbody>
<tr>
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<td>220</td>
<td>Maxcel</td>
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<td>6.6 a</td>
<td>722 a</td>
<td>32 a</td>
<td>142 a</td>
<td>141 a</td>
<td>5,103 a</td>
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</table>

**Contrast Maxcel vs. No Maxcel**

**LSD P=0.05**

### 2015 Results

<table>
<thead>
<tr>
<th>Variety/rootstock</th>
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</thead>
<tbody>
<tr>
<td>Gala/B.9</td>
<td>220</td>
<td>No Maxcel</td>
<td>44 a</td>
<td>7.1 a</td>
<td>776 a</td>
<td>35 a</td>
<td>160 a</td>
<td>160.0 a</td>
<td>6,810 a</td>
<td>-</td>
</tr>
<tr>
<td>Gala/B.9</td>
<td>220</td>
<td>Maxcel</td>
<td>37 a</td>
<td>5.8 a</td>
<td>632 a</td>
<td>28 a</td>
<td>152 a</td>
<td>155.0 a</td>
<td>5,364 a</td>
<td>-</td>
</tr>
<tr>
<td>Gala/B.9</td>
<td>220</td>
<td>No Maxcel</td>
<td>49 a</td>
<td>7.3 a</td>
<td>792 a</td>
<td>36 a</td>
<td>149 a</td>
<td>147 a</td>
<td>5,543 a</td>
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**Contrast Maxcel vs. No Maxcel**

**LSD P=0.05**

### 2016 Results

<table>
<thead>
<tr>
<th>Variety/rootstock</th>
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<td>632 a</td>
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<td>978 a</td>
<td>44 a</td>
<td>274 ab</td>
<td>272 ab</td>
<td>18,843 a</td>
<td>-</td>
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</tbody>
</table>

**Contrast Maxcel vs. No Maxcel**

**LSD P=0.05**

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1 In 2014, a Maxcel rate of 16 oz/A was applied to Gala and Honeycrisp at the 8–10 mm fruit stage (1 spray).
2 In 2015, a Maxcel rate of 32 oz/A was applied to Gala and Honeycrisp at the 8–10 mm fruit stage (1 spray).
3 In 2016, a Maxcel rate of 64 oz/A was applied to Gala 1 time at the 6–7 mm fruit stage or 2 times at the 8–10 mm fruit stage. A lower rate of Maxcel of 32 oz/A was applied to Honeycrisp 1 time at the 6–7 mm fruit stage or 2 times at the 8–10 mm fruit stage.
treatment with the string-thinning machine, as the rotational speed was adjusted. For example, the same rows that were treated at 240 rpm in 2014 were treated at 220 rpm in 2015 and were finally treated at 200 rpm in 2016 (the same adjustment occurred for the rows that were originally treated at 220 rpm in 2014, then at 200 rpm in 2015, and finally at 180 rpm in 2016). Return bloom evaluations were conducted in May 2015 and 2016. In September of each of the three harvest seasons, whole tree fruit counts and fruit weight of three data trees per plot in 2014 and 2015 and of four data trees per plot in 2016 were collected at harvest, one time for Gala and two times for Honeycrisp. Percent fruit color was also assessed for each cultivar at the NYS Agricultural Experiment Station in Geneva in October 2016.

**Results**

**Effects of mechanical blossom thinning treatments on fruit set, fruit number, fruit size, fruit weight, and yield**

**Gala**

In 2014, all string thinning treatments reduced fruit set and fruit number, and did not increase fruit size. The string thinning treatment applied at 240 rpm without Maxcel caused much greater thinning than the string thinning treatment applied at 220 rpm followed by Maxcel or not. Maxcel applied at 8–10 mm did not improve fruit size and had minimal effect. String thinning at 240 rpm caused as much as a 40-g decrease in fruit weight compared with the control trees.

In 2015, all string thinning treatments reduced fruit set and did not significantly reduce fruit size, fruit weight, and fruit numbers compared with the control trees. Maxcel applied at 8–10 mm did improve fruit size and had a better effect than in 2014. The string thinning at 220 rpm and the string thinning at 220 rpm followed by Maxcel caused as much as a 7-g and 2-g decrease in fruit weight compared with the control trees, respectively. The 220 rpm speed resulted in a much safer speed than the 240 rpm in 2014.

In 2016, the string thinning at 200 rpm (alone or in combination with Maxcel) was a more effective thinning treatment than 180 rpm. Maxcel applied early at 4–6 mm and then at 8–10 mm improved fruit size and had a substantial effect on Gala fruit growth. Overall, two Maxcel sprays were better than one Maxcel spray. The string thinning at 200 rpm followed by two Maxcel applications caused as much as a 4-g decrease in fruit weight. Also, the number of fruit per tree and the yield were not statistically different compared with the control trees. Darwin 180 rpm (alone or followed by one Maxcel spray) did not thin effectively and had 35 and 42 more fruit on the trees compared with the control trees, respectively.

**Honeycrisp**

In 2014, all string thinning treatments reduced fruit set, fruit number, and did not increase fruit size and crop value. These 2014 results were similar when compared with Gala except that the effect on fruit size was non-significant but there was still a reduction in crop value. A 30-g decrease in fruit weight was the highest difference between the control trees and the string thinning treatment applied at 220 rpm without the use of Maxcel.

In 2015, all string thinning treatments (for both rotational speeds with or without Maxcel) did not significantly reduce fruit number/tree and yield (kg/tree) at harvest. The string thinning treatment applied at 200 rpm followed by Maxcel increased fruit size and was not statistically different from the control trees. There were as much as 48-g and 21-g increases in fruit size from the string thinning treatments at 200 rpm and 220 rpm followed by Maxcel, respectively. The highest fruit weight reduction was achieved with the string thinning treatment at 200 rpm without Maxcel, and there was a 55-g decrease in fruit weight compared with the control trees.

In 2016, all string thinning treatments significantly affected yield, fruit number, and fruit size compared with the control trees at harvest. For example, the most productive treatment (kg fruit/tree) was measured with the string thinning at 180 rpm plus two Maxcel sprays, followed by the string thinning at 180 rpm plus one Maxcel, the control trees, and the string thinning at 200 rpm without Maxcel. The higher number of fruit per tree was evaluated with the string thinning at 180 rpm plus two Maxcel sprays, followed by string thinning at 180 rpm plus one Maxcel, the string thinning at 180 rpm without Maxcel, and the control trees. The string thinning at 200 rpm followed by two Maxcel sprays did not significantly reduce fruit size compared with the control trees. There were as much as 24-g and 29-g increases in fruit size from the string thinning treatments at 180 rpm and 200 rpm followed by two Maxcel sprays, respectively.

**Effects of mechanical blossom thinning treatments applied on May 2014 and 2015 on return bloom of Honeycrisp and Gala**

**2015 Results (data not shown):** String thinner treatments had a negative effect on return bloom of Honeycrisp. There were fewer blossom clusters per tree when the string thinner spindle was operated at 240 rpm in 2014. Based on the negative effect on return bloom of Honeycrisp, we decided to decrease the rotational speed from 240 rpm to 220 rpm in 2015. String thinner treatments had a positive effect on return bloom of Gala. There was no reduction in blossom clusters per tree in the low, medium, or upper sections of the trees. The 220 rpm-treated trees had the higher number of blossom cluster per tree.

**2016 Results (data not shown):** String thinner treatments again had a negative effect on return bloom of Honeycrisp. There were fewer blossom clusters per tree when the string thinner spindle was operated at 220 rpm in 2015. However, based on the negative effect on return bloom of Honeycrisp, we decided to decrease the rotational speed from 220 rpm to 200 rpm and from 200 rpm to 180 rpm in 2016. Both string thinner treatments and the treatments followed by Maxcel did not significantly reduce the blossom clusters per tree in the low, medium, or upper sections of the Gala trees compared with the grower standard trees. In both 2015 and 2016, the reduction on the rotational speed of the Darwin was the same. The effects of mechanical blossom thinning treatments applied on May 2016 on return bloom of Honeycrisp and Gala will be evaluated in early May 2017.

**Discussion**

We began this three-year study with very disappointing results for Gala in 2014. At harvest we measured a significant reduction in Gala fruit size and yield from the string thinning
treatments, which also reduced crop value. The string thinning treatments applied at 220 or 240 rpm caused as much as a 30- and 40-g decrease in fruit weight compared with the control trees. The addition of Maxcel to the mechanical thinning program did not improve fruit size or crop value compared with the grower standard chemical thinning program. The Gala control trees used for this study received multiple sprays of Maxcel, which likely stimulated cell division and gave larger fruit size, while the string thinner treatments reduced spur leaf area, which likely inhibited initial fruit growth and cell division. The string thinning treatment at 240 rpm was too invasive in the tree canopy. Damage to the spur leaves and reproductive and vegetative structures was significant with this rotational speed. Increasing the rotational velocity of the string thinner (from 220 to 240 rpm) caused more string contact with the narrow canopy and increased leaf damage, especially for Honeycrisp. This higher rpm removed more Honeycrisp blossom clusters, spur leaves, and broke fruiting shoots compared with Gala. The most severe treatment removed 100 more Honeycrisp spur leaves compared with the control (data not shown). As the spindle speed of 220 rpm provided the best overall thinning response and minimized injury to leaves, this was the rotational velocity tested the following year. In 2015, on the Honeycrisp or Gala rows that were treated the previous year at 220 rpm and 240 rpm, we reduced string thinner speeds to 200 and 220 rpm, respectively.

The canopy width for Gala and Honeycrisp trees was narrowed and improved through mechanical dormant pruning followed by manual pruning, to obtain maximum and safe thinning efficiency with the string thinner. This narrowed canopy (24 inches width, 12 inches from the trunk) allowed the Darwin's driver to apply the machine closer to the trunk, so that when its cords hit the canopy, some also hit the trunk, fruiting branches, or the wires, retracting when they struck these surfaces. This method of application, more than the reduction of Darwin's speed in year 2, did effectively reduce the removal of entire spurs and the loss in spur leaf area as experienced in year 1. Our 2015 data indicate that string thinning treatments at 200 rpm and 220 rpm minimized spur leaf injury and provided the safest overall fruit thinning, with less than 4 and 2 blossom clusters removed per tree after the thinning treatment was applied for Gala and Honeycrisp, respectively (data not shown).

Although 2014 and 2015 were severe fire blight infection seasons, the risk of spreading fire blight after string thinning followed by an antibiotic was not a problem for the sensitive Gala cultivar used in this study. In 2014, the severity of thinning, even at the higher rotational velocity of 240 rpm, did not increase the incidence or severity of fire blight, even though an adjacent/grafted block had severe fire blight pressure. The environmental conditions before, during, and after bloom were also conducive to fire blight development in 2015. However, the second-year study again showed no increase in the severity of fire blight in May 2015. Our results are contradictory with past evaluations of the risk of spreading fire blight in apple orchards with a string thinner. The incidence and likelihood of fire blight infection were increased by using the machine in a Penn State study (Ngugi and Schupp 2009). They found that when a string thinner was used on non-inoculated trees immediately after thinning trees infected with fire blight, infection with fire blight was significantly increased in the previously non-inoculated trees. They also concluded that the use of a string thinner should be limited to orchards with no history of disease in the last 3 years, and on days when predicted weather is not suitable for tree infection by Erwinia amylovora; otherwise, a severe fire blight epidemic could develop in the orchard. Therefore, in deciding whether to use a string thinner, it is important to mention that additional fire blight work will be conducted at the NYS Agricultural Experiment Station in Geneva in the spring of 2017 (K. Cox, personal communication) to validate our positive results in orchards with a fire blight epidemic and determine the risks of string thinning in orchards that are infected with fire blight, but asymptomatic. Such efforts are needed before the technique can be fully recommended in our humid continental type climate.

The use of string thinning treatments in combination with 6-BA (Maxcel) proved to be a more successful strategy for fruit size enhancement in the second and third years of this study. Crop values were still lower compared with the chemical thinning programs, but closer. Because a single spray of Maxcel at a lower rate of 16 oz/A did not work for Gala in year 1, we tested a higher rate of 32 oz/A for enhancing Gala's fruit size without promoting additional thinning. The Maxcel “fruit size effect” desired for Gala (a small fruiting variety) was only achieved with Honeycrisp in 2014, although this effect was not our main research goal for this bigger cultivar. For Honeycrisp, we were more interested in evaluating the influence of mechanical thinning on return bloom, which was negatively affected in 2015 and 2016.

Today, US consumers are increasingly demanding larger Gala fruit (> 180–200 g fruit, ideally 88 sizes) and growers prefer to produce a bigger, high quality Gala than a smaller one outside the desired size range. Fortunately, the addition of a higher rate of Maxcel to the mechanical thinning program did improve fruit size or crop value compared with the control trees in year 2. In 2016, we increased the Maxcel rate to 64 oz/A for Gala and doubled down on the Maxcel applications, to see an even better improvement on Gala fruit size from the second application. In 2016, the Gala trees that were string thinned at 200 rpm followed by two Maxcel sprays did not significantly reduce fruit size compared with the control trees.

The uncertainties of optimal fruit set, ideal fruit distribution on branches, or similar crop values are valid concerns or aspirations for any grower considering mechanical blossom thinning as an alternative to chemical thinning without carbaryl. In this study, our grower cooperators were actively engaged and concerned that the apples tended to clump on the branches, and this may have affected color development in 2014 or 2015 (fruit samples not evaluated). In 2016, fruit samples were taken to measure fruit surface color distribution in Geneva. No treatment effects on color distribution were observed compared with the control trees for both cultivars.

**Conclusion**

After string thinning the same trees for 3 consecutive years, our data indicate that the use of a string thinner at 200 rpm, with 216 plastic cords, at a tractor speed of 5 mph, and in combination with 2 Maxcel sprays, was the most effective and safe mechanical thinning program for enhancing Gala’s fruit size in an orchard with a compact, rectangular box, and with shoots no more than 12 to 14 inches from the trunk. We have identi-
fied another strategy as a future alternative to thinning without carbaryl in apples. The adoption or transitioning to narrower tree wall systems will facilitate the use of this technology.

**Literature Cited**

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New York State Horticultural Society

EDUCATING, PROMOTING
and PROTECTING
New York’s Commercial Fruit Industry

Founded in 1855, the mission of the New York State Horticultural Society is to foster the growth, development and profitability of the fruit industry in New York State.

NYSHE accomplishes this by:
• Supporting educational opportunities for members
• Promoting the industry
• Representing the industry in matters of public policy

OBJECTIVES

Education - providing education programs for members that include:
• obtaining and disseminating information to the fruit industry
• sponsor and/or cooperate with other groups to provide and support tours
• sponsor trade shows
• cooperate with and encourage others to provide educational opportunities

Promoting the Fruit Industry by:
• promoting ideas which will benefit the economic health of the fruit industry
• educate the general public about the New York fruit industry

Representing the New York fruit industry by:
• Have cemented our role as legislative voice in both Albany and Washington, DC for the fruit industry
• representing the industry’s interest as well as other agencies and institutions

NYSHE ISSUES
• Pesticide Registrations
• Food Quality Protection Act
• Integrated Pest Management
• Agricultural Labor and Immigration
• Fruit Industry Economic Development
• Cornell Research and Extension
• Education Public Officials
• Educating Industry
• Food Safety