Fruit Notes

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Fruit Notes

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Cover: Apple fruitlets. Wes Autio photo.

It is Time to Rediscover Amid-Thin®

Duane W. Greene, James Krupa, and Maureen Vezina
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An important breakthrough in chemical thinning occurred in the late 1930's when it was discovered that the group of hormones known as auxins could cause fruitlet abscission. Two compounds in this hormone class that were especially effective were naphthaleneacetacetic acid (NAA) and naphthaleneacetamide (NAD, Amid-Thin). Both of these compounds ultimately were registered as thinners for use on apples and pears. Over time NAA became the preferred product, because it was a more potent thinner and appeared to perform better when used at the 7-to-14-mm fruit size stage, the time fruit are most vulnerable to chemical thinners. NAD was reserved for use as a bloom or petal-fall stages and especially on early maturing varieties. The Amid-Thin label was written in the 1950s and it remains essentially intact including use recommendations for cultivars such as Yellow Transparent, William Early Red, Early McIntosh and Wealthy, to mention just a few. The label and the use of Amid-Thin have remained essentially unchanged for the last 60 years. It has and continues to play a relatively minor role as a thinner on apples.

Why is is Important to Resurrect an old Thinner?

In years when bloom is heavy, it is important to start thinning early. The strategy of multiple times for thinner application has been emphasized by researchers and extension personnel across North America, and this approach is being embraced by the industry as a whole. The majority of thinning, however, is still done during the traditional thinning time, when fruit are at 7 to 14 mm in diameter. Successful thinning at this time is determined to a very large extent by the weather and especially how weather influences the carbohydrates present in the spurs. Development of the carbohydrate model and the fruit growth model recently have improved the precision of thinning at this time particularly when packaged in a Precision Thinning Program that has been championed by Terence Robinson and coworkers in New York, by Phil Schwallier in Michigan, and others. The weather, however, cannot be controlled, and it can only be imprecisely predicted, so considerable variability in thinning response can still be expected. Clearly, the ability to do significant and perhaps the majority of thinning earlier and safely would be advantageous and it would allow orchardists to use a less aggressive thinning program during the 7-to-14-mm fruit growth stage.

Blossom thinning has not been popular with growers in the East because weather events can occur after thinner application, such as frost or poor pollination weather, that can affect crop load. Caustic thinners can thin effectively, but phytotoxicity and the resulting damage to spur leaves may affect fruit size. Petal fall is a much more popular time to apply thinners for growers in the East, and a large percent of growers take advantage of this important thinning opportunity. Carbaryl has been the thinner of choice but its use is either being discouraged or forbidden by some retailers. Its use is not allowed in many European countries. Consequently, incorporating carbaryl in the future thinning programs is very much in question. NAA is a viable thinner that can be used at bloom and petal fall, but there is the perception that it can over thin when very warm temperatures follow application.

The biological responses of plants to NAA and NAD was studied in the 1930s. Plant responses such as epinasty and ethylene production were much less with NAD than when NAA was applied indicating that side effects, including more variable thinning due to weather, are much less likely. NAD is a stronger thinner than carbaryl, and based upon recent research, it appears to be quite safe. The goal of applying thinners at bloom and/or petal fall are to accomplish most of the thinning before fruit ever reach the 7 mm stage. The objective of research over the past couple of years has been to determine if Amid-Thin is a thinner we are looking for that can provide substantial yet safe thinning at bloom and/or petal fall.

Materials & Methods

In a block of mature Macoun/M.9 apple trees growing at the University of Massachusetts Cold Spring Orchard, 48 uniform trees were selected. At the pink stage of flower development two limbs per tree 10 to 15 cm in diameter were selected, tagged, and the diameter measured. At the pink stage of flower development, all blossom clusters were counted and the blossom cluster density calculated by dividing the number of blossom clusters by the limb cross-sectional area. Trees were blocked into 6 groups (replications) of 7 trees each based upon limb cross-sectional area. Within each replication trees were randomly assigned to receive one of the following 7 treatments:

Untreated control
Amid-Thin 40 ppm applied at bloom (May 19)
Amid-Thin 50 ppm applied at bloom (May 19)
Amid-Thin 40 ppm applied at petal fall (May 22)
Amid-Thin 50 ppm applied at petal fall (May 22)
Amid-Thin 40 ppm applied at bloom and petal fall (May 19 and 22)
Amid-Thin 50 ppm applied at bloom and petal fall (May 19 and 22)

Two hours following the petal-fall spray trees received about 0.5 inches of rain. The spray had dried by the time the rain started. In my experience, once a droplet dries you can expect at least an 80% response (or more) to an applied thinner.

At the end of June drop in July all persisting fruit on the tagged limbs were counted and the fruit set was calculated. In addition, each spur on all tagged limbs was examined and the number of fruit on each spur was recorded. At the normal harvest time on September 30, a 50-apple sample was randomly harvested from the periphery of each tree and weighed, and then the diameter of each was measured using a hand-held caliper.

Results

All Amid-Thin treatments appeared to reduce fruit set (Table 1, Figure 1). The results were statistically significant when expressed as fruit per cm^2 limb cross-sectional area and as fruit per 100 blossom clusters (% set). The 50 ppm treatments appeared to be slightly more effective than the 40 ppm treatments. The 40 ppm treatment applied at bloom was the least effective, and it was the not significantly different from the control trees. The thinning following application at either bloom or petal fall appeared to be very similar. It was interesting to note also that when applications were made at both bloom and petal fall, the thinner response appeared not to be additive. With the exception of trees that were treated with 40 ppm at bloom, Amid-Thin treatments reduced the number of spurs having 2 fruit per spur and increased the number of spurs carrying just one fruit (Table 2). The Amid-Thin treatments increased the weight of all fruit on treated trees although the differences were small and not statistically significant (Table 1). The weather for the 3 to 4 days following bloom and petal fall sprays was generally favorable and fell within the temperature and solar radiation range deemed acceptable.

Table 1. Effect of Amid-Thin (NAD) treatments applied at bloom, at petal fall and bloom, and at petal fall on fruit set and fruit weight of Macoun/M.9 apples in 2014.

			Fruit set		
Treatment[1]	Rate (ppm)	Timing	Number per cm^2 limb cross-sectional area	Number per 100 blossom clusters	Fruit weight (g)
Control	---		11.2 a	99 a	142
Amid-thin	40	Bloom	8.5 ab	79 ab	151
Amid-thin	50	Bloom	5.7 b	55 b	146
Amid-thin	40	Petal fall	7.8 b	75 ab	151
Amid-thin	50	Petal fall	7.6 b	66 b	164
Amid-thin	40	Bloom + Petal fall	7.9 b	69 ab	154
Amid-thin	50	Bloom + Petal fall	6.7 b	63 b	154

[1]Treatments applied as a dilute tree row volume spray of 125 gal/acre at bloom, May 19, and petal fall, May 22.
[2]Mean not followed by a common letter are significantly different at odds of 19 to 1 (Duncan's New Multiple Range Test, *P* = 0.05).

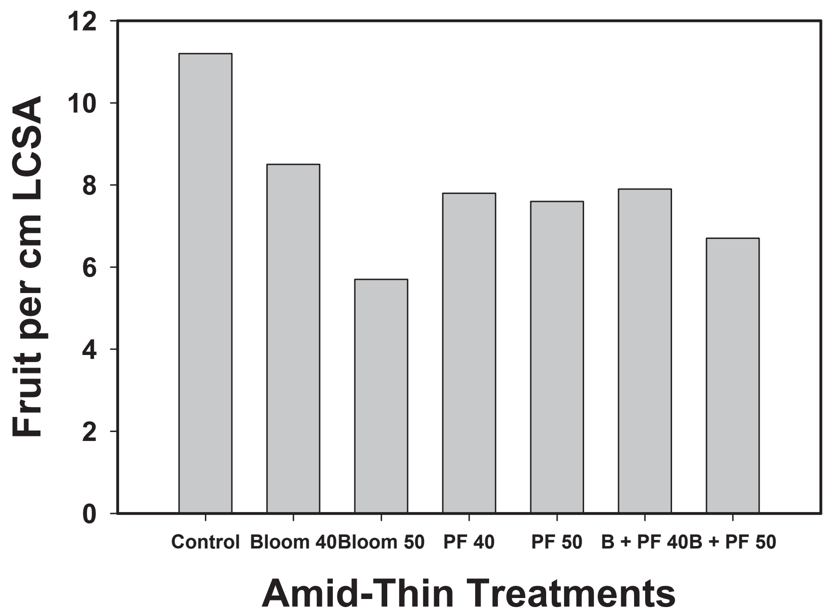

Figure 1. Influence of Amid-Thin time of application, concentration and number of applications on fruit set of Macoun/M.9 apples. 2014.

Discussion

The results presented here show convincing evidence that significant and effective thinning can be achieved by application of Amid-Thin at either bloom or petal fall. Petal fall has been the time suggested for the application of Amid-Thin, but the bloom timing appears to be comparably effective. Since no additional thinning was noted when Amid-Thin was applied a second time on some trees, it appears to show the carbaryl-like response of not showing a dose response. The fact that it appeared to be equally effective over different physiological stages and somewhat immune to additional sprays, it has demonstrated remarkable flexibility and safety in this investigation. We hope to confirm this in the 2015 thinning season.

The ideal crop load in this block is suggested to be about 6 fruit per cm^2 limb cross-sectional area, and in general, this amount of thinning was not achieved in this investigation. We rarely achieve an ideal thinning job with a bloom or petal-fall spray nor do we really want to. Many weather-related events can occur that are unforeseen and not controllable. Therefore, our hope is to reduce crop load enough so that only a modest thinner application can finish the thinning job. This we have achieved in this experiment. A concern is that the fruit size was not increased as much as would have expected given the amount of thinning. It appears that both modest thinning and a further increase in fruit size could be achieved by the use of MaxCel. This is a thinner that increases fruit size directly, and it is a modest thinner when used in the absence of carbaryl. This suggestion should be tested.

Table 2. Effect of Amid-Thin (NAD) treatments applied at bloom (B), petal fall (PF) and bloom, and petal fall on the percent single, double and triple fruit on individual spurs of Macoun/M.9 apples. 2014.

Treatment[1]	Rate (ppm)	Timing	Fruit per spur (%) Single	Double	Triple
Control	---		60	37	3
Amid-thin	40	Bloom	59	35	6
Amid-thin	50	Bloom	77	18	5
Amid-thin	40	Petal fall	67	29	4
Amid-thin	50	Petal fall	75	23	2
Amid-thin	40	Bloom + Petal fall	74	24	2
Amid-thin	50	Bloom + Petal fall	79	19	2

[1]Treatments applied as a dilute tree row volume spray of 125 gal/acre at bloom, May 22, and petal fall, May 22.

The results presented here are extremely encouraging in light of the increasing pressure from various external sources to eliminate the use of carbaryl in the thinning program. The results presented here are some of the most promising so far to identify an alternative thinner for carbaryl. The most attractive aspects of this work are its time of application and the ability to achieve meaningful and safe thinning at this early stage of fruit development. Thinners applied at bloom and petal fall are less influenced by weather conditions following application. When fruit grow to the 7 to 14 mm size, relatively small changes in weather can translate into fairly large responses to thinners. An additional advantage of thinning at this time is that there is more than ample time to apply a thinner later after initial set, and subsequent need for further thinning can be assessed. Naphthaleneacetic acid (NAA), a closely related thinner, can be used at these times as well, but it appears to show a greater amount of variability due in large part to its greater response to temperature changes, thus perhaps making NAA a more tenuous choice for thinning a bloom and petal fall when compared with Amid-Thin.

We gratefully thank AMVAC Chemical Company for providing the Amid-Thin® and for grant-in-aid funds which allowed us to conduct this experiment.

An Evaluation of Cornell-Geneva and Budagovsky Apple Rootstocks with Honeycrisp, the 2010 NC-140 Apple Rootstock Trial after Five Years

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The NC-140 Multi-State Research Committee has studied apple, peach, cherry, and pear rootstocks for nearly 40 years. Results from NC-140 trials form the basis for nearly all current North American rootstock recommendations. In 2010, an NC-140 apple rootstock trial was established at 14 locations with Honeycrisp as the scion variety and seven locations with Fuji. It included numerous named and numbered rootstock clones from the Budagovsky (Russia), Geneva (USA), and Pillnitz (Germany) breeding programs in comparison to standard Malling rootstocks.

Materials & Methods

As part of the 2010 NC-140 Apple Rootstock Trial, a planting of Honeycrisp on 31 rootstocks was established at the University of Massachusetts Cold Spring Orchard Research & Education Center in Belchertown, MA. In 2010, trees in this planting grew relatively little, but growth has been good in the subsequent seasons. The planting includes four replications in a randomized-complete-block design, with up to three trees of a single rootstock per replication.

Yield per tree was counted and weighed in 2013 and 2014, so data presented include both the 2014 yield and cumulative yield as the sum of 2013 and 2014. Yield efficiency was calculated for 2014 and cumulatively utilizing trunk cross-sectional

Table 1. Trunk cross-sectional area, cumulative root sucker number, and zonal chlorosis of Honeycrisp apple trees on various rootstocks in the 2010 NC-140 Honeycrisp Apple Rootstock Trial.[z]

Rootstock	Trunk cross-sectional area (2014, cm^2)	Tree height (2014, cm)	Canopy width (2014, cm)	Cumulative root suckers (2010-14, no.)	Zonal chlorosis (2014, % canopy affected)
B.9	6.3	238	128	4.8	24
B.10	10.4	281	175	0.0	24
B.7-3-150	18.1	344	194	0.9	20
B.7-20-21	17.3	306	185	2.8	48
B.64-194	21.3	366	200	0.0	16
B.67-5-32	19.6	337	182	1.2	21
B.70-6-8	19.9	348	188	0.5	20
B.70-20-20	34.7	388	245	8.8	12
B.71-7-22	2.0	143	71	3.2	57
G.11	8.7	290	190	8.4	33
G.41N	9.3	278	172	0.4	14
G.41TC	8.6	259	170	8.8	34
G.202N	19.8	353	232	24.5	24
G.202TC	12.6	292	215	14.8	38
G.935N	12.7	322	213	9.9	44
G.935TC	9.2	255	178	12.4	83
CG.2034	9.7	255	142	0.2	59
CG.3001	20.7	320	265	1.3	64
CG.4003	7.6	293	159	1.9	19
CG.4004	16.9	337	230	9.3	16
CG.4013	12.0	349	230	15.4	52
CG.4214	13.8	327	200	20.3	58
CG.4814	12.7	297	204	16.6	72
CG.5087	12.4	294	206	4.3	53
CG.5222	15.6	300	204	13.9	47
Supp.3	8.2	282	168	2.3	63
PiAu 9-90	16.0	282	178	0.0	81
PiAu 51-11	15.4	315	194	4.5	44
M.9 NAKBT337	10.0	290	175	10.2	33
M.9 Pajam 2	9.2	249	159	16.1	39
M.26 EMLA	9.8	282	185	7.7	30
HSD ($P = 0.05$)	7.6	74	56	19.3	45

[z] If two means in a column differ by more than the HSD, then they are significantly different at odds of 19 to1 (Tukey's HSD, P = 0.05).

area in October, 2014. Fruit size (weight) was calculated from total weight and number of fruit harvested per tree in both 2013 and 2014, so data presented here are for 2014 and the average weight of all fruit harvested in 2013 and 2014. Root suckers were counted and removed each year, so presented data are cumulative counts. Tree size (trunk cross-sectional area, tree height, and canopy width) was measured in October, 2014. Honeycrisp leaf yellowing (zonal chlorosis) was assessed after harvest in 2014 as the percent of the leaf canopy affected.

As an added assessment of the effect of rootstock on apple trees, each tree in the trial was rated subjectively as to its suitability for a Tall Spindle system, i.e. the "Clements Tall Spindle Index." The system utilized a scale from 0, indicating a tree poorly suited to tall spindle, to 3, indicating a tree excellently suited to tall spindle.

Table 2. Yield per tree, yield efficiency, and fruit weight in 2014 of Honeycrisp apple trees on various rootstocks in the 2010 NC-140 Honeycrisp Apple Rootstock Trial.[z]

Rootstock	Yield per tree (2014, kg)	Cumulative yield per tree (2013-14, kg)	Yield efficiency (2014, kg/cm^2 TCA)	Cumulative yield efficiency (2013-14, kg/cm^2 TCA)	Fruit weight (2014, g)	Average fruit weight (2013-14, g)
B.9	6.3	13.4	1.05	2.10	240	229
B.10	7.0	22.8	0.71	2.20	247	215
B.7-3-150	9.9	20.8	0.56	1.17	281	256
B.7-20-21	8.5	25.7	0.45	1.46	219	224
B.64-194	5.6	21.4	0.25	0.94	244	228
B.67-5-32	5.8	18.2	0.31	0.97	248	234
B.70-6-8	7.9	25.2	0.40	1.28	242	233
B.70-20-20	6.2	23.4	0.18	0.67	257	236
B.71-7-22	1.2	2.9	0.64	1.58	164	179
G.11	14.1	28.8	1.60	3.30	269	246
G.41N	12.3	26.7	1.35	2.84	263	244
G.41TC	10.0	18.1	1.08	2.00	259	241
G.202N	12.2	50.3	1.10	2.54	239	246
G.202TC	13.2	34.0	1.03	2.69	218	205
G.935N	17.6	42.2	1.36	3.26	229	221
G.935TC	3.1	18.2	0.40	2.04	206	201
CG.2034	7.0	14.0	1.09	1.96	247	231
CG.3001	10.8	52.9	0.53	2.53	248	224
CG.4003	12.0	25.6	1.57	3.29	188	209
CG.4004	13.5	40.1	0.77	2.35	248	232
CG.4013	6.4	29.4	0.54	2.36	206	210
CG.4214	11.0	26.7	0.77	1.93	234	238
CG.4814	10.5	31.0	0.83	2.46	212	213
CG.5087	6.4	28.9	0.52	2.09	259	234
CG.5222	6.7	21.9	0.44	1.42	205	206
Supp.3	6.4	18.3	0.73	2.21	223	214
PiAu 9-90	0.7	9.7	0.06	0.56	125	129
PiAu 51-11	5.7	19.7	0.34	1.27	249	238
M.9 NAKBT337	13.6	24.3	1.35	2.41	242	235
M.9 Pajam 2	6.0	17.7	0.60	1.92	222	211
M.26 EMLA	9.4	18.5	0.94	1.88	226	221
HSD (*P = 0.05*)	10.4	17.5	0.88	1.1	88	57

[z] If two means in a column differ by more than the HSD, then they are significantly different at odds of 19 to1 (Tukey's HSD, *P* = 0.05).

Results

At the end of the 2014 growing season, largest trees were on B.70-20-20, and smallest trees were on B.71-7-22 (Table 1, Figure 1). The largest number of root suckers were produced (cumulatively, 2010-14) by G.202N (Table 1). The greatest portion of the canopy affected by Honeycrisp zonal chlorosis was for trees on G.935TC and PiAu 9-90, and the lowest amount was assessed for trees on B.70-20-20, B.64-5-32, CG.4004, and CG.4003 (Table 1).

In 2014, yield was greatest from trees on G.935N and least from trees on PiAu 9-90 (Table 2). Cumulatively (2013-14), greatest yields were harvested from trees on CG.3001, and lowest yields were from trees on B.71-7-22 (Table 2). The most yield efficient trees in 2014 and cumulatively (2013-14) were on G.11, and the least were on PiAu 9-90 (Table 2, Figure 2). The largest fruit in 2014 and on average (2013-14) were harvested in from trees on B.7-20-21, and the smallest were harvested from those on PiAu 9-90 (Table 2).

The Honeycrisp trees rated most suited for the Tall Spindle system were on G.935N, G.202N, and CG.4214 (Figure 3). Honeycrisp trees deemed least suited for Tall Spindle were on B.70-20-20, B.71-7-22, PiAu 9-90, B.64-194, CG.2034, and B.9.

Discussion

Honeycrisp, obviously, is a weak scion cultivar,

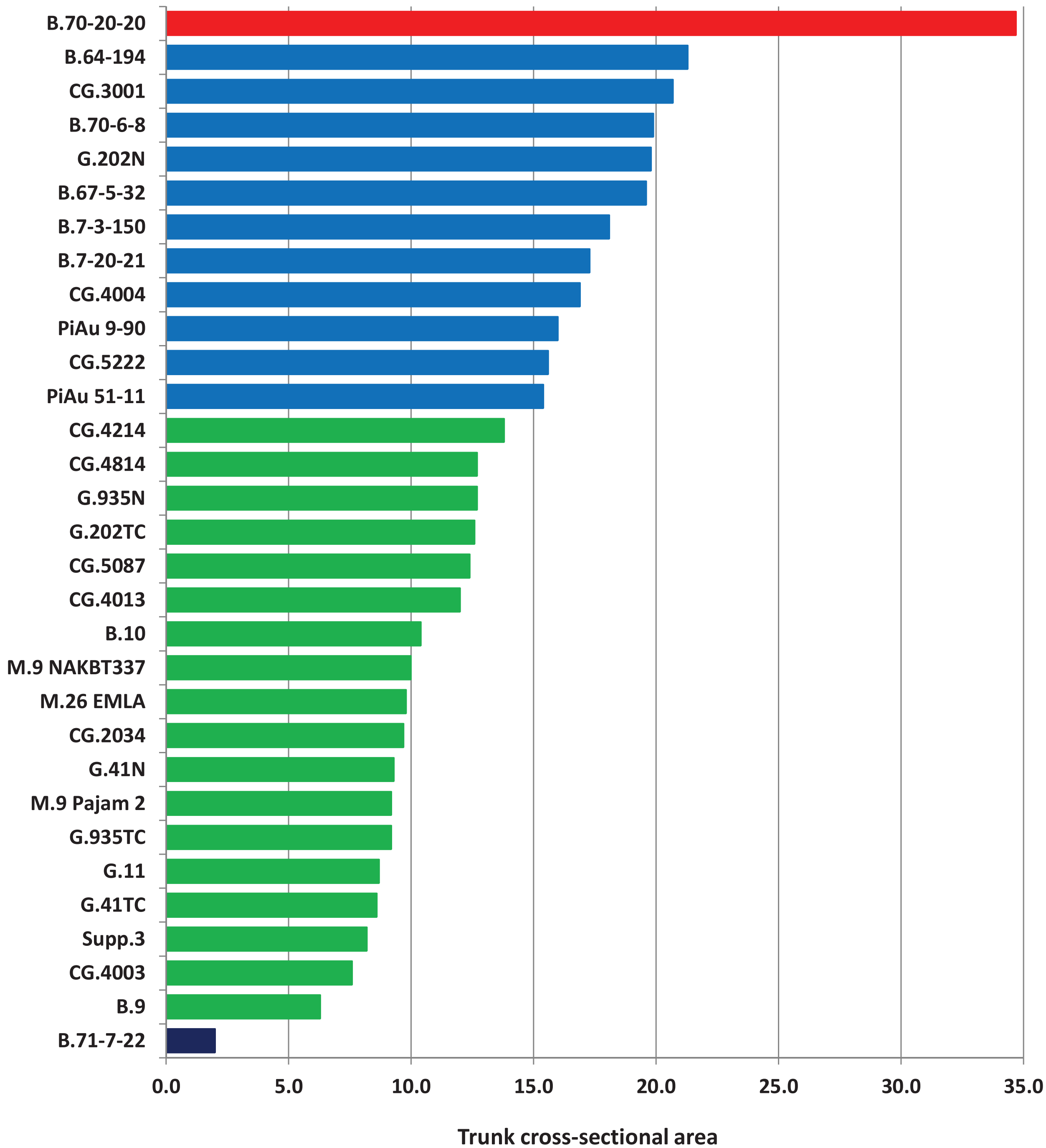

Figure 1. Tree size (trunk cross-sectional area) in 2014 of Honeycrisp apple trees on various rootstocks in the 2010 NC-140 Honeycrisp Apple Rootstock Trial. Bar color: red -- standard size tree; blue -- semi-dwarf tree; green -- dwarf tree; dark blue -- subdwarf tree.

and optimal rootstocks for Honeycrisp, may be different than those for more vigorous scions. That said, it is interesting to look at the results in a bit more detail. First, the bars in Figure 1 are color coded, with one red bar representing the standard-sized B.70-20-20. This rootstock clearly is not suitable for modern planting, too vigorous even for Honeycrisp. Blue bars represent those rootstocks that could be considered semidwarf,

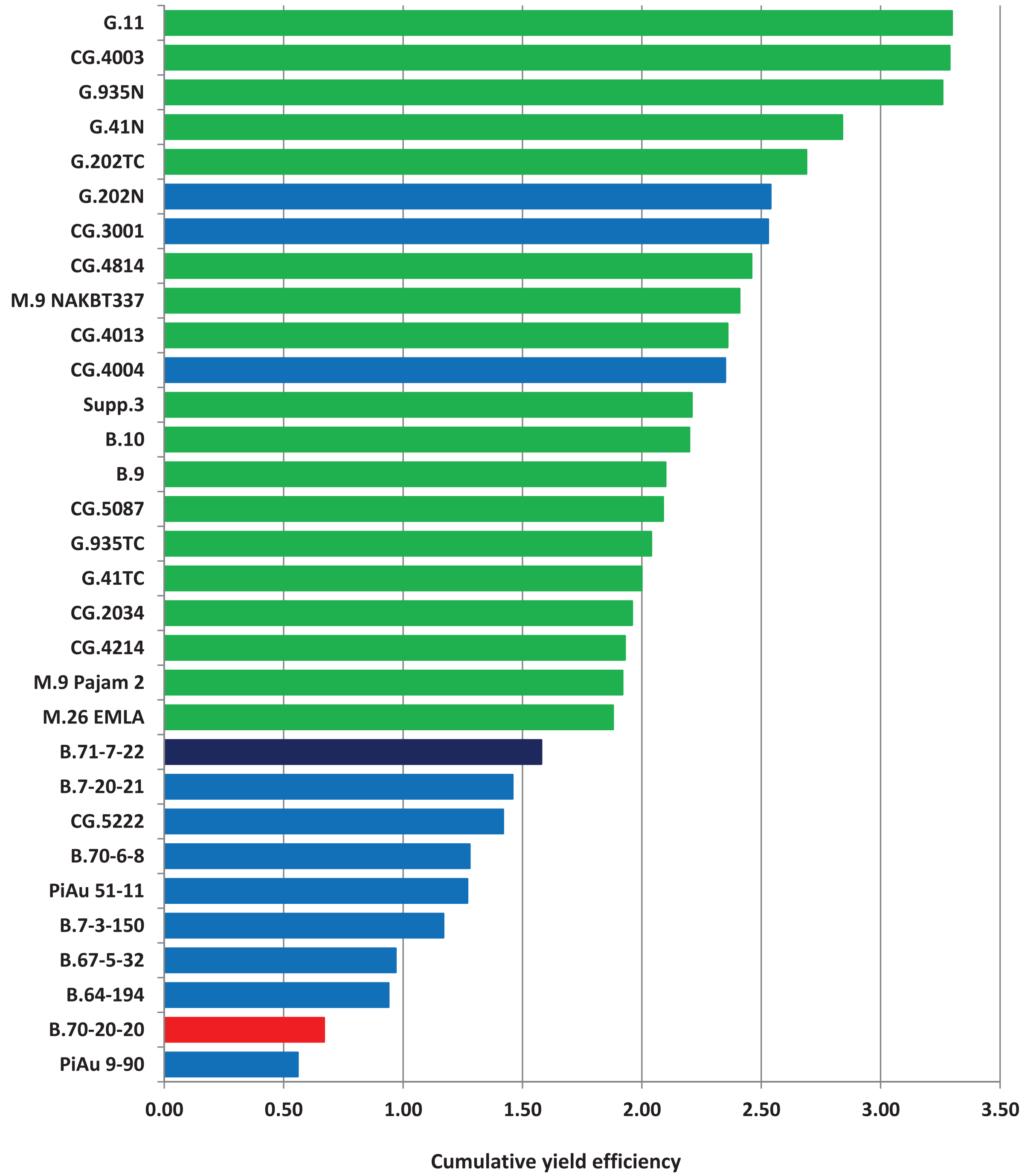

Figure 2. Cumulative yield efficiency (2013-14, yield per unit of trunk cross-sectional area) in 2014 of Honeycrisp apple trees on various rootstocks in the 2010 NC-140 Honeycrisp Apple Rootstock Trial. Bar color: red -- standard size tree; blue -- semi-dwarf tree; green -- dwarf tree; dark blue -- subdwarf tree.

green representing dwarf rootstocks. Dark blue represents the subdwarf B.71-7-22, which also is likely unsuitable for modern planting because of the low vigor.

In Figure 2, rootstocks are arrayed from the most yield efficient at the top to the least at the bottom. Trends are as you would expect, for the most part. Dwarf trees tend to be more efficient than semidwarfs. Notable exceptions include the semidwarf G.202N,

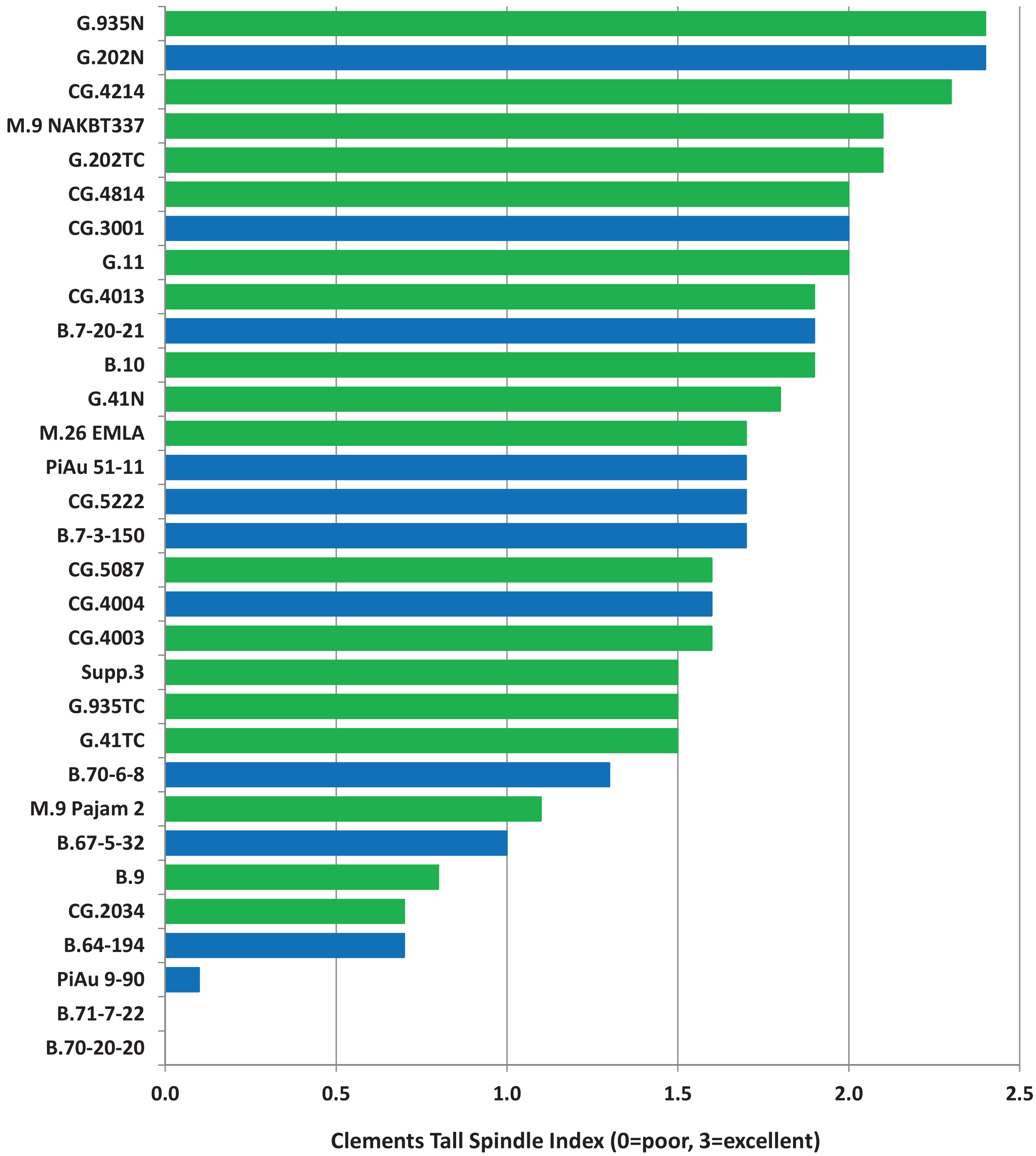

Figure 3. Horticultural rating (Clements Tall Spindle Index) in 2014 of Honeycrisp apple trees on various rootstocks in the 2010 NC-140 Honeycrisp Apple Rootstock Trial. Bar color: red -- standard size tree; blue -- semi-dwarf tree; green -- dwarf tree; dark blue -- subdwarf tree.

CG.3001, and CG.4004. All three of these rootstocks produced semidwarf trees that were quite yield efficient. The subdwarf B.71-7-22 was relatively low in yield efficiency. B.70-20-20 had very low yield efficiency, but the substantially weaker rootstock PiAu 9-90 was even less efficient (numerically).

The Clements Tall Spindle Index is a subjective assessment of trees just prior to harvest. Jon individually rated each tree from 0 to 3. Being a subjective index, there was a lot of variability in the data, but some results are clear. The very large trees on B.70-20-20 and the very small ones on B.71-7-22 were poor for the Tall Spindle system. Likewise, PiAu 9-90 was rated as very poor. Other vigorous and weak rootstocks also rated as poor. Amongst the others, both dwarf and semidwarf trees were in the highest categories. G.935N and G.202N rated the best. G.935N was among the largest dwarfs and the most yield efficient trees. G.202N was the most yield efficient semidwarf and among the largest semidwarfs. The ability of G.202N to perform well in this trial likely is due to the low vigor of Honeycrisp.

This trial is our first rootstock evaluation planted to a Tall Spindle System, and it is very interesting to follow these trees with more competition and in what is closer to a real world situation. In the next few years, more separation among the rootstocks will occur, and we will be able to make better recommendations as to their future value. At this point, however, several Cornell-Geneva rootstocks are performing very well, and the most of the new Budagovsky rootstocks are not.

Application of Blush® on Zestar!® Apple to Improve Red Skin Color

Jon Clements
University of Massachusetts Amherst

Zestar! apple has become a favorite of direct-market and small wholesale apple growers in the east and mid-west. It is harvested in late August to early September with very good early fall apple quality. (*Fruit Notes*, Volume 65, pp. 17-19. http://umassfruitnotes.com) Unfortunately, Zestar! does not develop particularly good red skin color, especially when August is warm. Red blush color of less than 50% is not unusual. Growers would like to see better red color on Zestar! in many years, particularly when the apples are packed and sold wholesale by the grower or broker to another retailer.

Blush can be applied pre-harvest "for red color enhancement in bi-color apple varieties" according the manufacturer, Fine Americas. The active ingredient of Blush, prohydrojasmon, promotes red color by increasing anthocyanin, the natural red pigment in apples. Blush has been successful in improving red skin color of Honeycrisp. Zestar!, being a bi-color apple, is a good candidate for trying to improve red color with Blush; however, no experimental trial applications of Blush have been made on this variety to date.

Materials & Methods

Blush was applied to a row of Zestar! apple trees at the UMass Cold Spring Orchard Research & Education Center in Belchertown, MA. The trees are approximately 150-gallons-per-acre dilute tree row volume. The row was divided into four replications, and two treatments: Blush vs. contrl. Each treatment group was 10 trees, therefore trees, therefore a total of 40 trees for each treatment. Two applications of Blush were made: July 30, 2014 and August 12, 2014. These timings represent about 30 and 14 days before anticipated harvest, respectively. Blush rate was 52 fluid ounces per acre, applied in a water volume of 75 gallons per acre

Figure 1. Blush-treated Zestar! apple tree on August 21, 2014 at UMass Cold Spring Orchard.

Figure 2. Control Zestar! apple tree on August 21, 2014 at UMass Cold Spring Orchard.

Figure 3. Zestar! apples treated with Blush evaluated for percent red skin over-color and red skin brilliance.

(2X). Both applications were made in the morning during fair weather and moderately rapid drying conditions.

Just before harvest on August 21, 2014 samples of 50 apples for each treatment x replicate group (200 apples total per treatment) were harvested from randomly selected trees in the middle of each treatment group. The 'best' apples were generally selected as would be representative of a first 'pick.' These apples were individually evaluated for percent red over-color and red 'brilliance' (1 = below average, 2 = average, 3 = above average) by an unbiased research technician.

Results

Blush-treated and control fruit did not differ in red color (51% for control and 47% for Blush) or red skin brilliance (2.2 rating for both: 1=below average, 2=average, 3=above average). Also see pictures of the trees and evaluated fruit (Figures 1-4).

Conclusions

Blush in this experiment did not improve red over-color or color brilliance of Zestar! apples. In addition, visual (subjective) evaluation of apples on the tree did not note any observable difference in color or color quality (brilliance) of the fruit. A better, more complete evaluation would have been to run a full pack-out of the harvested fruit. Personal communication with company representative suggests that only a 5-10% improvement of red color is observed, which can be difficult to ascertain visually, however, it will make a difference when all the fruit is run across a grading line and packed-out.

August of 2014 was a cool month and good color was generally observed on *all* apple varieties approach-

Figure 4. Zestar! control apples evaluated for percent red skin over-color and red skin brilliance.

ing harvest. Perhaps, application of Blush to Zestar! during a warmer pre-harvest maturity season would give different results. Timing and rates could also be adjusted. Application to larger (200 gallons per acre or larger) Zestar! apple trees with more 'green' fruit might also benefit from Blush application. Perhaps Blush just does not give enough measurable improvement to color of Zestar! apples to justify the expense? But, growers in the east and mid-west would for certain like to have a tool to significantly improve color of Zestar! apples, particularly those growers who bring Zestar! to a broker for packing and distribution to regional supermarkets.

Thanks to Kevin Forney, Fine Americas for supplying Blush for this experiment.

Proven Performers
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An Annual Fire Blight Management Program for Apples: An Update

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Seven years ago we wrote a guide for fire blight management in apples, stressing that fire blight needed attention every year. This followed a major epidemic in Massachusetts and other parts of the Northeast that occurred in 2007. Fire blight epidemics strike erratically, and often catch growers by surprise. In 2014, another major outbreak hit orchards from Pennsylvania/New Jersey to Nova Scotia, and we have decided to update our recommendations.

Fire blight frustrates growers and management consultants more than most apple diseases. Blight appears suddenly and moves quickly, and can cause significant damage in a matter of days. Orchards that have never had fire blight may suddenly be hit by an outbreak for no apparent reason. There are no foolproof ways to stop an epidemic in an orchard once it starts, and the chances that the disease may start up again the next year, and the next, are relatively high. Fire blight is both destructive and difficult to stop. Given how devastating a bad blight outbreak can be, it is important to be prepared.

There is an understandable but unfortunate tendency for people who have not experienced fire blight recently, or who have never faced it, to focus on other issues. But to keep an orchard fire blight free, it is critical that growers recognize that the potential for the disease is there every year, and use an appropriate management strategy. That strategy is to use multiple tactics in a year-round approach every year.

Know the Disease Cycle

Fire blight produces a well-known set of symptoms in a reasonably predictable cycle. Fire blight bacteria overwinter around the edges of cankers in tree wood, some of which may be very small and difficult to see. With warm weather, the bacteria produce a sugary, sticky ooze that attracts insects. The ooze with millions of bacteria in it sticks to insects, which then carry the bacteria to the apples and other plants they visit. When wind and rain come together, fire blight bacteria may be blown from tree to tree.

Blossom blight. Near bloom, the number of bacte-

Canker blight. The canker in this picture is active, with the bacterial ooze showing on the bark surface. (Photo: Utah State University) ria will increase rapidly if temperatures are above 65ºF, and the warmer it is, the more rapid the increase. Bloom provides the most important natural entry point for the bacteria, and moisture that is sufficient to wash them to the base of flowers. This water may come as rain, but sometimes a heavy dew or the water in an airblast spray application is enough to move the bacteria to the base of the flower. Once there, they can enter nectaries, will lead to infections. Pollinating insects will also carry bacteria from flower to flower at this time. Once inside the plant, if there are enough bacteria, they will start to produce a toxin that kills apple tissue, releasing the contents of cells, which the bacteria use as food. The blossoms and stem tissue around them turn brown or black and wilt.

Canker blight. When bacteria become active in overwintering cankers, the edges or margins of the canker become less distinct. A water-soaked band of green or brownish tissue forms between the dead canker interior and the healthy surrounding bark. With warm weather, the bacteria move from the canker margins systemically into the new parts of trees. Even without blossom blight infections, in orchards where blight is established canker blight can cause significant damage, and is a source of inoculum for shoot blight.

Shoot blight. Fire blight bacteria can travel from blossom infections into the vascular tissue of the plant to shoots. Alternatively, new, succulent shoots can be infected directly well after bloom by inoculum from infected fruit clusters or active cankers. It is not clear whether bacteria gain entry to apple shoots via insect feeding or some other mechanism. Young trees, 3 to 8 years old, develop shoot blight rapidly. Infections can move from shoots to the main trunk in a few days. Bacteria in shoot infections often move a few feet ahead of any visible symptoms. New shoot blight does not develop after terminal buds have set.

Rootstock blight. Sometimes, bacteria from a few infections in the blossoms or shoots of a tree will move into the trunk and down it without causing any visible symptoms. If the tree is on a sensitive rootstock, for example M9, the bacteria will infect and destroy the rootstock. Symptoms including wilting, poor growth, yellow or red leaves may show up in mid-summer to fall, though sometimes the damage is not discovered until the next growing season. This damage is most common on relatively young trees, and inevitably it kills them.

Trauma blight. Sometimes physical damage may

Top: Damage from blossom blight. Bacteria entered through the flowers in the fruiting cluster, and spread into leaves and the stem. Middle: Shoot blight symptoms early July. Bottom: Tree with rootstock blight, showing healthy scion and dead rootstock. (Photos: J. Clements, Univ. of Mass.)

also allow bacteria to enter plants and establish infections. Wind whipping and hail associated with summer storms are the most common cause such infections.

As growth slows and trees set terminal buds, fire blight bacteria stop moving. The tree becomes much more resistant to them, stopping the spread of infection in trees, and from tree to tree. In response, bacteria collect around the edges of damaged tissue, the canker margin, and wait for the plant tissue to start growing again the next spring.

Dormant fire blight canker. It should have been pruned out when the infected branch was pruned, rather than leaving it in the orchard. (Photo: M. Longstroth, Mich. State Univ.)

Watching the Microbe

Unfortunately, unlike insects and most other kinds of pests, bacteria cannot be seen. Populations of *Erwinia amylovora*, the bacteria that cause fire blight, are usually present at some level in all apple and pear orchards, on the surface of most apple trees and on other plants as well. There just are not enough of them to cause disease. But bacterial populations explode, and when they do, they can cause serious damage in very little time. To avoid that, assume that *E. amylovora* is always in an orchard, and steps need to be taken to keep the population below damaging levels. In the next sections, we outline a set of practices that should be done each year to accomplish that goal.

Winter

1 - Winter pruning. Dormant pruning of infected wood is critical to fire blight management. Even in “clean” orchards, it is important to look for possible cankers and remove them. This pruning gets fire blight primary inoculum out of the orchard, so that it will not be there to launch an epidemic in the spring. Applying copper or other chemicals will not kill bacteria inside cankers, but only affects bacteria on the surface. The wood that contains the bacteria has to be removed.

Green Tip

2 – Early season copper. Regardless of whether fire blight has been a problem in the past, at silver tip to green tip growers should apply copper to the orchard. Copper is applied because it is toxic to the fire blight bacteria. It is applied this early in the season because it can also be toxic to new apple leaves and fruit. Copper applied later than half-inch green will russet fruit. To be effective, copper residues need to cover the tree as thoroughly as possible - think dilute. The purpose of the copper is not to kill bacteria inside the tree, but rather to reduce build-up of bacteria on apple buds and bark. The more dilute the spray, the better the coverage and efficacy. To minimize the risk of russeting, apply when drying conditions are good, and avoid applying to wet foliage or when drying will be slow.

There are many types of copper. Formulations used on apples have generally been “fixed”, meaning that they are less soluble in water. Examples of the most common fixed coppers include basic copper sulfate, copper hydroxide, and copper oxychloride sulfate. Typical copper products contain from 20% to 50% metallic copper. Newer products, such as copper octanoate (Cueva) and copper ammonium (Previsto) contain less metallic copper (1.8% and 3.2%, respectively), and are being evaluated for use on apples against fire blight during active growth later in the growing season.

Because the amount of copper in different products varies, it is useful to think in terms of pounds of metallic copper applied per acre, though it isn’t always easy to calculate. Apply a minimum of 2 lb. of metallic copper per acre, as this should generally provide enough copper residue on bark and leaves through to pink to have some impact on bacteria without causing russet. Formulations vary in how well copper is retained, and of course weather will also have an impact, but the 2 lb./A rate of metallic copper is a reasonable rate for both efficacy and safety. If in doubt about how much metallic copper a product contains, use the high label rate recommended at silver to green tip. Copper may be used with oil (1 qt./100 gal.), which can act as a spreader/sticker for the copper. Copper also may be applied with a regular 3% oil spray applied at delayed dormant to quarter-inch green.

Because copper sprays are meant to suppress the population of *E. amylovora* in an orchard, spray the whole orchard, not just the most susceptible cultivars or places where fire blight has occurred in the past. Leaving some trees unsprayed by the early season copper application may leave places for the fire blight bacteria to build up to dangerous levels. The tolerant cultivars may not be damaged, but bacteria may mover to susceptible trees after copper protection has decreased or disappeared. The spray will also protect against apple scab for a week.

3 – Monitor for fire blight risk at bloom. Protecting trees at bloom is critical. The overwhelming majority of fire blight epidemics start at bloom, with bacteria carried from flower to flower by insects. Fire blight bacteria grow on flower pistils, and with rain or other moisture, move to nectaries at the bases of flowers where they get inside apple tissue. The shock waves from these primary infections will reverberate in an orchard through the summer and beyond, so it is essential that growers make a focused effort to stop blossom blight. Growers or their advisors should use a fire blight forecasting model.

There are several options that may be used to forecast fire blight risk. Probably the simplest solution is to use an on-line service, such as NEWA (Network for Environment and Weather Applications, Cornell), SkyBit which sells E-Weather Service (Bellefonte, PA) or Ag-Radar (University of Maine Extension), that provide weather-based fire blight risk forecasts. Note that New Jersey growers have free use of NEWA via 55 weather stations managed by Rutgers University. The NJAES covers the cost of funding NEWA on behalf of New Jersey Growers. Take advantage of this service! Note growers can also purchase their own weather station and subscribe to NEWA directly. http://newa.cornell.edu/

Ultimately these forecasts rely on one or the other of two models, CougarBlight developed in Washington State or MaryBlyt developed in Missouri and Maryland. See the article in the upcoming 2015 summer issue of Horticultural News Or Fruit Notes on fire blight forecast models for details on differences between these options. Independent crop consultants or university outreach may also give either on-line or individual forecasts of fire blight risk. Regardless of how it is done, it is critical that growers know what the fire blight risk is during bloom and take appropriate action.

4 – Spray streptomycin at bloom if needed. There are other antibiotics and products that can be used to manage fire blight, but the most effective and cost effective is streptomycin. In some areas, resistance to streptomycin has developed, but so far in New England no resistance has been found. Recently, organic growers lost streptomycin as an option. While some growers may need to consider alternatives, it is more difficult or expensive or both to use these products.

To preserve its effectiveness, streptomycin should not be overused. If risk of fire blight is low, then it should not be sprayed. The only time streptomycin should be used is when there is a predicted risk of fire blight during bloom. Streptomycin is not effective against cankers or shoot blight, and should not be used in protective sprays targeting either problem. Using it at this time promotes resistance. (There is one exception

Russet caused by copper on apple fruit. (Photo: T. Smith, Washington St. Univ.)

to this, and that is when there is a damaging "trauma" event such as a hailstorm, when streptomycin can be applied within 12 to 18 hours to reduce the risk of fire blight infection).

Streptomycin is sold under multiple brand names including Ag-Streptomycin, Agri-Mycin, AS-50, Bac-Master, Firewall, Harbour. There are other antibiotics available. Kasugamycin (Kasumin) is an antibiotic that is as effective as streptomycin, and can be used where resistance has developed to streptomycin. However, at this time Kasumin is significantly more expensive than streptomycin products. Oxytetracycline (FireLine, Mycoshield) is another antibiotic that is registered for fire blight on apples, but it is not as effective as streptomycin or kasugamycin.

There are several biopesticides registered for use against fire blight, but these also are not as effective as streptomycin. These products include Bloomtime (bacteria, *Pantoea agglomerans*), BlightBan (bacteria, *Pseudomonas fluorescens* A506), Serenade (bacteria, *Bacillus subtilis* qst 713), Double Nickel (bacteria, *Bacillus amyloliquefaciens* D 747), Actinovate (bacteria, *Streptomyces lydicus* WYEC 108) and Regalia (a plant extract from giant knotweed). Blossom Protect (yeast, *Aureobasidium pullulans*) is registered in some states, but not New England. The performance of these biologicals is less consistent than the antibiotics, particularly streptomycin. In tests where they have been effective, they at best achieve about half the level of control as streptomycin.

IInsects carry fire blight bacteria from apple blossom to apple blossom. Adapted from photo by Orangeaurochs from Sandy, Bedfordshire, United Kingdom [CC BY 2.0 (http://creativecommons.org/licenses/by/2.0)], via Wikimedia Commons

Streptomycin injury on apple leaves. (Photo: D. Rosenberger, Cornell Univ.)

Streptomycin has little ability to penetrate closed flowers; bloom must be open for the best effect. When streptomycin is applied to open flowers, those flowers generally will be well protected through petal fall. However flowers do not open all at the same time. Again - only open flowers at the time of the application are protected. New-formed fruit do not have an opening to allow bacteria to enter, and are much more resistant to infection. It is critical that streptomycin applications cover flowers well, so avoid poor spray conditions (wind, etc.) and no alternate row applications. Apply as high a water volume per acre as practical (100 gallons per acre minimum is suggested. Adding the nonionic spreader-activator Regulaid will improve coverage and uptake of streptomycin.

For maximum uptake, apply streptomycin when drying is slow. Evening or night applications are good, as light also breaks down streptomycin. Be careful about using Regulaid with some fungicides, such as captan, as uptake of captan into fruit can cause russet.

"Hopper burn" on apple (top). Browning along edges, curling and yellowing are typical of potato leafhopper damage on apple. (Photo: R. Bessin, Univ. of Kentucky Extension). Potato leafhopper adult and nymph (bottom). (Photo: Michigan State University).

(Many are recommending that Captan not be used until second cover. Instead, the EDBC fungicides should be used as protectants until then). Apply 8 to 16 oz. of formulated streptomycin (24 to 48 oz./acre) plus 1 pint of Regulaid per 100 gal in the first spray. If you have small trees and calculate tree row volume, do not drop below 12 oz. streptomycin product per acre. If no Regulaid or gylcerin is added, the minimum rate of streptomycin should be 24 ounces per acre.

While streptomycin may be concentrated in low volume sprays, Regulaid should be mixed based on the actual water volume. For example, if a sprayer holds 300 gal, and the spray rate is 50 gal per acre, at a rate of 12 oz. streptomycin per acre, put 60 oz of streptomycin in the tank with 3 pints of Regulaid.

When risk of fire blight remains high for several days during bloom it may be necessary to reapply streptomycin within two or three days of the first application because a significant number of new flowers open. In some cases, a third or fourth application may be required. Too much streptomycin in tissue can damage leaves, causing yellowing particularly around the leaf edges. It is not clear that this damage significantly impacts tree health or fruit yield. But if second, third or fourth applications are needed, use streptomycin alone at the 24 oz/A rate without Regulaid to minimize phytotoxicity.

5 – Deal with late blossoms. Another often overlooked problem with bloom sprays is that bloom is not synchronized across all trees in an orchard. It does not start or stop all at once. In any given cultivar, bloom may stretch over a week or two, and cultivars differ. As long as forecast models indicate a high risk of blight, and flowers are opening, streptomycin will need to be reapplied to them for protection.

Late blooming varieties, young trees, or cultivars that have a few late blossoms present a particular problem. As long as there are high numbers of bacteria and open flowers, blight can get started.

Remember that many of our newer cultivars have a significant amount of bloom occurring on one-year wood. This bloom is undesirable horticulturally as it produces small fruit which need to be thinned. It also may happen 7-10 days later than regular bloom. For these non-bearing trees, getting rid of the flower buds by pinching them off will remove the opportunity for bloom infections. But pinching can also open trees to infection. So, do not pinch off flower buds during wet weather, and apply streptomycin before pinching flower buds.

Finally, do not spray streptomycin after bloom. While limiting streptomycin to one to four applications during bloom has never been shown to cause resistance to streptomycin, spraying after bloom has. Spraying streptomycin after bloom has relatively little impact on fire blight, but will greatly increase the risk that *E. amylovora* will become resistant to it.

6 - Control leafhoppers- Once bloom is over, there is still a risk of new infections appearing as shoot blight. Shoot blight infections start on the very youngest two or three leaves at the end of a shoot, and the bacteria need some way to get into the leaves. Microscopic damage, the type caused by piercing and sucking insects, is enough. Whether leafhoppers actually carry bacteria from shoot to shoot is not known, but their feeding alone can open new leaves to infection if the population of bacteria on the leaf surface is sufficiently high. It is worth making sure that leafhoppers are controlled if conditions favor fire blight, and especially if there is fire blight in or near an orchard.

There are three species of leafhopper present in most orchards: 1) white apple leafhopper, 2) rose leafhopper, and 3) potato leafhopper. Of these, potato

Fire blight susceptibility ratings for apple rootstocks, listed in order of size reduction of the rootstock*			
Rootstock	**Fire Blight Rating**	**Rootstock**	**Fire Blight Rating**
Seedling	Tolerant	Geneva 11 (G.11)	Mod. resistant
MM.111	Tolerant	Ottawa 3 (O.3)	Susceptible
MM.106	Mod. susceptible	Geneva 16 (G.16)	Very resistant
M.7a, EMLA 7	Tolerant	M.9 strains	Very susceptible
CG. 6210	Resistant	Geneva 41 (G.41)	Highly resistant
Supporter 4	Highly susceptible	Bud. 9 (B.9)	Field tolerant**
Geneva 30 (G.30)	Highly resistant	Mark	Susceptible
Geneva 935 (G.935)	Highly resistant	Geneva 65 (G.65)	Very resistant
Geneva 202 (G.202)	Highly resistant	M.27, EMLA 27	Susceptible
M.26, EMLA 26	Highly susceptible		

*Adapted from NC 140 report, http://nc140.org/2011/rootstockcharacteristics.pdf
**Bud 9 is sensitive to fire blight in laboratory tests, but shows resistance in field tests, particularly on trees over 3 yr old

Root suckers at the base of an apple tree. (Photo: J. Clements, University of Massachusetts.

leafhopper has been most often implicated in the spread of fire blight. Potato leafhoppers are yellowish to pale green, and nymphs move sideways when disturbed. They overwinter in southern states and near the Gulf coast, move into our area in early June, and are present until the end of the season. Physical feeding injury will appear along leaf margins as a dried "burned" look, and may often be confused with nutrient deficiencies. Again, if fire blight is present, no PLH should be tolerated. They should be controlled with an insecticide.

7 – An Apogee decision for shoot blight. The growth regulator Apogee has the ability to control shoot blight. Under normal conditions, Apogee does not control blossom blight. It works by thickening cell walls, making them more resistant to bacterial attack. Unfortunately, Apogee has to be applied well before shoot blight symptoms are visible. It takes 10 days for the first application to take effect. At the same time, Apogee's primary purpose is to slow or stop tree growth, and this will impact how quickly a new planting can be developed and brought to optimum productivity. Ultimately the decision to use Apogee has to weigh the risk of shoot blight against growth inhibition.

Increasingly plant pathologists are recommending that growers use low rates of Apogee on all young trees (2 to 5 years in the orchard). In addition to age, the risk of shoot blight increases with the severity and number of bloom infection periods, the susceptibility of the cultivars and rootstocks in the orchard. Research indicates that 3 to 4 oz./ 100 gal. Apogee (9 to 12 oz./A dilute on 300 gal./A trees) applied at bloom and again 7 to 10 days later gives significant protection against shoot blight, while allowing trees to still grow and develop adequately. This rate is well below the 18 to 36 oz./A rate recommended for 300 gal./A trees on the Apogee label and the approach must be considered experimental. Correct timing is critical and rates must be adjusted according to the tree row volume directions on the Apogee label if concentrating.

Do not use Apogee with boron or calcium as these will reduce its effectiveness. If spray water is "hard", that is, high in calcium and other minerals, it will reduce Apogee uptake. To insure good uptake, add ammonium sulfate equal to the weight of Apogee used, even if you are unsure about the amount of calcium in your spray water. Two pints of the water conditioners Quest or Choice Weather Master can be used instead of 1 lb. of ammonium sulfate.

8 – Rootstocks and sucker control. Many of our commonly planted dwarfing rootstocks are highly susceptible to fire blight, though tolerant and resistant rootstocks are available. We recommend that growers consider moving away from the highly susceptible M9 and M26 rootstocks, and consider the Geneva rootstocks. It is interesting that B9 is rated susceptible in laboratory tests, but shows resistance in the field, and many growers are using it in tall spindle orchards.

Controlling root suckers is essential as root suckers may provide an entry point for fire blight bacteria. They should be removed. Ripping or pruning suckers can leave an open wound, and that may be an entry point in itself. So chemical treatment of suckers with NAA should be done in blocks where there are susceptible rootstocks. Several herbicides have activity on apple suckers, though care needs to be taken in their use so as not to damage trees. Always avoid contact with green bark on the tree, and never use glyphosate for sucker control.

In blocks with active blight, it may be more important to prune (not rip) suckers as soon as possible rather than waiting for NAA or other chemical treatment to kill them. When it comes to pruning, the highest priority is for root suckers on M.9 and M.26 rootstocks.

Early fire blight symptoms in a fruit cluster. (Photo: V. Philion, IRDA, Quebec.

Summer

If models indicated a risk of infection during bloom, monitor trees closely for signs of fire blight after petal fall. If trees were infected, the sooner the infections are found and removed, the better. In addition, new shoot blight infections may develop after petal fall but before terminal buds are set. After terminal buds are set, fire blight stops moving as the trees become much more resistant to the disease.

9 - To cut or not to cut? When a surprised and anxious grower first sees the hooked and wilting tips of blighted fruit clusters or shoots, the next question is almost always "Should I cut it out?" The answer is "Yes, as soon as possible." It is important to remove the infected tissue before the bacteria have a chance to move along shoots and into branches and cause significant damage. So keep an eye out for damage.

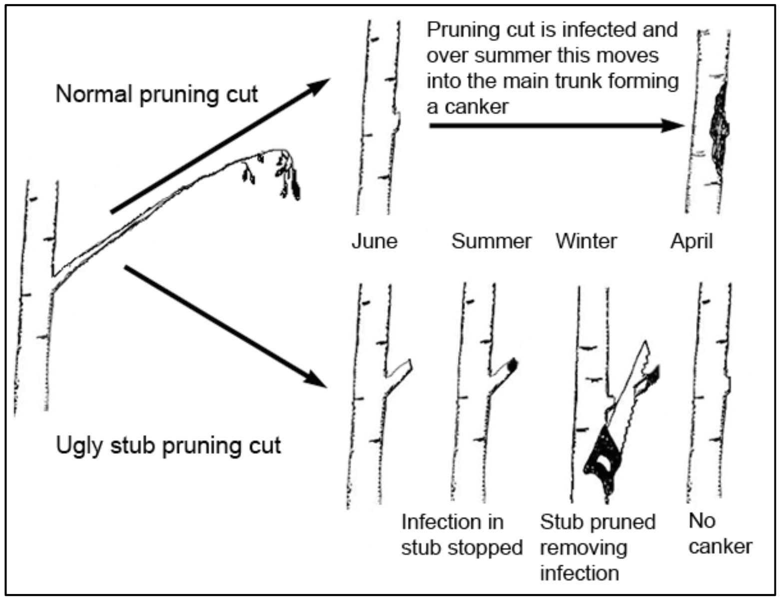
But do not prune during wet weather. It will spread the bacteria. Throw prunings on the ground in the aisle and allow them to dry a couple of days until the bark no longer slips and the cambium is brown. Moving them out of the orchard when they are fresh risks spreading bacteria.

Dave Rosenberger of Cornell suggests a type of "fire blight triage" when it comes to making pruning decisions going from highest to lowest priority: 1) young orchards 3-8 years old with just a few strikes; 2) young orchards 3-8 years old with severe strikes; 3) older orchards with a few strikes; and 4) walk away group- orchards with so many strikes that most of the tree would need to be removed, severe pruning can stimulate new growth that can become infected.

Again, to be most effective, strikes should be pruned out as soon as symptoms appear, and daily checks should be done to stop developing disease. Fire blight bacteria move quickly, up to several inches a day, and new infections can be established in a matter of hours. Work fast, and train workers – pruning fire blight is far different from pruning for fruit production!

When pruning fire blight, the best method to use is the "ugly stub" approach developed by Paul Steiner. Make cuts into wood that is at least two years old. Two-year-old wood is more resistant to fire blight than one-year wood, and can slow or stop infection movement in the tree. Fire blight bacteria travel well ahead of visible infection, so cut at least 18 inches below visible infections. Cutting back to a 4 to 6 inch naked stub in two-year-old or older wood allows the tree to use its own resistance to isolate disease in the stub.

Inevitably the fire blight bacteria will form a canker an inch or two in from a cut surface. Sterilizing tools will not stop this, so it is not worth the effort. As a result, if a flush cut is made back to the branch collar, the resulting bacteria colonization and canker will form an inch or two into the next limb or in the trunk. By leaving a stub, the canker forms in it, and the stub can be cut off with the canker during the next winter.



Ugly stub pruning to reduce spread of fire blight and canker formation. (Revised from University of Maryland Extension)

10 – Do not expect much from summer sprays. Most fruit growers are used to answering disease outbreaks with their sprayers. Unfortunately, there is no proven, chemical response that is effective against active shoot blight. Remember, streptomycin sprays at this time are largely a waste of time and will hasten resistance.

We mentioned newer copper materials and biological alternatives earlier. Any of the suggestions given here are new, and their effectiveness and potential problems are not well understood.

Field tests of a Cueva, a copper product (copper octanoate) containing a relatively low concentration of metallic copper, in combination with a biocontrol, Double Nickel (*Bacillus amyloliquefaciens* strain D747), has shown promise in stopping shoot blight comparable to the performance of Apogee, with minimal russet (Yoder, Virginia Tech). The Double Nickel apparently significantly reduces the russet produced by Cueva alone. Another new formulation of copper, Mastercop (copper sulfate pentahydrate) plus Double Nickel has shown similar results in one year of tests in Virginia.

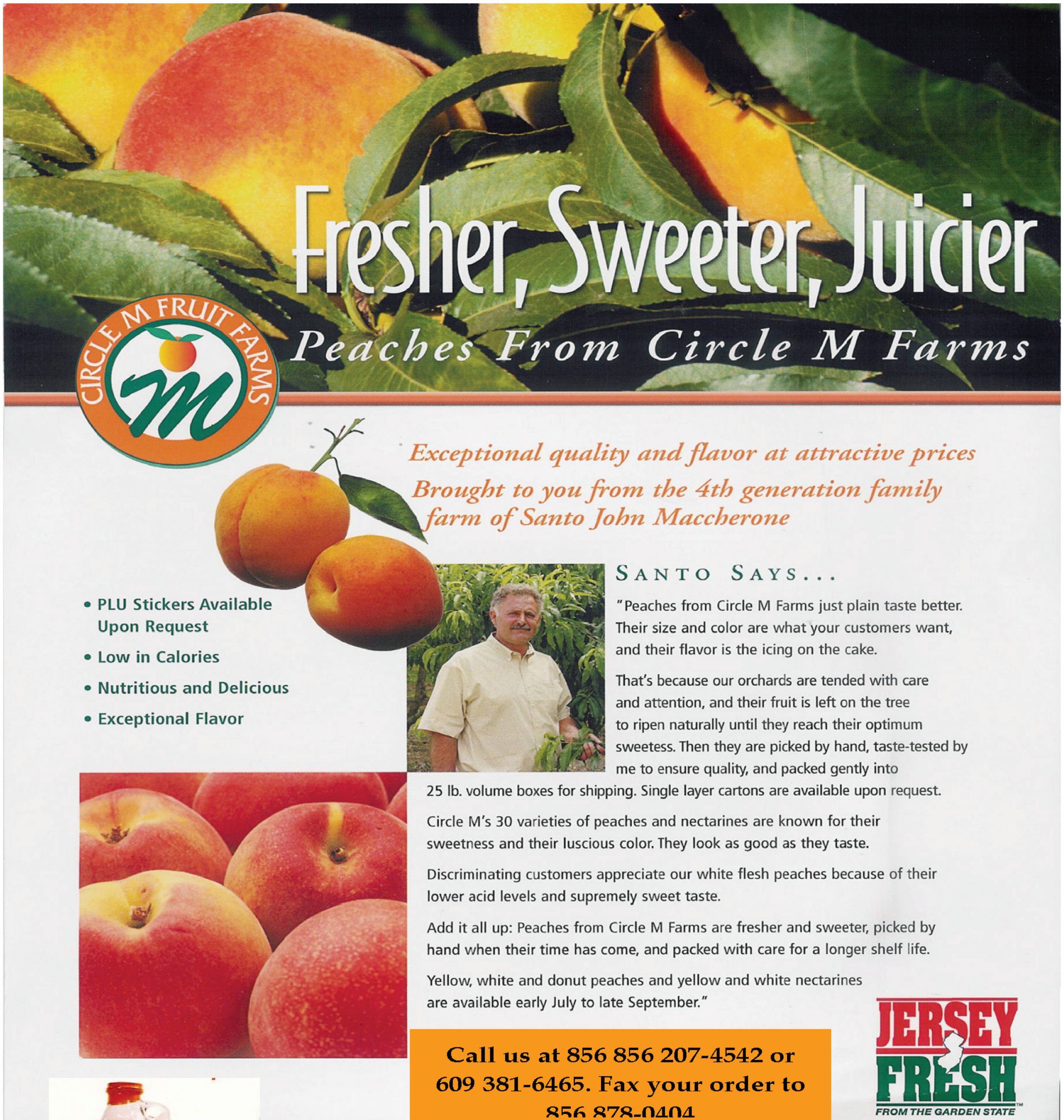
Apogee can slow fire blight if applied at bloom to petal fall Applications made after that, for example on infected shoots, are not effective. Apogee is not effective on active fire blight.

In addition to Double Nickel, other biointensive products have shown some level of control against fire bight. Generally, these materials used alone are about half as effective as streptomycin against blossom blight. There are far fewer tests of biopesticides against shoot blight. Serenade Optimum (*Bacillus subtilis* QST 713) and Taegro (*Bacillus amyloliquefaciens* strain FZB24) have shown some efficacy. Taegro performs similarly to Double Nickel. Regalia, a plant extract, has also shown some efficacy. Again, these materials are still being evaluated.

Since the introduction of Aliette, there have been suggestions, even recommendations, that phosphorus compounds known as phosphites and phosphonates (e.g. ProPhyte, AgriFos, Phostrol) can control fire blight. Unfortunately trials indicate that these compounds are not effective against shoot blight.

Use an Integrated Approach

Keeping fire blight out of an orchard, or at least down to acceptable levels, takes year-round effort and involves several tools. Perhaps with fire blight more than other apple diseases, there is no silver bullet. Preserving the best single tool there is, streptomycin, requires that other practices for fire blight be used as well. But used together on an annual basis, an integrated program greatly reduce the chances that fire blight will become a serious epidemic in an orchard.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