Title:	Evaluating Floricane-bearing Blackberry Response to Bed Renovation and Fertilizer Application Timing
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Introduction:

Management of floricane-fruiting blackberries relies on selective pruning to remove senescing floricanes after harvest. Semi-skilled manual labor is required to discern between floricanes to remove and primocanes to retain. Pruning in this manner is a labor intensive and increasingly expensive process. A 2017 production budget for thornless erect blackberries in Kentucky projected that pruning would require 30 hours of labor per acre, costing $375 in the fourth fruiting year (Ernst et al., 2017). Not accounted for is the additional time that is required for commercial growers to train unskilled labor. Explaining the growth and development of brambles to those unfamiliar with their management is often confusing and can lead to hesitation when performing pruning tasks (personal observation).

Transitioning to mechanical removal of floricanes along with all emerged primocanes either by mowing or hedging near ground level soon after harvest could decrease labor inputs associated with pruning. The equipment available to most berry growers is nonselective and is already suited to this task. Proactive removal and destruction of floricanes is a recommended sanitation practice to inhibit the spread of anthracnose and cane blight (Becker and Gauthier, 2017). The simultaneous removal of early primocanes could provide a valuable opportunity to break the cycle of these and other cane and leaf diseases that overwinter in infected floricanes. Mechanical pruning could also potentially destroy the eggs and young larvae of flat headed cane borers in early primocanes (Agnello, 2008).

Disadvantages exist when practicing primocane suppression, especially when it is delayed later into the growing season (Lawson and Wiseman, 1983). The first flush of primocanes in the spring are more numerous and vigorous than later flushes and can also produce a greater number of flower buds with larger inflorescences (Takeda et al., 2020). Successive emergence will occur if the initial flush is eliminated, but often with less vigor (Bell et al., 1995). Cutting actively growing primocanes removes biomass and diminishes the amount of soluble protein and carbohydrates available within the plant to drive regrowth. (Thompson et al., 2009). Delayed regrowth is noted to negatively affect yield both the same year it is practiced on primocane-fruiting raspberries (Oliveira et al., 2004) as well as the following year on floricane fruiting blackberries (Strik, 2018).

Fertilizer application timing has been used to regulate plant growth. Relative to plant phenology, it is an important consideration that affects nitrogen (N) partitioning in brambles (Strik, 2008). Early season floricane reproductive development depends primarily on N stored within overwintering plant tissues (Strik and Bryla, 2015). Most of this N is derived from fertilizer applied the previous year. Early application from late dormancy to early bloom favors spring fruit development and primocane growth. As the growing season progresses, primocanes will partition an increasing share of any applied N, especially after the green fruit stage and once harvest is complete. Delaying or withholding N application can reduce primocane number and length along with fruiting laterals and flower buds. Thus, the potential exists to influence primocane growth and subsequent fruit production by adjusting the timing of fertilization (early vs. late) as alluded by Thompson et al. (2009).

Objectives:

Research has shown that delayed suppression of primocanes can negatively affect the development and productivity of treated brambles. However, knowledge is lacking on whether it is possible to counteract this response in floricane-fruiting blackberries by adjusting the timing and amount of fertilizer applied, particularly to later in the growing season. Since brambles are perennial crops, the actions taken in one season will affect plant response in both current and future years; it is anticipated that meaningful results will develop over time.

This research seeks to examine the response of the thornless erect cultivar ‘Ponca’ when beds are completely renovated post-harvest versus standard or delayed renovation practices. Increased nutrient loss from the plant system is expected in most treatments due to early removal of senescing floricanes along with a reduction in plant biomass from primocane removal. To counteract nutrient losses, this study will compare several application timing strategies. If maintenance of vigor is possible, growers will potentially benefit from a new production practice that may offer means to reduce labor inputs via increased mechanization.

Progress to Date:

The research site is located at the University of Kentucky Research and Education Center (latitude 37.099212°, longitude -87.841630°) at 626 ft elevation on Sadler silt loam soil. Average annual precipitation is ≈51 inches and the average number of days between last spring and first fall frost is 160-175 days. The trial location was fallow mowed sod for four years after a previous (2013-2018) thornless erect blackberry cultivar trial was removed (Wolfe and Travis, 2018).

Site preparation began in May 2022 with tillage and incorporation of preplant fertilizer as recommended for new blackberry plantings in Kentucky (Ritchey and McGrath, 2020). A winter wheat, tillage radish, and field pea fall cover crop mixture was seeded in August (Figure 1). Tissue culture plugs of ‘Ponca’ arrived in 72-cell trays later the same month and were planted into 4-inch square pots filled with Berger BM5 mix (Berger, Saint-Modeste, QC). Plants were watered and fertilized as needed and were overwintered in a high tunnel for protection (Figure 2). Cover crop termination occurred in April and May the following year with mowing and glyphosate herbicide application. Cover crop residue was incorporated along with additional preplant fertilizer based on another soil analysis.

Figure 1. *Fall cover crop mixture with winter wheat and tillage radish present. Photo taken in November 2022 after field pea winter killed by Daniel Becker.*

Figure 2. *Blackberry transplants in 4-inch pots overwintering in a high tunnel. Photo taken in March 2023 by Ginny Travis.*

Transplanting followed in June 2023 into 8-inch raised beds covered with 2-foot-wide strips (made from 4-foot width) of black, 3.2-ounce woven landscape fabric secured to the soil with sod staples. Irrigation water was supplied through drip tubing with 18-inch embedded emitters placed underneath the cover on each side of the planting bed (8-inches from the crown). A layer of pine bark mulch was distributed over the 4-inch width between fabric strips to help inhibit weed emergence. Plants were spaced 3 feet apart in five, 90-foot rows, spaced 18 feet apart, center-to center. Trellising consists of pressure treated wood posts with 36-inch cross-arms and wires suspended 42-inches above ground level. Posts are set 15 feet apart with five plants per panel and five panels per row. Each row end includes two border plants to reduce edge effects for a total of 145 plants at the trial location, with 125 in the experiment.

Plants were fertilized post-transplant with one cup of starter solution prepared by mixing 3 pounds of 10-52-17 water soluble fertilizer in 50 gallons of water. A follow-up application using the same rate was made in July about 30 days later. Sorghum-sudangrass was used as the initial mown cover crop in the aisle, followed by fescue in the fall (Figure 3). The young plant canopy was temporarily supported with tomato twine stapled to posts with C-clips to keep the canes from sprawling (Figure 4).

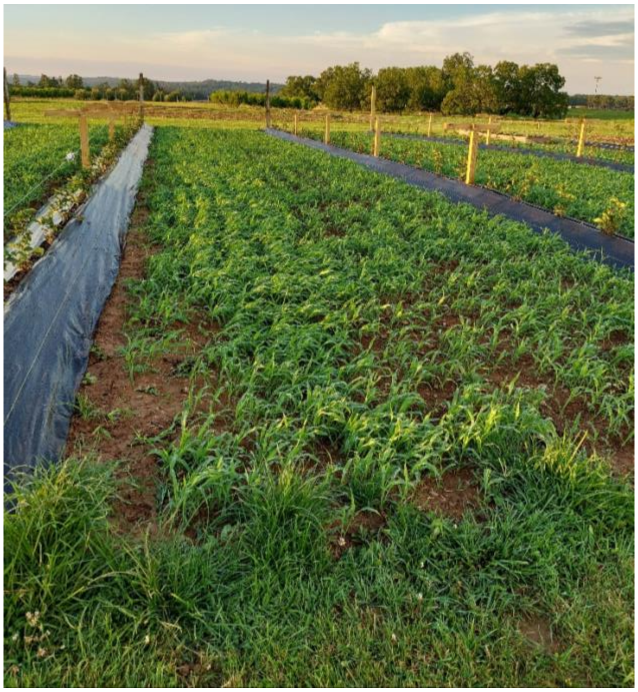


Figure 3. *Transplanted blackberries with woven fabric ground cover and sorghum-sudangrass cover crop in aisle. Photo taken in July 2023 by Daniel Becker.*

Figure 4. *Young plant canopy supported with twine and orange C-clips. Photo taken in July 2023 by Ginny Travis.*

In 2024, all plants in the trial were managed uniformly according to industry standards. Plants were pruned in March 2024, leaving two canes per crown with canes topped 12 inches above the trellis wire, when possible (Figure 5). Prunings from each plant in the pre-treatment plots (n=125) were weighed to check for uniformity. Canes were trimmed and bundled together with twine and measurements were taken with a hanging scale. During the growing season, as the canopies grew a moveable monofilament catch wire was added to the trellis to increase cane support and reduce movement, using 2.5-inch BranchLok's (AgFast Corporation, Pomona, CA) as ties (Figure 6).

Figure 5. *Plants pruned to two canes per crown to limit yield during the first harvest year and to encourage primocane growth. Photo taken in March 2024 by Daniel Becker.*

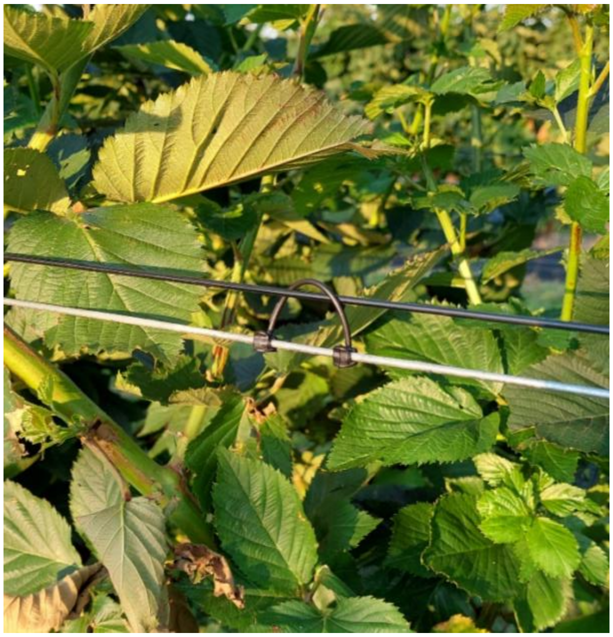


Figure 6. *High tensile trellis wire and monofilament catch wire with BranchLok tie. Photo taken September 2024 by Daniel Becker.*

Fertilization with 9.2 ounces of 10-10-10 (26 g N) per plant occurred on March 28 during late bud break according to standard recommendations for Kentucky (Jones and Strang, 2005). This rate is equivalent to approximately 69 pounds of actual N per acre based on a 3-ft by 12-ft spacing and 1,210 per acre plant population. In April and May the strip between the landscape fabric ground cover was widened to 10-12" to accommodate crown growth and primocane emergence (Figure 7). Any primocane suckers emerging away from established crowns were pulled, including any prominent ones growing underneath the fabric. Additional mulch was spread over the strip soon afterward to cover the soil and reduce weed emergence.

Figure 7. *Woven landscape fabric covered raised beds with fabric cover strip widened to 10-12" with mulch for weed control. Photo taken in June 2024 by Daniel Becker.*

Spring 2024 was exceptionally warm which led to plant growth being advanced roughly seven to ten days earlier than anticipated based on previous blackberry trials. Harvest began on June 6 and ended on July 26 for a total fruiting period of 50 days for the season. Harvest passes were made twice per week, every three or four days (15 total), to collect ripe fruit from each five-plant plot (n = 25/harvest). A 25-berry sample pooled from each row was used to measure berry weight, soluble solids (°Brix), pH, and titratable acidity (TA) from extracted juice (n = 5/harvest). Cumulative yield for the season along with combined dormant and post-harvest pruning weight was used to assess pre-treatment plot uniformity and will serve as a baseline to compare future results.

Average yield per plot increased gradually from the start of harvest, peaking on 5 July, shortly after the harvest mid-point (approximately 30 June), and then declined gradually thereafter (Figure 8). The average plot yield per harvest pass was 34.6 oz with a cumulative yield of 21 lb, and roughly 522 lb of fruit harvested from all 25 plots for the season. In the plant patent for 'Ponca', Clark (2021) recorded that the average first ripe date at Clarksville, AR was 3 June.

A 55-day average fruiting period was also noted. While the 50-day fruiting period observed in 2024 is comparable, it is expected that the beginning of harvest will be later in future years as the trial site at the UKREC in Princeton, KY is located approximately 94 miles north and 334 miles east of the Arkansas Agricultural Experiment Station. Berry weight varied across the fruiting period but was always above 6 oz. per 25 except during the final harvest which was similar to the 6.2-gram (155 g, or 5.5 oz per 25) average listed in the plant patent. It is possible that berry size will decrease during future harvests as the planting matures and yield increases.

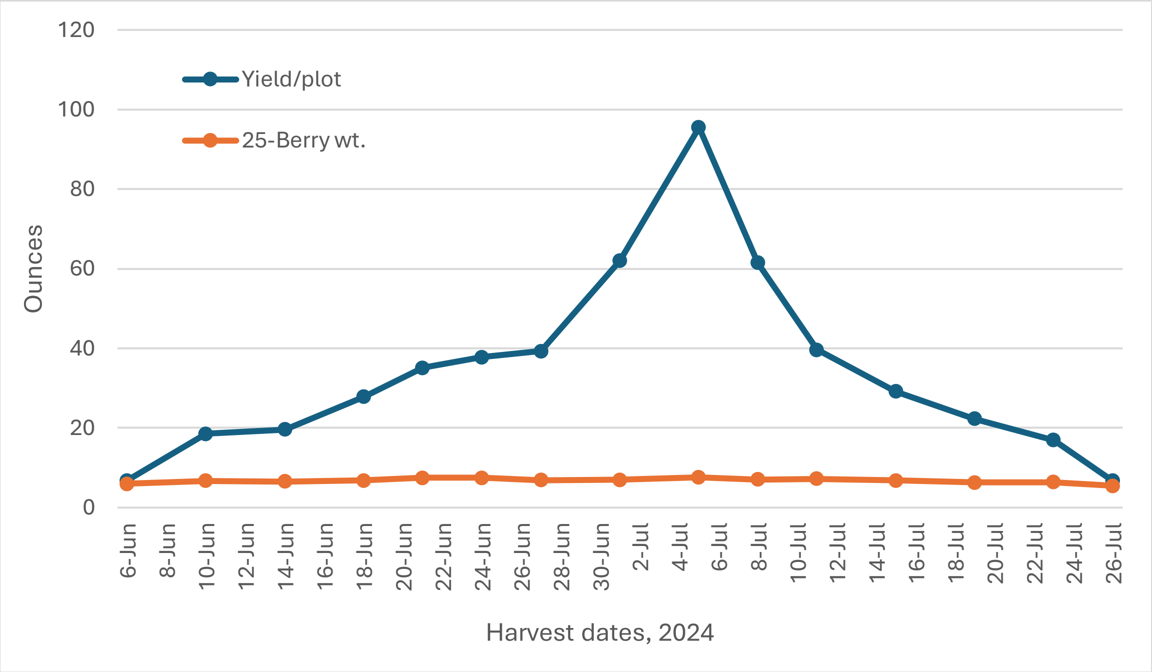


Figure 8. Yield (oz/plot) and 25-berry sample weight (oz) of ‘Ponca’ blackberry collected from 25 plots as a pre-treatment assessment during harvest season 2024. Average plot yield and 25-berry weight was 36.4 oz and 6.8 oz across all harvests.

Fruit SS peaked early, followed by the SS:TA ratio, then both gradually declined throughout the remainder of harvest (Figure 9). Average SS content was at or above 13.0% and comparable to the 13.4% reading recorded in the patent only during three harvests. As this is the first year collecting fruit quality components it is unknown whether SS concentration will increase or become more stable across the fruiting period in the future. A ratio of SS and TA is used as a measure of fruit quality. A high ratio in fruits results in the increased perception of sugars by consumers. A low SS level and high acid results in a tart berry. Increasing fruit tartness became more noticeable in the final three weeks of harvest (after 8 July) when SS fell below 11%. Readings of juice pH and TA remained relatively stable across all harvest samples. The 3.4 average pH and 1.0 g/100 ml TA (citric acid equivalent) were lower and higher than what is listed for ‘Ponca’ in the plant patent (pH: 3.83; TA 0.54). Readings pH, TA, and other quality parameters may become more like those found in literature for this cultivar as canopy size and leaf area per fruit during harvest increases.

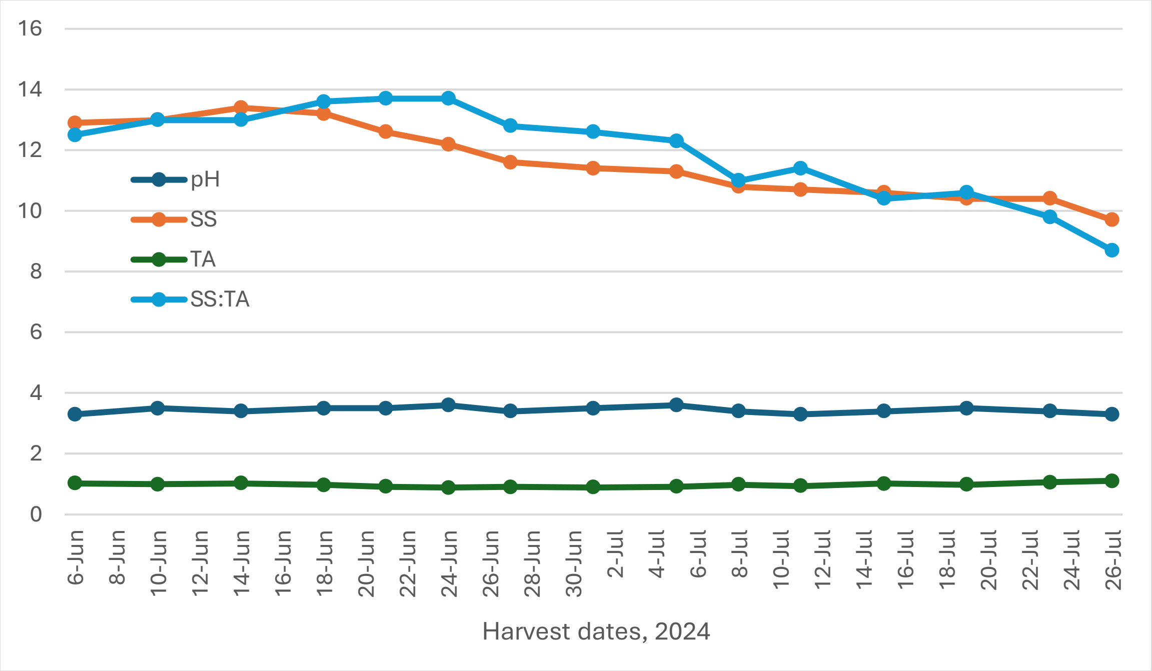
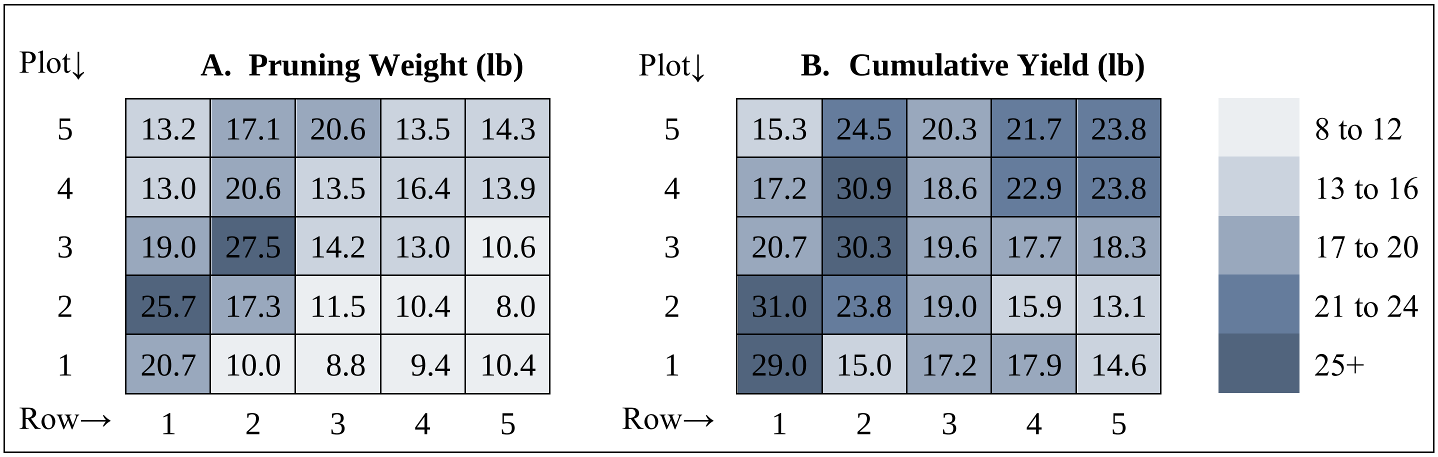


Figure 9. Berry chemistry and quality components of 'Ponca' blackberry collected from 25 plots as a pre-treatment assessment during harvest season 2024. Average pH, soluble solids (SS), titratable acidity (TA) expressed as citric acid equivalent, and SS:TA ratio was 3.4, 11.6%, 1.0, and 11.9, respectively, across all harvests.

There is a slight gradient in plant size across the trial site, expressed as the total weight of dormant and post-harvest floricanes removed during pruning (Figure 10). Plant size generally increased diagonally from right to left, going from the first plot in row five towards rows one and two. The largest plant size was found in plot two of row one and plot three of row two. It is possible that difference in plant size across plots is due to difficulty in tillage and incorporation of fertilizer encountered during site preparation. Working around trellis end posts and irrigation risers from previous trials with a tractor-driven PTO tiller required making careful passes to avoid hitting existing hardware. Tillage depth in the area where plant size is lower may not have been as deep as in other areas. It was also noticed that soil texture was also rougher in this area and that may have affected fertilizer incorporation as well as water retention. Cumulative plot yields show a similar increasing trend across the field as with pruning weights, but the gradient is less distinct. Visual differences in post-harvest canopies composed of primocanes during summer 2024 are also less distinguishable across plots. With care, as plantings become more established, differences that arise during site preparation, planting, and thereafter may gradually diminish. While some differences between plots is expected to carry over once treatments are applied, it is expected that any variation this may cause will be diminished through blocking treatments by row, replication, and randomization using a randomized complete block experimental design.



A. Pruning Weight (lb)

Plot↓					
5	13.2	17.1	20.6	13.5	14.3
4	13.0	20.6	13.5	16.4	13.9
3	19.0	27.5	14.2	13.0	10.6
2	25.7	17.3	11.5	10.4	8.0
1	20.7	10.0	8.8	9.4	10.4
Row→	1	2	3	4	5

B. Cumulative Yield (lb)

Plot↓					
5	15.3	24.5	20.3	21.7	23.8
4	17.2	30.9	18.6	22.9	23.8
3	20.7	30.3	19.6	17.7	18.3
2	31.0	23.8	19.0	15.9	13.1
1	29.0	15.0	17.2	17.9	14.6
Row→	1	2	3	4	5

Figure 10. Weight of (A) dormant and post-harvest floricanes removed by pruning and (B) cumulative fruit yield collected from 5-plant plots of ‘Ponca’ blackberry. Average pruning weight and cumulative yield across all plots was 14.5 lb and 21 lb in 2024.

Future Work:

The trial will have treatments implemented beginning in 2025, the second year following transplanting. Plug plants were not delivered until August 2022, which delayed planting until June 2023 when soil conditions were dry enough to begin field work. Fall transplants have generally been less successful establishing in Kentucky compared to those planted in the spring season. High temperatures and low soil moisture in the fall and the subsequent freeze-thaw cycle during the winter season causes stress which has led to increased plant mortality. This would potentially introduce a source of variability into the experiment that could produce confounding effects on any results generated. In addition, beginning suppression earlier may lead to excessive devigoration of the treatment plants. Delaying primocane suppression until plantings are at least three years old is recommended for commercial brambles (Pritts, 2008).

The following treatments are planned:

1) *Standard renovation, fertilized at bud break (control).* Floricanes are selectively removed after final harvest; all primocanes that emerge are retained until thinned during dormant pruning; 9.2 oz of 10-10-10 fertilizer (≈69 lb./acre) applied per plant at bud break.
2) *Delayed renovation, fertilized at bud break.* Floricane removal is delayed until dormant pruning when thinning primocanes; 9.2 oz of 10-10-10 fertilizer applied at bud break.
3) *Complete renovation, fertilized at bud break.* Primocanes are removed along with floricanes after harvest; 9.2 oz of 10-10-10 fertilizer applied at bud break.
4) *Complete renovation, fertilized after harvest.* Same practices as the previous treatment, except that 9.2 oz of 10-10-10 fertilizer is applied within a week after final harvest.
5) *Complete renovation, split fertilizer application.* Same as previous, except that fertilizer application is split ½ (4.6 oz) at bud break and ½ (4.6 oz) after final harvest.

Dormant pruning will entail removal of excess primocanes and floricanes left over in the delayed renovation treatment, retaining no more than six of the strongest (most vigorous) canes per crown, with fruiting laterals shortened to 12-inches, consistent across treatments. Remaining canes will have any laterals originating within 24-inches of the bed surface removed. Complete renovation will entail pruning whole plants to the crown, keeping floricane and primocane biomass separate. During the growing season, emerging (standard and delayed renovation) or reemerging (complete renovation) primocanes will remain un-thinned until dormant pruning. Primocanes will be periodically soft-tipped by hand to remove the apical growing point once they reach 54-inches (12-inches above the trellis wire). Pest management, including pesticide sprays, will follow standard practices, with controls applied as needed.

Anticipated data to be collected:

1) *During dormant pruning.* Will include counting and weighing of overwintering primocanes and floricanes after removing laterals, which are then counted and weighed separately. The number and weight of laterals collected will include any portion removed entirely or in part from any primocanes that are retained per crown.
2) *During harvest*. Will include measuring yield per five-plant plot. Each harvest pass will have a 25-berry sample collected from each treatment to measure berry weight, with juice extracted to measure total soluble solids (°Brix), pH, and TA.
3) *During post-harvest renovation*. Will include counting and weighing floricanes, separate from shortened laterals. The number and weight of emerged primocanes will include all those removed from the complete bed renovation treatments.

Data will be statistically analyzed using SAS v9.4 (SAS institute), subjecting it to analysis of variance (ANOVA), and means separation using Duncan's multiple range test LSD ($P \leq 0.05$). At the end of a multi-year suppression cycle, plants will have soil and tissue samples collected for analysis in mid to late August as recommended by Strik and Vance, 2017. Tissue sampling will occur during primocane regrowth of the complete renovation treatments. Sampling procedures will follow those outlined in Strang and Wright, 2011. Results will help in evaluation and interpretation of results, though, as each treatment will have a single, pooled sample collected across plots, comparative data analysis is not possible.

Timetable:

2025 – treatments implemented. Data collected during dormant pruning, harvest, post-harvest, and delayed renovation as outlined in the procedure section. No effect of treatment on growth or yield is expected because all plots were similarly managed the previous year.

2026 to 2027 – treatments and data collection continue. Research reports published in the 2025 and 2026 Fruit and Vegetable Crops Annual Research Report, a University of Kentucky College of Agriculture Food and Environment publication, available in print (usually by January) and online at https://www.uky.edu/hort/documents-list-commercial-fruit-nut.

2028 to ? – Complete renovation treatments will continue if reduction in vigor is not severe or if a clear production trend is not established. Otherwise, complete renovation is skipped for a year while the fertilizer treatments are continued to investigate the time required for recovery. During the skipped year these treatments will have delayed renovation practices applied.

Ongoing progress reports based on research articles published in the UK Fruit and Vegetable Crops Annual Research report will be sent to the North American Bramble Growers Research Foundation for publishing online when requested. A final report would potentially cover an initial renovation and recovery cycle, enough time to draw conclusions about the different treatments. Other project outputs may include extension publications and posters or presentations at the NARBA conference, and other regional, state, and local grower conferences.

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