PR-869

Agricultural Experiment Station

2024-2025 Specialty Crops Research Report

2024-2025 Specialty Crops Research Report

Edited by Rachel Rudolph

AUTHORS:

University of Kentucky

Horticulture

Faculty	Brent Arnoldussen
	Cindy Finneseth
	Rachel Rudolph
Extension Associate	Daniel Becker
Professional Staff	Christine Bradley
	Kathryn Pettigrew
	Martín Polo
	Ginny Travis
Graduate Student	P. Luize Lessmann
Undergraduate Student	Kaiden Walden

Kentucky State University

Faculty	Kirk Pomper
Professional Staff	Sheri Crabtree
	Jeremiah Lowe
Graduate Students	Prabina Bhujel
	Godswill Ujah

Oregon State University

Faculty	James Myers

Contents

Acknowledgments

Grants from the Agricultural Development Board through the Kentucky Horticulture Council have allowed an expansion of field research and demonstration programs to meet the informational and educational needs of our specialty crops industries.

Important Note to Readers

The majority of research reports in this volume do not include treatments with experimental pesticides. It should be understood that any experimental pesticide must first be labeled for the crop in question before it can be used by growers, regardless of how it might have been used in research trials. The most recent product label is the final authority concerning application rates, precautions, harvest intervals, and other relevant information. Contact your county's Cooperative Extension office if you need assistance in interpreting pesticide labels.

This is a progress report and may not reflect exactly the final outcome of ongoing projects. Please do not reproduce project reports for distribution without permission of the authors.

Cover: Purple cauliflower nearly ready to harvest at the University of Kentucky Horticulture Research Farm in the spring of 2025.

Photographer: Kathryn Pettigrew, University of Kentucky

The 2024-2025 Specialty Crops Research Program

Rachel Rudolph, Horticulture

Similar to the last compilation of reports (PR-832), this features work from the last two years. Additionally, readers will likely have noticed the name change from *Fruit and Vegetable Research Report* to *Specialty Crops Research Report.* With the addition of new faculty in the Department of Horticulture and the expansion of interest in cut flowers and ornamentals, we thought it appropriate to update the publication's name. Readers will still find rigorous and interesting trial information and perhaps find something new they may want to trial on their own farms. Research was conducted by University of Kentucky faculty, staff, and students from the horticulture department, as well as faculty, staff, and students of Kentucky State University.

Evaluation of cultivars is a continuing necessity and allows us to provide current information to growers across the state about the production and performance of various crops. The results are the basis for updating the recommendations in several of our production guides, which are updated every couple of years. We may also collaborate with researchers in surrounding states to discuss results of similar trials they have conducted. The results presented in this publication often reflect a single year of data at a limited number of locations. Although some plants or varieties perform well across Kentucky year after year, others may not. Below are guidelines for interpreting the results of our projects.

Our Yields vs. Your Yields

Yields reported in variety trial results are often extrapolated from small plots. Depending on the crop, individual plots range from one to 200 plants. Sometimes our yields are reported as is, and at other times, they are calculated by multiplying the yields in these small plots by correction factors to estimate per-acre yield. For example, if 4,200 tomato plants can be planted per acre (assuming in-row spacing of 18 in) and our trials only have 10 plants per plot, we must multiply our average plot yields by a factor of 420 to calculate per-acre yields. Thus, small errors can be greatly amplified. Due to the availability of labor, research plots may be harvested more often than would be economically possible for larger plots or entire acreages. Keep this in mind when reviewing the research papers in this publication.

Statistics

Often yield or quality data will be presented in tables followed by a series of letters (a, ab, bc, etc.). These letters indicate whether the yields of the varieties are statistically different. Two varieties may have average yields that are numerically different but statistically the same. For example, if tomato variety 1 has an average yield of 2000 boxes per acre, and tomato variety 2 yields 2300 boxes per acre, one would assume that variety 2 had a greater yield. However, just because the two varieties had different average yields does not mean that they are statistically or significantly different. In the tomato example, variety 1 may have consisted of four plots with yields of 1800, 1900, 2200, and 2100 boxes per acre. The average yield would then be 2000 boxes per acre. Tomato variety 2 may have had four plots with yields of 1700, 2500, 2800, and 2200 boxes per acre. The four plots together would average 2300 boxes per acre. The tomato varieties have plots with yield averages that overlap and, therefore, would not be considered statistically different, even though the average per-acre yields for the two varieties appear to be quite different. This example also demonstrates variability. Good varieties are those that not only yield well but also yield consistently. Tomato variety 2 may have had yields similar to variety 1, but it also had much greater variation. Therefore, all other things being equal, tomato variety 1 may be a better choice due to less variable yield in the field.

Statistical significance is shown in tables by the letters that follow a given number. For example, when two varieties have yields followed by completely different letters, they are significantly different; however, if they share even one letter, statistically they are no different. Thus, a variety with a yield that is followed by the letters "bcd" would be no different than a variety followed by the letters "cdef" because the letters "c" and "d" are shared by the two varieties. Yield data followed by the letters "abc" would be different from yield data followed by "efg."

When determining statistical significance, we typically use a P value of 0.05. In this case, P stands for probability. If two varieties are said to be different at $P \leq 0.05$, then at least 95 percent of the time those varieties will be different. If the P value is 0.01, then 99 percent of the time those varieties will be different. Different P values can be used, but typically $P \leq 0.05$ is considered standard practice for agricultural research. This approach may be confusing, but without statistics, our results would not be useful. Using statistics ensures that we can make more accurate recommendations for growers.

Apple Rootstock Performance in Western Kentucky

Daniel Becker, Kristine Bradley, Ginny Travis, and Brent Arnoldussen, Horticulture, University of Kentucky

Introduction

Apples (*Malus domestica* Borkh.) are an important tree fruit crop in Kentucky, being grown on 1,276 acres across the state (USDA 2022). Traditional orchard practices have focused on low-density plantings with wide space between trees and large tree sizes. But with increasing land, labor, equipment, and pesticide costs, interest is shifting toward higher-density plantings of smaller trees. Dwarfing and semi-dwarfing rootstocks are used to control scion vigor to plant trees at close spacing and to improve cropping performance. However, slow drainage of clay soils, hot and humid summers, winter temperature fluctuation, and the prevalence of fire blight and wooly apple aphids increase production difficulty compared to other growing regions. Identification of improved rootstocks is necessary to surmount these challenges.

Participation in the NC-140 Regional Research Projects allows for the evaluation of newly released and unreleased rootstocks for adaptation to Kentucky growing conditions. The NC-140 project "seeks to enhance economically and environmentally sustainable practices in temperate fruit production by focusing on rootstocks" (NC-140 Regional Rootstock Research Project 2025). Trials are located across multiple states, Canadian provinces, and Mexico to research rootstock adaptability to the soils and environmental conditions of different regions. Utilization of this multidisciplinary research is critical to improving the Kentucky tree fruit industry as it provides growers with the opportunity to select the most appropriate rootstock to suit their needs.

Materials and Methods

On 11 Apr 2019 a new NC-140 rootstock trial was established at the University of Kentucky Research and Education Center (lat. 37.099212°N, long. 87.841630°W, elevation 626 ft) in Princeton, KY. The soil on site is a Sadler silt loam that is eroded and moderately well drained, with 2% to 6% slopes and a 24-inch depth to a fragipan restrictive layer (Soil Survey Staff 2025). The planting consists of 'Buckeye Gala Simmons' grafted onto seven different rootstocks: 'Budagovsky 10' ('B.10'), 'Geneva 41' ('G.41'), 'Geneva 814' ('G.814'), 'Geneva 969' ('G.969'), 'Malling 9 NAKBT337' ('M.9 NAKBT337'), 'Malling 26 EMLA' ('M.26 EMLA'), and one that has been designated as 'NZ.2' by the NC-140 group for this trial only as it has not been released for distribution (Table 1). As a rootstock, 'NZ.2' is claimed to be similar in size to 'M.9 NAKBT337' (30% to 40% of standard), have high yield efficiency and tolerance to wooly apple aphids, and is possibly immune to fire blight. Characteristics of other rootstocks in this trial are described in Rootstocks for Kentucky Fruit Trees (Wolfe et al. 2019).

The experimental design consists of three trees of each rootstock organized in a randomized complete block with five single-row replications. Trees are spaced 3 ft apart with 13.5-ft spacing between rows and are pruned according to the tall spindle production system (Robinson et al. 2006). Each row is trellised with wires at 2.5-, 5-, and 7.5-ft heights, with metal posts for support at each tree. Water is provided through trickle irrigation tubing suspended on the lowest trellis wire. Ground cover is managed with mowed sod alleyways and 6.5-ft herbicide-treated strips. Trees are fertilized as needed according to tissue analyses, and pesticides are applied following local recommendations (Beckerman et al. 2022).

Trees were evaluated for fruit number and total weight (yield) during August harvest, with fruit size calculated as the average weight (oz) per fruit. Trunk circumference 12 inches above the graft union, tree survival, number of root suckers, and within-row tree height and across-row canopy width were measured in the fall annually. Trunk circumference is used to calculate trunk cross-sectional area (TCSA), which relative to the total weight of fruit harvested is used to calculate per-tree yield efficiency (lb/inch^2 of TCSA). Statistical analysis was performed using PROC GLM in SAS version 9.4 (SAS Institute, Cary, NC, USA), with means separation at a 5% level of significance using Tukey's honestly significant difference (HSD) test.

Table 1. Apple rootstocks being evaluated in the 2019 NC-140 trial at Princeton, KY.

Rootstock	Status	Origin	Program location
Budagovsky 10	Named	Michurinsk University	Michurinsk, Tambov Region, Russia
Geneva 41	Named	Cornell-USDA, New York State Agricultural Experiment Station[i]	Geneva, New York, United States of America
Geneva 814	Named		
Geneva 969	Named		
NZ.2	Unreleased	Biotechnology Science Institute, Plant & Food Research	Auckland, New Zealand
Malling 9 NAKBT337	Named (virus free sub-clone of M.9)	Naktuinbouw Inspection Service for Horticulture	Roelofarendveen, The Netherlands
Malling 26 EMLA	Named (virus free sub-clone of M.26)	East Malling Research Station	Kent, England

[i] For further information of the Geneva rootstock series, see https://ctl.cornell.edu/wp-content/uploads/plants/GENEVA-Apple-Rootstocks-Comparison-Chart.pdf.

In contrast to previous reports (Wolfe et al. 2023), results are based on all trees within the trial to increase sample size (n = 15) for each treatment and confidence in the statistical analysis. Earlier methodology evaluated only the center tree of each three-tree plot to reduce the confounding effects of having different rootstock sizes next to each other. However, this led to a much smaller sample size (n = 5). For the purposes of this article and the intended grower audience, inclusion of data collected from all trees in the analysis is permissible despite the likelihood of increased border effects.

Results and Discussion

Spring 2025 was challenging for crop load management. Pruning to narrow tree canopies to maintain the tall spindle training system led to the removal of many large branches and a substantial number of fruit buds. This negatively affected flower coverage, which was less in 2025 than in previous years. Cold, cloudy, and windy weather in the first two weeks of April during flowering limited bee activity, reducing pollination and fruit set. Excessive rainfall, totaling 14.3 inches for the month, also caused difficulties in maintaining spray coverage (Kentucky Mesonet 2025). In early May, cloudy weather before and after a chemical thinner was applied contributed to increased fruit drop despite a low rate being used. These difficulties negatively impacted the number of sound fruits present at harvest, which is why yields were not higher.

Fruit number, average fruit weight (size), and yield per tree varied significantly among the seven rootstocks (Table 2). Average fruit number was highest for 'G.969,' which also had the highest yield per tree in both 2024 and 2025. 'Geneva 814' produced the largest fruits but only differed significantly from 'G.969' and 'B.10.' Fruit size ranged from 5.9 ounces for 'G.814' down to 4.9 ounces for 'B.10.' While there has been some year-to-year variability, 'B.10' has tended to be among the lowest in fruit number, weight, and per-tree yields of all the rootstocks in the trial. Overcropping may be a possibility, but annual yield efficiency has also been low for trees on this rootstock. Thus far, 'NZ.2,' 'G.969,' and 'G.814' have been the most productive as reflected in the average annual yield when all trees in the experiment are included in the analysis. In contrast, when data from only the middle tree of each plot was analyzed in 2023, annual yields were only highest for 'NZ.2' and 'G.969' (Wolfe 2022). 'Geneva 814' did have the highest yield that year but was not significantly different from any other rootstock. Trees on 'NZ2' rootstock had the highest cumulative yield from six harvests (2020–25) and were similar to trees on 'G.969' and 'G.814' in total weight of fruit produced. As with average annual yield, cumulative yield was lowest for trees on 'B.10' but is not significantly different from 'G.41,' 'M.9 NAKBT337,' or 'M.26 EMLA.'

There was no significant difference among rootstocks for annual or cumulative yield efficiency. This lack of variance may be attributed to a combination of low yield, tree size, and planting age. Yield efficiency measures the ratio of fruit production to wood production and is used to express crop load capacity. While yield efficiency is useful in estimating productivity, it is most relevant for young trees that have not yet filled their allotted canopy space. As trees in high-density plantings mature, early differences in productivity tend to diminish over time (Wolfe et al. 2023).

Table 2. Fruit weight, number, and yield of trees evaluated in the 2019 NC-140 rootstock trial at Princeton, KY[i].

Rootstock[ii]	2025 fruit weight (oz)	2025 fruit no. per tree	2024 yield (lb/tree)	2025 yield (lb/tree)	2025 yield efficiency (lb/inch^2 of TCSA)	Average annual yield, 2020–25 (lb/tree)	Cumulative yield, 2020–25 (lb/tree)	Cumulative yield efficiency (lb/inch^2 of TCSA)
G.814	5.9 a	44.0 ab	10.6 ab	16.1 ab	2.7	16.0 a	92.4 ab	15.9
G.969	5.2 bc	51.8 a	11.4 a	16.6 a	3.0	15.8 a	92.7 ab	17.1
NZ.2	5.6 ab	37.4 ab	10.4 ab	13.2 abc	2.5	16.4 a	96.3 a	18.7
M.26 EMLA	5.4 abc	33.8 b	7.2 abc	11.5 abc	2.5	12.6 b	73.4 bc	16.6
M.9 NAKBT337	5.7 ab	33.5 b	7.9 abc	11.8 abc	2.8	11.7 b	70.4 c	17.0
G.41	5.6 ab	28.5 b	5.6 bc	10.1 bc	2.5	11.8 b	68.4 c	17.9
B.10	4.9 c	26.8 b	4.6 c	8.5 c	2.4	10.8 b	62.6 c	18.3
Means	5.5	36.5	7.9	12.5	2.6	13.6	79.4	17.4
LSD (5%)[iii]	0.6	17.5	5.5	6.1	NS	3.0	20.3	NS

[i] Results are based on all trees in a three-tree plot across five replications, n = 15.
[ii] Arranged in descending order of trunk cross sectional area (TCSA) for each rootstock.
[iii] Least significant difference (LSD) at $P \leq 0.05$. Means within columns followed by the same letter are not significantly different according to Tukey's honestly significant difference (HSD) test. "NS" indicates no significant difference in the analysis of variance.

Table 3. Survival and growth for 2025 of trees evaluated in the 2019 NC-140 rootstock trial at Princeton, KY[i].

Rootstock[ii]	Survival (%)	TCSA (inch^2)	Height (ft)	Width (ft)	Root suckers (#/tree)
G.814	93.3	6.2 a	13.8 ab	5.5 a	5.6 a
G.969	93.3	5.7 ab	13.4 abc	5.1 a	5.3 a
NZ.2	93.3	5.4 ab	14.1 ab	5.6 a	4.2 a
M.26 EMLA	93.3	5.0 abc	13.2 bc	4.9 ab	0.1 c
M.9 NAKBT337	100.0	4.5 bcd	13.7 ab	5.6 a	3.7 ab
G.41	93.3	4.1 cd	14.3 a	5.3 a	0.4 bc
B.10	93.3	3.7 d	12.5 c	4.3 b	0.0 c
Means	94.3	5.0	13.6	5.2	2.8
LSD (5%)[iii]	NS	1.2	1.1	0.8	3.5

[i] Results are based on all trees in a 3-tree plot across five replications, n = 15.
[ii] Arranged in descending order of trunk cross sectional area (TCSA) for each rootstock
[iii] Least significant difference (LSD) at $P \leq 0.05$. Means within columns followed by the same letter are not significantly different according to Tukey's honestly significant difference (HSD) test. "NS" indicates no significant difference in the analysis of variance.

Tree size, as measured by TCSA, was largest for 'G.814,' followed by 'G.969,' 'NZ.2,' and 'M.26 EMLA,' while 'B.10' had the smallest tree size, being grouped similarly with 'G.41' and 'M.9 NAKBT337' (Table 3). Measuring trunk area is a useful way to assess tree size and is more valuable as an estimate of potential yield than canopy dimensions. Once trees fill their allotted space and the canopy is manipulated through pruning to keep it contained, canopy size becomes less relevant as an assessment of productivity and vigor. Tree height ranged from 14.3 feet for 'G.41' to 12.5 feet for 'B.10,' which also had the smallest canopy width. Despite 'G.41' being considered fully dwarfing, it is grouped similarly with the semi-dwarf 'G. 814' and 'G.969' in terms of height. This is illustrative of the difficulty in pruning to narrow canopy width in a high-density planting system as growth is directed upward, hampering attempts to regulate tree height through rootstock selection. The expected vigor according to Rootstocks for Kentucky Fruit Trees (HO-82; Wolfe et al. 2019) has 'M.9 NAKBT337,' 'G.41,' and 'B.10' rootstocks grouped together as 30% to 40%; 'M.26 EMLA' and 'G.814' as 40% to 50%; and 'G.969' as 60% to 70% of standard, respectively. However, 'G.814' has regularly been the most vigorous rootstock in this trial, surpassing 'G.969,' while 'NZ.2' is more similar in vigor to 'M.26 EMLA.' Root sucker number per tree somewhat parallels TCSA, as 'G.814,' 'G.969,' and 'NZ.2' had the highest number of these develop annually.

Tree survival has remained stable since 2024, and no significant differences exist between any of the rootstocks. One tree has died for each rootstock except 'M.9 NAKBT337.' Cause of mortality has primarily been breakage at the graft union during storms and periods of high wind. One tree on 'G.969' was seemingly girdled by borers near the graft union in 2024, though these insects may not have been the primary cause of death and were merely capitalizing on weakness and dead tissue from earlier injury.

Evaluation of this trial is currently in its seventh year with six years of harvest data collected. Typically, NC-140 trials are evaluated over ten growing seasons. The current results are preliminary and do not represent final assessments. Once the trial is completed, results will be summarized with conclusions made about each rootstock.

Acknowledgments

The authors would like to thank Dwight Wolfe, retired horticulture research specialist, for helping with analyzing the data using the SAS statistical program. Thanks also to Ginny Travis and Kristine Bradley for helping with trial management and data collection.

Literature Cited

Beckerman J, Bessin R, Welty C, Athey K, Wahle E, Lewis D, Long E, Joshi N, Guedot, C, Meyer S, Strang J, Gauthier N. 2022. Midwest fruit pest management guide 2023-2024. Univ Kent Coop Ext Serv. ID-232. https://ag.purdue.edu/department/hla/extension/_docs/id-465.pdf. [accessed 28 Oct 2025].

Kentucky Mesonet. 2025. Monthly climatological summary, Caldwell County, Princeton, KY USA (Apr 2025). https://www.kymesonet.org/monthly_summaries.html?county=PRNC&year=2025&month=4. [accessed 20 Oct 2025].

NC-140 Regional Research Project. 2025. http://www.nc140.org/. [accessed 20 Oct 2025].

US Department of Agriculture, National Agricultural Statistics Service. 2022. Census of Agriculture. https://www.nass.usda.gov/Publications/AgCensus/2022/index.php. [accessed 10 Oct 2024].

Robinson TL, Hoying SA, Reginato GH. 2006. The tall spindle apple production system. 21–28. In: New York Fruit Quarterly. NY State Hort Soc. 14(2). https://nyshs.org/wp-content/uploads/2016/10/The-Tall-Spindle-Apple-Production-System.pdf. [accessed 21 Oct 2025].

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. https://websoilsurvey.nrcs.usda.gov/app/. [accessed 20 Oct 2025].

Wolfe D. 2022. 2022 results from 2019 'Buckeye Gala' apple rootstock trial at Princeton, KY. In: Becker D (ed). Nov-Dec 2022 fruit facts newsletter. Univ Kent Agric Exp Stn Fruit Facts Newsl. 2022-6.

Wolfe D, Becker D, Travis G, Arnoldussen B. 2023. Rootstock effects on apple tree growth and yield. 6–10. In: Rudolph R (ed). Fruit and vegetable 2023 annual research report. Univ Kent Agric Exp Stn Bull PR-832.

Wolfe D, Strang J, Becker D, Wright S. 2019. Rootstocks for Kentucky fruit trees. Univ Kent Coll Agric Food Environ Coop Ext Serv. HO-82. https://publications.mgcafe.uky.edu/sites/publications.ca.uky.edu/files/HO82.pdf.[accessed 20 Oct 2025].

Overwinter High Tunnel Production of Brussels Sprout Cultivars, 2023-2025

Daniel Becker, Christine Bradley, and Ginny Travis, Horticulture, University of Kentucky

Introduction

Brussels sprouts (*Brassica oleracea* var. *gemmifera*) are a cold-hardy member of the Brassicaceae family that can tolerate temperatures down to 20 °F if acclimated beforehand (Rudolph et al. 2024). Other more familiar members of this family include cabbage, broccoli, and cauliflower, known collectively as cole crops. Brussels sprouts are grown for their edible buds, which develop at the leaf axils along the sides of a long stalk. Sprouts are harvested either individually as they mature from the base of the stalk upwards or by removing the apical meristem of the plant (also referred to as topping) prior to harvest and then collecting the entire stalk for processing (Sideman et al. 2023).

Commercial production of Brussels sprouts is concentrated primarily in the central coast region of California where ideal conditions allow for year-round production, with smaller areas of production in the Skagit Valley of Washington state and Long Island, New York. In the most recent census, 2,385 farms harvested 17,185 acres of Brussels sprouts (USDA 2022). In Kentucky, Brussels sprouts were harvested from 57 farms and 15 acres (USDA 2022).

Kentucky's climate is well suited for fall production of most cole crops. Brussels sprouts are slow-growing, and many cultivars require more than 90 days from seeding to reach maturity. When grown as a spring crop, plants do not have enough time to mature before the arrival of hot weather, which will cause sprouts to lose firmness and become bitter. Due to their cold tolerance, successfully overwintering a fall-planted crop inside a protected structure such as a high tunnel might be possible. The objective of this trial was to evaluate the yield potential of Brussels sprout cultivars when grown through the winter inside a high tunnel.

Materials and Methods

On 21 Jul 2023 and the following year on 18 Jul 2024, eight Brussels sprout cultivars (Table 1) were seeded into 50-cell trays (Landmark Plastic Corporation, Akron, OH, USA) filled with Berger BM6 All-Purpose Mix (Berger, Saint-Modeste, QC, Canada). Trays were placed outside on a bench covered with 50% transmittance shade cloth. Seedlings were watered as needed. Beginning 14 days after seeding, a 100-ppm concentration of 20N–4.4P–16.6K water-soluble fertilizer was applied on a weekly basis. Applications of carbaryl (Sevin XLR Plus, NovaSource, Tessenderlo Kerley, Inc., Phoenix, AZ, USA) at a 0.75-fl oz/gal rate were sprayed as needed to control lepidopteran insects (*Lepidoptera* spp.). Two weeks prior to transplanting, the shade cloth was removed, and fertilizer application stopped to condition the transplants for growth in a high tunnel environment.

Seedlings were transplanted on 15 Sep 2023 and 12 Sep 2024 into tilled soil inside a 20 ft x 60 ft high tunnel covered with a single layer of 6-mil clear polyethylene. The tunnel is located at the University of Kentucky Research and Education Center (lat. 37.099212°N, long. 87.841630°W, elevation 626 ft) at Princeton, KY. The soil on site is a Sadler silt loam, which is eroded and moderately well drained, with 2% to 6% slopes and a 24-inch depth to a fragipan restrictive layer (Soil Survey Staff 2024). Soil test results prior to planting in 2023 indicated that at 0- to 8-inch depth the calculated soil-water pH was 6.68, while extractable phosphorous, potassium, calcium, magnesium, and zinc using the Mehlich III extraction procedure were 23, 184, 5085, 413, and 8.6 lb/acre, respectively (University of Kentucky Division of Regulatory Services 2025).

Table 1. Description of Brussels sprout cultivars grown for overwinter production in a high tunnel at Princeton, KY.

Cultivar	Days to Maturity[i]	Description
Attis[ii]	103	Tall plants with widely spaced, dark-green sprouts that are easy to pick. Sprouts are evenly sized, firm, and glossy.
Dagan	103	Erect plants with widely spaced, easy-to-pick, slightly elongated sprouts that remain firm throughout harvest.
Divino	105	Tall, straight stalks with dark-green sprouts that are very firm and glossy. Leaves and sprouts snap off easily.
Gustus	105	Large sprouts from medium-sized plants. Sprouts are prone to becoming soft if allowed to overmature.
Jade Cross	85	Older cultivar with compact growth habit and small, firm sprouts. Due to close spacing, sprouts may be difficult to harvest.
Marte	103	Upright plants with uniform, widely spaced sprouts. Sprouts are dark green and remain firm throughout harvest.
Scorpius	112	Large, evenly sized, bright-green sprouts from medium-sized plants. Sprouts snap off easily but may become soft if overmature.
Silvia	98	Medium-to-large sprouts on medium-tall plants. Sprouts are prone to becoming soft if allowed to overmature.

[i] Days to maturity from transplant obtained from supplier catalogs and seed packets.
[ii] All seeds were purchased from Seedway, LLC (Hall, NY) except for 'Dagan' and 'Jade Cross', which were purchased from Harris Seeds (Rochester, NY).

Each 6-ft plot consisted of four plants per cultivar, spaced 18 inches apart in rows spaced 5 ft apart. Plots with missing or dead transplants were replanted 7 days after the initial planting to achieve a 100% stand count. Rows had two lines of 5/8-inch drip tape (12-inch emitter spacing, 0.45 gal/min/100 ft; Aqua-Traxx, The Toro Company, Bloomington, MN, USA) spaced 3 inches on either side of the plants. The aisles were covered with a 5-ft strip of embossed black plastic mulch (Filmtech Corp., Allentown, PA, USA) with plant beds covered with rice hulls for weed control. The trial was arranged in a randomized complete block design with four replications of each cultivar.

Plants were fertilized immediately after transplanting with a 10N–13.1P–16.6K starter solution using a pounds-per-gallon of water equivalent rate of 3:50 and applying 8 fl oz per plant. Subsequent fertilizer applications using a 10 lb/acre rate of actual nitrogen with 20N–4.4P–16.6K began on 28 Sep in 2023 and 24 Sep in 2024, continuing weekly until 22 Nov 2023 and 24 Nov 2024 respectively, when plant growth slowed and overnight temperatures began to frequently drop below 32 °F. Fertigation was not resumed the following spring along with irrigation as it was expected that some unused fertilizer remained in the soil from the previous year. Irrigation scheduling was based on soil moisture monitoring using gypsum block sensors and a Watermark Soil Moisture Meter (Irrometer Company, Inc., Riverside, CA, USA). A single application of malathion (Malathion 57 EC, Loveland Products, Inc., Greeley, CO, USA) at a 1-pt/acre rate was needed on 7 Oct 2023 to manage lepidopteran insects. Two applications were needed the following year, on 4 Oct and 21 Oct due to increased feeding pressure.

Temperature regulation within the high tunnel depended entirely on passive methods. Side walls and end wall doors remained open except when overnight air temperatures dropped below 25 °F and were reopened if temperatures rose above 32 °F the following day. In 2024, additional plant protection was necessary from 14 Jan to 21 Jan during a period of subfreezing weather when the average daily and nightly high/low temperatures were 19.7/5.5 °F, with the lowest daytime (9.7 °F) and nighttime (0.7 °F) air temperatures occurring on 15 Jan and 21 Jan, respectively (Kentucky Mesonet 2024). Rows were draped with two layers of 0.9-oz-per-yard^2 polypropylene row covers (Agribon-30, Plantonix LLC., Ashland, OR, USA) to trap radiative heat released from the soil (Figure 1). Plants were briefly uncovered during the morning on 17 Jan and 18 Jan to dehumidify and allow sunlight to reach the leaves and were recovered before 3:00 PM each afternoon. In 2025, plants needed protection using the same methods from 4 Jan to 9 Jan, from 19 Jan to 22 Jan, and from 17 Feb to 22 Feb, when 13.1, 4.8, and 1.6 °F minimum air temperatures occurred, respectively (Kentucky Mesonet 2025). On 10 Mar 2024 and 17 Mar 2025, the exterior of the tunnel was covered with 50% transmittance shade cloth to reduce radiative heat capture when daytime temperatures began to consistently rise above 65 °F.

During the first year, harvest began on 19 Dec 2023, with another on 11 Jan 2024. During the following year, first and second harvest occurred on 18 Dec 2024 and 16 Jan 2025, respectively. One month prior to the first harvest (21 Nov 2023 and 25 Nov 2024) when the lowest sprouts were between ¼ and ½ inches in diameter, the bottom 9 inches of leaves were stripped from each plant to promote air circulation and encourage sprout development. Stripping was not necessary prior to the second harvest as short daylength, low light intensity, and cold temperatures had slowed plant growth. Further leaf stripping occurred before each of the following harvests, removing roughly 3 to 6 inches of canopy each time. Individual sprouts were hand harvested by snapping off the stems when they were over 1 inch in diameter and were not more than 2 ¾ inches in length, as specified for the U.S. No. 1 grading standard (US Department of Agriculture, Agricultural Marketing Service 2016). Sprout collection continued twice monthly in February and March with the final harvests on 5 Apr 2024 and 26 Mar 2025, once sprout firmness and quality had declined due to heat and floral development caused by vernalization.

The total number of marketable sprouts were counted and their weights recorded at each harvest from all four plants in a plot. Qualitative information useful in forming a description of each cultivar was recorded throughout the trial as observed. All data were statistically analyzed using PROC GLM in Statistical Analysis Software (SAS) version 9.4 (SAS Institute, Cary, NC, USA), subjecting it to analysis of variance (ANOVA) and means separation using Tukey's honestly significant difference (HSD) test ($P \leq 0.05$).

Figure 1. Brussels sprout plants being covered with polypropylene row covers ahead of forecasted subfreezing weather.
Photo by Daniel Becker, University of Kentucky

Results and Discussion

Brussels sprouts are an uncommon crop for high tunnel production, particularly when the objective is to grow them for overwinter harvests. Numerous cultivars exist from seed suppliers that are selected for field production based on high yield, consistency, and desirable sprout quality. The performance of cole crops grown in a high tunnel setting has been studied before by Rudolph and Yates (2020), but further evaluation of Brussels sprouts as a crop is necessary to establish viability and understand the limitations of production.

The results indicate that some yield differences exist between cultivars that may influence grower decisions. For year one (2023-24), 'Marte' had the highest yield per four-plant plot but was not significantly different from 'Dagan,' 'Gustus,' 'Silvia,' 'Scorpius,' and 'Jade Cross' (Table 2). 'Attis' and 'Divino' produced the lowest yield but similarly did not differ in comparison with the previous five cultivars. Sprout number per cultivar had a means separation comparable to marketable yield, except for 'Jade Cross,' which produced a similar number of sprouts as 'Marte.' Despite producing many sprouts, yield for 'Jade Cross' was not higher, as it had the lowest mean sprout weight of any cultivar. 'Jade Cross' is also unique in this evaluation as it has thick stalks with sprouts spaced closely together, which can make picking difficult. All other cultivars have similarly sized sprouts that are well spaced on thinner stalks, which makes sprout removal by hand easier.

Results for year two (2024-25) were similar to the previous season, with 'Marte' having the highest yield per plot and 'Jade Cross' the most sprouts harvested. Yield was lowest for 'Jade Cross' due to small sprout size, and 'Divino' had the lowest number of sprouts collected. Yield for the season was lower across all cultivars compared to year one despite sprout number being higher. More sprouts were harvested slightly earlier in year two than in year one in anticipation of potentially damaging cold weather in both January and February, which resulted in a greater number of small sprouts being collected.

'Marte' had the highest cumulative yield from both harvest seasons and was significantly different from 'Jade Cross,' 'Attis,' and 'Divino,' which produced the lowest overall yields. More sprouts were harvested from 'Jade Cross' than any other cultivar, but as previously observed, sprout size was small, which is why cumulative yield was not higher. 'Attis' and 'Divino' produced among the lowest number of marketable sprouts each year, which is reflected in their low cumulative sprout numbers. Despite 'Marte' appearing to be the most favorable cultivar, it is important to note that it is not significantly different from 'Dagan,' 'Gustus,' 'Silvia,' and 'Scorpius' in harvest capacity. This should give potential growers plenty of options to select desirable cultivars that suit their needs and demands of production.

Beyond yield, desirable characteristics include plant uniformity, resistance to heat, and production of firm, green, and glossy sprouts that are easy to harvest and require minimal trimming of loose wrapper leaves prior to sale. Most cultivars performed reasonably well when considering these criteria. From the fifth harvest (6 March 2024 and 13 March 2025) onward, 'Scorpius' and 'Dagan' developed some sprouts that required removal of wrapper leaves to improve appearance, but this deficiency was generally minor and did not substantially increase hand labor. 'Gustus' was noticeably sensitive to heat during harvest and will produce oversized, loose sprouts if they are left too long on the plant.

The timing of peak production is another important consideration. For most cultivars, production peaked during the fourth harvest on 20 Feb 2024 and 25 Feb 2025. However, productivity for 'Silvia,' 'Dagan,' and 'Marte' peaked earlier during the second (11 Jan 2024 and 16 Jan 2025) and third harvests (1 Feb 2024 and 7 Feb 2025), with a gradual decline in the total weight and number of sprouts collected thereafter. Despite 'Jade Cross' being described as having the shortest days to maturity, it was not noticeably earlier than any other cultivar in this trial. Small sprout size contributed to this outcome, as it was desirable to wait until later harvests to collect sprouts of marketable grade.

Table 2. Marketable yield, sprout number, and mean weight of Brussels sprouts harvested from a high tunnel overwinter in 2023-24 and 2024-25 at Princeton, KY.

	2023-24			2024-25			Cumulative	
Cultivar	Yield (lb) [i]	Sprout number [i]	Mean sprout weight (oz) [ii]	Yield (lb) [i]	Sprout number [i]	Mean sprout weight (oz) [ii]	Yield (lb) [i]	Sprout number [i]
Marte	10.1 a	218.5 a	0.74 a	8.8 a	237.5 ab	0.59 a	18.9 a	456.0 ab
Dagan	9.5 ab	200.5 ab	0.75 a	8.2 ab	216.0 ab	0.61 a	17.7 ab	416.5 abc
Gustus	8.9 ab	191.5 ab	0.76 a	7.4 ab	195.5 ab	0.60 a	16.3 ab	384.3 abc
Silvia	8.8 ab	188.8 ab	0.76 a	7.7 ab	196.8 ab	0.63 a	16.5 ab	388.3 abc
Scorpius	8.6 ab	198.3 ab	0.70 a	6.8 ab	203.5 ab	0.54 a	15.4 ab	401.0 abc
Jade Cross	8.4 ab	216.8 a	0.62 b	6.0 b	250.5 a	0.38 b	14.4 b	464.8 a
Attis	8.1 b	183.5 b	0.71 a	6.9 ab	193.0 ab	0.57 a	15.0 b	376.5 bc
Divino	7.9 b	183.0 b	0.69 a	6.5 ab	184.0 b	0.57 a	14.4 b	367.0 c
LSD (5%) [iii]	1.8	32.3	0.07	2.7	61.8	0.10	3.6	81.6

[i] Yield and sprout number are means based on seven (19 Dec 2023 to 5 Apr 2024) and six (18 Dec 2024 to 26 Mar 2025) harvests from four plants per plot averaged across four replications of each cultivar.
[ii] Mean sprout weight derived from the total yield of sprouts divided by the total number of sprouts collected from all harvests of each cultivar.
[iii] Least significant difference (LSD) at $P \leq 0.05$. Values within columns followed by the same letter are not significantly different according to Tukey's honestly significant difference (HSD) test.

As with other cole crops, Brussels sprouts have an optimum temperature of 60 to 65 °F, with 40 to 75 °F considered the minimum and maximum necessary for quality production (Maynard and Hochmuth 2007). Air temperatures inside the high tunnel were generally within this range except during autumn post-planting, when maximum daytime highs frequently exceeded 90 °F. Due to radiative heat capture, internal temperatures within a high tunnel can be 20 °F or more above external temperatures on sunny days. However, productivity did not appear to be negatively impacted by these conditions as cole crops can tolerate a period of heat prior to reaching maturity, at which point chilling is necessary for harvest quality.

Air temperatures below 20 °F can cause injury to Brussels sprouts, particularly if plants are young or unacclimated to cold weather conditions (Rudolph et al. 2024). Closure of side walls and end-wall doors overnight was occasionally necessary throughout the winter. High tunnels have minimal insulative potential but when well sealed can generally be relied on to provide some protection. During periods of subfreezing weather in year one and two of the trial, a centrally located max/min thermometer suspended at roughly 4 ft height recorded a 10 and 12 °F minimum temperature in respective years, while the maximum temperatures were 68 and 66 °F respectively within the closed tunnel. These minimum temperatures were higher than the lowest nighttime (0.7 °F) and daytime (9.7 °F) outside air temperatures recorded on 15 and 21 Jan 2024 (Kentucky Mesonet 2024). The same thermometer indicated an 8 °F difference in internal versus external nighttime temperature during a similarly cold period in year two. Any breaks in the plastic covering were sealed, and straw was used to cover any openings in the tunnel to reduce drafts, which likely aided in insulative potential.

The double layer of 0.9 oz/yard^2 polypropylene covers draped over rows were successful in providing cold protection, as the lowest temperature recorded by a max/min thermometer placed within the plant canopy was 24 °F in both year one and two. This is 14 and 12 °F higher than the minimum air temperature inside the tunnel and shows the cumulative insulative capacity when using multiple protection tactics. Conversely, the highest temperature underneath the covers was 62 °F (year one) and 64 °F (year two), which is 4 and 2 °F less than the air temperature recorded above the covers. Row covers inhibit light penetration and will reduce radiative heating around the plants if not removed during the daytime. Uncovering plants periodically during cold, sunny weather is necessary to increase canopy air temperature and to ensure ventilation of excess humidity. Plants had a slightly wilted appearance after cover removal but quickly recovered once temperatures warmed. We noted that several plants throughout the tunnel had purple discoloration of the leaves, primarily on the underside and near the edges in response to chilling (Figure 2). However, sprouts did not show any discoloration or apparent damage.

Figure 2. Purple discoloration of the undersides and edges of Brussels sprout leaves caused by chilling injury.
Photo by Daniel Becker, University of Kentucky

Figure 3. 'Dagan' Brussels sprouts exhibiting calcium deficiency symptoms of crown leaves.
Photo by Daniel Becker, University of Kentucky

Calcium deficiency symptoms were noticed on some cultivars beginning in January (Figure 3). 'Jade Cross' and 'Dagan' had the highest number of plants exhibiting symptoms, while 'Marte', 'Silvia', and 'Divino' were intermediate. 'Gustus', 'Attis', and 'Scorpius' did not have any plants affected. Symptoms were restricted to leaves near the crown and did not appear on any harvestable sprouts. Calcium and moisture were not limiting in the soil, as both were monitored with a pre-plant soil test and gypsum block sensors during production. Symptom development was likely related to cold soil temperatures that reduced root growth. Calcium is absorbed primarily by young roots through the soil solution in the region just behind the root tip. When the soil is cold, roots are not actively growing or are growing very slowly and are less efficient at absorbing nutrients to support growth. Water movement through the xylem cells of the plant upward toward the apical meristem and developing leaves is similarly slowed. Mild wilting was observed, particularly in the morning on warm days when the soil temperature remained cold, indicating that plants could not move water rapidly enough to support growth. Wilting diminished by midday and toward the evening once the soil began to warm. Despite discernable differences between cultivars, it is not apparent that the presence of symptoms affected yield in regard to either total number of sprouts or sprout weight in this experiment.

Bolting due to vernalization was first observed starting in early March on some cultivars. Plants began to exhibit elongation of internodes and the development of flower stalks as daylength and heat unit accumulation increased (Figure 4). 'Silvia', 'Gustus', and 'Scorpius' were the earliest to bolt and appeared to be particularly sensitive in this regard. Some sprouts collected from these three cultivars during later harvests were noticeably soft and elongated, making them unmarketable. 'Jade Cross' bolted later and during the final harvest produced many small sprouts with yellow wrapper leaves. Post-harvest trimming to remove these leaves was necessary to improve sprout appearance. 'Dagan', 'Attis', 'Marte', and 'Divino' maintained attractive, firm sprouts, but their size diminished toward the end of picking. Declining sprout quality due to bolting likely had only a minor impact on yield, even for those cultivars that exhibited an early response. Bolting only became advanced during harvests six (21 Mar 2024 and 26 Mar 2025) and seven (5 Apr 2024), when per-harvest yields were already in steep decline. Differences in bitterness caused by heat were not detected between cultivars in this trial.

Brussels sprouts may be a viable crop for growing overwinter in a high tunnel and could be useful in supplementing fall field production. Based on results, several cultivars exist that are options for growing in this setting because of their yields and desirable sprout characteristics. In terms of market potential, extending harvests into the late winter and early spring season may allow growers to further develop a niche for fresh sales to restaurants and specialty grocery stores (Combs and Ernst 2019). Picking sprouts individually is labor-intensive compared to whole-stalk harvest, but it is necessary to extend the harvest window and justify occupying valuable high tunnel space. Some labor savings are possible, as pest management requirements are low compared to field production due to a later planting date, though it does increase as temperatures rise in the spring (personal observation). Finally, Brussels sprouts are an unconventional high tunnel crop and could be useful in rotation with traditional high-value spring- and summer-season crops.

Figure 4. 'Silva' Brussels sprouts bolting in response to increased temperatures and daylength.
Photo by Daniel Becker, University of Kentucky

Acknowledgments

The authors wish to express their gratitude to the seed companies that supplied cultivars for evaluation. The authors would also like to thank Dwight Wolfe, retired horticulture research specialist, for help with analyzing the data using the SAS statistical program. Thanks also to Ginny Travis and Kristine Bradley for helping with trial management and data collection. This evaluation would not have been possible without funding from the Kentucky Horticulture Council and the Kentucky Agriculture Development Fund.

References Cited

Combs MH, Ernst M. 2019. Brussels sprouts. University of Kentucky Center for Crop Diversification, Lexington, KY, USA. Univ Kent Cent Crop Div. CCD-CP-89. https://ccd.uky.edu/sites/default/files/2024-11/ccd-cp-089_brussels-sprouts.pdf. [accessed 20 Oct 2025].

Division of Regulatory Services. 2025. Soil testing methods. Univ Kent Coll Agric Food Environ. https://www.rs.uky.edu/soil/methods.php. [accessed 28 Oct 2025].

Kentucky Mesonet. 2024. Monthly climatological summary, Caldwell County, Princeton, KY USA (Jan 2024). https://www.kymesonet.org/monthly_summaries.html?county=PRNC&year=2024&month=1. [accessed 11 Oct 2024].

Kentucky Mesonet. 2025. Monthly climatological summary, Caldwell County, Princeton, KY USA (Jan, Feb 2025). https://www.kymesonet.org/monthly_summaries.html?county=PRNC&year=2025&month=1. [accessed 14 Oct 2025].

Maynard DN and Hochmuth GJ. 2007. Knott's handbook for vegetable growers (5th ed). John Wiley & Sons, Inc., Hoboken, NJ, USA.

Rudolph R and Yates B. 2020. Evaluation of broccoli cultivars for winter high tunnel production. 14–15. In: Rudolph R (ed.) Fruit and vegetable 2020 annual research report. Univ Kent Agric Exp Stn Bull. PR-779. https://publications.ca.uky.edu/sites/publications.ca.uky.edu/files/PR779.pdf. [accessed 11 Oct 2024].

Rudolph R, Wright S, Bessin R, Gauthier N, Leonberger K, Munir M (eds). 2024. Vegetable Production Guide for Commercial Growers, 2024-25. ID-36. Univ of Kent Coop Ext Serv. Lexington, KY, USA. https://publications.mgcafe.uky.edu/files/ID36.pdf. [accessed 20 Oct 2025].

Sideman RG, Roman C, Hodgdon E. 2023. Brussels sprout cultivar performance and response to apical meristem removal. HortTechnology 33(2):193–202. https://doi.org/10.21273/HORTTECH05170-22.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. https://websoilsurvey.nrcs.usda.gov/app/. [accessed 10 Oct 2024].

US Department of Agriculture, Agricultural Marketing Service. 2016. United States standards for grades of brussels sprouts. https://www.ams.usda.gov/grades-standards/brussels-sprouts-grades-and-standards. [accessed 10 Oct 2024].

US Department of Agriculture, National Agricultural Statistics Service. 2022. Census of Agriculture. https://www.nass.usda.gov/Publications/AgCensus/2022/index.php.[accessed 10 Oct 2024].

Evaluation of Spring-Planted Cauliflower Cultivars

Rachel Rudolph, Kathryn Pettigrew, Martín Polo, and P. Luize Lessmann, Horticulture, University of Kentucky

Cauliflower (*Brassica oleracea* var. *botrytis*) is part of a group of vegetables known as cole crops. This group includes broccoli, cabbage, Brussels sprouts, collards, kale, kohlrabi, and others. Cole crops likely originated near the Mediterranean Sea and Asia Minor (Swiader and Ware 2002). For many years, it has been stated that cauliflower does not grow well in the spring in Kentucky and should only be grown in the fall (Gauthier et al. 2024). Although this has been in the text of the University of Kentucky Vegetable Production Guide for Commercial Growers, it is unclear where, when, or how this idea formed. For healthy growth and development, the optimum temperature range for cauliflower is from 60 °F to 65 °F, with a minimum of 45 °F and a maximum of 75 °F (Swiader and Ware 2002). Cauliflower benefits from uniform, cool temperatures and is moderately sensitive to temperature extremes. Although weather can be unpredictable from year to year and temperatures can swing dramatically in the spring in Kentucky, the temperature range for cauliflower would not be abnormal in the spring in central Kentucky. For example, the average daily high and low in April 2024 were 66.9 °F and 48.8 °F, respectively (Kentucky Mesonet 2024).

Kentucky growers may also be interested in capitalizing on the re-emergence of consumer interest in cauliflower in recent years (Lucier 2021). Lower-carb and gluten-free diets have been especially popular, and cauliflower can be a healthy, versatile substitute for other foods. Cauliflower is low in calories and high in vitamins C and K, as well as being an excellent source of folate and fiber (Terpstra 2023). As U.S. consumption of cauliflower has risen, so have imports (Lucier 2021). Being able to purchase locally grown cauliflower can add even more value from a consumer perspective. With the addition of new commercially available cultivars, many of which are bred for spring production, it is worth re-evaluating the possibility of spring cauliflower production in Kentucky.

Materials and Methods

A trial was conducted in the spring of 2025 at the University of Kentucky Horticulture Research Farm in Lexington, KY, to evaluate eight cultivars of cauliflower (Table 1) for open field production, yield, and quality. Prior to beginning the trial, a soil sample was collected to a depth of approximately 8 inches from the field where cauliflower was to be transplanted and submitted to the University of Kentucky Division of Regulatory Services for testing. The soil test indicated a soil pH of 6.41, 68 lb/acre extractable phosphorus, 151 lb/acre extractable potassium, 319 lb/acre extractable magnesium, 4304 lb/acre extractable calcium, 2.3 lb/acre of extractable zinc, 0.64 lb/acre of boron, and 2.58% organic matter.

On 11 Feb, cauliflower seeds were sown in 50-cell trays with potting soil (Vermont Compost Fort Lite, Montpelier, VT) and grown in a greenhouse with natural light. On 10 Mar the field was spaded and prepared for planting, including bed shaping and laying drip tape (8-inch emitter spacing; Aqua-Traxx, Toro, Bloomington, MN) and black plastic mulch. Beds were on 6-ft centers. A preplant fertilizer was also applied to beds at the time of bed shaping at a rate of 50 lb/acre of nitrogen (N; 10N–0P–8K, Nature Safe, Darling Ingredients Inc., Irving, TX). The trial was arranged as a randomized complete block design with five replicates of each cultivar. On 17 Mar, cauliflower seedlings were transplanted into the field by hand, 18 inches apart in a single row with seven plants per replicate. On 27 Mar, some plants had to be replaced, due to damage from wind. Weekly fertigation began on 17 Apr at a rate of 15 lb/acre of N using calcium nitrate (15.5N–0P–0K) and continued through 6 Jun. Wrapping (Figure 1), whereby leaves are pulled together to protect the curds, began on 9 May and continued as needed based on curd development. On 15 May, an insecticide application (spinosad; Entrust SC, Corteva Agriscience, Indianapolis, IN) was made to manage crucifer flea beetles (*Phyllotreta cruciferae*).

Table 1. Cauliflower cultivars planted and evaluated in the spring of 2025 at the University of Kentucky Horticulture Research Farm in Lexington, KY.

Cultivar	Estimated days to harvest[i]	Actual days to harvest[ii]	Description
Clementine	55	58–79	Bright orange, early maturing
Flame Star	62	73–86	Pale orange, tolerant to heat
Graffiti	80	73–86	Deep-purple heads
Paxton	67	58–86	Large white heads, self-wrapping
Purple Moon	62	58–73	Bright-purple heads, early maturing
Snow Crown	50	58–73	Medium off-white heads
Synergy	60	73–86	Large bright-white heads
Vitaverde	71	64–86	Bright-green heads

[i] Number of days from transplant to harvest, according to Johnny's Selected Seeds, where all seeds were purchased.
[ii] Ranges show number of days from the day of transplanting (17 Mar 2025) to first harvest through last harvest of marketable heads.

Figure 1. Wrapped cauliflower head secured with rubber band to protect the curd from being discolored by sunlight.

Figure 2. 'Purple Moon', a purple cauliflower cultivar, growing in a field in the spring of 2025 and nearly ready to harvest.

Figure 3. 'Snow Crown', a white cauliflower cultivar, growing in the spring of 2025 in Lexington, KY.

Figure 4. 'Clementine', an orange cauliflower cultivar, growing in the spring of 2025 in Lexington, KY.

Figure 5. 'Synergy', a white cauliflower cultivar, just harvested in the spring of 2025 in Lexington, KY.

Figure 6. 'Flame Star', a light-orange cauliflower cultivar, shortly after being harvested in the spring of 2025.

Figure 7. 'Graffiti', a deep-purple cauliflower cultivar, right before being harvested in the spring of 2025.

Figure 8. 'Paxton', a white cauliflower cultivar, after being harvested in the spring of 2025.

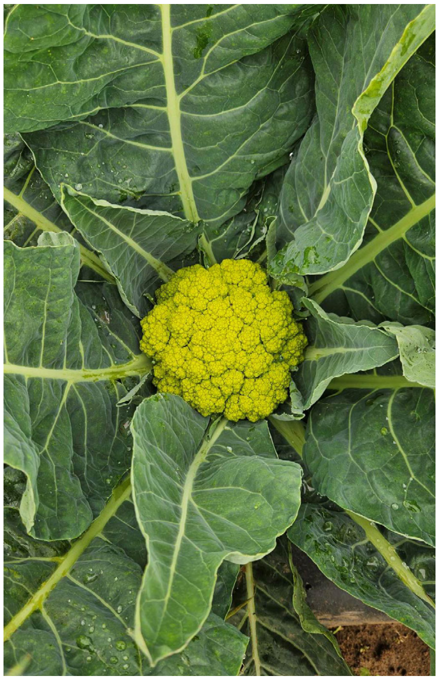

Figure 9. 'Vitaverde' cauliflower cultivar growing in the field in the spring of 2025 in Lexington, KY.

Figure 10. Hollow stem observed on a cauliflower plant grown in the spring of 2025.

Figure 11. 'Paxton' cauliflower displaying the beginning of self-wrapping, where leaves cover the curd.

Table 2. Marketable count, yield, head weight, and head diameter for cauliflower grown in the open field in the spring of 2025 in Lexington, KY.

Cultivar	Average marketable count[i]	Average marketable yield (lb)[iii]	Average marketable head weight (lb)	Average marketable head diameter (inches)
Clementine	6.0 a[ii]	4.51 ab	0.77 c	5.45
Flame Star	4.2 ab	6.59 ab	1.43 abc	5.85
Graffiti	2.2 b	2.71 b	1.36 abc	6.55
Paxton	6.2 a	9.74 a	1.65 ab	6.80
Purple Moon	5.6 ab	4.64 ab	0.83 bc	6.46
Snow Crown	6.4 a	6.82 ab	1.13 abc	6.28
Synergy	5.6 ab	10.21 a	1.72 a	6.09
Vitaverde	4.4 ab	4.46 ab	0.94 abc	5.67
P value	0.0263	0.0100	0.0133	0.2339

[i]Represents the average of seven plants from five replicates.
[ii]Values within the same column followed by the same letter(s) are not significantly different at $P \leq 0.05$.
[iii]Represents the average weight of curds from five replicates with seven plants per replicate.

Harvest began on 13 May and continued through 10 Jun, with a total of five harvest events. When cauliflower curds were at least 4 inches in diameter, they were cut from the stem. They were evaluated for marketability using USDA grading guidelines (USDA 2017). Wrapper leaves were removed, marketable head diameter was measured, and all heads were weighed. Data were analyzed using an analysis of variance test (ANOVA) with Statistical Analysis System (SAS) software (version 9.4; SAS Institute Inc., Cary, NC) Tukey was the post-hoc test used to separate the means where ANOVA tests were significant. Alpha was set at 0.05 for all data.

Results and Discussion

The average high and low temperatures from the day of transplanting to the first harvest were 66.1 °F and 47.4 °F, respectively (Kentucky Mesonet 2025a, 2025b, 2025c). These temperatures are well within acceptable temperatures for cauliflower production (Swiader and Ware 2002). However, days to harvest varied widely from the estimated days to harvest noted by the seed company. This is normal, as days to harvest is an estimate based on ideal conditions and does not take temperature fluctuations into account. Growing degree days represent the amount of heat accumulated over time and are a more reliable predictor of when a crop will be ready to harvest (University of California IPM 2016). 'Purple Moon' (Figure 2), 'Snow Crown' (Figure 3), and 'Clementine' (Figure 4) were the earliest to harvest, and 'Synergy' (Figure 5), Flame Star' (Figure 6) and 'Graffiti' (Figure 7) were the latest to harvest (Table 1). 'Paxton' (Figure 8) and 'Vitaverde' (Figure 9) were intermediate in terms of days to harvest.

Depending on a grower's market, head count may be more important than head weight. If selling individual cauliflower heads at a farmers market or including them in a Community Supported Agriculture (CSA) box, growers may be more concerned with head count than head weight. 'Snow Crown' had the highest marketable head count, but intermediate marketable yield weight (Table 2). 'Paxton' and 'Synergy' had similar marketable head counts to 'Snow Crown' and also had the highest average yields. Both 'Paxton' and 'Synergy' yielded more than three times that of 'Graffiti' (Table 2). 'Paxton' and 'Synergy' also had the largest head weight; both were significantly greater than the head weight of 'Clementine,' and 'Synergy' also had significantly greater head weight than 'Purple Moon' (Table 2). Marketable head diameter among cultivars was not significantly different (Table 2). 'Paxton' had the widest head diameter followed by 'Graffiti.' 'Graffiti' had the lowest marketable head count, which resulted in the lowest marketable yield. Both purple cultivars, 'Graffiti' and 'Purple Moon,' yielded less than half of 'Paxton' or 'Synergy' (Table 2).

In many cases, cauliflower heads were not harvested because they did not develop before temperatures became too hot. Overmaturity was the main reason for harvested unmarketable curds. Many overmature curds had bracts growing through and florets had buds beginning to open. There were also some instances of hollow stem. Hollow stem (Figure 10) was observed on several cultivars, but most predominately in plants of the orange cultivars Clementine and Flame Star. If hollow stem develops up close to the curd, it will cause the curd to be unmarketable. Excessive nitrogen and/or deficient boron fertility are often cited as causal agents of hollow stem (Zandstra et al. 2016). There was no additional boron applied in this trial, which may have caused hollow stem in susceptible cultivars.

Wrapping cauliflower heads is often done by tying leaves together with a rubber band. The leaves protect the curd from being discolored by the sun. During wrapping, leaves can be damaged slightly. Although we did not observe any signs or symptoms of disease in this trial, plant wounds are a common entry point for plant pathogens and can lead to disease. For this reason, as well as the additional time and labor that goes into wrapping leaves, growers may prefer a self-wrapping cultivar. Consistent with its cultivar description, 'Paxton' self-wrapped in this trial (Figure 11). 'Paxton' may be the preferred choice by growers, even though 'Snow Crown' had the highest marketable head count and 'Synergy' had the highest marketable yield and head weight. 'Synergy' did display self-wrapping tendencies in this trial but is not technically identified as a self-wrapping cultivar and may perform differently in other locations and environments. Of the white cultivars in this trial, 'Paxton' performed the best when considering all factors.

For growers interested in alternative colors to the traditional white cauliflower, there were five non-white cultivars evaluated in this trial: two orange, two purple, and one green. Of the orange cultivars, 'Flame Star' had higher marketable yield, marketable head weight, and head diameter, but it had more days to harvest compared to 'Clementine.' 'Clementine' had the highest marketable head count over all the non-white cauliflower cultivars (Table 2). Although vibrant in color, 'Graffiti,' a purple cultivar, was the poorest performer overall. 'Vitaverde' was the sole green cultivar evaluated in this trial. It was the second-lowest-yielding cultivar evaluated (Table 2).

Successful spring production of cauliflower is possible in Central Kentucky. 'Paxton' and 'Synergy' performed the best overall, and 'Flame Star' and 'Snow Crown' performed moderately well. Future trials will compare more planting dates in the spring. It would also be beneficial to compare spring-planted cauliflower yields to those of fall-planted, as certain cultivars may perform better in one season compared to the other.

References

Gauthier N, Rudolph R, Wright S, Bessin R, Leonberger K, Munir M. 2024. Vegetable production guide for commercial growers, 2024-2025. ID-36. Univ of Kent Coop Ext Serv. Lexington, KY, USA. https://share.google/UF0mDIw8nH-KvBJ3Ga

Kentucky Mesonet. 2024. Fayette County monthly climatological summary (4/2024). 31 Oct 2025. https://www.kymesonet.org/monthly_summaries.html?county=LXGN&year=2024&month=4

Kentucky Mesonet. 2025a. Fayette County monthly climatological summary (3/2025). 31 Oct 2025. https://www.kymesonet.org/monthly_summaries.html?county=LXGN&year=2025&month=3

Kentucky Mesonet. 2025b. Fayette County monthly climatological summary (4/2025). 31 Oct 2025. https://www.kymesonet.org/monthly_summaries.html?county=LXGN&year=2025&month=4

Kentucky Mesonet. 2025c. Fayette County monthly climatological summary (5/2025). 31 Oct 2025. https://www.kymesonet.org/monthly_summaries.html?county=LXGN&year=2025&month=5

Lucier G. 2021. Cauliflower's popularity re-emerges. 31 Oct 2025. https://www.ers.usda.gov/data-products/charts-of-note/chart-detail?chartId=100252

Swiader JM, Ware GW. 2002. Producing vegetable crops. 5th ed. Interstates Publishers, Inc., Danville, IL.

Terpstra C. 2023. Cauliflower: a versatile nutrition superstar. 3 Nov 2025. https://sncs-prod-external.mayo.edu/hometown-health/speaking-of-health/cauliflower-the-new-nutrition-superstar

University of California Agriculture and Natural Resources Integrated Pest Management. 2016. How to manage pests: degree days. 3 Nov 2025. https://ipm.ucanr.edu/WEATHER/ddconcepts.html

US Department of Agriculture. 2017. United States Standards for Grades of Cauliflower. https://www.ams.usda.gov/sites/default/files/media/CauliflowerStandard.pdf

Zandstra BH, Stephens CT, Grafius EJ. 2016. Cole crops: broccoli, Brussels sprouts, cabbage, cauliflower. Michigan St. Univ. Ext Bull E-1591. https://www.canr.msu.edu/resources/commercial_vegetable_recommendations_cole_crops_e1591

Acknowledgments

The authors thank Julie Collinsworth for her assistance with this project.

Fruiting Performance of Mild Habanero Pepper Varieties

Kirk W. Pomper, Godswill Ujah, Prabina Bhujel, Jeremiah D. Lowe, and Sheri B. Crabtree, Kentucky State University Land Grant Program, and James Myers, Oregon State University

Introduction

There continues to be strong interest in pepper (*Capsicum* spp.) production in Kentucky. According to the 2022 Agricultural Census (USDA 2022), there were 657 farms with bell pepper production on 302 acres in Kentucky. Additionally, there were 416 farms growing peppers other than bell, including chile peppers, on 104 acres in Kentucky. Large numbers of these peppers are sold on the fresh market, but many peppers are also processed to make value-added products such as hot sauce.

Peppers most likely originated in Bolivia and many varieties are well known for their ability to cause an intense sensation of heat when consumed (Bosland et al. 2012; Canto-Flick et al. 2008; Krajewska and Powers 1988). A widely used heat measurement for chile peppers is the Scoville heat unit (SHU; Scoville 1912). This measurement is the highest dilution of a chile pepper extract at which heat can still be detected by a human taste panel. In recent years, high-performance liquid chromatography (HPLC) has been used to detect capsaicin levels (Canto-Flick et al. 2008; Collins et al. 1995). 'Carolina Reaper'—considered to be the hottest variety in the world, with a pungency of 2,200,000 SHU—when cultivated in Yucatan, had a pungency of 3,006,330 SHU, which was greater than all the other varieties analyzed (Muñoz-Ramírez et al. 2018).

Fresh spicy peppers are widely purchased by consumers. A survey of consumers in the United States suggested that many consumers enjoy spicy peppers, but that consumption varies by pepper type (Lillywhite et al. 2013). The results also suggested that the most popular pepper types are not necessarily the "hottest" or "mildest" of those available in the market. The popularity or frequency of spicy pepper use differed among demographic groups.

Two mild habanero peppers known as 'Notta Hotta' and 'Mild Thing' have fruit with unique fruity and floral fragrance and flavors. These peppers, which were recently released by Oregon State University, have a Scoville heat scale ranking of approximately 500 to 1,000 SHU. Regular habanero peppers are between 100,000 and 300,000 SHU, where the 1,000 SHU is similar to the equivalent of an Anaheim or mild poblano pepper. 'Notta Hotta' and 'Mild Thing' were bred with flavor as a priority with low SHU. Although these varieties have been released to the public, they have not been trialed in Kentucky for regional suitability. The objective of this study was to examine 'Notta Hotta' and 'Mild Thing' fruiting and yield under Kentucky growing conditions.

Materials and Methods

A trial was established at the Kentucky State University (KSU) Harold R. Benson Research and Demonstration Farm in Frankfort, KY. The experimental design was a complete randomized design with three replicates of five cultivars of peppers, which included the habanero peppers of 'Helios' (*C. chinense*), 'Mild Thing' (*C. annuum*), 'Notta Hotta' (*C. annuum*), and 'Roulette' (*C. chinense*), as well as the bishop's crown cultivar Mad Hatter (*C. baccatum*). There were four plants in each replicate plot for each pepper cultivar, for a total of 12 plants of each cultivar. Seeds of the pepper cultivars were sown on 11 May 2025 in the KSU greenhouses in trays with 2 × 5-inch (width × depth) cells containing potting soil (ProMix – BX, Premier Horticulture, Quakertown, PA). Seedlings were transplanted on 30 May with a spacing of 2 ft between plants and 8 ft between rows on raised beds covered in black plastic mulch with drip tape installed underneath for irrigation. Plants were irrigated as needed. Fertilizer (Peters 20–20–20, JR Peters, Allentown, PA) was applied once at the flowering stage through the drip irrigation lines using a fertilizer injector (D14MZ2 Dosatron, Dosatron International, France) at a rate of 18 lb/acre (3.6 lb/acre nitrogen).

Pepper fruits were harvested weekly on six harvest dates, beginning on 14 Aug, when the fruit displayed complete color. Fruit counts and fruit weights were determined for each plot and cultivar of pepper in each block. Data were analyzed using CoStat Statistical software (CoHort Software, Monterey, CA) and subjected to analysis of variance and least significant difference (LSD) means separation. Treatment means were separated based on a significance level of $P \leq 0.05$.

Table 1. Fruit weight and yield for five cultivars of peppers grown in a cultivar trial conducted at the Harold R. Benson Research and Demonstration Farm in Frankfort, KY, in 2025.

Pepper cultivar	Average fruit weight (g)	Yield (lb/acre)
Mad Hatter	22.4 a[i]	600 c
Roulette	13.5 b	13,633 a
Helios	9.2 bc	10,614 ab
Notta Hotta	6.9 c	6,693 b
Mild Thing	8.3 c	6,678 b
P value	0.0002	0.0018

[i]Different letters for means in the same column indicate a least significant difference (LSD) at $P \leq 5\%$.

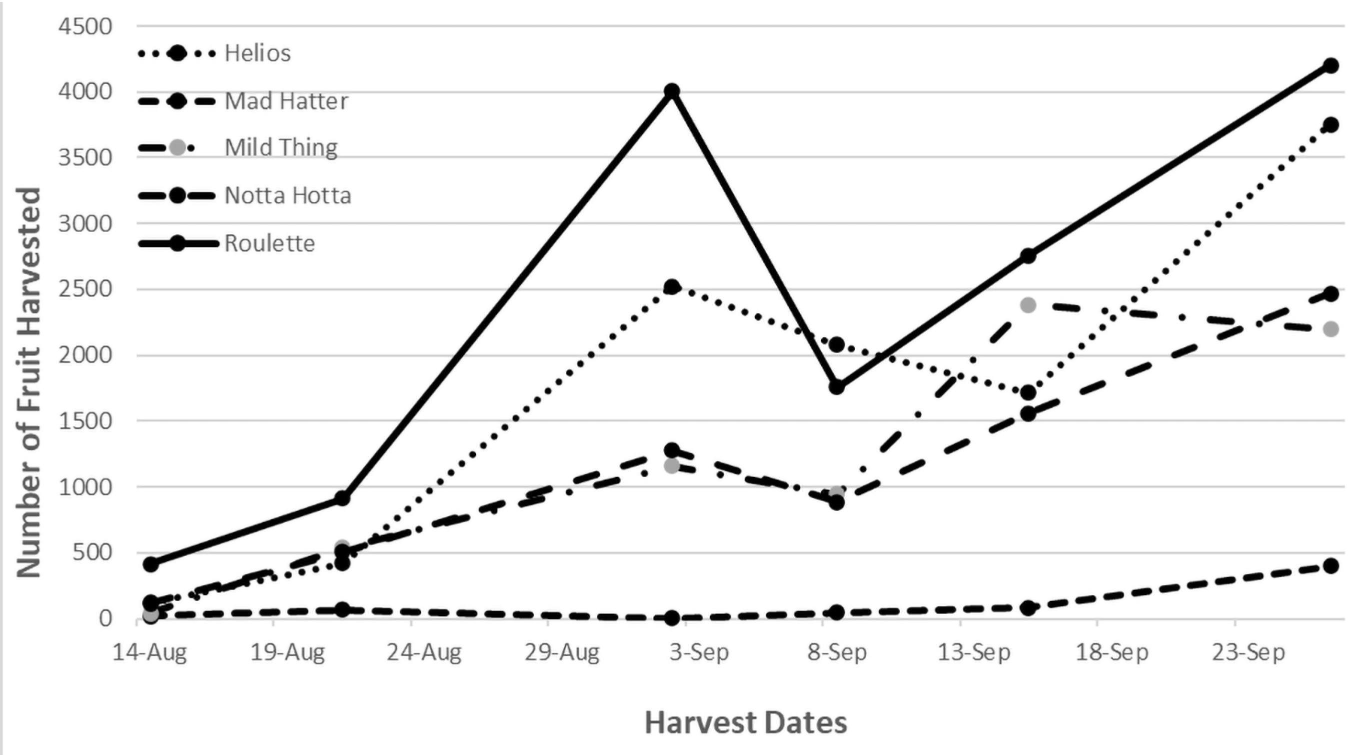

Figure 1. Number of pepper fruit harvested at harvest dates for five cultivars of peppers grown in a cultivar trial conducted at the Harold R. Benson Research and Demonstration Farm in Frankfort, KY, in 2025.

Figure 2. Representative fruits harvested from the five cultivars of peppers grown at the Harold R. Benson Research and Demonstration Farm in Frankfort, KY, in 2025. The first two columns of peppers on the left are 'Helios'. The next two columns to the right are 'Roulette', the next two columns to the right are 'Notta Hotta', and the last two columns on the far right are fruit from 'Mild Thing'.

Figure 3. Representative fruit harvested from the cultivar Mad Hatter from the pepper trial grown at the Harold R. Benson Research and Demonstration Farm in Frankfort, KY, in 2025.

Results and Discussion

Fruit weight varied by cultivar, with the largest fruit produced on 'Mad Hatter' and 'Roulette,' and the smallest fruit on 'Helios,' 'Notta Hotta,' and 'Mild Thing' (Table 1; Figure 1, 2, and 3). 'Roulette' had the highest total yield per acre, with lower yields from 'Notta Hotta' and 'Mild Thing' (Table 1). Although there was a trend for 'Helios' to have higher yields than 'Notta Hotta' and 'Mild Thing,' this was not significantly higher. 'Mad Hatter' produced the lowest yield per acre. In terms of production over time, all peppers had some harvestable fruit by 14 Aug (Figure 1). 'Roulette,' 'Helios,' 'Notta Hotta,' and 'Mild Thing' were in full production by 3 Sep. However, 'Mad Hatter' did not come into full production until 23 Sep.

'Notta Hotta' and 'Mild Thing' were bred with flavor as a priority with low SHU. Although there was a trend for the habanero pepper 'Helios' to have higher yields than 'Notta Hotta' and 'Mild Thing,' it was not significantly higher. An additional year of data will need to be collected to fully judge the performance of 'Notta Hotta' and 'Mild Thing' in comparison to 'Helios.' With the popularity of snack peppers in grocery stores and the consideration that the most popular pepper types do not necessarily appear to be the "hottest" or "mildest" of those available in the market (Lillywhite et al. 2013), these new releases hold new market potential for vegetable growers in Kentucky.

Conclusions

Yields of 'Notta Hotta' and 'Mild Thing' were similar to the habanero pepper 'Helios' in 2025. The new pepper releases 'Notta Hotta' and 'Mild Thing' hold new market potential for vegetable growers in Kentucky. An additional year of data will be needed to further determine the regional suitability for growing these pepper cultivars in Kentucky.

Literature Cited

Bosland, P. W., Coon, D., and Reeves, G. 2012. 'Trinidad Moruga Scorpion' pepper is the world's hottest measured chile pepper at more than two million Scoville heat units. HortTechnology, 22:534–538. https://doi.org/10.21273/HORTTECH.22.4.534

Canto-Flick, A., Balam-Uc, E., Bello-Bello, J. J., Lecona-Guzmán, C., Solís-Marroquín, D., Avilés-Viñas, S., Gómez-Uc, E., López-Puc, G., Santana-Buzzy, N., and Iglesias-Andreu, L. G. 2008. Capsaicinoids content in habanero pepper (*Capsicum chinense* Jacq.): Hottest known cultivars. HortScience, 43:1344–1349. https://doi.org/10.21273/HORTSCI.43.5.1344

Collins, M. D., Wasmund, L. M., and Bosland, P. W. 1995. Improved method for quantifying capsaicinoids in capsicum using high-performance liquid chromatography. HortScience, 30: 137–139. https://doi.org/10.21273/HORTSCI.30.1.137

Krajewska, M.A. and Powers. J. J. 1988. Sensory properties of naturally occurring capsaicinoids, J Food Sci, 53:902-905. doi:10.1111/j.1365-2621.1988.tb08981.x

Lillywhite, J. M., Simonsen, J. E., and Uchanski, M. E. 2013. Spicy pepper consumption and preferences in the United States. HortTechnology, 23:868–876. https://doi.org/10.21273/HORTTECH.23.6.868

Muñoz-Ramírez, L. S., Peña-Yam, L. P., Avilés-Viñas, S. A., Canto-Flick, A., Guzmán-Antonio, A. A., and Santana-Buzzy, N. 2018. Behavior of the hottest chili peppers in the world cultivated in Yucatan, Mexico. HortScience, 53"1772–1775. https://doi.org/10.21273/HORTSCI13574-18

Scoville, W.L. 1912. Note on Capsicum. J. Amer. Pharm. Assoc. 1:453-454.

US Department of Agriculture, National Agricultural Statistics Service. 2022. Kentucky agricultural statistics 2022. https://www.nass.usda.gov/Publications/AgCensus/2022/Full_Report/Volume_1,_Chapter_1_State_Level/Kentucky/st21_1_037_037.pdf. [Accessed 10 Nov 2025].

Evaluation of Herbaceous Native Perennial Plants for Commercial Cut Flower Potential

Cindy Finneseth and Kaiden Walden, Horticulture, University of Kentucky

Introduction

More than 230 cut flower operations are in production across Kentucky, which represents an increase of more than 150% since the 2017 USDA Ag Census (US Department of Agriculture, National Agricultural Statistics Service 2024). These 233 farms reported a total sales value of $2.2 million for cut flowers and cut florist greens in 2022. Based on producer feedback, local cut flower growers are looking for ways to differentiate their products and increase profitability. Showy native herbaceous perennials as cut flower crops can provide growers with unique flowers and foliage. As native species are often well suited to local growing conditions, once established, these crops may have increased cold hardiness, resistance to pests, and lower water and fertility demands compared to non-native annual cut flower crops. Perennials also have an advantage in that the initial investment in plant material can have long-term returns through multiple seasonal harvests. Additionally, native plants provide ecosystem benefits through plant biodiversity, water conservation, and service as nectar sources for pollinators. To provide growers with information about herbaceous native perennials to consider as cut flower crops, species were selected based on attractive floral or foliage characteristics and grown under field production conditions to evaluate survival and potential yield.

Materials and Methods

Fifty-three different native herbaceous perennial species were selected for the trial based on bloom time and attractive floral and foliar characteristics (shape, structure, and color, for example; Table 1). The production site was prepared at the University of Kentucky Horticulture Research Farm (Lexington, KY) by plowing and installing 36-inch-wide polypropylene woven landscape weed barrier walkways between planting blocks. Ten plugs of each commercially available species were sourced from local nurseries and planted on 25 Oct 2024. Where plugs were unavailable, seeds were purchased from commercial sources and germinated in a greenhouse and planted (along with any replacement plants) on 29 Apr 2025. At each planting, 2-inch plugs were hand-set in a single block of two rows at 12-, 18-, 24- or 36-inch spacing between plants, based on anticipated mature plant size. Plugs were watered in and mulched with wood chips to a depth of at least 2 inches. Drip irrigation tape with emitters every 12 inches was installed under the mulch layer between the planted rows, with water applied intermittently throughout the growing season. Mortality ratings were determined in early spring (17 Apr 2025) and mid-autumn (23 Oct 2025). Stems were harvested throughout the growing season, with the total number of stems counted and length measured and recorded. Stem length was determined from the basal cut to the tip of the inflorescence or to the topmost floret of single/spike or cluster/spray flower types, respectively.

Results and Discussion

Plant mortality over the winter was high (80% or more) in six species (blazing star, prairie sage, Letterman's ironweed, Missouri ironweed, sundial lupin, and yellow wild indigo), compared to 100% winter survival in four species: boneset, Drummond's aster, early goldenrod, and golden Alexander. In some species, plant loss was high (70% or more) over the growing season, most likely due to excessive moisture (thimbleweed, tall larkspur, hardy sunflower, sundial lupin, early goldenrod, and golden Alexander), planting depth (meadow blazing star, bottlebrush blazing star, dotted blazing star, and prairie blazing star), and wildlife damage (white prairie clover). For species adapted to drier conditions, minimal irrigation and planting into raised beds would be beneficial management strategies. Attention to planting depth will benefit plants that thrive under shallow planting to avoid pressure from stem and root rots (Stevens and Gast 1992). For small-scale sites with heavy wildlife pressure (i.e., voles, rabbits, and deer), exclusionary fencing or other control methods (trapping, repellents, or toxicants, for example) may be effective in preventing plant damage and crop loss (Nierman et al. 2023). When a repellent or toxicant is used, growers should always refer to and follow the label for product handling and application instructions.

Many perennial plants do not flower in the first year and can take two to three years to produce commercial volumes of marketable stems. In this study, 13 different perennials—goatsbeard, Ozark bluestar, Eastern bluestar, thimbleweed, white indigo, false blue indigo, yellow wild indigo, sundial lupin, American agave, dotted blazing star, prairie blazing star, meadow blazing star, and white prairie clover—did not produce a single flowering stem. In contrast, four perennials—Tennessee coneflower, boneset, orange coneflower, and early goldenrod—produced more than 100 flowering stems, each with an average stem length suitable for commercial purposes (≥12 inches; Table 2). A detailed description of these four species follows:

Tennessee coneflower (*Echinacea tennesseensis*). Nine plants produced 251 flowering stems, 80% of which were 10 inches or longer and more than half (54%) were at least 12 inches in length. Average stem length was 12 inches, with a range of 4 to 23 inches (Table 2). Stems were erect and topped with 1- to 3-inch pink-purple ray flowers around a stiff cone of orange disk flowers (Figure 1A). Plants grew to approximately 24 inches tall and bloomed from July through September.

Table 1. Plant spacing, planting date, and survival ratings of herbaceous perennials native to Kentucky evaluated in Lexington, KY, for potential as cut flower crops.

Scientific name	Common name	Plant spacing (inches)	Planted in fall (F) or spring (S)	Early-season survival (17 Apr) (%)	Late-season survival (25 Oct) (%)
Allium cernuum	Nodding onion	12	F, S	90	80
Allium stellatum	Prairie onion	12	S		70
Amsonia illustris	Ozark bluestar	12	F, S	70	100
Amsonia tabernaemontana	Eastern bluestar	12	S		90
Anemone virginiana	Thimbleweed	12	F, S	90	10
Artemesia ludoviciana	Prairie sage	24	F, S	20	80
Aruncus dioecus	Goatsbeard	36	F, S	80	90
Baptisia alba	Wild white indigo	24	F, S	40	50
Baptisia australis	False blue indigo	36	F, S	90	80
Baptisia sphaerocarpa	Yellow wild indigo	24	F, S	10	10
Carex grayi	Bur sedge	12	F, S	70	70
Dalea candida	White prairie clover	24	S		0
Dalea purpurea	Purple prairie clover	12	F, S	40	80
Delphinium exaltatum	Tall larkspur	12	F, S	90	0
Doellingeria umbellata	Flat-topped aster	24	F, S	80	100
Echinacea paradoxa	Yellow coneflower	12	F, S	60	90
Echinacea purpurea	Purple coneflower	12	F, S	60	90
Echinacea tennesseensis	Tennessee coneflower	12	F, S	60	90
Eryngium yuccifolium	Rattlesnake master	24	F, S	50	80
Eupatorium perfoliatum	Boneset	36	F	100	90
Eutrochium maculatum	Spotted Joe pye weed	36	F	80	100
Heliopsis helianthoides scabra	Hardy sunflower	12	S		10
Liatris ligulistylis	Meadow blazing star	12	S		0
Liatris mucronata	Bottlebrush blazing star	12	S		20
Liatris punctata	Dotted blazing star	12	S		0
Liatris pycnostachya	Prairie blazing star	12	S		0
Liatris spicata	Blazing star	12	F, S	0	100
Lupinus perennis subsp. *perennis*	Sundial lupin	12	F, S	10	0
Manfreda virginica	American agave	36	F, S	40	40
Monarda bradburiana	Eastern beebalm	24	S		100
Oligoneuron album	Upland white goldenrod	12	F, S	30	90
Parthenium integrifolium	Wild quinine	12	F, S	50	70
Pycnanthemum incanum	Hoary mountain mint	36	S		90
Pycnanthemum muticum	Clustered mountain mint	24	F, S	70	100
Pycnanthemum pilosum	Hairy mountain mint	24	S		90
Pycnanthemum tenuifolium	Slender mountain mint	24	S		50
Pycnanthemum virginianum	Mountain mint	24	S		100
Rudbeckia fulgida	Orange coneflower	12	F	90	80
Rudbeckia triloba	Brown-eyed Susan	12	S		80
Rumex hymenosepalus	Sand dock	18	S		70
Schizachyrium scoparium 'Standing Ovation'	Little bluestem	18	S		100
Solidago 'Solar Cascade'	'Solar Cascade' goldenrod	18	S		80
Solidago juncea	Early goldenrod	24	F	100	30
Solidago nemoralis	Grey goldenrod	12	F	80	100
Solidago ohioensis	Ohio goldenrod	24	F	70	90
Solidago uliginosa	Bog goldenrod	36	F	40	60
Symphyotrichum drummondii	Drummond's aster	24	F	100	90
Symphyotrichum novae-angliae	New England aster	24	F, S	80	100
Vernonia altissima	Tall (common) ironweed	36	S		100
Vernonia lettermannii	Letterman's ironweed	24	F	20	90
Vernonia missurica	Missouri ironweed	36	F, S	20	80
Veronicastrum virginicum	Culver's root	36	S		70
Zizia aurea	Golden Alexander	12	F	100	30

Table 2. Number of stems harvested, average stem length, and range of stem length of herbaceous perennials native to Kentucky being evaluated in Lexington, Kentucky for commercial cut flower crops.

Scientific name	Common name	Total stems harvested	Stem length average (inches ± std dev)	Stem length range (inches)
Allium cernuum	Nodding onion	14	22 ± 2	17–25
Allium stellatum	Prairie onion	15	17 ± 4	8–28
Dalea purpurea	Purple prairie clover	31	6 ± 2	2–11
Echinacea paradoxa	Yellow coneflower	7	18 ± 2	15–20
Echinacea purpurea	Purple coneflower	76	19 ± 9	5–37
Echinacea tennesseensis	Tennessee coneflower	251	12 ± 3	4–23
Eupatorium perfoliatum	Boneset	229	19 ± 5	9–37
Heliopsis helianthoides scabra	Hardy sunflower	74	32 ± 8	16–48
Liatris spicata	Blazing star	9	45 ± 5	38–53
Parthenium integrifolium	Wild quinine	57	24 ± 5	7–34
Rudbeckia fulgida	Orange coneflower	170	21 ± 7	4–30
Solidago juncea	Early goldenrod	100	28 ± 9	10–51
Solidago nemoralis	Grey goldenrod	15	11 ± 2	9–19
Solidago ohioensis	Ohio goldenrod	28	24 ± 4	14–32
Solidago uliginosa	Bog goldenrod	56	18 ± 4	6–27
Vernonia missurica	Missouri ironweed	61	18 ± 5	8–29
Veronicastrum virginicum	Culver's root	27	16 ± 5	10–28

Figure 1. Flowers of Tennessee coneflower (A), boneset (B), orange coneflower (C), and early goldenrod (D), herbaceous perennials native to Kentucky with commercial cut flower potential.

Boneset (*Eupatorium perfoliatum*). Nine plants produced 229 creamy-white, broad, flat-topped, terminal corymbs (Figure 1B). Flowering stem length averaged 19 inches, with the shortest stems measuring 9 inches and the longest 37 inches (Table 2). Nearly all (97%) of the harvested stems were 12 inches or longer. Plants grew to approximately 36 inches and bloomed from late June to mid-October.

Orange coneflower (*Rudbeckia fulgida*, also commonly called black-eyed Susan). Nine plants produced 170 orange-yellow, branched daisy-like flowers (Table 2; Figure 1C). Flowering stem length ranged from 4 to 30 inches, with an average stem length of 21 inches. Most (90%) of the flowering stems were at least 12 inches. Plants grew to approximately 30 inches and bloomed from mid-June to mid-October.

Early goldenrod (*Solidago juncea*). One hundred flowering stems were harvested from 10 plants. The average stem length was 28 inches and ranged from 10 to 51 inches (Table 2). Only two stems were less than 12 inches in length. Flowers were bright yellow, dense, plume-like panicles (Figure 1D). Harvest started in mid-July and continued through early October. Plants grew to 36 inches in height. Late-season mortality was high, most likely due to overwatering.

No grading system for specialty cut flowers is mandatory in the United States; however, commonly accepted quality factors include stem length, stem strength, stem deviation, bloom quality (size, uniformity, symmetry, and form), and freshness. When selling bunches into wholesale markets, uniformity is critical, with common industry standards of no greater than 10% deviation in stem length, relative uniform stem diameter, flowers of uniform size, and stage of development (Scoggins 2019). While longer stem lengths are required for wholesale market channels, cut flowers of a shorter stem length are commonly used in hand-tied, posy, and nosegay bouquets and small arrangements sold directly to consumers. Most of the harvested stems (Table 2) were usable for different purposes. Lower uniformity in stem length was observed in early goldenrod, hardy sunflower, and purple coneflower based on higher standard deviations (Table 2). In subsequent production years, stem length is expected to increase for many species—purple prairie clover, for example—as plants become established and allocate resources to flower production.

Harvest stage is important for flower durability, appearance, and longevity. For some species, this is when one-quarter to one-third of the florets are open (*Allium* spp.), one-half of florets are open (larkspur and lupin), or when flowers are fully open (*Rudbeckia* spp. and *Heliopsis* spp.; Whipker and Cravins 2000). Very little information is available describing harvest stages for herbaceous native perennials, and growers will benefit from additional observations and post-harvest observations.

Plants were not trellised, and several species that produced robust vegetation (the mountain mints, for example) and extremely long stems (tall ironweed, for example) would benefit from support. Some type of system (horticultural netting, trellising, or corralling, for example) should be installed early to ensure straight stems, minimize breakage due to high winds, and improve ease of harvest (Scoggins 2019).

Weed pressure was high in the observation plots, with annual (henbit, crabgrass, foxtail, and purslane, for example) and perennial (dandelions, bindweed, and thistles, for example) weeds present. Weeds compete with the flower crop, reducing quantity and quality of harvestable stems and increasing crop management and time to harvest (Whipker and Cravins 2000). Cultural and chemical options can be used to control weeds in cut flower crops. Growers must follow all label recommendations when using chemical control options.

Conclusion

Many herbaceous native perennials have attractive floral and foliage characteristics and appear to be well-suited to cut flower production; however, for production sites where space is extremely limited, a grower may not be able to justify allocating square footage to establish perennials that may not flower or only produce a few usable stems in the first production year. Also, herbaceous native perennial plantings are not maintenance-free and growers will need to be prepared to efficiently and economically manage production conditions. Additional investigation is needed to determine the best management practices to produce the highest quality stems for commercial purposes. Species identified in this study will continue to be trialed for another year and evaluated for survival and yield as well as post-harvest handling to develop general guidelines for local growers.

Literature Cited

Nierman J, Ibach A, Springer MT. 2023. Vole issues and management around homes, orchards, and row crops. FOR-173. Univ of Kentucky, Lexington, KY.

Scoggins HL. 2019. Getting started in the production of field-grown, specialty cut flowers. 426-618. Virginia Coop Ext, Virginia Tech, Blacksburg, VA.

Stevens AB, Gast KLB. 1992. Specialty cut flowers—a commercial growers guide. MF-1034. Kansas State Univ Agricultural Experiment Station and Coop Ext Service, Manhattan, KS.

US Department of Agriculture, National Agricultural Statistics Service. 2024. 2022 Census of Agriculture, Kentucky state and county data: Kentucky. AC-22-A-17. USDA, Washington, DC.

Whipker B, Cravins TJ (eds). 2000. Southeast outdoor cut flower manual. North Carolina Commercial Flower Growers' Association.

A Current Snapshot of Nursery, Greenhouse, Floriculture, and Sod Operations in Kentucky

Cindy Finneseth, Horticulture, University of Kentucky

Every 5 years, the United States Department of Agriculture (USDA) publishes the Census of Agriculture. Data on horticultural crop production are tracked and nursery crops, greenhouse crops, floriculture crops, and sod farm characteristics are reported. Production may be under cover (glass or plastic) or in traditional field production systems. Based on the 2022 Census, there are 1,326 farms producing nursery, greenhouse, floriculture, and sod crops in Kentucky, with a market value of $101.5 million (USDA 2024). This is up from 2017, when 1,101 farms reported a market value of $84 million . These numbers show an overall growth in ornamental crop production and sales in Kentucky, while the change in number of operations and geographic distribution provides insight about industry dynamics.

Operations are well distributed across Kentucky, with 93% of the counties having at least one production operation. Nineteen counties currently have more than 20 local operations producing nursery crops, greenhouse crops, floriculture crops, and sod (Figure 1). Christian County in Western Kentucky and Shelby County in Central Kentucky rank at the top, having 58 and 47 operations respectively. Todd (37), Allen (35), and Fayette (34) round out the top five counties in Kentucky with the largest number of operations. Not surprisingly, counties with or near larger population centers—Warren (33), Boone (31), Jefferson (28), Madison (28), Laurel (23), and Oldham (23) counties—also have larger numbers of operations within the local area. Many of the counties with larger numbers of operations in Western Kentucky—Christian, Todd, Allen, Trigg, and Logan—and Central Kentucky—Casey and Lincoln—have larger populations of plain-sect community growers and are in close proximity to produce auctions, which offer a wholesale market outlet for specialty crops. Only nine counties—Ballard, Elliott, Fulton, Leslie, Livingston, Martin, McCreary, Powell, and Webster—have no operations of this type. Each of those counties does, however, have at least one operation in every adjacent county.

Overall, the nursery, greenhouse, floriculture, and sod industry segment added 225 operations between 2017 and 2022, an increase of 20%. Most counties (87%) experienced changes in the number of operations (Figure 2). More than half of the counties (63, shaded green in Figure 2) added at least one operation, with Boone, Shelby, Adair, Madison, and Breathitt counties adding the most farms, at 19, 19, 18, 18, and 15 operations, respectively. Many counties that previously had no operations added at least one nursery business during the interval (Hancock, Harlan, Hickman, Johnson, Knott, Lee, Letcher, McLean, Owsley, and Perry counties). About one-third (34%) of Kentucky counties experienced a decline in the total number of operations (41, shaded red in Figure 2). Campbell, Crittenden, and Todd counties had the largest reductions, at 14, 10, and 10 operations respectively. Seven counties (shaded in gray) that had operations in 2017—Carlisle, Carroll, Floyd, Lyon, McCreary, Pike and Whitley—had no change in the number of operations in 2022. Of the 16 counties that experienced no change in the number of operations (shaded in gray), eight counties—Barren, Carlisle, Carroll, Floyd, Lyon, McCracken, Pike and Whitley—had existing operations in 2017.

The USDA Census of Agriculture contains a large amount of valuable information; however, there are limitations when interpreting the data, particularly a lack of granularity when a range of horticultural crops are combined. This evaluation, which focuses on the number of operations and geographic changes, can be valuable for the industry as well as extension and other technical service providers in identifying where large concentrations of growers exist (for hosting educational events or to support opportunities for collective purchasing and marketing, for example), where there are no growers (a potential entrepreneurial opportunity, for example), and broader industry trends (shifting production toward or away from population centers, for example). During a time when a loss of farms is a concern, the addition of 225 operations is a positive trend for Kentucky's specialty crop industry. The Green Industry Research Consortium quinquennial survey results are currently under evaluation and will provide additional details about characteristics of Kentucky's nursery and greenhouse industries as well as economic impacts of the Kentucky green industry.

Literature Cited

US Department of Agriculture, National Agricultural Statistics Service. 2024. 2022 Census of Agriculture Kentucky state and county data: Kentucky. AC-22-A-17. USDA, Washington, DC.

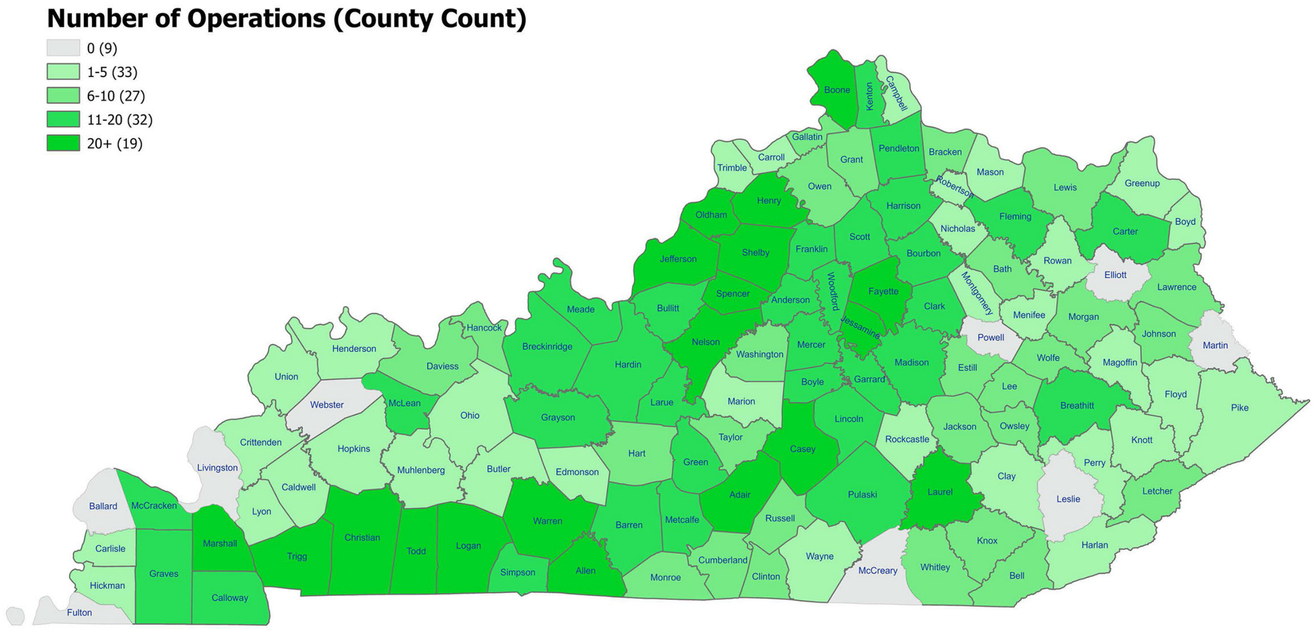

Figure 1. Geographic distribution of nursery, greenhouse, floriculture, and sod operations by county in 2022, based on the USDA Census of Agriculture (2024).

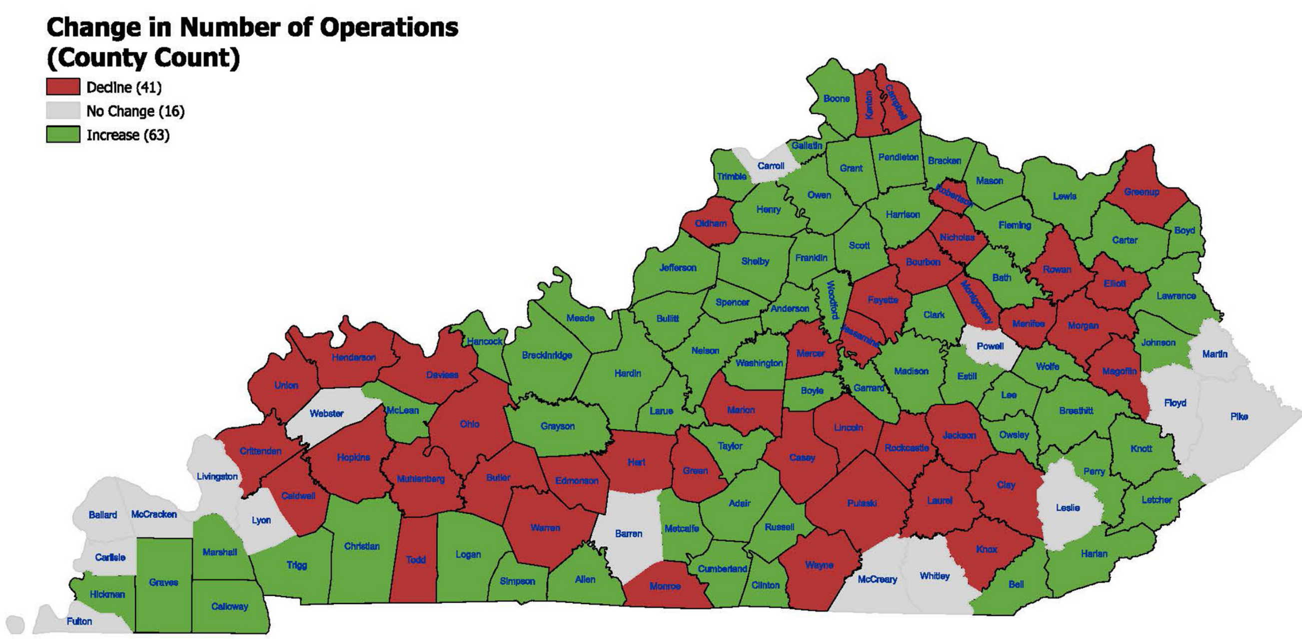

Figure 2. Change in number of farms producing nursery, greenhouse, floriculture, and sod crops between 2017 and 2022, based on the USDA Census of Agriculture (2024).

Notes

Notes

Notes