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Fruit Notes

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Cover: Redfield apple at the UMass Cold Spring Orchard, Belchertown, MA. Released by the New York Agricultural Experiment Station in 1938, Redfield is a cross between Wolf River and a crabapple (Malus pumila 'Niedzwetzkyana'). It produces a red-fleshed fruit which is tart and astringent. Photo: Jon Clements.

Evaluation of Apple Varieties and Comments Made by Students in the Stockbridge School of Agriculture Deciduous Orchard Class

Duane W. Greene
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Articles that are routinely published in Fruit Notes are often based upon results from applied research. However, the results gatherer from a laboratory taught in the Stockbridge School of Agriculture collected during one of the laboratories in the class seemed that it would be of interest to commercial apple growers.

During the first two months in the fall I conduct laboratories where student can be intimately involved in various aspect of tree fruit production including several orchard visits, fruit maturity evaluation, integrated pest management, and apple variety evaluation. One of the most popular laboratories is variety evaluation. In this laboratory I attempt to present apple varieties that are close to optimal maturity and represent different tastes, textures, sizes, and cosmetic appearance. In the laboratory in the fall of 2019, I selected 14 varieties. The evaluation was done on October 6. Unfortunately, varieties that ripen in early September are often not in prime condition, and late maturing varieties are cannot be selected, because they are not mature enough.

In the apple variety laboratory, I have two objectives that I hope to accomplish: 1) show students that there are a wide variety of apples available that can create interest beyond what they may normally be exposed to in grocery stores; 2) show that individuals vary considerably in their taste preference for apples. I selected 14 varieties that appear listed in Table 1. Each student was given one apple to evaluate. They were asked to assess the appearance, texture, and taste. The instructions were to evaluate each apple and rate each one using the overall scale 1= Poor, 4=Fair, 7= Good and 10=excellent. Student were then given the opportunity to comment on each apple, and then their scores were collected and recorded. After students had made their assessment of the apple, information about each variety was distributed, including the parentage, the potential uses, problems, attributes, and normal time of ripening. The scores for each variety were given orally and the results were put on a blackboard for later calculation. Each student was asked to write a report on the lab.

Results & Discussion

A summary of the variety evaluation by students is presented in Table 1. Varieties are presented in the order of student preference (highest to the lowest). Equally important is the range in student responses. The order in which they were presented was random (appears in the last column), and it appears that the order did not affect evaluation scores.

Honeycrisp. Honeycrisp is probably the most popular apple for sale at roadside stands in New England, so the number one ranking is certainly not surprising. The range of 5-10 indicates clear acceptance of this apple.

SweeTango. This variety was essentially tied with Honeycrisp for the best apple. Sale of this variety is restricted, and we have a limited number of trees. However, I included this in the tasting for two reasons. First, it does have a taste different from other apples, and second after harvesting them on October 5, over 3 weeks after they would normally be harvested, they were the best tasting SweeTango I have ever had. Students agreed. "The SweeTango apple had the perfect amount of crunchiness and sweetness." This is another example where a delay in ripening of some varieties using 1.5 to 2 pouches of ReTain can lead to a vast improvement in taste and overall eating experience.

Hudson Golden Gem. We have been growing and selling this variety for over 20 years. It is a large russetted apple that is somewhat elongated. The skin is a little tough and the taste of the apple is very reminiscent of a pear. It is not a very attractive apple but among the others it certainly stands out. Students liked it.

Gala. This just became the most heavily produced

Table 1. Evaluation of apple varieties by Stockbridge School of Agriculture the Deciduous Orchards class.

Cultivars	Ranking (1-10)	Average student response[1]	Range of student responses	Order in which presented
Honeycrsip	1	8.0	5-10	8
SweeTango	2	7.8	3-10	14
Hudson Golden Gem	3	7.1	3-9	10
Gala	4	6.9	4-8	1
Silken	5	6.6	5-7.5	2
Ambrosia	6	6.5	3-8.1	4
Empire	6	6.5	4-8	6
Macoun	8	6.2	5-8	9
Spencer	9	6.1	4-8	7
Shamrock	10	6.0	4-7.5	10
Cortland	11	5.2	3-9	13
Roxbury Russet	12	4.5	2-9	3
McIntosh	13	4.5	1-7.2	5
Delicious	14	2.7	1-6.8	11

[1]1= Poor 4=Fair 7= Good 10=Excellent

variety in the US. It is a very popular variety nationally and apparently it popular locally as well.

Silken. This is a beautiful, crisp, and juicy apple that is russet-free. It bruises very easily, so it is only useful for local sales. Normally, it ripens at the end of the first week in September. These fruit were treated with 1.5 pouches of ReTain, and they were harvested on October 5. They were incredibly juicy and crisp, and it is quite obvious that student liked them.

Ambrosia. This variety originated from British Columbia, and it just came off patent protection. It is a very good apple that is moderate in size, has a nice blush red color over green, and ripens about the first of October. I recommend this apple.

Empire. This apple has been available for a number of years. Although it was rated quite high by the students, it has not been one of the more popular apples recently.

Macoun. I was surprised to see that Macoun was not rated higher, since it is generally one of the varieties that is very popular. A reoccurring theme in this tasting was that several of the student rated any apple with McIntosh as a parent relatively low.

Spencer. This is a cross between Golden Delicious and McIntosh. It is not one of the varieties that is normally sold at roadside stands. It has a loyal following at Cold Spring Orchard; however, it softens quite fast and popularity wains when this happens.

Shamrock. This is an apple that we normally harvest early when it is still green (middle of September). When harvested green, it tastes quite similar to a Granny Smith. There are some customers who like tart green apple and this is popular with them. The parents are Golden Delicious and McIntosh. When fully ripe, it tastes like a very good McIntosh, but it lacks and red color. There is a limited marketing period for Shamrock.

Cortland. The range in evaluation scores show that there is a diverse opinion about Cortland as a dessert apple. These apples did not receive 2 pouches of ReTain, which we often like to do at the UMass Cold Spring Orchard. If ReTain-treated Cortland were presented, I think that the score would have been higher.

Roxbury Russet. This is a russsetted heirloom variety. Opinion was quite divided with this apple. There is a segment of the customer base that like it, but opinion is quite divided.

McIntosh. It was quite surprising to see the ranking of McIntosh. For years it was the most popular apple in New England. One student stated "A lot of apples that I didn't like had parental genes from McIntosh. I feel the McIntosh are too mealy and flavorless." This is trend that we are seeing now, indicating that the popularity of McIntosh is definitely on the decline especially with younger consumers.

Delicious. This variety caused the most visible and verbal display of emotion of any in the tasting. Clearly, there was a strong dislike for Delicious by a

majority of the class. The samples presented were good apples, and they were ready to eat and attractive. One very perceptive student commented on Delicious. "The Delicious we tested in the lab was much tastier than I remember of the favor profile of the same variety in my elementary school, but even now I would not consider it to be especially delicious. When we received prepared paper bag lunches on field trips, it was guaranteed that most would end up in the garbage. Schools preach healthy eating and a balanced diet, yet the apples they provided are disingenuous to the values that make fruit delicious. It is foolish to provide children with such a bland apple, especially in such young years where a broad range of new experiences are crucial for child development."

Summary and Take Home Message

1. Student who evaluated these apples represent and important segment of future apple consumers. These students were 18-22 years old. Their preference and comments should be taken very seriously when planning and selecting apple varieties that you will sell at your farm in the future.
2. Three of the most popular apples that were grown in New England for many years were rated at the bottom and were the least popular.
3. Students like the diversity and the choice of not only different tastes but different colors and textures. One student agreed. "It was interesting to see the range of differences in people's personal preferences when it came to many of the apples we tasted. That is why it is important to have a variety of selections offering different flavors, textures, and colors."
4. Apple appearance did not appear to play an important role the rating of apples. For example, Hudson Golden Gem is not a very attractive apple but it was rated well, because it had very different texture, taste, and appearance.
5. The use of relatively high rates of Retain to delay ripening enhanced the flavor of some apples that ultimately resulted in a higher rating. Growers should consider using elevated rates of ReTain (1.5 to 2 pouches per acre) on some traditional varieties to see if the harvest season can be extended and fruit quality may be improved.
6. Students were quite surprised at the difference in taste preference others had. A prevalent comment was that a relatively large selection of different colors, tastes, and appearances may be a key to attracting a broad spectrum of the consumer public.

Influence of Foliar Urea on Branching of Apple in Response to MaxCel Application at Bloom

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The majority of apple orchards that are being planted now are high density, and the trees are invariably propagated on a dwarfing rootstock. These plantings frequently have a tree density of over 1000 trees per acre. When the required support system and usual trickle irrigation associated with these planting are added to the cost of trees, the initial investment is very high. In such plantings, it is very important to grow trees to fill their allotted space rapidly, to allow early and substantial production, and to start to receive an early return on the investment. Frequently, newly planted trees are slow to grow even when appropriate management is followed. One procedure used by many growers is to apply prior to or at bloom a spray containing benzyladenine (BA) such as MaxCel or one containing both BA and gibberellins GA such as Promalin. I have used both of these to increase branching and enhanced tree growth. Sometimes, I have been successful, and at other times, trees have not responded with increase branching and growth. Although good horticultural practices are a necessary prerequisite, sometimes increased branching is not observed even when proper care was done. What was lacking in these situations where poor response was observed?

Lailiang Cheng, Professor of tree fruit nutrition at Cornell University, published a paper in the *New York Fruit Quarterly* that appeared to provide a clue that might explain the lack of response while he was working with nursery trees. He noted that early growth of a tree in the spring is dependent upon storage nitrogen and storage carbohydrate. Carbohydrate produced by a tree in the spring is not available for growth for at least a couple of weeks after shoots start to grow. Carbohydrate to support growth must be available early, so it must come from storage reserves. If a tree grew well the previous year and terminal growth was stopped early enough to allow translocation of carbohydrate to the tree, storage carbohydrate will probably not be limiting. Dr. Cheng suggested, however, that the availability of storage nitrogen might be deficient. In his paper, he showed that even when significant amounts of nitrogen are applied to nursery trees during the growing season, much of it is not available to support growth the following spring. If he sprayed urea on a tree in October, however, much of it was translocated into the tree and was available to support growth the following spring. He further showed that a substantial amount of this foliar-applied storage

Table 1. Influence of urea spayed on young trees in the fall and benzyladenine (MaxCel) applied in the spring on lateral branching and growth of Empire/M.9 NAKBT337 apple trees.

Treatment	Lateral branches (no./tree)	Avg length of lateral branches (cm)	Total lateral shoot growth (cm/tree)	Total terminal growth (cm)	Total shoot growth (cm/tree)
Control	13.2	21.4	313	349	661
Urea[1]	14.9	23.0	283	337	602
MaxCel[2]	18.6	28.4	501	236	737
Urea + MaxCel	20.0	24.2	487	252	739
Significance					
MaxCel	**	NS	**	NS	*
Urea	NS	NS	NS	NS	NS
Urea x MaxCel	NS	NS	NS	NS	NS

[1]Urea applied as a foliar spray on October 23, 2019 as a dilute spray containing 3% urea
[2] MaxCel applied as a dilute foliar spray at bloom in 2020

nitrogen was used to support growth the following spring.

At the UMass Cold Spring Orchard, we selected a row of Empire/M.9 NAKBT337 that were planted in 2018. Accepted pomological practices were employed, such as early planting, trickle irrigation applied early, and they were planted in land that was well prepared and was in cover crops for the 2 years prior. They grew acceptably, but as is often the case with Empire, lateral branching was sparse. In this row, 40 similar trees were selected, and they were divided into 10 groups (replications) of four trees each. In the third week in October (2019), half of the trees were sprayed with a dilute 3% urea spray. No phytotoxicity was observed. In the following spring (2020) at bloom time, 10 trees that were previously unsprayed and 10 trees that previously received 3% urea in the fall were sprayed with a 300 ppm spray of MaxCel. Trees were cared for following accepted horticultural and pest management procedures. In April, one pound of 10-10-10 per tree was applied, and in May one pound of urea per tree was applied. In November (2019), all growth and branching measurements were taken. The results of the growth response to treatments are presented in Table 1.

Application of MaxCel increased lateral branching on Empire/M.9 apple trees, and it increased the total number and amount of lateral shoot growth. Urea had no influence on the number of lateral branches or the total growth of the lateral branches, and when it was combined with MaxCel it did not increase the number or total growth of lateral branches on these trees treated with MaxCel. No treatment increased the growth of terminal shoots. Total growth on these trees was increased when MaxCel was applied at bloom. All of this increased growth can be attributed to the increase in lateral shoot length. While it is disappointing that a foliar application of urea in the fall did not increase either branching or growth of the trees, with or without MaxCel application, it is reassuring to note that it appears that the nutrition program used on these trees early appeared to be sufficient to satisfy the nitrogen requirements needed for an early growth response.

Literature Cited

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Evaluation of a Grower-friendly Attract-and-kill Strategy for Apple Maggot Control in New England Apple Orchards

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In New England and New York, and to a lesser extent in apple production areas south of these states, the apple maggot fly (AMF) has historically been the sole fruit-injuring pest active after June against which insecticide is applied to apple orchards. Currently, one exception is the invasive pest brown marmorated stink bug in states where populations are causing agricultural damage. Given that the principal threat of AMF injury in commercial orchards arises from flies immigrating from unmanaged hosts, then attract-and-kill strategies that intercept immigrating AMF before they have the opportunity to penetrate into the apple blocks could prove effective at managing AMF.

Previously, trap-based control strategies have focused on captures of AMF at the orchard perimeter using either, odor-baited Tangletrap-coated red spheres or odor-baited attracticidal spheres, with excellent results. The attracticidal sphere is made of a red plastic sphere topped by a disc comprised of an insecticide, sugar (as feeding stimulant) and paraffin wax (as binder). Multi-year research involving use of odor-baited sticky spheres and attracticidal spheres has clearly demonstrated the potential of controlling AMF in commercial orchards. However, several concerns have prevented the use of these devices for AMF control by commercial growers. For example, sticky spheres must be maintained at least biweekly to retain capturing effectiveness, and the labor and mess associated with handling sticky-coated traps on a large scale are prohibitive to commercial application. Unfortunately, regulatory hurdles, among other issues, have largely prevented the further research and development, leading to commercialization, of attracticidal spheres. While research involving the optimization of attracticidal spheres continues to be conducted, it is imperative to evaluate alternative control strategies for AMF that could be implemented right away by growers.

The goal of this study was to assess the level of AMF control achieved in commercial orchard blocks using an attract-and-kill strategy involving use of synthetic lures deployed in perimeter-row trees in combination with insecticide sprays with 3% sugar added to the tank mix. Sugar is a phagostimulant that readily induces feeding by adult fruit flies upon contact. We expected to bring AMF adults to perimeter-row trees where they could be killed by the insecticide sprays, before they could penetrate into interior trees. Subsequent flies arriving to the baited tree canopies were expected to continue sensing sugar on the foliage and fruit, inducing flies to ingest insecticide residue.

Materials & Methods

This study was conducted in six commercial apple orchards (3 in Massachusetts, 2 in New Hampshire, and 1 in Maine). For each orchard, growers made two

Table 1. Area of the experimental blocks and number of synthetic lures used in the attract-and-kill blocks in six commercial orchards located in Massachusetts, New Hampshire, and Maine, in 2019.

Orchard	Area (A&K / GC)	No. AMF lures (A&K block)
Clarkdale (MA)	1.7 ac / 1.7 ac	11 lures (5.8/ac)
Red Apple (MA)	3.0 / 2.8 ac	13 lures (4.3/ac)
UMass Cold Spring Orchard	1.8 ac / 2 ac	10 lures (5.5/ac)
Poverty Lane (NH)	3.5 ac / 2.7 ac	13 lures (3.7/ac)
Apple Hill (NH)	4 ac / 3.8 ac	17 lures (4.3/ac)
Ricker Hill (ME)	5 ac / 5 ac	25 lures (5.0/ac)

blocks available for the research. While the size of the blocks ranged from 1.7 to 5 acres (Table 1), efforts were made to have the two blocks of similar size within each orchard. Each of the four sides of a block was bordered by grower-sprayed orchard trees, open field, hedgerow, or woods. For each orchard, two treatments were evaluated (1) attract-and-kill and (2) grower control.

The attract-and-kill block made use of 5-component lures (= 'attract' component) deployed every ~30 yards along the four perimeter rows. The lures were purchased from Great Lakes IPM. The average lure density was 5 per acre (Table 1). The 'kill' component of this strategy consisted of insecticide sprays mixed with 3% sugar (3 lbs. per 100 gallons of water) applied during July and August. The control block was treated by the grower most commonly with two or three insecticide sprays to control AMF. Each participant grower applied the insecticide of their choice, most commonly the organophosphate imidan (phosmet) and the neonicotinoid Assail (acetamiprid). One orchard alternated the use of Assail, the anthranilic diamide Exirel (Cyantraniliprole), and the neonicotinoid Belay (Clothianidin).

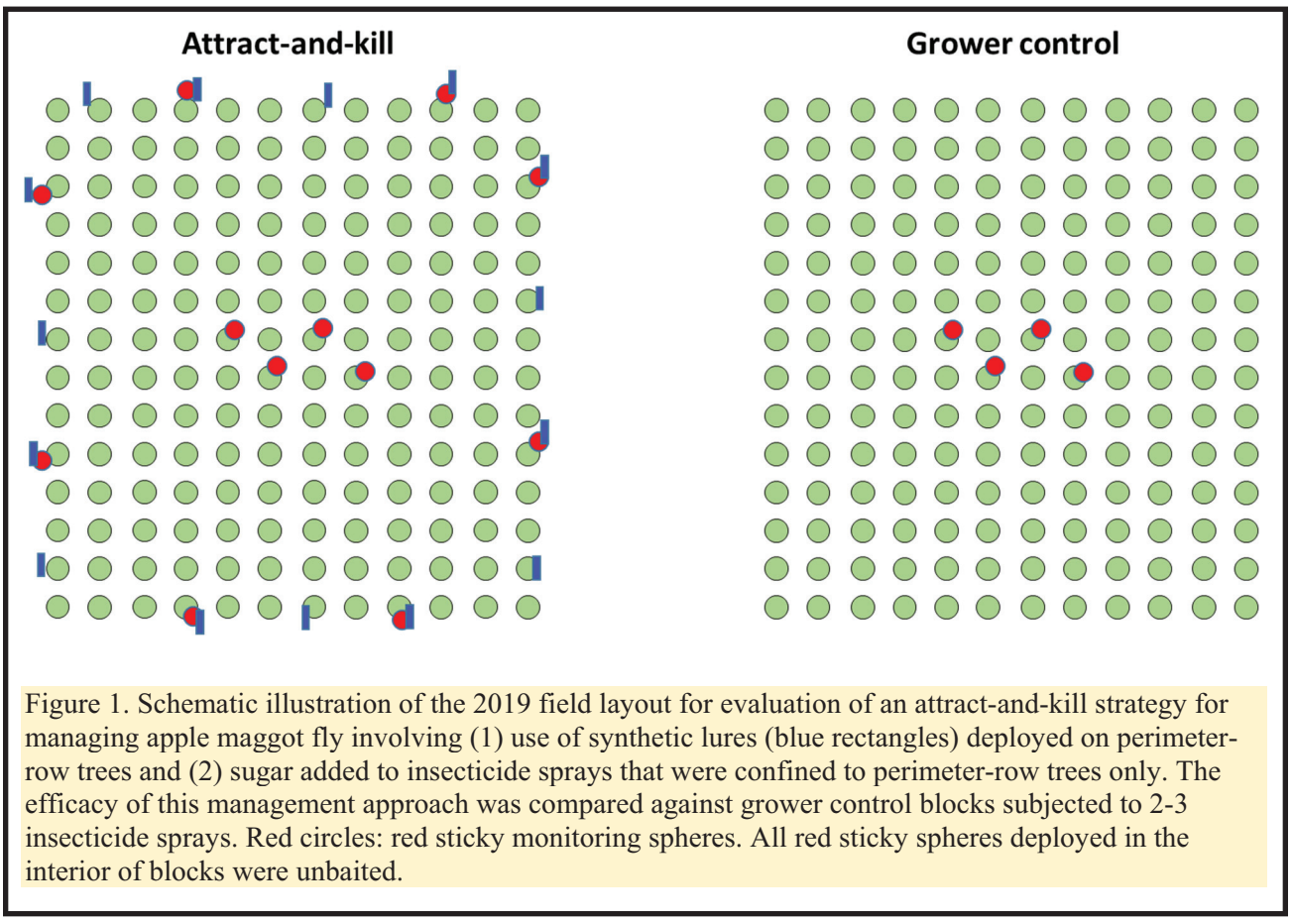

Figure 1. Schematic illustration of the 2019 field layout for evaluation of an attract-and-kill strategy for managing apple maggot fly involving (1) use of synthetic lures (blue rectangles) deployed on perimeter-row trees and (2) sugar added to insecticide sprays that were confined to perimeter-row trees only. The efficacy of this management approach was compared against grower control blocks subjected to 2-3 insecticide sprays. Red circles: red sticky monitoring spheres. All red sticky spheres deployed in the interior of blocks were unbaited.

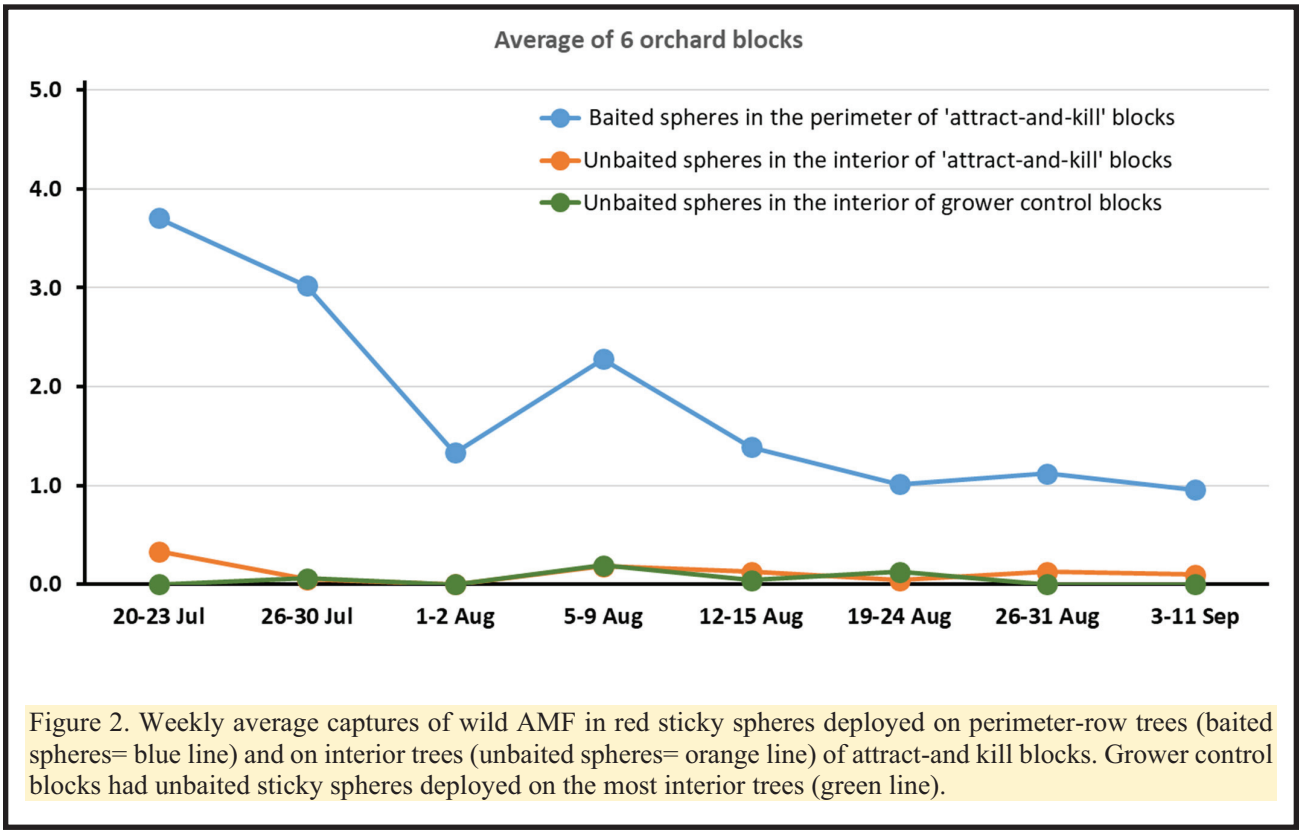

Figure 2. Weekly average captures of wild AMF in red sticky spheres deployed on perimeter-row trees (baited spheres= blue line) and on interior trees (unbaited spheres= orange line) of attract-and kill blocks. Grower control blocks had unbaited sticky spheres deployed on the most interior trees (green line).

AMF monitoring. Due to logistic constrains, monitoring spheres were deployed in mid-July 2019. The attract-and-kill block received 6-8 unbaited red sticky spheres (3.5 inches in diameter) to quantify AMF densities on perimeter-row trees (Figure 1, Table 1) whereas the grower control blocks had no sticky spheres in the perimeter. Each of the two blocks received 3-4 unbaited sticky spheres in the most interior trees to monitor the degree of AMF penetration (Figure 1).

Assessment of treatment performance. We used two methods of assessing treatment performance. First, every week from trap deployment until harvest we counted and removed all AMF captured by the red sphere traps placed on perimeter-row trees and on interior trees of attract-and-kill plots, and by the unbaited spheres in the interior of grower-sprayed plots. Captures by interior spheres were used as an indicator of relative numbers of AMF adults that penetrated into the interiors of the two types of blocks. Second, at harvest we sampled 20 fruit from each of five trees on each of the four sides of each baited-sphere and each grower-sprayed plot plus ten fruit on each of five interior trees, for a total of 500 fruit per block. All sampled fruit that were suspected to have AMF injury upon visual inspection were brought to the laboratory (UMass Amherst), where they were kept inside individual plastic containers with moist sand (as a pupation substrate) at 70-75 degrees Fahrenheit for six weeks. Then, each fruit was dissected for signs of tunneling and/or presence of AMF pupae in the sand.

For this study to be considered successful, we expected AMF numbers on perimeter-row monitoring spheres to be significantly greater than the number recorded on interior sticky spheres of attract-and-kill blocks. We also expected no differences in the level of AMF penetration, as measured using interior unbaited spheres, into either type of block.

Results

AMF trapping. For each trap inspection session, red sticky spheres deployed on perimeter-row trees in association with synthetic AMF lures in attract-and-kill blocks captured substantially more (9-60 times more) wild AMF than interior unbaited spheres in the same blocks (Figure 2). This result indicated that the

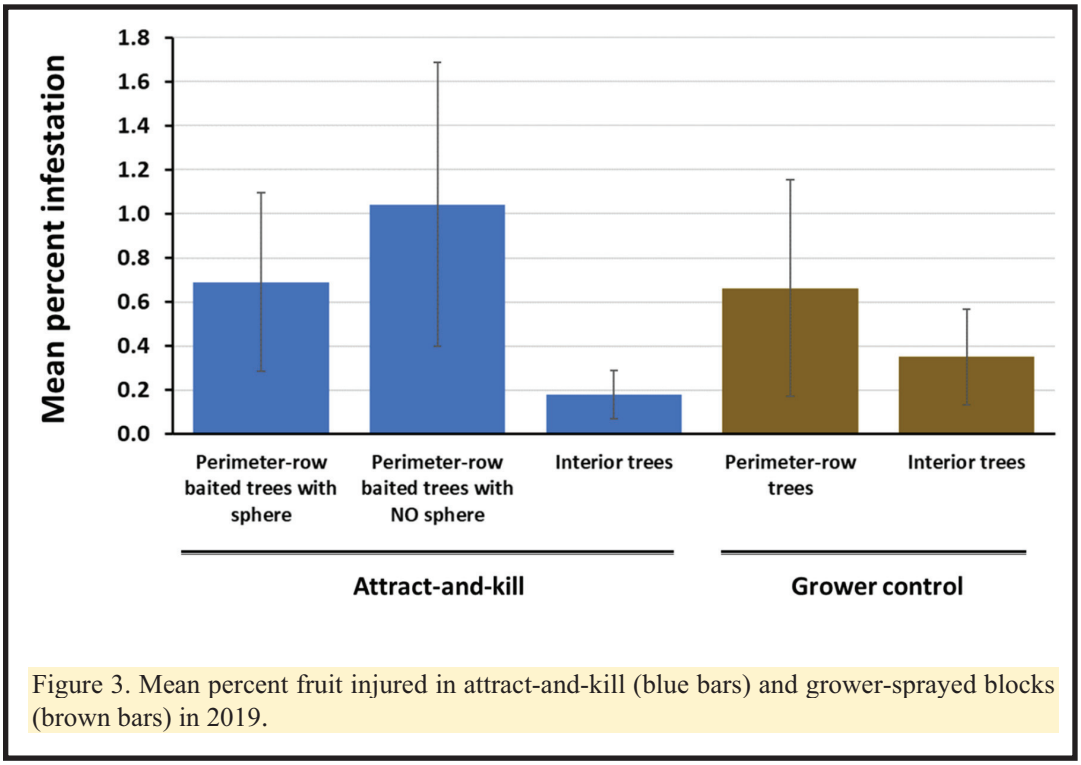

Figure 3. Mean percent fruit injured in attract-and-kill (blue bars) and grower-sprayed blocks (brown bars) in 2019.

lures were effective at pulling AMF to perimeter-row trees. Overall, AMF captures in unbaited monitoring spheres deployed in the interior trees of both blocks were very low, and there was virtually no difference in the level of AMF pressure in the interior of attract-and-kill blocks (despite the lack of insecticides sprayed inside those blocks) and the grower control blocks (Figure 2).

Infestation data. The percentage of fruit that was infested with AMF larvae was statistically similar regardless of whether the fruit was sampled from attract-and-kill blocks o from grower control blocks. While some variability in results was observed, the amount of fruit injured was numerically greatest on perimeter row-trees and lowest on interior trees, for both types of blocks (Figure 3). Because the number of AMF lures deployed on perimeter-row trees was greater than the number of red sticky-coated monitoring spheres, and therefore some trees had lures but no red sticky spheres, then the results from fruit sampling are presented separately for perimeter-row trees that harbored (or not) a baited monitoring sphere. The results show that the presence of lures in the absence of a red sticky sphere does not lead to greater AMF infestation on those

Conclusions

Results from this single-season study indicate that an attract-and-kill approach involving synthetic lures deployed on perimeter-row trees in association with perimeter-row sprays of insecticides containing 3% sugar was effective in controlling AMF, as determined by trap captures and infestation data, when compared to grower control blocks. Future research ought to compare the performance of the attract-and-kill strategy involving perimeter-row sprays of insecticide mixed with sugar against that of perimeter trapping using odor-baited spheres in the absence of insecticide sprays. Conducting this type of research using a greater number of orchards is expected to reduce variability in results.

Acknowledgments

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Assessment of a Non-pheromonal Lure System for Attracting Adult Tortricid Moths

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Fruit orchards are attacked by a number of tortricid pests (e.g., codling moth, oriental fruit moth, leafrollers) that are either key or important secondary pests directly damaging the fruit. Fruit growers can use sex pheromones to monitor male moth populations and to control pest species directly via mating disruption. Further improvement of monitoring and management tools for these pests might be achieved with traps and plant volatiles that are effective in tracking female moth activity in orchards. In this study, the attractiveness of candidate non-pheromonal lures to male and female codling moth (CM), oriental fruit moth (OFM), and red-banded leafrollers (RBLR) was evaluated in three commercial apple orchards in Massachusetts. The goal of this study was to identify at least one candidate lure that would attract females of these three economically important moth species.

Materials & Methods

This study was conducted from July 13 to September 14, 2019, in three commercial apple orchards in Massachusetts using orange Delta-shaped traps (Pherocon VI, Trécé Inc., Adair, OK). Four treatments (3 candidate lures = A, B, and C, and one control involving unbaited traps) were evaluated. Each treatment was replicated 10 times. Traps were deployed in groups (= blocks) of four traps/treatments, along perimeter-row trees. Traps were spaced 10 yards apart within each block and 25 yards between blocks.

All traps and lures were deployed on July 11, 2019. Traps were examined for captured moths beginning on July 20 and every 7-8 days thereafter for nine weeks until September 14. All lures were renewed on August 22, about mid-way through the experiment. At each trap examination, traps were switched one position clockwise within a block to minimize the effects of position. All plots received insecticide sprays or other control methods as deemed necessary by the grower. Traps baited with the synthetic sex pheromone of each species (CM, OFM, RBLR; one trap per moth species) were deployed at each orchard to monitor male populations. For CM, the pheromone-baited traps were deployed

View of trap deployment for the evaluation of candidate lures for attractiveness to adult codling moth, Oriental fruit moth, and red-banded leafrollers, conducted at three commercial orchards in Massachusetts.

from the onset of the study and the lures were renewed on 17 August- the date at which traps baited with the OFM and RBLR pheromone lures were deployed.

Data collection and analyses. All adult moths captured were identified according to species (i.e., CM, OFM, RBLR). Moths were not sexed for the first three weeks of the study. All adult moths were identified by sex starting on August 17.

Results

For the first trapping period (July 13 – August 5), and across all three orchards, lure A captured significantly more OFM (adults were not sexed) than any other lure (Figure 1A). Lure C was the second best-performing lure, which attracted about one-third of OFM when compared to lure A. Captures of CM were very low, and no differences among lures were noted. Captures of adult RBLR were greatest in traps baited with lure A, and lures B and C did not attract any moths of this species (Figure 1A).

Results from the second period (August 6-13) revealed that lure A continued to perform best at attracting OFM, although captures did not differ from those recorded with lure C. For this moth species, the least-performing lure was lure B. Of the 232 OFM that were captured in this period, seven moths (3%) were females and the vast majority (97%) were males. While the average captures of CM were slightly greater (97 CM were captured in all) than in period 1, no differences in attractiveness among lures were recorded (Figure 1B). Eleven percent of CM captured in this time period were females. Captures of RBLR were very low during this period.

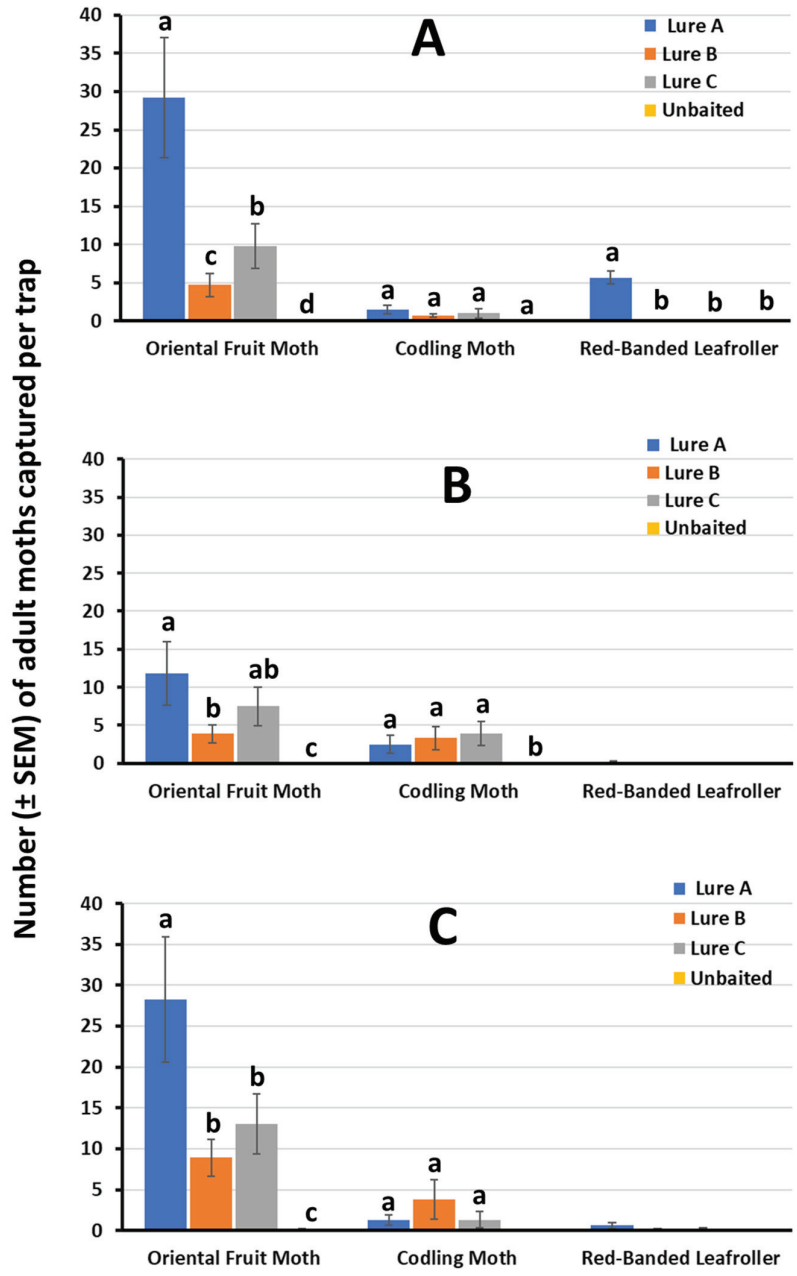

Figure 1. Captures (mean ± standard error of the mean [= SEM], *a measure of how precise the estimate is*) of adult (male and females combined) Oriental fruit moth, codling moth, and red-banded leafrollers captured by Delta-type traps baited with non-pheromonal lures according to trapping period. The study was conducted in three commercial orchards in Massachusetts from July 11 to September 14, 2019. For each moth species, means superscribed by the same letter are not significantly different at odds of 19:1.

For the third and last trapping period (Aug. 24 –

Table 1. Mean captures of oriental fruit moth, codling moth, and red-banded leaf-rollers in traps baited with either, experimental non-pheromonal lure A or sex pheromones, according to orchard and trapping date. Baited traps were deployed on July 13, 2019. N/A= For the first four trapping dates, no pheromone lures were present for OFM and OBLR.

Honey Pot Hill Orchards (Stow, MA)	**Jul. 20**	**Jul. 27**	**Aug. 5**	**Aug. 17**	**Aug. 23**	**Aug. 30**	**Sept. 14**
Oriental fruit moth - lure A	4.3	3.3	0.8	0.5	0.5	0.5	2.5
Oriental fruit moth - Pheromone trap	N/A	N/A	N/A	N/A	9	4	15
Codling moth - lure A	1.8	0.3	0	4	2	2	1.3
Codling moth - pheromone trap	1	1	1	16	15	14	9
Red-banded leafrollers - lure A	4.8	3	0	0	0	1	0
Red-banded leafrollers - Pheromone trap	N/A	N/A	N/A	N/A	10	11	6
Sholan Orchards (Leominster, MA)	**Jul. 20**	**Jul. 27**	**Aug. 5**	**Aug. 17**	**Aug. 23**	**Aug. 30**	**Sept. 14**
Oriental fruit moth - lure A	26	14	12.5	14.3	9	10.8	26.8
Oriental fruit moth - Pheromone trap	N/A	N/A	N/A	N/A	10	18	33
Codling moth - lure A	0.5	0.3	1	0.3	0	0	0
Codling moth - pheromone trap	11	0	0	9	2	0	1
Red-banded leafrollers - lure A	1	2.3	0.5	0	0.5	0	0
Red-banded leafrollers - Pheromone trap	N/A	N/A	N/A	N/A	36	14	11
Cold Spring Orchard (Belchertown, MA)	**Jul. 20**	**Jul. 27**	**Aug. 5**	**Aug. 17**	**Aug. 23**	**Aug. 30**	**Sept. 14**
Oriental fruit moth - lure A	1.5	5.5	17.5	6	4.5	17.5	43
Oriental fruit moth - Pheromone trap	N/A	N/A	N/A	N/A	13	19	119
Codling moth - lure A	0	0	0	0	0	0	0
Codling moth - pheromone trap	1	0	1	1	0	0	0
Red-banded leafrollers - lure A	3.5	2	0	0	0	0	1
Red-banded leafrollers - Pheromone trap	N/A	N/A	N/A	N/A	0	16	8

Sept. 14), lure A performed best at attracting OFM whereas lures B and C were similarly attractive (Figure 1C). For this time period, 503 OFM were captured by traps, and only 1.2% of OFM were females. No differences in attractiveness to CM among lures were recorded (Figure 1B). Of the 64 CM captured, 5 (7.8%) were females. Captures of RBLR were very low during this period.

Table 1 shows average captures of adult OFM, CM and RBLR in pheromone-baited traps and in traps baited with the experimental non-pheromonal lure A (the most attractive lure identified), according to orchard and date. Results show that OFM populations were higher in some locations (e.g., Belchertown) than in other locations, whereas CM was most abundant in the Stow location. While, as expected, captures of male

moths were consistently greatest in pheromone-baited traps, it was striking to note that lure A, which lacks moth pheromones, also attracted substantial numbers of moths. For example, in Sholan Orchards, OFM captures in traps baited with lure A approached those recorded in pheromone baited traps (26.8 vs 33 on September 14; Table 1). The number of adult OFM captured in the UMass Cold Spring Orchard on August 30 was similar in traps baited with lure A and traps with the OFM sex pheromone (17.5 vs. 19) (Table 1).

Conclusions

Results indicate that, under the conditions of this study, some of the experimental lures evaluated, in particular lure A, attracted substantial numbers of OFM, the most abundant moth species in this investigation. However, for both OFM and CM, most of the moths that were captured were males, which was not the target sex. Further evaluations ought to determine whether non-pheromonal lures can be optimized by adding selected plant volatiles, to attract more female moths to baited traps.

Acknowledgments

I thank Joanne M. DiNardo (Sholan Orchards, Leominster, MA) and Chelcie and Andy Martin (Honey Pot Hill Orchards, Stow, MA) for allowing me to work on their orchards. Thanks to Mr. Brent Short (Trece, Inc.) for providing the lures and trapping materials, to Isabel Jacome and Heriberto Godoy-Hernandez for assistance, and to Miguel Pinero-Jacome for comments.

Selected Minnesota White Grape Varieties for the Northeast

J. Stephen Casscles, Tom Plocher, and Todd Trzaskos

This article covers white cool climate grape varieties that can be grown throughout most of the Northeast that were developed by Elmer Swenson (1913-2004) and the University of Minnesota grape breeding program. It outlines the viticultural aspects and the kinds of wine that these grapes produce. Wine-making capability is an important consideration as growers need to grow varieties that are not only consistently productive, and economically & ecologically sound to grow; but which produce high quality wine. The winter hardiness of these varieties is not generally covered here because all of them are either cold hardy or very cold hardy and will generally survive in most parts of the Northeast.

In the Northeast, many growers also operate a winery, and are therefore interested in growing grapes in a profitable manner that can produce quality wine. These varieties can produce more than one style of wine; this versatility in the cellar is an added bonus for the wine producer.

La Crescent (*aestivalis, labrusca, riparia, rupestris, vinifera)* is a hybrid of St. Pepin x E.S. 6-8-25 (Riparia 89 x Muscat Hamburg) that was released by the University of Minnesota in 2002. It has moderately loose to compact long conical clusters with one wing, and a vigorous, sprawling growth habit. The vine is moderate to vigorous in growth, depending on the fertility of its soils. La Crescent is easy to grow and somewhat resistant to all fungus diseases. Its bud break is relatively early and has a small to medium secondary crop if hit by a late spring frost. The grape ripens by late early to mid-season and has sugars of around 24 Brix. The yields are moderate on lighter soils and heavier on richer soils.

The wine is quite floral and fruit driven by aromatics and flavors of apricots, with undertones that range from apples to white peaches, tropical fruits, pineapples, mangoes, and honey. Some New England winemakers are making lovely "Orange wines" with skin contact fermentation methods. La Crescent can lend interest and character when blended with more neutral bulk wines. The wines have good body and balance with elegant fruit flavors that are not aggressive. Its flavor profile is similar to Vignoles or Riesling. It can make dry to semi-sweet wines. La Crescent acids can be firm to high, so balanced residual sugar levels or vinification techniques may be needed to offset its acidity.

La Crosse *(labrusca, lincecumii, riparia, rupestris, vinifera)* is a sibling of St. Pepin. It has Seyval Blanc and Rosette (S.1000) in its genetic heritage (E.S. 114 (MN 78 x Rosette) x Seyval Blanc). The medium-sized cluster is slightly loose to well filled with medium-sized yellow-green to light golden berries. It looks similar to its pollen parent Seyval Blanc with a more open and semi-upright growth habit. La Crosse is moderately vigorous to vigorous and productive. It has solid fungus disease resistance, but is susceptible to black rot and bunch rot. It has a mid-season bud break, that produces a secondary crop if hit by a late spring frost. The variety ripens by mid-season, a bit before Seyval Blanc and about two weeks after St. Pepin with sugars at 19 Brix. For the colder parts of New England and Upstate New York, there are not sufficient heating degree days to consistently ripen La Crosse, but it can do well in the southern coastal areas of New England, the Mid-Hudson Valley, and south to New Jersey. It has a higher acid profile and less aromatics that St. Pepin.

It is balanced for wine both in sugar and acid, and similar in flavor profile to its parent Seyval Blanc. These wines have been successfully barrel-fermented with a malolactic fermentation to reduce its acid profile. Nose and flavor descriptors include rich fruits of pears, apricots, melons, grapefruit, and citrus, with some floral, Muscat, and spice elements. The wines can stand on their own or used in blending to add body to thinner wines. This Minnesota hybrid has a wide range of styles that it can produce from off-dry barrel-aged whites to semi-sweet wines.

Frontenac Blanc / Frontenac Gris *(aestivalis, berlandieri, cinerea, labrusca, lincecummi, riparia,*

Frontenac Blanc.

rupestris, vinifera) are both mutant forms of Frontenac Noir. Viticulturally, all three are similar, coming from a cross of MN 89 Riparia x Landot 4511. Its ancestors include the highly productive French-American hybrids Villard Blanc and Plantet. Frontenac Noir was introduced by the University of Minnesota in 1996. It is vigorous to very vigorous in growth habit, consistently very productive, and does well in most soils. With its high vigor, vine management techniques such as shoot positioning, leaf pulling, and hedging should not be neglected. Its conical clusters are loose to moderately loose, long, and medium to large in size. It has a slightly upward growth habit and then droops. It buds out by mid-season. All three clones have good fungus disease resistance, with only moderate resistance to black rot. Its moderately loose clusters negate bunch rot and berry-splitting problems. Due to high productivity, cluster thinning may be needed to maintain crop quality. The Frontenacs ripen late mid-season to late, about one week after Baco Noir with sugars of 24 to 27 Brix or more. With its *riparia* heritage, the wines can be very high in total acidity. To curtail these high acid levels, it is best to harvest fruit only after reaching 24 Brix or more.

Frontenac Gris, named by the University of Minnesota in 2003, is an amber colored mutant of Frontenac Noir. While it has similar viticultural characteristics to Frontenac Noir, it seems to have slightly better fungus disease resistance. It makes very fruity semi-dry white to copper-colored wines with aromas and flavors of peaches and apricots, with hints of pineapple, honey, grapefruit, and some tropical fruits such as passion fruit. With a good balance between its fruit and acidity, Frontenac Gris produces a clean wine with little or no herbaceous or *labrusca* aromas. It should to be finished semi-dry to offset its high acidity.

Frontenac Blanc is a mutant of Frontenac Gris. Viticulturally, it is similar to Frontenac Noir and Gris, except that it ripens slightly earlier. This mutation was found by Quebec nursery-owner Alain Breault in 2005. The wines have flavors of apricots, peaches, and pomme fruits, expressing more pure stone fruit and melon in the nose. Due to their high acids, they tend to be made semi-dry, but can be made dry if malolactic fermentation is used or if blended with other less acidic whites.

Itasca *(aestivalis, berlandieri, cinerea, labrusca, lincecummi, riparia, rupestris, vinifera)* was recently introduced by the University of Minnesota in 2017. It is a hybrid of Frontenac Gris x MN 1234 (MN 1095 x Seyval Blanc). Itasca is very cold hardy and possesses good fungus disease resistance. It is productive and has a vigorous, but manageable, upright growth habit. It ripens by mid- to late-mid-season and can attain sugars of between 24 to 27 Brix. Unlike some Minnesota whites, it has lower, more manageable, acid levels, allowing for the production of multiple styles of high-quality dry wines that do not need residual sugar to offset their high acids. The wines are clean, carry a long finish, with soft fruits that include pear, melons, green melons, gooseberries, apples, and subtle honey and violet flavors, with some mineral and floral notes.

St. Pepin *(labrusca, lincecumii, riparia, rupestris, vinifera)* is one of Swenson's first hybrids that he bred

during the 1950's, but introduced much later in 1983. It is a sister seedling to La Crosse described above, having Seyval Blanc and Rosette in its genetic heritage. St. Pepin is the seed parent for La Crescent. The variety's moderately large conical clusters are moderately compact to loose and made up of medium-sized slip-skin berries that look similar in color to its pollen parent Seyval Blanc. The juice that it yields is a very light pink.

The vine grows well and is moderately to very vigorous and moderately productive to productive, depending on the fertility of its soil. St. Pepin has an upward growth habit with a somewhat open canopy which is somewhat resistant to most fungus diseases, except for powdery mildew, to which it is susceptible. It grows easily with little maintenance and prefers to be pruned to the top wire. The vine has only female flowers, so it needs to be planted near other grape varieties, such as La Crosse, so that it can cross pollinate for fruit production

It ripens by early mid-season, anywhere from ten days to two weeks before its sibling La Crosse, and is fruiter in flavor, similar to Riesling. It attains sugars of between 20 to 24 Brix, with acids that are relatively low that are balanced for wine production. It can be used either alone or in a blend.

Brianna *(aestivalis, berlandieri, cinerea, labrusca, lincecummi, riparia, rupestris, vinifera)* was bred during the latter part of Swenson's breeding program in 1983. It was selected in 1989 as a table grape that had winemaking applications. Genetically, it has MN 78, Golden Muscat, Villard Blanc, and Swenson Red in its heritage. It has medium to high vigor depending on the fertility of its soil. It is moderately resistant to most fungus diseases, but less so to black rot and botrytis. It can be susceptible to crown gall. To combat these diseases, Brianna is not sensitive to sulfur applications.

Brianna is tolerant to most soil types and is relatively easy to control in the field, except for very fertile soils where it is very vigorous and needs appropriate management techniques to control its vigor. Further, it is tolerant of both hot and cold temperature extremes. It has a secondary crop if hit by a late spring frost. It has a medium-sized, semi-compact cluster, with medium to large berries that are thick-skinned and greenish-gold to gold when fully ripe. It ripens by early mid-season.

When picked fully ripe, it is generally made into a semi-sweet wine, with pleasing pineapple aroma and tropical flavor. When vinified as dryer wines, it can have additional flavors of grapefruit, bananas, and mangoes. Brianna is a good blending component that does not overpower the other wines that it is blended with. With its refreshing acid levels and flavor profile, it can be used to make lovely dessert wines. This variety can benefit from cool fermentation temperatures to help retain its fruit flavors.

Louise Swenson *(labrusca, lincecumii, riparia, rupestris, vinifera)*, named for Elmer's wife, was developed around 1980, and introduced in 2001 by Elmer Swenson, with the assistance of Tom Plocher and Bob Parke. It has Seyval Blanc, Seneca, Golden Muscat, and Rosette in its genetic heritage. It is moderately loose to well-filled, small-to-medium sized conical clusters with small-to medium sized light-green and translucent berries. It has good fungus disease resistance on a vine of medium vigor, but may be susceptible to anthracnose. It is sensitive to sulfur applications. Its production is moderate, but it does not like droughty conditions or light sandy soils. It has few problems in the field, but its sugars tend to remain at or below 20 Brix with only moderate acidity. It buds out late, so it is not affected

Louise Swenson.

by late spring frosts. Further, it has an orderly trailing to semi-upright growth habit, so it is easy to maintain in the field. It ripens early mid-season.

The variety is one of the better Swenson whites in the cellar with soft, fruity aromas and flavors of pears, and honey, which have no hybrid characteristics. The wines are consistently good and balanced, but because of its light body and presence, it benefits from enhancements by other wines to augment it. It blends well with Prairie Star because while Louise Swenson has delicate aromas and lighter body, Prairie Start has the requisite body and finish to compliment it.

Prairie Star *(aestivalis, berlandieri, cinerea, labrusca, lincecumii, riparia, rupestris, vinifera)* has Villard Blanc and Swenson Red in its genetic background; the seedling was selected in 1984, and introduced in 2001 by Swenson, with the assistance of Tom Plocher and Bob Parke. The cluster is long, thin, and moderately loose to well filled, with small-medium-sized berries that are yellow-gold. The cluster looks like Vidal Blanc. This variety is generally resistant to fungus diseases, with only moderate resistance to black rot and anthracnose. The vine is vigorous with a semi-upright growth habit. The bud break is by mid-season and it produces a modest secondary crop after a late spring frost, but it can be susceptible to poor fruit set. In the spring, its young shoots have a tendency to break off in high winds, so low cordon pruning may be needed with catch wires to protect its shoots from such high winds. Prairie Star ripens by mid-season, around the same time as Baco Noir or a bit earlier. It is noticeably more productive on heavier soils or if grafted.

Fruit sugars measure between 20 to 22 Brix with acid that is proportionate for winemaking. Its wines are well balanced and somewhat floral, but generally are neutral with no *labrusca* flavors. It offers good body, mouth feel, and a finish that can be used in blending to support thinner white wines. Prairie Star pairs well with Louise Swenson's delicate aromatics providing complimentary body and finish.

Swenson White *(aestivalis, berlandieri, cinerea, labrusca, lincecummi, riparia, rupestris, vinifera) (Edelweiss (MN 78 x Ontario) x E. S. 442 (MN 78 x S.11803)* has a medium to large loose to well-filled conical cluster of large berries of a light green color with some yellows. It was bred by Swenson around 1981 to 1983 and introduced in 1994. One of its grandparents is the Geneva developed white hybrid Ontario (Winchell x Diamond), whose seed parent is the Vermont bred heirloom variety Winchell. Ontario is also a grandparent to Cayuga White.

The skins are thick, which allows the variety to hang on the vine so that it can be made into late-harvest or ice wines. Further, its thick skins seem to help minimize bird and insect damage. It has good fungus disease resistance, except for downy and powdery mildew, to which it is somewhat susceptible. It is, however, a healthy grower. The bud break is by mid-season, but it has a small secondary crop if hit by a late spring frost. Due to its large cluster size, sometimes cluster thinning is needed. It is good in the field and in the cellar, ripening by late mid-season to late and achieves sugars of no more than 22 Brix.

The must is well balanced in sugar with moderate acidity so that it can make quality dry wine. The wines have a nice pronounced floral nose that is similar to St. Pepin, with substantial fruit in the body and finish, as well as pleasant *labrusca* elements.

This article is based on the three authors' average collective experience of over 30 years in growing cool climate grapes, including the Minnesota hybrids, and making wine from them. It is also based on J. Stephen Casscles, *Grapes of the Hudson Valley and Other Cool Climate Regions of the United States and Canada* (Coxsackie, NY: Flintmine Press, 2015); Tom Plocher and Bob Parke, *Northern Winework: Growing Grapes and Making Wine in Cold Climates,* (Hugo, MN: Northern Winework, Inc., 2001); and Todd Trzaskos, *Wines of Vermont: A History of Pioneer Fermentation* (Charleston, SC: American Palate, 2015).

Selected Minnesota Cool Climate Red Grape Varieties for the Northeast

J. Stephen Casscles, Tom Plocher, and Todd Trzaskos

This article covers red cool climate grape varieties that can be grown throughout most of the Northeast that were developed by Elmer Swenson (1913-2004), Tom Plocher, and the University of Minnesota grape breeding program. It outlines the viticultural aspects and the kinds of wine that these grapes produce. Wine-making capability is an important consideration as growers need to grow varieties that are not only consistently productive, and economically & ecologically sound to grow; but which produce high quality wine. The winter hardiness of these varieties is not generally covered here because all of them are either cold hardy or very cold hardy and will generally survive in most parts of the Northeast.

In the Northeast, many growers also operate a winery, and are therefore interested in growing grapes in a profitable manner that can produce quality wine. These varieties can produce more than one style of wine; this versatility in the cellar is an added bonus for the wine producer.

Frontenac Noir *(aestivalis, berlandieri, cinerea, labrusca, lincecummi, riparia, rupestris, vinifera)* is the initial red variant of this cultivar, which has two mutant forms, Frontenac Blanc and Frontenac Gris. Viticulturally, all three are similar, coming from a cross of MN 89 *Riparia* x Landot 4511. Its ancestors include the highly productive French-American hybrids Villard Blanc and Plantet. Frontenac Noir was introduced by the University of Minnesota in 1996. It is vigorous to very vigorous in growth habit, consistently very productive, and does well in most soils. With its high vigor, vine management techniques such as shoot positioning, leaf pulling, and hedging should not be neglected. Its conical clusters are loose to moderately loose, long, and medium to large in size. It has a slightly upward growth habit and then droops. It buds out by mid-season. Frontenac Noir has good fungus disease resistance, with only moderate resistance to black rot. Its moderately loose clusters negate bunch rot and berry-splitting problems. Due to high productivity, cluster thinning may be needed to maintain crop quality. Frontenacs ripens late mid-season to late, about one week after Baco Noir with sugars of 24 to 27 Brix or more. To curtail its high acid levels, it is best to harvest fruit only after reaching 24 Brix or more.

The wines can be very dark and inky or a bright purple, depending on how the wine is made. Even with all of its color, the wines have only medium body. With its *riparia* heritage, the wines are very high in total acidity, low in tannins, and herbaceous if harvested too early. To help reduce its acids, malolactic fermentation needs be considered. Even with ripe fruit, Frontenac can be a bit one-dimensional with flavors of pronounced dark cherries, plums, cooked elderberries, and wood. At times, these cherry, plum, and elderberry flavors can become too fruity and grapey with cotton candy, bubblegum, and cough syrup-like overtones. It can also have a distinctive mint/wintergreen flavor that sometimes integrates with the fruit and some-times it does not.

Frontenac Noir is versatile in the cellar and is capable of producing a dry table wine, blush, rose, or port. Barrel aging is recommended to take the rough edges off. If made as a Rose, the grape's acids are more in keeping with a white wine. The grape also lends itself to dessert port production because of its big forward fruit flavors and high acidity, which can handle fortification with brandy.

Marquette *(aestivalis, berlandieri, cinerea, labrusca, lincecumii, riparia, rupestris, vinifera)* was released by the University of Minnesota in 2006. It is a genetically complex hybrid with Pinot Noir as a grandparent and a shared ancestor to Frontenac, Landot 4511. The variety has very good resistance to all standard fungus diseases and needs only a minimal spray program. Resistance to foliar phylloxera infestation is only moderate. Marquette produces a moderate to good crop. Its bud break is somewhat early, but has a secondary crop if hit by a late spring frost. It has moderate vigor and an open and orderly, somewhat upright growth habit that facilitates fungicide applications and exposes its fruit and leaves to air and sunshine to minimize fun-

gus diseases. Its shoots tend to have only two small to medium-sized clusters with small-medium-sized black berries. Hence it does not over-produce or need cluster thinning to enhance its crop quality. It ripens by mid-season, a few days before Frontenac. The sugar levels can be higher than 25 Brix, with high acids, which are lower than Frontenac.

The variety has an attractive deep ruby-red color, nice flavors of cherry, black currants, black pepper, spice, and berry in the nose and palate, with only moderate body and tannins that is better than Frontenac. The wine's flavors and aromas are integrated with a clean finish. These wines can have the elements of a southern Rhone with white pepper and raspberries like Grenache, smooth tannins and plum flavors like Syrah, without a too thin body. The wine benefits greatly from barrel aging and malolactic fermentation to reduce its high acids. Also, barrel aging, but not too much barrel aging, can help round out the rough edges of Marquette.

Marquette. Tom Plocher photo.

Sabrevois *(labrusca, lincecummi, riparia, rupestris, vinifera)* is a sister to St. Croix, developed by Elmer Swenson in 1978, that has Seyval Blanc and Seneca in its genetic heritage. It is hardier, more reliable, and a more productive variety than its sibling. It was named by Gilles Benoit of Quebec. This Swenson hybrid has a small- to medium-sized, semi-loose cluster. The black berries are of small to medium size. It is a vigorous vine, with an upright and then drooping growth habit, that can be a good producer. The variety has high resistance to fungus diseases and anthracnose, but a preventative spray is needed to maintain clean fruit. Phylloxera may be a concern. The variety ripens by early mid-season, about one week after St. Croix, and is a consistent and reliable producer.

The acid is higher than St. Croix, but it is still workable and its sugar content rarely goes above 20 Brix. Malolactic fermentation should be considered to offset the wine's lack of sugar to balance its high acids. However, it cannot hang too long on the vine because its pH will increase to unacceptably high levels, so often it is picked when the sugars are around 19 Brix. The wine's color can be from an electric blue-purple to very dark with nice berry-like fruitiness, but it tends to lack tannin and body. The wines can be made either into a Rose or fairly full-bodied red. The heavy reds are complex, powerful, and have up-

front, plummy Zinfandel and black pepper flavors that do well when aged for a few years. It is not difficult for Sabrevois to acquire a bacon sort of aroma if the wine-maker is not careful about skin contact. It may be best if carbonic maceration techniques are used. The result can be an electric blue color, but it minimizes the bacon aroma. These wines are lighter, with some fruitiness. While good on its own, it is best used in blends with other high-sugar varieties such as Baco Noir, Frontenac, Marechal Foch, and St. Croix. The variety ages well.

St. Croix *(labrusca, lincecumii, riparia, rupestris, vinifera)* is a sibling to the Swenson bred variety Sabrevois listed above. The clusters are of medium size and compact, with thin-skinned, medium-large blue berries. Like Sabrevois, it works hard to achieve 20 Brix, but its acid levels are lower. The vine is vigorous with very heavy vegetative growth, but is only moderately productive. It may be precocious in bearing, but is moderately disease resistant, with good reistance to black rot. The fruit ripens early to early mid-season, about one week before Sabrevois, so it may be vulnerable to bird damage.

St. Croix produces attractive, light-to medium-bodied red wines that have soft tannins and flavors of leather, tobacco, cooked or jammy berries, black currants, and other dark fruit flavors. The wines can be dark, somewhat lacking in tannins, and have a vegetative nose and flavor of tobacco, but is otherwise rather neutral, so should be blended with other wines. Vinification techniques, such as carbonic maceration, can be used to enhance its fruit flavors. While St. Croix can be made as a varietal, it is best to used it as a component in a blend.

Petite Pearl (T.P. 2-1-24) *(berlandieri, labrusca, lincecumii, riparia, rupestris, vinifera)* is a cross of MN 1094 x E.S. 4-7-26 bred by Minnesota grape breeder Tom Plocher in 1996 and introduced in 2010. Petite Pearl usually has a small cluster, similar to Leon Millot, tight and dense with a prominent shoulder. It has moderate vigor and an open growth habit with few laterals, resulting in low canopy maintenance and good fruit exposure on a high cordon. Using a standard spray program, resistance to all major fungus diseases is good. However, extra applications for Botrytis are recommended for New England and the Middle Atlantic states. Petite Pearl holds its dormancy well during warm spells in the early spring. Bud break is about twelve days after Marquette, allowing it to avoid most late frosts. Petite Pearl needs about 2,600 degree days to fully ripen, later than Marquette, but earlier than Frontenac. Typically, it will mature to 22-24 Brix, with low acidity. While it has been cropped at eight tons per acre in Vermont with little affect on its winter hardiness, a crop

Petite Pearl. Tom Plocher photo.

of four tons per acre is more suitable for the production of quality wine.

As a wine grape, it has relatively low total acidity and malic acids. No acid reduction is needed other than a malolactic fermentation. Petite Pearl has a suitable tannin structure for wine production. Skin contact of twelve to twenty-four days is typically used. The wines have good acid, tannin, and alcohol balance. As a dry red, it is complex, with aromas of black currant, cherry, and plums, with secondary aromas of "forest floor", star anise, and almond. Often Petite Pearl is blended with small amounts of Crimson Pearl or Marquette to add more fruit to the wine.

Crimson Pearl (T.P. 2-1-17) (USPP30,263) *(aestivalis, cinerea, berlandieri, labrusca, lincecumii, riparia, rupestris, vinifera)* is a sister to Petite Pearl that is covered above and was introduced in 2015. The clusters are medium in size, long, and slightly loose. The vine has moderate vigor, with an open growth habit, and some low vigor laterals. Crimson Pearl has low canopy maintenance demands and good fruit exposure on a high cordon system. With a standard spray program, it has good resistance to all major fungus diseases. In New England and the Middle Atlantic states, Crimson Pearl needs additional sprays for Phomopsis. Crimson Pearl holds its dormancy during warm periods of time in March-April. Its bud break is about ten days after Marquette, which helps it to avoid late spring frosts. It needs about 2,500 degree days to fully ripen, which is about five days before Petite Pearl. When fully ripe, it attains 21 to 22 Brix of sugar with low acidity.

Crimson Pearl. Tom Plocher photo.

Like its sister, Petite Pearl, the wines from Crimson Pearl have relatively low acidity, but a malolactic fermentation can help its wine quality. The tannins are less than Petite Pearl and more than Marquette. The flavor profile of Crimson Pearl is fruitier than Petite Pearl, with more pronounced aromas of cherry, blackberries, and raspberries. It lends itself to the production of soft and well balanced fruit-forward dry wines. Cold soaking and skin-contact of between twelve and twenty-four days are typically used. Small amounts of Petite Pearl added can enhance its structure. Crimson Pearl is a good grape to produce Rose wines, with aromas ranging from raspberry to melon to tropical fruits depending on how it is fermented.

Verona (T.P. 1-1-34) (USPP30,631) *(aestivalis, berlandieri, labrusca, lincecumii, riparia, rupestris, vinifera)* is a 1997 cross (Macgregor's *riparia* x St. Croix # 5) x E.S. 5-4-16 by Tom Plocher, that was introduced in 2015. The cluster is medium to large and relatively compact. Its vigor is medium to high, with more lateral growth

Verona. Tom Plocher photo.

than Petite Pearl or Crimson Pearl. It needs more canopy management than either Petite or Crimson Pearl to achieve good fruit exposure. Verona is generally grown on a high wire cordon. With a standard spray program, it has good disease resistance to most fungus diseases. In New England and the Middle Atlantic states, its berries may split during extremely rainy harvest seasons, but foliar calcium sprays can reduce such splitting. Verona holds its dormancy well during early spring warm spells. Bud-break is about ten days after Marquette, allowing it to avoid late spring frosts. Verona ripens rather late, needing 2,700 degree days to fully ripen, about ten days after Petite Pearl, and shortly after Frontenac. Verona is recommended for the warmer parts of the Northeast including New Jersey, Pennsylvania, Conneticut, and the lower Hudson Valley. When ripe, Verona has sugars of 22-23 Brix and low to moderate acidity.

Verona has low to moderate acids, but it can benefit from a malolactic fermentation. Of the three Plocher varieties, Verona has the most tannin structure. Skin contact times of between twelve and twenty-four days are generally used. The wines have good balance between acidity, tannins, and alcohol. Verona has aromas of raspberries and blackberries, with notes of cocoa and coffee. In style, the wines are very fruit forward.

This article is based on the three authors' average collective experience of over 30 years in growing cool climate grapes, including the Minnesota hybrids, and making wine from them. It is also based on Tom Plocher and Bob Parke, *Northern Winework: Growing Grapes and Making Wine in Cold Climates,* (Hugo, MN: Northern Winework, Inc., 2001); Todd Trzaskos, *Wines of Vermont: A History of Pioneer Fermentation* (Charleston, SC: American Palate, 2015), and J. Stephen Casscles, *Grapes of the Hudson Valley and Other Cool Climate Regions of the United States and Canada* (Coxsackie, NY: Flintmine Press, 2015). For more information on Petite Pearl, Crimson Pearl, and Verona, see www.petitepearlplus.com.

NC-140 Fuji and Honeycrisp Apple Rootstock Trials in New Jersey

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Selection of the best dwarfing apple rootstock is essential. Rootstocks selection is the key piece of the planting puzzle in order to provide compatibility with the desired varieties and planting systems. Correct rootstock selection is key to obtain the tree vigor to match the desired production system, to maximize yield, and to maximize disease and insect resistance. Rootstocks must match the vigor of the soil as well as that of the cultivar. Proper rootstock selection is one of the most important decisions made prior to orchard establishment. Rootstock selection will impact the cost of establishment, production systems and yield for the life of the orchard.

Most modern rootstocks are releases from university or government breeding programs worldwide. NC-140 evaluates rootstocks throughout North America to assess rootstock performances with different varieties, planting systems, and local environmental conditions. NC-140 has driven the move to high density via dwarfing rootstocks for more than 40 years.

Trial Parameters

As part of the 2014 NC-140 Rootstock Trial, two research blocks, Fuji and Honeycrisp varieties were established at the Rutgers Snyder Research and Extension Farm in Pittstown, NJ. Fuji trees were planted at 5' X 13'or 672

Table 1. Trunk cross-sectional area, yield, fruit size, and yield efficiency in 2019 of Fuji trees in the 2014 NC-140 Apple Rootstock Trials at the Rutgers Snyder Research and Extension Farm in Pittstown, NJ.

Rootstock	Trunk cross-sectional area (in^2)	Yield (lb)	Fruit size (oz)	Yield efficiency (lb/in^2 TCA)
G.202	8.9 f	6 c	7.1 ab	0.7 c
G.214	10.5 ef	36 bc	7.0 ab	3.4 abc
G.935	11.5 def	36 bc	6.6 ab	3.1 abc
G.11	11.5 def	47 bc	6.6 ab	4.1 abc
M.9 NAKBT337	12.3 cdef	8 c	5.1 b	0.6 c
M.26 EMLA	14.7 bcde	24 bc	5.5 ab	1.6 bc
V.1	16.3 abcd	77 ab	8.6 a	4.8 abc
G.30	16.7 abc	104 a	7.5 ab	6.2 a
V.5	18.4 ab	77 ab	7.9 ab	4.2 abc
V.6	19.1 ab	103 a	8.2 ab	5.4 ab
V.7	19.9 a	120 a	8.1 ab	6.1 a

Means separated within columns by Tukey's HSD (P=0.05).

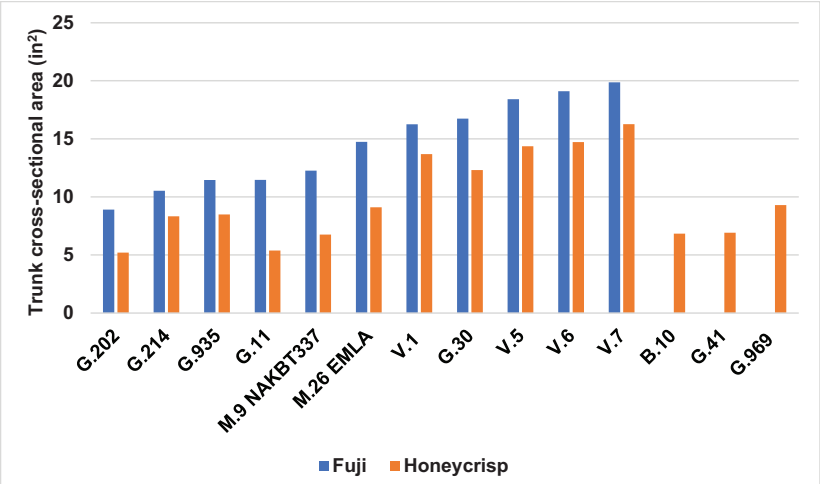


Figure 1. Trunk cross-sectional area in 2019 for Fuji and Honeycrisp trees in the 2014 NC-140 Apple Rootstock Trials at Rutgers Snyder Research and Extension Farm, Pittstown, NJ.

Table 2. Trunk cross-sectional area, yield, fruit size, and yield efficiency in 2019 of Honeycrisp trees in the 2014 NC-140 Apple Rootstock Trials at the Rutgers Snyder Research and Extension Farm in Pittstown, NJ.

Rootstock	Trunk cross-sectional area (in^2)	Yield (lb)	Fruit size (oz)	Yield efficiency (lb/in^2 TCA)
G.202	5.2 e	10 b	7.1 a	1.9 a
G.11	5.4 e	19 ab	6.0 a	3.5 a
M.9 NAKBT337	6.8 de	32 ab	7.0 a	4.7 a
B.10	6.8 de	13 ab	8.0 a	1.9 a
G.41	6.9 de	12 ab	7.0 a	1.7 a
G.214	8.3 de	16 ab	8.4 a	1.9 a
G.935	8.5 de	18 ab	8.1 a	2.1 a
M.26 EMLA	9.1 cd	30 ab	7.4 a	3.3 a
G.969	9.3 cd	21 ab	7.6 a	2.2 a
G.30	12.3 bc	35 ab	9.9 a	2.9 a
V.1	13.7 ab	29 ab	7.7 a	2.1 a
V.5	14.4 ab	43 ab	9.1 a	3.0 a
V.7	14.7 ab	52 a	8.6 a	3.5 a
V.6	16.3 a	37 ab	10.0 a	2.3 a

Means separated within columns by Tukey's HSD (P=0.05).

trees/acre, and Honeycrisp trees were planted at 4' x 12' or 907 trees/acre. Trees were maintained to current commercial standards, in a modified tall spindle planting system (spacing's further apart than a typical tall spindle). The Fuji and Honeycrisp blocks at the Rutgers Snyder Farm included 11 rootstocks and 14 rootstocks, respectively, in a completely randomized design each with 10 trees on each rootstock for each variety.

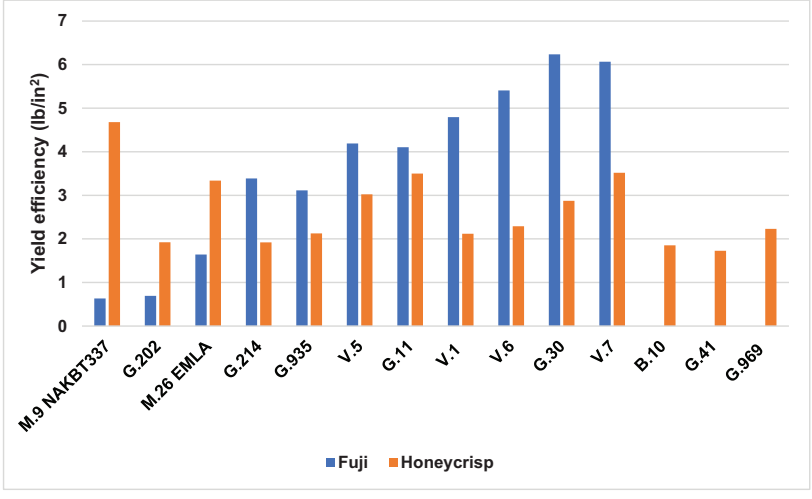


Figure 2. Yield efficiency in 2019 for Fuji and Honeycrisp trees in the 2014 NC-140 Apple Rootstock Trials at Rutgers Snyder Research and Extension Farm, Pittstown, NJ.

Results for 2019

The 2019 growing season in New Jersey began with a very wet spring, but it dried out by the late summer. It was notably dry for the last 8 weeks of the growing season. Overall growth did not appear to be impacted by the wet spring. In fact, trickle irrigation applied late in the season during the dry period maintained normal tree vigor. Trunk cross-sectional area, yield, yield efficiency, and fruit weight were assessed for each tree from 2014 through 2019.

At the end of the 2019 growing season, Fuji trees on V.7 were the largest, followed by those on V.6, V.5, and G.30 (Table 1 and Figure 1), whereas Honeycrisp trees V.6 were the largest, followed by those on V.7, V.5, V.1, and G.30 (Table 2 and Figure 1). The smallest trees in both the Fuji and Honeycrisp trials were on G.202 and G.11.

Fuji yields were strikingly varied, ranging from a low of 6 lb per tree to a high of 120 lb. The greatest yields were harvested from trees on V.7, V.6, and G.30 and the lowest from those on G.202 and on M.9 NAKBT337 (Table 1). Trees on V.7 and G.30 were the most yield efficiency, and trees on M.9 NAKBT337 and G.202 were the least yield efficiency (Table 1 and Figure 2).

Yields were lower during 2019 for the Honeycrisp trial. The lowest yields were harvested from trees on G.202, and the greatest were harvested from trees on V.7 (Table 2). In 2019, yield efficiency of trees on different rootstocks did not differ significantly (Table 2 and Figure 2). In 2019, the largest Fuji

Table 3. Change in trunk cross-sectional area, cumulative yield, and cumulative yield efficiency for 2015-19 of Fuji trees in the 2014 NC-140 Apple Rootstock Trials at Rutgers Snyder Research and Extension Farm, Pittstown, NJ.

Rootstock	Change in trunk cross-sectional area (in^2, 2015 – 19)	Cumulative yield (lb, 2015-19)	Cumulative yield efficiency (lb/in^2 TCA, 2015-19)
G.202	7.0	69	7.7
G.214	8.6	117	11.1
G.935	8.7	134	11.7
G.11	9.2	119	10.4
M.9 NAKBT337	10.2	80	6.5
M.26 EMLA	12.3	91	6.2
G.30	13.2	208	12.4
V.1	13.4	155	9.5
V.5	15.4	140	7.6
V.6	15.7	191	10.0
V.7	16.8	200	10.1

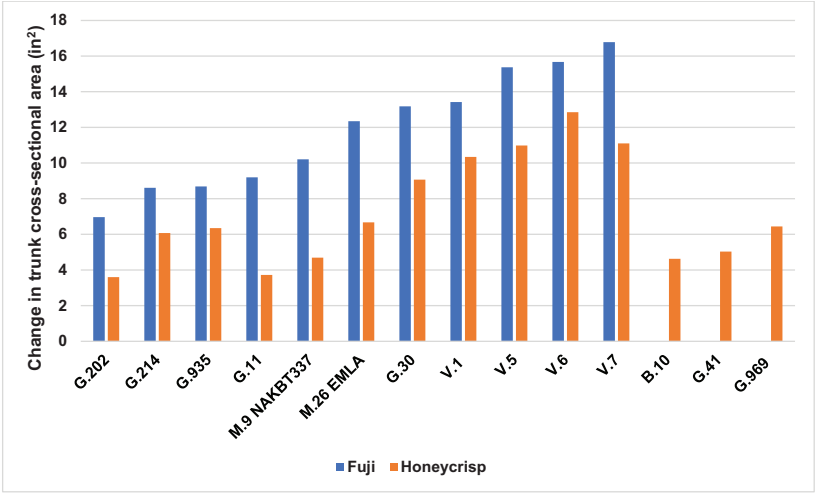


Figure 3. Change in trunk cross-sectional area (2015-19) of Fuji and Honeycrisp trees in the 2014 NC-140 Apple Rootstock Trials at Rutgers Snyder Research and Extension Farm, Pittstown, NJ .

fruit were harvested from trees on V.1, and the smallest were harvested from trees on M.9 NAKBT337 (Table 1). Honeycrisp fruit size did not vary significantly by rootstock (Table 2).

Cumulative results 2015-2019

For both Fuji and Honeycrisp trees, the greatest increase in trunk cross-sectional area from 2015 to 2019 was seen for trees on V.5, V.6, and V.7, and the lowest was measured for trees on G.202 (Tables 3 and 4, Figure 3).

Greatest cumulative yields (2015-19) for Fuji trees were harvested from trees on G.30, and the lowest were from trees on G.202 (Table 3, Figure 4). The greatest cumulative Honeycrisp yields (2015-19) were harvested from trees on V.5 and G.30, and the lowest were from trees on G.202 (Table 4, Figure 4).

The most cumulatively yield efficient (2015-19) Fuji trees were on G.30, G.935, and G.214 (in descending order), and the least yield efficient trees were on M.26 EMLA and M.9 NAKBT337 (Table 3). The most cumulatively yield efficient (2015-19) Honeycrisp trees were on M.9 NAKBT337 and G.11, and the least yield efficient were on the four Vineland rootstocks (Table 4).

Conclusions

These trials will be ongoing for 3 to 5 more years, but some conclusions can be made already. G.30 is a very efficient and productive rootstock (particularly with Fuji in this trial), and it has been evaluated in numerous NC-140 and other rootstock trials over several years. It fell out of favor with our US nurserymen as it is hard to propagate, so there are very few stool beds of G.30.

In general, G.30, M.26 EMLA, V.1, V.5, V.6 and V.7 are too vigorous for tall spindle systems. The exception might be for Honeycrisp.

Table 4. Change in trunk cross-sectional area, cumulative yield, and cumulative yield efficiency for 2015-19 of Honeycrisp trees in the 2014 NC-140 Apple Rootstock Trials at Rutgers Snyder Research and Extension Farm, Pittstown, NJ.

Rootstock	Change in trunk cross-sectional area (in^2, 2015 – 19)	Cumulative yield (lb, 2015-19)	Cumulative yield efficiency (lb/in^2 TCA, 2015-19)
G.202	3.6	41	7.3
G.11	3.7	61	11.4
B.10	4.6	56	8.1
M.9 NAKBT337	4.7	81	12.1
G.41	5.0	57	8.3
G.214	6.1	70	8.4
G.935	6.4	74	8.8
G.969	6.4	73	7.9
M.26 EMLA	6.7	77	8.7
G.30	9.1	96	7.8
V.1	10.3	78	5.7
V.5	11.0	97	6.8
V.7	11.1	88	6.0
V.6	12.9	85	5.2

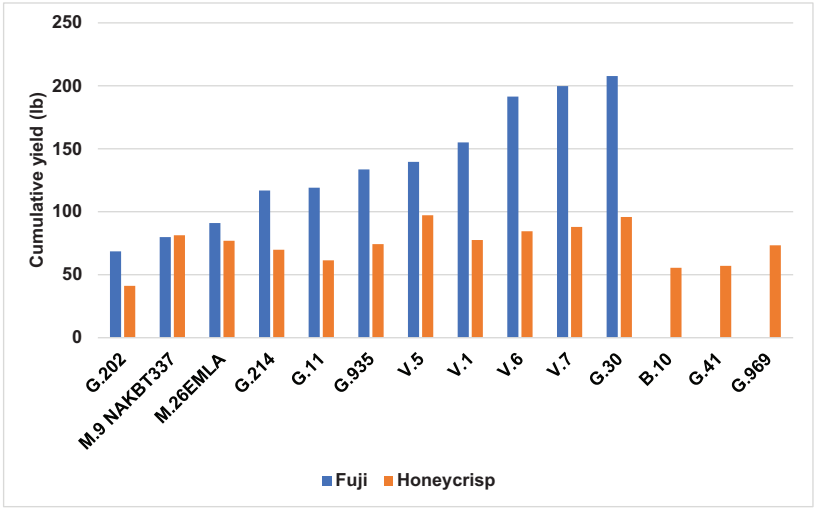


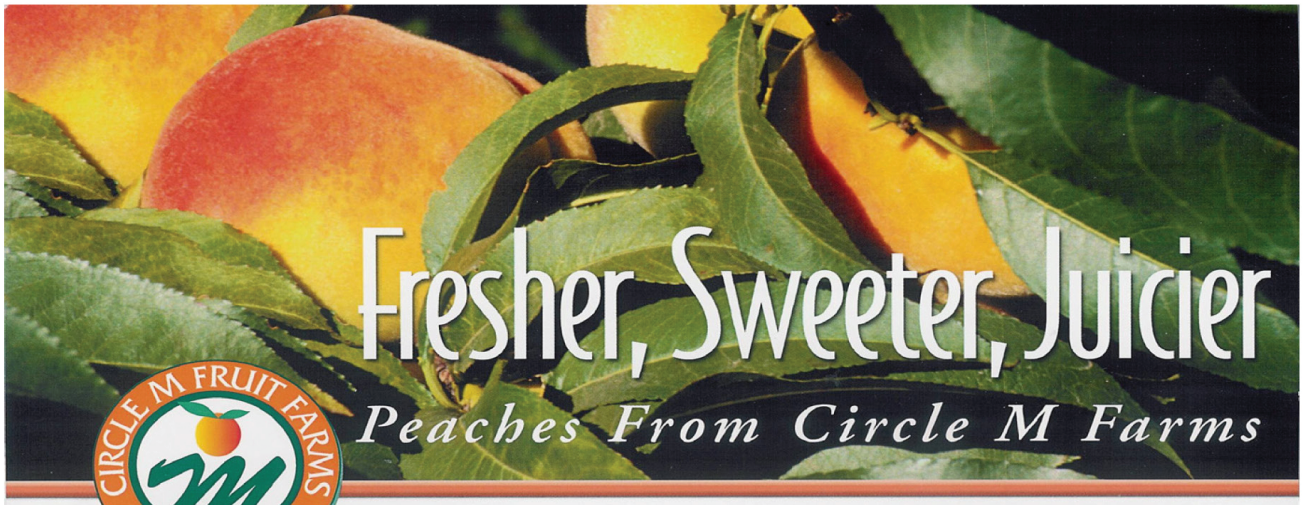
Figure 4. Cumulative yield (2015-19) from Fuji and Honeycrisp trees in the 2014 NC-140 Apple Rootstock Trials at Rutgers Snyder Research and Extension Farm, Pittstown, NJ.

The most yield efficient rootstocks in this trial at the spacing's selected for Honeycrisp were M.9 NAKBT337 and G.11. Since M.9 NAKBT337 is very susceptible to fireblight and root rots, G.11 would be the better choice because of its resistance to both. The most efficient rootstocks in this trial at the spacing's selected for Fuji were G.30, G.935, and G.11.

For tall spindle systems in New Jersey and Massachusetts we have moved to tighter spacing's for maximum production, usually 3 x 12' or 3' x 11', depending on soil type, variety, and location. At these spacing's, G.30, and G.935 would be too vigorous for Fuji. G.11 would be the best choice for a full dwarf stock at these closer spacing's for Fuji in tall spindle. With Honeycrisp, G.11 could be planted at 2.5' x 11' or 12' and be well suited for tall spindle.

Also, a caution on G.935, we now know it to be susceptible to latent viruses, so only trees propagated with virus-free bud wood should be grafted onto G.935.

Editors' Note: The performance of G.202 in the 2014 NC-140 Apple Rootstock Trials does not match what would be expected of G.202 and what has been measured in numerous other trials. It is likely that the trees labeled G.202 are actually some other rootstock.



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