Editorial: Use Social Media for Positive Information on Fruit Farming

I recently made a Facebook post with a picture of my apricot trees in bloom with an explanation of why I can grow apricots. When I went back a few hours later, I was amazed at how many people liked it, loved it, shared it and commented. With all the negative press out there about modern agriculture, these was an epiphany for me. People want information. They want good information. They want it from people who really know and trust. They trust real farmers.

The response to my Facebook post made me realize I should do that more often. In fact, I think every farmer should do this once in a while. But I’m not on Facebook or Instagram or Twitter you say. Most likely someone on your farm is. Give them the responsibility of posting something about your farm regularly. Once a week will do.

But you may not sell directly to the consumer. So what. Even people who buy at the grocery store want information on the food they are buying.

What do I post, you might ask? I posted a picture of apricot trees in bloom with an explanation. I could post a weekly picture of those same trees to show changes from bud to blossom to fruit.

How about a piece of equipment and an explanation of what it is used for. Planting new trees always gets a lot of attention. You can post pictures and short explanations of pollinators working, grafting trees, pruning, harvesting, to name a few. Really, anything you are doing on your farm today can be a good social media post. The point is, most everything you do on your farm is of interest to the general public.

How often? Do what fits in your schedule. Once a day, once a week. This flow of information is important. Put it on your calendar to do it. While you or someone on your farm is posting, take the time to see who else is posting. Share their photos. Ask them to share yours.

After I posted my picture, my wife shared it. My audience tripled. Too often the posts on Facebook remind people about the Dirty Dozen or Frankenfoods. If you start a steady stream of information, people will start looking for that. They will ask questions. They will look forward to your next post.

I know we all have a lot on our plates, but I’ve been thinking that if together we start a flow of information the public will see us as a trusted source for that information. When issues arise, they will think about what you posted or ask a question.

You can find me on Facebook as Jim Bittner and Bittner Singer Orchards U-Pick Cherries.

Friend me, share your posts on my pages. Let’s start a trickle of information that can become a river.

Jim Bittner
Bittner Singer Orchards | 6620 Lake Rd. | Appleton, NY

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Crop load management is arguably the most critical horticultural practice that orchardists perform. Managing crop load directly affects yield, fruit size, quality, and alternate bearing, which all contribute to crop value and, therefore, profitability (Marini et al., 2002). Achieving consistent target crop loads, however, is notoriously challenging. Fruitlet response to chemical thinners, for example, varies considerably due to complex interactions among numerous abiotic and biotic factors (Greene, 2002; Lakso and Robinson, 2015). Several models have been developed to improve the precision of crop load management and guide thinning decisions over a wide range of crop and fruitlet development (Robinson et al., 2013).

Elimination of future crop can be enacted as early as dormant or green tip timing by counting the number of fruit buds and pruning to a ‘target’ bud number (Robinson et al., 2013, 2014). Flower density is a strong predictor of final fruit set and crop load (Lordan et al., 2019). Applying caustic compounds to eliminate excessive pollination is guided by the pollen tube growth model (Yoder et al., 2009; Peck and Omlstead, 2018). These early interventions can substantially mitigate the burden of post-bloom thinning. Following petal fall, fruitlet thinning can be efficacious up to ~20 mm fruitlet diameter, depending on the chemistry and conditions. Apples tend to be most sensitive to thinners around 10-12 mm when fruitlets become increasingly more dependent on current season photoassimilates to meet their growth demand. Hence, the current-season carbohydrate supply, which is based on temperature and light conditions, plays a key role in the fate of a fruit to persist or abscise. The MaluSim model was developed to estimate the carbon balance (surplus or deficit) of an apple tree and the carbohydrate demand of growing fruitlets (Lakso et al., 2005; Robinson et al., 2010; Lordan et al., 2019). The sensitivity of a fruitlet to carbohydrate stress subsequently informs the type and dose of thinner to apply. Typical growth rates of apple fruitlets are ~0.8 mm per day; the consequence of which is a relatively narrow thinning window to achieve target crop loads. If the desired number of fruits is not achieved before the window for chemical application closes (approximately 30 days after full bloom), hand thinning is necessary. This practice, however, is cost prohibitive, heavily dependent on the availability of labor and too late to ensure adequate return bloom for biennial bearing cultivars.

These models which were designed to optimize the timing of thinner applications do not, however, ensure thinner efficacy. Visible signs of abscission after the application of thinning compounds do not manifest quickly enough to be useful predictors of fruit set. Thus, the Fruitlet Growth Model (FGM) was developed to predict abscission of fruitlets based on repeated measures of fruit diameter (Greene et al., 2013). Based on empirical data, the model assumes that fruit with reduced growth rates will abscise compared to the most rapidly growing fruit (Greene et al., 2013; Marini, 2003). Subsequently, the FGM requires repeated measures of individual fruitlet every 3 to 4 days to assess the growth of individual fruitlets (Figure 1). The model’s estimate of fruit set informs the need for additional thinner applications to achieve the target crop load before fruitlets abscise and the thinning window closes. Time intensive measurements, however, have limited broad adoption of this powerful model. Here, we describe a simplified procedure to separate fruitlets based on differences in their size, not growth rate, to predict orchard fruit set.

### Material and Methods

Two procedures were compared for predicting apple fruit set on untreated control and chemically thinned ‘Gala’ Tall Spindle trees. For the modified fruit set prediction model, termed Size Distribution model (SDM), five replicates comprising 7 trees each were flagged. On each tree, 20 random spurs were selected and tagged at bloom, all flowers were counted and entered into an Excel spreadsheet, and spurs were harvested every other day.
for a two-week period, starting from the date of the first thinner application (Figure 1A). One tree per replicate was used per sample date; thus, a total of 100 spurs was collected (five trees, 20 spurs per tree). Sample collections of spurs harvested into Ziploc bags were stored in a refrigerator until processing. Based on the tight curvilinear relationship between fruitlet diameter and fresh weight, either measure can be used to express fruit size (Figure 2). Given the simplicity of balances that automatically export data to an Excel spreadsheet, harvested fruitlets were weighed. We additionally tracked fruitlet position in the cyme inflorescence to determine the relative setting potential of King and lateral fruitlets (data not shown). Fresh weight of fruitlets were processed by formulae within the Excel spreadsheet to generate a fruit set estimation, similar to that used for the FGM. The spreadsheet macro program sorts fruitlets from the largest to the smallest and compares all fruit to the mean of the largest 10%. Fruit that are 50% or less the size of the top 10% are predicted to abscise. This model was compared directly to the FGM, which comprised five replicate trees and 20 tagged spurs per tree. Repeated measures of those individually tagged fruitlets was performed every other day with a digital caliper and manually entered into a spreadsheet (Figure 1B).

In 2021, the experiment was replicated in Michigan, North Carolina, Washington, and New York using the procedure described above (2021 data for the UTC treatment are not shown). A standard thinner was applied in accordance with conditions at each location. At each site, final fruit set was recorded at harvest from 40 spurs per replicate tree (200 spurs total), preselected at bloom. A simplified illustration of how the SDM model could be applied in a commercial orchard is shown (Figure 3).

Results and Discussion

During both seasons a side-by-side comparison of the SDM and the FGM was performed. In 2020 the SDM showed greater precision in the prediction of fruit set than the FGM for fruitlets of an untreated control (UTC) treatment, which received no thinning applications, and those that received a standard chemical thinner application at 6 mm (Figure 4). The predictions generated from FGM data underestimated final fruit set, assessed as total number of fruit per tree at harvest, by 26% in the UTC and 15% in the thinned treatment. The FGM, therefore, overestimated the percentage of fruitlets abscising from the population growing at rates less than 50% of the most rapidly growing fruit.

To expand and further validate the SDM model in 2021, comparisons between the two models were tested in four different locations across the U.S. In Michigan, the SDM and FGM produced similar fruit set predictions for the thinned treatment (~22% predicted fruit set), which was a slight underestimate of final fruit set by 3%; however, additional abscission occurred after June drop (Figure 5A). In North Carolina, the FGM predicted 19% fruit set and the SDM predicted 14%; both models overestimated fruit set, but the SDM prediction was closer to the final fruit set of 12% (Figure 5B). In Washington, both models overestimated fruit set; again, the SDM was slightly closer to the final fruit set (Figure 5C). In New York, both models predicted final fruit set well and only slightly diverged from final fruit set of 25% (Figure 5D).
5D). The first measure of the FGM in NY, however, suggests high abscission rates only two days following the thinner. Because fruit growth rates are sensitive to temperature fluctuations, marked daily changes in temperature have a pronounced effect on FGM predictions, at least when collecting data at frequent intervals.

Precision crop load management requires accurate and early estimates of fruitlet responses to thinners in order to facilitate repeat applications before the thinning window closes. A notable advantage of the FGM is that data reach asymptotic values, approaching final fruit set, several days earlier than the SDM (Figure 5 A, B, D). Given that the pattern of SDM over time is more consistent than the FGM (e.g., see consistent patterns of SDM data), we expect that a functional analysis of the data will facilitate robust estimates of final fruit set prior to reaching the asymptote and thus facilitate similarly early predictions as produced by the FGM.

Conclusions and Future Work

The FGM has gained deserved attention, but adoption of the model has been limited due to real or perceived time constraints and/or a measurement-intensive procedure. A simplified procedure based on sampling and weighing fruitlets from harvested spurs generated accurate, real-time predictions of fruit set in apple that were comparable to those achieved with the FGM. Overall, the SDM accurately predicted final fruit set for two years in Michigan and one year in a multistate collaboration in four distinct regions. The SDM may offer an alternative, more time-efficient approach to the FGM. Our data further suggest that repeat measures may not be necessary to produce reliable fruit set predictions, which should expedite nascent vision-automation technology to generate fruit set predictions. Eliminating the need to geo-reference fruitlets to facilitate repeated measures using image analysis tools would expedite nascent vision-automation technology to generate fruit set predictions. Eliminating the need to geo-reference fruitlets to facilitate repeated measures using image analysis tools would expedite nascent vision-automation technology to generate fruit set predictions.

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Herbicide Resistant Horseweed in New York and Possible Implications for Perennial Crop Systems

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Keywords: Weeds, weed control, herbicide resistance, horseweed, marestail, Erigeron canadensis, Conyza canadensis

Weeds compete with perennial crops for water and nutrients, particularly during the establishment phase and, again, during flowering and fruit set in bearing systems (Breth and Tee 2013; Breth et al. 2016; MacRae et al. 2007; Majek et al. 1993; Mitchem and Lockwood 2017; Parker and Meyer 1996; Alcorta et al. 2011; Weller et al. 1985). Dense weed populations can also harbor undesirable pests, impede the deposition of crop protection chemicals, slow harvest operations, and increase labor costs, among other impacts (Belding et al. 2004; Derr 1995; Derr 2001; Killian and Meyer 1984). Herbicide applications are a frequently used tool for managing unwanted vegetation under the canopy. However, there can be risks associated with their use; this includes the evolution of herbicide resistance in the targeted weeds.

According to the International Survey of Herbicide Resistant Weeds, 511 unique cases of resistance have been confirmed, globally, across 153 dicot and 113 monocot species (Heap 2022). Weeds have evolved resistance to 165 different herbicides and to 21 of 31 known sites of action. Herbicide resistant weeds have been reported in 96 crops in 71 countries, including orchards, berries, and vineyards. Worldwide, 53 cases of resistance have been identified in apple, blueberry, grape, peach, and pear, collectively. In North America, at least nine herbicide resistant species, including horseweed (Erigeron [= Conyza] canadensis L.), have been identified in tree and vine production.

Horseweed is a commonly occurring weed in New York where it can be found growing in a variety of habitats including along roadsides, in field crop and vegetable operations, in berries, grapes, and tree fruits. Because of its small seed size, horseweed is adapted to environments with minimum or no soil disturbance. Horseweed has limited endosperm resources and seedlings often do not emerge from burial depths greater than a few millimeters. Often considered a winter annual, horseweed has a wide germination window and seedlings can emerge in the spring, summer, and fall (Uva et al. 1997). Seedlings initially form a rosette with hairy, round- to long-oval leaves with slightly scalloped edges (Fig. 1 and 2). As the plants grow, leaves become longer, narrow, and irregularly toothed (Fig. 3). Horseweed stem elongation (called bolting) begins in late-spring to early-summer (Fig. 4). Mature plants are unbranched, unless the main stem becomes damaged, and grow to heights 0.9 to 1.8 m. Individual horseweed can produce thousands to hundreds of thousands of small, dandelion-like seeds with the potential to travel long-distances on wind currents (Dauer et al. 2007; Shields et al. 2006). Globally, resistance to multiple herbicides/herbicide classes has been documented in horseweed; this includes the acetolactate synthase (ALS)-inhibiting herbicides (WSSA 2), the photosystem II (PSII)-inhibiting herbicides (WSSA 5), glyphosate (WSSA 9), and paraquat (WSSA 22) (Heap 2022).

With the assistance of Cornell Cooperative Extension (CCE) specialists, horseweed seeds were collected in 2020 and 2021 from populations distributed across the state; the goal was to conduct a preliminary assessment of the species’ response to glyphosate and alternate herbicide chemistries.

Materials and Methods

In the summers of 2020 and 2021, seeds were collected from 29 New York horseweed populations located in the following counties: Cayuga (population 10), Chenango (populations 13, 14), Erie (population 11), Genesee (populations 8, 15), Jefferson (populations

Figure 1. Horseweed seedlings growing in an apple orchard.

Figure 2. Horseweed seedlings growing in the greenhouse.

Figure 3. Large horseweed rosette with long and linear, irregularly toothed leaves.

Results from this study suggest that many horseweed populations in New York are resistant to glyphosate and some are resistant to paraquat. If horseweed is present in a fruit production system, growers crop consultants and personnel should monitor population responses to these herbicide active ingredients, document escapes and contact university personnel if resistance is suspected.
Results and Discussion

Results showed that most of the horseweed populations surveyed were not effectively controlled by glyphosate applied at the treatment rate (0.87 kg ae/ha). Notable exceptions were the samples collected from hops (population 5), apple (population 7), and grape (population 9) sites, which did not have any plants surviving the glyphosate treatment. For all populations except 5, 7, and 9, the percent difference in vegetative biomass between the control and the glyphosate-treated plants ranged from 3% to 50%, with an average biomass reduction of 21% (Fig. 6). In general, horseweed plants in the putative resistant populations were only stunted in response to the herbicide application (Fig. 7). With respect to paraquat, all populations were completely controlled at 0.73 kg ai/ha, except for 5, 7, and 9, each of which had plants surviving the treatment (Fig. 8).

Supplemental studies conducted on populations 7, 8, 9 and 11 showed that 8 (roadside) and 11 (soybean) were tolerant of glyphosate applications but sensitive to paraquat (Tables 1). Mean per plant biomass, expressed as a percent of the untreated check (0 kg ae or ai/ha), for populations 8 and 11 was 79% and 116%, respectively, when glyphosate was applied at 0.87 kg ae/ha and 83% and 100% when glyphosate was applied at 1.74 kg ae/ha. No plants in populations 8 and 11 survived paraquat applications at 0.73 kg ai/ha and 1.46 kg ai/ha. The opposite responses were observed for populations 7 and 9, which were susceptible to glyphosate but tolerant of paraquat (Table 1). Mean per plant biomass, expressed as a percent of the untreated check, of populations 7 and 9 was 2 and 7%, respectively, when glyphosate was applied at 0.87 kg ae/ha; no plants survived applications of 1.74 kg ae/ha. No plants in populations 7 and 9 showed that 8 (roadside) and 11 (soybean) were tolerant of glyphosate applications but sensitive to paraquat (Fig. 8). Supplemental studies conducted on populations 7, 8, and 9 were performed in a greenhouse study, four populations (7, 8, 9 and 11) were selected for additional evaluation; treatments included glyphosate at 0, 0.87, and 1.46 kg ai/ha and paraquat at 0, 0.73, and 1.46 kg ai/ha applied using a cabinet sprayer with a single nozzle (8002E, Teejet Technologies) boom set to deliver 187 L/ha. Six plants from each population were left untreated to serve as control plants to measure herbicide impacts. The trial was repeated with paraquat (Gramoxone 2.0 SL, Syngenta Crop Protection) applied at 0.73 kg ai/ha. Adjuvants were included in all spray solutions according to label recommendations for both runs. Following treatment, all plants were returned to the greenhouse for 21 days. At 21 days after treatment, individual plants were harvested to evaluate biomass accumulation following herbicide applications. In a greenhouse study, four populations (7, 8, 9 and 11) were selected for additional evaluation; treatments included glyphosate at 0, 0.87, and 1.74 kg ae/ha and paraquat at 0, 0.73, and 1.46 kg ai/ha applied using a cabinet sprayer with a single nozzle (8002E, Teejet Technologies) boom set to deliver 187 L/ha. Each herbicide rate was replicated 12 times for each population. Biomass was harvested at 21 days after treatment.
mechanisms of resistance.

In New York, horseweed is ubiquitous along roadsides. It is also commonly found in agronomic crop settings where glyphosate has been regularly used and selection pressure for resistance is high. Horseweed can also be found in orchards, vineyards, Christmas tree production and other perennial systems where soil disturbance may be minimal, and glyphosate is a commonly used herbicide. Glyphosate-resistant horseweed is a concern in tree, vine, and berry crops in other states (California, Michigan) and countries (China, France, Italy, Spain, and more) (Heap 2022). New York populations that were collected from hops, apples, and grapes were completely controlled by the glyphosate at 0.87 kg ae/ha under greenhouse conditions; these same populations were the only ones sampled to have plants survived paraquat treatments. Supplemental analyses indicate that populations 7 and 9 are susceptible to glyphosate and insensitive to paraquat, although the degree of resistance is still unknown. Ongoing dose response assays are formally confirming the paraquat responses and describing possible cross-resistance to diquat. Paraquat resistance in horseweed has been formally confirmed, previously, in Belgium (nurseries), Canada (peaches), Japan (orchards, grapes, roadsides, railways), California (almonds), Delaware (soybeans) and Mississippi (soybeans) (Heap 2022). There are also two known cases of multiple resistance where populations were resistant to both glyphosate and paraquat (Heap 2022).

So, what does this mean for fruit growers in New York? Horseweed is widespread throughout the state. The seed is wind-dispersed, and resistance can be moved within and between production environments via atmospheric currents (Dauer et al. 2007; Shields et al. 2006). If horseweed is present in a fruit production system, growers, crop consultants and other personnel should monitor the population’s responses following glyphosate and paraquat applications and document escapes. Plants that are not controlled can set seed leading to increases in the size of infestations over time. If resistance is suspected, contact local extension personnel about the possibility of resistance screening. Diversify control strategies to include herbicides that are effective at suppressing the species, which includes glufosinate (WSSA 10) and herbicides in WSSA Groups 4 (synthetic auxins), 14 (protoporphyrinogen oxidase (PPO)-inhibitors), and 29 (cellulose synthesis-inhibitors), among other classes. Confirmation of potential resistances to ALS- and PS II-inhibiting herbicides are ongoing. Check herbicide labels and university crop production recommendations for additional information regarding effective chemistries and consider the use of non-chemical alternatives as is appropriate.

Conclusions

Results from this study suggest that many horseweed populations in New York are likely resistant to glyphosate. Personal communications with CCE specialists have confirmed that the herbicide was mostly ineffective against the species under field conditions. Most of the horseweed samples evaluated in this study (>50%)
were collected from agronomic fields, fence lines, and roadways, one was collected from a hop yard and two were collected from fruit crop settings where growers had expressed concern that the species was not being effectively managed. The populations collected from perennial systems were sensitive to glyphosate but were not controlled by paraquat, an alternative chemistry often used to manage glyphosate-resistant weed species. Consequently, conclusions drawn from populations derived from field crop settings may not accurately reflect the nature of herbicide resistance in specialty crops. The type and distribution of resistance in horseweed in orchards and vineyards remains unknown although the results from this study suggest that further evaluation and documentation is needed to better describe the impacts of herbicide resistance to fruit growers. Horseweed seed collected from perennial crop production environments are subjected to additional screening to better define the resistance profile of the species in New York’s fruit systems.

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Storing ‘Honeycrisp’ at 33°F is a Risky Proposition

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Keywords: Chilling injury, soft scald, bitter pit, storage disorders

Honeycrisp apples are susceptible to a range of physiological disorders during storage, bitter pit and soft scald being the most problematic. High bitter pit incidence in fruit from susceptible orchard blocks is associated with warmer storage temperatures, while soft scald incidence is associated with temperatures close to 32°F (0°C). Keeping fruit at 38°F will reduce the incidence of soft scald but depending on the orchard block severe losses can still occur because of higher bitter pit incidence. We have developed a conditioning protocol in which fruit are kept at 50°F for one week before being moved to 38°F. This management protocol reduces the risk of soft scald development to very low or zero levels and is the standard recommendation for ‘Honeycrisp’ apples in New York and elsewhere. However, conditioning further exacerbates bitter pit development, typically by more than 50% compared with that found in fruit without conditioning (Al Shoffe et al., 2016).

In summary:
- Storage at 33°F minimizes bitter pit incidence but increases potential fruit loss due to soft scald.
- Storage at 38°F minimizes soft scald incidence but increases potential fruit loss due to bitter pit and the effect of conditioning is to further increase bitter pit.

Three factors have led us to ask the question – is it possible to store fruit for short periods of time at 33°F in order to minimize bitter pit development, while avoiding the development of soft scald? This question was asked because:
1. When the dynamics of bitter pit and soft scald development during storage have been investigated, bitter pit develops early in the storage period while soft scald develops more slowly.
2. Orchards differ significantly in their susceptibility to bitter pit and soft scald, and a general relationship exists whereby fruit with high susceptibility to bitter pit have low susceptibility to soft scald (Figure 1).
3. We have developed prediction models that could be used to identify high bitter pit risk fruit, and therefore with a lower risk of soft scald development, that could be stored at lower storage temperatures.

The objective of this study therefore was to test the hypothesis that fruit from orchard blocks with a high risk of bitter pit development could be stored for short time periods at 33°F to minimize its development without the risk of fruit loss due to soft scald and other low-temperature disorders.

Materials and Methods:

‘Honeycrisp’ apples were harvested from trees in a single but different orchard in 2019 and 2020 in Western New York. The orchards chosen each year were ones with a high predicted bitter pit incidence from the passive bitter pit test. Fruit were divided into replicates of 100 fruit. An additional 10 fruit per replicate were used for the assessment of harvest indices. Four replicates in 2019 and 3 replicates in 2020 were treated as follows.

2019:
1. Stored at 33°F
2. Stored at 38°F
3. Stored at 33°F for 5 weeks before transfer to 38°F
4. Conditioned for 1 week at 50°F before transfer to 33°F
5. Conditioned for 1 week at 50°F before transfer to 38°F

2020:
1. Stored at 33°F
2. Stored at 38°F
3. Stored at 33°F for 1 week before transfer to 38°F
4. Stored at 33°F for 2 weeks before transfer to 38°F
5. Stored at 33°F for 3 weeks before transfer to 38°F
6. Stored at 33°F for 4 weeks before transfer to 38°F
7. Stored at 33°F for 6 weeks before transfer to 38°F
8. Stored at 33°F for 8 weeks before transfer to 38°F
9. Conditioned for 1 week at 50°F before transfer to 33°F
10. Conditioned for 1 week at 50°F before transfer to 38°F

The total storage time in 2019 and 2020 was 16 weeks and 20 weeks, respectively. Fruit disorders were evaluated after 4 days at 68°F after removal from cold storage. The incidences of physiological disorders were assessed by cutting equatorially at least five times from the calyx end to the stem end of the fruit. External and internal disorders were calculated based on the percentage of the total fruit assessed.

Results

Fruit in 2019 had higher internal ethylene concentration (IEC), starch pattern index (SPI), and differential absorbance values (I_{AD}) and lower flesh firmness and soluble solids concentration (SSC) compared with those in 2020 (Table 1).

![Figure 1 Bivariate analysis for soft scald after storage at 33°F against bitter pit after conditioning for 7 days at 50°F followed by storage at 38°F for ‘Honeycrisp’ apples harvested from WNY in three years. Soft scald (%) at 33°F = 44.8 - (0.6 × BP (%) for conditioning + 38°F). Modified from Al Shoffe et al. (2020)](image-url)
Table 1 Internal ethylene concentration (IEC), flesh firmness, soluble solids concentration (SSC), titratable acidity (TA), starch pattern index (SPI) and difference of absorbance (ΔAD) values of ‘Honeycrisp’ apples at harvest in 2019 and 2020. Data presented as means ± standard errors (SE).

<table>
<thead>
<tr>
<th>Year</th>
<th>IEC (ppm)</th>
<th>Firmness (lb)</th>
<th>SSC (%)</th>
<th>TA (%)</th>
<th>SPI (1-8)</th>
<th>ΔAD value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td>43 ± 1.5</td>
<td>13.4 ± 0.1</td>
<td>11.1 ± 0.04</td>
<td>6.0 ± 0.1</td>
<td>0.66 ± 0.03</td>
<td>7.6 ± 0.1</td>
</tr>
<tr>
<td>2020</td>
<td>10 ± 1.4</td>
<td>14.2 ± 0.2</td>
<td>12.4 ± 0.4</td>
<td>6.0 ± 0.1</td>
<td>0.61 ± 0.05</td>
<td>6.0 ± 0.1</td>
</tr>
</tbody>
</table>

However, no difference was detected in titratable acidity (TA) between fruit from two years.

Effects of temperature manipulation in 2019. In 2019, only one time period of 5 weeks at 33°F was used before transfer of fruit to 38°F. Bitter pit incidence was highest in fruit that were conditioned and then transferred to 33 or 38°F (Figure 2A). However, the incidence of the disorder in fruit conditioned and stored at 33°F and those stored at 33°F for the entire 16 weeks or moved to 38°F after 5 weeks were statistically the same.

In contrast, soft scald incidence was negligible in fruit stored at 38°F with or without conditioning, while numerically slightly higher in fruit that were conditioned and then stored at 33°F (Figure 2B). The highest soft scald incidence occurred in fruit kept at 33°F for the 16 weeks storage period, and was lower in fruit stored at 33°F for only 5 weeks before transfer to 38°F; however, at 32% the incidence in transferred fruit was unacceptably high.

Vascular browning (Figure 3) was detected at trace levels and only in fruit stored continuously at 33°F (Figure 2C). Cavity formation, which we typically associate with carbon dioxide injury, was highest in fruit stored at 33°F for 5 weeks and in fruit conditioned and then stored at 33°F (Figure 2D). The effects of all other treatments on cavity incidence were similar.

Effects of temperature manipulation in 2020. A wider range of time periods for keeping fruit at 33°F was investigated in 2020 (Figures 4A-D). The effects of storage temperatures and manipulations on bitter pit incidence were variable (Figure 4A). The lowest bitter pit incidences numerically were 33°F for 20 weeks or 33°F for 8 weeks before transfer to 38°F but were not statistically different from most other treatments.

For soft scald, treatment effects were much more pronounced (Figure 4B). The lowest soft scald incidence was found in the fruit stored at 38°F with or without conditioning, whereas the disorder incidence increased markedly with increasing time periods at 33°F before the transfer of fruit to 38°F. As little as 2 weeks of storage at 33°F more than doubled the soft scald incidence compared with that after 1 week.

The incidence of vascular browning was much higher in 2020 than in the orchard block used in 2019. Overall, the incidence of vascular browning was highest in fruit stored at 33°F and then transferred to 38°F but was not clearly related with increasing time at 33°F (Figure 4C). Interestingly, the effect of increasing storage time at 33°F on cavity incidence was similar to that found for vascular browning, with lower incidences found in the continuous 33°F and 8 weeks at 33°F before transfer to 38°F (Figure 4D).

Discussion

The results of this study indicate that ‘Honeycrisp’ apples cannot be safely stored at 33°F for even short time periods. The risk of low temperature injury such as soft scald was shown after as little as two weeks at this temperature.

It is possible that fruit could be stored without soft scald development for a shorter time than the 16 and 20 weeks used in 2019 and 2020, respectively. The long storage times might have allowed the disorder to develop, and maybe a shorter storage time of a month might be safe. However, this possibility has not been investigated, and there are at least four arguments against this approach:

1. In many cases, the way fruit is managed after it leaves the market is unknown, and they may remain in the marketing chain for longer than expected.

2. The results of this study indicate that ‘Honeycrisp’ apples cannot be safely stored at 33°F for even short time periods. The risk of low temperature injury such as soft scald was shown after as little as two weeks at this temperature.

3. It is possible that fruit could be stored without soft scald development for a shorter time than the 16 and 20 weeks used in 2019 and 2020, respectively. The long storage times might have allowed the disorder to develop, and maybe a shorter storage time of a month might be safe. However, this possibility has not been investigated, and there are at least four arguments against this approach:

4. In many cases, the way fruit is managed after it leaves the market is unknown, and they may remain in the marketing chain for longer than expected.
2. The risk of soft scald is well known to vary greatly from orchard to orchard and from season to season, and even in this study, the incidence of the disorder was twice as high in 2020 as in 2019.

3. The variation in soft scald incidence occurred even though bitter pit incidence was similar across both years. However, the blocks were chosen because of high bitter pit susceptibility based on the passive prediction model for the disorder. Even though the method is highly promising it is variable as is the case for all prediction models. The lack of certainty means that a model that is reliable enough to be used for a high-risk endeavor such as the use of 33°F is not yet available.

4. The marked increase in susceptibility of fruit to vascular browning and cavities when transferred to 38°F after a few weeks at 33°F is concerning. We do not know the physiological mechanism of the increased injury although the appearance of cavities suggests that it might be associated with effects on the respiration of the fruit.

Conclusions

In conclusion, we do not recommend storing ‘Honeycrisp’ apples for any period of time at 33°F because of the risk developing devastating chilling injuries. A large variation between orchard blocks and years makes it difficult to develop a safe storage protocol at 33°F. However, the effects of 38°F compared with conditioning and 38°F on disorders other than bitter pit were low. Additional fruit losses due to enhanced bitter pit that occurs as a result of conditioning are high. Therefore, we recommend to not condition fruit from the Hudson Valley and Western New York that have predicted bitter pit risk that is greater than 30% based on peel sap mineral analysis or the passive methods. The reduced losses due to bitter pit achieved by not conditioning the fruit are likely to be much greater than the smaller risk of soft scald developing in these fruit.

Acknowledgment

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Literature Cited


Yosef Al Shoffe is a research associate working on postharvest biology projects in the Watkins laboratory. DoSu Park is a postdoctoral scholar working in the Watkins laboratory. Burak Algul was a postdoctoral scholar from Aydin Adnan Menderes University, Faculty of Agriculture, Department of Horticulture Aydin, Turkey in the Watkins laboratory. Chris Watkins is a research and extension professor who leads Cornell University’s program on postharvest biology of fruit and vegetables, as well as being the Director of Cornell Cooperative Extension, and the Herman M. Cohn Professor of Horticulture.

Figure 4 Bitter pit (A), soft scald (B), vascular browning (C), and cavities (D) of ‘Honeycrisp’ apples after storage for 20 weeks in 2020 plus 4 d at 68°F. After harvest fruit were conditioned (C) for one week at 50°F before transfer to 33 or 38°F or kept at 33°F for different weeks (w) before transfer to 38°F. Results are presented as means ± standard errors (SE). Differences between means (n=3) are indicated by different letters where P ≤ 0.05.
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Protecting Tart Cherry from Spotted-Wing Drosophila Infestation: 2020-2021

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Keywords: Tart cherry, crop loss, SWD, IPM, monitoring, spray programs, crop protection

We evaluated the Spotted-Wing Drosophila IPM program developed by Michigan State University in Western NY. The program was successful and protected the tart cherry crop from SWD infestation. In the Lake Ontario microclimate, SWD arrives earlier and builds up to higher populations sooner in orchards close to the lake than in locations further inland. This places tart cherry orchards within about one mile of Lake Ontario at extreme risk of SWD infestation.

The introduction of spotted-wing drosophila (SWD *Drosophila suzukii*) into New York State coupled with zero tolerance for white worms in processing fruit has added another significant challenge to profitably grow tart cherries, because of the added SWD-insecticide inputs now required from the onset of ripening through harvest. Furthermore, the introduction of European cherry fruit fly (ECFF *Rhagoletis cerasi*) into Niagara County, the instituted quarantine, and ECFF’s eastward spread along Lake Ontario into Wayne County requires that essentially all of the state’s commercial tart cherry acreages must apply ECFF-insecticides starting 30 days prior to harvest and continuing every 6-10 days until harvest is complete. The low return-on-investment and the added insect pests have led many tart cherry growers to push out their orchards (Figure 1).

Leading up to and continuing after the SWD outbreak in 2017, there has been a trend of earlier arrival of SWD across NY, as shown in the chart of the earliest, yearly first trap catch dates obtained by the SWD statewide monitoring network (Figure 2). In 2017, first catch date was 45 days ahead of 2012 and, as of 2021, first catch date is 75 days earlier than it was in 2012. Before 2017, SWD arrival in cherry orchards typically occurred near to the end of harvest, allowing the crop to escape infestation. We found in 2018 and 2019 that first trap catch of SWD was often earlier in orchards within one or two miles of Lake Ontario compared to further inland (Carroll 2021). Yet, crop development was held back along the lakeshore, delaying harvests and increasing exposure time of fruit to SWD and thereby creating higher risk of fruit infestation.

An IPM program developed at Michigan State University for SWD in tart cherries was successfully tested in 2018 and 2019. This program delayed SWD-insecticide sprays until one SWD was caught and fruit were ripe. In some orchards, especially those inland from Lake Ontario, SWD insecticide sprays were not required. In addition, the orchard’s insecticide program was optimized for SWD efficacy, by using insecticides against other cherry insect pests, such as plum curculio and cherry fruit flies, which also had efficacy against SWD. We report on the continuation of this work in 2020-2021.

Materials and Methods

In 2020 and 2021, traps to monitor for SWD’s first catch were set in orchards in Niagara, Orleans, and Wayne Counties. Each year, about half of the orchard blocks were approximately one mile or less away from Lake Ontario and the others were further inland. In early May, two Scentry traps and lures were deployed at each orchard block, one on the edge of the orchard and one within the orchard. In 2021, two Trécé red sticky card traps and lures were also placed in each orchard block, approximately 60 ft. from the Scentry traps. The effectiveness and utility of the sticky card traps was compared to the standard jar traps. All lures were changed at four to six week intervals. Traps were checked weekly for SWD.

Bloom dates were tracked and used as the biofix for a 4°C base temperature degree-day model for cherry fruit susceptibility, developed by Julianna Wilson et al. (2022), Michigan State Uni-

Figure 1. A tart cherry orchard that was removed. Low return-on-investment makes it hard to grow tart cherries profitably and therefore growers take these orchards out of production.

Figure 2. Chart of the earliest, yearly first trap catch dates obtained by the SWD statewide monitoring network for the years 2012-2021 in New York State.
versity. This model is derived from a ‘Montmorency’ fruit growth model (Zavalloni et al. 2006) and predicts fruit softening and thus susceptibility risk to SWD oviposition and resultant infestation. The degree-day accumulation from bloom risk windows for this model, which uses the Baskerville-Emin formula to accumulate degree days above the 4°C base temperature, are: low risk 400-529 DD<sub>4C</sub> BD, moderate risk 530-649 DD<sub>4C</sub> BD, high risk 650-1000 DD<sub>4C</sub> BD.

During the monitoring season through harvest, weekly emails were sent to the tart cherry group, which included growers, consultants, extension educators, and entomology faculty. The emails provided anonymous results from the monitoring sites and management information on the need to spray and insecticide choices (Agnello et al 2021, van Zoeren et al. 2021). Farm-specific results were provided individually to the specific grower. Each year, a report summarizing the IPM program's findings at each orchard block was sent to the collaborating grower.

In each orchard prior to harvest, 50 fruits were collected from the two trees the jar traps were set on to check for fruit infestation. Fruit were brought back to the lab, weighed, and assayed for SWD larvae using the salt flotation method of Van Timmeren et al. (2017). Spray records were obtained from each grower and compared to the trap catch and fruit infestation results for each orchard block, paying attention to the active ingredients used, their efficacy against SWD, and spray intervals. We compared the spray program to the risk predicted by the DD model.

**Results**

In both 2020 and 2021, the Lake Ontario microclimate that typically delays bloom in tart cherry orchards near the lakeshore did not affect bloom strongly and in both years bloom dates were similar across all orchards. The DD model (Wilson et al. 2022) that used bloom date as a biofix also gave similar results for the orchards, with small delays in the low and moderate risk thresholds in orchards near the lake, but comparable high-risk onset dates for both lake and inland orchards (Figure 3). Harvest dates were later for the orchards nearer the lakeshore.

Despite the microclimate not strongly affecting spring bloom dates, spring arrival of SWD as determined by trap catch was earlier in the orchards closer to Lake Ontario, on average 9 and 13 days earlier, respectively, though not as much earlier as in 2018 (18 days earlier) and 2019 (44 days earlier) (Table 1), when the lake microclimate did affect bloom dates. The later harvest dates and earlier arrival of SWD nearer the lake created two-fold longer SWD-exposure times for cherry fruits in 2020 and 2021, as can be seen by comparing the average

<table>
<thead>
<tr>
<th>Orchard Code</th>
<th>Distance from Lake Ontario (mi)&lt;sup&gt;a&lt;/sup&gt;</th>
<th>First catch date&lt;sup&gt;b&lt;/sup&gt;</th>
<th># Days: First catch to harvest&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inland 1</td>
<td>3.5</td>
<td>July 16</td>
<td>-</td>
</tr>
<tr>
<td>Inland 2</td>
<td>9.4</td>
<td>July 11</td>
<td>-</td>
</tr>
<tr>
<td>Inland 3</td>
<td>4.4</td>
<td>July 25</td>
<td>-</td>
</tr>
<tr>
<td>Inland 4</td>
<td>5.2</td>
<td>July 9</td>
<td>June 1</td>
</tr>
<tr>
<td>Inland 5</td>
<td>2.9</td>
<td>July 8</td>
<td>June 29</td>
</tr>
<tr>
<td>Inland 6</td>
<td>9.2</td>
<td>July 6</td>
<td>June 28</td>
</tr>
<tr>
<td>Inland 7</td>
<td>1.8</td>
<td>July 16</td>
<td>June 26</td>
</tr>
<tr>
<td>Inland Average</td>
<td>9.7</td>
<td>July 17</td>
<td>June 18</td>
</tr>
<tr>
<td>Lake 1</td>
<td>0.1</td>
<td>July 5</td>
<td>May 21</td>
</tr>
<tr>
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<td>0.2</td>
<td>July 5</td>
<td>May 21</td>
</tr>
<tr>
<td>Lake 3</td>
<td>0.6</td>
<td>May 31</td>
<td>May 28</td>
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<tr>
<td>Lake 4</td>
<td>1.8</td>
<td>July 18</td>
<td>-</td>
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<tr>
<td>Lake 4B</td>
<td>0.9</td>
<td>June 8</td>
<td>-</td>
</tr>
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<td>May 17</td>
</tr>
<tr>
<td>Lake 6</td>
<td>0.1</td>
<td>June 1</td>
<td>June 28</td>
</tr>
<tr>
<td>Lake Average</td>
<td>0.7</td>
<td>June 29</td>
<td>May 23</td>
</tr>
</tbody>
</table>

<sup>a</sup> Approximate number of miles from Lake Ontario. <sup>b</sup> Dash (-) indicates orchard not monitored that year. *none = No SWD were caught in this orchard in 2021.

**Table 1. Trapping results obtained with the two Scentry jar traps set in the tart cherry orchards showing the dates SWD was first caught and the number of days from the first catch date until harvests began. Results are given for all years of the study, 2018 to 2021.**

![Figure 3](http://example.com/figure3.png)

**Figure 3. The total number of SWD caught in the two traps as a function of time. The data are plotted for two orchards: one near Lake Ontario (top two charts) and one inland (bottom two charts). Charts on the left are data from 2020 and on the right from 2021. Arrows indicate timing of insecticide applications: gold arrows show SWD-effective active ingredients (ai's); black show non-SWD-effective ai's; black and gold stripes show insecticides with two ai's (one effective and one not). Green dashed horizontal lines show approximate harvest dates. The three overlay rectangles indicate MSU degree-day-model cherry fruit SWD susceptibility risk: green = low risk, yellow = moderate risk, and red = high risk.**
number of days from first catch to harvest for the inland and lake orchards. In 2018 and 2019, when a greater effect of the lake microclimate occurred, the longer exposure time was 13-fold and four-fold, respectively (Table 1).

The average total SWD caught in traps at first catch did not differ between the inland and lake sites (Table 2) and typically showed greater variability across years than between the two microclimates within years. The average total SWD caught at harvest was higher in the lake orchards than in inland orchards in all years, except 2021. In 2021, all the tart cherry orchards were under strict spray regimens for ECFF and this could have affected our SWD results across the two orchard microclimate groups. Over all four years, the average total SWD caught at harvest time in the lake sites was 42, compared to 6 in inland sites.

In 2020, one of 11 orchards, a lake site, had a single SWD larva detected in 100 fruits using salt flotation. No larvae were recovered via salt flotation in all orchards in 2021.

The use of insecticides that have efficacy against SWD against the other major insect pests of tart cherry was adopted by the growers, especially as fruit turned straw color. This can be seen in the gold-colored arrows in the charts in Figure 3. The intensity of the ECFF insecticide program with spray coverage required at 6- to 10-day intervals can be seen by comparing the 2020 and 2021 charts. In 2021 compared to 2020, one or two additional sprays were used, more SWD-effective materials were applied, and lower overall numbers of SWD were seen throughout the growing season. We put together a quick guide to facilitate the selection of insecticides for ECFF that also had activity against SWD (van Zoeren et al. 2021).

The red sticky cards did not perform as well as had been hoped, with later catch or no catch in all the lake orchards (Figure 4). A more detailed two-year study using these types of traps is being launched this year, led by Laura McDermott, Janet van Zoeren, and Anya Osatuke, Cornell Cooperative Extension.

Discussion

The use of SWD monitoring can effectively inform IPM decisions against this pest in tart cherry. Our research demonstrated to growers the validity of the one-SWD-caught threshold coupled with ripening fruit in the orchard. A degree-day model (Wilson et al. 2022) to predict SWD infestation risk may prove useful for growers to help them time sprays to correspond to periods of high susceptibility. Nationally, an enormous amount of research has been done on SWD and work continues. A comprehensive review article on SWD was recently published, which provides perspectives on new and emerging technologies to manage this insect (Tait et al. 2021).

The European cherry fruit fly New York State quarantine spray program that was put into place has protected the NY tart cherry and sweet cherry crops from ECFF infestation, allowing these fruits to be sold and processed in permissible areas outside the quarantine zone. In addition, the insecticides used in the quarantine program will protect the crop from SWD, provided growers choose SWD-effective insecticides as part of their arthropod management program. Therefore, the ECFF spray program may preclude the need for an intensive SWD monitoring and management program, at least until such time as the quarantine is lifted. In 2021, this spray program may have skewed our results on SWD in tart cherry.

Spotted-wing drosophila now has over 10 years of exposure to pyrethroid and spinosad active ingredients and reduced sensitivity in SWD to these ai’s is being found in some areas of the US. It continues to be essential to rotate IRAC groups to delay the onset of insecticide resistance in SWD.

The effect of proximity to Lake Ontario being correlated with earlier SWD first trap catch was again found in 2020 and 2021. In orchards within about a mile from the lakeshore, while the cherries ripen later, we have found that SWD numbers build up earlier. This creates near perfect conditions for SWD infestation.
of tart cherries, with later-ripening cherries exposed to SWD on average 3 weeks longer, and to higher numbers of SWD as harvest approaches, on average seven times higher. The potential risk of fruit infestation or lack thereof underlines the importance of IPM monitoring for SWD in tart cherry.

The phenology of bloom across the tart cherry production region of Lake Ontario NY might be used as an indicator of the impending SWD season. If bloom occurs at similar times in orchards near the lake as in orchards further inland, this might indicate an easier SWD management season for orchards near the lake. By contrast, when bloom is later near the lake, this might indicate that the SWD management season could be difficult in orchards near the lake. More research and careful record-keeping on the farm is needed to determine if bloom synchrony or asynchrony can be used as an indication of seasonal SWD risk.

Across New York State, both tart and sweet cherry orchards appear to be increasingly at risk from SWD. Our work has field-validated an IPM approach to effectively manage this serious, invasive pest in cherries. More research is needed to validate this IPM approach on more farms, such as in sweet cherry orchards in the Hudson Valley, and to test the use of easier trapping systems for SWD monitoring.

Conclusions

Overall, the IPM program implemented by the growers was successful and protected the tart cherry crop from SWD infestation. In the Lake Ontario microclimate, SWD arrives earlier and builds up to higher populations sooner than in locations further inland, while the microclimate can delay tree phenology, crop ripening and cherry harvest dates. This combination places tart cherry orchards within about one mile of Lake Ontario at extreme risk of SWD infestation. Orchards near the lake benefit from a moderated winter climate and the later bud break protects their blossoms from late spring frosts. But, early and continuous trap catch of SWD in orchards near the lake correlates with high risk of fruit infestation, even with low trap-catch numbers. Growers now understand the risks and know that SWD monitoring can inform the timing and choice of sprays so that they can protect the tart cherry crop. The SWD IPM Program for tart cherry includes the following steps:

- Monitor SWD using effective traps and lures to determine first SWD catch.
- Make note of bloom dates in orchard blocks.
- Continue monitoring SWD until fruit becomes susceptible. Use the MSU 4°C base temperature degree-day model or fruit sampling to determine color and softness.
- If one SWD has been caught, initiate a spray program through harvest.
- Choose insecticides for other arthropod pests in tart cherry orchards that also have efficacy against SWD.
- Apply the insecticide with the highest efficacy against SWD first to knock back the population.

Acknowledgements

This research was supported by the NYS IPM Program and the NYS Department of Agriculture and Markets. Technical support was provided by Elizabeth Tee, Lake Ontario Fruit Program, and Percival Marshall, Nicole Mattoon, and Ryan Parker, NYS IPM Program, without whom this work would not have been possible. The authors would like to thank the grower collaborators and private consultants who participated in this research and acknowledge their generosity and the trust they placed in us during the validation of this IPM program for SWD in New York.

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Juliet Carroll is a retired Senior Extension Associate in the NYS IPM Program at Cornell AgriTech in Geneva, NY who coordinated fruit IPM research and extension across New York State. Janet van Zoeren is an IPM Specialist with the Lake Ontario Fruit Program, Cornell Cooperative Extension and is based out of Albion, NY.
Viruses that infect apple trees cause losses in apple production mostly due to tree decline and death, graft union incompatibility, decreased tree growth, deformation of branches and roots, and by making fruit unmarketable (Campbell, 1981; Sampson and Johnstone, 1974). Thanks to recent advances of DNA and RNA high throughput sequencing technologies, a number of viruses and viroids have been discovered in apple tissues and apple orchard related material (Liu et al., 2021, Umer et al., 2019; Wright et al., 2020). However, only a few of these have been directly implicated with adverse symptomatology including the latent viruses Apple chlorotic leaf spot virus (ACLSV, Trichovirus), Apple stem grooving virus (ASGV, Capillovirus), Apple stem pitting virus (ASPV, Foveavirus), Tomato ring spot virus (ToRSV, Nepovirus), Tobacco ring spot virus (TRSV, Nepovirus), and Apple mosaic virus (ApMV, Ilarvirus) (Hu et al., 2019; Keshavarz and Hajnajari, 2019; Koike et al., 1993; Lana et al., 1983; Li et al., 2020; Stouffer et al., 1977; Xing et al., 2018). Other viruses and viroids like Apple hammerhead viroid (AHVd, Pelamoviroid) and Citrus concave gum virus (CCGaV, Coguvirus) (Liu et al., 2021; Serra et al., 2018; Wright et al., 2018) have only suspected associations with symptoms that include trunk splitting, mosaic, necrosis, shoot decline, and dieback (Lim et al., 2019; Messmer et al., 2017; Nabi and Baranwal, 2020; Sanderson and James, 2019; Szostek et al., 2018; Wright et al., 2020). Because these viruses are often found in conjunction (mixed infections) with other apple viruses, more research is needed to assess the influence of each when it is the only virus present in an apple tree.

Our understanding to date is that most viruses are spread by grafting, where infected clonal rootstocks or scions are the media for transmission from one tree to another (Barba et al., 2015; Li et al., 2020; Rubio et al., 2020; Wood, 2000); however, a recent report suggests the possibility of pollen transmission of ASGV (Isogai et al., 2018). Millions of trees propagated prior to the discovery of viruses affecting apple trees, the transport of these trees across continents, and propagation on common virus infected apple rootstocks like M.9, M.7, MM.111, B.118, M.8 etc. have all contributed to the historical spread of these viruses and viroids around the world. Nurseries in the Netherlands may have been some of the first to adopt virus elimination as a practice after several experiments demonstrated the adverse nature of viruses in apple rootstocks (Baumann and Louis, 1980; Oosten, 1975a, b, c, 1979; Robitaille and Carlson, 1973). To complicate things, as we have been reminded lately with the COVID 19 pandemic, viruses, including the ones that affect apple trees, mutate and may form many strains within a certain type. Some of these strains may be more or less virulent depending on the individual type of apple (or apple rootstock) being exposed (Howell et al., 1996). Some wild species of apple seem to react severely to the presence of viruses (Kirby et al., 2001; Silva et al., 2008), hence they have been used as live indicators (biological indexing) for the presence of viruses in budwood. In apple rootstocks, some of these wild species have been the source of positive traits like resistance to fire blight (Malus robusta, M. floribunda) and cold tolerance (M. baccata) (Gardner et al., 1980; Warner et al., 1984). One of the best apple rootstocks to survive extreme cold events ‘Ottawa 3’ displays susceptibility to at least ASGV (James et al., 1997). Several apple rootstocks released by the Geneva® breeding program (G.935, G.214, G.890, G.969, G.814) are derived from parents ‘Ottawa 3’ and ‘Robusta 5’ and...
was a need to conduct a virus census of all the elite breeding lines finished trees for which the virus status was unknown. Hence there and well and maintain their “seedling-virus-free” status, at times the program has the goal to keep the original seedling trees alive in the breeding program which may suffer similar problems. Furthermore, as the breeding program releases additional rootstocks derived from both parents and is hypersensitive to latent viruses, causing nursery trees to decline and die within 2 years of grafting with virus-infected wood (Figure 2). In some cases, the demise of apple trees due to the presence of viruses can be slow and display a gradual decline caused by graft union necrosis among certain rootstock/scion combinations in the presence of ToRSV (Tuttle and Gotlieb, 1985), as observed in MM.106 rootstock grafted with ‘Delicious’ scion. The bottom line is that viruses and sensitivity to viruses are detrimental and should be avoidable by the implementation of elimination practices and perhaps the discovery and selection against the genes that cause hypersensitivity in apples.

Virus research in the Geneva® apple rootstock breeding program has taken many forms throughout the years including nursery trials in 2003 comparing G.16 and other advanced apple rootstocks grafted with the same scion cultivar infected with viruses or cleaned (Figure 2), the testing of 50 rootstocks in the Hudson Valley Lab and at Virginia Tech planted in 2012 to identify sensitivity to ToRSV, and other field trials throughout the U.S. that featured scion-wood loaded with diverse virus types. More recently, incidents of decline of G.935 rootstock when grafted with certain strains of ‘Delicious’ and ‘Honeycrisp’ cultivars urged the need to develop experiments that would reveal the viral causes of this decline and their genetic components in apple rootstocks in order to identify other rootstocks in the breeding program which may suffer similar problems. Furthermore, as the breeding program releases additional rootstocks for industry use, it needs to make sure that the material distributed is free of viral agents that may compromise the industry, therefore experiments aimed at the detection and elimination of apple viruses have been conducted. In this article we describe some of these experiments and the results obtained so far.

Breeding Program Testing for the Presence of Viruses and Viroids in Elite Breeding Lines

The process of breeding apple rootstocks includes the maintenance of thousands of individual breeding lines and the evaluation of thousands of apple trees grafted with different scion varieties. While the program has the goal to keep the original seedling trees alive and well and maintain their “seedling-virus-free” status, at times these seedlings were lost and we had to rescue the rootstocks from finished trees for which the virus status was unknown. Hence there was a need to conduct a virus census of all the elite breeding lines being propagated in the program to identify the ones that needed to be cleaned up. Iterations of this census were attempted at different times in the history of the program, however, in 2021, thanks to a cooperation between USDA-APHIS Plant Germplasm Quarantine Program’s (PGQP) and the Geneva breeding program and under the leadership of Abe Steinberger (currently a PhD student at the University of Minnesota) the program was able to utilize testing protocols established at APHIS PGPQ to identify apple rootstock breeding lines that had been compromised by viruses and viroids. Having established in-house RT-PCR and qRT-PCR testing methods for eight apple viruses and one viroid [ACLSV, Apple green crinkle associated virus (AGCaV), AHvD, ApMV, Apple rubbery wood-associated virus type 1 (ARWaV-1), Apple rubbery wood-associated virus type 2 (ARWaV-2), ASGV, ASPV, and CCCaV] the census found that out of 1,395 tests only 186 were positive. Most times, the same rootstock was infected by more than one virus (mixed infections). Analysis of the co-presence of viruses in these rootstocks with mixed infections (Figure 3) revealed that ACLSV, ASPV, ARWaV-1, ARWaV-2, and CCCaV were often found together, whereas ASGV was not associated with these except for ARWaV-2. We are utilizing this information to target elite apple rootstock lines for eradication.

Cryotherapy and Thermotherapy Experiments to Eradicate ASGV, ACLSV and AHvd from Elite Rootstock Breeding Lines

The Geneva breeding program has adopted a procedure to establish “clean” propagation material at key centers and micropropagation laboratories prior to release of elite breeding lines into the commercial stream as rootstock cultivars. While preparing to release a set of new apple rootstocks for the U.S. industry, the program collaborated with Foundation Plant Services in Davis, CA and APHIS PGQP in Beltsville, MD to index plant material with what is known as High Throughput Sequencing (HTS) or Deep Sequencing, which is a powerful technology that allow the detection of known viruses that also include variants that might escape regular RT-PCR testing, including novel viruses. This procedure found that some of the stocks were infected by viruses. At the same time, Dr. Bettoni and Dr. Volk at USDA ARS National Laboratory for Genetic Resources Preservation (NLGRP), were working on discovering new ways to eradicate viruses from apple germplasm destined for...
cryopreservation. As a result, a collaboration ensued between the Geneva breeding program and NLGRP to investigate whether thermotherapy or cryotherapy alone or in combination could effectively eradicate ACLSV, ASGV and AHVd from \textit{in vitro} cultures of four apple rootstocks developed in the Cornell-Geneva apple rootstock breeding program (CG.2034, CG.4213, CG.5257, and CG.6006) (Figure 4). For thermotherapy treatments, \textit{in vitro} plants were treated for four weeks at 36°C (day) and 32°C (night). Plant vitrification solution 2 (PVS2) and cryotherapy treatments included a shoot tip preculture in 2 M glycerol + 0.8 M sucrose for 1 day and then exposure to PVS2 for 60 or 75 min at 22°C, either without or with liquid nitrogen (LN, cryotherapy) exposure. Combinations of thermotherapy and PVS2/cryotherapy treatments were also performed. Shoot tips were then warmed, recovered on growth medium, transferred to the greenhouse, grown, placed in dormancy inducing conditions, and then grown again prior to sampling leaves for the presence of viruses and viroids. Overall, thermotherapy combined with cryotherapy treatments resulted in the highest percentage of virus- and viroid-free plants. The work was published in the journal \textit{Plants} in early 2022 (Bettoni et al., 2022). Although the efficacy of the combination of thermotherapy with cryotherapy has been reported for eradication of some apple viruses, to the best of our knowledge, this is the first study reporting success in eradicating of AHVd from infected \textit{in vitro}-cultured apple rootstock plants. This combination of procedures has great potential for producing virus and viroid-free planting materials for the apple industry. Furthermore, it could also be a valuable tool to support the global exchange of apple germplasm. We are in the process of replicating the eradication procedure in Geneva, NY with some promising results.

\textbf{Investigation on the Genetics of Sensitivity to Viruses in the Geneva Apple Rootstock Breeding Program}

As a result of the issues discovered with the rootstock ‘G.935’ when grafted with certain strains of ‘Honeycrisp’ and ‘Red Delicious’ that had been found to contain a somewhat rare mixture of viruses and viroids (Wright et al., 2020), the Geneva apple rootstock breeding program initiated a collaboration with Willow Drive Nursery to test how widespread the sensitivity was within some of the elite germplasm of the breeding program and to utilize some of the breeding populations to determine the genetics of sensitivity. Willow Drive Nursery had obtained virus-free and virus-laden material from the same ‘Honeycrisp’ strain that was associated with the slow decline experienced with ‘G.935’ (Figure 1) and grafted that material on a set of 12 rootstocks that represented some of the elite material available at that time (2017). Overall, the preliminary trial revealed that the presence of the virus cocktail inhibited growth on most rootstocks; however, some were more affected than others (Figure 5). In 2020, these preliminary results led to the preparation and planting of a larger replicated experiment featuring 165 different rootstock breeding lines grafted with both virus-free and virus-laden scions of the same ‘Honeycrisp’ strain. The experiment is in progress and has already produced some preliminary growth data that will be used to discover genetic links to virus sensitivity. These links will enable the breeding program to preselect material that is not hypersensitive to viruses and perhaps discover the genes underlying such hypersensitivity in the Geneva apple rootstock breeding program. Root systems of G.935 and G.969 are obviously being compromised by viruses, and in an effort to understand the mechanism by which root growth is being inhibited by viruses we have initiated another experiment (Figure 6) using aeroponics to test if root growth is being repressed by viruses and featuring...
several rootstocks including G.890 (symptomless), G.935, and G.969 grafted with virus-laden (V) and virus-free (VF) versions of a ‘Honeycrisp’ strain. The aeroponic system allows easy access to roots (Figure 7) for studying gene expression and measuring growth.

Conclusions

Viruses are detrimental for apple production and the nursery industry; therefore, they should be avoided whenever possible. Geneva® rootstocks G.41, G.202, G.222, G.214, and G.890 have not displayed the hypersensitivity of G.814 and G.16 or the slow decline that G.935 or G.969 experiences with certain virus-laden scion cultivars. Recent experiences with G.969 grafted with virus-laden ‘Granny Smith’ have shown that G.969 seems to have similar sensitivity as G.935 to one or a combination of latent viruses. Interestingly, in a current field trial with virus-laden ‘Granny Smith’ which includes G.969 and G.814, only G.969 is struggling, whereas G.814 seems to be growing well, perhaps indicating some genetic specificity to the viral factors in this strain of ‘Granny Smith’. The discovery that heat therapy combined with cryotherapy is able to eradicate even one of the most recalcitrant viruses is a big step toward the eradication of viruses from the breeding program. The Geneva rootstock breeding program is committed to understanding the genetic basis of this phenomenon and to providing virus free or ‘cleaned’ material to the industry.

Literature Cited


Gennaro Fazio is a research scientist with the USDA-ARS who leads the Geneva apple rootstock breeding program, Jean Carlos Bettoni was a research scientist at the USDA-ARS National Laboratory for Genetic Resources Preservation in Fort Collins CO but is now a researcher at the New Zealand Institute for Plant and Food Research Limited in Palmerston North, Larissa Carvalho Costa is a technician at USDA-APHIS Plant Germplasm Quarantine Program in Beltsville, MD who works with Oscar P. Hurtado-Gonzales who is a research scientist in charge of the plant quarantine station, Maher Al Rwahnih is a researcher in Plant Pathology at the Univ. of Calif. at Davis, Abraham Steinberger and Abby Nedrow are research technicians who work with Gennaro Fazio in the Geneva rootstock breeding program, Gayle M. Volk is a research scientist at the USDA-ARS National Laboratory for Genetic Resources Preservation, Fort Collins, CO, Stuart Adams and Richard Adams are owners of Willow Drive Nursery in Ephrata WA, Terence Robinson is a research and extension professor at Cornell University who is the co-leader of the Geneva apple rootstock breeding program.

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Methods 93:167-173.
Propagating Strawberry Plants Through Runners

Anya Osatuke\textsuperscript{1} and Brad Bergefurd\textsuperscript{2}

\textsuperscript{1}Cornell Cooperative Extension, Harvest NY | \textsuperscript{2}The Ohio State University

Keywords: Strawberries, runners, patented varieties, propagation

The production of strawberry plants is challenging due to the rigorous sanitation needs that must be met, especially in field propagation settings, but also in greenhouse settings. Growers in New York may find it more difficult to obtain their preferred strawberry varieties in the coming years, as fewer nurseries are propagating strawberries. The production of strawberry runners in a controlled environment such as a greenhouse or high tunnel must be kept separate from the production of strawberry fruit, because the energy allocation of strawberry plants will tend to favor either runner production or fruit production, but not both.

From conversations I’ve had with growers, there could be a market for plug plants in the northeast market, particularly when it comes to rarer varieties that do well in the region, such as ‘L’Amour’ for perennial matted row systems and ‘Everest’ or ‘Albion’ for early-season annual plasticulture. Plug plants will fetch a higher price than dormant bare-root plants, due to the higher cost of production and lower availability in the Northeast, especially if plants are available in August. This article only discusses production and marketing potential of plug plants because successful field production of bare-root strawberries is very difficult to achieve without the use of highly restricted soil fumigants.

A bench-top system can easily prevent strawberry plants from coming into contact with natural soil, which will prevent their infection with soilborne diseases such as verticillium wilt, anthracnose, and red stele. Only soil-free potting mix should be used for plug production. If all flowers are removed, mother plants can be kept to produce runners for 2 - 4 years, with the greatest runner production in the first year.

Setting Up Mother Plants

Having the correct growing conditions is the first step in runner production. Prepare a protected site, such as a greenhouse or high tunnel, which can keep temperatures between 75 - 80°F during active growing periods (February - August). The site should receive 16 hours of light per day. The site should be equipped with an irrigation system, ideally with fertigation equipment. A good ventilation system is essential for preventing the spread of insect pests and powdery mildew; if working without a ventilation system, prepare to move strawberry plants outdoors if a pest outbreak occurs. Tables with wheels attached to the legs work nicely for these set-ups.

The second step in runner production is to source mother plants. These will be the plants that produce runners. We recommend dormant, bare-root strawberries for mother plants. As soon as your shipment arrives, check for crown diseases by cutting the crown in half lengthwise. If the crown is anything but creamy white inside, it may be harboring a disease. (The crown will yellow and oxidize naturally after being cut). Using a knife, gently scrape away the skin from the roots. If the roots are not white and beige inside, that is another indication of disease. Test one plant from each bundle of bare-root strawberries. If you find disease, document the diseased plants and do not plant them. They will not be vigorous and are likely to infect your runners.

Plant mother plants between February and June. One-gallon containers are sufficient. Use soil-free potting mix; researchers at Penn State Extension have had success with Pro-Mix BK25 as well as a 2:1 mixture of peat and perlite. Wet the potting mix before placing it into the containers. Install drip irrigation to reduce water splashing onto leaves, which will reduce risk of fungal diseases. Sanitize drip tubing before installation.
Sanitize a pair of scissors, and use them to trim the roots of plants back to 2 inches in length. Wipe scissors down with sanitizer after finishing a bundle of plants.

Plant strawberries so that the crown sits at the soil level, and the roots go straight down into the potting mix. A plastic mulch can be stretched over rows of containers to reduce exposed soil area, which will prevent arthropod pests. Mother plants can be fertigated with a high-N, high-P solution to encourage vegetative growth. A 20-10-20 formulation injected at a rate of 100 ppm N per irrigation should encourage vigorous growth. Scout mother plants regularly for flowers, and pinch off all flowers whenever they form. Runner tips should be ready to harvest 8 - 10 weeks after planting.

**Harvesting and Growing Out Runner Tips**

- Sanitize a pair of scissors and a plastic bin with drainage holes.
- Mature runner tips will have visible root pegs and at least 2 expanded trifoliate leaves; they will be 2.5 - 4 inches long from the base to the end of the longest leaf. Runner tips that are larger or smaller than this size will have difficulty establishing.
- Snip runner tips off using scissors, leaving a ½ inch nubbin of stem attached to the developing crown. This will be used to anchor the runner tip in potting soil.
- After snipping off the runner tips, keep them in a cool, dark, humid place such as a cooler. Some growers have better establishment if they harvest them into a container of water.
- Plan to plant the runner tips within 24 hours of harvest.
- Fill 50-cell plastic trays loosely with moistened soil-less potting mix; the same mix used for the mother plants will work well for the runner tips. Gently pat the runners into the potting mix, burying the root pegs and 1/2-inch of stem but keeping the developing crown aboveground.
- For the first weeks after planting, runner tips are vulnerable to desiccation. A mist propagation system will be helpful in regulating moisture; humidity domes can also help increase air moisture. Runners will root in 5-10 days. After rooting has occurred, growth can be sped up using fertilizer. A weekly application of 10-10-10 is recommended. Runners will be mature plug plants in approximately 1 month: mature plants will have 3 - 5 expanded leaves and at least a ½ inch crown diameter. A mature plug plant can be lifted out of its growing cell without dropping the soil from the root system. As pest pressure is high in plug plants, established trays can be moved outdoors to increase ventilation and improve access to natural insect predators. These plants are ready for sale or planting.

**Inventory Management**

Day neutral strawberries can be propagated in the spring and sold in the summer. They will fruit in the same year. Everest, Seascape, and Evie 2 are very cold-hardy and overwinter well in the field. Albion and Mara des Bois have been overwintered with success, as well, especially with winter mulching. Most other day neutrals are likely to die off in the winter cold. If customers are buying for a strawberry farm, encourage them to pinch off flowers for the first 2-3 weeks after planting to help plants establish and maximize yields later in the season.

June bearing strawberries need to undergo cold temperatures and short days before they make flower buds. One strategy is to harvest June bearing tips in the early spring and sell them in the summer, encouraging customers to pinch off all flowers in the year of planting. Do not sell June bearers after September—the plants may not have time to establish after planting.

Mother plants can be overwintered in an area with controlled cold storage, where temperatures will remain between 29–32˚F.

**Winter Care of Mother Plants**

Mother plants can be allowed to go dormant in the wintertime. Prevent cold damage by protecting from temperatures below 29˚F. Supplemental light is not needed during winter dormancy. Check water status of plants every 2 weeks to prevent roots from drying out. Do not apply fertilizer until the early springtime; when mother plants begin to send out young leaves, expose the plants to 16 hours of light per day. After temperatures are consistently around 55˚F, begin fertilization again.

**Disease & Pest Management in Greenhouse or Hoop House**

Managing disease in strawberry plug production systems is extremely difficult without cultural controls and pesticides. The humid, vegetative environment can create ideal conditions for fungal leaf diseases, fungus gnats, mites, and aphids.

Blocking access to the potting mix using a plastic mulch can prevent insects from laying eggs in the strawberry pots. However, plastic mulch can only remain intact if a fertigation system is in place. A soil application of a physical insect deterrent, such as diatomaceous

<table>
<thead>
<tr>
<th>Cultivar name</th>
<th>Patent expired?</th>
<th>Breeding program</th>
<th>Commercial fruit?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aromas</td>
<td>Yes (2016)</td>
<td>UC Davis (US)</td>
<td>No</td>
</tr>
<tr>
<td>Everest</td>
<td>Yes (2018)</td>
<td>Edward Vinston (UK)</td>
<td>No</td>
</tr>
<tr>
<td>Mara des Bois</td>
<td>Yes (2011)</td>
<td>Jacques Marionnett (FR)</td>
<td>No</td>
</tr>
<tr>
<td>Seascape</td>
<td>Yes (2010)</td>
<td>UC Davis (US)</td>
<td>Yes</td>
</tr>
<tr>
<td>Tribute</td>
<td>Yes (no patent)</td>
<td>US Dept of Agriculture</td>
<td>No</td>
</tr>
<tr>
<td>Tristar</td>
<td>Yes (no patent)</td>
<td>US Dept of Agriculture</td>
<td>No</td>
</tr>
<tr>
<td>Albion</td>
<td>No (2024)</td>
<td>UC Davis (US)</td>
<td>Yes</td>
</tr>
<tr>
<td>Carabillo</td>
<td>No (2035)</td>
<td>UC Davis (US)</td>
<td>No</td>
</tr>
<tr>
<td>Evie 2</td>
<td>No (2026)</td>
<td>Edward Vinston (UK)</td>
<td>Yes</td>
</tr>
<tr>
<td>Monterey</td>
<td>No (2028)</td>
<td>UC Davis (US)</td>
<td>Yes</td>
</tr>
<tr>
<td>Monie</td>
<td>No (2040)</td>
<td>UC Davis (US)</td>
<td>No</td>
</tr>
<tr>
<td>Portola</td>
<td>No (2028)</td>
<td>UC Davis (US)</td>
<td>Yes</td>
</tr>
<tr>
<td>San Andreas</td>
<td>No (2038)</td>
<td>UC Davis (US)</td>
<td>No</td>
</tr>
<tr>
<td>Royal Royale</td>
<td>No (2039)</td>
<td>UC Davis (US)</td>
<td>No</td>
</tr>
</tbody>
</table>
earth, is another means of discouraging egg-laying in the strawberry pots.

Some fungal diseases, such as botrytis and powdery mildew, will concentrate on fruits. Removing flowers and fruits on a weekly basis will prevent many pests on the runner plants. Good airflow is critical to preventing the spread of moisture-loving fungal diseases. Mowing the land immediately around the greenhouse can eliminate hiding spots for insect pests and fungal spores. If mold issues persist, reduce fertilizer applications and slow watering. The fungicides Quadris, Pristine, and Cabrio cannot be used for strawberry plug production.

Botrytis and powdery mildew can be controlled using fungicides in the greenhouse. It is recommended to alternate the fungicides Captan, CaptiElevate, and Switch for disease control. Only apply fungicides to established plants at least 2 weeks after planting, and only if presence of mold is confirmed on the strawberry plants. These fungicides can cause stunting in plants that are not yet established.

To prevent Phytophthora rot, use a phosphite-based product such as Prophyt, Aliette, or Phostrol. Use foliar sprays after plants have established roots, 2-3 weeks after planting. Always read the label instructions for specifications of application.

There is no fungicide that will control anthracnose crown rot in the greenhouse. Cull any diseased plants and surrounding trays. Anthracnose can first appear as a brownish-red leaf spot that spreads in patches throughout the trays; crowns cut in half will have a marbled appearance.

To reduce whiteflies, mites, and aphids, use a sulfur-based spray such as Thionex 3EC per label instructions. Only use 2–3 weeks after planting tips, on established plants.

Ornamental plants can harbor Phytophthora root rot, a waterborne crown rot that kills strawberry plants. If growing ornamental plants and strawberries in the same space, prevent water and soil from ornamentals to touching strawberry soil and plants.

**Patent Status of Select Strawberry Varieties**

Varieties with expired patents can be propagated commercially without a license.

Patented varieties will have their patent expire 20 years after issue in the United States.

**Patent-Protected Varieties**

To obtain rights to propagate a patent-protected variety, contact the breeding program that released it.

Cornell / NYSAES (Cornell AgriTech) manages a strawberry breeding program in Geneva, New York. This program is renowned for its focus on developing flavorful, disease-resistant, June bearing strawberries that are adapted to New York seasons.

Patent-protected varieties as of 2022 are L’Amour, Archer, Herriot, Clancy, and Dickens. New York Growers propagating patented varieties agree to pay $0.02 per every plant sold. Sales are reported annually. For more

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**Table 2. Patent Status of June bearing Strawberries**

<table>
<thead>
<tr>
<th>Cultivar name</th>
<th>Patent expired?</th>
<th>Breeding program</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camarosa</td>
<td>Yes (2013)</td>
<td>UC Davis (US)</td>
<td>Early season. Highly susceptible to fusarium wilt crown rot.</td>
</tr>
<tr>
<td>Honeoye</td>
<td>Yes (1999)</td>
<td>Cornell AgriTech (US)</td>
<td>Early season. Sensitive to terbacil (Sinbar), susceptible to black root rot.</td>
</tr>
<tr>
<td>Ovation</td>
<td>No (2018)</td>
<td>US Dept of Agriculture</td>
<td>Late season. Adapted for annual plasticulture. Resistant to red stelle and moderately resistant to anthracnose crown rot.</td>
</tr>
<tr>
<td>Sparkle</td>
<td>Yes (1964)</td>
<td>Rutgers New Jersey Agricultural Experiment Station (US)</td>
<td>Late season.</td>
</tr>
<tr>
<td>AC Valley Sunset</td>
<td>No (2034)</td>
<td>Agriculture and Agri Food Canada</td>
<td>Late season.</td>
</tr>
<tr>
<td>AC Wendy</td>
<td>No (2025)</td>
<td>Agriculture and Agri Food Canada</td>
<td>Early season.</td>
</tr>
<tr>
<td>Cabot</td>
<td>Yes (2022)</td>
<td>Agriculture and Agri Food Canada</td>
<td>Midseason.</td>
</tr>
<tr>
<td>Clancy</td>
<td>No (2024)</td>
<td>Cornell AgriTech (US)</td>
<td>Late season. Resistant to red stelle.</td>
</tr>
<tr>
<td>Galletta</td>
<td>No (2028)</td>
<td>North Carolina Agricultural Research Service</td>
<td>Early season.</td>
</tr>
<tr>
<td>Malwina</td>
<td>No (2011)</td>
<td>Peter Stoppel (GR)</td>
<td>Late season. Resistant to verticillium wilt and red stelle.</td>
</tr>
</tbody>
</table>
information, contact Jessica Stein at (607) 227-1916 or at jessica.stein@cornell.edu.

UC Davis The University of California, Davis Strawberry Breeding and Research Program is located in Davis, California. This program is renowned for its creation of highly productive day neutral strawberries.

Patent-protected varieties as of 2022 are Albion, Aromas, Cabrillo, Monterey, Portola, San Andreas, Rolls Royce, Valiant. New York Growers propagating these varieties will pay a $300 one-time fee, and $0.09 per every 100 plants sold. For more information, contact Isaac Rainwater at (530) 304-6266 or at isarainwater@ucdavis.edu.

Literature Cited

Anya Osatuke is an extension educator with Cornell Cooperative Extension, Harvest NY Program. Brad Bergefurd is an extension educator at The Ohio State University.

Any image or graphic present in the document has been omitted from the transcription.
The New York State Horticultural Society has announced the 2022 award recipients for the Paul Baker Memorial Scholarship. The scholarship awardees receive $500 scholarship each to be used towards their college/trade school expenses. Each year there is the opportunity for three students to receive this award from 4 different school districts on Niagara County.

Paul Baker worked in the Agricultural industry in one capacity or another his whole life. Before he passed, he had been the Executor Director of the NYS Horticultural Society for over 16 years. Paul Baker was an outstanding spokesman for the fruit and vegetable farmers of NY. He was loved and respected by all who knew him. The NYSHS BOD, and Paul’s family, are so proud to be able to continue his legacy through this scholarship.

The Paul Baker Memorial Scholarship winners for 2022 are Abigail Hurtgam and Grace Johnson, both from Ransomville, NY.

Abigail Hurtgam will be graduating from Wilson Central School in Wilson, NY. She will be attending Cornell University in the fall to pursue a Bachelor’s Degree in Agricultural Science. After college Abby plans on taking over her family’s farm, Hurtgam Farms, and will also continue to run her cut flower business, “Cut Flowers by Abby”. Her goal is to become a hardworking, successful business owner that will allow her to bring quality produce and products to her community.

Grace Johnson will be graduating from Lewiston Porter High School in Youngstown, NY. She will be attending Hobart and William Smith Colleges in the fall. Her goal is to help with the advancement of agriculture with her country and her community.

NYSHS would like to congratulate Abigail and Grace for all their hard work throughout their High School career and to wish them all the best in their future educational and work careers.

For more information about the Paul Baker Memorial Scholarship, please visit NYSHS.org for eligibility requirements and an application form or by contacting Karen Wilson, Business Manager at NYSHS@hotmail.com

Abigail Hurtgam — I am attending Cornell University in the fall to pursue a Bachelor’s Degree in Agricultural Sciences. After college I plan on taking over my family’s farm, Hurtgam Farms, and will continue to run my cut flower business, Cut Flowers by Abby.

Grace Johnson — I am honored to be one of the recipients of the Paul Baker Memorial Scholarship. I will be using my award towards continuing my education at Hobart and William Smith Colleges. I plan on majoring in political science. I enjoy spending time outside, playing tennis, and music. I am so greatfull to be receiving this award.
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