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Table of Contents

Research Report: Grower Impressions of Low Tunnel Utility for June-Bearing Strawberry Production

Elisabeth Hodgdon & Laura McDermott, Cornell Cooperative Extension Eastern NY Commercial Horticulture Program; Rebecca Sideman & Kaitlyn Orde, University of New Hampshire Cooperative Extension

Keywords: strawberry, low tunnel, June-bearing, on-farm demonstration

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While low tunnels have previously been shown to have benefits for fall-bearing (DN) varieties, these on-farm studies showed that low tunnels may also increase yield and quality in June-bearing strawberries. Low tunnels offer an economical entry into protected culture resulting in higher quality fruit, potential early ripening, and reduced need for fungicides.

The major challenges observed in our demonstrations on individual farms centered around labor requirements. Tunnels require some management which is a challenge for many farms. For farms using tractor-drawn boom sprayers, pesticide application may be impacted. Other cultural system considerations including row width, frost protection, and bird control would also need to be addressed in order to successfully integrate low tunnels.

Strawberry growers know that the first berries to market in the spring can be sold for premium prices, drawing in customers to retail operations. With more and more high tunnels being constructed on farms every year, growers are interested in diversifying their crop production in tunnels, including strawberries in addition to tomatoes and other crops. We see a wide variety of strawberry production systems under cover around the state, ranging from sophisticated greenhouses with hydroponic production to high tunnels and smaller caterpillar tunnels. These structures help extend the season for June-bearing (JB) strawberries, hastening maturity in May. They also protect plants from rain and extreme weather events, reducing disease pressure. Although larger tunnel structures are a more common sight on New York farms due to federal funding initiatives, we seldom see low tunnels—waist-high plastic structures—on farms. Low tunnels offer many of the same benefits as larger tunnels, but at a lower cost: approximately $20,000 for materials to construct one acre of low tunnels.

Benefits and challenges of low tunnel use

Plastic tunnel structures offer a variety of benefits for improving crop yield and quality. When grown in tunnels, strawberries benefit from an extended harvest season, greater yields of marketable berries, higher berry quality, and decreased disease pressure (Conner and Demchak 2018; Demchack 2009; Orde and Sideman 2019). The plastic covering of tunnels creates a beneficial environment through increased daytime temperatures and protection from precipitation and wind. Keeping rain and hail off fruit decreases diseases pressure from Botrytis and other pathogens, resulting in a higher percentage of marketable yield. Additionally, new types of plastic reduce UV and infrared light transmission, preventing fungal spore germination and reducing heat, which improve crop quality (Anderson et al 2019; Elad 1997). Few studies have been conducted on low tunnels in the Northeast, but Orde and Sideman (2019) measured higher marketable berry yield of day-neutral (DN) strawberries grown in low tunnels compared to traditional open field production. They also found that late-season berry yields were increased, allowing for an extended season when fewer local strawberries are available. While research has been done on DN strawberries in low tunnels, little is known about whether low tunnels are worthwhile for JB production.

Low tunnels are simple structures that do not require specialized expertise to install and maintain but do require additional materials and labor investment at the start and end of the season. They consist primarily of short hoops, clear plastic film covering, stakes, and bungee cords holding the covering in place. In comparison to larger, more sophisticated structures, they allow for more flexibility for movement from field to field according to crop rotation. Annual strawberry systems with low tunnels are a logistical good fit in vegetable crop rotation schemes. While low tunnels are simple to use, materials can be costly and labor is required to set up and take down the tunnels at the beginning and end of the season. Additionally, tunnels covering rows of strawberries render in-season pesticide application and weed control difficult for some equipment because rows are not easily accessible by tractor-drawn equipment Strawberry growers know that the first berries to market in the spring can be sold for premium prices, drawing in customers to retail operations. With more and more high tunnels being constructed on farms every year, growers are interested in diversifying their crop production in tunnels, including strawberries in addition to tomatoes and other crops. We see a wide variety of strawberry production systems under cover around the state, ranging from sophisticated greenhouses with hydroponic production to high tunnels and smaller caterpillar tunnels. These structures help extend the season for June-bearing (JB) strawberries, hastening maturity in May. They also protect plants from rain and extreme weather events, reducing disease pressure. Although larger tunnel structures are a more common sight on New York farms due to federal funding initiatives, we seldom see low tunnels—waist-high plastic structures—on farms. Low tunnels offer many of the same benefits as larger tunnels, but at a lower cost: approximately $20,000 for materials to construct one acre of low tunnels.

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On-farm demonstrations

In 2021 and 2022, we installed low tunnels over JB strawberries at two commercial farms in eastern New York and two farms in New Hampshire to gather grower input on whether they impacted maturity, yield, and quality of JB strawberries. One of the farms is certified organic, while the other three are conventional. All farms participating in the low tunnel demonstrations are diversified fruit and vegetable farms that include retail sales of their products. At each site, the grower compared quantity and quality of berries grown under three 40' long low tunnels versus in the open field in adjacent rows. Our low tunnel materials were sourced from Dubois Agrinovation (St-Rémi, QC; Table 1) and were installed by extension staff. At the end of the strawberry season, we recorded our observations and those of the grower host. Here, we discuss our findings from the past two seasons and grower conclusions as to whether low tunnel systems were feasible for JB strawberries on their farms.

Farm A

Farm A is a diversified organic small fruit and vegetable farm that sells strawberries through farmers markets and community-supported agriculture (CSA) in eastern New York. The growers manage their small-scale production intensively, utilizing multiple high tunnels and row covers for season extension. Grower A was intrigued by the use of low tunnels for earlier harvests of berries to bring to spring markets.

We installed low tunnels over three sections of their rows of 'Chandler' plasticulture strawberries in late April in 2021 and 2022 at first bloom. No drip irrigation was installed in the field, and straw was used between rows for weed management. Due to deer and bird pressure, Farm A uses wide-mesh bird netting as a deterrent (Figs. 1 & 2). We draped the bird netting over the tunnels to accommodate the low tunnel system. Unfortunately, due to a freeze later in May 2021 (several hours of temperatures in the 20's F), Farm A lost most of the primary strawberry blossoms. Due to the warming effect of the tunnels, the plants and flowers within the structures were slightly more mature than those in the open field, and therefore tunnel plants may have lost a higher number of primary blossoms than the uncovered plants.

The quality of fruit in low tunnels was good with less loss from disease than field berries. Remaining low tunnel fruit in 2021 also ripened earlier by a few days which was encouraging for the growers. In 2022 the fruit under the low tunnels was also slightly larger and again ripened earlier than the uncovered strawberries. The growers did report that they found that the low tunnel plants finished quicker than did the field grown berries – resulting in a slightly shorter total season by about 4 days.

Lessons learned from Farm A

Low tunnel structures do not provide protection from low nighttime temperatures. Additional frost protection (e.g. row cover or micro-irrigation) is still needed to protect flowers from late frosts and freezes. Despite yield losses due to the freeze in 2021, Farm A observed improved fruit quality under the low tunnels.

Bird netting plus the tunnel structures created an overly complex harvesting environment for employees. Netting had to be removed, and the sides of the tunnels needed to be raised at each harvest.

The seasonality of the fruit is impacted by the low tunnel environment, causing earlier ripening and possibly shorter bearing seasons.

Farm A Conclusion

Low tunnels were not worth the management effort for Farm A, particularly while using bird netting. Farm A growers are still interested in protected culture of strawberries given the improved fruit quality, but believe that caterpillar or high tunnels would be easier for them to manage.

Farm B

Farm B is a conventional diversified fruit and vegetable operation in eastern New York offering strawberries at their retail store and for pick-your-own. Grower B was interested in using low tunnels to determine whether the structures would hasten berry harvest; earlier berries in May would draw customers to their farm store.

On Farm B, we installed the low tunnels over matted row 'Dickens' strawberries (Figs. 3 & 4) in 2021 and 2022. We were limited in where we could install the tunnels, because only one field had drip irrigation set up. The grower typically uses overhead irrigation for strawberries and preferred using tunnels only where drip irrigation was available. Shortly after setup in 2021, we needed to replace and repair plastic over the tunnels due to ripping during spraying with a boom sprayer. The plastic covering on the tunnels was rolled up during sunny days and closed during storms to prevent rain from contacting berries underneath. In addition to the farm workers' harvests, we harvested some of the berries for comparison between the tunnels and adjacent bare rows in 2021. In 2022, Farm B opened the low tunnels for pick-your-own customers and we did not harvest berries for data collection.

Lessons learned from Farm B

To reduce risk of crop loss, low tunnels are best used with drip irrigation. Not all growers, however, use drip irrigation.

The strawberry season was very dry in Farm B's region in 2021, thus there was little disease pressure from Botrytis and anthracnose overall. Workers reported firmer, higher quality berries under the tunnels, nevertheless. Strawberry yield early in the season was higher under the tunnels.

1. THREE LOW TUNNELS DRAPED IN BIRD NETTING AT FARM A IN APRIL 2021.

2. INNER TUNNEL ENVIRONMENT AT FARM A, WITH PLASTIC COVER DRAPED IN BIRD NETTING OVER PLASTICULTURE STRAWBERRIES.

3. LOW TUNNELS INSTALLED OVER MATTED ROW STRAWBERRIES AT FARM B IN MAY 2021.

4. SIDES ROLLED UP TO ALLOW FOR AIR FLOW AND TEMPERATURE CONTROL AT FARM B.

5: LOW TUNNELS WERE UNABLE TO FULLY COVER WIDE ROWS OF PLANTS AT FARM D.

Spraying with a boom sprayer is challenging with low tunnels. Tunnel plastic could be rolled up to its highest point on the hoops during spraying, but it can be difficult to navigate the structures in the field, particularly when tunnels are placed over rows with narrow spacing. Harvesting under the tunnels was less efficient. While workers typically straddle rows to harvest, one can only harvest one side at a time under a tunnel.

Pick-your-own customers did not provide negative feedback on their experiences picking strawberries under the low tunnels.

Farm B Conclusion

Low tunnels would be useful for a small proportion of the farm's early strawberry varieties to achieve earlier harvests. They would be too challenging to implement on a larger scale. Farmer B is interested in constructing more low tunnels for early varieties that could boost spring sales in addition to using their high tunnel for strawberry production in the future.

Farm C

Farm C is a diversified conventional fruit and vegetable farm in southern New Hampshire. Their strawberries are sold through wholesale and retail through their farm store. All berries are pre-picked by farm workers.

We installed low tunnels on the farm in 2021 over 'AC Valley Sunset' strawberries in a field using white plastic mulch and straw for weed management. The beds received drip irrigation and were the tallest of the four farm sites used in the trial. Plastic on the tunnels remained rolled up to the top of the hoops during most of the season to allow for pesticide application and easier management. Grower C closed tunnels at their discretion during a few time periods.

Lessons learned from Farm C

Strawberry yield at Farm C in 2021 was excellent overall in open-field production. Because the sides of the tunnel remained rolled to the top of the hoops to facilitate management, little difference in berry quality was observed.

Pesticide application was not an issue at Farm C because the tunnels were strategically placed to avoid spray lanes. The sprayer boom was able to clear the tunnels.

Harvesting berries under the tunnels was not challenging for Farm C. To harvest the tunnel berries, one worker picked berries on one side, and another worker on the opposite side of the bed. Ergonomically, there were no differences between harvesting under tunnels versus open ground.

Farm C Conclusion

Farm C did not feel as though the low tunnels were worth the cost. They are more interested in using high tunnel structures for their strawberries.

Farm D

Farm D is a conventional diversified fruit and vegetable farm located in central New Hampshire. Their strawberries are sold through their CSA program, farm store, and through pick-your-own. Grower D was particularly intrigued by the ability of the tunnels to reduce disease and improve marketable berry yield, and was willing to keep the tunnel sides lowered while spraying for a true comparison of disease incidence between the tunnels and adjacent open ground plants.

At Farm D, low tunnels were set up in 2021 over AC Valley Sunset berries grown in a traditional matted row system. Because the rows of berries were very wide, the low tunnels did not cover the outer edges of the rows of plants (Fig. 5). The strawberries were irrigated using drip tape, which was also used to apply fungicides and fertilizer. The 2021 berry season was particularly wet, with rain events of up to 7" in June. Workers harvested berries from the tunnels, and grower D provided observations on berry quality and disease incidence during the season.

Lessons learned at Farm D

Although the low tunnels did not eliminate disease, marketable berry yield was higher under the low tunnels during the rainy 2021 season.

Leaf spot, leaf scorch, and powdery mildew were observed on plants in the low tunnels, but not on other plants in the open field. Heat may have contributed to these symptoms. Overall, the numbers of Botrytis-infected berries in the low tunnels were not reduced, but overall incidence at Farm D was very high.

Workers preferred harvesting berries under the tunnels because it was easier to find marketable fruit. Two workers harvested each row of low tunnel berries, one on each side of the bed.

Applying pesticides using a boom sprayer was not a problem; Farm D's boom sprayer could be raised high enough to clear the tunnels.

Farm D Conclusion

Because of the width of the plant rows and overall disease pressure in the field, Botrytis was not significantly reduced in the low tunnels. Low tunnels may not be a good fit for Farm D because their rows cannot be covered entirely with the hoops used; caterpillar tunnels may be a more suitable system for Farm D.

Overall Conclusions

Low tunnels offer an economical entry into protected culture resulting in higher quality fruit, potential early ripening, and reduced need for fungicides. Low tunnels are used in Europe and elsewhere across the globe with great success, but they may not be appropriate for all operations in the northeastern U.S.

The major challenges observed in our demonstrations on individual farms centered around labor requirements. Tunnels require some management which is a challenge for many farms. Workers would need to change their harvesting practices to be compatible with low tunnels. For farms using tractor-drawn boom sprayers, pesticide application may be impacted. Other cultural system considerations including row width, frost protection, and bird control would also need to be addressed in order to successfully integrate low tunnels.

Differing precipitation patterns across the regions allowed us to observe effects of low tunnels in both unusually wet and dry seasons. In a changing climate, the Northeast will continue to experience increased incidence of extreme weather events. Low tunnels may be an important tool in mitigating effects of heavy rain, hail, and wind brought by spring and early summer storms, as long as tunnel structures are wide enough to cover rows of plants. While low tunnels have previously been shown to have benefits for fall-bearing (DN) varieties, these on-farm studies showed that low tunnels may also increase yield and quality in June-bearing strawberries.

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We thank technicians Andy Galimberti and Natasha Field, as well as our demonstration site hosts for their assistance with this project.

Table 1. Materials used for low tunnel demonstrations at commercial farms in New York and New Hampshire during 2021-2022 strawberry seasons

Material	Size	Notes
Galvanized steel "TunnelFlex" hoops	46" wide x 39.5" tall	Hoops include loops on each side for grounding stakes
Rubber-coated end hoop[1]	~46" wide x 30" tall	Thicker steel end hoop set at 45° angle to taper plastic to anchor stake
Galvanized steel extension posts	2' tall	To anchor ends of tunnel
Galvanized steel anchor stake	18" tall	Grounding stakes for hoops
Clear perforated plastic film	39.5" wide	1.5 mil thickness with 12" strip of small holes for ventilation on each edge
Bungee cord	1 x ~8' long piece per hoop	Tied in a loop, to hold film tightly on hoops
Ratchet, paracord, and zip-ties	Variable	To tie plastic to anchor posts at ends of tunnel

[1]While shorter end hoops were used in our demonstrations, they are optional.
The larger steel TunnelFlex hoops may be used in their place.

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Research Report: Adapting Reduced Tillage Systems to Muck Soils

Ethan Grundberg and Chuck Bornt, Cornell Cooperative Extension Eastern NY Commercial Horticulture Program

Keywords: reduced tillage, vine crops, muck soils

From 2017-2020 Ethan Grundberg and Chuck Bornt tested reduced tillage systems in muck soils for vine crops. The trials of reduced tillage systems on muck soils showed reduced weed pressure and reduced soil staining of squash. The cleanliness of the squash at harvest was one of the most impressive impacts of the reduced tillage system.

While reduced tillage systems in vine crops, are fairly common on mineral soils, few growers in Eastern NY had tried to adapt the practices on the black dirt. ENYCH specialists Ethan Grundberg and Chuck Bornt spent three years working with vine crop growers on the black dirt of Orange County to trial heavy residue reduced tillage systems on muck soil. This article highlights some of their findings.

Weed Pressure

Weed pressure was statistically significantly different in the best reduced tillage treatments compared to the conventionally tilled bare ground control. In 2020, there were, on average, over 20 weeds per 3.33 square foot quadrat across five sampling dates. In contrast, the spring barley reduced tillage field averaged just under 5 weeds per quadrat, the fall barley and spring oats fields averaged just over 2 weeds per quadrat, and the winter rye reduced tillage field had the fewest weeds with just 0.1 weeds per quadrat.

Crop Yield

There was no significant impact on crop yield in the reduced tillage fields compared to the control. Grundberg and Bornt never anticipated an increase in yield, but transitioning to reduced tillage can result in short-term yield decreases as growers learn how to better manage the different fertility needs in these systems.

Soil Staining of Fruit

Soil staining on squash was significantly different in the reduced tillage fields compared to the bare ground control. The most impressive impact of the reduced tillage systems to the growers and researchers was how clean the squash was at harvest. While the squash harvested in the control field in 2020 averaged over 12.5 percent of the rind stained with soil, the squash harvested in the reduced tillage fields averaged between 3.6-6.4 percent of rind staining.

1. A FIELD OF REDUCED TILLAGE KABOCHA SQUASH GROWN ON A TERMINATED SPRING OAT COVER CROP IN 2019.

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We thank technician Natasha Field, as well as our demonstration site hosts for their assistance with this project.

Research Report: Management of Wireworms in Sweet Potatoes with Persistent NY Entomopathogenic Nematodes

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Elson Shields and Tony Testa, Department of Entomology, Cornell University.

Keywords: nematode, organic, vegetable, wireworm, persistent EPNs, biological control

Peer reviewed article: Great Lakes Entomologist. 2021, 54(2), https://scholar.valpo.edu/tgle/vol54/iss2/4/

Wireworms are the larval stages of click beetles (*Coleoptera: Elateridae*) and common polyphagous soil dwelling pests feeding on different plant parts including seeds, roots, stems, and tubers inhibiting plant growth eventually leading to plant death. With the ban of persistent synthetic insecticides such as lindane in 2009 due to negative effects on the environment, no effective control tactics (chemical or biological) are available for wireworms. Some entomopathogenic nematode species/strains (EPNs) have been reported to attack wireworms in the soil, causing death. The focus of this study was to examine the efficacy of persistent native NY EPNs against wireworms in an organic NY production system.

Wireworms are the larval stages of click beetles (*Coleoptera: Elateridae*) and common polyphagous soil dwelling pests feeding on different plant parts including seeds, roots, stems, and tubers, inhibiting plant growth eventually leading to plant death. Crop losses in the United States, Canada, and United Kingdom due to wireworms can reach up to 25% (Parker et al. 1990). With the ban of persistent synthetic insecticides such as lindane in 2009 due to negative effects on the environment, no effective control tactics (chemical or biological) are available for wireworms.

As a result, there is a need for alternative methods of wireworm control/suppression to reduce plant damage from feeding. Some entomopathogenic nematode (EPN) species/strains have been reported to attack wireworms in the soil, causing death. Non-native EPN species have the advantage of being easily available commercial products for insect pest control (Kaya et al. 2006, Lacey et al. 2015). However, these strains do not persist and require annual application as a biopesticide. Native EPN species provide an advantage because application is a single event with multi-year persistence and pest suppression (Shields et al. 2018). Persistent EPNs strains from a single application are present to attack soil insects for the entire growing season, resulting in greater biological control efficacy (Shields et al. 2018).

The focus of this study was to examine the efficacy of persistent native NY EPNs against wireworms in an organic NY production system.

Materials and Methods

This set of experiments was located on the Hudson Valley Farm Hub located near Hurley, NY. The field was a sandy loam and was planted to a rye cover crop the previous season. The experiment was established with three treatments and four replicates. Each experimental plot measured 3.7 m wide by 30 m long. The placement of each treatment within each replicate was randomized.Each plot within a replicate was separated by 15 m and replicates were separated by 10 m to reduce potential cross contamination from entomopathogenic nematode (EPN) movement within and across growing seasons. In the initial year, four soil hills were formed on 0.9 m centers the entire length of the plot (30 m), prior to the application of EPNs. After EPN application for the 3-year duration of the experiment, all tillage work was regulated. The untreated checks were tilled first across all replicates before the EPN plots to reduce the probability of contamination from the tillage equipment. Each EPN treatment was then tilled across replicates with the equipment cleaned between treatments.

Table 1: The Persistent EPN species/strains used in this study

Name	Abbreviation	Year Isolated	Soil Sample Location
Steinernema carpocapsae (Weiser) 'NY 01'	Sc	1990	Jefferson County
Steinernema feltiae (Filipjev) 'NY 04'	Sf	2004	Jefferson County
Heterorhabditis bacteriophora (Poinar) 'Oswego'.	Hb	1990	Oswego County

Prior to the application of EPNs, the experimental areas were pre-sampled for the presence of native EPNs (27 April 2017) in the same manner as the post treatment samples. Entomopathogenic nematode treatments were applied on 23 May 2017.

- Treatment one was a species mix of S. *carpocapsae* 'NY 01' (*Sc*) + S. *feltiae* 'NY 04' (*Sf*) at a rate of 250 million Sc infective juveniles (IJs) per ha and 170 million *Sf* IJs per ha.
- Treatment two was a species mix of *Sf* + *H. bacteriophora* 'Oswego' (*Hb*) at a rate of 170 million *Sf* IJs per ha and 250 million *Hb* IJs per acre. In both treatments, the total 420 million IJs per ha were applied.
- Treatment three was an untreated check. EPNs were applied to the soil surface using a modified ATV small plot sprayer with all screens and filters removed and calibrated to apply 945 L per ha through fertilizer stream nozzles mounted 30 cm apart.

Application timing was late in the day to allow the UV sensitive IJs to enter the soil with limited UV exposure. After Treatment 1 was applied, the sprayer was thoroughly washed before being used to apply treatment 2.

EPN sampling protocol

Starting at 30 days after treatment (22 June 2017) all individual plots (including the untreated control plots) were sampled for EPNs. They were sampled again at 150 days, 390 days, 487 days, 694 days, 860 days and finally at 1,076 days (5 May 2020).

At each sampling date, a total of 25 soil cores (2 cm × 20 cm) were collected from each plot and returned to the laboratory to be bioassayed for the presence of EPNs. At the time of collection, the top 7 cm was placed in a 100 ml plastic cup with lid and the lower 13 cm was placed in a 240 ml cup with lid. Each container had a tight fitting lid. Soil cores were divided in this manner to isolate *Sc* in the upper layers from Sf in the lower layers in the *Sc* + *Sf* treatment (Trt 1) for the bioassay. Likewise, soil cores were divided in this manner to isolate Sf in the upper layers from Hb in the lower layers in the *Sf* + *Hb* treatment (Trt 2) for the assay (Ferguson et al. 1995). A similar procedure was followed for the untreated checks to detect any EPN contamination. All soil samples were laboratory bioassayed using *G. mellonella* larvae as indicator hosts (5 larvae per 7 cm core, 10 larvae per 13 cm core).

Wireworm sampling

During the first two weeks of June 2017, in areas of rye cover crop adjacent to each plot (untreated and EPN treated), wireworm larval bait stations consisting of eight cut potato pieces in a mesh bag were buried to the depth of 30 cm and left in place for 14 days. After retrieval, contents of each bait station was examined for the presence of wireworm larvae and the larvae present were identified.

Crop procedures

2017–2018: Sweet potato,'Covington', slips (20–30 cm) were planted into EPN trial plots on 30 May 2017 and 31 May 2018. In both years, slips were planted into ridges by hand at 10" in-row spacing. Fertilizer was applied at rate of 91 Kg N, 23 Kg P2O5, 23 Kg K2O/hectare. Weed control in planted ridges included two mechanical cultivations in June and hand pulling weeds the remainder of the season. Buffer zones around plots were over-seeded in rye cover crop and mowed twice during growing season. There were no applications of pesticides and no supplemental irrigation to plots or buffer zones in the field. Sweet potatoes were harvested on 26 Sept. 2017 and 24 Sept. 2018. Sweet potatoes were mechanically lifted out of the ridges which placed the sweet potato on top of the ridge it grew in. In each plot/rep a total of 200 potatoes were harvested. Fifty potatoes were randomly harvested from each of the four ridges in a plot. potatoes from the two outer ridges were collected and binned separately from the sweet potatoes collected from inner ridges. The potatoes were cured for one week and stored at ~ 55 °F during the damage assessment period.

Damage assessments took place the week of 23 Oct. 2017 and 15 Oct. 2018. In 2017, a total of 200 sweet potatoes from each plot rep were evaluated including 100 "inner ridge" sweet potato samples and 100 "outer ridge" samples. Within each treatment and grouping of potato, damage was incidence of wireworm feeding (0 = none, 1 = observed), number of wireworm mines and weight of the sweet potato in each plot. In 2018, assessment for white grub damage was added to the data set and was recorded as the number of inches of grub channels observed on the surface of the sweet potato. Wireworm damage assessment remained the same as 2017 except weight was recorded for each 100th sweet potato within each treatment.

2019: In 2019, Irish potatoes, 'Eva' were planted in the research plots rather than sweet potatoes due to increased attractiveness to wireworms. The potatoes were hand planted on 7 May 2019. Plots were slightly modified; three rows of potatoes (15 spuds per row) 10 feet in length that were used in observations. Fertilizer program was similar to the one used in 2017 & 2018. No supplemental irrigation was used and no pesticides were used in the plots. Plots were hand weeded after planting. Plots were harvested on 15 August 2019. On this date, 30 potatoes were dug from within each plot and examined for wireworm feeding.

Statistical analysis

The study was designed as a randomized complete block design with four replications using three treatments (EPN species mix 1, EPN species mix 2, and untreated). Wireworm feeding damage was evaluated using analysis of variance for a Random Complete Block Design (ANOVA) with post-hoc t-test applying Bonferroni correction (Systat Software Inc. 2009). EPN population levels expressed in percent of soil samples with a positive bioassay for the presence of EPNs were normalized with Arcsine transformation before analysis.

Significant differences in populations between years was tested using analysis of variance for a Random Complete Block Design (ANOVA) with post-hoc t-test applying Bonferroni correction (Systat Software Inc. 2009).

Results

The wireworms collected from the plot area using subsurface bait stations were identified as a mix of the Eastern field wireworm, *Limonius agonus* (Say), corn wireworm, *Melanotus communis* (Gyllenhal) and *Glyphonyx inquinatus* (Say). There was little relation between the low number of wireworm collected in the subsurface bait stations and resulting damage to the sweet potatoes. As a result, wireworm baiting was discontinued during the remainder of the study.

EPN persistence

Throughout the duration of the experiment (3 years), no EPNs were detected in the untreated control plots. *Sf* × *Hb*: Bioassay results for *Sf* ranged from 28–33% of the soil samples positive for the presence of *Sf* across the 1076 days (3 yrs) of the study. The levels of *Sf* remained significantly unchanged throughout the duration of the study (F = 0.37; df = 6; P = 0.05). The levels of *Hb* also were not significantly different across the 1076 days with the results ranging from 1–3% of the soil samples positive for the presence of *Hb* (F = 0.48; df = 6; P = 0.05). *Sc* × *Sf*: Bioassay results for *Sf* ranged from 24–35% of the soil samples positive for the presence of *Sf* across the 1076 days (3 yrs) of the study. The levels of *Sf* remained significantly unchanged across the duration of the study with the exception of the 150 d bioassay (F = 0.67; df = 6; P = 0.05) where the level of *Sf* dipped significantly below the mean level (24% vs 30%). This may have been a sampling issue since the levels increased to the former level for the remainder of the study. The levels of *Sc* also were not significantly different across the 1076 days with the results ranging from 0–6% of the soil samples positive for the presence of *Sc* (F = 0.58; df = 6; P = 0.05). In addition, the levels of *Sf* were statistically identical when comparing levels of *Sf* across the two treatments (F = 0.35; df = 13; P = 0.05).

Wireworm feeding damage

In the first harvest (2017)

- The EPN combination of *Sf* × *Hb* had significantly less wireworm feeding damage than the untreated check irrespective of whether the plants were located in the outside rows or the inside rows (F = 2.39; df = 23; P = 0.01).
- The EPN combination of *Sc* × *Sf* was numerically different from the untreated checks but the fewer wireworm feeding wounds were not statistically different from the untreated check (F = 0.95; df = 7; P = 0.05).
- When comparing the outside rows between the two EPN combinations, the *Sf* × *Hb* combination had significantly fewer feeding wounds than the Sc × *Sf* combination (F = 2.15; df = 11; P = 0.05). However, when comparing the inner rows between the two EPN combinations, the numerical difference was not statistically different (F = 1.05; df = 11; P = 0.05).

1. CHARLES BORNT ASSISTS GROWER WITH EPN APPLICATION USING GRAVITY FLOW PVC BOOM CONNECTED TO A 50-GALLON TANK STRAPPED ONTO A PALLET. PHOTO T. RUSINEK

2. THE NY PERSISTENT EPNS COME IN CUPS FILLED WITH WAX WORM HOSTS AND WOOD SHAVINGS. THE WAX WORMS MUST BE BROKEN UP WITH A WATER STREAM TO RELEASE THE EPNS INTO THE SOLUTION TO BE APPLIED TO THE FIELD. PHOTO T. RUSINEK

At the second year harvest

- The level of wireworm feeding wounds across all treatments were reduced from year 1.
- Comparing the outside rows across treatment, only the EPN combination of *Sf* × *Hb* has significantly less damage than either the untreated control plots or the *Sc* × *Sf* combination. (F= 2.05; df = 11; P = 0.05).

At the third year harvest

No wireworm damage was recorded in any of the treatments.

Discussion EPN levels

The levels of *Sf* in both of the nematode species combinations were not significantly different from each other and the level of *Sf* (24–35%) is very similar to the long-term persistence levels reported by Shields et al. (2018) across 75 fields ranging from clay loam to sandy loam. In the multi-year and multi-field study reported in Shields et al. (2018), the long-term persistence level of *Sf* (NY04) is suggested to be in the 20–30% range under NY agricultural conditions. Results reported in this study were in line with levels reported in Shields et al. (2018).

The levels of *Sc* (NY01) were lower in this study (0–6%) than reported by Shields et al. (2018) in alfalfa fields (8–13%), but more closely matched the levels reported in continuous corn (1–14%) or alfalfa following corn (1–6%). Ferguson et al. (1995) reported *Sc* preferred the top 5–7 cm of the soil profile and this zone can become very dry in sandy loam soils when row crops are grown. This may explain the lower level of *Sc* in this study along with the reported levels in continuous corn in Shields et al. (2018). In addition, the ambush nature of *Sc* along with limited dispersal behavior (Kaya and Gaugler 1993) often results in *Sc* hotspots separated by areas without *Sc*, resulting in a lower reported level of *Sc* than actually is present in the field. When *Sf* is matched with *Sc*, *Sf* ranges deeper in the soil and is less effected by the dry upper soil layers (Ferguson et al. 1995; Neumann and Shields 2006, 2008, 2011) coupled with a hybrid searching behavior using both ambush and cruising strategies. When these two species are mixed, data suggests that Sf fills in the gaps between the Sc areas of concentration (hotspots) resulting in a more complete coverage of the soil environment.

The levels of *Hb* in this study range from 1–3% of the soil samples across the duration of the study. With the relatively low density of hosts in this study, these low levels are not unexpected. *Hb* is a cruising nematode resulting in two issues; 1) this behavior matched with the bioassay technique of removing a soil sample for laboratory bioassay significantly underestimates the presence of *Hb* in the soil profile searching for hosts, 2) *Hb* numbers rise after the host has increased to economic numbers and 3) *Hb* prefers to attack larger larvae, often after damage has occurred to the crop (Shields et al. 1999). *Hb* numbers can rise to 100% of the soil samples in the presence of large numbers of hosts (Shields et al. 1999), but a more typical range under moderate host densities are 2–10% (Shields and Testa 2020). The very presence of *Hb* 1076 d after inoculation indicated that *Hb* is established in the soil and available to respond to host invasion

Availablity of NY persistent nematodes

The Shields' lab at Cornell offered assistance with the requirement to successfully rear and produce the biocontrol nematodes for resale to members of the organic community who were interested in starting a business to provide these NY persistent nematodes to the Northeast organic agriculture community.

Acknowledgements

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Research Report: Specialty Crop Participation in Federal Risk Management Programs

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Keywords: risk management, organics, Federal Crop Insurance Program, Noninsured Crop Disaster Assistance Program

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This study characterizes recent changes in FCIP and NAP use by conventional and organic specialty crop farmers using a case study of growers in New York State, which has a high number of NAP applicants and a large and diverse specialty crops sector, this report describes the reasons some farmers choose whether to participate in these programs.

What Is the Issue?

Specialty crops is a broad term that includes fresh or dried fruits, tree nuts, vegetables, beans (pulses), and horticulture nursery crops. In 2020, these crops accounted for 25 percent of the value of U.S. crop production (USDA, ERS, 2021). Specialty crop growers have fewer insurance and policy tools for managing risk than growers of major field crops like corn and soybeans. Specialty crop organic producers, in particular, do not commonly use crop insurance for risk management purposes (USDA, NASS, 2020). The lower adoption of crop insurance, where available, may be because organic farmers can access alternative risk management strategies, such as using crop rotation to manage yield risk or diversifying sales between spot markets and marketing contracts to manage marketing risk (Hanson et al., 2004).

Understanding which specialty crop producers tend to purchase Federal Crop Insurance Program (FCIP) and Noninsured Crop Disaster Assistance Program (NAP) coverage and how these programs matter for farms' financial risk management could help policymakers evaluate the effectiveness of federal farm safety net programs for specialty crop producers, identify risk management needs unmet by current Farm Act policies, and decide how to target future policies.

Since 1994, provisions in successive Farm Bills have expanded U.S. Department of Agriculture (USDA) products for specialty crops. Federal Crop Insurance Program (FCIP) products are available for a variety of organic and conventional specialty crops in counties where sufficient data are available for the USDA Risk Management Agency (RMA) to develop an actuarially sound insurance product and there is sufficient demand from growers for insurance to justify the effort to develop the product. In 2021, FCIP offered individual specialty crop policies for 76 crops in select counties and States. All crops covered by Federal crop insurance also are assessed for organic price elections. These elections allow growers to insure their crop using either their contract price or the published RMA organic price, which more closely reflects the value of the farmer's crop. The number of crops with organic price elections is increasing. In 2018, over 80 percent of insured crops had organic price elections, fewer than 60 percent had organic price elections in 2016 and less than 20 percent in 2014 (USDA, RMA, 2018).

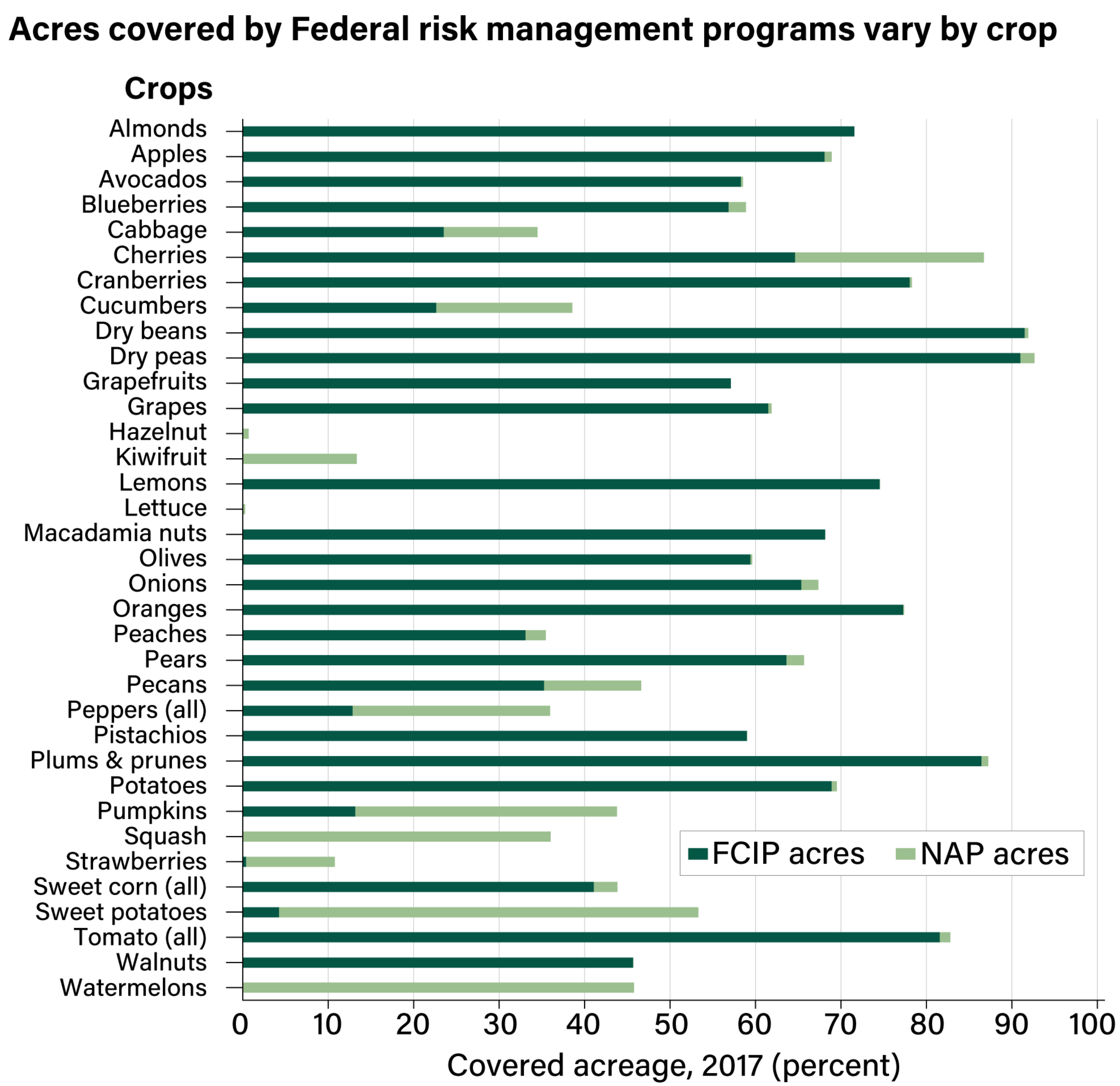
For crops grown in counties with insufficient data or grower demand to develop actuarial FCIP products, crop-loss protection is available through the USDA, Farm Service Agency (FSA) Noninsured Crop Disaster Assistance Program (NAP), which is a disaster program.

Because NAP is only available in counties where FCIP is not available for a particular crop, both programs must be examined to understand how growers of different specialty crops manage risk. Authors analyzed the concentration of crop insurance by State and trends in the adoption of crop insurance tools. Because acreage-level data are only available for 2017, that year's NAP and FCIP acreage was analyzed to determine how much specialty crop acreage is covered by the combination of the two programs. The use of coverage level options are also compared. Authors also describe the reasoning behind individual specialty crop growers' choices whether to participate in FCIP or NAP and how these programs fit with their overall risk mitigation strategy.

How Was the Study Conducted?

This study characterizes recent changes in FCIP and NAP use by conventional and organic specialty crop farmers using a case study of growers in New York State, which has a high number of NAP applicants and a large and diverse specialty crops sector. This report describes the reasons some farmers choose whether to participate in these programs. The specialty crop producers across New York State were chosen from the USDA, Agricultural Marketing Service (AMS) National Organic Program (NOP) Organic Integrity Database. The producers

Figure 1. Percent of vegetable acreage not covered by insurance, covered under FCIP, or covered under NAP for commonly grown vegetables in the United States, 2017



Notes: **FCIP** = Federal Crop Insurance Program. **NAP** = Noninsured Crop Disaster Assistance Program. **Dry peas** include dry chickpeas and lentils. **Squash** data exclude applicants flagged for fraudulent activity.

Source: USDA, Economic Research Service using data from USDA, National Agricultural Statistics Service (NASS), 2017 Census of Agriculture; NASS, Vegetables 2019 Summary; NASS, Crop Production; USDA, Risk Management Agency, Summary of Business Report; and USDA, Farm Service Agency.

were interviewed twice—first between June and August of 2019 and then between May and June of 2021. This report also uses publicly available and non-publicly available data from: RMA on the Federal Crop Insurance Program (FCIP) from 1988 to 2020; FSA on the Noninsured Crop Disaster Assistance Program (NAP) from 2011to 2020; and National Agricultural Statistics Service (NASS) 2017 Census of Agriculture, Vegetables Summary, Crop Production and Quick Stats for the year 2017. RMA datasets contain the number of conventional and organic FCIP policies, the amount of conventional and organic acres covered, total liabilities, and the total value of farmerpaid premiums. FSA datasets contain the number of conventional and organic farm applicants and applications for NAP, and for 2017, the total amount of acreage covered.

What Did the Study Find?

In 2017, FCIP or NAP covered a large portion of acreage for some crops: about 93 percent for dry peas, 92 percent for dry beans, 87 percent for plums and cherries, and 83 percent for tomatoes. In 2017, FCIP or NAP covered a smaller share of acreage for other crops: about 47 percent for pecans, 39 percent for squash, 13 percent for kiwifruit, 11 percent for strawberries, and less than 1 percent for hazelnuts and lettuce.

Insurance coverage remained relatively popular between 2015 and 2020. Buy-up coverage, which allows growers to insure a higher percentage of their crop yield against loss for a higher premium, was included in about 80 percent of FCIP liabilities for organic specialty crops between 2015 and 2020, while FCIP liabilities with buy-up coverage for conventional specialty crops increased from about 72 percent to about 82 percent. The value of specialty crops insured by FCIP (i.e., liabilities) increased from about $12 billion in 2011 to about $21 billion in 2020 (not adjusted for inflation).

The data required to create an actuarially sound insurance product are most often available for counties that are major producers for certain specialty crops; therefore, FCIP insurance is offered and used more often in States with the most acres of a crop grown or in counties where there is a high concentration of a single crop (like onions in New York). The States with the most policies are top producers of fruits and vegetables—California, Florida, and Washington for crops that have FCIP policies like tomatoes and apples—and specialty field crops such as dry beans or dry peas in Montana and North Dakota where growers also have access to FCIP policies for field crops like wheat and corn.

In general, States and crops that have fewer FCIP policies available have a higher number of NAP applications. NAP is a highly used safety net for crops that would otherwise tend to be insured by an FCIP policy (like tomatoes) but the FCIC program is not available in the grower's state or county. In 2020, the States or U.S. territories with the highest number of conventional specialty crop NAP applications were North Carolina, Puerto Rico, and New York. NAP is also the only loss protection option for some commonly grown crops, including squash, watermelon and strawberries.

The number of specialty crop producers who applied for NAP coverage trended up—from about 8,000 in 2015 to over 9,000 in 2020. Changes to NAP in 2015, such as the ability to purchase higher levels of coverage (buy-up), likely made NAP a more attractive risk management tool. Before the change NAP only covered "catastrophic" losses. In 2018 40 percent of NAP applications included buy-up coverage. There was no difference between organic and conventional farms in the decision to purchase buy-up coverage.

Discussions with nine New York specialty crop farmers revealed that five did not purchase any Federal risk management policy, three purchased FCIP, and one purchased NAP. These farmers generally reported the paperwork and cost associated with Federal risk management programs to be burdensome, especially for small and diversified farms. These farmers reported the most significant barriers to purchasing crop insurance were the application process and limited

Table 1: Summary of Interviews with NYS Specialty Crop Farmers

Farm Number	Acres	Organic	Crops	Crop Insurance
1	5	Yes	Apples, beans, fruit and mixed vegetables	NAP, FCIP for Apples
2	25	Yes	Apples	FCIP
3	112	Yes	Mixed vegetables and field crops	None
4	56	Yes	Mixed vegetables	None
5	130	Yes	Mixed vegetables	None
6	70	Yes	Mixed vegetables	None
7	45	Yes	Mixed vegetables and hemp	None
8	500	No	Apples, mixed fruit, mixed vegetables	FCIP for Apples
9	54	Yes	Onions	FCIP
Apples and Onions have the FCIP program available (all of the farmers were using CAT (catastrophic) level coverage).				

time available due to farming and marketing commitments. Several growers we interviewed had never actually priced crop insurance and were basing their impression of the programs from anecdotal information. As supported by the RMA and FSA data, farmer discussions also revealed that specialty crops like apples and onions where there is an FCIP program available and more awareness in the industry about crop insurance, are more likely to be covered by Federal risk management programs.

Acknowledgements

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Research Report: A New, Satellite NDVI-Based Sampling Protocol for Grape Maturation Monitoring

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Keywords: grape, maturation monitoring, remote sensing, NDVI

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Traditional sampling methods, both randomized and spatially stratified, often require visiting many different locations in a vineyard, making then very inefficient.

NDVI is normalized differential vegetation index, an indirect measure of leaf area and photosynthetic activity. This information is now readily available to growers through satellite images collected by numerous satellite platforms. The NDVI3 protocol uses Landsat imagery to identify a three pixel (30m x 90m) area along one vineyard row that best represents the range of NDVI reflectance over an entire vineyard, enabling the sample technician to limit sampling to a single location in the vineyard.

Traditional sampling methods often require many locations in a vineyard be sampled, which requires excessive precision and time for those collecting the samples. While stratified sampling requires fewer locations, usually around four, it still results in technicians traversing a large portion of the vineyard. It's also difficult, using these techniques, to get a representative sample. Limiting sampling to a single row in the vineyard could significantly decrease sampling time, thus reducing costs.

Normalized differential vegetation index (NDVI) uses special sensors to quantify the spectrum of light reflected by plant surfaces. It is a good indicator of vegetation density and photosynthetic activity. The information needed to calculate this value is readily available for growers using available satellite technology.

This study compared two traditional sampling methods, a random one and a stratified one, with a new method that uses satellite images to select a single location which represents the entire vineyard, based on NDVI values for each pixel in a vineyard.

The experiment

All experimental vineyards were in California's Central Valley. Three sampling protocols were used:

1. R20: A randomized sample consisting of 1 cluster is taken from each of 20 random locations.
2. CM8: Samples are stratified to represent each quadrant of a vineyard. To accomplish this, a technician walks 60m in each quadrant and collects 5 clusters. This is repeated for each of the four quadrants.
3. NDVI3: A satellite image from the previous year is used to identify one location in each vineyard, in which a technician walks 90m down a row, collecting 20 clusters at a single sample location. Each pixel of the satellite image covers 900 square meters of land (30m x 30m). The sample location consists of three pixels selected to represent the lower, middle, and upper third of the range of NDVI values for the vineyard.

To compare these sampling strategies, fruit composition was measured in each of the two seasons with CM8 (stratified) and NDVI3 being compared to R20 (random) as a quality reference. In 2016, fruit samples were analyzed to quantify Brix and titratable acidity (TA). In 2017, fruit samples were analyzed to quantify Brix, TA, pH, and total anthocyanins. Chemical analysis was performed using proprietary protocols.

In both seasons NDVI3 produced samples of the same quality as the random sampling, while the stratified technique only produced an acceptable sample in one season. Thus the NDVI3 protocol resulted in more efficient and accurate sampling than the currently popular stratified sampling method.

Additionally, NDVI3 represented the entire vineyard better than stratified or random sampling in 12/13 blocks. This means that samples taken this way more accurately represented the entire vineyard than either of the traditional sampling techniques.

NDVI3 stability

Running the algorithm to select a sampling location can be time consuming, so the temporal stability of the location was compared in 24 different vineyards over four years. A selected location produced reliable results for up to four years, decreasing the necessary frequency of running the NDVI3 algorithm.

Conclusions and practical considerations

This novel approach to grape sampling based on remote sensing data is functionally the same as or better than random or stratified sampling to accurately estimate vineyard fruit quality.

Overall this technique could dramatically reduce labor requirements for vineyard sampling throughout the season without decreasing sample quality. Because NDVI3 sampling requires that a field technician locate and visit only one location within a block, rather than four for CM8 or 20 for R20, it would require substantially less time for vineyard staff to perform. The demonstrated temporal stability of NDVI3 solutions suggests that optimal solutions do not need to be computed for each season in Central Valley vineyards and that block spatial patterns are persistent across multiple seasons. Using NDVI images that were up to four years old resulted in a p-value of <0.05 for the Kolomogorov-Smirnov test in a maximum 11% of blocks.

The NDVI3 protocol has the potential to vastly improve the efficiency of sampling in Central Valley vineyards. However, vineyards grown in regions with more spatial and season-to-season variability than the studied vineyards could decrease the efficacy of NDVI3 sampling, perhaps required sampling protocols that cover more than three pixels.

All blocks in this study were uniform in soil type, drip irrigated, and receive very little natural rainfall compared to many other wine growing regions. For that reason, they are expected to be more uniform than vineyard blocks in most other wine growing regions. A location with greater soil or climate variability, such as found in New York, may require a sampling area of more than three pixels.

The results of this study suggest that remote sensing and/or other spatial images warrant further investigation in their usefulness for guiding sampling in agricultural production systems.

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Research Report: Effects of Growing Techniques on Yield, Grade, and *Fusarium* Infestation Levels in Garlic

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Keywords: garlic, Fusarium bulb rot, cultural practices, black plastic, white plastic, straw mulch, spring planting

We trialed common and novel techniques growers use to cultivate garlic focusing on cultural changes such as variety selection, raised beds and mulches and tracked both the levels of Fusarium in the cloves and the quality of the garlic in each approach.

Across two sites, *Fusarium* levels were significantly different for the Rocambole variety and for straw mulch. Other differences were numerically but not statistically different. There was no effect of raised bed versus flat ground. For total yield While there are numerical differences between the treatments, only the black flat ground treatment was significantly different.Spring planted garlic was significantly smaller than all other treatments.

Almost every garlic grower struggles to a greater or lesser extent with *Fusarium* diseases, which are naturally found in most soils. Two primary *Fusarium* diseases historically concern garlic growers: *Fusarium* Bulb Rot, caused by F. *proliferatum*, causes brown to reddish sunken lesions on the bulb surface; and *Fusarium* Basal Rot, caused by organisms F. *culmorum*, causes the basal plate and gradually the entire bulb to break down. Because the diseases are nearly almost always present, the focus for growers and researchers alike is on management rather than eradication. *Fusarium* diseases tend to be worse in fields with poor drainage, but we were unsure what impact other techniques, such as the use of straw mulch or black plastic, have on *Fusarium* levels.

We focused this study on four categories of cultural changes: variety selection, raised beds vs flat ground, 3 different mulches vs bare soil and spring vs fall planting. The trial was located in the Hudson Valley and replicated in western New York. During the growing season, each of the treatments was monitored for disease development as the garlic grew. Diseased garlic was sent to a Cornell lab in Geneva, NY where the *Fusarium* was genetically tested to see if the disease is always the same, or if there are different species or pathovars of *Fusarium* in different locations or situations.

In July the garlic was harvested and brought to high tunnels to be dried. When it was dry, all the garlic was cleaned, roots and tops were trimmed, and it was graded into small (less than 1.5 inches in diameter), medium (1.5 to two inch diameter) and large (greater than two inch diameter) categories.

Samples of each treatment were assessed during the winter of 2017/18 to determine if *Fusarium* severity varied by treatment. Ten randomly selected cloves from ten different bulbs were rated for percent of total surface area infested with *Fusarium*.

The comparison of raised beds to flat ground, were blocked (not randomized) because of the difficulty of switching between raised beds and flat ground in one row. One row of the trial was a 4-inch raised bed, the other was flat ground. The other seven treatments were randomly replicated three times within the rows. Each treatment was twenty feet long, with a small buffer between treatments.

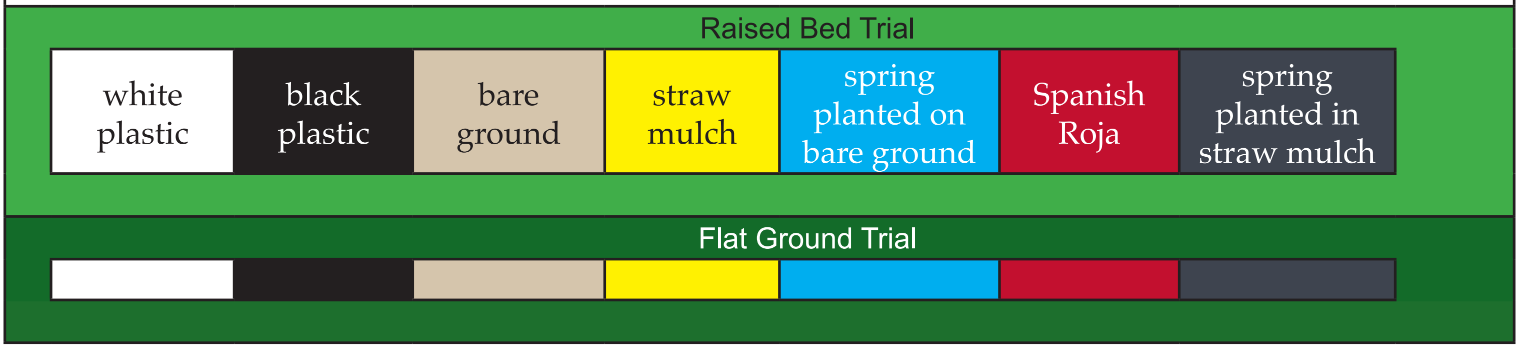
Variety selection plays a role in disease susceptibility and adaptability to various environments. For this trial, we compared two varieties grown by the majority of garlic growers: a Porcelain variety (German White) as our primary, and a Rocambole (Spanish Roja). Porcelain varieties are very vigorous and perform well under most growing conditions; Rocambole varieties are often considered to have better flavor but seem more susceptible to disease under many conditions.

Spring planting of garlic is something that growers tend to avoid if possible, but occasionally we are asked if it is possible to do. We also wanted to know if winter injury contributes to *Fusarium* levels on garlic. For this trial we cracked seed at planting time and then stored it in a standard refrigerator at 40 degrees F over the winter. As soon as the ground was thawed in the spring, we planted garlic into bare ground and straw mulch. Fall planted garlic was planted in Mid-October, and spring planted garlic was planted in April.

For the mulch treatments we compared white plastic mulch, black plastic mulch and straw mulch. All were were chosen for their excellent weed control. The bare ground treatments were regularly hand weeded so that weed pressure would not interfere with the results of the trial.

White plastic has similar properties to black plastic related to weed control and moisture moderation. However, because it reflects light rather than absorbing it, it keeps the soil cooler rather than warming it. This reflective property might also provide more light to the garlic. White plastic has typically

Figure 1. Map of the first of three replications of the garlic treatments, the following replications in the same row are randomized



been used in brassica production during parts of the growing season, but has not traditionally been used in garlic production. White plastic may shed snow during the winter similarly to black plastic, which was a concern with this treatment as well. The effect that temperature moderation would have on early growth was a question mark with this treatment, as was the cooler soil temperature during the summer.

Black plastic is used as another option for weed control. Moisture levels under black plastic tend to stay relatively constant, because not much rainfall makes it under the plastic and because evaporation is minimized. Black plastic also warms the soil more quickly in the spring, encouraging earlier top growth than straw mulch or bare ground systems. There are two primary concerns that growers have about black plastic. The primary concern is that it can actually get too hot under black plastic during the growing season, restricting garlic sizing in late June and early July. The second concern is that plastic can shed snow during the winter, leaving garlic more exposed to winter injury than in other growing systems. A third concern is that in very dry years, it may be necessary to irrigate garlic under plastic, which necessitates the use of drip tape.

Straw mulch is commonly used in organic garlic production where all fertility is applied in the fall, at planting. Straw mulch can help protect garlic from freezing and thawing in the winter and spring, can moderate soil moisture and temperature, and can suppress annual weed growth. It also reduces soil compaction and contributes to soil organic matter and soil health. Concerns about using straw mulch focus on two main issues: the potential for mulch to hold too much moisture in wet years and contribute to fungal disease issues (*Fusarium*); and weed control failures, which can lead to increased labor weeding compared to bare ground mechanical cultivation. We were careful to use weed-free straw, applied at about 5 inches deep in fall which compressed to 2.5 inches deep after the winter.

Bare ground cultivation of garlic is common because it allows for mechanical weed control as well as side-dressing nitrogen in the spring. Mechanical weed control is very time sensitive, so growers need to be quite attentive to keep weeds from competing with the crop. In a field with high weed pressure, up to 6 cultivations may be necessary for weed control. An additional consideration in growing garlic in a bare ground system is that the soil becomes more compacted than in a system with straw or plastic mulch.

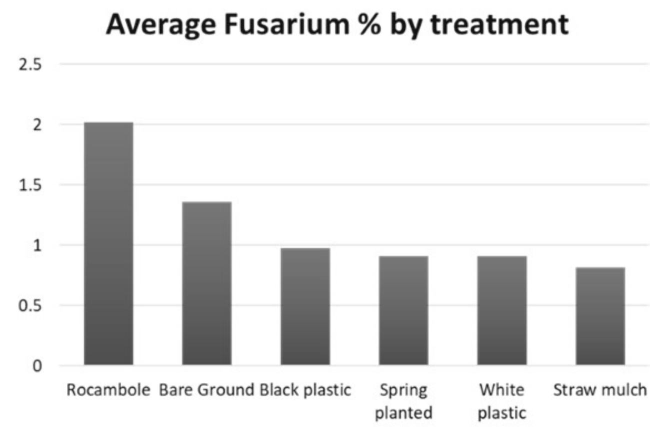
Trial Results

After harvest, garlic from both the Hudson Valley and Western NY trials was dried at the Hudson Valley Farm Hub, in high tunnels. Each of the plots was kept in enough separate bags to allow for good airflow for optimum drying. All treatments had their tops clipped in the field at approximately 4 inches. When the garlic was dried, determined by the innermost wrapper leaf being dry to the touch, the marketable bulb and cull counts and weights were recorded by plot. Data analysis was based on the average weight per bulb, as well as by the size distribution. The average weight per bulb was used rather than weight per plot because some of the plots were damaged by factors not considered part of the trial, such as crows picking garlic from the mulched sections. This damage changed bulb number per plot.

The average weight per bulb metric showed black plastic provided the highest yield, followed by white plastic, bare ground, and then straw. Not surprisingly, spring planted garlic had the lowest yields. While there are numerical differences between the treatments, only the black flat ground treatment was significantly different. White plastic (raised and flat), bare ground, and black raised were all statistically indistinguishable, and straw mulch and Spanish Roja were statistically indistinguishable from white plastic and bare ground. Only spring planted garlic was significantly smaller than all other treatments.

Besides total yield, we also examined the distribution of small, medium and large bulbs. White plastic mulch yielded the highest percentage of large bulbs on both flat ground and raised beds. Spanish Roja had the most even distribution of small, medium and large bulbs. Black plastic, raised beds, and straw mulched garlic all yielded more medium bulbs than the white plastic. Not surprisingly, the spring planted garlic yielded the most small bulbs.

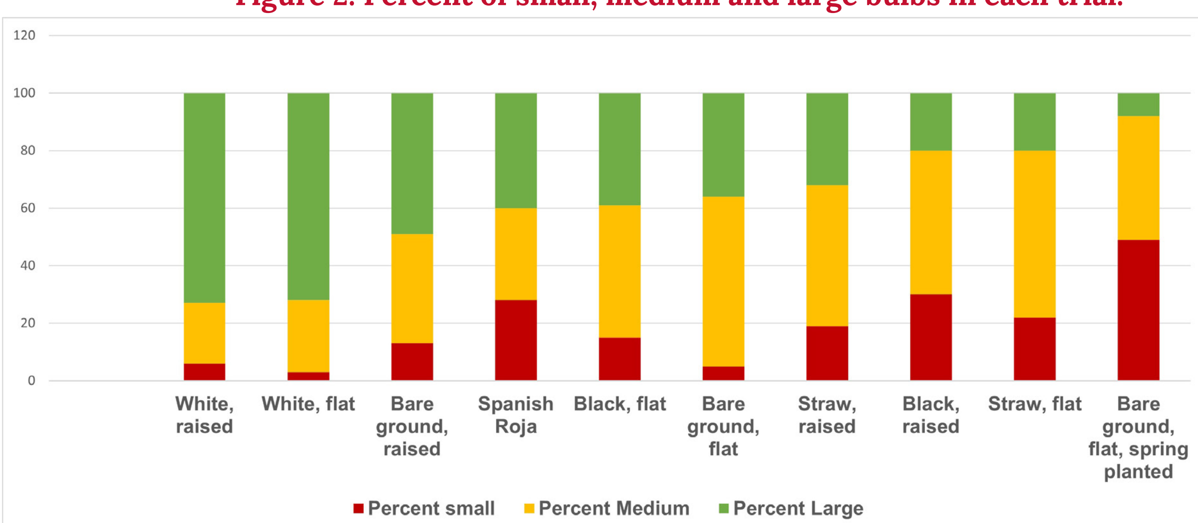
To assess *Fusarium* severity, we selected ten cloves per rep from storage and estimated total percentage coverage with lesions. Across two sites, *Fusarium* levels were significantly different between the Rocambole variety and straw mulch. Other differences were numerically but not statistically different. There was no effect of raised bed versus flat ground, so during the analysis data were combined to increase the number of plots.



Acknowledgements

This project was funded in part by the Specialty Crop Block Grant Program of New York State and in part by Northeast SARE. We also thank technician Natasha Field, as well as our demonstration site hosts for their assistance with this project.

Figure 2: Percent of small, medium and large bulbs in each trial.



Large bulbs > 2 inches, Medium bulbs 1.5-2 inches, Small bulbs < 1.5 inches

Research Report: The Effect of ProVide® on Scarf Skin in NY-1 Apples: Results from a 2019 Research and Demonstration Trial

Dan Donahue, Cornell Cooperative Extension Eastern NY Commercial Horticulture Program

Keywords: scarf skin, apple, Snapdragon, NY-1

Scarf skin is a physiological disorder of apple that results in a dull, cloudy appearance of the skin. The condition has been observed in NY-1 ('Snapdragon') apples at an increasing frequency, with growers becoming increasingly concerned. A commercial-scale airblast demonstration trial was established in a commercial NY-1 orchard to evaluate the efficacy of Provide® for the reduction on scarfskin in NY-1. Scarfskin incidence in the ProVide® treatment was identical with the control treatment, indicating that there was no treatment effect. ProVide was not effective in reducing losses.

Scarf skin is a physiological disorder of apple that results in a dull, cloudy appearance of the skin (Figure 1). The condition has been observed in NY-1 ('Snapdragon') apples to the concern of growers. Fruit with scarf skin is rejected by retailers because consumers are unlikely to purchase the fruit due to its appearance. Affected fruit must be marketed at a much lower price for juice which is an economic loss to growers.

The plant growth regulator (PGR) ProVide® (Valent BioSciences) is commonly used to improve fruit finish by reducing russeting and other physiological skin disorders such as flecking and scarf skin. According to the manufacturer, ProVide® is a mixture of two gibberellic acids (GA); GA4 and GA7. ProVide® conditions epidermal cells in apples, making them more elastic and able to withstand extremes in moisture and relative humidity without breaking during the cell expansion phase of fruitlet growth. A commercial-scale airblast demonstration trial was established in a commercial NY-1 orchard to evaluate the efficacy of Provide® for the reduction on scarfskin in NY-1.

Methods and Materials

The study was conducted in a (6th leaf) tall spindle commercial block of NY-1 in Orange County where the trees had filled their allotted trellis space. A split-plot experimental design was implemented where half of the block had been sprayed with ProVide® and half left as an untreated control. The treatments were separated by a wide drive row in the orchard. During the 2019 season, 4 sprays of Provide were applied to the treated half of the block. The dates of application were 5/11, 5/22, 6/1, and 6/14 at a rate of 3.5 oz per acre in 100 gallons of spray solution per acre applied by every row middle in order to ensure thorough coverage of fruit and foliage.

Three hundred and twenty (320) apples were selected from each of the treated and untreated (control) plots. Two rows were randomly chosen in the block. Within each row four trees were selected, skipping 3 trees in between each. In total, 16 trees (8 per treatment) were selected. The trees had approximately 125 fruit, from which 40 apples were picked sequentially starting at the bottom of the tree and proceeding upward.

Apples were assessed post-harvest immediately in the field. The desired appearance of an apple was a red blush cheek that appears bright and non-cloudy (Figure 2). The standards of the rating were based on a marketer-defined commercial packing house standard of minimum 50% clear red cheek. The degree of scarfskin was not considered, only the quality and coverage of the red cheek, considered by the marketer to be the most significant factor ensuring customer satisfaction. The apples either passed or failed this standard, and the ratings were recorded.

Results

Three-hundred and twenty (320) apples each were rated in the treatment and control. In the control we found 264 apples (82.5% incidence) with a commercially unacceptable degree of scarfskin (Table 1). Scarfskin incidence in the ProVide® treatment was identical at 82.5%, indicating that there was no treatment effect. Since mean incidence ratings were identical in the treatment and control, statistical analysis was deemed unnecessary.

Discussion

The high rate of incidence of scarf skin (82.5%) may be attributed to several factors in this study. Our sampling method of selecting apples in the lower third of the tree was designed to maximize scarfskin potential. Scarf skin symptom expression is influenced by the weather conditions during and following the bloom period, specifically precipitation, humidity and temperature. Apples were chosen from the lower 1/3 of the tree. This is also the area that receives the least sunlight and airflow. Any moisture in the environment will remain on this part of the tree longer than the areas with better light penetration and airflow. Therefore, the apples sampled for evaluation in this study may have been more prone to scarfskin than if a whole tree sample had been evaluated.

The lower Hudson Valley experienced a period of wet and cool weather during the bloom and post-bloom period, conditions conducive for scarfskin development. Total rainfall for this location during the month of May was 6.21", with only 7 dry days, higher than the historical expectation. Rainfall during the month of June was more normal at 2.07", delivered in frequent small doses with only 15 of 30 days being dry. The initial application of Provide, timed for king bloom petal fall, was followed by 2.15" of rain over three days. The second application was applied on 05/22 and followed by cool and damp conditions. The third application was applied on 06/01 and followed by dry conditions, with the fourth and final application applied on 06/22 and followed by a week of rain totaling 0.93". Provide applications started reasonably early in the fruitlet development process, application timings were according to label recommendations and appear to have been well-timed to match rain events through the course of the susceptibility period. Frost injury during and shortly after bloom can also result in scarfskin development. A light frost during this period in 2019 in the Hudson Valley is thought by some to be responsible for a significant degree of surface russeting observed at harvest, particularly in the 'Empire' variety. However, on-farm weather records indicate that the lowest temperature experienced during this period at the trial

1. NY-1 APPLE WITH SCARF SKIN

2. NY-1 APPLE WITHOUT SCARF SKIN

Table 1. Incidence of Scarf Skin for each tree replication and totals within the two treatments. Variation appeared between each tree replication, but overall incidence was equal between the two treatments.

ProVide			Non-ProVide Control		
Treatment #	Scarf Skin Incidence	Total # of Fruit	Treatment #	Scarf Skin Incidence	Total # of Fruit
1	26	40	1	33	40
2	38	40	2	32	40
3	35	40	3	33	40
4	30	40	4	36	40
5	32	40	5	27	40
6	30	40	6	33	40
7	35	40	7	36	40
8	38	40	8	34	40
Total	264	320	Total	264	320

location was 39.40F which discounts the possibility that frost injury was responsible for the high degree of scarfskin incidence observed.

In summary, we observed a commercially unacceptable incidence of scarfskin in this trial and ProVide was not effective in reducing losses. Sampling method and weather conditions likely contributed to the high scarfskin incidence observed. The orchard location was one of the oldest commercial NY-1 plantings in the Hudson Valley, well-pruned with 100% of the trellis filled. As such, it may be representative of what NY-1 producers can expect as young plantings reach maturity and experience seasons with weather conditions similar to those experienced in the Hudson Valley (HV) of New York State in 2019. Maintaining excellent sunlight penetration and air circulation in the lower canopy of mature tall-spindle plantings may be critical with NY-1. Another consideration is the suitability of the 50% clear red cheek grade standard as it may result in excessive cullage in some situations. It may be necessary to find a balance between the desire to market as attractive an apple as possible versus what may be the horticultural reality of this variety. Anecdotal observations suggest there is some variation in the expression of scarfskin symptoms between the warmer lower HV and the slightly cooler upper HV, suggesting that heat unit accumulation during certain periods of fruitlet development may be a consideration, meriting further investigation.

Acknowledgements

We thank technicians Sarah Elone and Sarah Tobin, as well as our demonstration site host Joel Crist for their assistance with this project.

Thank you to Crist Bros. Inc. and Cornell Cooperative Extension for in-kind and financial support of this field trial.

Research Report: Utilizing Computer Models and Additional Thinning Materials for Precise Crop Load Management in Northern New York Apple Orchards

Michael Basedow, Cornell Cooperative Extension Eastern NY Commercial Horticulture Program. Terence Robinson and Gregory Peck, Cornell University School of Integrative Plant Science, Cornell AgriTech.

Keywords: crop load management, NAA, ammonium thiosulfate, ATS, pollen tube growth model, PTGM, Gala, Honeycrisp, bloom thinning

Bloom thinning of apples has great potential to take more fruit off the trees beginning at bloom which may increase fruit size, improve fruit quality, and promote return bloom the following season in biennial varieties like Honeycrisp.

The pollen tube growth model is a strategy to help growers better time bloom thinning materials to increase their accuracy reducing the liklihood that trees will be over- or under-thinned. In this project, our primary objective was to further test and validate the efficacy of alternative bloom thinning materials, at their currently recommended spray rates, precisely timed with the pollen tube growth model. Our secondary objective was to utilize the fruit growth rate model on the same orchard blocks to precisely reduce the crop load to the growers' target crop density through additional thinner applications, and to further validate the utility of the fruit growth rate model.

From our three years of trials, we recommend growers continue to thin with either NAA or 2.5% ATS in Gala in northern NY. For Honeycrisp we found that 2.5% ATS provides similar levels of thinning as NAA at bloom, and similar levels of return bloom.

Apple crop load management is the single most important management practice affecting an orchard's crop value. Growers must balance reducing crop load (yield) sufficiently in order to achieve optimum fruit size and obtain good levels of return bloom in the following season. For each variety of apple, there is an optimum number of fruit per tree where yield, fruit size, and fruit quality are balanced to bring the greatest economic return to the grower.

In Northern New York, most crop load management is performed by thinning trees when fruit are between 10-12mm in size following the petal fall period. Thinning at this timing relies on the use of hormone-based plant growth regulator materials, such as NAA and 6-BA, and carbaryl, an insecticide that also acts as a mild fruit thinner. While NAA and 6-BA materials are currently industry standards, their efficacies are highly temperature-sensitive. The optimal temperature for the application of these hormone-based materials is generally in the mid-70°F's. Below 70°F efficacy is greatly reduced, leaving too many fruit on the tree. At the same time, temperatures in the mid-80°F's can remove all the fruit from a tree. In Northern New York, these narrow temperature windows are sometimes difficult to achieve, making crop load management with these hormone-based materials relatively ineffective in some years.

An alternative method for crop load management is to begin thinning earlier at bloom. This method uses different materials, like ammonium thiosulfate (ATS, a common row crop fertilizer) and lime sulfur (LS, an organic fungicide product) to inhibit flower fertilization. These materials have the potential to take more fruit off the trees beginning at bloom. Trees thinned earlier at bloom may produce larger fruit at harvest, and have greater return bloom the following spring, reducing orchard biennial bearing (many fruit on the trees one year, few the following year). This would be particularly valuable in Northern New York apple production, as growers across the region had poor thinning results with some hormone-based thinners in 2018, 2019, and 2020, and had poor return bloom in 2019 and 2021 on their Honeycrisp crop, one of Northern New York's most valuable apple varieties.

While bloom thinning is a promising approach for crop load management, and is being used extensively in Washington State, it remains difficult to perform locally, as it requires precise timing of the thinning applications to inhibit the correct number of blossoms. When materials are applied at the incorrect timing, trees are likely to be over-thinned or under-thinned. To better time these applications, some Northern NY growers have begun to use the pollen tube growth model (PTGM).

The pollen tube growth model was developed through a decade of research at Virginia Tech. This model estimates the amount of time between pollination and fertilization of the apple flowers, allowing growers to better time their bloom thinning materials. Growth rate models have been developed for the Honeycrisp, Gala, Golden Delicious, Fuji, Cripps Pink (Pink Lady), Granny Smith, and Red Delicious varieties.

By beginning the thinning process at bloom, growers have multiple opportunities to thin their trees, and can gauge how trees are responding to each thinner application. This response can be quantified using the fruit growth rate model, developed by researchers at the University of Massachusetts and Cornell University. In this model, fruitlet growth is monitored after each thinning application to determine how many fruitlets will be removed by the previous thinning spray, allowing growers to more precisely reach their target crop load.

In this 2022 NNYADP project, our primary objective was to further test and validate the efficacy of alternative bloom thinning materials, at their currently recommended spray rates, precisely timed with the pollen tube growth model.

Our secondary objective was to utilize the fruit growth rate model on the same orchard blocks to precisely reduce the crop load to the growers' target crop density through additional thinner applications, and to further validate the utility of the fruit growth rate model.

We anticipated that combining the fruit growth rate model with an effective bloom thinning protocol with applications of ATS or LS will bolster the profitability of Northern NY apple growers by making thinning applications in our region more reliable, allowing fruit growers to achieve optimum crop loads to maximize their fruit yield and quality, while reducing biennial bearing in Honeycrisp.

Methods

We established two field trials in commercial orchards in Northern New York in 2022, one in Gala (Northern Orchard), and one in Honeycrisp (Forrence Orchards). We trialed four different thinning treatments at bloom:

1. 10ppm NAA
2. PTG model using ATS at 2.5%
3. PTG model using ATS at 3%
4. PTG model using LS at 2% and oil at 1%

Northern Orchard: Gala Variety Trial

Our Gala experiment at Northern Orchard in Peru consisted of a block of Buckeye Gala, initially planted in 2012 at 4x12-foot spacing. We selected 15 trees in April 2022 (five replications of three trees) within the orchard to receive one of the four thinning treatments at bloom

Working with the grower, we determined the target crop load for the block was 100 fruit per tree. At the pink bud growth stage, the number of flower buds were counted on 10 trees within the experiment, and trees were subsequently pruned to reduce some of the crop load. Following pruning, 15 flower clusters on five representative trees (75 clusters total) within Treatment 3 were flagged and numbered, so we could run the fruit growth rate model on the trees to track the estimated crop load following each thinning application (Figure 1: Photos section).

As bloom began, 30 king flowers were collected from trees within the experiment block at random (Figure 2). Flower styles were measured in the field (Figure 3), and the average style length from these flowers was added to the pollen tube growth model (PTGM; freely available to growers at ptgm.newa.cornell.edu.) As more flowers opened, we monitored the block

1. A TREE AT NORTHERN ORCHARD, PRUNED, COUNTED AND CLUSTERS TAGGED - PHOTO A. GALIMBERTI

2. COLLECTING KING FLOWER BLOSSOMS - PHOTO A. GALIMBERTI

3. MEASURING FLOWER STYLE LENGTH - PHOTO A. GALIMBERTI

closely to estimate that the targeted 100 king flowers per tree opened in the block on May 13, 2022, allowing us to "start" the PTGM.

Treatment 1 received an application of Fruitone (an NAA product) at the rate of 4 oz. per 100 gallons dilute tree row volume (TRV) on May 14. The first applications of ATS and LS were applied to Treatments 2-4 on May 14 when the PTGM estimated that pollen tube length reached 53% of the style length. The second applications of ATS and LS were applied on May 15, when the model reached 31%, and the third applications of ATS and LS were applied on May 17, when the model reached 85%. We were unable to apply at the ideal timings this season due to rainy weather conditions.

All of the bloom treatments were then followed with a petal fall thinning application of 3 oz. Fruitone per 100 gallon dilute TRV + 1 pt Sevin per 100 gallons on May 25.

Following the petal fall application, fruitlet growth was measured on the clusters we had flagged at the pink bud stage (Figure 4). Measurements were made on May 26, and again on May 31. Following the petal fall application, the fruit growth rate model predicted there were still 284 fruit per tree remaining, so a 12 mm thinning application of 64 oz Maxcel per 100 gallon dilute TRV + 1 pt Sevin per 100 gallon was made on June 2. We measured fruitlet growth again on June 3 and June 7, and the model predicted 185 fruit per tree remained. Given that we were now relatively close to our desired crop load, we decided to stop thinning. Fruitlets were measured again on June 14, at which point the model predicted 86 fruit per tree remained.

A first pick of fruit was conducted on September 16, 2022. A second pick was conducted on October 5, 2022. As fruit were harvested, we recorded the total fruit count and fruit weight per tree. From these measurements, average fruit size per tree was also tabulated. A subsample of 50 fruit per treatment was shipped to Dr. Terence Robinson at Cornell AgriTech in Geneva, New York, and were sorted over a color and size grader. Fruit were also examined for their level of fruit russeting. These data were then used to tabulate total crop value per acre of each treatment.

Return bloom data from our 2021 trial was collected in May of 2022 by assessing the number of flowering spurs on three limbs on five trees in each treatment of our 2021 field trial.

Forrence Orchards: Honeycrisp Trial

This site consisted of Honeycrisp trees, initially planted in 2012 at a 3x14-foot spacing. We selected 15 trees (5 replications of 3 trees) to receive one of the four bloom thinning treatments.

Working with the grower, we determined the target crop load for the block was 85 fruit per tree. At the pink bud growth stage, the number of flower buds were counted on five trees within the experiment to help us determine our starting bud load. We flagged and numbered 15 flower clusters on five representative trees (75 clusters total) within Treatment 3, so we could run the fruit growth rate model on the trees to track the estimated crop load following each thinning application.

As bloom started, 30 king flowers were collected from trees within the experiment at random. Flower styles were measured, and the average style length from these flowers was added to the PTGM. As more flowers opened, we monitored the block closely to estimate that the targeted 85 king flowers per tree had opened in the block on May 13, allowing us to "start" the PTGM. The bloom NAA application of 4 oz NAA per 100 gallons dilute TRV was applied to Treatment 1 on May 14. The first applications of ATS and LS were made to Treatment 2-4 on May 14, when the pollen tube model was at 60%. The second applications were made at 36% on May 15. We were unable to apply at the ideal timings this season due to rainy weather conditions.

Due to concern of overthinning, no petal fall thinner applications were made after the bloom thinners on our Honeycrisp trial.

Following the petal fall time period, fruitlet growth was measured on the clusters we had flagged at the pink bud stage. Measurements were made on May 26, and again on May 31. At this timing, the fruit growth rate model predicted there were 152 fruit per tree remaining, so we did not apply a 12mm application. We measured fruitlet growth again on June 7, and the model predicted only 22 fruit per tree remained.

Fruit were harvested on September 16, September 23, September 30, October 6, and October 12. As fruit were harvested, total fruit count and weight were recorded per tree. From these measurements, average fruit size per tree was also tabulated. A subsample of 50 fruit per treatment was shipped to Dr. Terence Robinson at Cornell AgriTech in Geneva, New York, and were sorted over a color and size grader. Fruit were also examined for their level of fruit russeting. These data were then used to tabulate total crop value per acre for each treatment.

Return bloom data from our 2021 trial was collected in May of 2022 by assessing the number of flowering spurs on three limbs on five trees in each treatment of our 2021 field trial.

Statistical Analysis

From the Northern and Forrence Orchards' field trials, treatment differences in number of fruit per tree, yield per tree (kg), fruit size (oz.), and russeting were analyzed in SAS statistical software using the Generalized Linear Model (GLM) procedure. Where the model determined significant treatment differences, differences between individual treatments were assessed using Duncan's Multiple Range Test in SAS statistical software. Return bloom differences were assessed using the Fit Model function on JMP statistical software. Treatment differences were then evaluated using Tukey's Honestly Significant Differences test.

Northern Orchard: Gala Trial Results

None of the treatments achieved the desired level of thinning in 2022 (Table 1). While our target crop load for this block was 100 fruit per tree, the number after treatment ranged from a low of 144 to a high of 236. Significant differences in thinning in terms of total fruit per tree at harvest were observed (p=.0025). Yield per tree also differed significantly between treatments (p=.0022). Fruit size did not differ between treatments. Fruit percent red color did not differ significantly between treatments. Russeting did not significantly differ between treatments. Crop values did not significantly differ between bloom thinning treatments.

The fruit growth rate model predicted that the Gala trees in our 3% ATS treatment started with an initial crop load of 1,234 fruit per tree. Following the bloom and petal fall applications, the model predicted there were 284 fruit remaining per tree. This prediction suggests that three applications of 3% ATS alone at bloom would have been inadequate for reaching the target crop load.

The fruit growth rate model had predicted a final crop load of 86 fruit per tree (49% less than what was on the trees at harvest). Our actual average fruit per tree at harvest was 170 in the 3% ATS treatment, suggesting that the fruit growth rate model was very inaccurate in this block in this research year.

Forrence Orchards: Honeycrisp Trial Results

None of the treatments achieved the desired level of thinning in 2022 While our target crop load for this block was 85 fruit per tree, actual load ranged from 135 to 236 (Table 2). Fruit per tree at harvest differed significantly in our trial (p=.0015). Yield per tree was significantly different in our trial (p=.0485). Average fruit size differed significantly (p=.0051) Percent red color differed significantly between treatments (p=.0236). Russeting did not differ significantly between treatments. Taking into account the yields and fruit quality data, crop value per acre differed significantly between treatments (p=.0229).

The fruit growth rate model predicted that Honeycrisp trees in our 3% ATS treatment started with an initial crop load of 2,174 fruit per tree. Following the bloom application, the model predicted there were 152 fruit remaining per tree. The fruit growth rate model predicted a final crop load of 22 fruit per tree (89% less than what was on the trees at harvest). Our actual average fruit per tree at harvest was 208 in the 3% ATS treatment, suggesting that the fruit growth rate model was very inaccurate in this block this year.

Return Bloom from 2021 Trials

The 2022 return bloom in our 2021 Gala trial was not affected by our bloom thinning treatments. The 2022 Honeycrisp return bloom was affected by thinning treatment in our 2021 Honeycrisp trial (p<.0001). Trees treated with 2% LS + 1% oil in 2021 had significantly more return bloom in 2022 than trees treated with 2.5% ATS or with NAA.

Discussion

In our Gala trial, the 2.5% ATS rate yielded fewer fruit per tree than the industry standard NAA application. This contrasts to our previous two years of results, which found no significant difference in thinning efficacy between these two treatments. 3% ATS at bloom and 2% LS + 1 % mineral oil also yielded fewer fruit per tree than the standard NAA treatment, and yielded similar levels of fruit per tree as the 2.5% ATS treatment. Unfortunately, this extra thinning did not lead to significantly improved fruit size and color relative to the NAA treatment. The different bloom treatments had no effect on fruit russeting of Gala.

2.5% ATS bloom treatment returned the highest crop value per acre, followed by 3% ATS, NAA, and LS. However, none of these values differed significantly from each other. Please note that these crop values do not incorporate the amount of labor time it takes to harvest more or less fruit from each tree.

In our Honeycrisp trial, the 2.5% ATS rate gave similar levels of thinning as the NAA treatment, with no significant differences in fruit per tree or yield per tree. Contrary to our expectations, the 3% ATS and 2% LS + 1 % mineral oil treatments thinned off fewer fruit per tree than the NAA and 2.5% ATS

Table 1. Harvest and crop value data from the Northern Orchard Gala trial

Treatment		# Fruit	Yield per Tree (kg)	Bu per Ac (est)	Fruit Size (kg)	Fruit Count per Bushel	Fruit Color (% Red)	% Russet-Free Fruit	Crop Value per Acre
1	NAA	236	35.97	1800	0.15	126	63.5	99.6	$15,347
2	2.5% ATS	194	31.37	1570	0.16	118	69.0	99.1	$16,886
3	3% ATS	170	27.71	1386	0.16	118	70.9	99.1	$15,559
4	2% LS + 1% oil	144	23.74	1188	0.16	118	75.5	100	$14,320
P-Value		0.0025	0.0022		0.0820		0.2138	0.7886	0.0896

Table 2. Harvest and crop value data from the Forrence Orchard Honeycrisp trial

Treatment		# Fruit	Yield per Tree (kg)	Bu per Ac (est)	Fruit Size (kg)	Fruit Count per Bushel	Fruit Color (% Red)	% Russet-Free Fruit	Crop Value per Acre
1	NAA	236	35.97	1800	0.15	126	63.5	99.6	$15,347
2	2.5% ATS	194	31.37	1570	0.16	118	69.0	99.1	$16,886
3	3% ATS	170	27.71	1386	0.16	118	70.9	99.1	$15,559
4	2% LS + 1% oil	144	23.74	1188	0.16	118	75.5	100	$14,320
P-Value		0.0025	0.0022		0.0820		0.2138	0.7886	0.0896

treatments. We expected to see a positive rate response from ATS, where increasing concentrations would lead to increased thinning. Our findings are also in disagreement with our previous year's results, where LS + mineral oil gave similar levels of thinning as 2.5% ATS.

Honeycrisp fruit size was smallest in our 3% ATS and 2% LS treatments. Red color was also negatively affected by crop load, as 2% LS had significantly less red fruit than trees treated with NAA. Russeting was worse in the NAA treatment and lowest in the 3% ATS treatment, but did not significantly differ.

The NAA-thinned blocks returned the highest crop value per acre, followed by 2.5% ATS, 3% ATS, and then LS. In these blocks, the Honeycrisp that had the most thinning had the best fruit quality in terms of size and color, which helped to significantly increase the fruits' value despite the yield reductions. Again, please note that these crop values do not incorporate the amount of labor time it takes to harvest more or less fruit from each tree.

Our results suggest that 2.5% ATS timed with the PTGM can provide comparable levels of thinning as traditional NAA bloom thinning in Honeycrisp when used in a traditional thinning program, followed up with additional hormone thinner applications at petal fall, 12mm, and beyond. In Gala, we found 2.5% ATS, 3% ATS, and 2% LS + 1% oil can thin significantly more fruit, but this additional thinning had limited effects on fruit quality and crop value this year. In Honeycrisp, fruit thinned with 3% ATS and 2% LS + 1% oil thinned substantially fewer fruit than NAA and 2.5% ATS, resulting in higher yields of poor quality fruit, resulting in lower crop values.

Fruit Russeting

Excessive fruit russeting can decrease the value of fruit. Previous studies have found an increased risk of russeting from using lime sulfur and ammonium thiosulfate for bloom thinning (Peck et al., 2017; Marchioretto et al., 2018). While the exact reasoning for this russeting is not always clear (Allen et al., 2021), the standard guidance has been to use reduced rates of the materials or to avoid using these materials under slow drying conditions.

Fruit treated at 2.5 and 3% ATS had the most russeting in our Gala trial in 2022, followed by NAA, followed by 2% LS + 1% oil, not significantly different. Russeting was minimal on all the 2021 Gala treatments, and, therefore, had a negligible impact on fruit quality.

The NAA treatment had the most russeting in our 2022 Honeycrisp trial, followed by the 2.5% ATS treatment, the 3% ATS, and 2% LS + 1% oil treatment, not significantly different.

In our 2021 Honeycrisp trial, the 2% LS + 1% oil treatment produced significant russeting, ATS at 2.5% moderate russeting, and NAA very little russeting on Honeycrisp. In that trial, the extra size and color gain from the lime sulfur led to similar overall returns to the grower with either the lime sulfur or NAA treatment. Russeting was less severe in the ATS-treated fruits and with the extra color gain made the ATS treatment the most profitable.

Economics

Per-acre cost of treatment was the lowest for NAA ($24.65/ac for both trials) followed by 2.5% ATS ($44.40 and $29.60); 3% ATS ($47.28 and $31.52); then 2% LS+oil ($143.11 and $107.60). With costs considered, the 2.5% ATS treatment was the most profitable bloom thinner in our Gala trial, while the NAA treatment was our most profitable thinner in the Honeycrisp trial.

Weather Impacts

Weather was not very conducive to good hormonal thinning during our petal fall application for Gala in 2022, nor was it particularly conducive to good thinning at our 12mm application. This may help to explain why we did not reach our target crops at either site.

The weather in 2022 during bloom was not conducive to bloom thinning with the PTGM. Rain showers were predicted for each day we wanted to make applications, which required us to get applications on earlier than we would have liked for the second ATS application and both of the LS applications. The first applications also went on under very warm conditions, when it was approximately 82°F. These hot temperatures likely led to increased leaf burn on the trees. Trees grew out of this damage, though, and we feel it prevents little risk to grower profitability. Applications made the next day probably gave good efficacy, as conditions were warm and humid, and we expect higher levels of thinning efficacy when these materials are applied under slow drying conditions (Janoudi and Flore, 2005). However, even under these strong thinning conditions, timing issues due to rain likely impacted overall efficacy this season in the Honeycrisp trial. Our third Gala application was made when the daily temperature was a high of 61°F, so we expect this likely did some mild additional thinning of the remaining fruit buds. Since applications were made early at both sites, it is very likely that the Honeycrisp site would have benefited from a third application of bloom materials, but we were unable to get a third application on due to time and weather constraints.

Thinning at Bloom Alone

Our fruit growth rate model results from the Northern Orchard Gala trial site suggest that three applications of 3% ATS alone would have been insufficient to adequately reduce crop load. Kon et al. (2018) found that two applications of 2.0% ATS at bloom did not reduce final crop load sufficiently. Given our results, Gala treated with three bloom applications of 3% ATS may require additional thinner applications at later fruit growth stages. Commercial recommendations suggest concentrations of ATS between 2% and 4% for bloom thinning. Given the limited amount of russet we saw at 3% in our Gala study, we feel comfortable recommending up to 3% ATS at this timing when conditions are favorable, following up with additional hormone materials as needed.

Our harvest results from the Forrence Orchard Honeycrisp trial site shows two applications of 3% ATS alone was insufficient to adequately reduce crop load. Given the limited amount of russet we saw at 3% in our Honeycrisp study, we feel comfortable recommending up to 3% ATS at this timing when conditions are favorable, following up with additional hormone materials as needed.

Return Bloom Considerations

Other researchers have suggested an additional benefit of treating trees with ATS at bloom may be an improved return bloom in biennial varieties such as Honeycrisp (Robinson, 2020). In 2022 we evaluated return bloom in our 2021 trial blocks. In our Honeycrisp trial, bloom thinning had a significant impact on return bloom the following season ($p<.0001$). We found 2.5% ATS at bloom increased return bloom by 12% relative to bloom NAA treatments, and LS at bloom significantly increased return bloom by 36%.

We only saw a 4% return bloom increase in our 2021 Gala trial block. In our 2020 trials, we found no significant increase in return bloom in either Honeycrisp or Gala. We note that return bloom was very low in many Northern NY Honeycrisp blocks in 2021, which could have contributed to ATS being less effective at improving return bloom in that year. We plan to evaluate return bloom for our 2022 trials in spring 2023 to better understand the effects of thinning with 3% ATS and 2% LS on return bloom.

Under- and Over-Prediction Variability

The fruit growth rate model under-predicted the amount of fruit remaining on the trees in 2022 at both orchard sites. The model under-predicted final fruit per tree by 49% at our Gala site, and by 89% at our Honeycrisp site. The Gala trees we tagged had many additional fruits at the tops of the trees at harvest, whereas the clusters we had tagged were more uniformly distributed throughout the canopy. This might explain the under-prediction we observed in Gala this season.

We found excessive king bloom damage in our Honeycrisp trial this season. Conversations with the model developers (Robinson, 2022) suggest the model likely greatly underestimated in 2022 due to the lack of king fruits growing. In years with excessive king damage, the model may not be able to determine if lateral blossoms are going to abscise or not. In our Honeycrisp trial, the model likely thought more laterals were going to thin off than actually did.

In our 2021 trial, the model under-predicted remaining fruit by 44% in our Gala experiment, and by 16% in our Honeycrisp experiment. Earlier experiments have found that the model tends to slightly overestimate in trials by about 10% (Robinson, 2020).

The three years of data results indicate that the fruit growth rate model can be a valuable tool in roughly estimating the amount of fruit left on the tree to help growers to determine when to stop thinning, but it is unlikely to be exact, and may be inaccurate in years where excessive king damage is present.

Moving Forward into 2023

Our target crop loads were not met at either of our trial sites this season. However, given the increased risk of leaf damage and russet above 3% with ATS, we currently recommend growers use ATS rates between 2.5 and 3% when conditions are favorable on Honeycrisp blocks that struggle with biennial bearing. Since we had poor weather conditions in 2022, we believe further research is required to refine the use of these models in commercial settings to incorporate them into an integrated thinning program in Northern New York. Updated bloom thinning models are currently in development at Cornell University, and we plan to partner with the developers on a small trial basis in 2023 to support their implementation in northern New York.

Conclusions

The bloom thinning of apples has great potential to increase early thinning to improve fruit quality, and to promote return bloom the following season in biennial varieties like Honeycrisp.

In our 2022 Gala trial, bloom thinning with 2.5% ATS, 3% ATS, or 2% LS + 1% mineral oil with the PTGM thinned more fruit at bloom than NAA, but this additional thinning did not provide additional benefits in fruit quality or crop value when followed with the same thinning protocols at petal fall and 12mm. While not statistically significant, fruit thinned with two applications of 2.5% ATS at bloom was the most profitable option. However, the labor costs of setting up the PTGM should also be strongly considered. Since Gala does not tend to have an issue with return bloom, we generally recommend growers continue to thin with NAA at bloom, and to complement this with additional thinners at petal fall, 12mm, and 18mm as needed.

At the Honeycrisp field site, 2.5% ATS provided similar levels of thinning and crop value as NAA applied at bloom. 3% ATS and 2% LS + 1% mineral oil provided less thinning efficacy, and was met with reduced fruit quality and crop value. At this site, the NAA bloom treatment was the most profitable bloom thinner. While we haven't assessed the 2022 season's return bloom yet, our 2021 trial data shows that return bloom is slightly increased with 2.5% ATS over NAA at bloom. Therefore, where growers have a particularly biennial block of Honeycrisp that is going to be in a high bloom year, they might consider treating the block with 2.5-3% ATS if conditions for the application are favorable on a limited trial basis. Lime sulfur remains unlabeled for bloom thinning in New York. Companies have shown little interest in adding this use to their labels. New York growers should not use lime sulfur for bloom thinning.

The fruit growth rate model under-predicted the number of fruit at our Gala site, and greatly underestimated the number of fruit at our Honeycrisp fruit site. The fruit growth rate model might be of limited utility in orchards that have sustained winter damage to the king blooms. Additional work is required to further evaluate the most appropriate rates of these materials under various weather scenarios. Updated versions of the

PTGM being developed at Cornell might make implementing it on commercial orchards easier in the following years.

From our three years of trials, we will recommend growers continue to thin with either NAA or 2.5% ATS in Gala in northern NY. Given the additional labor expenses with setting up the PTGM, NAA may still be the best option for Gala growers, particularly since return bloom is much less of a concern. Our three years of studies with bloom thinning with the PTGM in Champlain Valley Honeycrisp suggest 2.5% ATS provides similar levels of thinning as NAA at bloom, and similar levels of return bloom. Unfortunately, we did not see additional benefits on fruit quality from thinning with 3% ATS in 2022, or 2% LS + 1% oil in either 2021 or 2022. We did see an increase in return bloom in Honeycrisp with 2% LS + 1% oil in our 2021 trial, but we will need to see if this trend is consistent in 2023.

We believe additional research is needed to find the most effective concentration of ATS to use at bloom on these varieties relative to the weather conditions on the day of application.

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Research Report: A First Look at Precision Spraying and Electrical Weeding Technology for Possible Use in NY Fruit Crops

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Keywords: weeds, weed control, herbicide resistance, herbicide injury, novel technology, precision spraying, electrical weed control

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Novel weed control technologies include precision vision-guided sprayers and electrical weeders. In this article we report on our evaluation of these two systems. Both gave promising results for weed control in fruit crops.

This article describes results from 2021 and 2022 trials to evaluate the performance of a precision, vision-guided sprayer and an electrical weeder designed for use in perennial crops.Weed control has routinely been identified by growers as one of the biggest barriers to growing fruit, especially small fruit and organic or low-spray fruit, in NY – second only behind labor challenges.

Synthetic herbicides are important tools for managing unwanted vegetation in fruit crops although their use carries the risk of crop injury (Breth et al., 2011; Breth and Tee, 2013; Derr,2001a; Derr, 2001b). Postemergence, foliar-applied products, like glufosinate and glyphosate, have been reported to cause damage in perennial crops through direct contact with trunks, suckers, stems, and leaves. For example, glufosinate can be moved from the surface of young almond bark into the cambium layer, where it causes localized cell death and canker development (Doll, 2015). Simulated drift studies in pecans and cherries showed that glyphosate contact with foliar tissue can have negative impacts on subsequent plant growth and productivity (Al-Khatib et al., 1992; Foshee et al., 2008). In New York, glyphosate use has been associated with trunk injury and scaffold decline in apples (Rosenberger et al., 2013).

Novel weed control technology is being explored for systems where herbicide options are limited, herbicide resistance threatens the efficacy of commonly used chemicals, soil disturbance in not desirable, and where there is also concern regarding the economic and environmental sustainability of current practices. While most innovation is occurring in annual crops, tree fruit, grapes, and berries are candidate environments for adoption of new weed management tools.

Materials and Methods

Vision Spray Trial

The vision spray trial looked at the effecacy of targeted herbicide applications made using a precision, vision-guided sprayer compared to a continuous herbicide treatment made using a CO2-pressurized backpack sprayer. Unlike the backpack sprayer, which broadcasts herbicide across the whole area to be treated, the precision sprayer nozzles are only turned on when its coupled sensor detects plant material via chlorophyll fluorescence (Rometron, 2022).

In July and August 2021, Palmer amaranth (*Amaranthus palmeri*) and horseweed/marestail seedlings were grown in greenhouses set to 77 F (25 C) on Cornell's AgriTech campus in Geneva, NY 14456. Both species were selected for use in the trial as they represent two different growth habits of annual broadleaf weeds: upright erect (Palmer amaranth) and low-growing rosette (horseweed/marestail). Once Palmer amaranth and horseweed/marestail reached heights and diameters of 2 to 3 inches (5 to 7.5 cm) and 1 to 1.5 inches (2.5 to 3.8 cm) respectively, plants were transferred to the field. Backpack spray applications were made using a 2-nozzle boom with nozzles (flat fan 11002) set 19 inches (48 cm) apart and held at a height of 19 inches (48 cm) above the treated material. The broadcast application was made at a travel speed of 2.5 mph (4 kmh). Vision-guided sprayer treatments were made using a customized Weed-It Quadro system with 4 sensor-nozzle units conveyed on a Polaris Sportsman ATV driven at 5 mph (8 kmh) (Figure 2). Sensors and spray nozzles on the Weed-It Quadro were positioned at a height of 19 inches. Palmer amaranth plants were treated with either 0.188 or 0.375 gal/A Rely 280 (1.75 or 3.51 l/ha); horseweed/marestail plants were treated with Rely 280 at rates of 0.125, 0.25 or 0.375 gal/A (1.17, 2.34, or 3.51 l/ha). Herbicides were applied at a spray volume of 20 GPA (187 l/ha), regardless of application strategy. Each rate by application system combination was replicated 36 times for both Palmer amaranth and horseweed/marestail. Following treatment, all plants were returned to the greenhouse and monitored for 2 weeks after which their aboveground biomass was harvested and weighed. Untreated checks were included for comparison.

Electrical Weed Trial

A preliminary trial was initiated June 2022 at Cornell AgriTech to evaluate the performance of an electrical weeding unit. Electrical weeders apply a high voltage current directly to unwanted vegetation; the flow of electricity through the plant produces heat, which causes water in cells to vaporize; in turn, the resulting pressure causes tissues to burst and die. In these experiments, the electrical current was generated using a Zasso Electroherb system, which was powered by a tractor PTO system (Figure 1). The trials were conducted in a weedy agricultural field. Soil at the site is a moderately well- drained Lima loam. Less than 1 inch (2.54 cm) of rain was received at the study site in the week prior to treatment establishment. Treatments included two tractor speeds (1 and 1.6 mph (1.7 km/h and 2.6 km/h)) and two generator settings that produced an average of 11.5 and 51.0 Amps under field conditions. Each plot consisted of two treated strips that were 2 feet (1.6 m) wide and at least 100 feet (31 m) long. The weed community in the field was dominated by common lambsquarters (*Chenopodium album*), Powell amaranth (*Amaranthus powellii*), common ragweed (*Ambrosia artemisiifolia*), large crabgrass (*Digitaria sanguinalis*), yellow foxtail (*Setaria pumila*), barnyardgrass (*Echonochloa crus-galli*), and yellow nutsedge. Weeds were small at the time of application with heights ranging from 1 to 4 inches (2.5 to 10 cm). Weed cover, on a scale ranging from 0% (no live weeds) to 100% (complete weed cover), was estimated in at least 10 replicated quadrats (388 inches^2 (2500 cm^2) in size) that were regularly spaced throughout each of the treated plots. Weed cover was also estimated in untreated areas directly adjacent to the electrically weeded strips to provide base- line data for estimating weed control efficacy. Data was taken at 7 and 14 days after treatment. Aboveground weed biomass was also harvested and weighed at 14 days after treatment.

Results and Discussion

For the most part, precision weed control technology, including vision-guided herbicide applications, has been primarily explored for use in annual cropping systems (Fennimore et al., 2014; Westwood et al., 2018). With respect to tree nuts, tree fruits and grapes, there are limited publications describing the efficacy and safety of smart-sprayer technology for managing weeds. The most comprehensive study published, to date, is a dissertation by Rector (2007) to evaluate the use of an automatic spot-sprayer in western tree crops. Results showed that precision spraying could reduce total herbicide use by 36%, compared to broadcast applications, without negatively impacting weed control efficacy or crop fitness and yield. Concomitant economic analyses suggested that the rate of return on investment of adopting the technology decreased with increased acreage, with a projected recovery time of five years for lemons and pecans in Arizona.

In the current study, applications of Rely 280 herbicide made using a vision guided sprayer were as effective as a broadcast treatment at reducing Palmer amaranth and horseweed/marestail biomass relative to untreated controls. Mean biomass for untreated Palmer amaranth plants was 1.86 g. Averaged over both rates of Rely 280, mean biomass for the backpack and vision-guided applications were 0.32 g (83% reduction from the control) and 0.30 g (84% reduction from the control), respectively. Similar results were obtained for horseweed/marestail. Mean biomass for untreated horseweed/marestail check plants was 1 g. Averaged over all rates of Rely 280, the mean biomass for the backpack and vision-guided applications were 0.043 g (96% reduction from the control) and 0.068 g (93% reduction from the control), respectively.

The first electrical weeders were patented in the 1880's (Vigneault and Benoit 2001). In the 1970's and 1980's, electrical weeders were successfully used in sugar beets to control weeds and bolting crop plants (Diprose and Benson, 1984; Diprose et al., 1980; Diprose et al., 1984). More recently, Schreier et al. (2022) reported that electrocution using a Weed Zapper™ 6R30 model could control common broadleaf weed species, such as horseweed/marestail, common ragweed, and waterhemp (*Amaranthus tuberculatus*) 71 to 91% and reduce the production of viable weed seed 60 to 80%. Results from

1. ZASSO ELECTROHERB SYSTEM

2. WEED-IT QUANDRO RESEARCH SPRAYER

observational studies in organic soybean and table beets in NY also showed significant reductions in both weed biomass and reproductive output where growers used a Weed Zapper™ as compared to check plots (no electrical weeder activity). Across fields, broadleaf weed fresh weight (per plant) was reduced 59 to 86%; per plant reproductive output was reduced 67 to 87% (Sosnoskie, unpublished data).

Results from the 2022 trials at Cornell AgriTech showed significant reductions in total weed cover 7 and 14 days after electrical treatments were applied (Figure 6 and 7). At 7 days after treatment, mean weed cover in the untreated check quadrats ranged from 40 to 60%; in the electrically treated plots, weed cover was reduced 94 to 99% and there were no differences observed with respect to travel speed or amperage. At 14 days after treatment, mean weed cover in the untreated check plots ranged from 59 to 86%. Weed cover reductions of 90% were observed for the higher amperage treatment, regardless of travel speed. For the lower amperage treatment, weed cover was reduced 85% when the tractor was traveling at 1 mph and 71% when the tractor was traveling at 1.6 mph. The differences in control among treatments at the 14-day observation point suggests that the interactions between setting and travel speed likely influence the amount of current treated weeds receive, which may impact regenerative ability, especially for perennial plants. Mean aboveground weed biomass at 14 days after treatment was similarly reduced; com- pared to the untreated check quadrats (99 to 254 g), electrical weeding reduced weed biomass 81 to 97%. Many of the weeds sampled at 14 days after treatment were broadleaf species that emerged at after the electrical treatments were applied, although some weeds, especially grasses and nutsedge, did regrow despite being severely damaged.

Conclusions and Future Work

Results from the preliminary 2021 and 2022 precision sprayer and electrical weeding studies indicate that the technologies can reduce weed biomass and cover, significantly, relative to untreated checks. It is important to note that our results were conducted under optimum conditions; specifically, the target weeds were both small and succulent, which is a developmental stage that facilitates control success.

Precision spray trials are ongoing at the Cornell Lake Erie Research and Extension Laboratory in Portland, NY; early results suggest that the technology is effective for managing suckers while reducing herbicide use. These studies will be expanded to describe how weed biology, size, and total cover impact sprayer performance in a field setting.

Electrical weeding trials will begin in apples and blueberries in NY in 2023, with the goal of describing the biological and environmental factors influencing weed control success as well as crop safety. Trials will also describe the impacts of electrical weeding on soil health parameters, such as soil structure and microbial community composition. Preliminary data from 2022 found no impacts of electrical weed control on soil microbial respiration or microarthropod numbers. Economic analyses will also be conducted.

Ultimately, the Specialty Crop Weed Science Lab hopes to identify new tools for use in perennial fruit crop systems to manage unwanted vegetation.

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Research Report: Optimizing Herbicide Strategies for Weed Control, Tree Growth, and Soil Quality in High Density Apple Orchards

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Keywords: weeds, weed control, herbicide resistance, herbicide injury, novel technology, precision spraying, electrical weed control

This study compares the effectiveness of using pre-emergent herbicides in the fall, in the spring with just using post-emergent herbicide treatments to control weeds in apple orchards. The fall treatments were the most effective in controlling weeds, as part of a season-long weed management program.

In addition to making an herbicide application in the fall to manage your problem perennials, post-harvest can also be a good time to get pre-emergent materials on to get a leg up on annual weeds heading into the next growing season. In this study, we compared fall versus spring timings of two pre-emergent herbicide combinations. In the fall of 2020, we applied Chateau and Prowl (along with glufosinate for burndown of existing vegetation) on a portion of a commercial herbicide strip in Peru and Albion, respectively. Another portion of the strip received that same combination of materials the following spring, while a third treatment received no pre-emergent application at all, just glufosinate to burn down existing vegetation. We repeated these methods in the fall of 2021, this time using Alion as our preemergent material. We scouted the weed plots throughout the growing season, paying close attention to the plots during the critical weed free period of May through July. We made follow up applications with post-emergent materials to each plot as needed.

Methodology

The weed management trials were established in two commercial orchards in the spring of 2020. Participating orchards include Kast Fruit Farms in Albion, NY and Everett Orchards in Peru, NY. At each site, plots were laid out in five replications of three separate weed management treatments, which were

1. a fall applied pre- and post-emergent herbicide program,
2. a spring applied pre- and post-emergent program, and
3. an herbicide program based solely on post-emergent applications.

Each plot consisted of 36 trees, 12 trees per herbicide treatment. In the fall we applied pre-emergent herbicides with backpack CO_2 sprayers. In spring of 2022, the spring pre-emergent treatments received the same application.

Weed surveys were performed in March, every other week from May through July, and once in August, September, and October. For each weed survey, the percentage of weed ground cover was estimated across the total area of each plot; the average maximum weed height of each plot was determined by measuring the tallest weed species present within each plot. Weed species were identified and counted for each plot by placing a .25m2 transect at four locations per plot, straddling the drip line between trees. All weeds with roots originating within or touching the transect frame were counted. Weed cover within the transect were also evaluated. Post-emergent applications were applied as needed, as determined by using thresholds of 20% ground cover, when weed height or spread was greater than 25cm, or when perennial weeds were at the appropriate growth stage, whichever came first.

At the Peru field site, perennial weed species presence required additional follow up treatments with post-emergent products. An application of Select Max at 15 fl oz/Acre, a grass herbicide, was applied on April 26th to control quackgrass. A post-emergent application of glufosinate at 48 fl oz/Acre was made on the post emerge only treatment plots on May 11th. A follow-up glufosinate application at 48 fl oz/Acre was made on the fall pre-emergent treatment on May 20th. An additional Select Max application at 16 fl oz/Acre was applied on May 31st across all treatments. On July 7th, an application of glyphosate at 96 fl oz/Acre was applied, and on August 16th paraquat was applied at 48 fl oz /Acre. We also hand cut milkweed and rootsuckers throughout the season as needed.

At the Albion field site, the post-emergent only treatment was applied on May 6. All treatments received an application of glyphosate at 2.5qt/Acre on July 11th, and an application of glufosinate at 80oz/Acre on August 19th. The fall pre-emergent treatment of 5oz Alion/Acre plus 48oz glufosinate /Acre was then applied on October 22nd. All applications also included label recommended adjuvants for each product, including stickers and water conditioners.

Weed cover, seedling counts, and weed height were averaged by treatment across each scouting date. Treatment differences were analyzed using Standard Least Squares with Restricted Maximum Likelihood options in the Fit Model feature in JMP Statistical Software. Data was log transformed where appropriate. Seedling data were analyzed using the Generalized Regression model with Poisson distribution in the Fit Model feature when data were not normally distributed.

Seasonal Weed Cover Differences between Treatments

Peru:

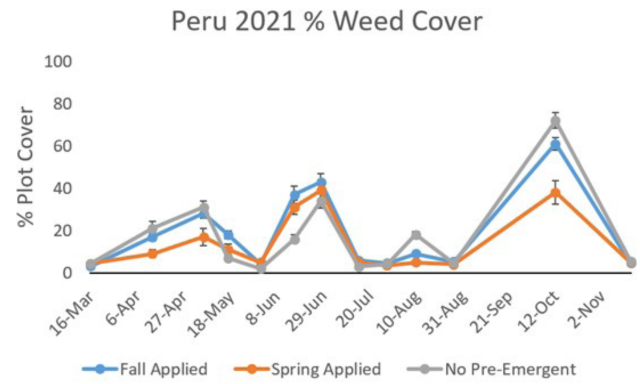
In Peru, fall and spring applications of Chateau and Prowl gave similar levels of control, except on August 10 and October 12th when the fall treatment had more weed cover. We found there were no differences between any of the three treatments during the critical weed free period from May through July. This was likely due to us needing to make multiple follow-up burndown applications on all three treatments to keep the perennial weeds in check in these plots (refer back to figure 1 to see dates of follow up applications on each treatment).

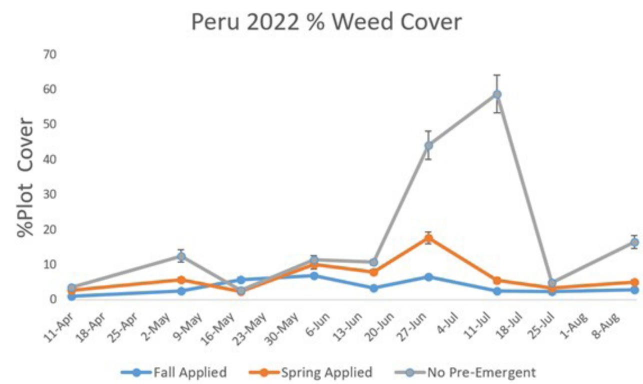
Alion-treated herbicide strips had 3.6% or less weed cover on April 11th at our first scouting date in 2022. Weed cover was lowest in the fall-applied treatment on this date. Weed cover was lowest on the fall-applied treatment on May 5th. Weed cover was then highest in our fall-applied plot on May 18th, following herbicide applications to the spring-applied and post-emergent only treatment plots. We then applied an additional burndown application to the fall plot on May 20th to control perennial weed growth. Fall-applied treatment weed cover was similar to the spring-applied and less than the post-emergent only plot on June 3. Weed cover was then lowest in the fall-applied treatment from June 16th through July 13th. It was equal to the spring-applied treatment and less than the post-emergent only treatment on July 25th. It had the least weed cover on August 12th. It was equal to the spring-applied plots, and less than the post-emergent only plots, on September 1 and October 12th. Weed cover was lowest in the fall-applied treatment when averaged over the weed free period from May through July.

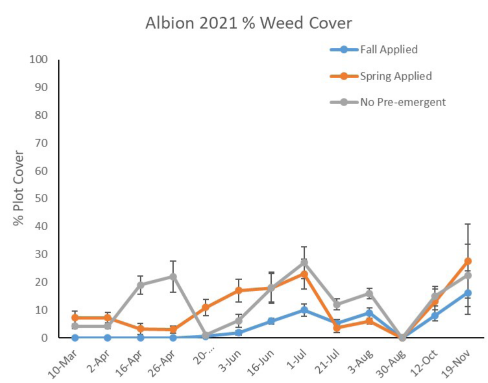
Albion:

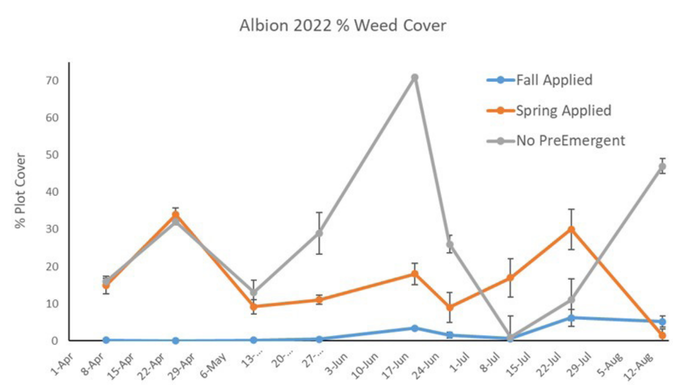
In Albion, the fall-applied Chateau and Prowl had the least weed cover during the weed free period relative to the spring and post-emergent only treatments.

Using Alion, weed cover was significantly lowest in the fall applied treatment on our first spring sampling date of Apr 9th, showing that the fall application was quite efficacious and carried over to provide excellent control through spring. Following the spring application (applied on April 30th) there was no difference between spring or fall applied treatments, although only the fall applied treatment had lower weed cover than the post-emergent only treatment. The spring applied









treatment broke sooner than the other treatments. On average across the weed free period the fall applied treatment had the least weed cover, the spring applied treatment was second best, and the post-emergent only treatment had the most weed cover. The fall pre-emergent herbicide application timing continued to work best at suppressing weed ground cover in this location, where winter annuals were the predominant weed species.

Cost of Treatments

In both sites the pre-emergent treatments were more expensive as Alion, for example, is a fairly expensive material at roughly $68 per application, not including the costs of adjuvants and labor. But reduced costs of labor over time from reduced weed pressure was not considered.

Other Impacts

In July/August, soil samples were collected from the three treatments at each site in 2020, 2021, and 2022. They were sent to the Cornell Soil Health Lab, where physical, biological, and chemical factors of the soil were tested and rated on a scale of 0-100, with 0 being very low functioning and 100 being very high functioning. Overall soil health ratings declined in each herbicide treatment in Peru, with the greatest decline observed in the no pre-emergent herbicide treatment (-3). In Albion, soil health scores decreased in all plots, with the greatest decline in the no pre-emergent herbicide plot (-15).

The treatments did not seem to have an impact on tree health. In October of 2020 and again in November of 2021, the circumference of each tree was measured 30cm above the graft union. 10x10-inch Tyvek trunk guards were installed on six of the twelve trees within each treatment plot in July of 2020. In August 2022, trees were rated for their relative health. Trees rated as healthy were rated '1', while trees that were struggling or dead were rated '0'. Trees were also rated for symptoms of foliar glyphosate (leaf chlorosis and distortion) and glufosinate (leaf chlorosis and spotting) injury, with '0' representing damage absent, and '1' as damage present. In October/November, tree trunks were inspected for canker development from 0 to 70cm above the graft union. '0' represented damage absent, and '1' as damage present. In Peru, there were no significant differences between herbicide or guard treatments on any of the tree health parameters evaluated. In Peru, cankers were often wrapped around the tree trunks, and were not limited to a particular side of the tree.

Herbicide treatments did not seem to have an affect on tree nutrient uptake. Leaf samples were collected in each herbicide treatment plot in July/August of 2022. We did not observe noteworthy differences between the different herbicide treatments at either site. We also did not see any clear trends from year to year, suggesting our different herbicide programs had a limited effect on tree nutrient uptake.

Conclusion

Given these results, we conclude fall applications of these materials at both sites provided efficacy as good or better than applications made the following spring when integrated into a season-long weed management program. We recommend making fall applications of pre-emergent herbicides where your herbicide strips are clean enough and weather conditions are favorable.

Acknowledgements

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We would like to thank our technician Andy Galemberti and our host orchards for their assistance with this trial.

Research Report: Optimizing Spinosyn Insecticide Applications for Allium Leafminer Management in Allium Crops

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Keywords: Phytomyza gymnostoma, spinetoram, spinosad, Allium

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Allium leafminer, *Phytomyza gymnostoma Loew (Diptera: Agromyzidae)*, is an invasive pest of allium crops in North America. Spinosyn insecticides, spinetoram and spinosad, have been effective choices for managing P. *gymnostoma* infestations in allium crops, but their use should be optimized for economical and resistance management purposes. In New York from 2018 through 2020, performance of each spinosyn insecticide was evaluated by making two applications spaced either 1 or 2 wk apart beginning at various intervals after P. gymnostoma was first detected in the field; a weekly spray program also was included. Optimizing applications of spinetoram and spinosad will save growers time, reduce insecticide costs, and mitigate resistance development without significantly increasing the risk of yield reduction.

The purpose of this study was to optimize spinosyn insecticide use for managing Allium Leafminer (*P. gymnostoma*) on allium crops. Our approach was to evaluate the performance of each spinosyn insecticide by making only two applications spaced 1 to 2 wk apart beginning at varying times after initial detection of *P. gymnostoma* in the field compared with a weekly spray program. All field trials were conducted during a 6-wk window in the fall because infestations are typically much higher in the fall than in the spring. We hypothesized that spinosyn insecticides would most effectively control P. gymnostoma when applied twice during the middle of the flight, when adult activity and egg laying likely peak, compared with treatments timed when *P. gymnostoma* was first detected, which would be too early and miss a majority of the adult and egg laying activity.

Allium leafminer, *Phytomyza gymnostoma Loew*, has been a pest of allium crops in Europe for many years, but recently has become a serious concern in North America (Barringer et al. 2018). *Phytomyza gymnostoma* was first detected in Pennsylvania, USA in 2015 and subsequently has spread to Connecticut, Maryland, Massachusetts, New Jersey, New York, and Virginia (Barringer et al. 2018; B.A.N., personal observation). Allium crops such as onion, chive, garlic, leek, ramps, shallot, and scallion are susceptible to *P. gymnostoma* (Barringer et al. 2018, Nault et al. 2020).

Phytomyza gymnostoma damages leaves and lower portions of their hosts including bulbs and cloves. Females puncture leaves with their ovipositor leaving a linear trail of highly visible white spots along the upper portion of the leaf (Agallou et al. 2004, Barringer et al. 2018). Subsequent feeding by early instars causes mining on leaves. Oviposition punctures and larval mining on leaves of scallions and chives can reduce their aesthetic quality and in severe situations may render them unmarketable. In contrast, oviposition marks and mining on leaves do not impact the marketability of bulb onion, leek, and garlic. Later instars move downward towards the plant base as they continue to feed and ultimately pupate (Coman and Rosca 2011b). This is the most serious type of damage because the mining creates pathways that facilitate bacterial soft rots and fungal infections (Coman and Rosca 2011a). Similarly, larvae and pupae infesting plants during harvest contaminate the crop, which also reduces the quality and market value. Infestation levels can reach up to 100% in Europe (Coman and Rosca 2011a, b), Pennsylvania and New York, USA (Nault et al. 2020) and has resulted in total crop loss.

1. ADULT ALLIUM LEAFMINER AND OVIPOSITION SCARS - PHOTO E. GRUNDBERG

Phytomyza gymnostoma infestations in allium crops can be managed effectively using foliar applications of insecticides (Coman and Rosca 2011a, Nault et al. 2020, Talotti et al. 2004). In the United States, the best insecticides to manage the fall generation of *P. gymnostoma* were identified using a weekly application program that spanned 4 to 6 wk that began as soon as oviposition marks were first observed on leaves (Nault et al. 2020). Although this approach was successful, fewer applications also may have provided an accept able level of control. There is a need to determine how fewer insecti cide applications can be made to effectively manage P. *gymnostoma* in allium crops, thereby saving growers time, reducing insecticide costs, and adhering to insecticide label restrictions designed to miti gate resistance development.

Materials and Methods

Field experiments for the 2019 and 2020 Spinetoram Timing Trials (see below) were conducted on a commercial farm near Red Hook, NY and on another commercial farm near New Paltz, NY, respectively. In 2019, the trial was conducted on bare ground with no irrigation, whereas the 2020 trial was conducted on black plastic mulch with drip irrigation. Field experiments for the 2018 and 2019 Spinosad Timing Trials (see below) were conducted at the Hudson Valley Farm Hub near Hurley, NY on white plastic mulch with drip irrigation. Because this project focused on managing the fall generation of *P. gymnostoma*, transplanting occurred during the summer after the spring generation was completed and before the fall generation emerged.

Experimental Designs and Insecticide Application Approaches

Spinetoram Timing Trials Design

Scallion seeds (cv. Nabechan F1) were planted in 162-cell plug flats with 5 to 8 seeds per cell on 18 June 2019 and 15 July 2020. Seedlings were maintained in a greenhouse at MX Morningstar Farm in Claverack, NY until transplanting on 1 August and 14 August in 2019 and 2020, respectively. In 2019, the plots were 3.1 m long and 1.5 m wide with two rows spaced 0.5 m apart. One plug of scallion plants was transplanted by hand every 0.3 m within a row for a total of 60 plugs per plot (30 plugs per row × 2 rows). In 2020, plots had similar dimensions as in 2019, but rows were spaced 0.4 m apart. Plots within and across rows were separated from each other by 0.8 and 1.5 m, respectively.

Plots were maintained using a combination of pesticides and hand weeding in 2019 and hand weeding only in 2020. In 2019, weeds were managed using an application of pendimethalin (Prowl H2 O) at a rate of 0.8 kg a.i./ha (24 fl. oz product/acre) on 1 August and again at the same rate co-applied with oxyfluorfen (GoalTender) at a rate of 0.035 kg a.i./ ha (1 fl. oz product/acre) on 3 September. Foliar diseases and foliar-feeding insects like *Thrips tabaci* never reached levels that warranted management.

Spinetoram (Radiant SC) was evaluated at a rate of 0.07 kg ai/ha (8 fl. oz product/acre) in both years. To enhance coverage and penetration into the foliage, spinetoram was co-applied with phosphatidylcholine, methylacetic acid, and alkyl polyoxyethylene ether (LI-700) at a rate of 0.25% v:v in 2019, and co-applied with methyl esters of C16-C18 fatty acids, polyalkyleneoxide modified polydimethylsiloxane and alkylphenol ethoxylate (Dyne-Amic) at a rate of 0.5% v:v in 2020. Foliar applications were made using a CO_2 -pressurized backpack sprayer. In 2019, applications were made using a boom equipped with four, twin flat-fan nozzles that delivered 383 liters/ha at 276 kPa. In 2020, applications were made using a boom equipped with two, twin-turbojet nozzles that delivered 423 liters/ha at 276 kPa.

2.EVALUATING LEEKS FOR PEST DAMAGE - PHOTO E. GRUNDBERG

In 2019, there were seven treatments plus an untreated control. Treatment number 1 was the standard, weekly application strategy that began on 18 September. Treatment numbers 2, 3, and 4 were timed 1 wk apart during weeks 1 and 2 (18 and 24 September), weeks 2 and 3 (24 September and 2 October), and weeks 3 and 4 (2 and 8 October), respectively. Treatment numbers 5, 6, and 7 were timed 2 wk apart during weeks 1 and 3 (18 and 24 September, weeks 2 and 4 (24 September and 8 October), and weeks 3 and 5 (2 and 15 October), respectively.

In 2020, there were four treatments plus an untreated control. Treatment number 1 had weekly applications beginning on 21 September. Treatment numbers 2 and 3 were timed two weeks apart during weeks 1 and 3 (21 September and 5 October), and weeks 2 and 4 (28 September and 12 October), respectively; treatment number 4 had two sprays timed 1 wk apart during weeks 3 and 4 (5 and 12 October). In both years, treatments were arranged in a randomized complete block design and each treatment was replicated four times. Weeds were managed by hand in these experiments; neither foliar diseases nor other insect pests required management during these studies.

Spinosad Timing Trials Design

Leek seeds (cv. Megaton) were planted in an environmentally controlled greenhouse at the Hudson Valley Farm Hub on 27 April 2018 and 15 April 2019, where they were maintained until transplanting on 6 July and 25 June, respectively. Both trials had plots that were 3.1 m long and 1.5 m wide with 2 rows spaced 0.5 m apart. Leeks were transplanted by hand 15 cm apart from each other for a total of 40 plants per plot (20 plants per row × 2 rows). Plots within and across rows were separated from each other by 0.8 and 1.5 m, respectively. Treatments were arranged in a randomized complete block design and each treatment was replicated four times.

Spinosad (Entrust) was applied at a rate of 0.105 kg a.i./ha (6 fl. oz product/acre) in both years. Spinosad coverage and likely penetration into foliage were enhanced by co-applying it with K salts of fatty acids (M-Pede) at a rate of 1.5% v:v. Foliar applications were made using the same CO2 -pressurized backpack sprayer, boom, nozzle arrangement and type, volume and pressure as described for the 2020 Spinetoram Timing Trial.

In 2018 and 2019, there were eight treatments plus an untreated control. Treatment number 1 was the standard, weekly application strategy. In 2018, Treatment 1 began on 14 September. Treatment numbers 2, 3, 4, and 5 were timed 1 wk apart during weeks 1 and 2 (14 and 21 September), weeks 2 and 3 (21 and 28 September), weeks 3 and 4 (28 September and 5 October), and weeks 4 and 5 (5 and 12 October), respectively. Treatment numbers 6, 7, and 8 were timed 2 wk apart during weeks 1 and 3 (14 and 28 September), weeks 2 and 4 (21 September and 5 October), and weeks 3 and 5 (28 September and 12 October), respectively.

In 2019, Treatment 1 began on 13 September. Treatment numbers 2, 3, 4, and 5 were timed 1 wk apart during weeks 1 and 2 (13 and 20 September), weeks 2 and 3 (20 and 27 September), weeks 3 and 4 (27 September and 4 October), and weeks 4 and 5 (4 and 11 October), respectively. Treatment numbers 6, 7, and 8 were timed 2 wk apart during weeks 1 and 3 (13 and 27 September), weeks 2 and 4 (20 September and 4 October), and weeks 3 and 5 (27 September and 11 October), respectively. The test site was managed following typical, non-chemical weed management practices used on this farm. No other insect pests caused damage to these trials.

Sampling *P. gymnostoma* Adult Activity

The most effective approach for detecting P. gymnostoma adult activity was to visually inspect allium foliage for flies and for oviposition marks along the distal portions of leaves (B.A.N., personal observation). Visual detection of *P. gymnostoma* adults on allium plants and using aerial nets to collect adults in fields were mentioned as being more successful monitoring techniques than using stationary colored sticky cards to capture adults (Barringer et al. 2018). In all experiments in all years, 80 to 160 plants were visually inspected for flies and oviposition marks using a stratified random sampling approach in which similar numbers of plants were inspected per replication. Detection of either a single P. gymnostoma adult or leaf with oviposition marks triggered the initiation of insecticide applications during week 1.

Damage Assessments

Mature plants were systematically harvested throughout each plot, taken to the laboratory, and then destructively sampled to assess numbers of P. gymnostoma larvae and pupae within each plant. Harvested plants were dissected by removing all green upper leaves and then all white, cylindrical sheaths of basal leaves. Although some larvae and pupae were observed in the green leaf tissue, a majority were embedded in the sheaths of the basal leaves. In the Spinetoram Timing Trials, 30 scallions were sampled per plot on 11 November 2019 and 17 November 2020. In the Spinosad Timing Trials, 20 leeks were sampled on 8 November 2018 and 30 October 2019. Voucher specimens are kept in the Department of Entomology, Cornell University, Cornell AgriTech, Geneva, NY.

Statistical Analyses

Density of *P. gymnostoma* larvae + pupae per plant was the response variable in all experiments. Data were analyzed using regression analysis for mixed models (PROC MIXED, SAS Institute 2016) in which insecticide treatment was a fixed main effect and replication was a random factor in the model. Data were transformed using a log10 (x + 1) function to stabilize variances before analysis. Treatment means were compared using Tukey's Studentized Range (HSD) Test at $P < 0.05$ (SAS Institute 2016).

Spinetoram Timing Trials Results

In 2019, all insecticide timing treatments significantly reduced *P. gymnostoma* densities below those in the untreated control and provided a commercially acceptable level of protection. Plots treated on a weekly schedule for 6 wk had significantly fewer *P. gymnostoma* compared with those treated during weeks 2 and 3, whereas all other treatments were statistically similar to both of these treatments.

In 2020, all insecticide treatments significantly reduced *P. gymnostoma* densities below those in the untreated control and provided excellent protection. Plots treated on a weekly schedule for 6 wk had significantly fewer *P. gymnostoma* compared with those treated during weeks 1 and 3, whereas all other treatments were statistically similar to both of these treatments.

Spinosad Timing Trials Results

In 2018, all treatments significantly reduced *P. gymnostoma* densities below those in the untreated control. All treatments provided a commercially acceptable level of *P. gymnostoma* control, except for Treatment 2, which had two consecutive applications beginning when *P. gymnostoma* was first detected in the field (weeks 1 and 2). Plots treated weekly for 6 wk had significantly lower densities of *P. gymnostoma* compared with plots treated during weeks 1 and 2 and weeks 1 and 3. All other treatments had *P. gymnostoma* densities that were not significantly different from those treated weekly.

In 2019, all treatments significantly reduced *P. gymnostoma* densities below those in the untreated control, except for Treatment 2 that was sprayed during weeks 1 and 2. Only plots treated weekly reduced *P. gymnostoma* densities to a commercially acceptable level, whereas a few others nearly provided acceptable protection when treated on weeks 2 and 4, weeks 3 and 4, and weeks 3 and 5. In addition to Treatment 2, other treatments that performed poorly included those sprayed on weeks 1 and 3, weeks 2 and 3, and weeks 4 and 5.

Results

Overall, results showed that it is possible to obtain a commercially acceptable level of *P. gymnostoma* by making only two spinosyn insecticide applications under low to moderate pressure. However, when the *P. gymnostoma* infestation is extremely high (i.e., 38 insects per plant in the untreated control), two applications of spinosad will not be sufficient. In general, the best control using spinosyn insecticides tended to occur when first applied 2 to 3 wk after initial detection of P. gymnostoma in the field. The exception was when spinosad was used to manage an extremely high infestation of P. gymnostoma in 2019; such situations will require at least one additional application of spinosad timed 1 to 2 wk after the initial two applications.

The application strategy used for managing the fall generation of *P. gymnostoma* also should be successful against the spring generation. The spring generation is shorter than the fall generation (Lingbeek et al. 2021; B.A.N., personal observation) and as temperatures increase during the spring, the period of egg laying and larval development may be truncated compared with the development of the fall generation. Consequently, a two-application approach with spinosyns would arguably span a greater period of *P. gymnosoma* egg laying and larval development compared with the fall generation and result in even better protection of the crop.

Optimizing spinetoram and spinosad application timing will reduce overall insecticide costs for managing P. gymnostoma in allium crops as well as the time needed to make insecticide applications, especially during the fall generation when other farm activities (e.g., harvesting and selling produce at local and regional markets) are a higher priority. Another important variable to consider is reducing overall insecticide use to mitigate the possibility of insecticide resistance in *P. gymnostoma* populations.

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Research Report: Honeycrisp' Bitter Pit Response to Rootstock and Region under Eastern New York Climatic Conditions.

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Keywords: B.9; M.26; M.9; PLSR model; environment; fruit quality.

Peer Reviewed Publication: Plants (Basel). 2021 May 14;10(5):983. doi: 10.3390/plants10050983.

There are still unknown factors at play in the causation of bitter pit in 'Honeycrisp' as well as in other apple varieties. To investigate some of these factors, we conducted a survey of 34 'Honeycrisp' orchard blocks distributed across two disparate production regions in eastern New York State, representing a variety of rootstocks, over three growing seasons. Weather, soil, horticultural traits, fruit quality traits, pick timing, leaf and peel minerals were evaluated for their impact on bitter pit incidence; These factors were further evaluated for their interaction with region and rootstock.

Study Objective

The aim of this study was to broadly examine potential contributors to the large variation observed in the rate of bitter pit incidence on 'Honeycrisp' in the New York State climatic environment. We focused on rootstock and region, analyzing weather, soil, horticultural and fruit quality variables, using multivariate and binomial distribution analysis techniques.

In the course of this work, we evaluated a high number of parameters as possible indicators of BP incidence, including weather and soil traits, horticultural and fruit quality characteristics, through the perspective of region and rootstock choice, by conducting a detailed survey of 34 'Honeycrisp' blocks distributed across two growing regions in Eastern NY, which at the end we included 30 blocks in our analysis. Our goal was to describe as much of the biological and abiotic world that our 6-tree experimental units were expected to thrive in while producing marketable fruit in commercial settings. This article will focus on four findings we believe to be the most immediately valuable to commercial 'Honeycrisp' producers. A much more complete and detailed analysis and discussion can be found in the full-length Plants paper. The authors can say with confidence that the commercial producers who donated their orchards to this study were among the most skilled in New York State, with well-managed 'Honeycrisp' plantings.

Materials and Methods

There remain unknown factors at play in the causation of bitter pit in 'Honeycrisp' as well as in other apple varieties. To investigate some of these factors, we conducted a survey of 34 mature tall spindle and vertical axis 'Honeycrisp' orchard blocks distributed across two disparate production regions in eastern New York State, representing a variety of rootstocks, over three growing seasons. Each experimental unit consisted of six contiguous trees selected for their uniformity. Weather, soil, horticultural traits, fruit quality traits, three pick timings, leaf and peel minerals, at total of 43 parameters were evaluated for their impact on bitter pit (BP) incidence; factors were further evaluated for their interaction with region and rootstock. A total of 13,770 apples were individually rated and tracked through storage for selected fruit quality parameters whenever practical. Continuous, binomial, parametric and non-parametric statistical analyses were applied as appropriate.

Results and Discussion

Commonly Considered Horticultural Parameters

'Honeycrisp' trees on B.9 rootstock were smaller but with comparable terminal shoot growth when compared to those on M.26 and M.9 rootstocks. B.9 fruits, which had similar fruit size to M.26 and M.9 and had good fruit quality at harvest and after storage, were much less likely to express bitter pit symptoms compared to M.9 and M.26 rootstocks.

Regional and Rootstock Effects on Bitter Pit

Regional and local environmental and soil conditions must be taken in consideration when planting a new orchard and may be significant contributors to BP predisposition. To the best of our knowledge, this is the first study evaluating the region effect on the occurrence of BP. After three years and comparing the two regions, we found that, in general, 'Honeycrisp' orchards from the HV region presented high BP incidence relative to the Champlain Valley. This region received more rain and experienced higher temperatures over the study period, which may explain partially the difference in BP.

Rootstock choice is one of the most critical elements of any apple orchard to provide sufficient growth control, enhanced precocity, higher yield, improved adaptability to environmental conditions, and better fruit quality [1]. In addition to effects on these traits, apple rootstocks have a diverse influence on the nutritional status of the tree canopy, are implicated in the physiology of BP and, therefore, can affect the occurrence of BP [2,3,4], as it is demonstrated in our results. However, the BP response to tissue mineral status is variable depending on the rootstock and the region where it is planted. As a result, the occurrence of BP can be more or less intense or absent even as local tree tissue mineral measurements suggest otherwise.

We evaluated three of the most popular rootstocks used in high-density apple orchards in New York State: B.9, M.26 and M.9 clones [1]. Among them, fruits from 'Honeycrisp' grafted on M.26 were slightly more susceptible to BP than those from M.9 clones and much more susceptible than B.9. In agreement with Lordan et al. [4], B.9 rootstocks had a much lower incidence of BP compared to M.26 and M.9 clones, even in the very dry year of 2016. In general, B.9 BP incidence values did not differ significantly among years by region, even when both regions were evaluated together. Kim and Ko [5] reported that BP is more intensive on moderate, vigorous rootstocks compared to less vigorous rootstocks, which is consistent with our results, as M.26 is the most vigorous rootstock in terms of TCSA evaluated in this study.

Shoot Growth Effects on Bitter Pit

Terminal shoot extension (ALTS) was a poor indicator of vigor and BP incidence as ALTS was very similar between the three rootstocks while BP differed significantly.

Nutrient Status Effects on Bitter Pit

In terms of nutrient status, region and rootstock had a significant effect on some of these traits, results that were somewhat expected. Other authors have also reported that region and rootstock can affect similar horticultural traits under Hudson Valley and Champlain Valley climatic conditions for 'Gala', 'Fuji' and 'Honeycrisp' [6,1,4]. In this study, the most vigorous rootstock, M.26, had higher leaf K/Ca, Mg/Ca and B/Ca ratios, leaf K, and peel B, but lower leaf Ca, Mn, and P values as compared to B.9 and M.9 clones.

Between regions, 'Honeycrisp' orchards, despite showing significant differences, some of these nutritional traits were not correlated to BP incidence after a period of refrigerated storage. 'Honeycrisp' fruits from CV orchards tended to have less BP incidence after storage (less than 10%) compared to those from HV. This lower BP value may explain the lower number of correlations with the horticultural traits, as well as the higher BP incidence values of M.26 orchards from HV could explain the higher number of significant correlations with horticultural traits compared to those from CV region.

Little correlation was found between BP incidence after storage on 'Honeycrisp' fruits from B.9 in terms of nutrient status, TCSA, peel Mg/Ca and peel Ca, whereas more significant correlations were found in fruit from the M.26 and M.9 clones, mainly the peel minerals. The lower BP incidence values from B.9 fruits could explain the lack of correlations compared to M.26 and M.9 clone rootstocks. These two rootstocks had some correlations in common, such as peel K/Ca, peel Mg/Ca, peel B/Ca, peel B, peel Ca, peel K and peel P, but M.9 clone rootstocks had higher values.

Recent studies have shown that BP, a Ca2+-related deficiency disorder, is not necessarily related to low Ca2+ concentration in fruit tissue in a "global" sense. In fact, chemical and X-ray analysis have shown that apple fruit tissue with visual Ca2+ deficiency symptoms had higher Ca2+ concentration than healthy fruit tissue [7]. Most Ca2+ in fruit tissue, between 60 and 75%, is bound to the cell wall. More Ca2+ binding to the cell wall is consistent with the finding that BP-damaged tissues have more Ca2+ than the surrounding healthy tissues [8,9]. In agreement with this statement and previous studies [3,10], we found a high and negative correlation between peel Ca2+ concentration and BP incidence after storage for all three rootstock categories and two regions.

Fruit Quality Trait Effects on Bitter Pit

Fruit quality traits were also affected by region and rootstock, in agreement with previous rootstocks studies performed in 'Gala', 'Fuji', 'Honeycrisp' and 'Red Delicious' under Hudson Valley and Champlain Valley climatic conditions [6,1,4,11]. Both regions (CV and HV) had similar correlations between fruit dimensions and BP incidence after storage, despite showing significant differences on these traits. However, blush only correlated with BP on those 'Honeycrisp' from CV. BP incidence after storage had few and inconsistent correlations with fruit dimensions and fruit quality traits when rootstocks were compared. 'Honeycrisp' fruits from M.26 rootstock, which had in general smaller FD because they were more elongated but similar FW to B.9 and M.9 clones, presented a moderate positive correlation with BP incidence after storage on these three parameters, and a medium negative correlation with blush. In contrast, B.9 did not present any correlation on the same traits, while M.9 clones did in FD and FW, perhaps this finding is associated with lower levels of BP and less variability in the B.9 orchards. A similar trend was observed regionally for B.9.

Effect of Pick Timing on Bitter Pit Incidence

'Honeycrisp' fruits were harvested at optimum commercial harvest quality at each of the three weekly picking times. Minor fruit quality and maturity differences between picks at harvest were found but considered to be commercially acceptable for storage and marketing purposes. BP incidence at the time of harvest was relatively low and varied only slightly by pick with the pick 3 (last pick) apples expressing slightly more BP (Figure 2A). It would be unlikely for a commercial producer to observe the slight uptick in BP in the field. In contrast, BP incidence after storage showed a significant decreasing trend in each of the later picks in the HV, while in the lower BP environment of the CV, picks 2 and 3 were found to be similar, and lower than pick 1 (Figure 2B).

'Honeycrisp' fruits picked earlier were firmer, smaller, with more red blush and presented higher BP in storage. Therefore, in agreement with Prange et al. [12], BP is more severe in early-picked than in later-picked apples. However, there may be an optimum stage of fruit maturity (or harvest date) for 'Honeycrisp' when fruit are of sufficient size and color to meet market requirements while minimizing the risk of manifesting BP, especially if the fruit are >250 g in size. Our study did not attempt to specifically evaluate that possibility. We closely adhered to commonly accepted commercial quality standards. In any case there may not be much room available to adjust harvest dates and maintain a balance of quality factors acceptable to the marketplace.

Fruit Size and Bitter Pit Incidence

Increasing fruit size has been associated with increased BP incidence [13]. The relationship was further defined by Reid and Kalcsits [14] in a water relations study where fruit size was categorized into four classes based on diameter, with BP incidence effectively doubling between the 80–90 mm and over 90 mm categories. Our study takes this approach a step further, with the use of ten commercial weight categories in the range of 48 count (largest) down to 140 count (smallest) based on common marketing practice (Figure 3). For all storage fruit in this study the frequency distribution of across the ten categories approximated the bell shape of a normal distribution with the top of the "bell" flattened (data not shown), with 92% of the fruit falling into count categories 56 to 113. For all three rootstocks, fruit in the categories 48 and 56 were the most susceptible to BP. While our categories were based on weight ranges, our fruit diameter data shows that 48 count apples averaged 94.1 mm and 56 count apples averaged 89.3 mm, both categories roughly equivalent to the largest size category described in the Reid and Kalcsits [14] study which also experienced an elevated incidence of BP. The relationships start to change by rootstock as we move into the more commonly marketed size categories. Fruit produced on B.9 had a relatively neutral relationship of BP to size in the range from 64 to 140 as the BP incidence curve flattened and oscillated around a mean of 11.2% incidence (Figure 3B). Fruit produced on M.9 demonstrated a decline in BP incidence with decreasing size, with incidence falling from 29.2% (64 count) to 13.3% (113 count) (Figure 3D). Fruit produced on M.26 demonstrated the most severe relationship falling from 40.6% to 14.6% over the same count size range (Figure 3C). There are orchard management implications associated with these findings. As much as the industry recognizes that larger fruit have more bitter pit, as a practical matter the first priority of a properly managed crop load reduction program is to produce fruit in marketable sizes, and then facilitate adequate return bloom to avoid biennial bearing. Minimizing the production of 48 and 56 count apples will have a positive effect on orchard financial returns for all rootstocks represented in this study. Beyond that, a shift in frequency distribution to smaller fruit is not likely to help in a B.9 orchard and will only slightly reduce the average BP incidence in M.9 clone and M.26 orchards.

The Complexity of Bitter Pit Prediction Modeling

While BP incidence has been related to individual mineral element concentrations and ratios of mineral pairs in many apple studies, one should not underestimate the complex environment that the roots (soil type, soil pH, water availability, soil moisture, etc.), and the scion (rainfall, light intensity, crop load, heat unit accumulation) operate in, in conjunction with the final fruit traits influence by producer management practices during the course of the dormant and growing seasons. For this reason, we pooled together all the traits evaluated in this study, except for CL, which was not evaluated in 2018, to identify the PLS prediction model on BP for each region and each rootstock based on the NIPALS algorithm.

Based on the results, the PLS prediction model for each region (CV and HV) and each rootstock (B.9, M.26 and M.9 clone) showed a different threshold of variables correlated to BP, described above for each PLS prediction model (Figure 4). However, comparing all PLS analysis, only seven VIP variables were in common, peel K/Ca, peel Mg/Ca, and peel B/Ca ratios, peel Ca, FD, L/FD, and FW, showing the great variability found in this study. It is also interesting to point out that none of the environmental variables and soil variables evaluated in this study were VIP variables in common among rootstocks or between regions. The 34 orchards evaluated in this study over three years represent a wide range of these variables, therefore, these results could help to emphasize their influence on BP incidence when taking in consideration each rootstock and each region as a single unit to evaluate.

Summary and Conclusions

The results of this work have the potential for a dramatic impact on commercial management and mitigation of BP in 'Honeycrisp' production. In order to facilitate real-time management changes, producers and marketers need practical tools and proven horticultural practices that mitigate bitter pit incidence and reduce storage decision risk. Bitter pit prediction models are currently in various stages of development, validation, and commercial implementation [15,16,17] with all three taking different approaches to meet the same goal of reliable pre-harvest prediction of 'Honeycrisp' fruit BP performance in storage. Recommended approaches should be on those that are simple to implement at a low cost to the producer. However, the large number of variables suggests that simple and commercially achievable models consisting of 1–3 variables will always be lacking in absolute accuracy. Fortunately for practical implementation within the apple industry, accuracy thresholds for commercial implementation are more tolerant of error than those considered acceptable in academic settings. The goal is to provide effective storage management guidance which ultimately protects the producer from making the unprofitable decision to store fruit from an orchard that turns out to suffer substantial losses to BP months later.

Not all traits evaluated individually correlated significatively with bitter pit incidence after a period in storage. Depending on rootstock and region, the correlation could be significant in one situation, with no correlation at all in another. In this study, peel Mg/Ca ratio and peel Ca correlated with BP for all three rootstocks, with the strongest correlations associated with the M.9 clones. These same traits correlated with BP for both regions. Pick timing had a significant influence on BP incidence following storage, with later picks offering better bitter pit storage performance. While excessively large fruits, those in the 48 and 56 count size categories, were found to be highly susceptible to BP regardless of rootstock, B.9 BP fruit susceptibility for lesser sizes was found to be size neutral. A PLSR prediction model for each rootstock and each region showed that different variables correlated to BP depending on the situation.

We suggest that the BP performance of a rootstock should be a major consideration when choosing a rootstock for a new 'Honeycrisp' orchard in New York State and likely elsewhere as well. Unfortunately, data beyond anecdotal observations is difficult to find, and considering the variability found in this study, likely to be highly unreliable. We suggest that rootstocks newly introduced to the commercial market should be tested for BP performance during the developmental phase and before being recommended for widespread use with 'Honeycrisp", beyond the scope of modest producer test plantings.

In a more basic sense, these results could also suggest that in addition to the variables considered in this study, and commonly studied in others, there are other, less studied factors or triggers (genetic, histological, hormonal, abiotic stress situations, etc.) that can influence the physical expression of BP symptoms. With that said, identifying and understanding these factors may help to uncover the mechanism within the tree associated with the fruit, maintaining an adequate supply of calcium cations in the vicinity of groups of cells, making sure that they are available at the appropriate time, and what factors or combinations of factors influence the effectiveness of this calcium delivery mechanism, if possible.

Acknowledgments

The authors wish to acknowledge the efforts and in-kind contributions of all who collaborated with us towards the successful implementation of this project. Thank you to the Cornell Nutrition Analysis Laboratory, the Cornell Hudson Valley Research Laboratory, The Cornell Cooperative Extension Eastern New York Commercial Horticulture Program, and the 13 Eastern New York State apple producers (Table 1) for their contribution of laboratory and cold storage space, orchard sites, and substantial donations of experimental fruit. A special thank you to the many people who have helped our team by providing valuable guidance and insight including but not limited to Michael Rutzke, Christopher Watkins, Lailiang Cheng, Yousef Al Shoffe, Srdan Acimovic, Andy Galimberti, Sarah Tobin, Dana Acimovic, and Jeff Alicandro.

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Figure 1. Rootstock effect on 'Honeycrisp' bitter pit incidence and on 'Honeycrisp' bitter pit severity

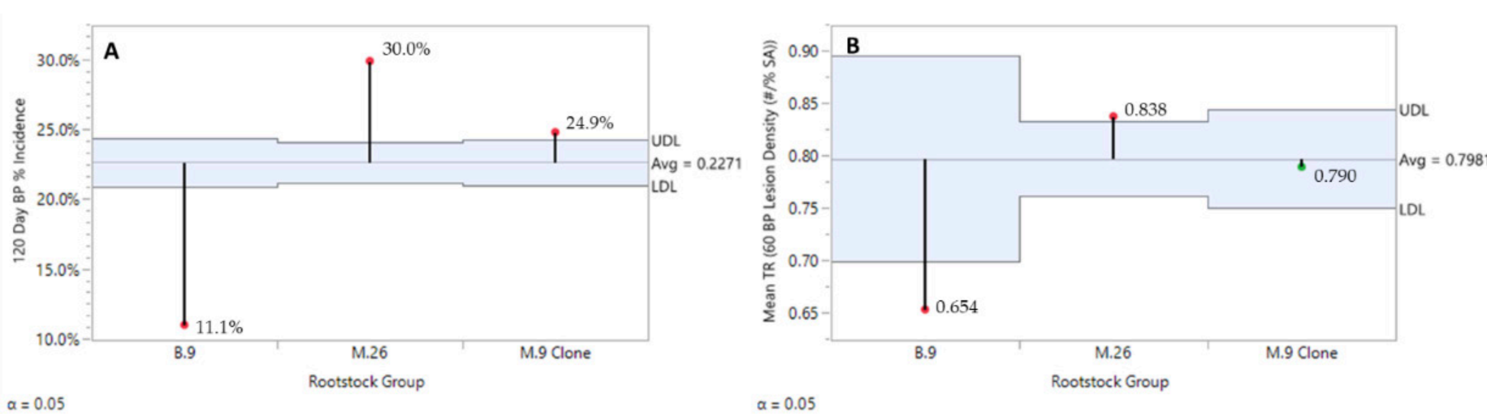


Figure 1. Rootstock effect on 'Honeycrisp' bitter pit incidence (A) and on 'Honeycrisp' bitter pit severity (B) after 120 days of refrigerated storage with all years and both regions combined (A). JMP Fit XY Platform, Analysis of Means of Proportions of the binomial dataset, alpha = 0.05. The B.9 rootstock demonstrated superior BP performance in incidence (does the apple have BP? Yes or no) and in severity as well (if the apple has BP, just how dense are the lesion counts?).

Figure 2. Pick timing effect on ‘Honeycrisp’ bitter pit incidence

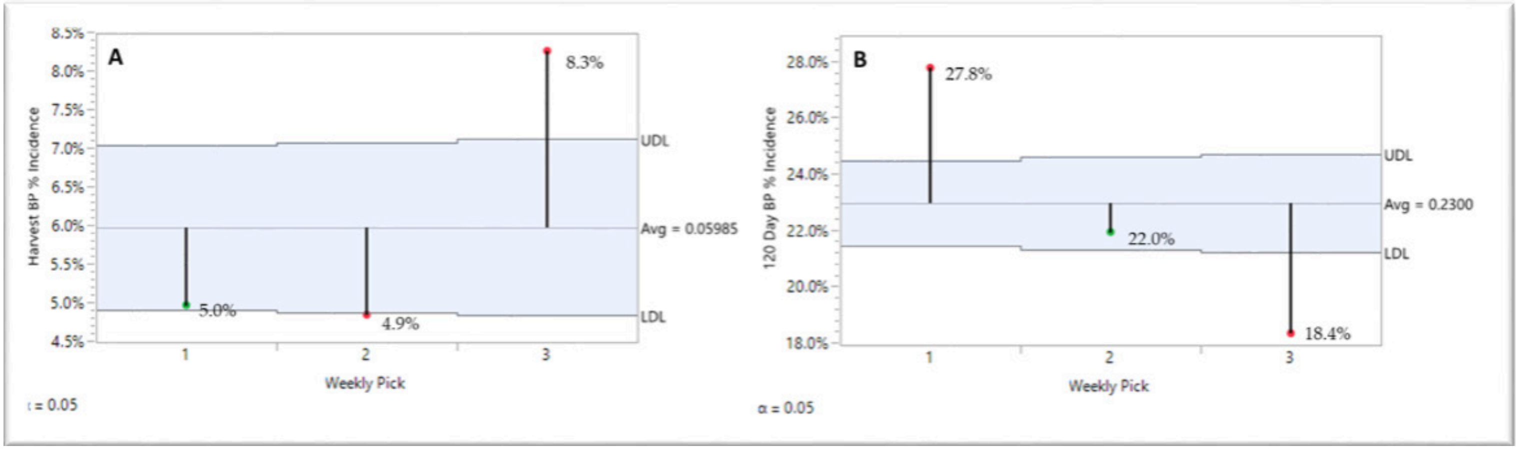


Figure 2. Pick timing effect on ‘Honeycrisp’ bitter pit incidence at harvest (A) and after 120 days of refrigerated storage (B) with all rootstocks and years combined. JMP Fit XY Platform, Analysis of Means of Proportions of the binomial dataset, alpha = 0.05.

Figure 3. ‘Honeycrisp’ bitter pit incidence after 120 days storage

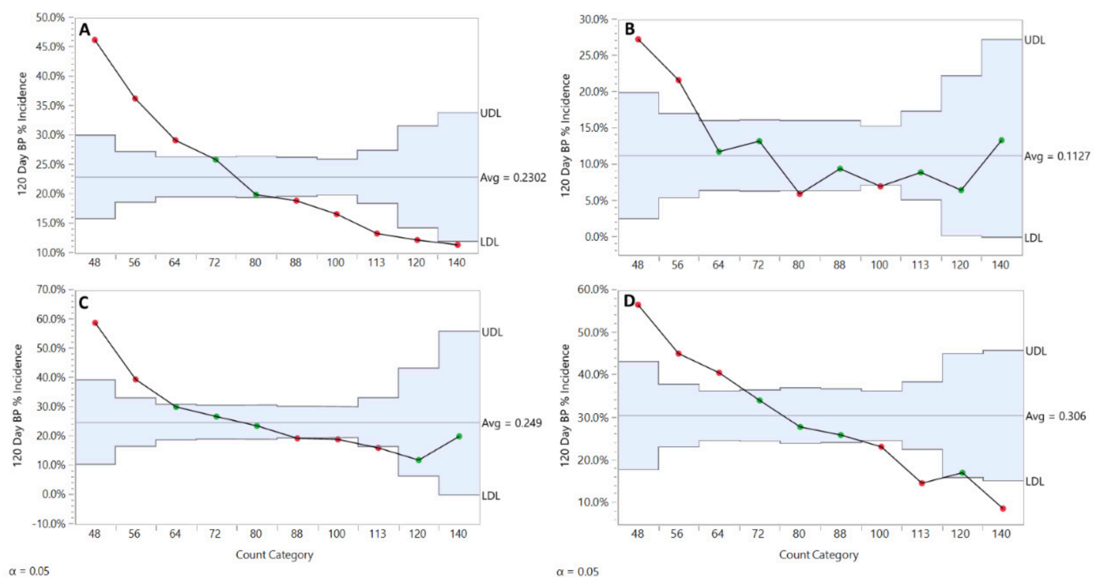


Figure 3. ‘Honeycrisp’ bitter pit incidence after 120 days storage by count size category, all rootstocks, regions, and years (A), and by B.9 (B), M.26 (C) and M.9 clone (D) all regions and all years. JMP Fit XY Platform, Analysis of Means of Proportions of the binomial dataset, alpha = 0.05.

Figure 4. Partial least square (PLS) analysis between BP incidence at 120 DAH

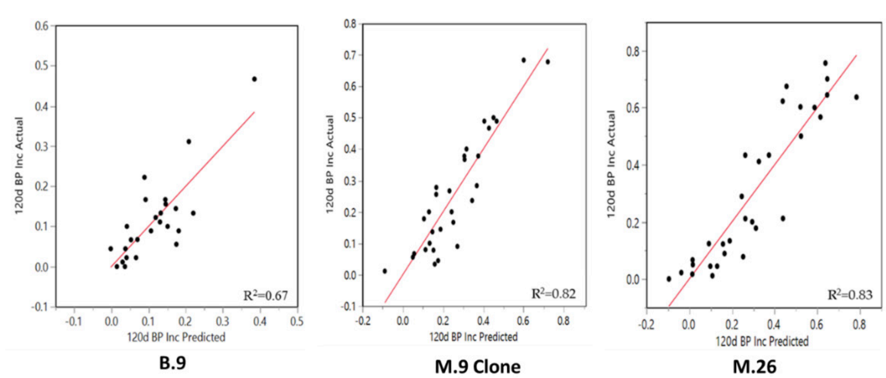


Figure 4. Results obtained from the partial least square (PLS) analysis between BP incidence at 120 DAH and the rest of variables evaluated all three years together, B.9, M.9 Clone, and M.26 rootstocks in HV and CV. Significant observed values versus PLSR-predicted values for BP for each rootstock. Of the 25 variables considered significant for B.9, 30 for M.9, and 31 for M.26, only seven variables with VIP graph values over 0.8 were found to be in common for all three rootstocks. Please refer back to the original paper for the related VIP graphics and descriptions.

Variety Trials

- Beefsteak Tomatoes
- Carrots
- Leeks
- Lettuce
- Onions, Storage
- Peas
- Potatoes
- Pumpkins
- Seedless Watermelon
- Sweet Potatoes

Beefsteak Tomato
2020 Variety Trial

Chuck Bornt, Natasha Field
Host Farm: Altobelli Family Farm, Columbia County
Thank you to Seedway and Sakata Seed for contributing seed to the trial

Seeding: May 7th

Transplanting: June 12, 2020

Tomatoes were transplanted in the field on June 12, 2020 into black plastic mulched raised beds on 6' centers with 24" between plants in-row.

Management

All plants were staked, pruned and tied in the Florida Basket weave system by the Altobelli Farm crew. All irrigation, fertility, and pest management were also completed by our host farm.

Harvest: Aug 21-October 2, 2020

Tomatoes were harvested by CCE ENYCHP staff starting on August 21st, September 1st, September 15th and October 2, 2020.

Fruit were graded into three marketable categories based on size or unmarketable (culls) due to defects such as radial cracking, size, misshapen etc.

Beefsteak Tomato Varieties

1. **Bejo 3212 (Bejo Seeds/Gowan)**
2. **Bejo 3353 (Bejo Seeds/Gowan)**
3. **Bejo 3437 (Bejo Seeds/Gowan)**
4. **Camaro (Sakata Seed)**
5. **Emmylou (Seedway/Gowan)**
6. **Galahad (Johnny's SS/Gowan)**
7. **Grand Marshall (Johnny's Selected Seeds)**
8. **Jolene (Seedway/Gowan)**
9. **Mountain Merit (Bejo Seeds)**
10. **Red Snapper (Seedway)**
11. **Roadster (Sakata Seed)**
12. **STM 2255 (Seedway/Gowan)**
13. **TastiLee (High Mowing Seeds)**

Table 1. Evaluation of Beefsteak Tomato Flavor, Appearance and Yield

Variety	Exterior	Description of Flavor	Comments
Bejo 3212	**Medium red flesh**	**Lots of seed cavity and gel. Medium core. Not fiberous. Flavor okay, soft texture.**	**17% of total yield were culls, primarily radial crack, blossom end rot and too small fruit**
Bejo 3353	**Orange red flesh**	**Small core. A lot of seed cavity and gel. Thick skin and very firm even when fully ripe. Flavor okay and very juicy.**	**Uniform in size and shape. 15% of total yield were culls, primarily radial cracks and too small fruit.**
Bejo 3437	**Medium to dark red flesh**	**Small core. A lot of seed cavity and gel. Delicious, flesh is firm but skin is thin and there isn't any chew. Best tasting in the trial**	**Highest yielding in marketable weight. 11% of total yield were culls, primarily radial cracks and zippers.**
Camaro	**Orange red flesh**	**Strong tomato flavor, firm texture with thin skin, good flavor.**	**Highest % of large fruit by weight. 26% of total yield were culls, primarily radial cracks and zippers.**
Emmylou	**Orange red flesh**	**Meaty texture. Pop of nice flavor with first bite. Skin lingers.**	**Oddly lobed shape in some fruit. 42% of total yield were culls, primarily radial cracks and blossom end rot**
Galahad	**Pink flesh**	**Long narrow core. Firm texture. Pop of flavor, pretty tasty.**	**Fruit either large or small. 78% of total yield were culls, all radial crack issues. This was a severe issue.**
Grand Marshall	**Pink orange flesh**	**Small core. White fibers through the whole tomato, harder texture. Unpleasant taste**	**18% of total yield were culls, primarily radial cracks and blossom end rot.**
Jolene	**Medium red flesh**	**Medium to large core. Fair amount of white fibers in side walls. Lots of seed cavity and gel and skin is tough. Texture is a little chewy due to skin. Very pleasant flavor and very juicy.**	**10% of total yield was culls, primarily radial cracks and blossom end rot. Had lowest % of culls.**
Mountain Merit	**Pink flesh**	**Small core with more seed cavity and gel space. Firm texture. Seeds unpleasant and too many. Flavor is okay.**	**Nice shape and size. 48% of total yield were culls, primarily radial cracks.**
Red Snapper	**Orange red flesh**	**Small core. Okay texture, okay flavor.**	**Medium stem scar and blossom scar. Highest total harvest and most large fruit by weight. 15% of total yield was culls, primarily radial cracks**
Roadster	**Orange red flesh**	**Dense, meaty texture. Skin is a little thick. Juicy and flavor is good.**	**Uniform in size and shape. 29% of total yield was culls, primarily radial cracks, but had blossom end rot, concentric cracks and rain check in some fruit.**
STM 225	**Light orange flesh**	**Meaty, little seed and gel space. Small core. Pleasant flavor and nice firm texture. Juicy.**	**18% of total yield was culls, primarily radial crack, blossom end rot and zippers**
Tastilee	**Dark orange flesh**	**Juicy with good texture. Flavor is decent, skin is decent.**	**Produced the highest number of marketable fruit. Best for quart basket market due to overall smaller size produced. Large blossom scar on almost all fruit. 11% of total yield was culls, primarily too small fruit and radial cracks.**

Figure 1. Composition of Yields for Each Variety (cull, small, medium, large)

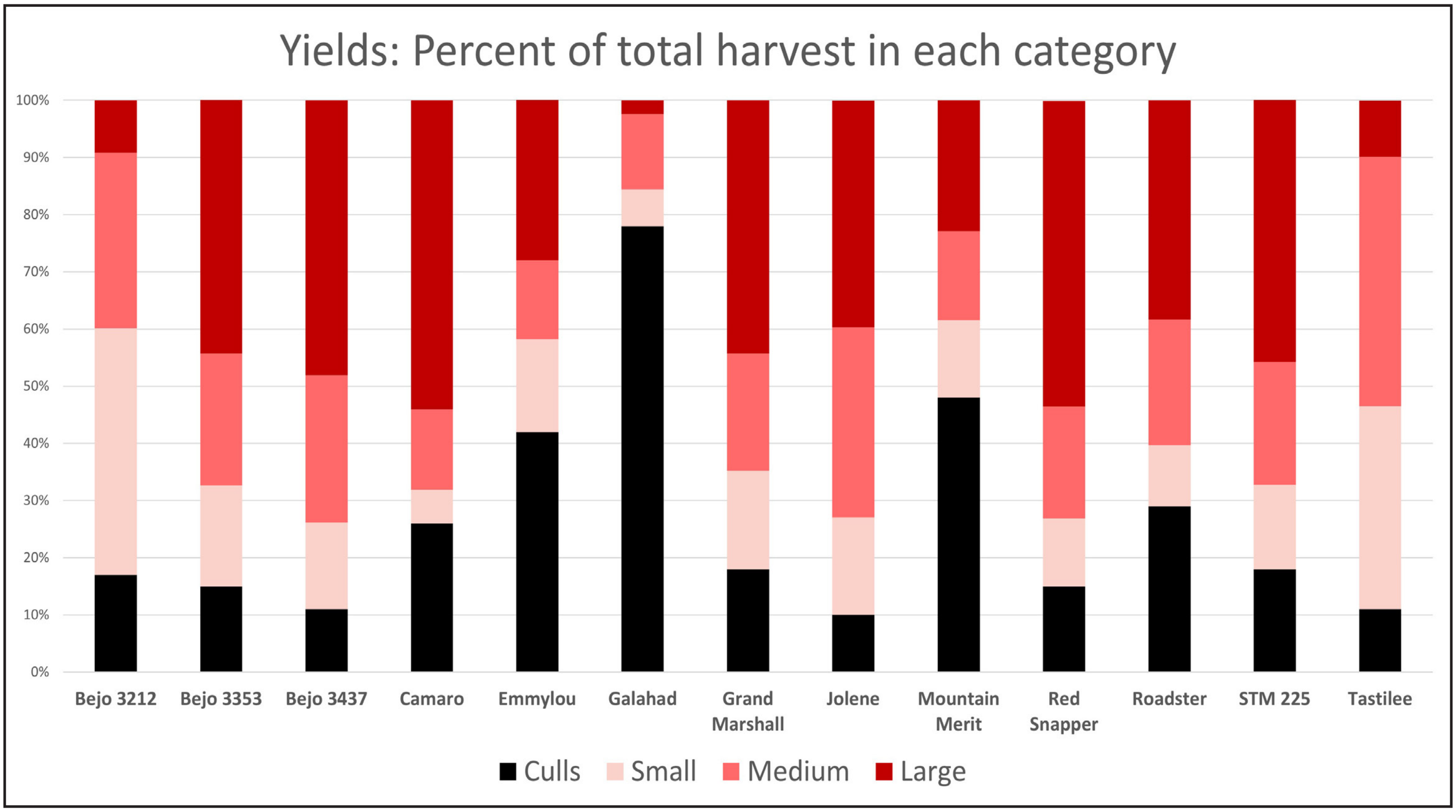


Figure 2. Volume of Marketable Fruit for Each Variety, by Weight and Total # of Fruit.

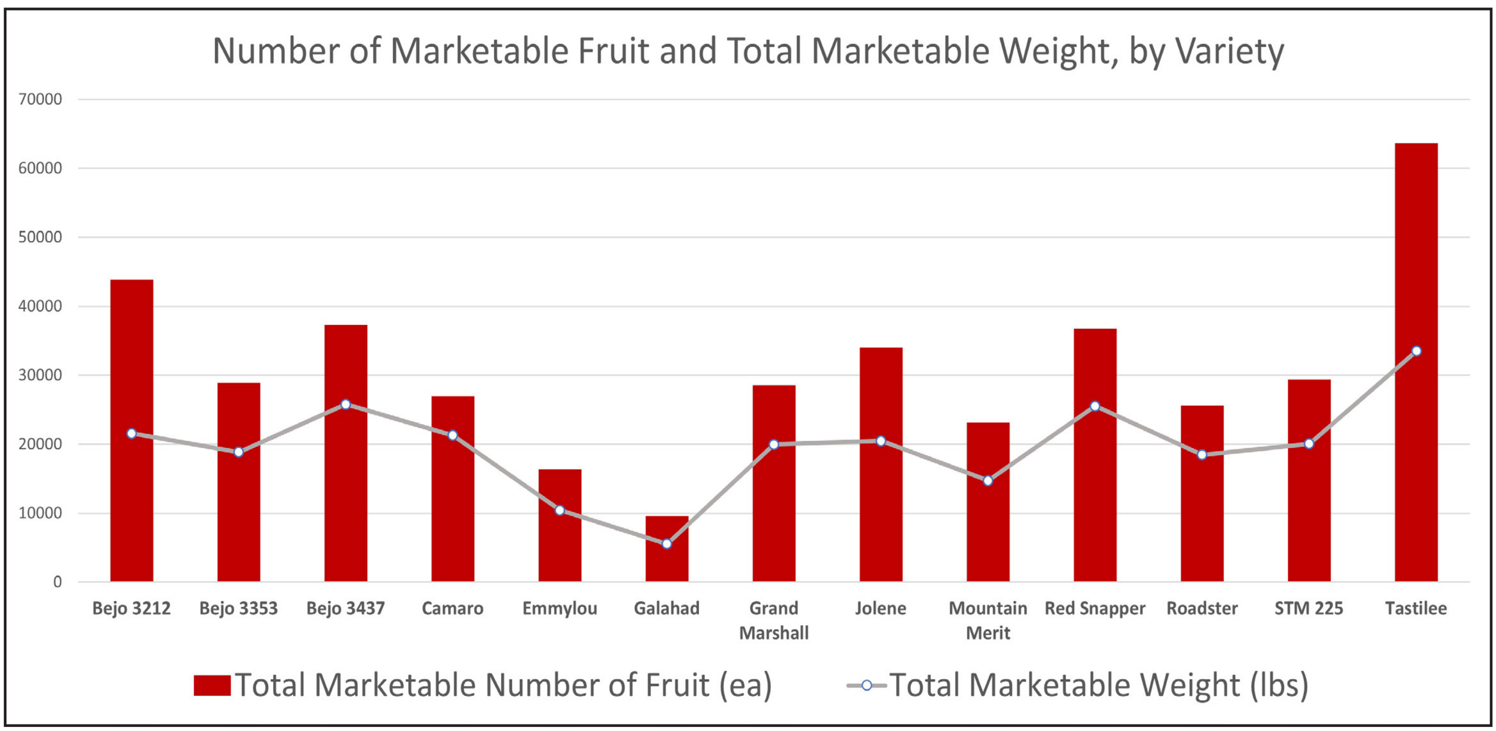


Table 2. Beefsteak Tomatoes, Disease Resistance

(H=High resistance; I= Intermediate resistance)

Variety	Fusarium wilt	Fusarium crown and root rot	Verticillium wilt	Grey leaf spot	Alternaria stem canker	Tomato spotted wilt	early blight	Tomato yellow leaf curl	late blight	nematodes
Bejo 3212	H							H		
Bejo 3353	H		H			H		I		
Bejo 3437	H					H		I		
Camaro	H	H		I	H			I		
Emmylou	H					H		H		
Galahad	H		H	H		H			H	H
Grand Marshall	H			I	H			I		
Jolene	H	H	H					H		
Mountain Merit						H	I			I
Red Snapper	H		H	I	H	I		I		
Roadster	H	H	H	I	H	I				
STM 225	H	H	H	I		I		I		
Tastilee	H		H							

Carrots

2016 Variety Trial

Crystal Stewart-Cortens

Host Farm: Hudson Valley Farm Hub (Hurley NY)

Thank you to Bejo Seeds, Fedco Seeds, Sakata Seed, and Stokes Seeds for contributing to our trial

Bed Preparation: Ridge-cultivated, non-irrigated

Seeding: June 9th, 2016
Using Jang seeder, unpelleted seed

Harvest: September 19, 2016

1. CARROT GREENS, PHOTO C. STEWART-COURTENS

Carrot Varieties

1. **Naval**
2. **Napoli**
3. **Mokum**
4. **Cupar**
5. **Bastia**
6. **Negovia**
7. **Yaya**
8. **Bolero**
9. **Magnum**
10. **Envy**
11. **Romance**
12. **Early Milan (OP)**
13. **Coral (OP)**
14. **SCR 8457**
15. **SCR 8431**
16. **FCR 14411**

2. CARROTS, PHOTO C. STEWART-COURTENS

Figure 1. Total & Marketable Yield of Carrots

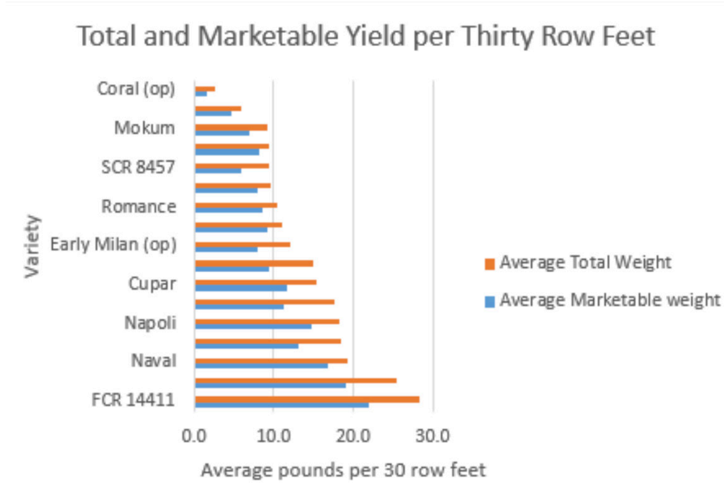
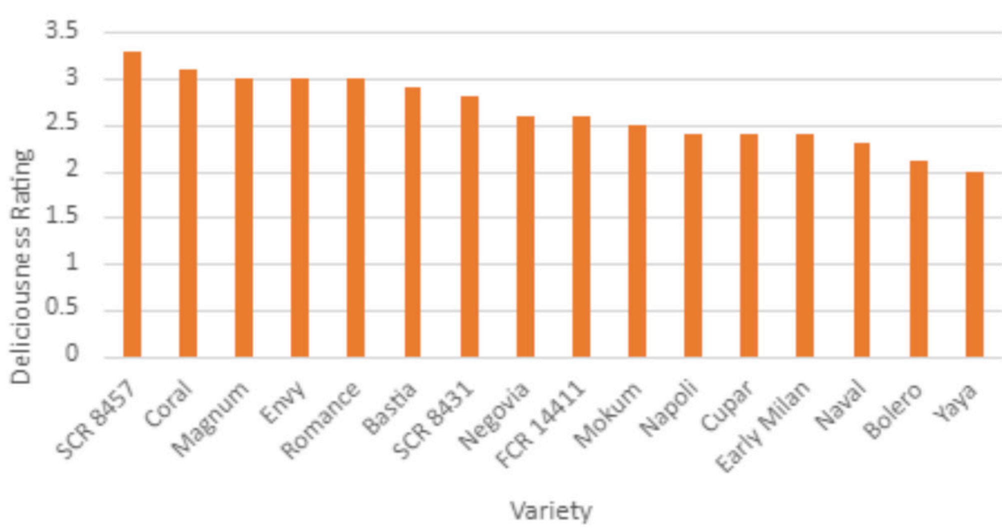


Table 1. Carrot Variety Trial Results

Row Labels	Total # Marketable Roots in 90 feet	Marketable Weight in 90 ft (lbs)	Total# Culls in 90 feet	Total Weight of Root Culls	Sum of Total yield	Average of % marketable roots by lb
Naval	560	50.45	142	7.5	57.95	88%
Napoli	384	44.05	130	10.7	54.75	79%
Mokum	251	21.05	82	6.55	27.6	76%
Cupar	368	35.15	356	11.05	46.2	76%
Bastia	643	56.95	715	19.2	76.15	74%
Negovia	496	39.35	487	16	55.35	71%
Yaya	174	15.85	48	3.3	19.15	81%
Bolero	236	27.7	115	5.75	33.45	83%
Magnum	142	14.15	38	3.9	18.05	80%
Envy	357	33.95	265	18.85	52.8	63%
Romance	269	25.85	104	5.7	31.55	82%
Early Milan (OP)	387	24.1	564	12.25	36.35	65%
Coral (OP)	49	3.4	65	1.8	5.2	64%
SCR 8457	173	103.05	102	16.8	119.85	69%
SCR 8431	80	11.65	42	7.1	18.75	63%
FCR 14411	237	65.55	157	19.5	85.05	78%
Grand Total	4806	572.25	3412	165.95	738.2	75%

Figure 2. Carrots Sorted by Flavor



Leeks
2020 Variety Trial

Crystal Stewart-Cortens, Natasha Field
Host Farms: Phila Farm, Fulton County
Thank you to Vitalis Seed, Bejo Seed, High Mowing Seeds, Seed Savers Exchange and Johnny's Selected Seeds for contributing seed to our trial.

Seeding: March 17, 2020

Seeded into strip trays, moved to open flats one month later

Transplanting: May 22 & May 27, 2020

Planted in two rows, 18 inches between rows and 6-inch spacing in-row

Harvest: August through November 2020

Varieties were harvested as they matured starting August 3 through November 10th. Varieties were evaluated on disease resistance, height, weight per 20 leeks, amount of bulbing, uniformity, and diameter.

Before entering the presentation of data, it is important to note that a number of leeks were harvested after the recommended days to maturity (DTM). In all of these cases the varieties could have been harvested at the suggested DTM, but when a variety showed no signs of bolting or splitting, and had low disease incidence, we chose to leave it until it appeared to have stopped improving in weight and size. The varieties with delayed harvest were: Skater, Jaune de Poitou, Jumper, Lancelot, Prizetaker, Tadorna, Esther Cook and Keeper. They all kept in the field at least a month longer than their recommended DTM.

The environmental conditions this season are also noteworthy. We had 32 days where the temperature was over 85°F and 3 inches less rain than average. Disease pressure was light for most of the season, with only a few varieties showing notable Purple Blotch damage. Susceptible varieties were Comanche, Takrima, Runner, and Walker.
One of the key takeaways from this trial is that there are many viable alternatives to the industry standards of King Richard early and Megaton later in the season. Personal favorites included Skater early, for its deeper blue-green color and stouter habit; Chinook as a mid-season selection for uniformity and size;and Keeper as a late selection for its beautiful upright habit and deep blue/green color.

Leek Varieties

Summer

1. Alto
2. Batter
3. Biker
4. Bowler
5. Columbus
6. Fencer
7. King Richard
8. Lancia
9. Pancho
10. Skater
11. Striker
12. Verdonnet

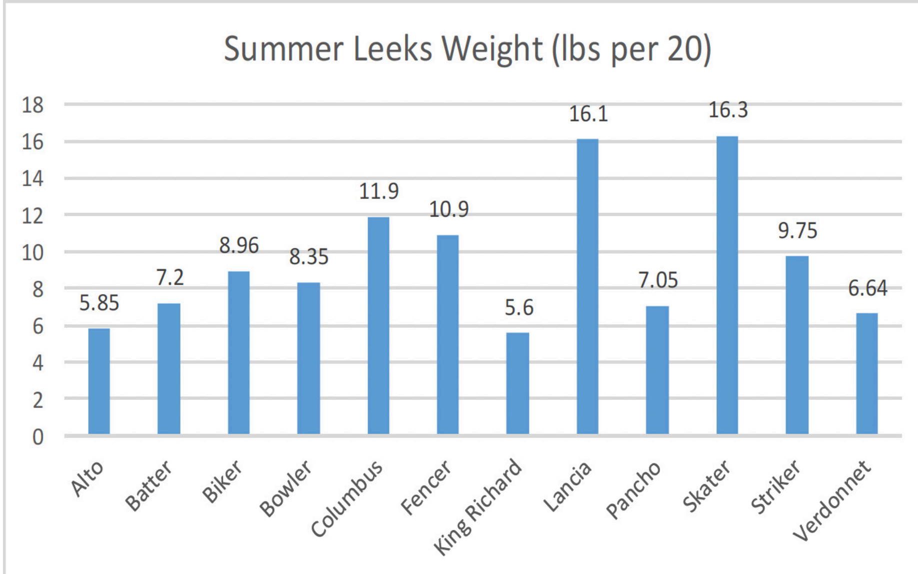
Fall

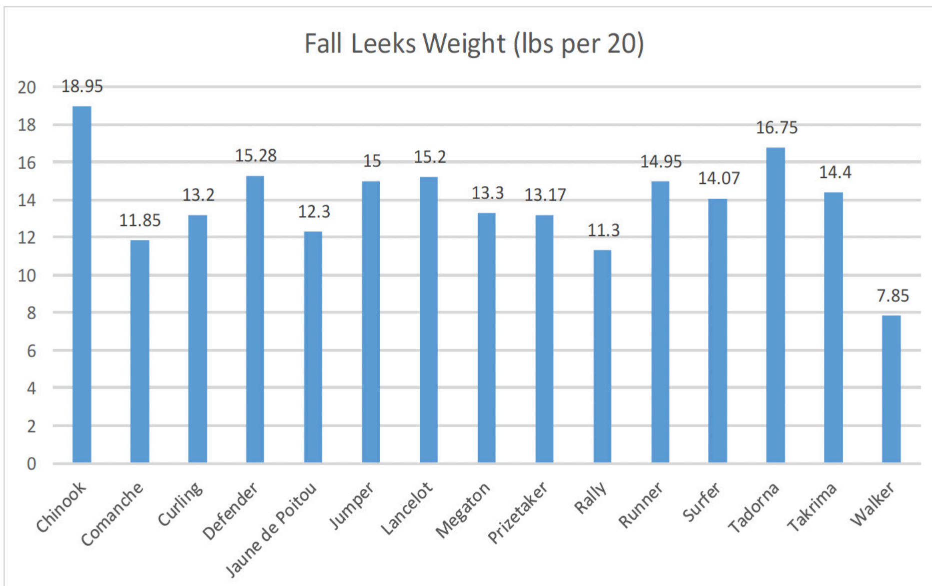
13. Chinook
14. Comanche
15. Curling
16. Defender
17. Jaune de Poitou
18. Jumper
19. Lancelot
20. Megaton
21. Prizetaker
22. Rally
23. Runner
24. Surfer
25. Tadorna
26. Takrima
27. Walker

Winter

28. Bandit
29. Blue Solaise
30. Dawn Giant
31. Esther Cook
32. Keeper
33. Liege Giant
34. Mechelen Blue Green
35. Shades of Belgian Blue

Comparison: Weight (lbs) of 20 Leeks Per Variety





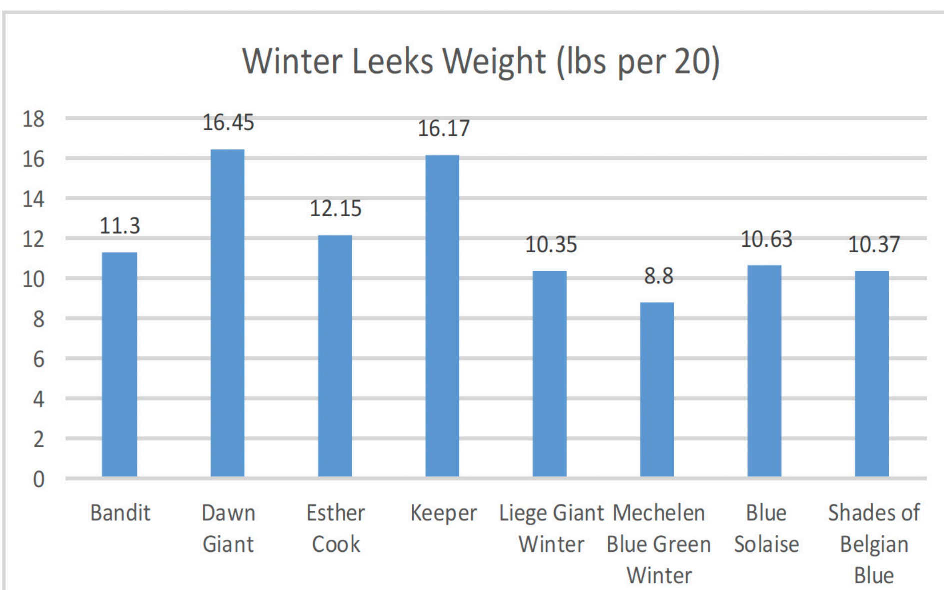


Table 1. Leek Variety Information & Assessment

Variety	Disease pressure (1-5)	Days to maturity (seed/ transplant)	Uniform?	Height (inches) July 15	Bulbing (1-5; 1 - onion, 5 - no bulb)	Average diameter at harvest
Alto	5	146/80	No	18	5	1.24
Bandit	5	155/84	Yes	18	2	1.41
Batter	5	146/80	Yes	18	5	1.13
Biker	5	139/73	Yes	18	5	N/A
Blue Solaise	5	238/167	No	12	3	1.57
Bowler	5	146/80	Yes	18	5	1.32
Chinook	4	183/117	No	16	5	1.76
Columbus	5	139/73	Yes	18	5	N/A
Comanche	4	155/89	No	18	4	1.45
Curling	5	205/139	Yes	16	4	1.54
Dawn Giant	5	183/112	Yes	18	4	1.83
Defender	5	205/139	Yes	18	4	1.87
Esther Cook	4	238/167	No	12	5	1.70
Fencer	5	164/99	Yes	14	5	1.55
Jaune de Poitou	5	224/158	Yes	8	2	2.16
Jumper	5	224/158	Yes	16	5	1.63
Keeper	5	238/167	Yes	18	5	1.73
King Richard	5	146/80	No	12	5	1.23
Lancelot	5	224/159	No	18	4	1.84

Table 1. Leek Variety Information & Assessment

Variety	Disease pressure (1-5)	Days to maturity (seed/ transplant)	Uniform?	Height (inches) July 15	Bulbing (1-5; 1 - onion, 5 - no bulb)	Average diameter at harvest
Lancia	5	164/99	Yes	16	5	1.63
Liege Giant	5	238/167	No	12	3	1.54
Mechelen Blue Green	5	238/167	No	12	3	1.71
Megaton	5	164/98	Yes	15	5	1.53
Pancho	5	146/80	No	18	5	1.41
Prizetaker	5	205/139	No	12	2	1.87
Rally	5	155/89	No	18	5	1.24
Runner	4	183/117	No	18	4	1.40
Shades of Belgian Blue	5	238/167	No	12	5	1.60
Skater	5	224/158	Yes	18	4	1.91
Striker	5	146/80	No	18	5	1.32
Surfer	5	205/134	Yes	16	5	1.65
Tadorna	5	205/139	No	18	3	1.93
Takrima	4	164/98	No	16	5	1.48
Verdonnet	5	139/73	No	12	4	N/A
Walker	4	155/84	Yes	15	5	1.09

Lettuce
2017-2020 Variety Trials

Crystal Stewart-Courtens, Natasha Field

Host Farm: Pleasant Valley Farm (Argyle, Washington County NY) and Philia Farm (Johnstown, Fulton County NY)
Thank you to seed contributors for contributing to our trial

Bed preparation: May 5, 2020

Beds were formed with a 4' roll of plastic and two lines of drip tape on 7' centers. Dry fertilizer was also applied during bed formation at a rate of 300lbs/acre of 13-13-13. Pre- plant herbicide was applied between rows of plastic after bed formation. A tank mix of Prowl H20 and Sandea at rates of 2pts and ½ oz per acre.

Seeding:
2017 – May 25 and July 19, 2017
2018 – May 28, July 15, and August 1, 2018
2019 – May 29, 2019

Transplanting:
Outdoor planting for heat evaluation
2017 – Transplanted 21 days after seeding (approximately June 15 and August 9 2017)
2018 -
2019 -

Harvest:
2017 -
2018 – August 1, 2018 (17 days above 85 degrees) September 15, 2018 (15 days above 85 degrees) and October 3, 2018 (12 days above 85 degrees)
2019 – July 23, 2019 (12 days above 85 degrees)

Trial Notes:

Bitterness Rating: 1 sweet - 10 bitter
Taste Rating - 1 worst - 5 best
Disease Rating: 1 most disease - 5 disease free
Weight = 1 representative head wt

Lettuce Varieties

1. Aerostar[17,18]
2. Aloha Gem[19]
3. Annapolis[18]
4. Annie Oakey[19]
5. Anuenva[19]
6. Augustus[17,18]
7. Auvona[18]
8. Blondie[19]
9. Bolsachica[17]
10. Breen[17,18,19]
11. Bronze Arrow[19]
12. Bronze Mignonette[19]
13. Brown Goldring[17,18]
14. Bunyard Matchless[17,18]
15. Cherokee[19]
16. Cimmaron[18]
17. Cinnamon Oak[19]
18. Coastal Star[17,18,19]
19. Concept[19]
20. Crisp Mint[19]
21. Dragoon[17,18,19]
22. Dubiya Dapple Density[18]
23. Elf Ears[19]
24. Ezbruke[18]
25. Fenberg[17]
26. Freckles[18]
27. Fusion[18,19]
28. Gentilling[17]
29. Gildensterns[19]
30. Greek Maroulli[17]
31. Green Forest[18]
32. Green Towers[18]
33. Holon[18]
34. InfraRouge[19]
35. Irene[19]
36. Italiensisher[17]
37. Jack Ice Leaf[19]
38. Jadeite[19]
39. Jericho[19]
40. Kalura[18]
41. Kilauea[19]
42. Kims Red Butter[17]
43. Kraginger Somer[19]
44. Little Gem[17]
45. M. de quatre Saisons[17]
46. Magenta[19]
47. Majestic[19]
48. Manoa[19]
49. Muir[19]
50. Nancy[19]
51. Nevada[19]
52. Newham[18]
53. Olga[19]
54. Optima[19]
55. Outredgeous[17,18]
56. Pablo Batavian[19]
57. Pablo[17]
58. Parris Is Cos[19]
59. Plato II[19]
60. Pomegranate Crunch[18]
61. Red Rosie[18]
62. Redina[19]
63. Romulus[18]
64. Salvius[18,19]
65. Snowflake[17]
66. Sparx[18,19]
67. Spotted Trout[17]
68. Spretnak[18]
69. Strawberry Cabbage[17]
70. Sweet Valentine[19]
71. Thiruness[18]
72. Treasure Isle[19]
73. Truchas[17, 18, 19]
74. Zeb Romaine[19]

Table 1. Lettuce Variety Trial Results, 1 of 3

Variety	Disease Rating	Number Bolted	Bitterness Rating	Taste/texture	Weight (lbs)	Year
Aerostar	2	11	3	Thicker leaves, but okay flavor	0.44	2017
Aerostar	4	0	8			2017
Aerostar	4.3	0	2.3	Average taste	0.43	2018
Aloha Gem	3	0	2	3	0.65	2019
Annapolis	4.7	0	1	Bitter, not good	0.16	2018
Annie Oakey	5	5	1	3	0.3875	2019
Anuenva	5	0	2	4	0.4375	2019
Augustus	5	1	4	weird taste	0.58	2017
Augustus	5	0	8	hard text.		2017
Augustus	3.3	0	2.7	Adequate taste, tough	0.75	2018
Auvona	4.3	0	1.7	Bleh taste, chewy and tough, grassy green flavor	0.62	2018
Blondie	4	0	1	3	0.65625	2019
Bolsachica	4	7	5	Sharp leaf edges	0.38	2017
Bolsachica	4	0	9			2017
Breen	3	0	3	okay - good	0.38	2017
Breen	5	0	9	nice		2017
Breen	4.3	0	2.7	A little sweet and refreshing	0.24	2018
Breen	5	0	2	4	0.5625	2019
Bronze Arrow	5	0	2	4	0.4375	2019
Bronze Mignonette	2	5	2	3	0.61875	2019
Brown Goldring	3	12	4	pleasant	0.64	2017
Brown Goldring	3	4	10			2017
Brown Goldring	2.7	26	1.7	Tastes sweet and good	0.37	2018
Bunyard Matchless	4	7	4	good, sweet	0.12	2017
Bunyard Matchless	3	0	9	hard, pretty sweet taste		2017
Bunyard Matchless	2.7	29	1.7	Tasted good! Really good! Possibly a celtuce cross as stems tasted good too, even though bolted.	0.37	2018
Cherokee	5	0	1	4	0.775	2019
Cimmaron	3.7	11	1.3	Nice texture, tastes good with a bitter aftertaste	0.63	2018
Cinnamon Oak	3	0	2	2	0.26875	2019
Coastal Star	3	2	4	not bad, semi tough	0.66	2017
Coastal Star	5	0	9	mild good flavor		2017
Coastal Star	3	8	1.3	Not tasty, bitter and tougher	0.77	2018
Coastal Star	5	0	2	5	0.80625	2019
Concept	2	0	2	3	0.8375	2019
Crisp Mint	4	0	1	1	0.9875	2019
Dragoon	3	0	5	variable taste	0.46	2017
Dragoon	5	0	6	nice crunch		2017

Table 1. Lettuce Variety Trial Results, 2 of 3

Variety	Disease Rating	Number Bolted	Bitterness Rating	Taste/texture	Weight (lbs)	Year
Dragoon	3.7	0	2.3	Awful, bitter, bad taste	0.34	2018
Dragoon	5	0	3	5	0.8875	2019
Dubiya Dapple Density	4.3	0	2	Tasty, adible, a little tough	0.35	2018
Elf Ears	5	2	1	2	1.20625	2019
Ezbruke	4.3	0	2	Not bad, inoffensive	0.16	2018
Fenberg	4	0	2	good, but tough	0.5	2017
Fenberg	4	0	7	crunch		2017
Freckles	3.3	3	2	Average taste	0.62	2018
Fusion	4.3	0	2.3	Crunchy, average taste	0.77	2018
Fusion	5	0	3	5	0.8875	2019
Gentilling	5	1	6	good	0.68	2017
Gentilling	5	0	5	buttery, nice text.		2017
Gildensterns	1	0	2	4	0.53125	2019
Greek Maroulli	5	0	8	bitter and leathery	0.52	2017
Greek Maroulli	2	4	9	hard/sweet		2017
Green Forest	3.7	0	2.3	Not bad, nice enough taste	0.78	2018
Green Towers	3	0	1.3	First bitter than neutral, kinda ew	0.72	2018
Holon	3.3	0	2.7	Nice flavor!	0.67	2018
InfraRouge	5	0	1	1	0.25625	2019
Irene	5	0	3	5	0.575	2019
Italiensisher	3	0	5	okay, but not great	0.22	2017
Italiensisher	5	0	7	okay, has sharp flavor		2017
Jack Ice Leaf	4	0	1	1	0.7375	2019
Jadeite	5	0	2	3	0.8	2019
Jericho	4	0	2	4	1.275	2019
Kalura	3.3	0	2.7	Grassy taste	0.77	2018
Kilauea	4	0	1	3	0.575	2019
Kims Red Butter					0.46	2017
Kraginger Somer	5	0	2	5	0.975	2019
Little Gem	1	1	2	not bad, but not great	0.5	2017
Little Gem	3	0	10			2017
M. de quatre Saisons	4	4	6	not great	0.4	2017
M. de quatre Saisons	4	0	9	nice		2017
Magenta	5	0	2	3	0.875	2019
Majestic	5	0	2	2	0.7875	2019
Manoa	3	0	2	5	0.725	2019
Muir	5	0	3	5	1.2375	2019
Nancy	4	0	2	4	0.9125	2019

Table 1. Lettuce Variety Trial Results, 3 of 3

Variety	Disease Rating	Number Bolted	Bitterness Rating	Taste/texture	Weight (lbs)	Year
Nevada	5	0	2	5	1.275	2019
Newham	4.7	0	2.3	Crunchy water but refreshing	0.46	2018
Olga	4	0	1	4	1.2	2019
Optima	4	0	3	4	1.0125	2019
Outredgeous	5	0	5	Not great flavor	0.4	2017
Outredgeous	5	0	8	good flavor mild		2017
Outredgeous	3	14	1.3	Meh, crunchy, watery, a little bitter	0.34	2018
Pablo	3	0	2	good overall! Crunch and nice flav	0.52	2017
Pablo	5	0	10	good crunch		2017
Pablo Batavian	5	0	3	5	0.5375	2019
Parris Is Cos	5	0	2	4	0.6875	2019
Plato II	4	0	2	4	0.6375	2019
Pomegranate Crunch	4	0	2.3	Crunchy water	0.31	2018
Red Rosie	3	29	2	Fine	0.36	2018
Redina	4	5	1	2	0.475	2019
Romulus	2.7	0	3	Sweet, tasty!	0.61	2018
Salvius	3.7	0	1.7	Meh, taste, tastes like storebought lettuce	0.67	2018
Salvius	5	0	2	5	0.85	2019
Snowflake	5	7	7	not good	0.62	2017
Snowflake	5	2	9	good		2017
Sparx	3.3	0	1.7	Gross flavor, bad taste	0.73	2018
Sparx	3	0	2	3	1.325	2019
Spotted Trout	5	0	4	sweet, good, tender	0.4	2017
Spotted Trout	5	0	8	soft, nice text.		2017
Spretnak	4.3	0	3	Good flavor, very tasty	0.48	2018
Strawberry Cabbage	2	0	6	weird taste and slimy text	0.4	2017
Strawberry Cabbage	3	0	9			2017
Sweet Valentine	4	0	1	2	0.9625	2019
Thiruness	4.7	0	2.3	Tough, not a lot of flavor, a little bitter	0.29	2018
Treasure Isle	5	0	2	4	0.5	2019
Truchas	5	0	1	Tastes great! Cool and crisp, noticably better than others	0.34	2017
Truchas	5	1	8			2017
Truchas	5	0	1	4	0.4375	2019
Truchas	4.7	0	2.3	Okay taste, fairly average	0.28	2018
Zeb Romaine	3	0	3	5	0.3625	2019

Onions, Storage
2021 Variety Trial

Crystal Stewart-Cortens, Natasha Field
Host Farms: Phila Farm, Fulton County
Thank you to High Mowing Seeds, Seed Savers Exchange, Bejo Seeds, Fedco Seeds and Johnny's Selected Seeds for contributing seeds to the trial

Seeding: March 16, 2021

4 seeds per cell in a 72 cell tray.

Bed preparation: May 5, 2021

Beds were formed with a 4' roll of plastic and two lines of drip tape on 7' centers. Dry fertilizer was also applied during bed formation at a rate of 300lbs/ acre of 13-13-13. Pre-plant herbicide was applied between rows of plastic after bed formation. A tank mix of Prowl H20 and Sandea at rates of 2pts and ½ oz per acre.

Transplanting: June 5, 2021

Plants were set into the field using a water wheel transplanter with 40" in row spacing.

Management

Two weeks post-transplant (at running) 20lb actual N/ acre side-dress was applied. After fruit set, another 20lb actual N/acre was applied.

Harvest: July and August 2021

Onions cured in high tunnel under cloth for three weeks before data collection.

Onion Varieties

Red Onions

1. Blush (Johnny's, bred by Bejo)
2. Red Carpet (Johnny's, bred by Bejo)
3. Red Globe (Fedco)
4. Red Mountain (Bejo)
5. Redwing (Fedco)
6. Rossa di Milano (Johnny's & High Mowing)

Yellow Onions

7. Calibra (Bejo)
8. Cartier (Bejo)
9. Cortland (High Mowing, bred by Bejo)
10. Frontier (Johnny's, bred by Takii)
11. New York Early (Johnny's - open pollinated and maintained)
12. Oneida (Bejo)
13. Powell (Bejo)
14. Sedona (High Mowing, bred by Bejo)
15. Talon (Johnny's, bred by Bejo)
16. Trapps Downing Yellow Globe (Seed Savers – open pollinated)
17. Yankee (Johnny's, bred by Bejo)
18. Yellow of Parma (Johnny's – open pollinated)

Figure 1. Days to Maturity: Most of the varieties in the trial matured in 107-110 days after planting. Aptly named New York Early was the earliest to mature at 98 days and Red Carpet matured almost a week after the other varieties at 116 days.

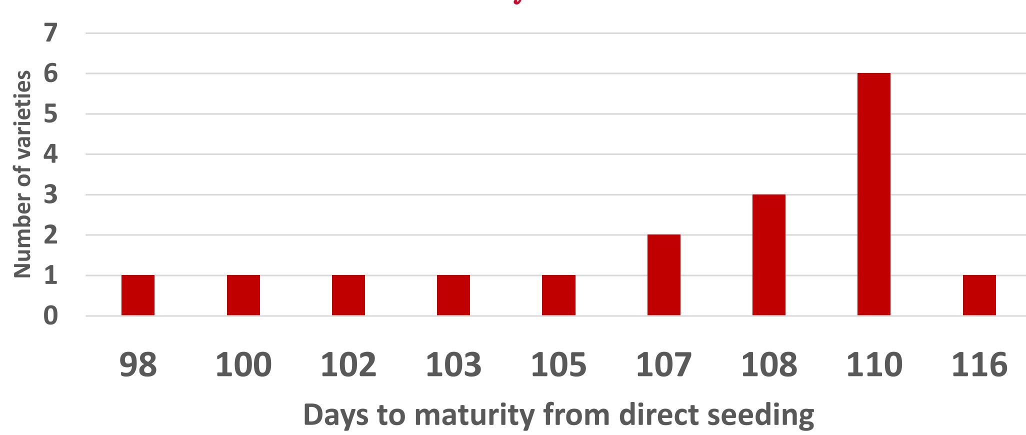


Table 1. Evaluation of Onion Appearance, Yield and Marketability.

Variety	Color	Days to Maturity	Description	Yield (lbs per acre)	Comments
Blush	Red	107	Nice color, round shape, nice skin, on the small side but uniform	38,565	
Calibra	Yellow	110	Deep color, round shape, nice thick skin, inconsistent size	33,686	
Cartier	Yellow	103	Nice round shape, overall small size, nice skins	27,530	
Cortland	Yellow	105	Shape was inconsistent and odd	46,232	Highest germination rate
Frontier	Yellow	100	Nice round shape, very pretty with nice skins, overall small size, consistent size and shape	28,575	
New York Early	Yellow	98	Inconsistent size	30,202	Hard to peel (layers came off oddly)
Oneida	Yellow	102	Good color, good size, nice round shape, easy to clean	42,515	
Powell	Yellow	108	Good size, round shape, relatively consistent, hard to clean	50,065	Second highest yielding
Red Carpet	Red	116	Nice shape and skin color, moderate size, some necks were oddly floppy	34,500	
Red Globe	Red	110	Pretty color, huge variation in size and shape (round to almost Cipollini shape), easy to clean	19,399	
Red Mountain	Red	107	Overall very nice – nice round shape, consistent size, large bulbs	48,903	Highest yielding red onion
Redwing	Red	110	Pretty color, huge variation in size and shape (round to almost Cipollini shape), easy to clean	34,500	
Rossa di Milano	Red	110	Johnny's: interesting shape, good color, inconsistent size. High Mowing: bulbs were larger, inconsistent size	32,874	Highest yielding open pollinated red onion
Sedona	Yellow	108	Round shape, huge size and consistent	58,312	Highest yielding variety, largest average bulbs, no culls
Talon	Yellow	110	Lots of small bulbs, hard to clean	32,757	
Trapps Downing Yellow Globe	Yellow		Variable shape (round to teardrop)	19,166	Lots of culls, issues with dry down
Yankee	Yellow	108	Nice round shape, relatively uniform in size and shape, thick skins, small necks	37,171	
Yellow of Parma	Yellow	110	Small size, decent skins, inconsistent size, round to oblong shape	30,318	Highest yielding open pollinated yellow

Peas
2020-2021 Variety Trials

Crystal Stewart-Cortens, Natasha Field
Host Farms: Phila Farm, Fulton County
Thank you to High Mowing Seeds, Pure Line Seeds, Territorial Seed, Adaptive Seeds, Fedco Seeds, and Harris Seeds for contributing to our trial contributing seeds to the trial

Planting: Trellised in high tunnel

2020: 11 varieties planted on March 31, 2020, and the other 8 were planted on April 9, 2020

2021: March 24, 2021. Comparison planting in tunnel outside failed due to unusual seed corn maggot pressure.

Harvest:

2020: Peas were harvested until plants either stopped producing pods or pods became unmarketable – last harvest was on July 1 2020.

2021: Peas were harvested until plants either stopped producing pods or pods became unmarketable – last harvest was on June 29 2021.

Notes: At end of 2020 season, all pea plants showed signs of heat stress and decline, no disease present. A deer did find and browse pea plants, affecting yield slightly. High heat in early 2021 season negatively impacted this year's taste tests. Peas also grew incredibly well in 2021 – yield may not be replicable.

Pea Varieties

1. Avalanche[20]
2. Cascadia[20]
3. Laxton's Progress[20]
4. Lincoln[21]
5. Magnolia Blossom[20]
6. Mammoth Melting[20]
7. Oregon Sugar Pod II[20]
8. Parlsey Pea[21]
9. PLS 14[20,21]
10. PLS534[20,21]
11. PLS560[20,21]
12. PLS566[20,21]
13. PLS595[20,21]
14. SS141[20,21]
15. SS32[20,21]
16. SS473[20,21]
17. Sugar Ann[20]
18. Sugar Daddy[20,21]
19. Super Sugar Snap[20,21]
20. Sweet Horizon[20]
21. Tendersweet[20,21]

Table 1. Evaluation of Pea Varieties

Variety	Type	Year	Days to Maturity	Length of Harvest (days)	Harvest Weight (oz)	Harvest Weight (lbs) per 100 ft	Average taste (1-5, with 5 being delicious)
Avalanche	Snow	2020	64	12	20.8	13	4.5
Cascadia	Snap	2020	78	7	27	17	4.8
Laxton's Progress	Shell	2020	73	12	39.8	25	4
Lincoln	Shell	2021	83	14	264	110	4
Magnolia Blossom	Snap	2020	78	12	51.8	32	4.5
Mammoth Melting	Snow	2020	73	19	66.6	42	3.8
Oregon Sugar Pod II	Snow	2020	67	18	43.6	27	3.7
Parlsey Pea	Garnish	2021	NA	NA	NA	NA	NA
PLS14	Shell	2020, 2021	73, 77	10, 13	15,147.40	9,61	4.5, 3.8
PLS534	Shell	2020, 2021	69, 72	5, 25	54, 156.4	34, 65	5, 3.8
PLS560	Shell	2020, 2021	78, 77	7, 13	35.2, 149.2	22, 62	4.5, 3.8
PLS566	Shell	2020, 2021	69, 77	7, 20	41.6, 170	26, 71	4, 3.5
PLS595	Shell	2020, 2021	74, 77	2, 20	30.6, 170	19, 71	3, 4
SS141	Snap	2020, 2021	72, 72	13, 25	26.6, 234.8	17, 98	5, 3.3
SS32	Snap	2020, 2021	69, 72	7, 25	23, 211	14, 88	5, 4.3
SS473	Snap	2020, 2021	76, 77	1, 20	10.4, 196.6	7, 82	4.5, 3.5
Sugar Ann	Snap	2020	67	25	47.2	30	4.2
Sugar Daddy	Snap	2020, 2021	69, 77	7, 20	26.8, 132.2	17, 55	4.8, 4
Super Sugar Snap	Snap	2020, 2021	72, 72	13, 25	53.6, 240	34, 100	4.5, 4.2
Sweet Horizon	Snow	2020	72	18	52	33	3
Tendersweet	Snap	2020, 2021	76, 72	1, 25	2, 149	1, 62	4, 4.3

Figure 1. 2020 Total Yield

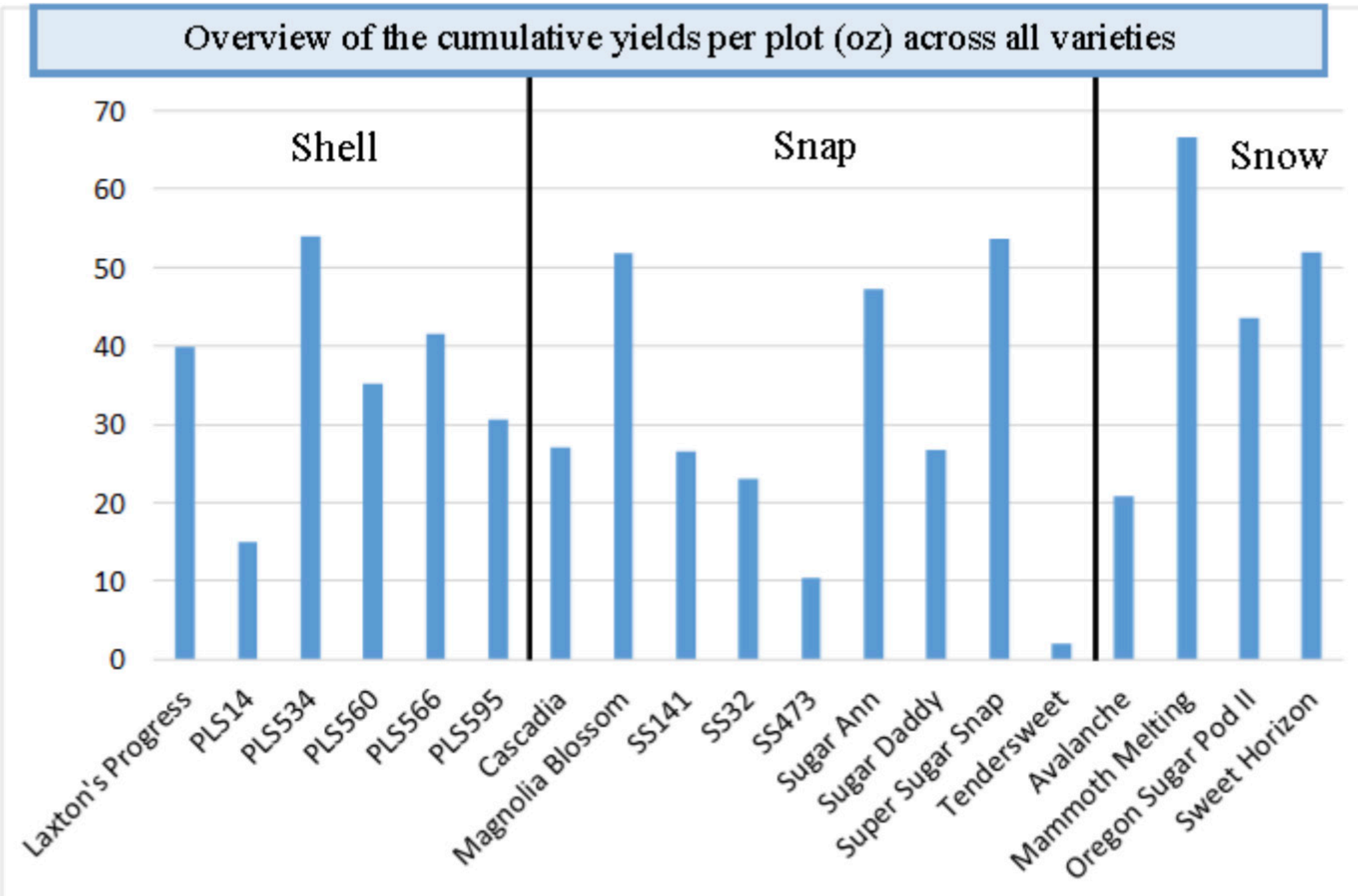
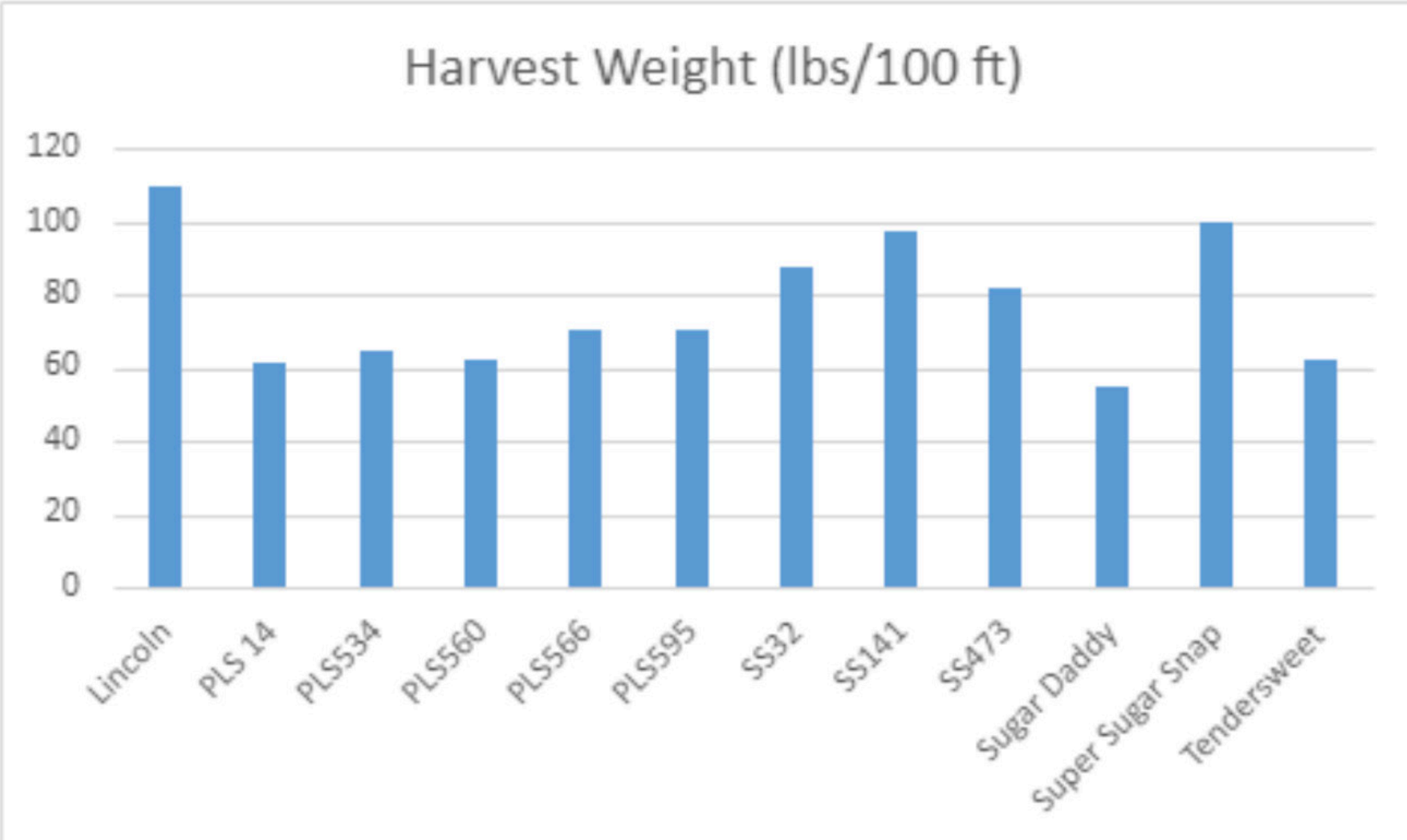


Figure 3. Pea Comparison Example

Figure 2. 2021 Total Yield



Potatoes
Variety Trials: 2017-2022

Chuck Bornt, Natasha Field

Host Farm: Barber's Farm (Middleburg, Schoharie County NY 2017-2019), Samascott Orchards (Kinderhook, Columbia County NY 2020-2022. Thank you to Childstock Farms (2017-2022), Cornell University Potato Breeding (2017-2022), University of Maine Potato Breeding (2017-2022), Michigan State University (2019-2022), University of Wisconsin-Madison Plant Breeding and Plant Genetics (2021-2022) for contributing to our trial.

Planting: Conventional

2017 – Schoharie County May 12, 2017 (row spacing 34", in row spacing 8") – irrigated 4 times in August
2018 – Schoharie County May 17, 2018 (row spacing 40", in row spacing 9") – dryland plot
2019 – Schoharie County May 31, 2019 and remainder June 10, 2019 (row spacing 40", in row spacing 8") – dryland plot
2020 – Columbia County May 7, 2020 (row spacing 30", in row spacing 12") – irrigated
2021 – Columbia County May 14, 2021 (row spacing 30", in row spacing 12") – irrigated
2022 – Columbia County April 29 2022 (row spacing 30", in row spacing 12") – irrigated

Harvest: No chemical desiccants used

2017 – Vines mowed over first week of September, dug up on September 27,
2018 – November 26, 2018
2019 – October 11, 2019
2020 – October 12, 2020
2021 – November 1, 2021
2022 – October 11, 2022

Grading

2017 – October 26, 2017
2018 – January 4, 2019
2019 – November 6, 2019
2020 – October 27 and November 7, 2020
2021 – November 18, 19, and 22, 2021
2022 – October 28 and November 1, 2022

Note for Table 1: Total Marketable Yield equals sum of marketable Chef's, A's and B's.

Potato Varieties

White Skin Lines

1. 747
2. AF11611-2
3. AF4138-8
4. AF4648-2
5. AF5225-1
6. AF5280-5
7. AF5563-5
8. AF5633-2
9. AF5682-3
10. AF5682-5
11. AF5819-2
12. AF6194-4
13. AF6541-3
14. AF6542-16
15. AF6559-4
16. Audrey
17. Belmonda
18. Butterfly
19. Eva
20. Golden Globe
21. Joli
22. Lehigh
23. Maggie
24. McBride
25. MSBB343-2Y
26. MSBB371-1YS
27. MST252-1Y
28. MSX156-1Y
29. NADF102629C-4
30. Natascha
31. NDAF102629C-4
32. NDAF1489-4
33. NY149
34. NY151
35. NY161
36. NY171
37. Paroli
38. Q112-5
39. R15-4
40. R203-1
41. R213-2
42. S40-1
43. S43-1
44. S48-1
45. Soraya
46. Sunshine
47. T61-4
48. Tacoma
49. Tessa
50. Tokio
51. W13103-2Y
52. W15234-5Y
53. W15240-2Y
54. W15248-17Y
55. WAF13058-1
56. WAF14096-5
57. Yukon Gold

Red Skin Lines

58. 6049
59. AF4331-2
60. AF4659-12
61. AF4831-2
62. AF6289-2
63. Baltic Rose
64. Chieftan
65. Dakota Ruby
66. Fenway Red
67. MSAA161-4
68. MSAA161-8
69. MSAA182-2R
70. MSBB238-1
71. MSCC553-1R
72. MSZ416-08
73. MSZ416-08RY
74. MSZ427-3R
75. NADF113484B-1
76. NDAF12143-1
77. NDAF12238Y-2
78. Norland
79. NY118
80. NY136
81. NY160
82. NY164
83. R20-3
84. R25-1
85. S51-1
86. S74-2
87. S77-1
88. T59-1

Specialty Lines

89. AF5245-1
90. AF5412-3
91. AF5414-1
92. AW081124PLY
93. Baltic Rose
94. Blackberry
95. Fleure Bleue
96. M12-3
97. Michigan Purple
98. MSAA101-1
99. MSAA101-1RR
100. MSAA157-2
101. MSAA183-2
102. MSZ108-08
103. MSZ109-08PP
104. MSZ413-6P
105. Purple Majesty
106. R219-1
107. Raspberry
108. S47-2
109. S47-3
110. S47-5
111. US Blue
112. WI6050

Russet Lines

113. AF3362-1
114. AF5164-19
115. AF5312-1
116. AF5406-17
117. AF5633-2
118. AF5707-1
119. AF5762-8
120. AF6338-6
121. AF6340-6
122. Caribou

Table 1. Potato Variety Evaluation by Type

			Yield of Marketable Tubers by Size Distribution (Cwt)			% of Marketable Yield by Size Distribution			
Variety Name	Skin/Flesh Color	Total Marketable Yield (Cwt)	Chef's (> 3")	#1 "A's" (>2.5")	"B's" (<2")	Chef's (%)	#1 "A's" (%)	"B's" (%)	Year
White Skin Lines									
747	White/White	301	16	193	92	5	NA	NA	2018
AF11611-2	White-Pink Splotch/ Yellow	252	38	187	26	15	74	10	2022
AF4138-8	Cream/White	133.4	4.93	65.83	62.64	3.7	49.35	46.96	2017
AF4648-2	White/White	235.48	5.51	152.83	77.14	2.34	64.9	32.76	2017
AF4648-2	White/White	205	23	144	38	11	NA	NA	2018
AF5225-1	White/Cream	189.95	0	73.95	116	0	38.93	61.07	2017
AF5225-1	White/Cream	194	16	130	49	8	67	NA	2019
AF5225-1	White/Yellow	353	104	224	25	29	NA	NA	2018
AF5280-5	White/White	156	13	89	54	8	57	NA	2019
AF5563-5	White/White	164	98	65	2	59	39	1	2021
AF5633-2	White	180.96	7.83	107.59	65.54	4.33	59.46	36.22	2017
AF5682-3	White/White	214	88	115	11	41	NA	NA	2018
AF5682-5	White/Yellow	159	41	97	21	26	NA	NA	2018
AF5819-2	White/White	192	77	108	8	40	56	4	2021
AF5819-2	White/White	164	52	108	4	32	66	3	2022
AF6194-4	White/White	202	77	121	4	38	60	2	2022
AF6541-3	White/Yellow	223	104	107	12	47	48	5	2021
AF6542-16	White/Yellow	154	14	112	28	9	73	18	2021
AF6559-4	White/White	206	54	141	11	26	68	5	2021
Audrey	White/White	107	10	52	45	10	48	NA	2019
Belmonda	White/Yellow	138	10	84	44	7	61	NA	2019
Belmonda	White/Yellow	193	65	116	12	34	60	6	2020
Belmonda	White/Yellow	385	23	263	99	6	NA	NA	2018
Butterfly	White/Yellow	274	0	47	227	0	NA	NA	2018
Eva	White/White	134.56	1.74	114.55	18.27	1.29	85.13	13.58	2017
Eva	White/White	350	145	196	9	41	NA	NA	2018
Golden Globe	White/Yellow	172	44	111	16	26	65	9	2020
Joli	White/White	287	56	174	57	20	NA	NA	2018
Lehigh	White/Yellow	356	172	174	9	48	NA	NA	2018
Maggie	White/Yellow	179	18	132	30	10	74	16	2020
McBride	Cream/cream	108.75	0	55.97	52.78	0	51.47	48.53	2017
MSBB343-2Y	White/Yellow	236	119	109	8	51	46	3	2022
MSBB371-1YS	White-Purple Splotch/Yellow	152	21	122	9	14	80	6	2022
MST252-1Y	White/Yellow	176	61	110	5	35	63	3	2021
MSX156-1Y	White/Yellow	75	21	51	4	27	68	5	2020
MSX1561Y	White/Yellow	110	37	61	12	34	55	NA	2019
NADF102629C-4	White/White	138	46	87	5	33	63	4	2020
Natascha	White/Yellow	80	7	46	26	9	58	NA	2019
Natascha	White/Yellow	179	24	118	38	13	66	21	2020
Natascha	White/Yellow	197	51	125	21	26	64	11	2021

			Yield of Marketable Tubers by Size Distribution (Cwt)			% of Marketable Yield by Size Distribution			
Variety Name	Skin/Flesh Color	Total Marketable Yield (Cwt)	Chef's (> 3")	#1 "A's" (>2.5")	"B's" (<2")	Chef's (%)	#1 "A's" (%)	"B's" (%)	Year
Natascha	White/Yellow	139	38	89	12	27	64	9	2022
Natascha	White/Yellow	223	4	119	100	2	NA	NA	2018
NDAF102629C-4	White/White	185	25	135	25	13	73	NA	2019
NDAF102629C-4	White/White	169	36	115	18	21	68	10	2021
NDAF1489-4	White-Purple Splotch/Yellow	226	30	177	19	13	78	8	2022
NY149	White, Pink Eyes/ Yellow	363	57	268	39	16	NA	NA	2018
NY149	White, Pink Eyes/ Yellow	151.38	0	68.44	82.94	0	45.21	54.79	2017
NY151	White/White	245.92	2.03	175.45	68.44	0.83	71.34	27.83	2017
NY151	White/White	374	122	217	35	33	NA	NA	2018
NY161	White/Purple Splash Eyes/Yellow	394	122	226	46	31	NA	NA	2018
NY161	White/Purple Splash Eyes/Yellow	203	1.45	121.22	80.33	0.71	59.71	39.57	2017
NY171	White-Purple Splotch/White	146	42	88	16	29	60	11	2020
NY171	White-Purple Splotch/White	200	83	99	18	41	50	9	2021
NY171	White-Purple Splotch/White	154	77	67	9	50	44	6	2022
Paroli	White/Yellow	118	20	50	48	17	43	NA	2019
Paroli	White/Yellow	169	53	108	7	31	64	4	2020
Q112-5	White/White	200	54	138	8	27	69	4	2020
Q112-5	White/White	150	30	110	10	20	73	7	2021
R15-4	White/White	157	64	87	6	41	56	4	2021
R15-4	White/White	281	108	165	8	38	59	3	2022
R203-1	White/Yellow	246	124	108	14	50	44	6	2021
R213-2	White/Yellow	154	8	118	27	5	77	18	2021
R213-2	White/Yellow	292	47	223	23	16	76	8	2022
S40-1	White/Yellow	92	3	74	15	3	80	17	2020
S43-1	White to Pink/ Yellow	157	0	116	41	0	74	26	2020
S48-1	White/Yellow	82	2	76	4	2	93	5	2020
Soraya	White/Yellow	216	61	131	23	28	NA	NA	2018
Sunshine	White/Yellow	98	13	41	44	13	42	NA	2019
T61-4	White/Yellow	194	0	106	87	0	55	45	2022
Tacoma	White/Yellow	110	3	54	52	3	50	NA	2019
Tacoma	White/Yellow	111	21	66	23	19	60	21	2020
Tessa	White/Yellow	52	5	24	24	9	45	NA	2019
Tokio	White/Yellow	124	1	42	80	1	34	NA	2019
W13103-2Y	White/Yellow	197	42	136	18	21	69	9	2022
W15234-5Y	White/Yellow	167	10	125	32	6	75	19	2022

			Yield of Marketable Tubers by Size Distribution (Cwt)			% of Marketable Yield by Size Distribution			
Variety Name	Skin/Flesh Color	Total Marketable Yield (Cwt)	Chef's (> 3")	#1 "A's" (>2.5")	"B's" (<2")	Chef's (%)	#1 "A's" (%)	"B's" (%)	Year
W15240-2Y	White/Yellow	105	12	82	11	11	78	11	2022
W15248-17Y	White/Yellow	189	12	165	12	6	87	7	2022
WAF13058-1	White/Yellow	178	73	90	16	41	50	9	2021
WAF14096-5	White/Yellow	269	51	216	2	19	80	1	2022
Yukon Gold	White/Yellow	141	51	85	5	36	60	3	2020
Yukon Gold	White/Yellow	110	58	49	3	53	44	3	2021
Yukon Gold	White/Yellow	212	106	98	9	50	NA	NA	2018
Red Skin Lines									
6049	Red/Yellow	387	23	270	94	6	NA	NA	2018
AF4331-2	Red	173.71	0	52.49	121.22	0	30.22	69.78	2017
AF4659-12	Red/Yellow	244.18	0	109.33	134.85	0	44.77	55.23	2017
AF4831-2	Red/White	357	58	234	65	16	NA	NA	2018
AF6289-2	Red/White	199	68	125	7	34	63	3	2022
Baltic Rose	Red/Yellow	100	6	48	46	6	48	NA	2019
Baltic Rose	Red/Yellow	251	70	166	15	28	66	6	2020
Baltic Rose	Red/Yellow	242	36	181	25	15	75	10	2021
Chieftan	Red/White	333	141	174	18	42	NA	NA	2018
Dakota Ruby	Red/White	329	36	226	67	11	NA	NA	2018
Fenway	Red/White	95	4	51	40	4	53	NA	2019
Fenway Red	Red/White	324	123	173	28	38	NA	NA	2018
MSAA161-4	Red/Yellow	174	31	120	23	18	69	13	2020
MSAA161-8	Purple-Red/Yellow	213	83	121	9	39	57	4	2021
MSAA182-2R	Red/White	148	4	113	31	3	76	21	2022
MSBB238-1	Red/Yellow	199	49	117	33	24	59	17	2020
MSCC553-1R	Red/White	164	38	116	11	23	71	7	2022
MSZ416-08	Red/Yellow	121	51	60	11	42	49	9	2021
MSZ416-08RY	Red/Yellow	222	39	136	46	18	61	NA	2019
MSZ416-08RY	Red/Yellow	104	23	73	8	22	70	8	2020
MSZ427-3R	Red/White	173	54	111	8	31	64	5	2021
NADF113484B-1	Red/White	130	26	99	4	20	77	3	2020
NDAF113484B-1	Red/White	159	14	106	39	9	66	NA	2019
NDAF113484B-1	Red/White	209	77	128	4	37	61	2	2021
NDAF113484B-1	Red/White	220	64	147	9	29	67	4	2022
NDAF113484B1	Red/White	249	91	139	19	37	NA	NA	2018
NDAF12143-1	Red/White	135	21	106	9	16	78	6	2021
NDAF12238Y-2	Red/White	251	58	174	18	23	70	7	2022
Norland	Red/White	272	92	150	30	34	NA	NA	2018
NY118	Red/White	161.24	10.15	121.22	29.87	6.29	75.18	18.53	2017
NY118	Red/White	130	72	54	4	56	42	3	2020
NY118	Red/White	100	17	73	10	17	73	10	2021
NY118	Red/White	188	115	71	3	61	37	2	2022
NY136	Red/White	220	97	100	23	44	NA	NA	2018
NY160	Pink/White	161	5	124	32	3	77	20	2021

			Yield of Marketable Tubers by Size Distribution (Cwt)			% of Marketable Yield by Size Distribution			
Variety Name	Skin/Flesh Color	Total Marketable Yield (Cwt)	Chef's (> 3")	#1 "A's" (>2.5")	"B's" (<2")	Chef's (%)	#1 "A's" (%)	"B's" (%)	Year
NY164	Red/White	213.44	18.56	47.85	147.03	8.7	22.42	68.89	2017
NY164	Red/White	352	105	214	33	30	NA	NA	2018
NY164	Red/White	143	31	85	27	21	60	NA	2019
R20-3	Red/Yellow	222	23	108	91	11	49	NA	2019
R25-1	Red/White	105	0	64	41	0	61	NA	2019
S51-1	Pink/White	49	0	37	12	0	76	24	2020
S74-2	Red/White	124	0	72	53	0	58	42	2020
S74-2	Red/White	64	0	44	20	0	69	31	2021
S77-1	Red/White	120	0	73	47	0	61	39	2020
T59-1	Red/White	156	24	120	12	15	77	8	2022
Specialty Lines									
AF5245-1	Purple/White	154.86	4.06	79.75	71.05	2.62	51.5	45.88	2017
AF5245-1	Purple/White	196	45	127	25	23	NA	NA	2018
AF5245-1	Purple/White	131	7	80	45	5	61	NA	2019
AF5412-3	Purple/Purple	314	134	147	33	43	NA	NA	2018
AF5412-3	Purple/Purple	107	21	74	13	20	69	NA	2019
AF5412-3	Purple/Purple	182	90	83	10	49	45	5	2020
AF5412-3	Purple/Purple Starburst	216	149	61	5	69	28	3	2021
AF5412-3	Purple/Purple	193	102	86	6	53	45	3	2022
AF5414-1	Red/Pink	163.85	0	93.09	70.76	0	56.81	43.19	2017
AF5414-1	Red/Pink	447	65	303	79	14	NA	NA	2018
AF5414-1	Red/Pink	225	12	114	98	5	51	NA	2019
AF5414-1	Red/Pink	153	37	97	19	24	64	12	2020
AF5414-1	Red/Pink	196	76	110	10	39	56	5	2021
AF5414-1	Red/Pink	218	81	121	17	37	55	8	2022
AW081124PLY	Purple/Yellow	217	8	158	51	4	73	24	2021
Baltic Rose	Red/Yellow	123	53	63	7	43	52	5	2022
Blackberry	Purple/Dark Purple	202	0	95	107	0	47	NA	2019
Blackberry	Purple/Purple	134	0	83	51	0	62	38	2020
Fleure Bleue	Dark Blue/Purple Starburst	391	35	135	220	9	NA	NA	2018
M12-3	Dark Blue/Starburst Blue	400	71	295	35	18	NA	NA	2018
Michigan Purple	NA	301.6	51.04	211.99	38.57	16.92	70.29	12.79	2017
MSAA101-1	Red/Pink	136	22	106	9	16	78	6	2020
MSAA101-1RR	Red/Red	210	45	151	14	21	72	7	2021
MSAA157-2	Purple/Yellow	127	37	79	12	29	62	9	2020
MSAA183-2	Purple/Yellow	204	19	153	32	9	75	NA	2019
MSZ108-08	Purple/Purple	106	6	79	21	6	74	20	2020
MSZ109-08PP	Purple/Purple	133	33	91	9	25	68	7	2021
MSZ413-6P	Purple/White	144	22	114	8	15	79	6	2020
MSZ413-6P	Purple/White	143	11	122	9	8	86	7	2021

			Yield of Marketable Tubers by Size Distribution (Cwt)			% of Marketable Yield by Size Distribution			
Variety Name	Skin/Flesh Color	Total Marketable Yield (Cwt)	Chef's (> 3")	#1 "A's" (>2.5")	"B's" (<2")	Chef's (%)	#1 "A's" (%)	"B's" (%)	Year
Purple Majesty	Purple/Purple	228	1	47	181	1	NA	NA	2018
R219-1	Red/Red	170	8	105	57	5	62	NA	2019
Raspberry	NA	84.1	0	8.12	75.98	0	9.66	90.34	2017
S47-2	Purple/Purple	83	0	18	65	0	22	78	2020
S47-3	Purple/Purple Starburst	135	1	82	53	1	60	39	2020
S47-5	Purple/Purple	33	0	14	20	0	41	59	2020
US Blue	Blue/ Starburst Blue	234	31	89	114	13	NA	NA	2018
WI6050	Purple/Yellow	155	4	114	37	3	73	24	2021
Russet Lines									
AF3362-1	Russet/White	161	108	65	14	51	NA	NA	2018
AF3362-1	Russet/White	182	82	88	12	45	48	NA	2019
AF3362-1	Russet/White	112	66	42	5	59	37	4	2020
AF3362-1	Russet/White	162	112	45	5	69	28	3	2021
AF5164-19	Russet	129.05	16.82	86.71	25.52	13.03	67.19	19.78	2017
AF5312-1	Russet/White	183.28	4.35	127.31	51.62	2.37	69.46	28.16	2017
AF5312-1	Russet/White	234	53	148	23	27	NA	NA	2018
AF5406-17	Russet	110.78	18.56	65.25	26.97	16.75	58.9	24.35	2017
AF5633-2	Russet	180.96	7.83	107.59	65.54	4.33	59.46	36.22	2017
AF5707-1	Russet	235	105	116	15	45	49	6	2022
AF5762-8	Russet	201	98	92	10	49	46	5	2022
AF6338-6	Russet	163	98	57	9	60	35	5	2021
AF6340-6	Russet	274	109	152	13	40	55	5	2022
Caribou Russet	Russet	196	146	43	8	74	22	4	2022

Pumpkins
2015 & 2018 Variety Trial

Chuck Bornt, Natasha Field

Host Farm: Wertman's Farm &Greenhouse (Melrose NY) & Robert O. Davenport and Sons Farm in Kingston, NY (Ulster County). Thank you to Harris Seeds, Stoke Seeds, Seedway, Rupp Seed, Sakata Seed, &Johnny's Selected Seeds for contributing to our trial.

Planted:
2015: June 11, 2015
2018: May 30, 2018

Hand-seeded using jab planter – planted on 400lbs per acre 19-19-19 at planting through the planter

Bed preparation:

2015: Each plot 2 rows wide, 6 hills per row (12 hills per plot), 2 seeds per hill = 24 seeds per plot

2018: Planted on six foot centers with in row spacing varying determined by the seed company [row spacing at Wertman's was 5ft, row spacing at Davenport's was 6ft]

Application (2018 ONLY):
0.5 ounces Sandea,
1.0 pints Command ME and 1 pint Dual Magnum per acre applied immediately after planting; top-dressed with 150 pounds urea in mid-July; 5 Fungicide applications starting last week in July (Alternated weekly between Quintec, Torino, Procure, Vivando plus Bravo)

Windrowed:
third week of September for data collection

Moved/Harvest:

2015: Harvested October 6, 2015
2018: Pumpkins were moved (from Field to Greenhouse)

Pumpkin Varieties

1. Ares*
2. Bayhorse Gold
3. Bellatrix
4. Big Loretta
5. Bisbee Gold
6. Blanco
7. Blaze
8. Capital
9. Cargo*
10. Cinnamon Girl*
11. Conquest 880
12. Cronus*
13. Denali 8775
14. Dynasty 8746
15. Early Abundance*
16. Edison 8902
17. Eros
18. Eureka 8747
19. Flame
20. Gumdrop
21. HMX53L6790
22. HMX53M6724
23. HSC 151
24. Hulk
25. Igor
26. Jason
27. JPN 62005R
28. Kratos*
29. Little Giant
30. Miniwarts
31. Naked Bear
32. Orange Sunrise
33. Orion 8883
34. Pegasus 8870
35. Racer Plus*
36. Renegade
37. Rhea*
38. RPX 5588
39. RPX 6208
40. RPX 6229
41. RPX 6680
42. RPX 6927
43. Secretariat
44. Skidoo Gold
45. Spark
46. Specter
47. Tallon
48. Thor
49. Warty Gnome
50. Warty Goblin*
51. Zeus*

Table 1. Pumpkin Variety Information

Variety Name	Year	Days to Harvest	In Row Spacing	Average Weight	Average Height (in)	Average Width (in)	Comments
Ares*	2015, 2018	115	7	19.5	13.8	11.5	Shape is lovely. Tall-round to tall, tall-round elongate. Not as big as Hulk &Big Loretta. Handles are there but all doughtly, whithering up, not attractive. Fruit shape is lovely &so is color. Medium ribbing, even. Attachments are good but the handles are crap. Pretty dense &heavy.
Bayhorse Gold	2018	100	5	16.4	10.3	10.3	Tall-round, barrel-round, round-round shapes. Medium to dark orange. Fairly good stems, well dried, grey color. Well anchored. Medium to deep numerous ribs. A really nice fruit. Very solid fruit.
Bellatrix	2018	95	4	15.2	9.3	10.7	Smooth fruit. 4 of 6 have basically no ribbing, some variability in this. Handles are only half decent, dried to grey/black. Round to tall-round, barrel shape. Don't mind it too much if handle was better.
Big Loretta	2018	105	5.3	27.6	14.1	10.9	Tall-round, tall-tall elongated shape. Mostly bad stems. Color is orange/yellow. Ribbing is variable, some with med/deep ribs &some are very slight. Shape is okay. Minimal heft.
Bisbee Gold	2018	90	4	4.5	5.7	6.1	Tall-round pie. Stems are marginal at best, only 1 of 8 has a okay stem, rest frayed open. Medium to dark orange. Some nice ribbing, some very slight. A little variable in size.
Blanco	2018	100	3	N/A	N/A	N/A	Grown as a spacer
Blaze	2018	100	1.5	2.2	3.3	5.8	Small, flat, round to very flat &round. Orange striped yellow with green mottling. Whispy handle, falling apart, thin &papery, very soft. Okay variety, Size variation present. 1/2 pound to 2 pounds. Some have pointed shape at handle attachment, others have a little dip.
Capital	2018	95	3	9.3	8	8.6	Several fruit have deep, numerous ribs look nice. Bad stems. Medium orange color. Meh overall. Tall-round fruit.
Cargo	2015, 2018	100	4	14.3	9.1	11.4	Only one fruit harvested &it's not bad. Hard dried stem to black grey color. Medium to slight ribbing. Medium dark orange color, similar to 15 in color. Pretty nice pumpkin if we could see more of them.
Cinnamon Girl	2015, 2018	85	2	N/A	N/A	N/A	Grown as a spacer
Conquest 880	2018	100	6	19.1	11.4	10.9	Really nice. Round-round, to tall-round, slightly pointed, variability. Massive stems, 2.5 inches diameter, dried grey/black &rock solid. Ribs are deep, narrow, numerous, with some wide deep ribs. Wholesale might have some concerns because of variable shape. Retail would be great. Good size, very heavy &thick, hefty.

Variety Name	Year	Days to Harvest	In Row Spacing	Average Weight	Average Height (in)	Average Width (in)	Comments
Cronus*	2015, 2018	115	7	21.4	9.6	12.2	Long handles that are okay, dried &fragile, don't hold up. Fruit is beautiful, round-round to tall-round, fairly uniform, very nice. Burnt orange/dark orange color. Medium rib. A little texture to skin. Barrel shapes to squat round.
Denali 8775	2018	95	6	26.2	12.5	12.2	All over the place shape wise. Goes from tall-round elongated to round-round, some high shoulders. Lots of ribs, orange/yellow color. Okay stems, for the size of the fruit, it would be nice to have bigger, some doughty when dried down, cracking pretty easy. Interesting shape but might not fly with consistency.
Dynasty 8746	2018	95	6	17.7	10.1	11.1	Okay. Handles are not great, variable, 3 have shrivled, one missing a stem, 2 have okay handles. Round-round shape. Medium orange color, average. Medium rib. Average pumpkin. Decently dense &hefty.
Early Abundance*	2015, 2018	90	2.5	4.8	5.6	6.6	Pie type, not bad. Really thick handle compared to fruit size, rock hard, tan/grey color to stem. Dark burnt orange color. Decent ribbing, not deep. Good attachment on the handle. A good medium sized pie. Round-round shape, very uniform.
Edison 8902	2018	100	3	11.3	9.1	9.2	Varies from squat barrel shape to a tall-round, variable shape, all over the place. Stems aren't good, some have long stems &dried okay. Orangy brown color. Some nice ribbing. Very dense fruit.
Eros	2018	100	4	10.1	7.9	9	Stems are terrible, dried &withered, frayed. Dark orange color, nice. High shoulder. Handles are well attached but garbage. Medium to deep rib. Light heft.
Eureka 8747	2018	100	3	12.5	8.6	10.3	Pretty uniform, flat-round, squat round to barrel shaped. Fairly well ribbed, medium to deep with numerous ribs so it looks nice. Handles aren't nice. Medium orange with some yellowy/orange. A little green background mottling that might be virus. Dense, heavy fruit.
Flame	2018	90	1.5	0.8	2	3.5	Munchkin type, Creamy to yellow skin with more orange in the ribs. Some more white &some more orange. Some 1/4 to a pound. High shoulders, deep ribs, flat type. Variation in shape - some more rounded. Grey, hard stems, firm handles.
Gumdrop	2018	95	2	7.5	7	7.6	Variable shape, but pleasing. Teardrop shape, a point near the top. Thick handles, dried down hard, grey color. Great attachments. Fairly ribbed &looks nice, catches the eye. Dark orange color, quite appealing.
HMX53L6790	2018	N/A	7	N/A*			One fruit harvested at observational trial
HMX53M6724	2018	N/A	4	N/A	N/A	N/A	None harvested

Variety Name	Year	Days to Harvest	In Row Spacing	Average Weight	Average Height (in)	Average Width (in)	Comments
HSC 151	2018	100	1.5	6.9	7.3	7.5	Naked seed variety, similar to Kakai. Tall-round, yellow with green splotches. Has more shoulder. Good stems, tan-grey but very hard. Tasty seeds when roasted. Fine looks but culinary use may be better.
Hulk	2018	100	5.3	22.8	13.7	10.1	Tall-round, tall-tall elongated shape. It's pretty nice. Some of the stems are dodgy, 4 of 9 have dried grey nicely, 5 are doughty. Great carver type. Color is medium orange, with some russeting in the back. Medium rib, skin is smooth. Nice but stems are a concern. A few stems are beautiful, a few are questionable. Okay heft.
Igor	2018	N/A	5	21.5	12.4	11.5	Interesting! Tall to tall-round to elongate-round. Ribs are very numerous &very deep. Skin texture is rippled. Okay handles, not the best. Kinda freaky looking, very cool. Some potential here similar to Mrs. Wrinkles, but this is taller. Beautiful ribs. Color is orangy brown, hard to describe. Pretty heavy.
Jason	2018	100	6	17.2	11.2	10.2	Intersting. Very uniform in shape, color, size. Tall-round shape but not super big. Medium category. Handles- of 6 fruit, 1 is nice, the rest are doughty, 3 very doughty. Shape &size is nice. Smaller carver or porch pumpkin. Got medium to dark orange color. Medium to deep ribs, fairly numerous.
JPN 62005R	2018	N/A	6	17.4	9.2	11.9	Nice, squat-round to round-round. Uniform shape. Handles are very nice, 6 of 7 have dried to black/grey &are very solid. Orangy brown color. Medium ribs, even. Nice pumpkin. Potential for medium/large jack. Two fruit didn't take frost well but they are lighter color.
Kratos*	2015, 2018	100	7	18.1	11.3	12	Beautiful, barrel shape round. Tall-round to round-round. Dark orange color. Nice medium rib. Nice handles, short &stocky, dried down pretty good, good anchors. Solid fruit, hefty. Medium rib, decent number of ribs.
Little Giant	2018	100	2	N/A	N/A	N/A	Grown as a spacer
Miniwarts	2018	110	4	2	4.3	5	Small warted variety. Hard as nails stems dried down. Mostly orange color with green/yellow/ orange warts. Not a dark orange, but a bright, happy orange. Round-round, very uniform. Excellent for this size market. Light heft
Naked Bear	2018	105	3	2.3	4.2	5.4	Naked seed variety, small, yellow skin. Big, thick, short stems dry very hard, grey/beige color. Round, squat fruit with good stem attachment. Seeds tasty when roasted.
Orange Sunrise	2018	80	3	12.6	9.8	9.6	Not bad looking, medium to dark orange color. Nice jack o lantern orange. Stems aren't terrible, dried down to grey/black color, very well attached. Fruit is tall-round, to medium tall-round to a round-round. Decent ribbing, shallow rib but numerous, makes it look nice. It's okay.

Variety Name	Year	Days to Harvest	In Row Spacing	Average Weight	Average Height (in)	Average Width (in)	Comments
Orion 8883	2018	95	6	17.6	11.3	11.2	Okay pumpkin. Tall-round to round-round. Stems are nice, grey color. Color is medium orange overall with one orange/yellow with some medium/dark orange. Medium to slight ribs. Not smooth. Handles could be bigger in comparison to fruit size.
Pegasus 8870	2018	95	3	13.1	9.1	9.5	Handles dried down rock hard but aren't very big, nicely sized for the fruit. Round-round, to barrel-round shape. Medium orange to yellow orange in color. Okay ribbing. High shoulders, stem in a little pocket. Fruit are very solid &heavy in comparison to same sized fruit.
Racer Plus*	2015, 2018	85	3	9.7	7.4	9.4	Round to squat-round shape. Stems are terrible, soft &withered &dry, brittle. Orangy brown color. Medium rib. It's a pumpkin.
Renegade	2018	120	3	10.5	8	9.1	Handles are frayed &not good, breaking. Round-round shape. Fairly uniform in shape &size. Only 2 out of 8 have even okay handles, the rest are bad. Medium rib. Color is medium to dark orange.
Rhea*	2015, 2018	110	7	15.6	8.6	11.2	Decent size, massive stems on some, some are a little whithered &doughty but not too bad. Round-round to squat-round, traditional cinderalla type pumpkin. Medium to dark orange color. Medium even ribbing, nicely placed.
RPX 5588	2018	100	5	11.8	8.9	9.6	Pretty heavy. Really nice, fairly uniform. Round-round shape. Stems have dried down grey, but nice. Medium, numerous ribs. Dark orange color. Really nice fruit for a medium size.
RPX 6208	2018	100	5	13.5	10.5	10.2	Not bad. Tall to round-round. Stems are thick &great, dried down nicely. A nice dark orange color, not burnt. A little texture to skin. Great handle anchors. Fruit are heavy/hefty.
RPX 6229	2018	90	6	9.7	9.1	8.3	Tan to yellow color. Round-round to slightly tall-round. Uniform in shape. Lighter color might be younger fruit. Medium rib, nice handles. Flecking in the skin, orange/brown flecks. Okay ornamental for some color variety. Down at Davenports, they are more dark tan/brown.
RPX 6680	2018	90	5	5.2	6	6.7	Love this. Tall-round to round-round pie. Beautiful dark orange color. Great stems, hard as rocks, dried down to grey. Fairly uniform. Medium, numerous ribs. Beautiful color, very pretty.
RPX 6927	2018	90	5	6.5	6.3	7.9	White pumpkin. Held color very well in the field into late season. Slight yellowing but mostly white. Stems are okay, short &a little thin but some dried okay. Round to squat-round shape. Medium ribbing. Fairly smooth skin texture. Impressed with color.

Variety Name	Year	Days to Harvest	In Row Spacing	Average Weight	Average Height (in)	Average Width (in)	Comments
Secretariat	2018	105	4	11.9	8.2	10.3	Excellent shape. Handles are in good shape. Barrel shape to round round/squat round with some variability but all nice. Deep ribbing, very nice, numerous. Anchors are excellent &very nice looking. Light heft.
Skidoo Gold	2018	90	5	10.1	7.2	8.5	Medium to dark orange, dark dark orange color. Very short stem, 1.5-2 inch stems, 7 fruit, 3 with nice hard stems, grey, rest are doughty. Shape is round-round, basketball size, decent size.
Spark	2018	90	1.5	0.4	1.5	2.8	Munchkin type but much smaller than Flame. Same coloration, tan/yellow orange in ribs, green mottling. Very uniform. Nice handles. High shoulders. Looks nice, decent yield. Flat, round, deep ribs, true munchkin. Dark orange in ribs, some with mottly orange, some with creamy orange with distinct orange in the ribs.
Specter	2018	95	4	11	8.2	9.5	A white variety, but yellow like a lemon after field sitting. Raised bumps &warts. Goes from a round-round to a tall-round. Handles aren't great. Out of 8 fruit, 3 good handles, rest are frayed &falling apart. A little black rot coming on these, &they may be more susceptible. Unique &different but not sure on market fit yet. Some have nice ribbing &some are smooth. Light fruit.
Tallon	2018	N/A	7	22.3	12.8	12.3	Tall-round, not quite elongated. These are fragile, doughty handles, won't hold up. Shape is lovely. Beautiful dark orange color, a little russeting. Ribbing is nice. Beautiful pumpkin with poor handles. Not super heavy for their size.
Thor	2018	105	4	14.8	9.3	10.5	Beautiful dark orange color, a little mottling behind it. Lumpy possibly due to virus. Horrible handles, might be the worst, nothing left to them. Shape is round round. Can't pick up to judge heft.
Warty Gnome	2018	95	5	2.5	3.3	5.8	Similar to Blaze but with warts. Space saucer shaped. Yellow background, dark yellow with yellow orange, medium dark orange on the ribs. Stems have dried rock hard, nice stems, 3 inches long, some longer. Lovely ribbing. For specialty market, it is nice. Pretty uniform.
Warty Goblin*	2015, 2018	105	4	12.7	8.8	10.4	Warted, larger variety. Tons of warts. Dark orange color with lighter/green warts which is cool. Stems are dried well &hard so they're solid. Retail sales would be good but packing in boxes might not go so well. Decently solid heft.
Zeus*	2015, 2018	110	4	11.3	9	10.1	Similar to Eros, smaller jack type. Color from dark orange to yellow/orange. Stems are whithered &doughty. Medium rib. Overall, not impressed.

Sweet Potato
2019 & 2020 Variety Trials

Chuck Bornt, Natasha Field
Host Farms: Morgiewicz Produce, Orange County and Samascott Orchards, Columbia County
Thank you to Jones Family Farm and Louisiana State University for contributing slips to the trial

Planting

In 2019 planting dates varied based on when we received the slips. In 2020 it varied by location of the trial.

- June 7, 2019: Bonita, Covington (purchased slips), Orleans, Averre, Bellevue, NC-531, Burgandy
- June 12, 2019 Production trial NY Covington slips
- June 13, 2019 Murasaki, sized slip trial
- June 19, 2019: 14-31, B-14 [Beauregard], 445
- June 3, 2020, Orange County trial
- June 4, 2020, Columbia County trial

Planted on 6.5 foot center raised black plastic mulch. All slips were planted 12 inches apart in-row.We trialed both 1 row and 2 row planting systems, with the 1 row centered in the plastic and the 2 rows being approximately 18 inches apart. 25 foot sections were planted and 10 feet of each section was harvested and graded.

Harvest:
October 15, 2019
September 24, 2020 (Orange County)
September 25, 2020 (Columbia County)

Slip production trial 2019

Growing slips has the advantage of helping a grower control timing of planting and control of supply of specific varieties. To test if growing slips makes economic sense in New York, we grew slips from roots in a greenhouse to determine cost and quality of producing slips. We planted roots in four different soil mediums on May 3rd in harvest totes lined with hardware cloth to keep the medium in the container. 20-28 roots fit in each tote. Soil mediums were sand, wood shavings, BM mix, 50/50 BM mix and sand. 2 inches of medium was placed in the bottom, roots placed on it and then more medium put in until roots were covered. We found that BM mix and 50/50 BM/ sand produced the most slips the fastest.

Totes were placed in a greenhouse on a heat mat with temperature set to 90 degrees F. Roots were watered when dry and slips were cut directly before field planting on 6/12/19. We harvested 80-150 slips out of each tub and planted them out into the field same day as cutting. They were planted 5 days later than the shipped Covington slips. It took roughly 40 days from planting roots to harvesting slips. The cost of producing slips was about the same as purchased slips. We also found that our NY-grown slips produced twice the marketable yield as purchased slips. Roots were more uniform, longer and straighter.

Sweet Potato Varieties

1. 14-31 [19]
2. 445 [19]
3. Averre [19,20]
4. B-14/Beauregard [19,20]
5. Bayou Belle [20]
6. Bellevue [19,20]
7. Bonita [19]
8. Burgundy [19,20]
9. Covington [19,20]
10. Murasaki [19,20]
11. NC-531 [19,20]
12. Orleans [19,20]

Graded slip trial 2019

Three reps were planted, harvested and averaged. Murasaki was the variety left at the time of planting so it was used for all reps in this trial. Small slips had 2-3 nodes with small diameter and very short, average length was 3.5 inches. Medium slips had at least 3-4 nodes and an average length of 6.7 inches. Large slips had at least 7 nodes and were at least 11 inches, with an average of 12 inches. Slips were planted at 12 inch spacing, one row, in 25 foot sections but were not replanted. A 10 foot section was harvested.

We found that it is most likely not worth planting the smallest slips since they were likely to die and needed replanting. Medium and small slips also generally produced fewer marketable roots than large slips and smaller-sized roots.

Table 1. Sweet Potato Variety Information

Variety	Year	Skin/Flesh Colors	Total Marketable Yield (lbs/acre)	Total Yield (lbs/acre)	County
445	2019	Red/orange	27804	39232	Orange
445	2019	Red/orange	17592	19028	Columbia
14-31	2019	Purple/purple	8485	12419	Orange
14-31	2019	Purple/purple	13735	16947	Columbia
Averre*	2019	Red/orange	31882	50108	Orange
Averre*	2019	Red/orange	18925	39173	Orange
Averre*	2019	Red/orange	27332	29028	Columbia
Averre*	2019	Red/orange	19526	20293	Columbia
Averre*	2020	Red/orange	47532	8.9	Orange
Averre*	2020	Red/orange	33473	33433	Columbia
Averre*	2020	Red/orange	30827	29641	Columbia
B-14 (Beauregard)*	2019	Red/orange	41921	42625	Columbia
B-14 (Beauregard)*	2019	Red/orange	35510	35569	Columbia
B-14*	2019	Red/orange	27095	48839	Orange
Bayou Belle	2020	Dark red/dark orange	37519	9.5	Orange
Bayou Belle	2020	Dark red/dark orange	49279	49232	Columbia
Bayou Belle	2020	Dark red/dark orange	39175	39135	Columbia
Beauregard*	2020	Red/orange	41441	9	Orange
Beauregard*	2020	Red/orange	43309	43289	Columbia
Beauregard*	2020	Red/orange	42813	42800	Columbia
Bellevue*	2019	Orange/orange	22179	32657	Orange
Bellevue*	2019	Orange/orange	14942	19094	Orange
Bellevue*	2019	Orange/orange	15125	18517	Columbia
Bellevue*	2019	Orange/orange	6323	6474	Columbia
Bellevue*	2020	Orange/orange	38408	7.6	Orange
Bellevue*	2020	Orange/orange	41453	41312	Columbia
Bellevue*	2020	Orange/orange	39523	39409	Columbia
Bonita	2019	White/white	25282	40649	Orange
Bonita	2019	White/white	24140	32711	Orange
Bonita	2019	White/white	23370	24698	Columbia
Bonita	2019	White/white	14547	15000	Columbia
Burgundy*	2019	Dark red/dark orange	32274	44831	Orange
Burgundy*	2019	Dark red/dark orange	14220	21770	Orange
Burgundy*	2019	Dark red/dark orange	9849	10749	Columbia
Burgundy*	2019	Dark red/dark orange	5511	8438	Columbia
Burgundy*	2020	Dark red/dark orange	39520	10.4	Orange
Burgundy*	2020	Dark red/dark orange	47952	47932	Columbia
Burgundy*	2020	Dark red/dark orange	35892	35858	Columbia
Covington*	2019	Red/orange	18725	30911	Orange
Covington*	2019	Red/orange	11729	25405	Orange
Covington*	2019	Red/orange	19794	20523	Columbia

Table 1. Sweet Potato Variety Information

Variety	Year	Skin/Flesh Colors	Total Marketable Yield (lbs/acre)	Total Yield (lbs/acre)	County
Covington*	2019	Red/orange	19011	19966	Columbia
Covington*	2020	Red/orange	45051	8.1	Orange
Covington*	2020	Red/orange	31108	31021	Columbia
Covington*	2020	Red/orange	27577	26150	Columbia
Murasaki*	2019	Purple/white	13445	17373	Orange
Murasaki*	2019	Purple/white	13349	16262	Orange
Murasaki*	2019	Purple/white	8723	9878	Columbia
Murasaki*	2019	Purple/white	5586	5724	Columbia
Murasaki*	2020	Purple/white	17562	5.1	Orange
Murasaki*	2020	Purple/white	24971	24971	Columbia
Murasaki*	2020	Purple/white	23035	22988	Columbia
NC-531*	2019	Red/orange	6752	11156	Orange
NC-531*	2019	Red/orange	3671	7747	Orange
NC-531*	2019	Red/orange	10523	12877	Columbia
NC-531*	2019	Red/orange	2726	2982	Columbia
NC-531*	2020	Red/orange	19597	7.4	Orange
NC531*	2020	Red/orange	21855	21728	Columbia
NC531*	2020	Red/orange	19973	19919	Columbia
NY Covington	2019	Red/orange	40401	41791	Columbia
NY Covington	2019	Red/orange	39182	39790	Columbia
NY Covington #2	2019	Red/orange	43488	62992	Orange
NY Covington #2	2019	Red/orange	28169	39626	Orange
NY Covington #6	2019	Red/orange	27089	35179	Orange
Orleans*	2019	Red/light orange	38865	53274	Orange
Orleans*	2019	Red/light orange	8914	36704	Orange
Orleans*	2019	Red/light orange	11972	15138	Columbia
Orleans*	2019	Red/light orange	10988	15866	Columbia
Orleans*	2020	Red/light orange	31062	6.9	Orange
Orleans*	2020	Red/light orange	34525	34505	Columbia
Orleans*	2020	Red/light orange	32743	32676	Columbia

Figure 1. 2019 Sweet Potato Yield

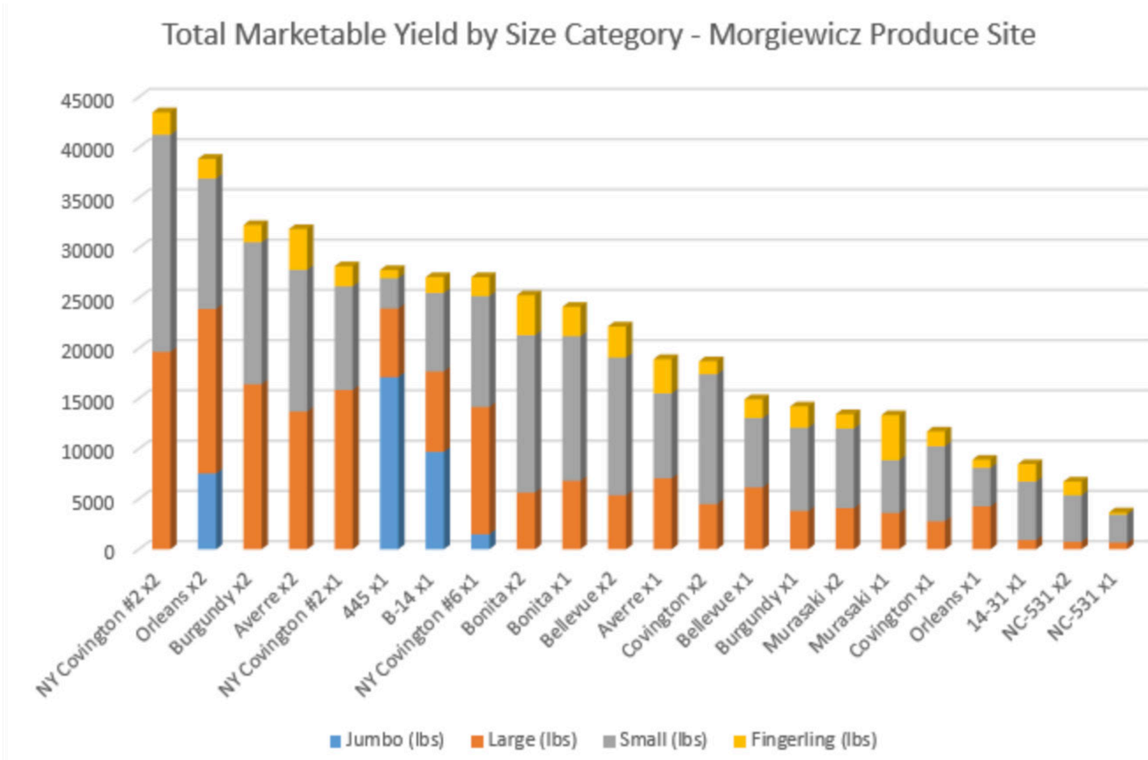
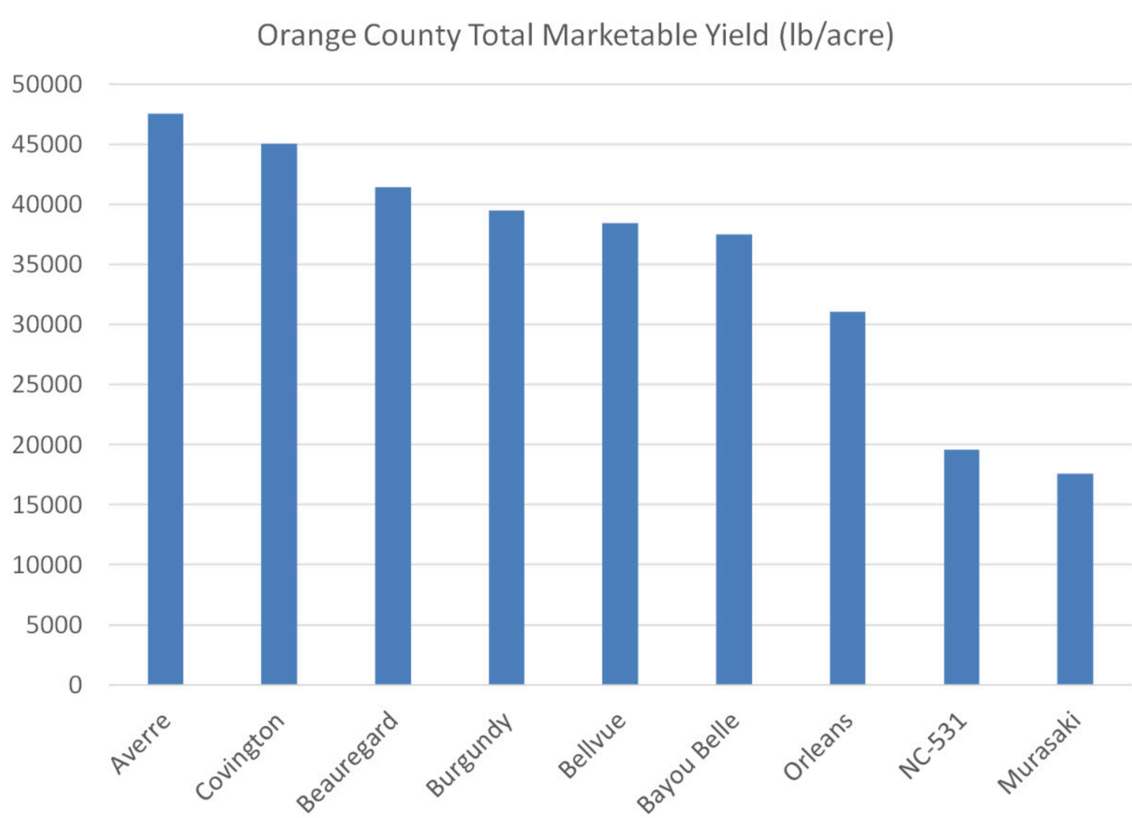


Figure 2. 2020 Sweet Potato Yield



Seedless Watermelon 2020 Variety Trial

Teresa Rusinek, Natasha Field, John Ferrante (Walkill View Farm)

Host Farm: Walkill View Farm, Ulster County

Thank you to Sakata Seed, Vitalis Seed and Seminis Seed for contributing to our trial

Bed preparation: May 5, 2020

Beds were formed with a 4' roll of plastic and two lines of drip tape on 7' centers. Dry fertilizer was also applied during bed formation at a rate of 300lbs/acre of 13-13-13. Pre- plant herbicide was applied between rows of plastic after bed formation. A tank mix of Prowl H20 and Sandea at rates of 2pts and ½ oz per acre.

Seeding: May 6, 2020

One seed per cell in 38 cell trays

Transplanting: June 5, 2020

Plants were set into the field using a water wheel transplanter with 40" in row spacing.

Management

Two weeks post-transplant (at running) 20lb actual N/acre side-dress was applied. After fruit set, another 20lb actual N/acre was applied.

Harvest: August 3, 7, 12, 18, & 25, 2020

The first melons were harvested on August 3, with 4 additional harvests.

Watermelon Varieties

1. Citation (Sakata Seed)
2. Cracker Jack (Vitalis Seed)
3. Eclipse (Sakata Seed)
4. Joyride (Seminis Seed)
5. Kingman (Sakata Seed)
6. Red Amber (Vitalis Seed)
7. Red Garnet (Vitalis Seed)
8. Red Opal (Vitalis Seed)
9. Secretariat (Sakata Seed)
10. Yellow Buttercup (Sakata Seed)

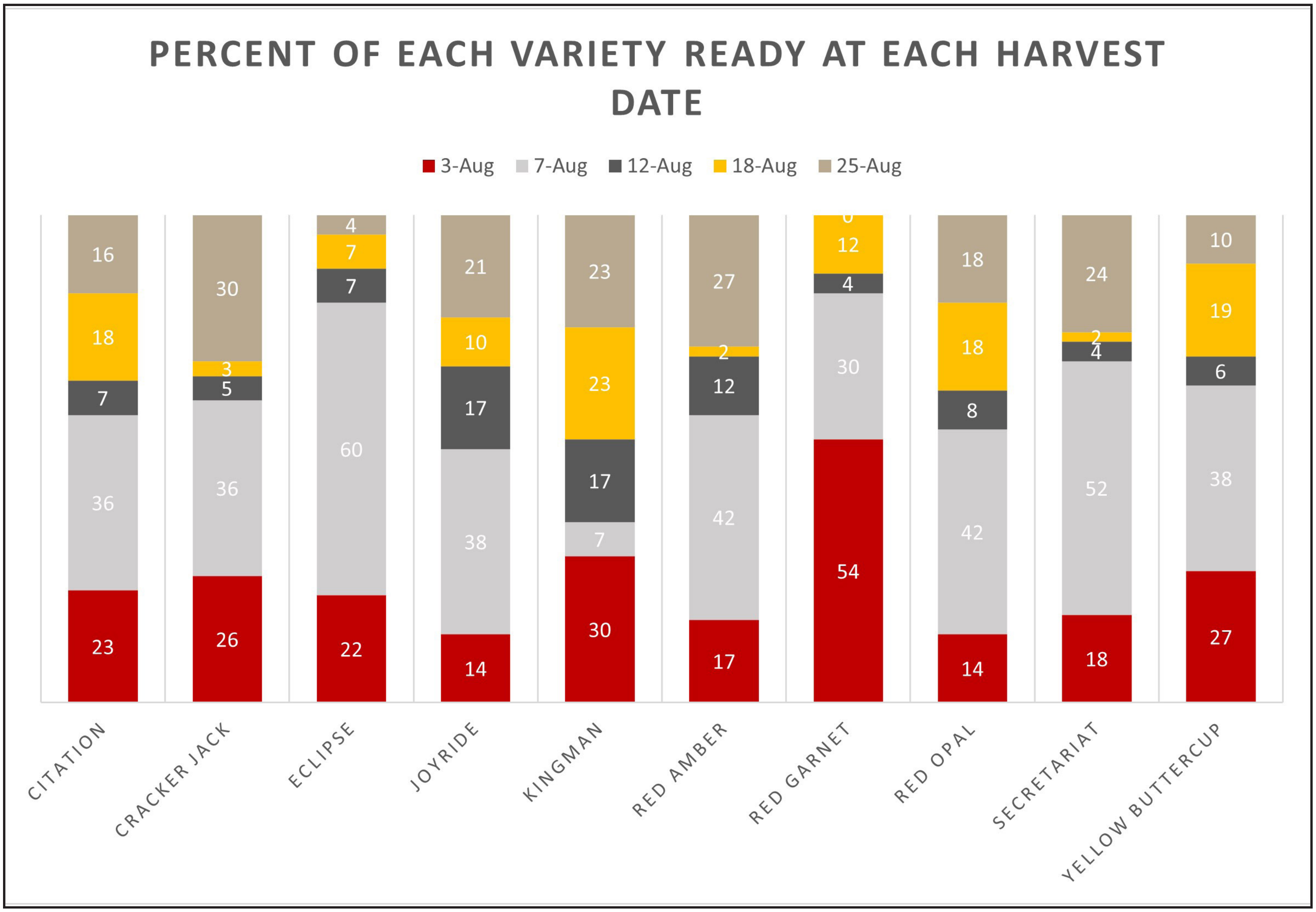
Table 1. Evaluation of Seedless Watermelon Flavor

Variety	Exterior	Taste Test 1 (worst) to 5 (best)	Description of Flavor
Citation	**Medium green striped skin, bright pink flesh**	**4**	**Strong flavor, not super sweet but still tasty. It was juicy and had a good texture.**
Cracker Jack	**Dark green striped skin, medium to dark red flesh**	**4.5**	**Super sweet, very delicous. Taste faded fast. Texture was crisp. Very juicy. Highest rated in the taste test**
Eclipse	**Dark green solid skin, medium red flesh**	**2.5**	**Internal splitting and dry. Taste was decent. All fruit we opened had internal cracking but flesh was still good to eat.**
Joyride	**Medium green striped skin, dark pink flesh**	**3.25**	**Decent tasting, super juicy. Texture was a little chewy.**
Kingman	**Light green striped skin, medium red flesh**	**3.75**	**Decent flavor, not super sweet. Decent texture. Flavor fades fast.**
Red Amber	**Light green striped skin, pink flesh**	**3.5**	**Good flavor, not super sweet. Very juicy with nice crunchy texture. Can get chewy if overripe.**
Red Garnet	**Medium green striped skin, medium red flesh**	**4.25**	**Nice sweet flavor, decent texture and very juicy.**
Red Opal	**Light green striped skin**	**3.75**	**Decent tasting, a little sweet. It was juicy. Texture varied, but generally softer.**
Secretariat	**Medium green, striped skin**	**3.75**	**Sweet and tasty. Had a good crisp texture.**
Yellow Buttercup	**Light green striped skin, yellow flesh**	**2.5**	**Different tasting. Musky and more acidic. Good flavor, decent texture.**

Table 2. Evaluation of Seedless Watermelon Yields

Variety	Average Weight (lbs)	Average Length (in)	Yield Description	% 60 count	% 45 count	%36 count	%30 count
Citation	**12.6**	**9.5**	**4,680 marketable fruit,** **58,995 pounds**	**73**	**25**	**2**	**0**
Cracker Jack	**15.9**	**11.2**	**4,149 marketable fruit** **65,835 pounds** **Fruit was consistent in size and shape** **Our favorite in the trial**	**21**	**49**	**31**	**0**
Eclipse	**12.3**	**8.9**	**4,893 marketable fruit** **60,536 pounds**	**80**	**20**	**0**	**0**
Joyride	**17.9**	**11.7**	**3,083 marketable fruit** **55,187 pounds** **Highest average weight in the trial**	**3**	**48**	**38**	**10**
Kingman	**16.0**	**10.9**	**3,191 marketable fruit** **51,113 pounds** **Inconsistent in size and shape of fruit**	**27**	**53**	**13**	**7**
Red Amber	**16.9**	**11.5**	**5,106 marketable fruit** **86,535 pounds** **Most total weight, most 36 count fruit.**	**19**	**31**	**48**	**2**
Red Garnet	**14.1**	**10.9**	**2,766 marketable fruit** **38,901 pounts**	**46**	**42**	**12**	**0**
Red Opal	**14.6**	**10.7**	**4,255 marketable fruit** **62,005 pounds**	**45**	**40**	**10**	**5**
Secretariat	**12.9**	**9.8**	**5,744 marketable fruit** **73,834 pounds** **Produced the most marketable fruit**	**63**	**35**	**2**	**0**
Yellow Buttercup	**12.0**	**8.7**	**5,531 marketable fruit** **66,484 pounds**	**81**	**17**	**2**	**0**

Figure 1. Harvest Date, by Variety



Peer Reviewed Research and CALS Extension Publications

We are not able, in this issue, to cover all of the research that has been conducted by team members in the past. The following is a list, by subject matter and year, of the peer reviewed and CALS Extension publications that have come from research projects or collaborations undertaken by ENYCH team members that are accessible to the public.

Tree Fruit Publications

2023

Strickland D, Spychalla J, van Zoeren JE, Basedow MR, Donahue DJ, and Cox K. Assessment of fungicide resistance via molecular assay in populations of *Podosphaera leucotricha*, causal agent of apple powdery mildew, in New York. Plant Disease. 2023; Online. https://doi.org/10.1094/PDIS-12-22-2820-SR.

2022

Donahue DJ, Reig Córdoba G, Elone SE, Basedow MR and McNamee K. New York Statewide Validation of the EMR Model and Passive Method for 'Honeycrisp' Bitter Pit Prediction. Fruit Quarterly. 2022; 30(4):14-17.

Khodadadi F, Martin PL, Donahue DJ, Peter KA, Aćimović SG. Characterizations of an Emerging Disease: Apple Blotch Caused by Diplocarpon coronariae (syn. *Marssonina coronaria*) in the Mid-Atlantic United States. Plant Disease. 2022; Online. https://doi.org/10.1094/PDIS-11-21-2557-RE.

2021

Donahue DJ, Reig G, Elone SE, Wallis, A.E.; Basedow, MR. Honeycrisp' Bitter Pit Response to Rootstock and Region under Eastern New York Climatic Conditions. Plants. 2021; 10,983. https://doi.org/10.3390/plants10050983.

Donahue DJ, Reig G, Michael Rutzke, Anna Wallis, Basedow MR, Elone SE, A Predictive Model for *Malus* × *pumila Borkh* c.v. 'Honeycrisp' to Reduce Storage Risk in Eastern New York State, U.S.A. Acta Horticulturae 1314. Proceedings of the International Symposium on Precision Management of Orchards and Vineyards, October 2019. 2021; https://doi.org/10.17660/ActaHortic.2021.1314.51

Donahue DJ, Reig Córdoba G, Elone SE, Anna E. Wallis and Basedow MR. Rootstock, Region and Pick Timing are Factors to Consider When Choosing 'Honeycrisp' Blocks to Minimize Bitter Pit in Storage. Fruit Quarterly. 2021; 29(3):14-19.

Donahue DJ and Elone SE. Case Study of a Declining Apple Orchard. Fruit Quarterly. 2021; 29(2): 28-31.

2020

Elone SE, Tobin S, Donahue DJ. Evaluation of Modern Communication Technologies for Certified Pesticide Applicators to Communicate with Non-Certified Sprayer Operators. Fruit Quarterly. 2020; 28(2): 28-31.

Reig G, Lordan J, Hoying S, Fargione M, Donahue DJ, Francescatto P, Acimovic D, Fazio G, Robinson T. Long-term performance of 'Delicious' apple trees grafted on Geneva® rootstocks and trained to four high-density systems under New York State climatic conditions. HortScience. 2020; 55(10). https://doi.org/10.21273/HORTSCI14904-20.

Singh J, Cobb-Smith D, Higgins E, Khan A. Comparative evaluation of lateral flow immunoassays, LAMP, and quantitative PCR for diagnosis of fire blight in apple orchards. Journal of Plant Pathology. 2020; Online: https://doi.org/10.1007/s42161-020-00644-w.

2019

Acimovic S, Higgins E, Meredith C. Effective post-infection programs of prohexadione-calcium for reducing shoot blight and preventing fire blight canker initiation on apple wood with cost-benefit analysis. Fruit Quarterly 2019; 27(2):25-31.

Khan A, Cobb-Smith D, Higgins E, Singh J. Pathogen Detection Assays for Fire Blight Management in Apple Orchards. Fruit Quarterly 2019; 27(3):27-30.

Reig G, Donahue DJ, Jentsch P. The Efficacy of Four Sunburn Mitigation Strategies and Their Effects on Yield, Fruit Quality, and Economic Performance of Honeycrisp Cv. Apples under Eastern New York (USA) Climatic Conditions. International Journal of Fruit Science. 2019; https://doi.org/ 10.1080/15538362.2019.1605558.

Reig G, Lordan J, Miranda Sazo M, Hoying S, Fargione M, Reginato G, Donahue DJ, Francescatto P, Fazio G, Robinson T. Long-term performance of 'Gala', Fuji' and 'Honeycrisp' apple trees grafted on Geneva® rootstocks and trained to four production systems under New York State climatic conditions. Scientia Horticulturae 2019; 244:277-293. https://doi.org/10.1016/j.scienta.2018.09.025.

2018

Acimovic, S., Wallis, A. and Basedow, M. Two Years of Experience with RIMpro Apple Scab Prediction Model on Commercial Apple Farms in Eastern NY. Fruit Quarterly. 2018. 26(4): 21-27.

Donahue DJ, Reig G, Wallis AE, Elone SE. Bitter Pit Mitigation and the 'Honeycrisp' Apple: Prohexadione-calcium and Bourse Pinching Effects on Bitter Pit, Shoot Extension, and Fruit Size. Fruit Quarterly. 2018; 26(3):23-28.

Fuchs M, Kahlke C, Donahue D, Wallis A Basedow M. Distribution of Viruses in New York Apple Orchards. Fruit Quarterly. 2018; 26(4): 5-9.

Reig G, Lordan J, Miranda Sazo M, Hoying SA, Fargione MJ, Hernan Reginato G, Donahue DJ, Francescatto P, Fazio G, Robinson TL. Effect of tree type and rootstock on the long-term performance of 'Gala', 'Fuji' and 'Honeycrisp' apple trees trained to Tall Spindle under New York State climatic conditions. Scientia Horticulturae 2018; 246:506-517.

2017

Agnello AM, Breth DI, Tee EM, Cox KD, Villani SM, Ayer KM, Wallis AE, Donahue DJ, Combs DB, Davis AE, Neal JA, English-Loeb FM. *Xylosandrus germanus* (*Coleoptera: Curculionidae: Scolytinae*) Occurrence, Fungal Associations, and Management Trials in New York Apple Orchards. J. Econ. Entomol. 2017:1-16.

Donahue D. Bitter Pit in Honeycrisp on G-41 vs M9-337: Observations from an Orchard Visit. Fruit Quarterly. 2017; 25(1):13-17.

Reig G, Donahue D, Jentsch P. Sunburn Management on Honeycrisp in the Hudson Valley in 2016. Fruit Quarterly. 2017; 25(2):19-24.

Wallis, A., Agnello, A. and Reissig, H. On-Farm Evaluation of Apple IPM Protocols in the Champlain Valley. Fruit Quarterly. 2017. 25(4):5-11.

2016

Breth D, Wallis A, Donahue D, Tee E. Managing Apple Orchard Weeds in the Fall. Fruit Quarterly. 2016; 24(4):9-15.

Reig G, and Donahue D. The Fallout from the 2016 Hudson Valley Pre-Bloom Freeze: Will Applications of Certain Foliar Nutrients and Promalin Help Save an Apple Crop? Fruit Quarterly. 2016; 24(4):17-20.

Robinson T, Francescatto P, Lordan J, Kahlke C, Wallis A, Donahue D, Miranda Sazo M, Tee E. Precision Harvest Management. Fruit Quarterly. 2016; 24(2):5-8.

Berry and Grape Publications

2023

Hodgdon E, McDermott L, Sideman R, Orde K. Grower impressions of low tunnel utility for June-bearing strawberry production. Fruit Quarterly. 2023; 31(1): 19-22.

2022

Sosnoskie LM, Butler-Jones A, Schulteis B, Van Zoeren J, McDermott L. A First Look at Precision Spraying and Electrical Weeding Technology for Possible Use in NY Fruit Crops. Fruit Quarterly. 2022; 30(4):23-26.

2020

Meyers JM, Dokoozlian N, Ryan C, Bioni C, Vanden Heuvel JE. A New, Satellite NDVI-Based Sampling Protocol for Grape Maturation Monitoring. Remote Sensing. 2020; 12(7):1159. https://doi.org/10.3390/rs12071159.

Stockton DG, Hesler SP, Wallingford AK, Leskey TC, McDermott L, Elsensohn JE, Riggs DI, Pritts M, Loeb GM. Factors affecting the implementation of exclusion netting to control *Drosophila suzukii* on primocane raspberry. Crop Protection. 2020; 135. https://doi.org/10.1016/j.cropro.2020.105191.

2018

McDermott L, Shields E, Testa T, O'Connell J, Field N. Understanding strawberry root problems that impact Northeast U.S. berry farm profitability: Results of Eastern NY survey. Fruit Quarterly. 2018; 26(3).

2017

McDermott L, Shields E, Testa T, Pashow, L, Ivy A. Managing Strawberry Root Problems for Improved Profitability and Sustainability on NYS Berry Farms: Using Entomopathogenic Nematodes to Control Strawberry Root Weevil Complex, Fruit Quarterly 2017; 25(2).

Pritts MP, McDermott L. Protected culture for strawberries using low tunnels. Cornell Cooperative Extension. 2017. http://www.hort.cornell.edu/fruit/pdfs/low-tunnel-strawberries.pdf

Pritts M, McDermott L, Demchak K, Hanson E, Weber C, Both AJ, Loeb G, Heidenreich C. High Tunnel Production Guide for Raspberries and Blackberries. Cornell Cooperative Extension. 2017. http://www.hort.cornell.edu/fruit/pdfs/high-tunnel-brambles.pdf

2016

Riggs DI, Loeb G, Hesler S, McDermott L. Using insect netting on existing bird netting support systems to exclude Spotted Wing Drosophila (SWD) from a small scale commercial highbush blueberry planting. Fruit Quarterly. 2016; 24(2).

2015

Sandler H, McDermott L, Ghantous K, Medeiros D. Assessment of resistance management education and experience of educators and growers in the Northeast. Cranberry Station Research Reports and Surveys, University of Massachusetts. 2015. http://scholarworks.umass.edu/cranberry_research_repts/15.

Pritts MP, Heidenreich C, McDermott L, Miller J. Berry Soil and Nutrient Management – A Guide for Educators and Growers. NESARE. Cornell University. 2015. https://blogs.cornell.edu/berries/productions/berry-soil-and-nutrient-management-a-guide-for-educators-and-growers/

2011-2014

McDermott L, Nickerson L. Evaluation of insect exclusion and mass trapping as cultural controls of spotted wing drosophila in organic blueberry production. New York Fruit Quarterly 2014; 22(1):25-28.

McDermott L, Bornt C. Optimizing strawberry production with a reduced tillage system. New York Fruit Quarterly; 2013 21(1).

McDermott L, Landers A. Designing a Better Sprayer for Pesticide Application in Strawberries. New York Fruit Quarterly. 2011;19(4).

Vegetable Publications

2023

Sideman RG, Roman C, and Hodgdon EA. Brussels sprout cultivar performance and response to apical meristem removal. HortTech. 2023; 33:193-202. https://doi.org/10.21273/HORTTECH05170-22

2022

Hodgdon EA, Campbell AEM, Connor, DA, Hoepting CA, Galimberti AK, and Chen YH. Farm-level economic losses and willingness to try new management strategies for swede midge: a grower survey. HortTech 2022; 32: 471-478. https://doi.org/10.21273/HORTTECH05063-22.

Hodgdon EA, Hallett RH, Heal JD, Stratton CA, Hoepting CA and Chen YH. Field tests of candidate pheromone blends show promise for mating disruption of the invasive swede midge (Diptera: *Cecidomyiidae*). Can Entomol. 2022; 154:1-17. https://doi.org/10.4039/tce.2022.20

Nault BA, Sandhi RK, Harding RS, Grundberg EA, Rusinek T. Optimizing Spinosyn Insecticide Applications for Allium Leafminer (Diptera: *Agromyzidae*) Management in Allium Crops. J Econ Entomol. 2022; 115(2):618-623. doi: 10.1093/jee/toac016. PMID: 35166346.

2021

Hodgdon EA, Hallett RH, Heal JD, Swan AEM, Chen YH. Synthetic pheromone exposure increases calling and reduces subsequent mating in female *Contarinia nasturtii* (Diptera: *Cecidomyiidae*). Pest Manag Sci 2021; 77: 548-556. https://doi.org/10.1002/ps.6054

Shields E, Testa A, Rusinek T, Bornt C. Management of Wireworms in Sweet Potatoes with Persistent NY Entomopathogenic Nematodes The Great Lakes Entomologist. 2021; 54(2). https://scholar.valpo.edu/tgle/vol54/iss2/4

2020

Nault BA, Iglesias LE, Harding RS, Grundberg EA, Rusinek T, Elkner TE, Lingbeek BJ, Fleischer SJ. Managing Allium Leafminer (Diptera: *Agromyzidae*): An Emerging Pest of Allium Crops in North America. J Econ Entomol. 2021; 113(5):2300-2309. doi: 10.1093/jee/toaa128. PMID: 32533179.

2019

Dunn A, Grundberg E. Efficacy and yield impact of transplant root dips for control of onion pink root, 2018. Plant Dis. Manag. Rep. 2019; 13:163. https://doi-org.proxy.library.cornell.edu/10.1094/PDMR13.

Business & Economic Publications

2022

Skorbiansky S, Astill G, Higgins E, Ifft J, Rickard B, Yuan R, Rosch S. Specialty Crop Participation in Federal Risk Management Programs. USDA ERS. 2022. https://www.ers.usda.gov/publications/pub-details/?pubid=104776

Stup R, Higgins E, Karszes J, Rickard B, Wolf C. How New York Farmers Adapted to New Farm Labor Overtime Requirements. Cornell Ag Workforce Development Research Report. 2022. https://agworkforce.cals.cornell.edu/research-reports/.

2020

Higgins E. Perspectives on Local Foods. Report on Impact of COVID-19 on New York's Farm and Food System. College of Agriculture and Life Sciences, Cornell University, Charles Dyson School of Applied Economics and Management. 2020 [white paper] retrieved from: https://cals.cornell.edu/sites/default/files/2020-10/covid19-impacts-white-paper-from-cornell-university.pdf.

Higgins E. Perspectives on Nursery and Cut Flowers. Report on Impact of COVID-19 on New York's Farm and Food System. College of Agriculture and Life Sciences, Cornell University, Charles Dyson School of Applied Economics and Management. 2020 [white paper] retrieved from: https://cals.cornell.edu/sites/default/files/2020-10/covid19-impacts-white-paper-from-cornell-university.pdf.

2019

Schmit, T. M., Severson, R. M., Strzok, J., & Barros, J. (2019). Improving Economic Contribution Analyses of Local Agricultural Systems: Lessons from a Study of the New York Apple Industry. Journal of Agriculture, Food Systems, and Community Development, 8(C), 37–51. https://doi.org/10.5304/jafscd.2019.08C.009

5/10/2023