# Assessing Biopesticide Effectiveness in Reducing Conventional Pesticide Use on American Grape Hybrids: A Comparative Study of Frontenac and Chardonel

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Biopesticides offer a promising alternative for sustainable disease management in grape production. Studies demonstrate their efficacy against powdery mildew and gray mold, with Moyer et al. (2016) highlighting their use alongside cultural practices. Research on microbial technologies, including entomopathogenic bacteria (Vicente-Díez et al., 2023), supports their potential in reducing synthetic pesticide reliance. However, controlling downy mildew remains challenging, as organic systems often depend on copper-based fungicides, which pose environmental concerns and phytotoxic risks (Dagostin et al., 2011; Lamichhane et al., 2018, Pertot et al., 2017).

Fungicide resistance, regulatory restrictions, and consumer concerns have driven advancements in biopesticides. Disease-resistant American hybrid grapes like Frontenac and Chardonel could further reduce pesticide use (UMass Extension, 2024). This study compares a biopesticide-based program to conventional methods by evaluating its effectiveness in disease control, yield performance, and juice quality in Frontenac and Chardonel grapes.

## Materials and Methods

***Study site.*** This trial was conducted during the summer of 2024 at a vineyard in Belchertown, Massachusetts. Figure 1 shows the average monthly temperatures and total monthly precipitation for the summer 2024 compared to historical data. Temperatures and precipitations appear to be in line with historical data, a summer with warm and wet conditions conducive to diseases. Two grape varieties, Frontenac and Chardonel, were selected for evaluation due to their contrasting characteristics in disease resistance. For detailed information on disease susceptibility and chemical sensitivity of these varieties, refer to the New England Small Fruit Management Guide.

***Experimental design.*** Each variety consisted of six rows, each consisting of 20 vines, with each row divided into two blocks of 10 vines. A treatment was randomly assigned to each of the two blocks within each row to account for potential spatial variability and ensure unbiased comparisons. Each treatment was therefore replicated six times.

***Treatments.*** The vineyard was divided into two treatment groups: a conventional pesticide program and a program in which many of the conventional products were replaced with biopesticides, hereafter referred to as the biopesticide program. The conventional program followed industry-standard chemical applications, primarily using products such as Manzate, Captan, Flint, and Movento (Table 1): six out of the ten sprays in this program were conventional. The biopesticide program predominantly utilized products from Marrone Bio Innovations, including Stargus and Regalia, which were mixed and applied according to industry recommendations: only three out of ten sprays contained conventional chemicals (Table 1). Stargus (*Bacillus amyloliquefaciens* strain F727) enhances plant resistance by colonizing plant tissues and activating natural defenses, while Regalia (extract of *Reynoutria sachalinensis*) induces systemic resistance, prompting the plant to inhibit pathogen growth. Both products act preventively, aiming to inhibit disease establishment rather than eliminating existing infections, necessitating early and regular application.

***Spray schedule.*** All sprays this season included 1 pint/acre of Nufilm. Table 1 outlines the spray schedule for both conventional and biopesticides treatments.

***Vine Maintenance.*** Shoot thinning was performed on May 20-21, 2024, to maintain 6 shoots per foot of linear canopy. Other vineyard management practices, such as leaf pulling and shoot positioning, were consistent across treatments.

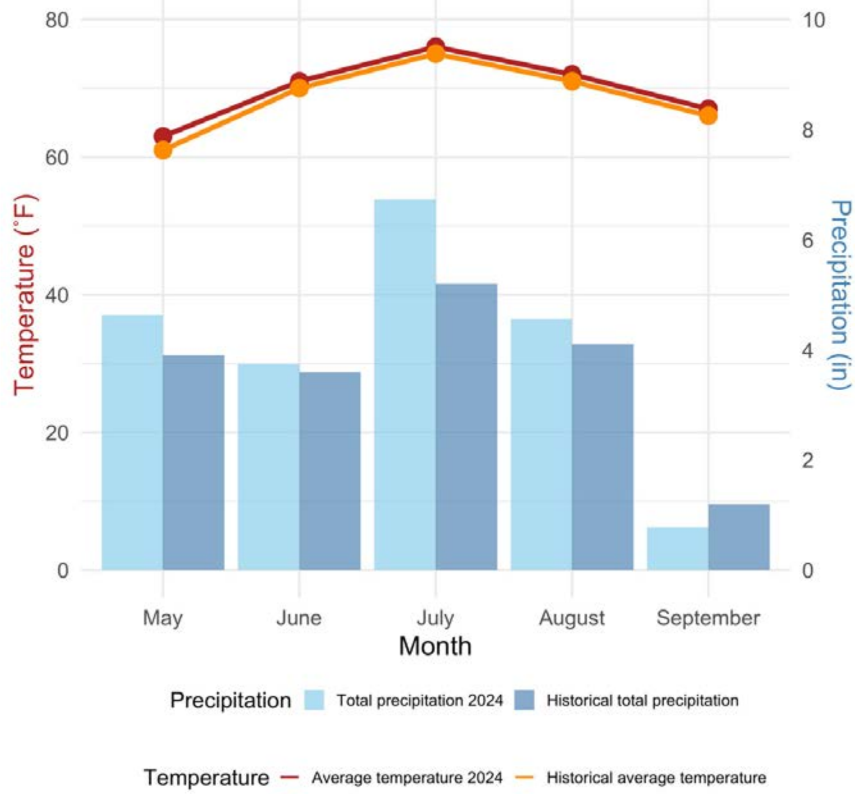

**Figure 1.** Average air temperature and total precipitation in summer 2024 compared to historical data.

**Table 1.** Spray schedule.

| Date | Conventional Program | Biopesticide Program |
|---|---|---|
| **5/17/2024** | Manzate @ 3 lb/a, Rampart @ 3 qt/a | Stargus/Regalia mix @ 3 qt/a |
| **5/28/2024** | Manzate @ 3 lb/a, Captan @ 2 lb/a, Flint @ 2 oz/a, Movento @ 7 oz/a | Manzate @ 1.5 lb/a, Captan @ 1 lb/a, Flint @ 2 oz/a, Movento @ 7 oz/a, Stargus/Regalia @ 1.5 qt/a |
| **6/04/2024** | Manzate @ 3 lb/a, Captan @ 2 lb/a, Pristine @ 12.5 oz/a | Manzate @ 1.5 lb/a, Captan @ 1 lb/a, Pristine @ 6.25 oz/a, Stargus/Regalia mix @ 1.5 qt/a |
| **6/13/2024** | Stargus @ 4 qt/a, Regalia @ 2 qt/a | Stargus @ 4 qt/a, Regalia @ 2 qt/a |
| **6/20/2024** | Revus Top @ 7 oz/a, Manzate @ 4 lb/a | Stargus @ 4 qt/a, Regalia @ 2 qt/a |
| **6/28/2024** | JMS Stylet oil @ 2%, Flint @ 2 oz/a | Stargus @ 1.5 qt/a, Regalia @ 1 qt/a |
| **7/09/2024** | Stargus @ 4 qt/a, Regalia @ 2 qt/a | Stargus @ 4 qt/a, Regalia @ 2 qt/a |
| **7/19/2024** | Sevin @ 2 qt/a (insecticide), Scala @ 18 oz/a | Sevin @ 2 qt/a, Stargus @ 2 qt/a, Regalia @ 1 qt/a, Scala @ 9 oz/a |
| **7/30/2024** | Stargus @ 4 qt/a, Regalia @ 2 qt/a | Stargus @ 4 qt/a, Regalia @ 2 qt/a |
| **8/21/2024** | Stargus @ 4 qt/a, Regalia @ 2 qt/a, Captan @ 2.5 lb/a | Stargus @ 4 qt/a, Regalia @ 2 qt/a |

***Data Collection.*** The following metrics were collected to evaluate the impact of the conventional and biopesticide programs:

- **Diseases evaluated:** The main grape foliage diseases were quantified: black rot, downy mildew, powdery mildew, Phomopsis. We also noticed phytotoxicity in the form of leaves burned after certain pesticide treatments and evaluated it the same way as diseases.
- **Disease percentage**: Percentage of total foliage damaged with diseases was quantified. It was measured on each treatment the day before spraying. Here we report only on the day before the last spray, August 20, 2024.
- **Yield per vine**: Fruit production per vine was measured at harvest. For Frontenac, we encountered a main issue with bird feeding on the grapes thus the yield and juice quality data are inconclusive.
- **Fruit quality**: Soluble solids (Brix) and pH were measured for each treatment at harvest. Frontenac was harvested on September 6$^{th}$, 2024, and Chardonel on October 4$^{th}$ 2024.
- **Cost of chemicals:** We computed the total cost of chemical for each treatment for the season to evaluate whether there was a major difference.

***Statistical analysis.*** Statistical analysis was performed in R using one-way ANOVA to evaluate the effect of spray treatments on each measured variable (percent of diseases, yield and juice quality). Tukey's HSD post hoc test was conducted to identify pairwise differences between treatments, with significance determined at a p-value threshold of 0.05. Results are presented as treatment means (Table 2).

## Results

***Disease.*** The overall disease severity was very low on both varieties and for both treatments (Table 2). On August 20, there was a complete absence of downy mildew or Phomopsis recorded on Frontenac, and a complete absence of powdery mildew recorded on both Frontenac and Chardonel (Table 2).

On Frontenac, there were no statistical differences between the conventional and biopesticide treatments in the percentage of foliage diseases for any of the diseases assessed (Table 2). On Chardonel, there were also no statistical differences between the treatments in the percentage of foliage diseases, except for downy mildew (Table 2, Figure 2).

***Phytotoxicity.*** On both Frontenac and Chardonel, symptoms of burnt leaves were observed on August 20. Phytotoxicity was significantly higher in the conventional treatment than in the biopesticide treatment. We attribute this phytotoxicity to JMS oil, which, despite being considered organic, was only applied in the conventional treatment (Table 2, Figures 3A, B).

***Juice quality and yield.*** There were no statistical differences in juice quality, measured by Brix (sugar content) (Figure 4A,B), pH (Figure 5A,B), or in yield (Figure 6) between the conventional and biopesticide treatments (Table 2). The yield figure for Frontenac is not shown due to concerns that the numbers are not reflective of actual yield because of bird damage.

**Table 2.** Averages and P values showing statistical differences in diseases, burnt foliage, Brix (sugar), pH, and yield are presented. P values indicating statistical differences are marked with an asterisk in the results. When no disease was visible, statistical analyses were not conducted, and the P value was recorded as "NA" (not applicable). Yield in Frontenac was lower than expected due to bird damage.

| | Frontenac | | | Chardonel | | |
|---|---|---|---|---|---|---|
| Variable | Biopesticide | Conventional | P Value | Biopesticide | Conventional | P Value |
| Downy mildew (Percent) | 0 | 0 | NA | 0.03 | 0.01 | 0.04* |
| Phomopsis (Percent) | 0 | 0 | NA | 0.06 | 0.05 | 0.07 |
| Black rot (Percent) | 0.001 | 0.001 | 0.29 | 0.00067 | 0.00033 | 0.34 |
| Powdery mildew (Percent) | 0 | 0 | NA | 0 | 0 | NA |
| Burnt foliage (Percent) | 0.83 | 2.17 | 0.003* | 0.83 | 3.67 | 0.001* |
| Brix | 17.57 | 16.55 | 0.29 | 18.13 | 18.85 | 0.19 |
| pH | 3.14 | 3.2 | 0.19 | 3.12 | 3.13 | 0.94 |
| Yield per vine (Pounds) | 7.46 | 3.34 | 0.15 | 15.31 | 14.85 | 0.8 |

***Economic analysis.*** The Chardonel and Frontenac plots were estimated at a total of 0.7 acres (0.35 acres per treatment). The treatment costs

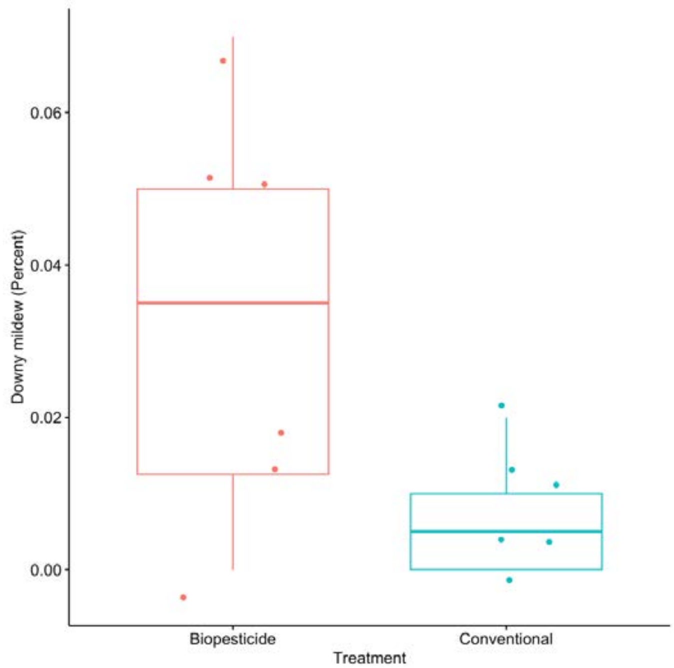


**Figure 2.** Downy mildew severity for the biopesticide and conventional treatments on Chardonel.

for conventional and biopesticide sprays differed minimally. The conventional treatment cost was $883 for the 0.35-acre plot, equating to approximately $1,600 per acre (Figure 7). The biopesticide treatment cost was $920 for the 0.35-acre plot, about $1,800 per acre (Figure 7).

## Conclusions

Both treatments effectively controlled disease on Frontenac and Chardonel, except for downy mildew on Chardonel. Despite this, yield and juice quality (pH and Brix) remained unchanged between treatments.

While biopesticides were slightly more expensive per acre, the overall cost difference was minimal, making them a viable alternative. Frontenac showed no differences in disease severity between treatments, suggesting it is well-suited for biopesticide substitution. For Chardonel, downy mildew may still require some conventional sprays.

With comparable costs and no observed yield or quality reductions, this study suggests that integrating biopesticides into pest management could help reduce toxicity and resistance risks and lower cost on disease-resistant varieties like Frontenac. However, because the study lacked vineyard and year replicates, the findings should be interpreted with caution. Conventional sprays remain essential during high disease pressure particularly in May and July and post-infection, as biopesticides like Stargus and Regalia prevent disease but do not eliminate infections. Future studies will test whether fewer applications of

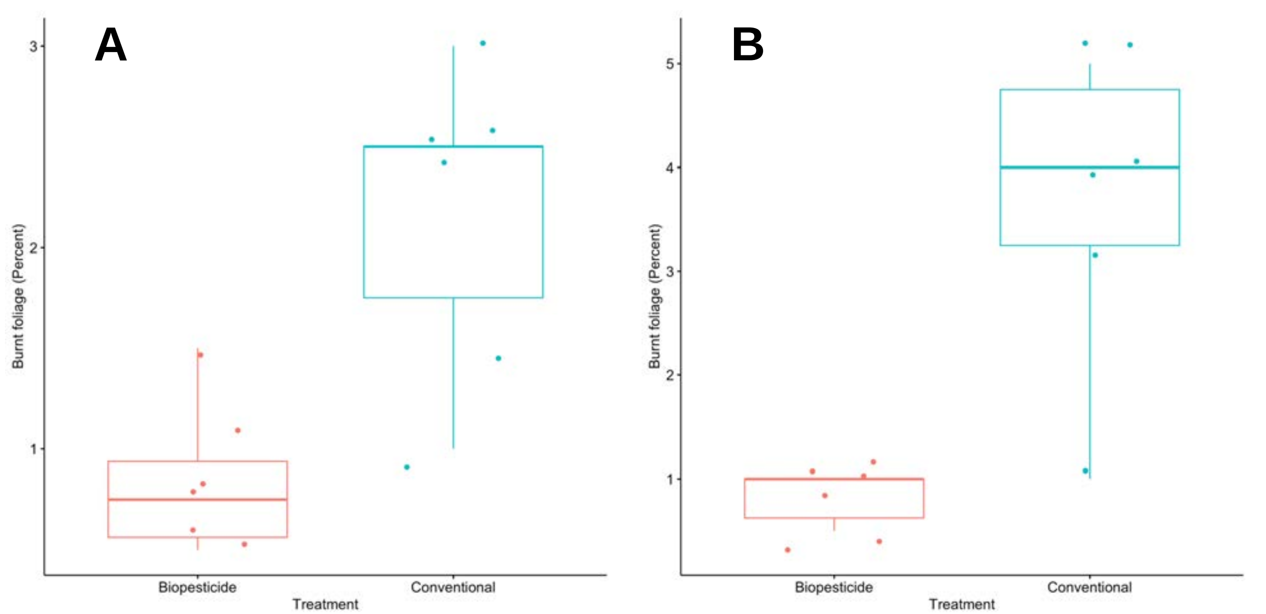


**Figure 3.** Phytotoxicity for the biopesticide and conventional treatments on (A) Frontenac, (B) Chardonel.

the mixed regimen on disease-resistant varieties like Frontenac can achieve similar results

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## Acknowledgements

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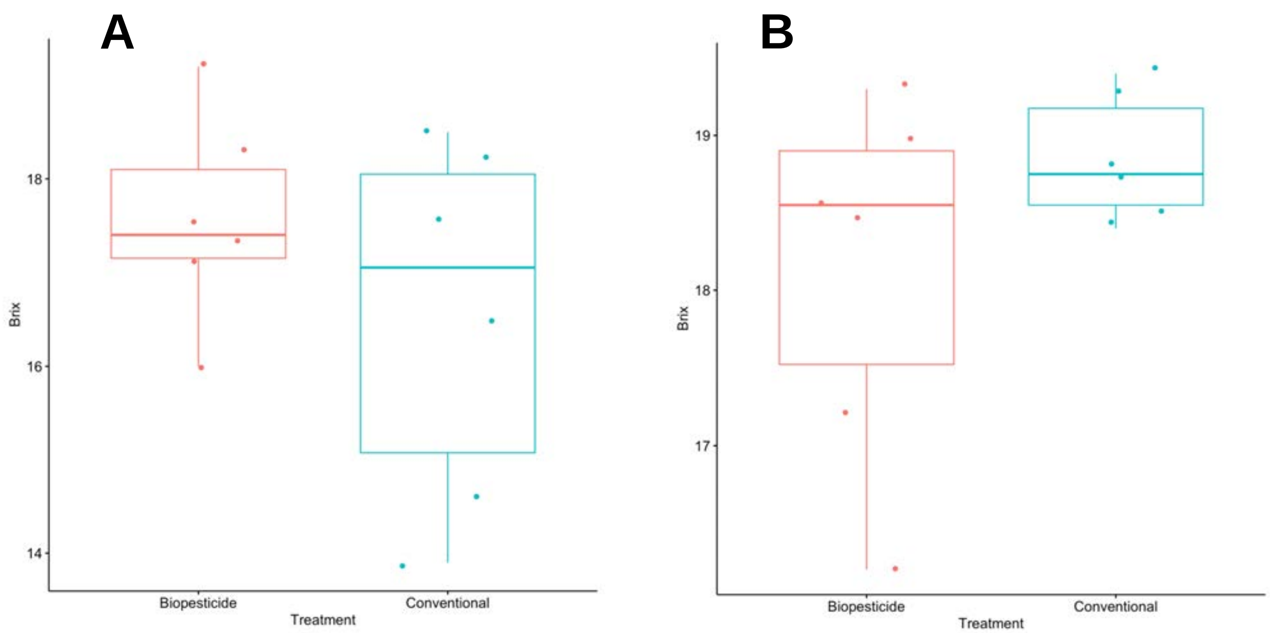


**Figure 4.** Brix for the biopesticide and conventional treatments on (A) Frontenac, (B) Chardonel.

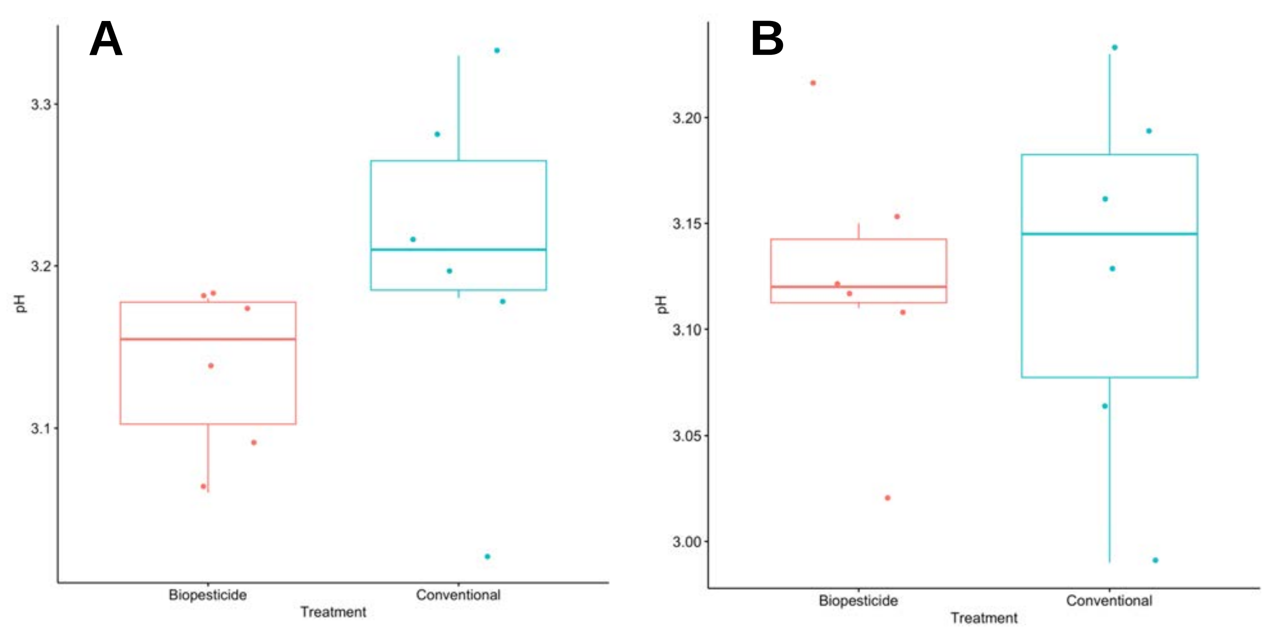


**Figure 5.** pH for the biopesticide and conventional treatments on (A) Frontenac, (B) Chardonel.

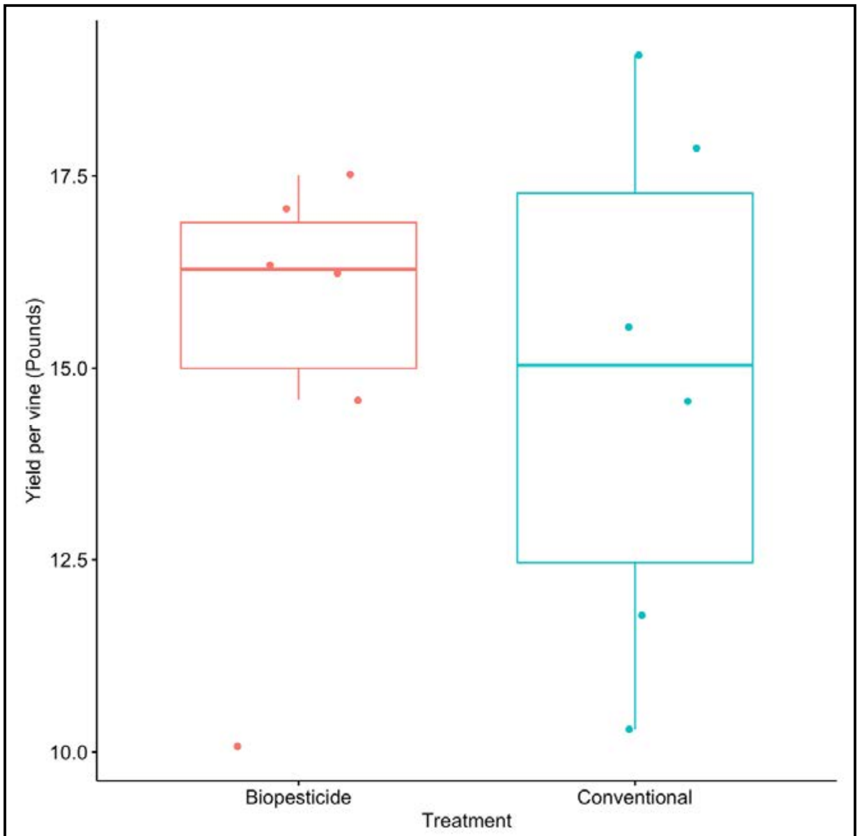


**Figure 6.** Yield for the biopesticide and conventional treatments on Chardonel.

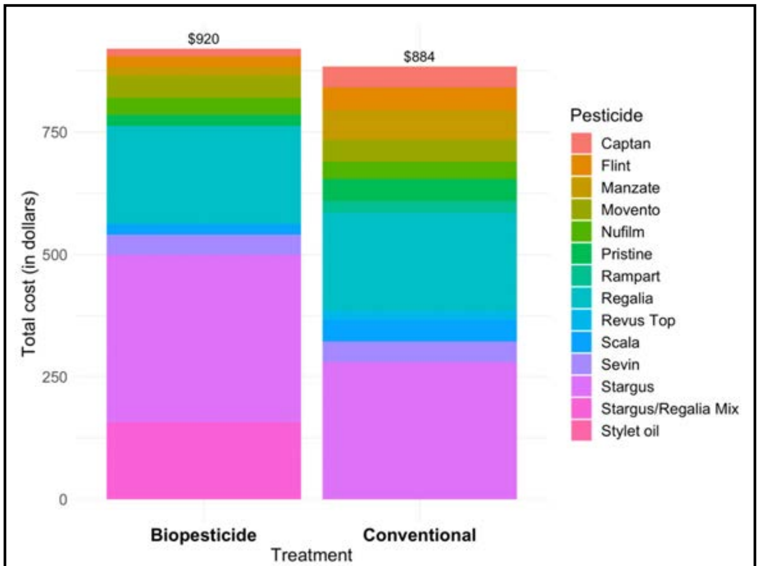


**Figure 7.** Comparison of the total cost for across varieties (about 0.35 acres) for conventional and biopesticide.

*Where brand names for chemicals are used, it is for the reader's information. No endorsement is implied, nor is discrimination intended against products with similar ingredients. Please consult pesticide product labels for rates, application instructions and safety precautions. The label is the law. Users of these products assume all associated risks.*

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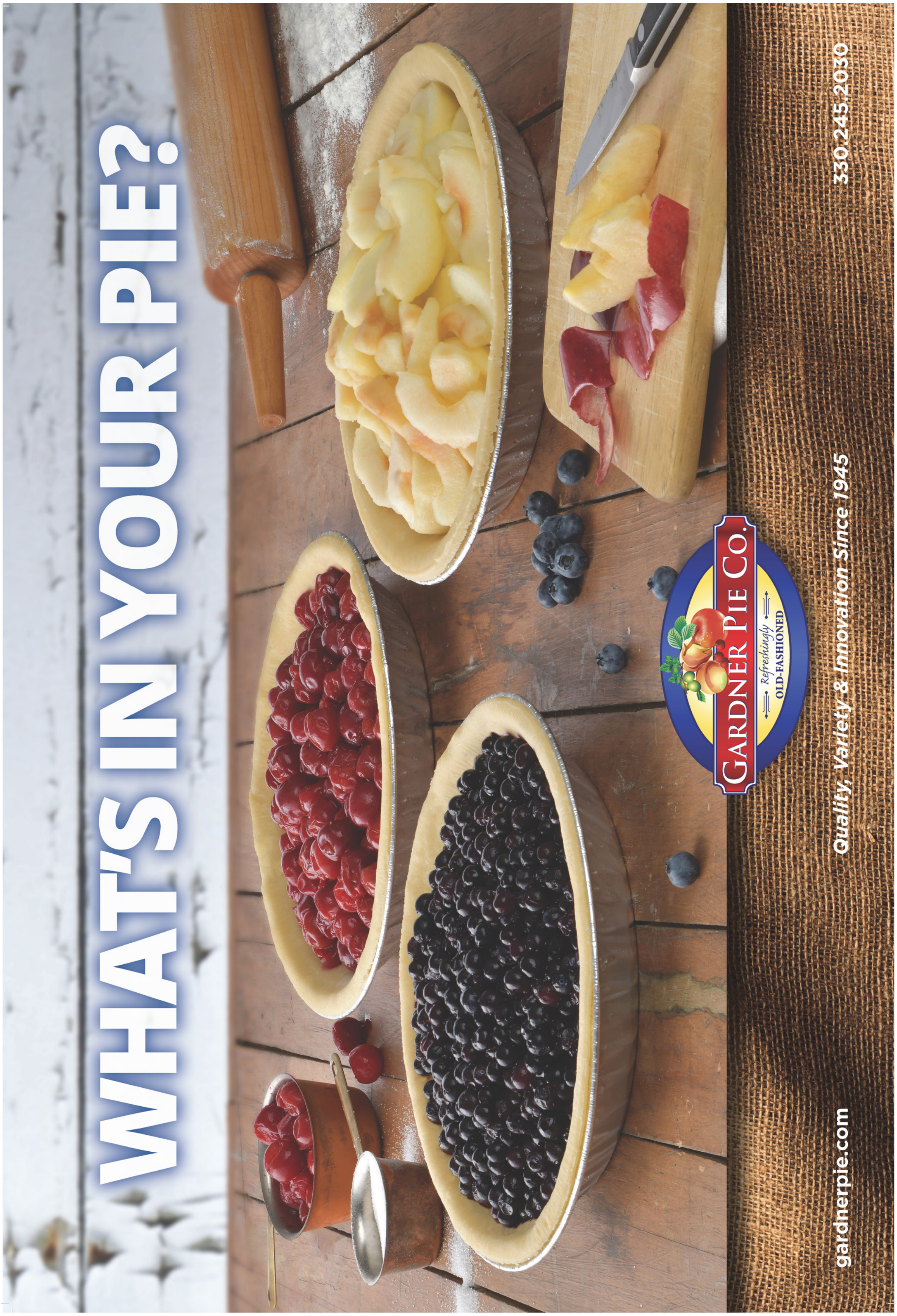
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