Center for Crop Diversification
Martin-Gatton College of Agriculture, Food and Environment

Center for Crop Diversification Fact Sheet
CCD-FS-29
www.uky.edu/CCD

Economic Evaluation of Rotating High Tunnel Tomato with Fresh-cut Flowers

Jonathan Shepherd[1], Rachel Rudolph[2], Savannah Columbia[3], Nicole Gauthier[4], Jonathan Larson[5], Alexis Sheffield[6], and Tyler Mark[7]

There are more than 1,500 high tunnels in Kentucky used to extend the growing season and provide a protected environment for high-value crops (Bajek and Rudolph 2023). Tomatoes are one of the most profitable crops that can be grown in a high tunnel (Galinato and Miles 2013). However, to increase profits and make the most of the high tunnel infrastructure, producers may want to add additional crops to rotate with tomatoes. In Kentucky, high tunnel tomatoes are often planted in spring and terminated in late summer or early fall. This leaves several months for growers to produce a fall crop to generate additional profits. Additionally, planting a crop from a different family can help to break up the pest and disease lifecycles as well as take up extra soil nutrients that may contribute to soil salinity (Rudolph et al. 2022). High tunnel production has unique disease and pest challenges compared to open-field production because they are subject to greenhouse structure rules where pesticides made for open-field production are often prohibited.

High tunnel growers maximize economic gross returns throughout the available growing season by producing more than one crop in a calendar year. Effects on net returns will depend on inputs and other cost considerations of producing and marketing a second crop. This second crop needs to not only improve returns but also provide a different environment that does not serve as the same host for plant pathogens and pests as the previous crop. To complement tomato production, a rotation at the end of the tomato growing season can be considered. It is common for fall-planted lettuce to follow spring-planted tomato. In efforts to diversify markets and potentially increase profits, fresh-cut annual flowers were evaluated to test their acceptability as a high-value fall season rotation for tomatoes. Many fresh-cut flowers have short days to maturity and require limited fertility inputs. Many flower types can be harvested multiple times in several months. Fresh-cut flowers have the potential to be a crop that can bring profit back to the producer when sold to florists or directly to consumers at farmers markets. Although there are cool-season flower species, many have over 100 days to maturity and may not be harvested until the winter or following spring, which may interfere with the subsequent tomato planting and production.

Flowers with short days to maturity were evaluated as a fall crop after tomatoes in a high tunnel system. (Photo: UKMG)

[1] Extension Specialist in Agricultural Economics at the University of Kentucky.
[2] Assistant Extension Professor in Horticulture at the University of Kentucky.
[3] Extension Associate in Agricultural Economics at the University of Kentucky.
[4] Professor in Plant Pathology at the University of Kentucky.
[5] Assistant Extension Professor in Entomology at the University of Kentucky.
[6] Extension Specialist in Horticulture at the University of Kentucky
[7] Professor in Agricultural Economics at the University of Kentucky.

Early in the first year of the trial, we surveyed potential cut flower consumers at the Woodford and Fayette County Farmers Markets along with participants in the University of Kentucky CSA to determine if they would be willing to pay a premium for locally grown cut flowers. There were 124 survey participants. Nearly 50% of participants responded that they typically spend $10-20 on a bouquet of flowers while approximately 12% of participants pay over $20 for a bouquet. Flower bouquets at farmers markets in Kentucky typically range from $10-20. When asked to rate certain factors that were important to them when purchasing flowers, 58% of survey participants responded that the flowers being locally produced was either important or very important to them. Fifty-seven percent of participants also stated that they highly preferred purchasing flowers from either a farmers market or a CSA. This demonstrates that there is consumer interest for locally grown flowers.

A study was conducted over three years to evaluate the viability of rotating spring-planted tomatoes with fall-planted flowers in the same calendar year in a high tunnel. The objectives of this work were to determine optimal planting dates, pest and disease challenges, optimal fertility, and economic profitability. In this publication, we will focus on the economic viability of adding fresh-cut flowers into a high tunnel as a secondary cash crop. This is a companion document to the fact sheet, Rotating Cut Flowers Within a Tomato High Tunnel Production System, which covers the management and horticultural methods in more detail (https://www.uky.edu/ccd/sites/www.uky.edu.ccd/files/HTflowers_tomatoes.pdf).

Figure 1: Tomatoes growing in the high tunnel with row cover for when temperatures dropped below 40°F. (Photo: Rudolph)

Horticulture Methods

The high tunnels involved in this study were located at the University of Kentucky (UK) Horticulture Research Farm (Fayette County) and the UK Robinson Center (Breathitt County). The high tunnels used in the study were 15 x 44 ft, unheated, and covered with a single layer of clear 6-mil polyethylene. Black woven weed mat covered the entire inside area of all high tunnels and was secured into place used sod staples. No herbicides were applied throughout the trial. There were two high tunnels at each site, one tunnel was the "low input" tunnel while the other was the "high input" tunnel. These different regimens take into consideration the spectrum of grower management.

Tomato Production

Tomatoes were seeded in 50-cell trays at the beginning of February. BHN 589 was the cultivar used in all the high tunnels in all years. Each year, 4–5-week-old tomato seedlings were transplanted into high tunnels between late March and mid-April. There were three rows in each tunnel on 3 ft centers with 18 in in-row spacing (Figure 1). Plants were suckered once based on recommendations for commercial determinate tomato (Gauthier et al. 2024). Tomatoes were trellised using the Florida weave method with a post placed every two plants. One line of drip tape was used per row of tomatoes. Plants were irrigated as needed from March through April based on weather conditions. Beginning in May, plants were irrigated once per day for 45 minutes per day.

High tunnel sides were left open during the day when temperatures exceeded 40°F because temperatures inside the tunnel were at least 10-15° warmer. When evening temperatures were below 50°F, the tunnels were closed. When evening temperatures were 40°F or lower, row cover was used to cover the tomatoes (Figure 1) and prevent cold damage. Row cover was always removed the next morning unless temperatures were below freezing.

Fertility applications were based on recommendations for commercial tomato production (Gauthier et al. 2024). The high input tunnel tomatoes received fertilization at a rate of 150 lb of N/acre (3.44 lb/1,000 ft2); 50 lb/acre was applied preplant and 100 lb of N/acre was applied weekly post-plant. It also included weekly scheduled fungicide applications. The low input high tunnel tomatoes were fertilized at a rate of 125 lb of N/acre (2.87 lb/1,000 ft2) with 50 lb of N/acre applied preplant and a bi-weekly post-plant rate of 75 lb of N/acre. Pesticide and fungicide applications were only applied as needed based on weekly scouting which resulted in approximately half the insecticide applications each year compared

to the high input tunnel. For more information on fertility and pesticides used, please see the companion factsheet Rotating Cut Flowers Within a Tomato High Tunnel Production System. https://www.uky.edu/ccd/sites/www.uky.edu.ccd/files/HTflowers_tomatoes.pdf

Tomato harvest began in mid-June and continued through mid- to late August. Fruit was harvested twice weekly, sorted as marketable and unmarketable based on standards for farmers markets, weighed, and counted.

Flower Production

Flowers species were selected based on their short days to maturity. In mi to late July each year, flowers were seeded in 50-cell greenhouse trays, grown for 4-5 weeks, and transplanted in late August or early September. There were two varieties each of zinnias, ornamental amaranth, cosmos, and strawflower. Each cultivar was planted in bed spacing of 4 ft x 5 ft with 9 inch spacing in-row and between rows with two lines of drip tape (Figure 2). Netting (Hortonova) was placed over flowers for trellising to maintain stem straightness (Figure 2). Two cultivars of sunflower

Figure 2: Netting was used to maintain straight stems of zinnias (Photo: UKMG)

Figure 3: Sunflowers were direct seeded at 6" spacing. (Photo: Rudolph)

were direct seeded in the high tunnels in six rows at 6-inch spacing in-row and between rows with three lines of drip tape (Figure 3). Apical bud pinching was performed on one bed of all transplanted flower types while the other bed was not pinched. The first flower harvest occurred approximately three weeks after transplanting. Flower harvesting continued twice weekly until late November. Sunflowers produced one bloom and were cut once.

The high input tunnel flowers received fertilization at rate of 87.12 lb of N/acre (2 lb/1,000 ft2). The low input tunnel flowers received fertilization at a rate of 65.34 lb of N/acre (1.5 lb/1,000 ft2). For both tunnels, 20% of total nitrogen was applied at planting, 30% was applied when the flowers were 10 inches tall, and the remaining 50% was applied 4 weeks before the final harvest (late October). On average, 11 applications of pesticides were used in the high input method, while only 4 applications were used for the low input method.

Economic Methods, Results, and Discussion

The total marketable pounds of tomatoes as well as marketable stems from each management approach (high vs. low) were averaged among the different trial years. Production practices were not changed during the trial years. As a result, no changes were made to the number or quantity of inputs used and were treated as a constant between the trials. Marketable flower stems were then calculated based on each 10-stem bunch. To be conservative with profitability estimates and concerning the lack of available data on mixed bunch (or floral arrangement) retail prices, it is assumed that all marketable stems are sold as single variety bunches for each variety. Flower prices were taken from the Michigan Flower Farm Retail Price List (Michigan Flower Farm). Tomato prices were taken from the University of Kentucky's Center for Crop Diversification KY Farmers Market Report (UK CCD) and can been seen in Figure 4.

All input costs (i.e. variable costs: chemical, fertilizer, and other input prices) were actual costs incurred by the researchers conducting this study (Table 1). In the very few cases where specific input prices were not available, an online query was conducted to approximate an average price of those missing prices excluding shipping costs . While this may not be ideal, it is important to note that any particular line item chemical or fertilizer cost has very little impact on the overall profitability of this research project. Further, input prices can vary based on geographical location.

The 2024 H2A contract hourly labor rate (adverse wage rate) was used to approximate hourly labor costs (U.S. Department of Labor). The research team recorded all labor hours for all activities (e.g., high tunnel preparation, fertilization, harvesting, etc.), and these actual hours per activity were used in conjunction with a labor rate of $15.14/hour to arrive at labor costs.

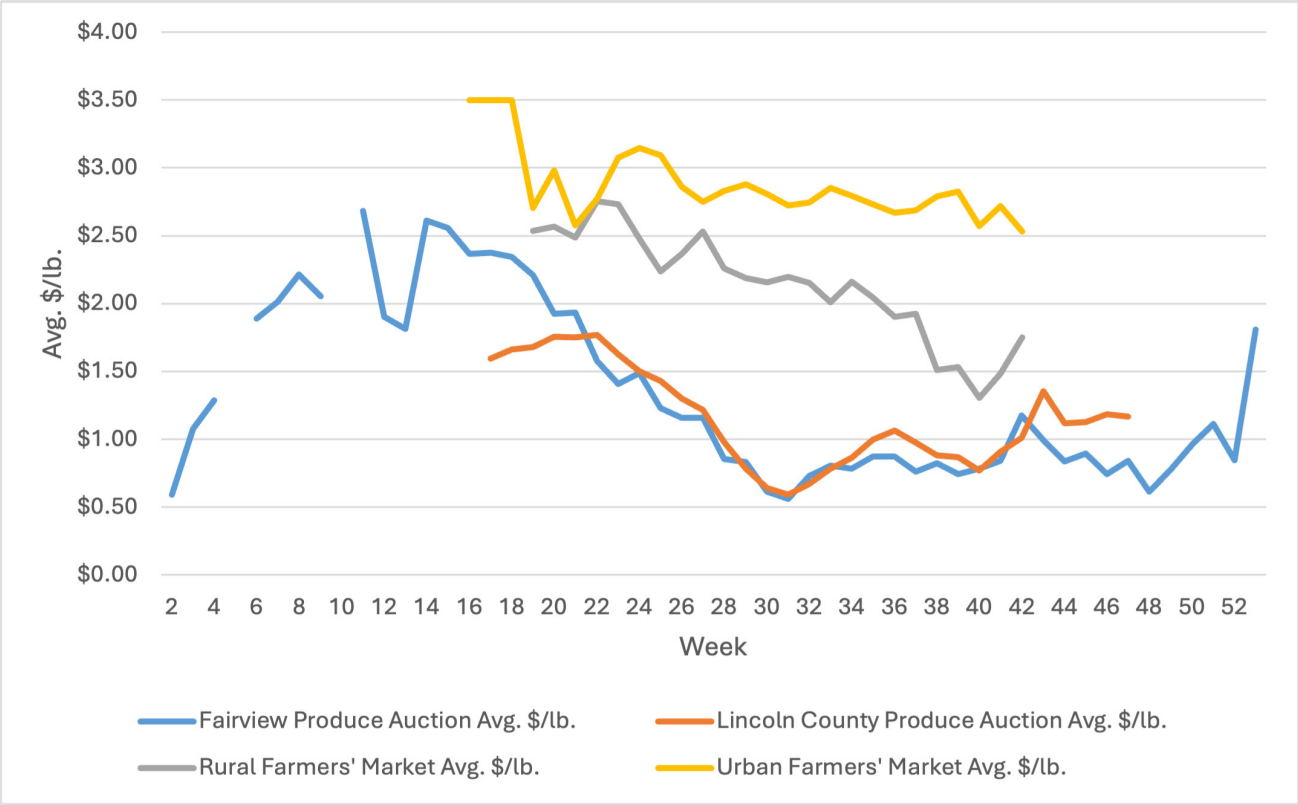
Fixed costs were approximated for the high tunnel structure and a walk-behind rototiller. High tunnel fixed costs include the price of periodic plastic replacement. The high tunnel structure and rototiller were depreciated using the straight-line method for 20 and 5 years, respectively.

Regarding costs and returns, the biggest difference that can be seen between these two management strategies is labor costs. The high-input management approach used an average total of 206 hours for both enterprises, whereas the low-input management approach only used an average of 191 hours total. However, higher yields of marketable tomatoes and marginally higher marketable flower stems produced sufficient revenue to offset the higher labor costs.

Returns above all specified costs were higher for the low-input management strategy. This is largely a result of the addition of flowers having a smaller negative impact on overall profitability. In other words, when evaluating the addition of the flower enterprise by itself (gross flower revenue less flower production variable costs) returns above variable costs were less negative under the low-input scenario. Total gross returns above all specified costs are likely understated for both high and low-input management strategies here as well as a result of using the average farm market price for tomatoes (UK CCD). Many high tunnel tomato producers will receive a price that is higher than the average farm market price, but only if they are selective to sell at markets willing to pay those higher prices. Those higher-paying markets also may come with additional costs such as travel distance, vendor fees, etc. Assess local market prices and costs before making production or marketing decisions.

This study finds that the addition of cut flowers to a high tunnel tomato rotation in the same production year decreased net returns for the high tunnel.

Figure 4: Average tomato prices at KY produce auctions and Farmers Markets.



In other words, for this three year field trial data it would have been on average less profitable to produce both tomato and cut flowers under high and low input management strategies. With both management approaches, cut flowers do not manage to cover their variable costs and did not provide positive returns above variable costs when analyzing their contribution to overall high tunnel profitability in the same growing season (gross flower returns less flower production variable costs). It is important to point out that this was only three years of data and there was a learning curve to cut flower production. Further, the current business landscape for selling locally produced flowers to local end users is improving and developing and will vary by location. The overall profitability of the cut flower segment of this production method is expected to improve with market development between producers and end users. This will likely take time as cut flower producers emerge and start developing strategic alliances with florists and other cut flower end users. In addition, enterprising and artisanal producers could direct-market floral arrangements but that is outside the scope of this study.

A value-added approach to the cut flower segment of this production method could positively contribute towards pushing the flower production into positive profit territory. Customers in our 2020 flower survey indicated that they would be willing to pay a premium for a bouquet of locally grown flowers. This is encouraging for the increased profit potential for incorporating cut flowers into the crop rotation. Flower selection is crucial for both production success and profit margins. There are cool-season flowers that perform well in the Kentucky climate, especially with the additional protection of a high tunnel. However, these have long days (100+) to maturity and may not be harvested until winter or the following spring. These flowers may not be mature when needed. Additionally, if a grower's primary focus is vegetable production, spring flowers may interfere with next year's high tunnel preparation and tomato planting.

Regarding labor, more efficient producers may be able to significantly reduce labor costs associated with both flower and tomato production. In the case where no labor is hired, many producers may choose to ignore labor costs while not accounting for the opportunity cost of their own or familial labor. From an economic standpoint, this is ill-advised. However, from a cash cost and return perspective, it is understandable why some producers ignore these opportunity costs. Even when accounting for actual labor hours used (either cash costs or opportunity costs), it is possible and to some degree, expected, that total labor costs would decrease if this study was replicated in a real business environment as opposed to the research environment. That is not to say that this research approach was inefficient with labor. However, from an actual applied business perspective, labor efficiencies may be found that were not available in the research setting.

Another key aspect of this research that is harder to quantify is the beneficial aspects of crop rotation. The limited time series of this study prevents us from providing empirical economic benefits of this crop rotation to help break and minimize pest and disease cycles while also providing another cash crop. The results from this study have been used to develop the High-Tunnel Tomato Cut Flower Rotation Enterprise Budget that allows potential producers to analyze their specific scenarios to arrive at estimated profits. This budget can be found at: https://www.uky.edu/ccd/sites/www.uky.edu.ccd/files/HTflowers_tomatoes.pdf. With this enterprise budget, producers can use their own specific data to analyze whether or not cut flowers are a reasonable addition to their high tunnel tomato production.

Table 1: Input costs from research study.

	High-Input Management					Low-Input Management				
	Quant.	Unit	Price	Total	Per Sq. Ft	Quant	Unit.	Price.	Total.	Per Sq Ft
Tomatoes*										
Total Marketable Pounds	1494.75	lbs	$ 2.50	$ 3,736.88	$ 5.66	$ 1,459.00	lbs	$ 2.50	$ 3,647.49	$ 5.53
Total Tomato Gross Returns				$ 3,736.88	$ 5.66				$ 3,647.49	$ 5.53
Cut Flowers **										
Sunflower Bunch (10 stems)	5.4	Bunches	$ 20.41	$ 110.21	$ 0.17	$ 4.80	Bunches	$ 20.41	$ 97.97	$ 0.15
Amaranth Bunch (10 Stems)	13	Bunches	$ 15.53	$ 201.89	$ 0.31	$ 11.20	Bunches	$ 15.53	$ 173.94	$ 0.26
Zinnia bunch (10 stems)	46.9	Bunches	$ 11.21	$ 525.75	$ 0.80	$ 44.00	Bunches	$ 11.21	$ 493.24	$ 0.75
Cosmo bunch (10 stems)	12.8	Bunches	$ 11.21	$ 143.49	$ 0.22	$ 11.50	Bunches	$ 11.21	$ 128.92	$ 0.20
Strawflower bunch (10 stems)	1.3	Bunches	$ 11.21	$ 14.57	$ 0.02	$ 11.00	Bunches	$ 11.21	$ 123.31	$ 0.19
Total Cut Flower Gross Returns				$ 995.91	$ 1.51				$ 1,017.37	$ 1.54
Total Revenue				**$ 4,732.79**	**$ 7.17**				**$ 4,664.86**	**$ 7.07**
Total Tomato Variable Costs				$ 2,044.28	$ 3.10				$ 1,911.04	$ 2.90
Total Cut Flower Variable Costs				$ 1,999.17	$ 3.03				$ 1,915.96	$ 2.90
Returns Above Variable Costs Per High Tunnel				**$ 689.34**	**$ 1.04**				**$ 837.86**	**$ 1.27**
Total Specified Fixed Costs				$ 169.00	$ 0.26				$ 169.00	$ 0.26
Returns Above All Specified Costs				**$ 520.34**	**$ 0.78**				**$ 668.86**	**$ 1.01**
*Cut flower prices obtained from 2023 Michigan Flower Farm Retail Price List: https://michiganflowerfarm.com/price_list.pdf										
**Tomato prices obtained from UKCCD KY Farmers Market Price Reports										

Conclusion

Continuous growing of tomatoes within a high tunnel production system allows for disease and pest pressure to build within the system. Producers should consider adding a second crop within the same calendar year to help break pest and disease cycles and also generate additional revenue.

Assessing revenue potential of high tunnel operations is the second objective of this study. High and low input levels were considered within the study. The key input variables that differed between the two levels are yields and labor. In general, we found that the higher yield levels of the high input systems were able to overcome the input costs they incurred. The incorporation of cut flowers did not provide any additional profitability to input level management strategies and decreased overall profitability. The key takeaways from this study are that even though adding cut flowers to a rotation did not increase profitability in this analysis, the long-term benefit of breaking disease cycles are not well captured in this limited trial. Other crop choices, market prices, marketing approaches, and labor efficiencies might yield different results. Further, as flower markets develop, or individual producers create more value-added products or form strategic alliances with cut flower end-users, profitability estimates may change. Figure 5 shows current commercial cut flower operations in the state (https://uk-horticulture.github.io/KY-Cut-Flowers/). It is also important to note that there is a learning curve most producers would have to overcome that may not be well represented in this data. For example, producers also must learn the best fertility and spray schedule for cut flowers. Additionally, the optimal time to remove tomatoes and plant cut flowers for a given producer may not be known and may vary year to year based on weather and climate conditions. Lastly, there undoubtedly will be a learning curve regarding the right combination of cut flowers that will maximize return in Kentucky. For producers considering the incorporation of cut flowers into their high tunnel production systems, we have developed the High-Tunnel Tomato Cut Flower Rotation Enterprise budget tool that producers can utilize to evaluate the profit potential given their input costs.

Key Takeaways

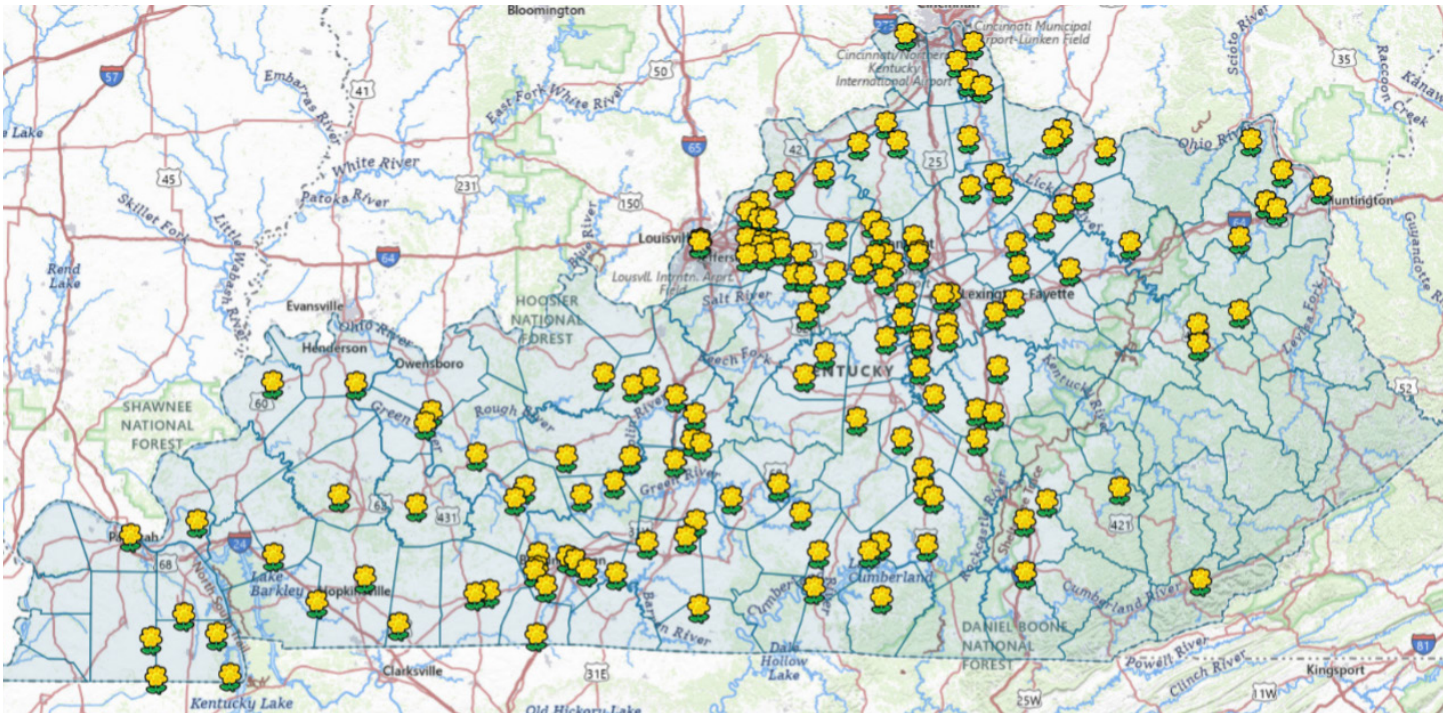
- High tunnel growers maximize economic gross returns throughout the available growing season by producing more than one crop in a calendar year.

- High-input system for both tomatoes and flowers produced higher yields, which offset higher labor costs.

- The addition of cut flowers to a high tunnel tomato rotation in the same production year decreased net returns for the high tunnel.

- A value-added approach to the cut flower segment of this production method could positively contribute towards pushing the flower production into positive profit territory.

Figure 5: An interactive map showing cut flower farms around Kentucky.



References

Bajek, V., Rudolph R. 2023. Managing southern root-knot nematode in Kentucky high tunnels using grafted tomato. HortScience 58(6):704-713. https://doi.org/10.21273/HORTSCI17141-23

Ernst, M. 2020. High Tunnel Economics. Center for Crop Diversification Fact Sheet. CCD-FS-15. https://www.uky.edu/ccd/sites/www.uky.edu.ccd/files/HT_Econ.pdf

Galinato, SP., Miles, CA. 2013. Economic profitability of growing lettuce and tomato in western Washington under high tunnel and open-field production systems. HortTechnology 23(4):453-461 https://doi.org/10.21273/horttech.23.4.453

Michigan Flower Farm. 2023. Retail Price List. https://michiganflowerfarm.com/price_list.pdf

Rudolph, R., Larson, J., Sheffield, A., Shepherd, J., Mark, T., Gauthier, N. 2021. Rotating Cut Flowers Within a Tomato High Tunnel Production System. University of Kentucky Center for Crop Diversification Fact Sheet. CCD-FS-23. https://www.uky.edu/ccd/sites/www.uky.edu.ccd/files/HTflowers_tomatoes.pdf

Rudolph, R., Lark, R., Jacobsen, K. 2022. Soil Salinity in High Tunnel Production. CCD-FS-24. 5 pp. https://www.uky.edu/ccd/sites/www.uky.edu.ccd/files/soilsalinity.pdf

U.S. Department of Labor. H-2A Adverse Effective Wage. https://flag.dol.gov/wage-data/adverse-effect-wage-rates

UK CCD. University of Kentucky Center For Crop Diversification. KY Farmers Market Price Reports. https://www.uky.edu/ccd/pricereports/KYFM

Suggested Citation:

Shepherd et al. (2024). *Economic Evaluation of Rotating High Tunnels Tomato with Fresh-cut Flowers.* CCD-FS-29. Lexington, KY: Center for Crop Diversification, University of Kentucky Martin Gatton College of Agriculture, Food and Environment.

This project was supported by a Kentucky Department of Agriculture Specialty Crop Block Grant (2021-2024).

Photos curtesy of the UK Martin-Gatton College of Agriculture, Food & Environment and Dr. Rachel Rudolph.

Reviewed by Natalie Bumgarner, Associate Professor of Plant Science at University of Tennessee and Brett Wolff, Senior Extension Specialist in Ag. Economics at the University of Kentucky.

December 2024