SCIENCE FOR THE PUBLIC GOOD

INSPIRED

Summer 2022

RESEARCH FROM THE NEW HAMPSHIRE AGRICULTURAL EXPERIMENT STATION

2022 Horticultural Research Report

NH Agricultural Experiment Station

MESSAGE FROM **THE DIRECTOR**

Dear members of the New Hampshire farming community and beyond:

For over a century, the New Hampshire Agricultural Experiment Station has supported research that helps New Hampshire produce crops that provide our state and region with food, add beauty to our homes and landscapes and sustain the livelihoods of our rural communities. Today, Station scientists continue the strong tradition of developing research to inform producers on how best to manage current risks and take advantage of existing opportunities, as well as to pioneer innovations that enable New Hampshire agriculture to lead long-term economic resilience and the environmental sustainability of our state.

The research briefs in this report cover a diverse set of issues and exciting opportunities for horticultural production in the Granite State and northern New England. The topics include using DNA-based methods to develop new crops for our region, testing alternative management approaches that could allow the production of warmer-climate crops in our state and determining whether seafood byproducts can be repurposed as biopesticides for tree fruits, to name just a few. Each brief offers a snapshot of the rigorous science and practical takeaways that can make individual farming operations more successful and, collectively, strengthen the Granite State through science.

As you learn about the research completed over the past several years, also know that there are always continued efforts underway. The science isn't always fast. It's never easy. But it always reflects the tenets that have made agricultural research at the New Hampshire Agricultural Experiment Station trusted for more than 130 years: addressing locally inspired questions, implementing rigorous and objective analysis and delivering data-informed recommendations that benefit our state, region and far beyond.

Thank you for supporting our efforts to improve the lives of every Granite Stater.

ANTON BEKKERMAN
Director, NH Agricultural
Experiment Station

INSPIRED CONTENT

SCIENCE FOR THE PUBLIC

LOCALLY INSPIRED. GLOBALLY IMPORTANT.

High-Stakes Issues
World-Class Science
Sustainable Advancement

The mission of your New Hampshire Agricultural Experiment Station (NHAES) is to ensure the resiliency of the Granite State's diverse communities and local economies. For more than 130 years, we've served the state as the agricultural, food, natural resource and environmental research arm of the UNH land-grant mission. From the lab to the field, forest and sea, our researchers push scientific frontiers in pursuing sustainable food production and natural resource management across New Hampshire and beyond.

As New Hampshire's complex modern food system continues to face new challenges and opportunities, the NHAES's research serves as the frontline of data-driven, objective solutions for the economic, environmental and societal good. Part of the UNH College of Life Sciences and Agriculture, the NHAES leads scientific innovations that are critical to sustainable lives and livelihoods.

GOOD

Kiwiberry (left) and broccoli (right) research programs at the Woodman Horticultural Research Farm and biopesticide research (center) at the Macfarlane Research Greenhouses.

The research you'll read about was supported through joint public funding from the USDA National Institute of Food and Agriculture and the State of New Hampshire and conducted largely at one of the NHAES campus-area research facilities. Our research facilities include horticultural and agronomy farms, a typical New England Holstein dairy, a diversified organic dairy farm, research greenhouses and the equine complex. Additional field sites near the UNH campus are used for research, teaching and engagement, and they directly contribute to farm operations by producing required dairy and equine feed.

All NHAES activities support the core institutional mission and goals of research, teaching and outreach for the Granite State. In addition to hosting approximately half of the 50 ongoing experiment station research projects, NHAES facilities provide opportunities for hands-on training for future scientists, support experiential learning for undergraduate students and offer space for public–private partnerships. The farms, dairies and greenhouses also host field days and are used by the UNH Cooperative Extension to engage with New Hampshire communities and communicate state-of-the-art knowledge.

KIWIBERRIES: A NEW CROP FOR THE NORTHEAST

I. HALE

Today, the commercial blueberry market is a $4 billion global industry, but the berry has been commercially produced for less than a century. In large part, the success of the blueberry was due to public sector scientists recognizing the fruit's potential and initially undertaking the research necessary to lay the groundwork for commercialization. Such exploratory work remains essential today in order to prepare for the uncertainty of future environmental and food security challenges. The kiwiberry—a small, grape-sized kiwi-like fruit—could be the next blueberry for the Northeast.

KEY TAKEAWAYS

- UNH's kiwiberry breeding program is the only one in the nation – and the first in the world – to develop genetic identification and selection procedures for the crop.
- The program has systematically evaluated the North American collection of kiwiberries and developed a needed method of variety verification for the nursery trade.
- The program has evaluated over 4,000 potential new varieties and advanced 29 elite selections to replicated trials.
- At least 5 commercial kiwiberry operations have been established in the Northeast because of research at UNH.

What is a kiwiberry?

Introduced to the Northeast in the 1870s and grown widely as a backyard and garden plant throughout the region for nearly 150 years, the **kiwiberry** (*Actinidia arguta*) shows great potential for commercial success. The plant is a woody perennial climbing vine that produces clusters of small, grape-sized kiwi-like fruit. Due to high levels of carotenoids and anthocyanins, the nutritious flesh of a kiwiberry can assume a wide range of attractive colors, from dark greens to yellows to reds to purples. The fruit is high in vitamin C and one of the richest sources of lutein (an antioxidant) in commonly consumed fruits.

Another promising aspect for commercialization is the fact that the berries are hairless. This characteristic, along with a thin, palatable skin, means the fruit can be consumed directly and conveniently without peeling, like other economically successful berries (grapes and blueberries, among others). Finally, with sugar levels on par with wine grapes (>20°Brix), citrus-level acidity and tropical notes reminiscent of mango and pineapple, the kiwiberry has a well-balanced sweet-tart flavor profile. With the proven commercial viability of a handful of pioneering kiwiberry farms in the Northeast, these merits combine to recommend the kiwiberry for strategic investment in genetic improvement, establishment of best production practices and development of a market.

Kiwiberry research at UNH

With their attractive appearance, intense and complex flavor profiles, high levels of bioactive compounds, easy consumability and adaptation to the region, kiwiberries are an economically promising fruit for New England producers. Since 2013, the kiwiberry research and breeding program at the NH Agricultural Experiment Station has had a mission to realize that promise for the state.

Plant breeding is a numbers game. The more plants that can be grown and evaluated, the more likely it is that one will discover superior varieties. But the kiwiberry presents a challenge. At commercial spacing, a single kiwiberry vine requires roughly 100 square feet of field space, limiting the number of plants that an acre of research can support compared to other crops (for example, a mere 400 kiwiberry vines versus ~1 million wheat plants per acre). Additionally, like many woody fruiting species, it takes several years before a kiwiberry vine reaches reproductive maturity to produce flowers and fruit.

The program evaluates both production and quality characteristics of the grape-sized kiwiberry.

The consequences are twofold. First, because flowers are required for fruit production, it takes many years before a vine can be evaluated for fruit quality. Second, because any given kiwiberry vine is either male (pollen-producing) or female (fruit-producing), years can be spent evaluating vines only to find, once they flower, that half of them are male and thus of no interest to the program. The result is that effective population sizes are cut in half—a major obstacle to progress.

With the development of DNA-based screening methods, the gender of a kiwiberry vine can now be determined at germination, thereby greatly enhancing selection efficiency for superior female (fruiting) varieties.

To overcome this challenge, targeted genomic characterization methods (DNA sequencing) were developed to determine a kiwiberry vine's gender at seed germination. Through such marker-assisted selection, female vines can be identified and transplanted to the field, effectively doubling population size on the same area of land. Additionally, through innovative canopy management, the planting density of breeding populations was increased, allowing nearly seven times the number of vines on the same amount of land. And through implementing rigorous vine management protocols (pruning, irrigation and fertilization), the program reduced the average flowering time from 5-6 years to just 3 years, effectively doubling the number of vines that can be evaluated in a given time period.

These innovations have led to a 30-fold increase in research efficiency, allowing the research program to screen thousands of potential kiwiberry varieties within the 1.5-acre research vineyard at the **Woodman Horticultural Research Farm**. With this gain in efficiency, replicated trials are being conducted to choose varieties that exhibit reliably superior characteristics. The assessments include fruit quality (berry size, appearance, sugar content, texture, flavor, storability and ripening behavior) and production traits (overall vigor, cold tolerance, flowering and generation time, water stress tolerance and yield). So far, nearly 30 selections have been advanced to replicated trials and the prospect of releasing new elite varieties to support this emerging industry is coming to fruition.

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Learn more about UNH's kiwiberry research at **noreastkiwiberries.com**

BREEDING EDIBLE AND ORNAMENTAL STRAWBERRIES FOR NEW ENGLAND

L. MAHONEY

With over 700,000 pounds produced and $2.3 million in farm sales, strawberries are an important crop for New Hampshire farmers. But improving the cultivated strawberry through breeding is particularly challenging. The cultivated strawberries has four times as many chromosome sets as humans, animals and most other crops, which significantly increases its genomic complexity. Research to untangle the plant's genetic structure will enable scientists to more quickly and effectively develop cultivated strawberry varieties that help New England farmers be more resilient and successful.

KEY TAKEAWAYS

- Research has significantly advanced genomic and technical information on cultivated strawberries.
- Genomic information is being used to develop northern New England-specific organic strawberry varieties.
- Crossing wild strawberry relatives with cultivated strawberries has been used to develop ornamental varieties with richly colored fruit and flowers ranging in color and hue from coral and lavender to orangish and raspberry red.

Strawberry genetics research at UNH

The cultivated strawberry is a challenging species for genetic studies due to its genomic complexity. Humans, most agricultural animals and many crop plants—including Gregor Mendel's peas—are "diploids," possessing two sets of chromosomes with one set inherited from each parent. The cultivated strawberry, however, is an "octoploid," having eight sets of chromosomes with four sets inherited from each parent.

New Hampshire is host to two wild strawberry species: the **woodland strawberry** (*Fragaria vesca*), a diploid, and the **Virginia strawberry** (*Fragaria virginiana*), an octoploid. *Fragaria vesca* was designated by the international strawberry community as a suitable species for genetic research. The UNH strawberry genetics and breeding initiative began in the mid-1990s with investigations into the evolutionary ancestry of the **cultivated strawberry** (*Fragaria × ananassa*) and efforts to develop genomic information and technical resources that could ultimately support a program of marker-assisted (DNA-based) breeding. In 1997, researchers created the first genetic map of *F. vesca* and established the chromosome numbering for all subsequent strawberry genetic and genomic maps.

Additionally, UNH researchers took a leading role in the design of the first high-throughput technology for marker-assisted strawberry breeding—the **IStraw90®** Strawberry SNP array—as members of the U.S. Department of Agriculture Specialty Crop Research Initiative "RosBREED". The IStraw90® technology enables strawberry breeders to test as many as 90,000 chromosomal sites in each plant of a breeding population. Now, the focus is to use this technology to breed seed-propagated strawberry varieties for organic production in northern New England.

Organic edible strawberry breeding

With the aid of the IStraw90® genotyping technology, researchers are developing strawberry varieties for organic agriculture. The varieties will include both vegetatively propagated and seed propagated selections. Seed propagation is particularly important because the strawberry's genetic complexity precludes the crop from breeding true from seed. Rather, strawberry varieties have traditionally been clonally propagated from runners and sold as bare-root plants, which are difficult to organically certify.

The development of organically certified, seed-propagated strawberry varieties is being done by selecting hybrids of regionally favored varieties, reducing their genetic complexity through inbreeding and then selecting out undesired genomic areas. This method reduces the genetic heterozygosity of the plants by half with every generation.

Strawberries in the organically certified chamber of the UNH Macfarlane Research Greenhouses.

F1 (i.e., the first filial generation of offspring produced by crossbreeding) hybrids were generated between fourth generation inbred plants. These F1 progenies were planted in organic plots at the **Woodman Horticultural Research Farm** in the summer of 2021. Crosses and inbreeding were conducted in the climate-controlled, organically certified chambers in the **Macfarlane Research Greenhouses**. Pollination sources were controlled by using mesh bags enclosing the fertilized female developing fruit. Evaluating these F1 families will occur in summer 2022. The families are being evaluated for fruit flavor, size and yield, as well as plant vigor and health. Inbreeding has progressed to the sixth generation in some lineages to further reduce residual heterozygosity.

This research was partially supported by a USDA National Institute of Food and Agriculture Organic Research and Extension Initiative grant.

Ornamental strawberry breeding

A group of pigments that includes two types of anthocyanins—pelargonidin and cyanidin—are responsible for strawberry flower and fruit color or hue variations. Pelargonidin confers the typical orange-red color of a strawberry and cyanidin confers the raspberry red color. Marker-trait associations for the presence and absence of flower color have been identified and may also be linked with a number of anthocyanin pathway genes, including "MYB regulators". This was the inspiration for crossing wild and cultivated strawberries to develop varieties for the northern New England region with richly pigmented fruit and varieties with beautiful flowers ranging in color and hue from coral and lavender to orange and raspberry red. Evaluation of advanced selections of ornamental bedding plants began in 2021 and evaluation of new seedlings will be completed in summer 2022. Additional selections are being propagated for a focused trial during summer 2022.

New NHAES-funded research allows for the breeding of many different-hued strawberry flowers.

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TABLE GRAPES: DETERMINING IDEAL TRAINING SYSTEMS AND CULTIVARS FOR NEW HAMPSHIRE

B. SIDEMAN, G. HAMILTON, A. CHANDRAKALA AND M. LIMA

Table grapes are a relatively new crop for the Northeast. Several new varieties – released since the 1970s – may be better adapted to our climate than the typical table grapes grown in California. In New Hampshire, the number of acres of grapes has risen since 2017, when farm sales of mostly wine grapes were valued at $385,000. The specific cultivars of table grapes grown and the way their vines are managed can impact productivity, fruit quality and disease susceptibility.

KEY TAKEAWAYS

Installation of a table grape vineyard requires considerable up-front investment and vines bear fruit after 2-3 years.

Vines planted using VSP training systems reached harvest maturity at least one year sooner than Munson-trained vines, resulting in an earlier yield. Munson-trained vines had higher annual yields once established.

Mars and **Canadice** varieties showed the most promise for commercial production in the region. **Vanessa** and **Lakemont** produced high quality fruit but were susceptible to downy and powdery mildews. Cracking and uneven ripening were frequently seen with **Reliance** and **Concord Seedless**, and **Marquis** and **Thomcord** showed very poor vigor and winter survival.

Vineyard establishment

In 2015, eight seedless table grape varieties were planted at the **Woodman Horticultural Research Farm**. The varieties were cultivated using two vine training systems: Vertical-Shoot Positioning (VSP) and Munson (M). Eight cultivars were planted in each of 12 rows and each plot contained three vines, which were spaced 8 feet apart within rows spaced 10 feet apart. Poles were placed between each plot, 24 feet apart, and the vines were fertilized with 0.1 oz actual nitrogen (N) per vine in 2016, 0.2 oz actual N in 2017, and 0.4 oz actual N from 2019–21. In September 2017, the aisles were tilled and fescue was seeded to establish permanent sod aisles.

Weed management was accomplished mechanically, with occasional applications of glyphosate or paraquat. Fungal diseases were managed with a very minimal schedule (1-2 fungicide applications per season) from 2016–18, and then with a more typical schedule (7-9 applications per season) from 2019–21. Diseases, including anthracnose, downy mildew, powdery mildew and black rot, were evaluated when diagnosed in the vineyard. Yield was measured annually for all fruiting vines.

Mortality rates, observed diseases and harvesting

The highest mortality and lowest vigor were observed for **Thomcord**, while **Lakemont** and **Marquis** had intermediate rates of mortality and vigor. The remaining varieties had 100 percent winter survival and showed good vigor throughout the trial. In the spring of 2017, all dead vines from the preceding fall were removed and replaced. More vines died during winter 2018–19, possibly because they were weakened by severe anthracnose and downy mildew in 2018.

Very low levels of black rot were observed in the vineyard, with no significant differences between cultivars.

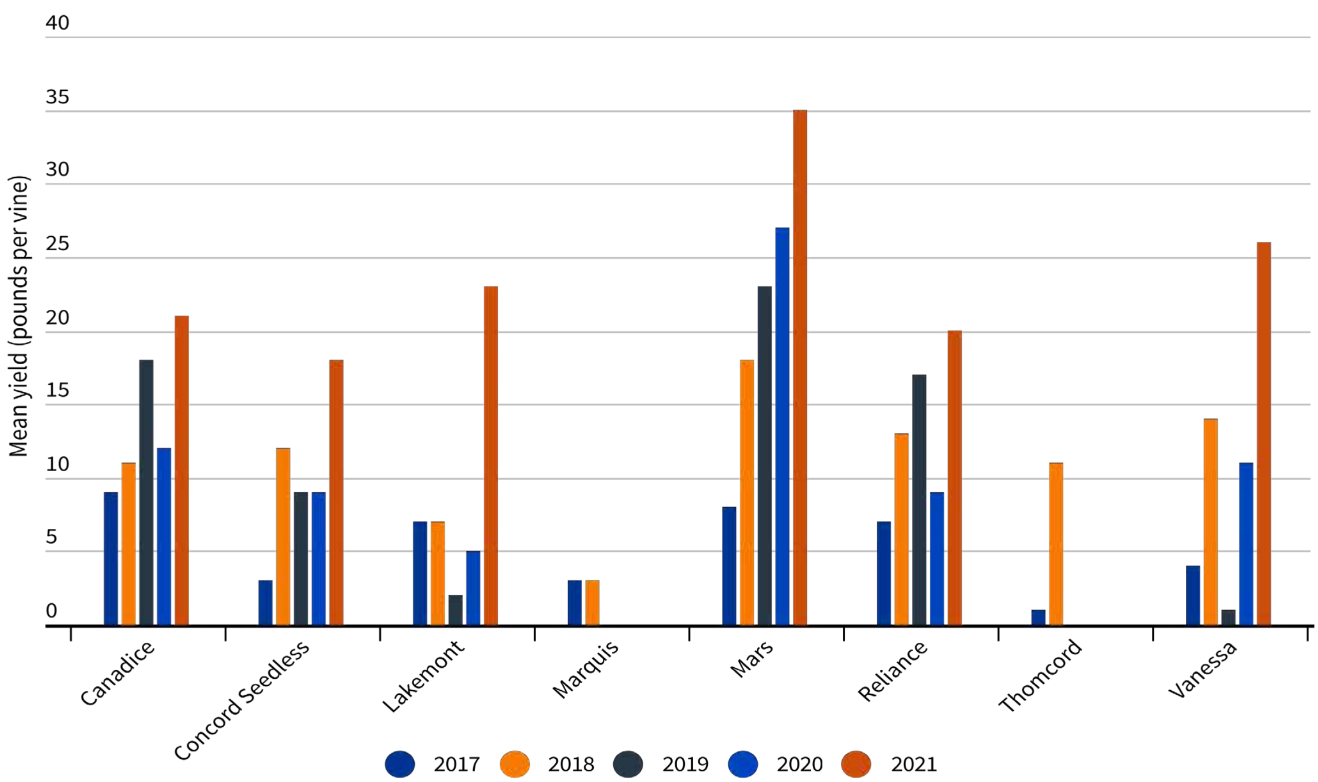
Moderate levels of anthracnose have been observed for the varieties **Marquis**, **Thomcord** and **Reliance**. Downy mildew has been by far the most damaging disease present, and the cultivars **Lakemont**, **Marquis** and **Thomcord** showed more symptoms than other varieties. Powdery mildew was also present in 2016, with **Marquis** showing significantly more symptoms than most cultivars, and **Canadice**, **Concord Seedless** and **Mars** remaining nearly symptom-free.

By 2017, all vines produced marketable yields and fruit was harvested over three weeks every year from 2017–21. Researchers measured Brix (for soluble solids content) to determine harvest maturity and began harvesting at 18°Brix. **Reliance**, **Thomcord**, **Vanessa** and **Lakemont** were the earliest to mature, and **Mars** and **Marquis** were among the last to mature.

Figure 1 show the yields for varieties and years across all management systems and **Figure 2** shows yields by system.

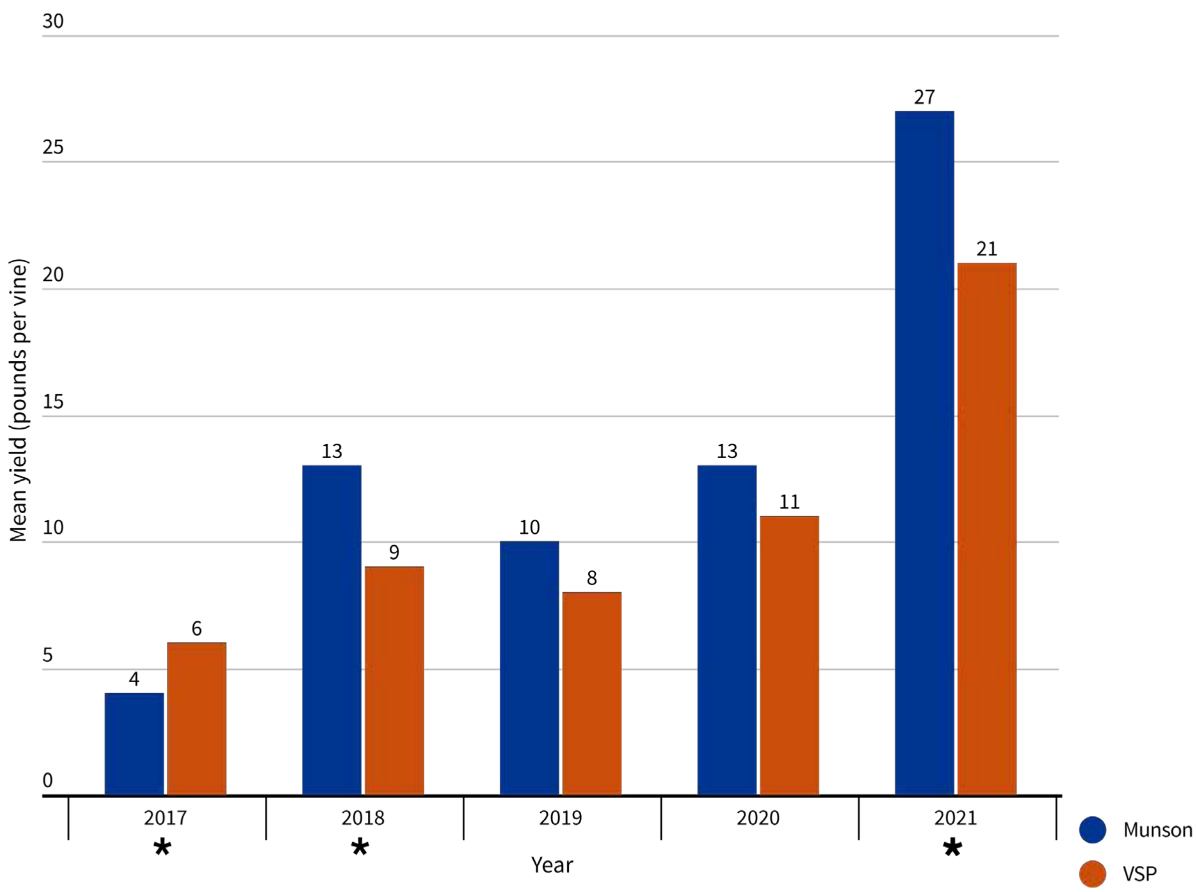
From top left clockwise: **Canadice**, **Mars**, **Lakemont** and **Vanessa** seedless table grapes.

Figure 1: Mean yields (lbs/vine) for 8 table grape varieties grown in Durham, NH.



Notes: Means include vines in VSP and Munson training systems. Thomcord and Marquis vines were removed from the vineyard in spring 2020.

Figure 2: Mean yields (lbs/vine) for seedless table grapes trained to Munson and Vertical-Shoot Positioning (VSP) training systems in Durham, NH.



Notes: Means include all varieties shown in Figure 1. Thomcord and Marquis vines were removed from the vineyard in spring 2020. Asterisks (*) indicate years when a significant (p<0.05) difference between systems was observed.

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GROWING FIGS IN COLD CLIMATES

B. SIDEMAN

Figs are grown commercially in mild climates where winter temperatures do not routinely fall below 10°F. However, avid gardeners successfully grow figs in cold climates using various strategies to protect them from freezing, such as growing them initially in pots that can be moved into a protected environment; growing in heated greenhouses; or digging, wrapping and burying them in soil trenches. Figs also have the potential to be a high-value crop. In 2019, sales of organic figs in the United States topped $14 million, $9 million of which came from fresh market sales. But to be profitable in New England, the production system must involve low-cost winter protection and each plant must be allowed to ripen during the frost-free periods of the year. In 2017, research began to successfully over-winter figs grown in-ground in northern New England. The research studied the effects of row covers, low tunnels and high tunnels on winter survival rates, plant growth and fruit yield for several varieties.

KEY TAKEAWAYS

Figs can be grown in-ground in northern New England; however, for the plants to bear fruit, early-ripening varieties and adequate winter protection must be used.

Figs grown outdoors produce relatively low yields of ripe fruit late in the season. Later varieties (**JH Adriatic**, **Maltese Beauty**) never fruited when grown outdoors. In unheated high tunnels, however, ripe fruit was harvested from mid-August through late October or early November. **Ronde de Bordeaux** was the earliest variety to ripen and it produced the greatest number of fruit overall.

Winter protection strategies can affect yield. Plants protected by an additional winter blanket or double layer of heavy row cover outyielded unprotected plants, despite a nearly 100 percent winter survival rate of all plants.

Growing figs at UNH

In summer 2017, large mother plants were obtained for several cultivars. When the plants went dormant in the fall, they were moved into a storage cooler and held at 40°F until the following April. In April 2018, 12-18 inch cuttings with 4-6 nodes were made, dipped in indole-3-butyric acid (Hormodin 2 or Hormodin 3, OHP of Mainland, PA), and placed in SureRoots 50 trays filled with PRO-MIX BX. The plants were maintained in a high humidity greenhouse and watered as needed until well-rooted. Once rooted, they were raised in 1-gallon pots for the growing season. In November, the plants were again moved into 40°F storage for the winter.

In April 2019, the one-year-old plants were pruned back to two buds and transplanted in the ground inside a high tunnel; in May, they were moved outdoors. Spacing was 4 feet within the row and 4 feet between each row. For both the high tunnel and outdoor experiments, the researchers used a split-block design with winter protection treatments as the main plot and a variety as the subplot. Each plot included five plants. The following varieties were included in all plots: RdB – **Ronde de Bordeaux**, TV – **Takoma Violet**, SR – **Saint Rita**, and JHA – **J.H. Adriatic**. Each plot also included either **Maltese Beauty** or **Malta Black**.

Winter protection and survival rates

Once plants were growing in-ground, researchers began preparing them for overwintering in November. They installed temperature sensors in the soil (1 per treatment) and air (2 per treatment).

Inside the high tunnel, winter treatments were:

- Winter protection fabric (6 oz/sq yd) – one layer
- Bare – no protection
- Heavy row cover (1.25 oz/sq yd) – two layers

Outdoors, winter treatments were:

- Winter protection fabric (6 oz/sq yd) – two layers
- Low tunnel: Heavy row cover (1.25 oz/sq yd) and 6 mil GH plastic supported by hoops
- Leaf cage: Chicken wire cage built around plants, filled with chopped leaves to a depth of around 3-feet high and 3-feet wide

Inside the high tunnel, plants covered with two layers of heavy row cover or with winter protection fabric were more vigorous and had better survival rates than plants that were not protected. Nearly all plants survived. Outside, plants buried in leaves were much more vigorous and had nearly a 100 percent winter survival (number of overwintered shoots that survived the winter and leafed out, length of shoots that survived the winter) compared with plants that were covered with two layers of winter protection fabric or with low tunnels. Varieties did not differ in winter survival.

Top: Fig plants in a high tunnel protected with two layers of heavy rowcover (far left and center right), winter protection fabric (far right and center left), and no supplemental protection (remaining rows).

Bottom: Figs protected with leaf cage (left), no protection (center), and winter blanket (right).

Yields

Fig varieties differed greatly in their ability to ripen fruit during the frost-free period of their first year (**Table 1**). In the high tunnel experiment, **Ronde de Bordeaux** and **Takoma Violet** produced the most fruit, followed by **Malta Black** and **Saint Rita**. Outdoors, **Ronde de Bordeaux** did not ripen fruit and **Norella** (not included in the high tunnel trial) produced a few ripe fruit.

In the second year (**Table 1**), ripe fruit were harvested from plants in the high tunnel as early as mid-August. Harvesting continued until the end of October or early November – an additional two weeks after the outdoor plants were impacted by frost. While all the figs had nearly a 100 percent winter survival, those protected by an additional winter blanket or double layer of heavy row cover outyielded those that were unprotected.

Figs grown outdoors had relatively low yields and ripened late in the season. Even though nearly all plants survived the 2019–20 winter and regrew, the winter protection strategy greatly impacted yields. Plants protected by a leaf cage produced significantly higher yields earlier in the season than those with a winter blanket or a low tunnel.

The outdoor experiment ended after the third winter, but researchers continued to harvest fruit from the high tunnel experiment. Yields in the third year (**Table 1**) were considerably lower than those from the second year. Extremely rainy weather resulted in high numbers of yellow jackets and spotted wing drosophila, resulting in a large proportion of fruit being unmarketable.

Other important considerations

Vole damage in protected treatments (under winter blankets, low tunnels, and within leaf cages) can be severe, so it is important to identify successful strategies to protect plants from voles. Research also showed that very dense plantings are more difficult to manage and more susceptible to fruit loss by spotted wing drosophila, yellow jackets and other pests.

Ripe figs are highly perishable, so creating a regular harvest and postharvest management plan is essential.

Table 1. Average number of ripe fruit produced per plant during first, second and third production years for 7 fig varieties.

	Year 1		Year 2		Year 3	
Variety	***High Tunnel***	***Outdoors***	***High Tunnel***	***Outdoors***	***High Tunnel***	***Outdoors***
J.H. Adriatic	0.8 c	0	21.9 c	0.0 b	1.0 c	n/a
Saint Rita	12.7 abc	1.6	47.8 bc	44.5 a	8.1 bc	n/a
Takoma Violet	21.9 a	1.5	63.8 ab	15.3 ab	22.1 b	n/a
Ronde de Bordeaux	22.0 a	0	82.2 a	22.0 ab	48.2 a	n/a
Malta Black	16.5	1.4	84.1	27.3	8.2	n/a
Maltese Beauty	1.3	0	7.7	0.0	0.2	n/a
Norella	n/a	1.2	n/a	16.4	n/a	n/a
Harvest period:	**9/18–11/8**	**9/26–10/22**	**8/19–10/26**	**9/1–10/19**	**8/16–10/7**	–

Note: Values followed by the same letter are not significantly different from one another. Statistical comparisons were considered among the first four varieties, highlighted in orange.

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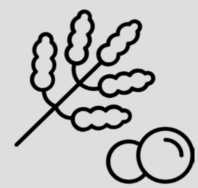
FROM NATIVE PLANTS TO NEW CROPS: *DE NOVO* PLANT DOMESTICATION IN NEW ENGLAND

T. DAVIS, S. LEVY, C. LUDWIG, E. NEFF, H. NOLEN AND M. SUBEDI

The northern New England region is rich in an untapped natural resource: its wild and weedy plant species. But can locally adapted, endemic species be rapidly domesticated into plants suitable for cultivation (a process known as *de novo* domestication)? This research is evaluating candidate native weeds and genetically defining traits for effective cultivation.

KEY TAKEAWAYS



Northern New England weeds could be domesticated and enriched with traits making them suitable for cultivation, like more compact sizes and larger seeds that remain on the plant during maturity, through an accelerated breeding process known as *de novo* domestication.

Researchers found that three traits (plant height, degree of branching and time of initial flowering) all correlated. For example, early flowering plants tended to be shorter and more compact in stature. Further investigation suggested that a single gene, known as FTL1 (Flowering Locus T-like), was associated with, and predictive of, each of the traits.

Suitable local weeds

One example of a New England weed suitable for domestication is *Chenopodium berlandieri*, a relative of quinoa. Having originated through conventional domestication in the highlands of South America, quinoa is not well-adapted to the hot and humid summers of northern New England. In contrast, its weedy sister species, *C. berlandieri*, is regionally adapted but lacks the "domestication traits" required of a crop plant. This research utilizes three different, locally adapted members of the genus *Chenopodium*, collectively known as the goosefoot family. They include *Chenopodium berlandieri* (**pitseed goosefoot**), *C. ficifolium* (**figleaf** or **fig-leaved goosefoot**) and *C. foggii* (**Fogg's goosefoot**) – all of them ancestrally related to quinoa. These ancestral species offer a genetic model useful for identifying genes that can influence domestication traits.

Through genome-enabled plant breeding, including marker-assisted (DNA-based) selection and genome editing, researchers are working to endow *C. berlandieri* with necessary domestication traits. A recently published study of *C. ficifolium* analyzed a Mendelian (F2 generation) progeny population derived by crossing representatives of the species collected from Portsmouth, NH, and Quebec City, Quebec. Just as Gregor Mendel's pea populations exhibited genetic "segregation" with respect to alternate traits – such as tall versus short and white versus purple flowers – the *C. ficifolium* progeny population segregated with respect to six easily defined traits, three of which were of particular relevance. These relevant traits were: plant height, degree of branching and time of initial flowering.

Early results indicate that the three traits could be predicted by a single gene, known as the FTL1 (Flowering Locus T-like). Next, the goal is to test whether assembling the complete genomic sequence and performing sequence-guided gene editing on *C. ficifolium* could determine the effects of specified gene variants on the traits in question.

Key aspects of this project are being pursued in collaboration with scientists at the Orphaned Crops Lab at Brigham Young University in Provo, Utah, and in cooperation with Dr. Kevin Murphy, quinoa breeder and Director of the Sustainable Seed Systems Lab at Washington State University. The authors thank fellow station scientist and UNH Natural Resources and the Environment Professor Rich Smith for spotting the Portsmouth, NH-based population of C. ficifolium.

Quinoa-related investigations to date are primarily the work of five graduate students: Master's students Sarah Levy, Erin Neff and Madhav Subedi; Master's/Ph.D. student Haley Nolen; and Ph.D. student Clayton Ludwig. Important contributions have come from UNH faculty members Rich Smith, Cheryl Smith and Anissa Poleatewich, post-doctoral scientist Melanie Shields and undergraduate Jonathan Moehlmann.

A potted *Chenopodium berlandieri*, also known as pit-seed goosefoot.

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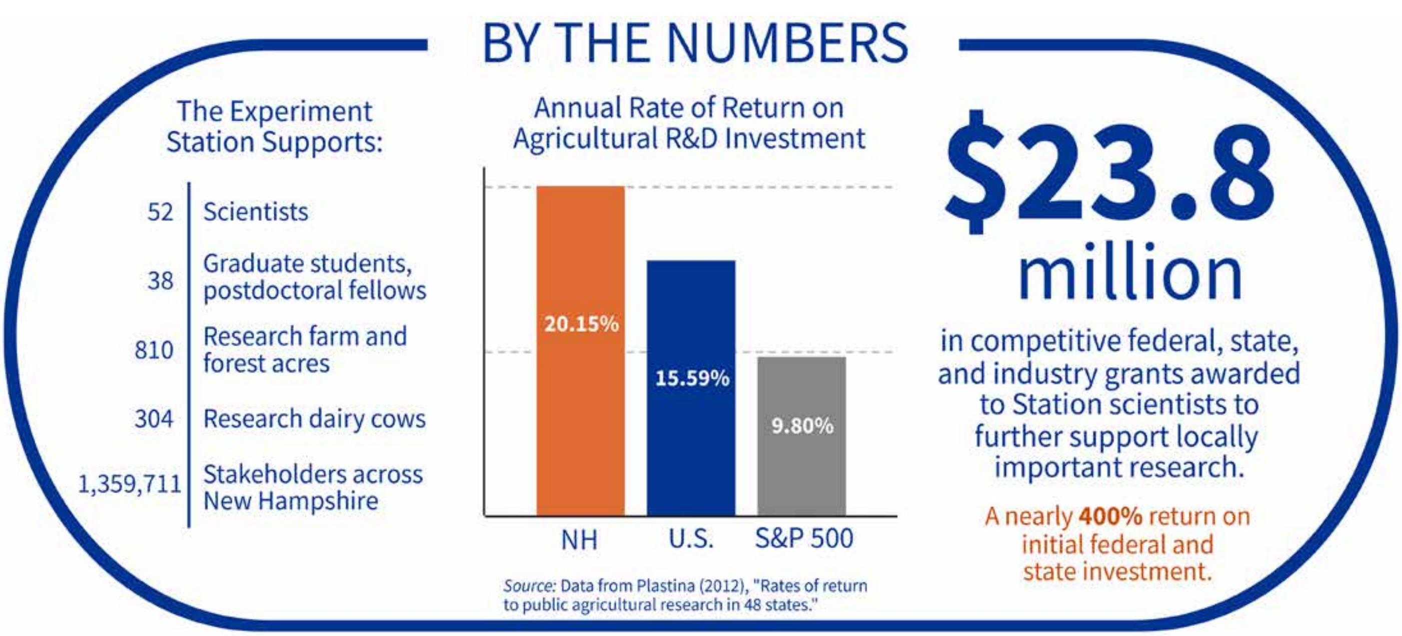

IDENTIFYING THE HIGHEST-YIELDING VARIETIES OF BRUSSELS SPROUTS FOR NEW HAMPSHIRE

B. SIDEMAN, O. SAUNDERS, E. HODGDON, T. LEVY
A. HARRIS, C. ROMAN AND S. BECK

Brussels sprout (*Brassica oleracea L. var. gemmifera*) is a popular fall crop in New England. However, rapid turnover in the commercial availability of Brussels sprout cultivars – coupled with dramatic differences in the performance and adaptability among cultivars – make it a challenging crop for growers outside of major production regions to select varieties that will consistently perform well. While a 2013–15 study of Brussels sprout varieties offered recommendations for New England producers, new varieties have since been released. This research focused on re-examining best-performing varieties for the northern New England region and updating best practice recommendations.

KEY TAKEAWAYS

Challenging pest problems, like cabbage aphids and Alternaria leaf spot, make growing Brussels sprout in the humid Northeast a challenge.

In 2021, NHAES researchers evaluated 16 Brussels sprout varieties, including old standards and newer releases.

Cultivars **Diablo**, **Divino** and **Nautic** had the highest yields, uniformity and resistance to Alternaria leaf spot.

Planting and harvesting

In 2013, 2014, 2015 and 2021, Brussels sprout plants were planted in a randomized complete block designs with four replications and 12 plants per plot. Plants were spaced 18 inches apart within a single row on 30-inch raised beds covered with biodegradable black plastic mulch for weed control. Plants were seeded between May 4 and June 3, then transplanted a month later. No fungicides were applied to these experiments. *Bacillus thuringiensis* (DiPel) was applied as needed to manage caterpillars. Plants were topped (i.e., the apical meristem was removed) in mid-September. To manage cabbage aphids, organically approved materials, including azadirachtin, pyrethrum and/or insecticidal soap, were applied.

In 2015 and 2021, symptoms of Alternaria leaf spot were evaluated at harvest. Brussels sprouts were harvested and data were collected in late October through early December.

For each plant, the following data were collected: Total stem length and weight of marketable sprouts (marketable consisting of between 0.75 and 2.5

Left: Alternaria leaf spot, or black spot, on a Brussels sprout leaf. *Right:* Cabbage aphids attack Brussels sprouts.

inches in diameter). For each plot, the proportion of sprouts that were too small or too large was also estimated. **Table 1** presents rankings for the different varieties based on yield and the presence of Alternaria leaf spot.

Table 1: Rankings for mean marketable yield and susceptibility to Alternaria leaf spot for several Brussels sprout cultivars grown in Durham, NH, in 2013, 2014, 2015 and 2021.

	Marketable yields (1 = highest)				Alternaria (1 = most susceptible)	
Variety	***2013***	***2014***	***2015***	***2021***	***2015***	***2021***
Catskill	8	8	11	–	6	–
Churchill	–	5	9	–	2	–
Confidant	–	–	2	7	9	4
Cryptus	–	–	–	12	–	8
Dagan	–	–	–	3	–	4
Diablo	3	2	6	5	12	13
Divino	–	–	–	2	–	11
Doric	6	6	–	–	–	–
Early Marvel	2	–	5	–	3	–
Falstaff	7	–	–	–	3	–
Gladius	–	–	–	8	–	3
Gustus	1	–	4	11	7	2
Hestia	–	–	8	4	4	15
Igor	–	–	10	9	1	7
Jade Cross E	4	4	7	10	5	1
Marte	–	–	–	1	–	10
Nautic	5	3	3	6	11	14
Nelson	–	7	–	–	–	–
Octia	–	1	1	–	10	–
Redarling	–	–	–	15	–	6
Redbull	–	–	12	14	–	6
Roodnerf	9	–	–	13	–	8
Rubine	–	–	–	16	–	16

Notes: Alternaria leaf spot was rated at harvest. The percentage of sprouts with Alternaria lesions was estimated for each plot. Mean values were calculated and then ranked.

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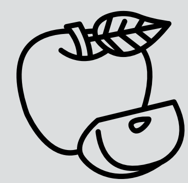
USING SEAFOOD BYPRODUCT CHITOSAN AS A NATURAL DISEASE SUPPRESSANT FOR APPLES

A. POLEATEWICH, L. DEGENRING AND K. PETER

Management of tree fruit diseases is especially challenging in the northeastern United States due to ideal climatic conditions for pathogen spread and infection leading to devastating fruit losses. Since the 1980s, research at UNH has been integral in collaborative efforts to develop disease forecasting models and integrated pest management (IPM) strategies that combine cultural, biological and chemical strategies to limit crop loss and reduce pesticide use in fruit trees. Today, UNH scientists continue to build on this legacy. Current research focuses on whether seafood byproducts can provide sustainable, cost-effective disease and pest management for New Hampshire growers battling tree fruit diseases.

KEY TAKEAWAYS



Apple trees treated with chitosan and biopesticides produced fruit with less severe apple scab symptoms comparable to the standard fungicide program.

When applied after harvest, chitosan reduced the severity of bitter rot and blue mold symptoms on apples.

Biopesticides

It is critical for growers to have a diverse set of tools in their "toolbox" to manage diseases. One strategy of IPM is to harness the power of beneficial microbes (biopesticides) and natural compounds to promote plant growth and suppress disease. Chitosan is a promising natural compound documented to have antifungal and disease suppressive properties (see **Figure 1**). Chitosan is one of the most abundant polymers on earth and is an important component of all insect and crustacean exoskeletons. Some companies have begun utilizing waste from the seafood industry as a source of chitosan for use in agriculture crop protection products. The use of chitosan to prevent disease and extend shelf life of perishable fruits has been well documented. Less is known about the potential of preharvest application of chitosan to suppress diseases during the growing season and whether chitosan acts synergistically with standard fungicide or biopesticide spray programs. This research seeks to identify the utility of chitosan as a tool to manage diseases of apple during preharvest and postharvest.

Studying chitosan applications

The research assessed two questions regarding chitosan application:

Can foliar (liquid spray) applications of chitosan alone or in combination with biopesticides reduce preharvest apple diseases?

Can chitosan applications reduce postharvest diseases of apple?

For the preharvest study, a commercial chitosan product (Tidal Grow) was evaluated and applied alone or combined with a program of reduced risk materials typical of Northeast orchards. Chitosan treatments were applied according to manufacturer recommendations and compared with a standard fungicide. Throughout the season, leaves and fruit were evaluated for apple scab and powdery mildew and for symptoms of summer fruit rot and rots that might remain dormant but appear later in storage.

Leaves and fruit from trees treated with the reduced risk program and the chitosan resulted in the lowest incidence of apple scab comparable to the fungicide control. While the

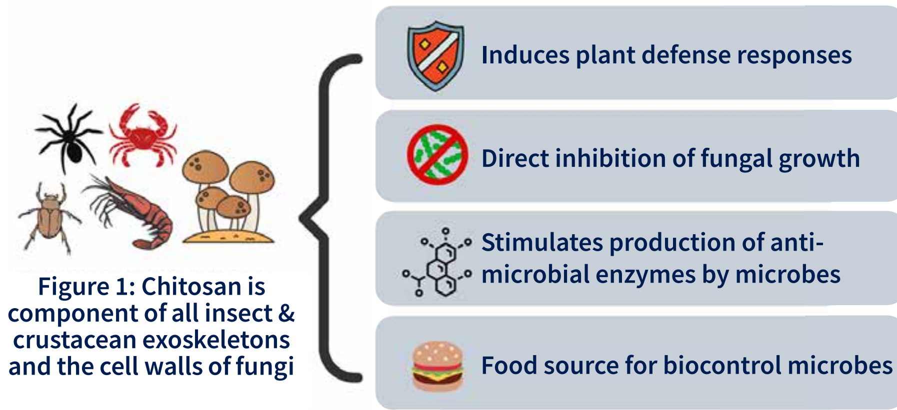


Figure 1: Chitosan is component of all insect & crustacean exoskeletons and the cell walls of fungi

Left: An apple with apple scab, one of the diseases that chitosan can reduce. *Right*: Research orchard at the Penn State Fruit Research and Extension Center in Biglerville, PA, where some of the research took place.

chitosan treatment alone did not reduce incidence of apple scab, the severity of symptoms was significantly less on fruit treated with chitosan compared with fruit treated with the fungicide control.

Chitosan's postharvest efficacy was assessed on fruit collected from local farms in New Hampshire and dipped in Tidal Grow or in water. Next, fruit was inoculated with two common fruit rot pathogens, *Colletotrichum fioriniae* (causing bitter rot) and *Penicillium expansum* (causing blue mold). Results indicate that fruit treated with chitosan had significantly smaller lesions caused by *C. fiorniae* and *P. expansum* compared to fruit dipped in water only.

This research suggests that chitosan may have potential as a new tool for growers to use as part of their IPM programs. However, additional research is needed to investigate application rate, application timing and compatibility with other grower practices.

This research was partially supported by the Northeast Sustainable Agriculture Research and Education program under subaward number GNE19-198-33243 and by the U.S. Department of Agriculture's Agricultural Marketing Service. The authors thank the Penn State Fruit Research and Extension Center and a number of New Hampshire farms for space to conduct trials.

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HIGH TUNNEL EGGPLANT VARIETIES, PRUNING AND POSTHARVEST STORING

B. SIDEMAN AND L. FORD

Recently, parthenocarpic varieties of eggplant (varieties that fruit without pollination) have been developed specifically for protected cultivation. In places where eggplant is frequently grown in greenhouses, various pruning systems are used to enhance plant productivity and growth. In this study, researchers compared 10 varieties of elongated Italian eggplants to determine whether pruning to a 2- or 4-leader system would impact yields (when compared with no pruning) and the effects of postharvest storage on different varieties.

KEY TAKEAWAYS

Low-labor pruning methods, like corralling plants, produced higher yields in all 10 varieties researched. While pruning plants to four leaders increased yields in one year for the varieties, it did not in the second year.

High tunnel eggplants are attractive to aphids and spider mites. Growers should monitor for these pests and have a plan in place to manage them if they are detected.

Planting and harvesting

Eggplants were seeded on April 12, 2018, and March 25, 2019, and transplanted into a high tunnel on June 1, 2018, and May 20, 2019. Soybean meal (7-1-2) and potassium sulfate (0-0-50) preplant were applied to provide 55 pounds per acre (lbs/acre) of Nitrogen and 145 lbs/acre of potash. Planting beds were spaced 4 feet on center, slightly raised (1-2 inches), and covered with embossed black plastic mulch. Plants were spaced 12 inches apart in single rows. In 2018, Azera (pyrethrins, neem) was applied in June to control aphids. Shuttle O (acequinocyl) was applied once in August to control spider mites. In 2019, Shuttle O was applied once in August.

Eggplants were harvested weekly between July 6 and October 18, 2018, and between July 3 and October 18, 2019, after which the plants were killed by frost. Fruit were counted, weighed and sorted into marketable and unmarketable (scarred or misshapen) groups. On two dates each year, harvested fruit were set aside for postharvest trials.

Marketability of fruit

Some varieties of eggplant produced over 6 pounds of fruit per plant during the season. In general, eggplant produced marketable fruit very early; the first fruit were harvested just five weeks after transplanting. All varieties showed good production continuity, aside from a dip in early September that may have been due in part to a spider mite infestation. Plants produced marketable fruit until experiments were ended in mid-October.

There were only slight differences in total marketable yield between varieties in 2018 and no significant differences in 2019 (**Table 1**). In 2018, the **White Star** variety had significantly lower yields compared with **Nadia** and **Angela**. **White Star** also had a significantly lower percentage of fruit that were marketable (69 percent), largely due to scarred and/or misshapen fruit. Of the two white varieties, **Aretussa** was very uniform whereas **White Star** (2018 only) was much more variable, with several plants that produced light-green, off-type fruit.

Of the purple varieties, **Traviata** and **Jaylo** had distinctly pear-shaped fruit, whereas **Nadia** and **Michal** fruit were more elongated. **Tucci** (added in 2019) fruit were very slender and more Asian than Italian type. **Jaylo** was a lighter purple color, with many of the fruit showing pale purple stripes near the base of the fruit. **Angela**, **Annina** and **Nubia** all produced uniform elongated striped fruit.


High tunnel-grown Italian eggplants in a range of colors.

Support and pruning systems

In 2018, researchers compared three pruning systems (2-leader, 4-leader and corralled) for three varieties (**Michal**, **Nadia** and **Traviata**), and in 2019, they compared only two systems (4-leader and corralled). The variety trial was corralled in both years. In a 2018 preliminary pruning experiment (two replicates only), the 4-leader system produced higher yields than the unpruned system. In a larger 2019 experiment, researchers did not observe differences in yield between the pruned and unpruned treatments (**Table 2**).

Table 1: Marketable yield for 10 eggplant varieties grown in the high tunnel in Durham, NH.

			2018 Yield		2019 Yield	
Type	**Variety**	**Fruit Color**	**Weight (lbs.) per plant**	**% of marketable fruit**	**Weight (lbs.) per plant**	**% of marketable fruit**
Greenhouse (GH)	Angela	Striped	6.1 a	94 a	6.4	99
GH	Annina	Striped	–	–	6.7	100
GH	Aretussa	White	4.7 ab	86 a	6.2	94
GH	Jaylo	Purple	5.0 ab	87 a	5.4	94
GH	Michal	Purple	5.1 ab	84 a	6.0	99
Field	Nadia	Purple	6.3 a	91 a	6.8	96
Field	Nubia	Striped	–	–	6.0	100
Field	Traviata	Purple	5.8 ab	88 a	6.8	97
GH	Tucci	Purple	–	–	4.9	95
Field	White Star	White	3.5 b	69 b	–	–

Notes: Angela, Aretussa, Jaylo, Nadia, Nubia: Johnny's Selected Seeds; Annina, Michal, Traviata: High Mowing Seeds; Tucci: New England Seeds; Annina, Traviata, White Star: Harris Seeds. Values followed by the same letter are not significantly different from one another.

Postharvest storage

Eggplant fruit are particularly sensitive to desiccation and weight loss at temperatures above 10-12°C (50-54°F) and to chilling injury at temperatures below this range. In four experiments, researchers held eggplants at different temperatures for two weeks to determine varieties' susceptibility to these postharvest problems.

At temperatures that were too warm (e.g., the packhouse), eggplant fruit lost much more weight and softened much more than when stored at cooler temperatures. At cold (refrigerator) temperatures, fruit lost the least weight and remained firm, but suffered chilling injury and showed surface pitting and browning. Several varieties exhibited mold on their calyxes after two weeks of storage; this was more evident at the higher temperatures than in the refrigerator (**Table 3**). In 2018, varieties differed in susceptibility to these problems. **Angela** lost significantly less weight and remained significantly firmer than some varieties (**Aretussa** and **Michal**, for example). Along with **Jaylo** and **Traviata**, **Angela** also showed the least browning after two weeks of storage; **Aretussa**, **Michal** and **White Star** showed the most browning.

Table 2: Marketable yield and frequency of marketable fruit for Michal, Nadia and Traviata varieties grown in three different fruit systems.

	2018		2019	
Pruning Treatment	**No. fruit per linear foot**	**Wt. (lbs) per linear foot**	**No. fruit per linear foot**	**Wt. (lbs.) per linear foot**
Unpruned (corralled), 12-inch plant spacing	9.0 b	5.7 b	9.6	6.5
4 leaders, 12-inch plant spacing	12.0 a	7.8 a	9.0	6.1
2 leaders, 6-inch plant spacing	11.0 ab	6.7 ab	–	–

Notes: Values followed by the same letter are not significantly different from one another.

Table 3: Postharvest storage conditions in 2018 eggplant experiments.

	Extreme Temperatures		Temperature (°F)	Relative Humidity (%)	
Postharvest storage conditions	**Max (°F)**	**Min (°F)**	**Average +/- SD**	**Average +/- SD**	
Packhouse	63.3	79.4	73.1 +/- 2.3	76.1 +/- 6.6	too warm
Cooler	60.0	64.3	62.5 +/- 0.9	90.1 +/- 3.5	close to ideal
Refrigerator	38.2	47.4	42.2 +/- 2.0	96.6 +/- 3.5	too cold

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TOMATOES: HIGH TUNNEL PRUNING STRATEGIES

C. ROMAN AND B. SIDEMAN

Different varieties of tomatoes with season-long harvest periods are commonly grown in high-tunnel structures throughout the world. However, many tomato varieties suffer from a phenomenon called ‘June drop’ in which a plant's first four to five fruit clusters set perfectly, but the subsequent two to three clusters set poorly and the plant's productivity suddenly drops. This may occur due to the excessive demand for resources by the already-set fruit. Reducing fruit load early in the season could prevent this productivity drop. This research examined the impact of thinning and removing tomato fruit clusters on fruit weight, total marketable yields, prevalence of defects and season-long fruit production.

KEY TAKEAWAYS

Cluster pruning increased fruit size but did not increase marketable fruit yield.

Cluster pruning treatments increased cracking. Environmental factors, including irrigation scheduling and daily temperature fluctuations, likely also played a role in the cracking.

Vegetative growth significantly increased by reducing fruit load. However, this did not correlate to greater yields and additional labor was required for trellising and sucker removal.

Study results thus far do not suggest that removing alternate fruit clusters is beneficial.

Planting and growing in high tunnels

In May 2021, **Big Beef** (Johnny's Selected Seeds of Albion, ME) tomato seeds were sown in seedling strip trays containing PRO-MIX BX in a heated greenhouse and fertigated (fertilized and irrigated) with 17-4-17 at 100 parts per million (ppm) N. After germination, seedlings were transplanted into 606 trays and received 17-4-17 fertilizer at 150 ppm N until transplanting.

The high tunnel was prepared by broadforking and then applying soybean meal and sul po mag to provide 100 pounds per acre (lbs/acre) of nitrogen (N) and 145 lbs/acre potash. Plants were spaced 18 inches apart in two rows located 6 feet apart. Two strands of drip irrigation tape were laid per row. Black plastic landscape fabric was installed between the rows to mitigate weed pressure. In May 2021, the tomato seedlings were transplanted into the high tunnel and a tomato clip was used to trellis each plant to a single strand of tomato trellising twine in a single-leader pruning system.

Sucker and cluster pruning was performed once a week throughout the season. Additional tomato clips were added every 1-2 weeks to trellis the plants. Bottom leaves were removed below the first fruit cluster and subsequently below the lowest remaining fruit cluster. Fruit cluster pruning treatments consisted of a control (no fruit pruned), 6 (six fruit per cluster), 3 (three fruit per cluster), 6A (every other cluster removed and six fruit per remaining cluster) and 3A (every other cluster removed and three fruit per remaining cluster).

The five treatments were applied in a randomized complete block design with 12 blocks and a single plant representing an experimental unit.

Harvesting, collecting samples and managing pests

Fruit removal for cluster thinning occurred after the flowers had set, when fruit was approximately marble-sized. All ripe fruit were harvested weekly from July through November. Each fruit was weighed, graded for size using U.S. Department of Agriculture guidelines and observed for deformities that would result in them being unmarketable (i.e., cracking, uneven ripening, yellow shoulder or smaller than U.S. grade small). Plant height and stem diameter were measured three times during the season.

The insecticide *Bacillus thuringiensis* (DiPel DF, Valent Biosciences) was applied once mid-season for tomato hornworm. On July 1, plants were side-dressed at a rate of approximately 120 lbs/acre of N and 200 lbs/acre of potash by applying soybean meal and sul po mag at the base of each plant. High tunnel sides were left open unless it was raining or the night temperature was below 55°F. Irrigation was applied based on the amount of soil moisture using the touch method and generally followed a schedule of watering one hour every other day and increasing this frequency during hot, dry periods and decreasing this frequency during rainy weather.

Research results

Total yield and fruit deformity impact. Total yields varied by pruning treatment (**Table 1**). Treatment 6 plants produced the greatest total yields, averaging 8,321 grams (g) per plant over the entire season. Plants with treatment 3A produced yields significantly lower than all other treatments, averaging 4,256 g per plant. The most prevalent deformity in all treatments was fruit cracking, particularly radial cracking originating from the stem scar, followed by uneven ripening of fruit. Treatment 3A had the highest percentage of unmarketable fruit, whereas treatment 6 had the lowest rate at 37 percent. These results were unexpected relative to the hypothesis that cluster pruning would decrease the fruit cull rate.

Table 1: Total Yield and Average Fruit Weight by Treatment

Treatment Type	*Total Yield (g)*			*Average Fruit Weight (g/fruit)*
	Marketable	*Unmarketable*	*Total*	
3	3,665	3,262	6,927	278.9
6	5,152	3,169	8,321	248.7
3A	869	3,388	4,256	340.1
6A	3,285	3,528	6,812	289.9
C	5,033	3,176	8,209	241.9

Individual fruit weight. Cluster pruning treatments had a significant effect on fruit size (**Table 1**). The pruning treatment 3A resulted in the largest fruit. Treatments 6 and the control had the smallest fruit, and treatments 3 and 6A had intermediate-sized fruit. Regardless of treatment, almost all fruit still fell into the medium, large or extra-large size categories. The larger fruit present in 3A plants seemed to correspond with higher rates of fruit cracking, which led to greater amounts of the 3A fruit being deemed unmarketable.

Pruning effect on production throughout the season. Across treatments, clusters rarely set more than five fruits (**Figure 1**). We hypothesized that cluster pruning would maintain productivity throughout the season by altering the ratio of photosynthesizing vegetative growth to carbohydrate sinks (fruit). In the control (unpruned) plants and in plants pruned to 6 fruit per cluster, yields began very high and dropped steadily throughout the season. In 3A plants, yields were low and steady throughout the season and cumulative yields did not reach those of other treatments. Treatments 3 and 6A showed intermediate performance; they started out with lower yields than the control plants but produced higher yields later in the season.

After the first four clusters, the control and 6 plants set fewer and smaller fruits. On the control plants, this was most apparent at the 5th and 6th clusters, with an average of only 2.8 and 2.7 fruits per cluster (**Figure 2**). In some cases, the cluster only produced three flowers; in others, several flowers aborted before fruit set. Many pollinators were present inside the high tunnel, suggesting that flower termination was not due to a lack of pollination.

Vegetative growth and nutrient utilization. Plants receiving treatments 3A and 6A were visibly greener and the leaves were thicker along with their increased height and stem diameters. These findings suggest that aggressive fruit pruning changes the source/sink relationship of vegetative growth to fruit production. While an adequate amount of vegetative growth is needed to photosynthesize, excess growth may be a waste of plant productivity.

Figure 1: Yields (in grams) by treatment over time

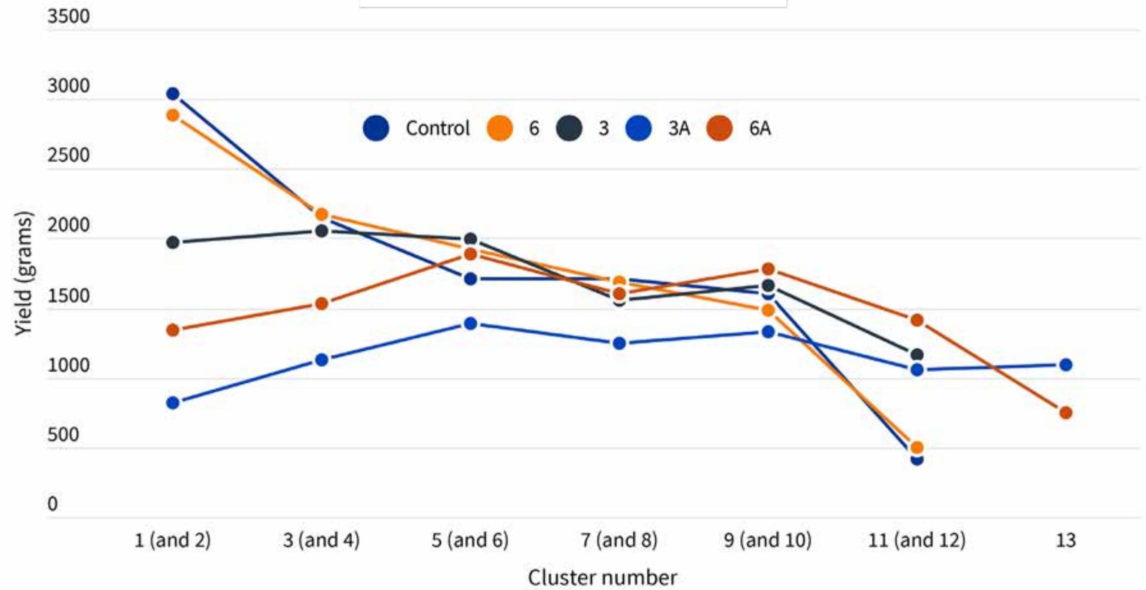
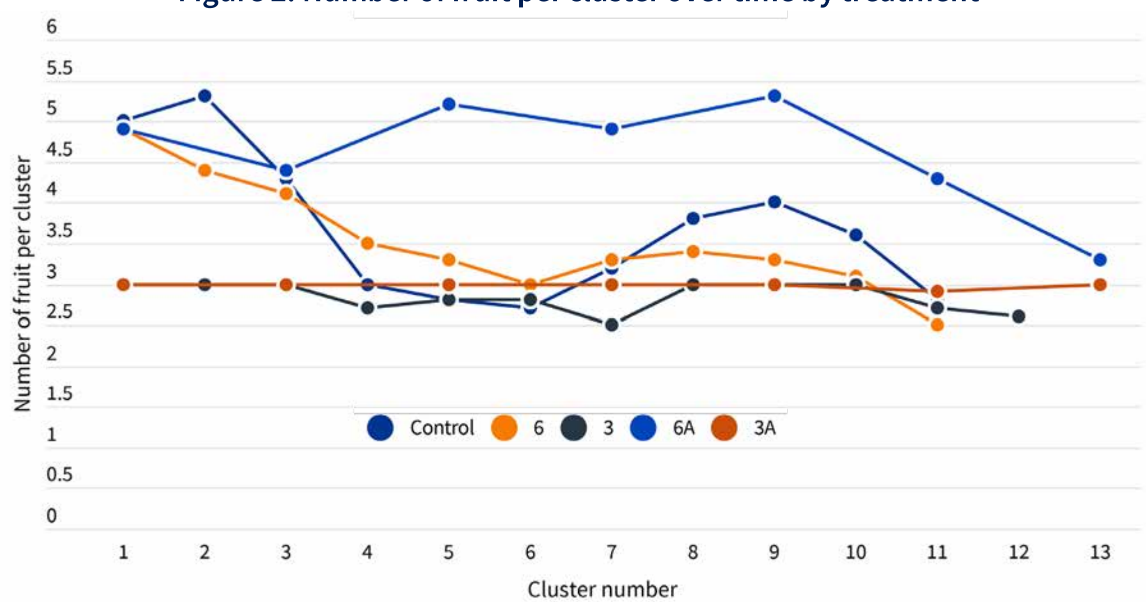


Figure 2: Number of fruit per cluster over time by treatment



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DISEASE THREATS AND BIOFUNGICIDE EFFICACY IN SOILLESS SUBSTRATES

A. POLEATEWICH, B. JACKSON AND I. MICHAUD

In greenhouse production, plants are not typically grown in soil but in soilless growth substrates. For decades, peat moss has been the primary substrate for container-grown ornamentals and for some vegetable crops. That is, until recently. Substrate suppliers have faced unprecedented demand, which has led to product shortages and an inability to fulfill orders. Substrate manufacturers have identified wood byproducts to be some of the most promising alternative sources of raw materials to use in substrate formulations. However, a change in substrate can be disruptive to a grower's production system, affecting everything from water to pest control. Wood components have unique properties compared to other substrates, which may affect activity of pathogenic and beneficial microorganisms. This research considers how wood substrate components affect the severity of soilborne diseases in greenhouse horticultural crop production.

KEY TAKEAWAYS

The inclusion of wood components, regardless of blend ratio or type, does not impact severity of damping-off disease and may lessen the effect of crown and root rot.

Additional research is needed to provide guidance to growers seeking to integrate these new substrates into their operation and IPM programs.

Studying peat-wood substrate mixtures

This study considers the following questions:

Are plants grown in peat-wood substrate mixtures more or less susceptible to disease and does wood-fiber (WF) type matter?

Does peat-wood blend ratio affect plant susceptibility to disease?

Wood components are manufactured in multiple ways, with the three most common being hammer milled, twin-disc refined and single- or twin-screw extruded. This study evaluated the three differently processed WFs for natural suppression of damping-off disease – caused by *Rhizoctonia solani* – on radish, as well as crown and root rot on chrysanthemum. Each substrate was blended with raw sphagnum peat at a ratio of 70:30 (peat:wood) by volume. A control blend was made up of 70 percent peat and 30 percent horticultural perlite.

Slightly lower disease severity was observed in the disc-refined wood and hammer-milled wood treatments compared to the peat control. The results suggest that the incorporation of wood components into peat may not significantly negatively or positively affect damping-off disease caused by *R. solani*.

Variations in wood fiber substrates. Photos courtesy of Brian Jackson.

WFs are commonly blended into peat at 10 to 50 percent by volume, but little is known about how that blend ratio affects the severity of soilborne plant diseases. As such, four substrate blends (10 percent, 20 percent and 30 percent WF) were tested and compared to a peat control. For radish, the 80:20 peat:WF blend tended to have lower disease and higher aboveground plant growth compared to the peat control. On chrysanthemum, researchers observed lower disease severity in all WF treatments compared to peat. These results suggest that blend ratio does not impact plant susceptibility to disease.

Ultimately, there is still little known about the effects of wood component type and inclusion rate on soilborne diseases and disease management. Additional research is needed to provide much needed guidance to growers seeking to integrate these new substrates into their operations and integrated pest management (IPM) programs.

Isobel Michaud, a Master's in Biological Sciences: Agricultural Sciences student in the Poleatewich Plant Pathology Lab at UNH, conducted this research.

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