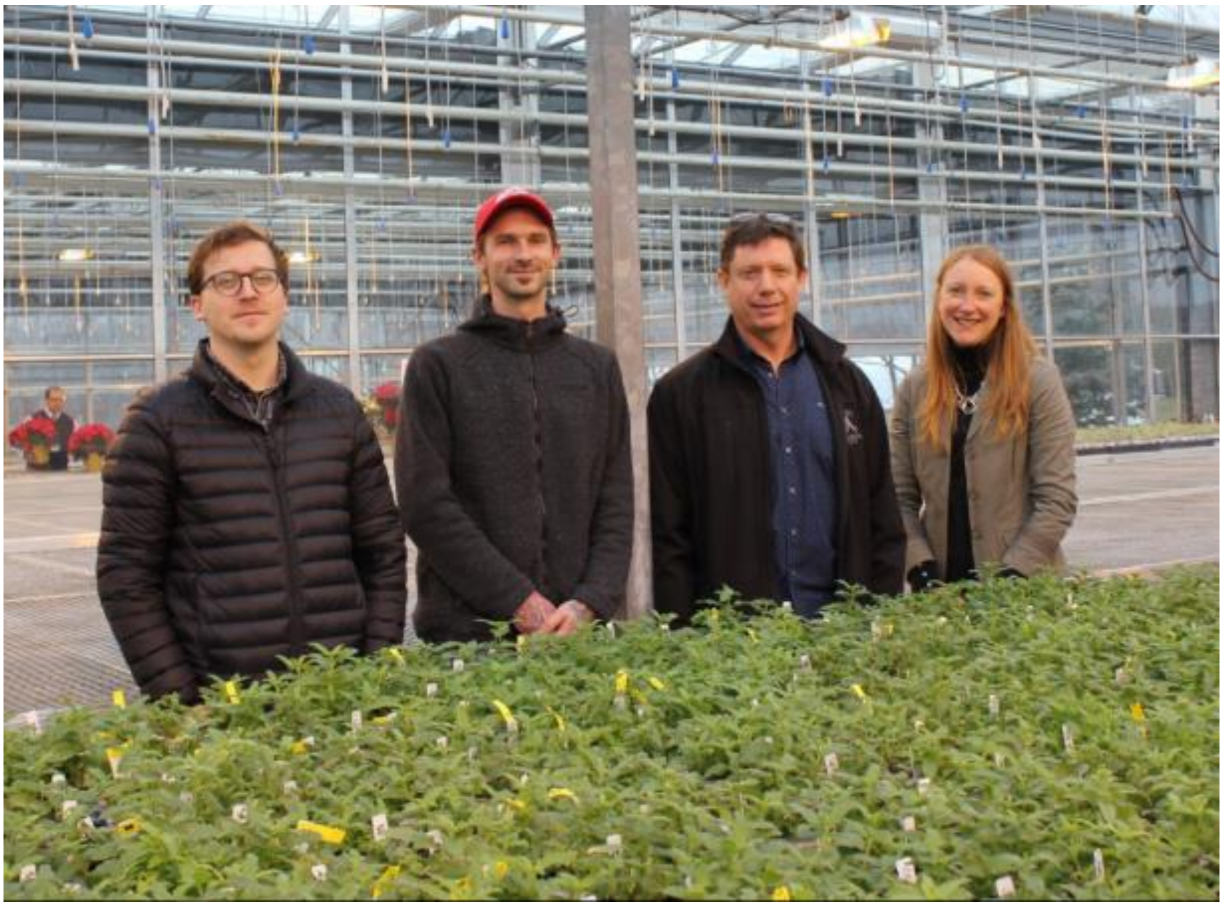
EVALUATING THE EFFICACY OF SILAMOL® IN REDUCING DISEASE INCIDENCE AND SEVERITY FOR *VERBENA X HYBRIDA* IN THE NIAGARA COLLEGE GREENHOUSE



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Acknowledgements

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Cover Photo Caption: (L-R) Student Researchers Evan Hadley and Charlie Laport with Frontline Growing Products Canadian Distributor Dave DeHaan and Niagara College Horticulture Professor Mary Jane Clark with Verbena plants from the research study in the Niagara College, Niagara-on-the-Lake Campus greenhouse.

Introduction

From October 4, 2017 to January 19, 2018, a research project was conducted at the Niagara College, Niagara-on-the-Lake greenhouse to evaluate the efficacy of the Silamol® product in reducing the incidence and severity of disease in a greenhouse-grown potted Verbena (*Verbena x hybrida* Quartz XP series) crop. Silamol® is a liquid product that contains Potassium Silicate in a concentrated and plant-available form. Once diluted in water, Silamol® produces $[Si(OH)_4]$ which is suggested to reduce stress from drought, as well as reduce phosphorus deficiency in greenhouse-grown crops (Frontline Growing Products, 2015).

Materials and Methods

Verbena was chosen by a local greenhouse producer as the ideal crop for this study, due to its high susceptibility to disease, especially powdery mildew. All plants were grown on the same bench in the Niagara College, Niagara-on-the-Lake Campus greenhouse, using no supplemental lighting. The average greenhouse temperature during the study was 21°C, and the average relative humidity (RH) was 70%.

On October 4, 2017, 240 Verbena plants were transplanted from seedling plug trays into 4" containers, filled with a shredded wood fines growing substrate (Gro-Bark®. Caledon, ON) **(Figure 1)**. The containers were evenly spaced on the bench in 20 trays, each containing 12 planted containers. Each tray contained plants assigned to one of four treatments, arranged in a randomized complete block design on the greenhouse bench **(Figure 2)**.

The treatments include:
Silamol® Foliar (SF): 100mL diluted Silamol® applied by a foliar spray method
Silamol® Drench (SD): 100mL diluted Silamol® applied by a growing substrate drench method
Control Foliar (CF): 100mL tap water applied by a foliar spray method
Control Drench (CD): 100mL tap water applied by a growing substrate drench method

The Silamol® applications were mixed at a ratio of 15mL of Silamol® concentrate per 12L of water. 100mL of the solution contained 0.0125mL of Silamol® concentrate. Treatment applications were completed every Tuesday for all four treatments beginning October 24th, 2017. In addition, all plants were fertilized weekly by applying 100mL of a 20-8-20 dilute fertilizer solution (200ppm N) to the surface of the growing substrate.

For each of the four treatments, five representative plants per treatment (one from each tray per treatment) were selected for weekly observations. The representative plants were chosen due to their average size within their respective trays. Using the pour through method (Wright, 1986), growing substrate pH and electrical conductivity (EC) were evaluated weekly. Growth measurements of canopy height (i.e., the distance from the growing substrate surface to the top of the tallest shoot tip) and width at two points (i.e., the distance between the leaf tips at the widest point of the plant, and the distance between leaf tips perpendicular to this widest point) were taken weekly and used to calculate Growth Index using the following equation: [(height · width1 · width2) / 300] (Ruter, 1992).

Plants were monitored for visual symptoms of diseases and pests from October 4, 2017 until December 18, 2018. At the completion of the study on January 8, 2018 disease/pest severity was ranked on a 0 to 10 scale and the total number of inflorescences with open and coloured bud-stage florets were counted per treatment. Also on January 8, 2018, all above-ground growth for each representative plant per treatment was placed into a paper bag and bags were dried at 70°C until a constant weight was achieved. The study concluded on January 19, 2018 when shoot dry weight was measured.

Throughout the study, an additional 100 Verbena plants in 4" containers were grown, evenly spaced around the research plants on the greenhouse bench, to reduce border effects. Border plants were watered and fertilized the same as the Control Drench treatment plants, but no data was collected for the border plants.

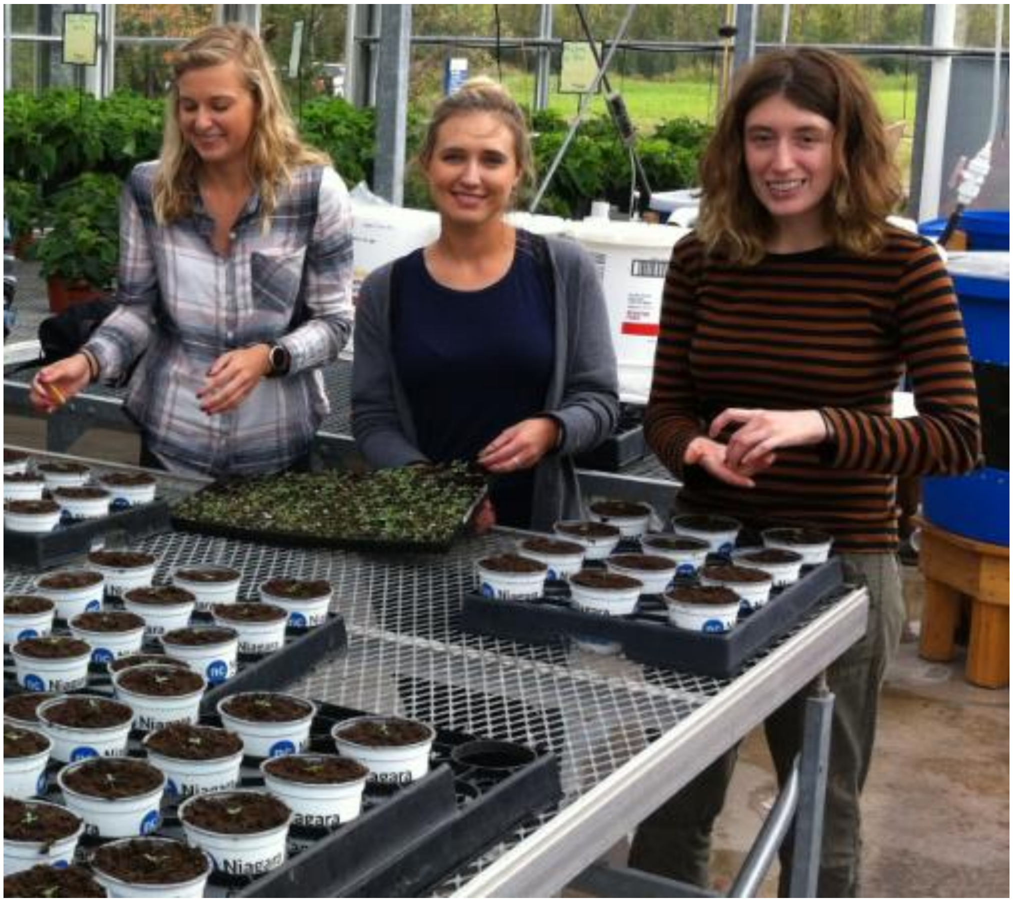

Figure 1: Niagara College students in the Applied Plant Pathology course transplanting Verbena into 4” containers in the Niagara College Greenhouse on October 4, 2017.

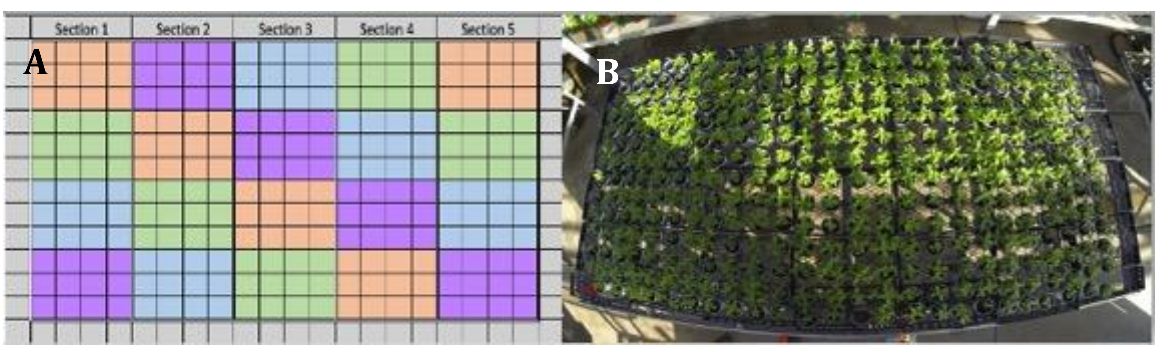

Figure 2: Stylized map (B) and overhead view (B) of the randomized complete block design of container-grown Verbena plants on the Niagara College greenhouse bench. Each colour section represents one tray with 12 plants having the same treatment, including Silamol® Foliar (orange), Silamol® Drench (green), Control Foliar (blue), and Control Drench (purple).

Results: Growing Substrate EC

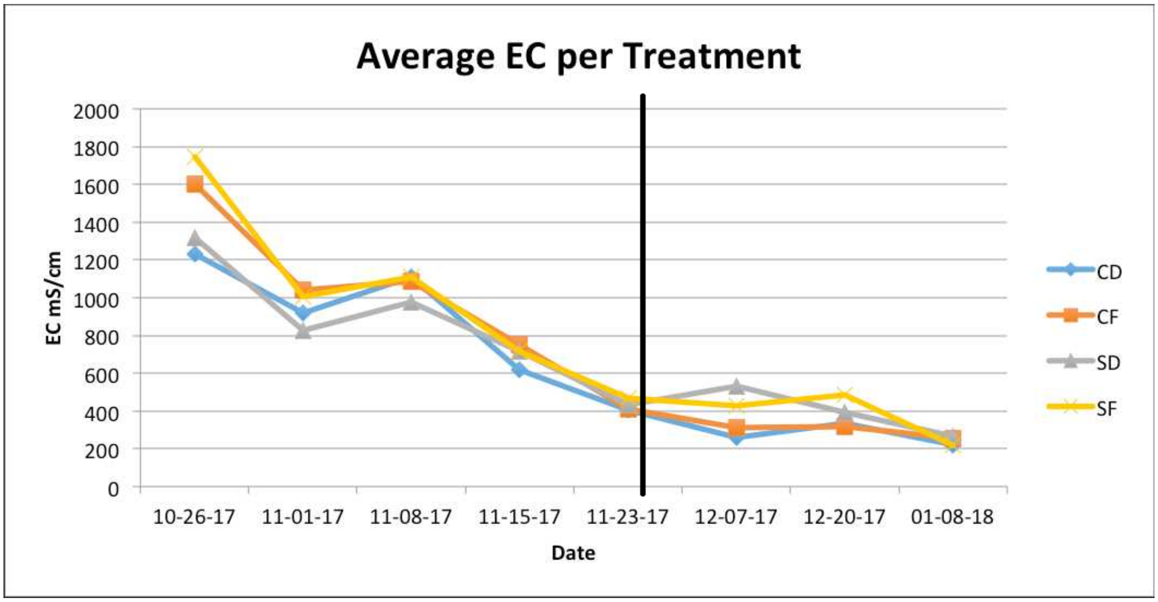

Figure 3: Average weekly growing substrate EC, measured for five plants per treatment for the Control Drench (CD), Control Foliar (CF), Silamol® Drench (SD) and Silamol® Foliar (SF) treatments. The vertical line indicates the date disease was first observed on treatment plants.

Over time during the 11-week evaluation period, the growing substrate EC declined steadily, despite weekly fertilization events **(Figure 2)**. The growing substrate EC may have declined due to greater nutrient uptake by plants than nutrient content in the growing substrate, as a result of fertilizer application only once per week. In addition, plants were fertilized each Friday, while the EC measurements were evaluated the following Wednesday. The time delay between fertilization and growing substrate evaluation may have caused a lower EC measurement, than the actual weekly average. Despite the decline in growing substrate EC over time, we did not observe negative impacts on plant growth due to nutrient deficiencies in any treatment.

Results: Growing Substrate pH

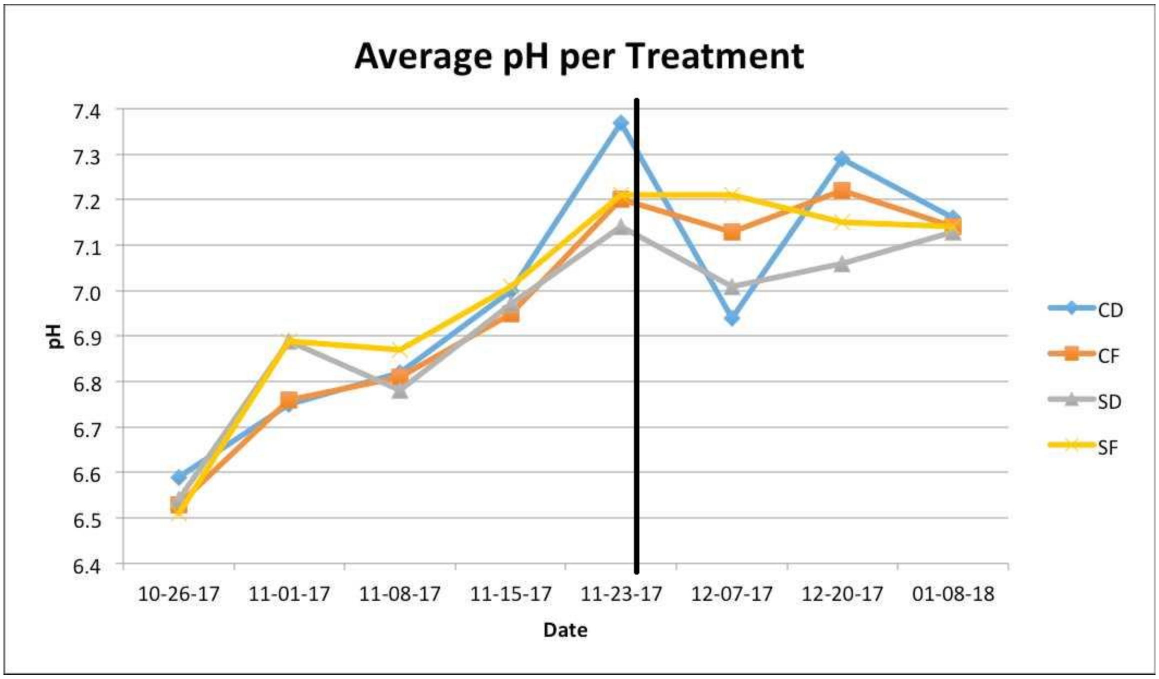

Figure 4: Average weekly growing substrate pH, measured for five plants per treatment for the Control Drench (CD), Control Foliar (CF), Silamol® Drench (SD) and Silamol® Foliar (SF) treatments. The vertical line indicates the date disease was first observed on treatment plants.

During the study, the growing substrate pH increased over time for all treatments **(Figure 3).** The main influence of the increase in pH was likely the water, which ranged in pH from 7.1 to 7.9 during the study and had an average pH of 7.4 between October 2017 and January 2018.

Results: Plant Growth Index

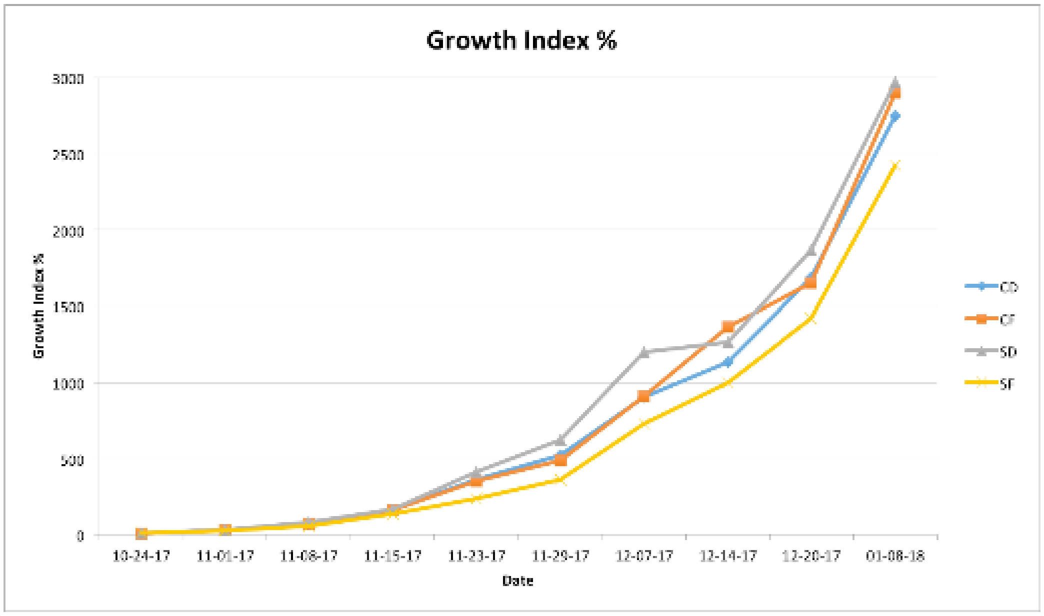

Figure 5: Growth Index of five representative plants per treatment over time for the Control Drench (CD), Control Foliar (CF), Silamol® Drench (SD) and Silamol® Foliar (SF) treatments.

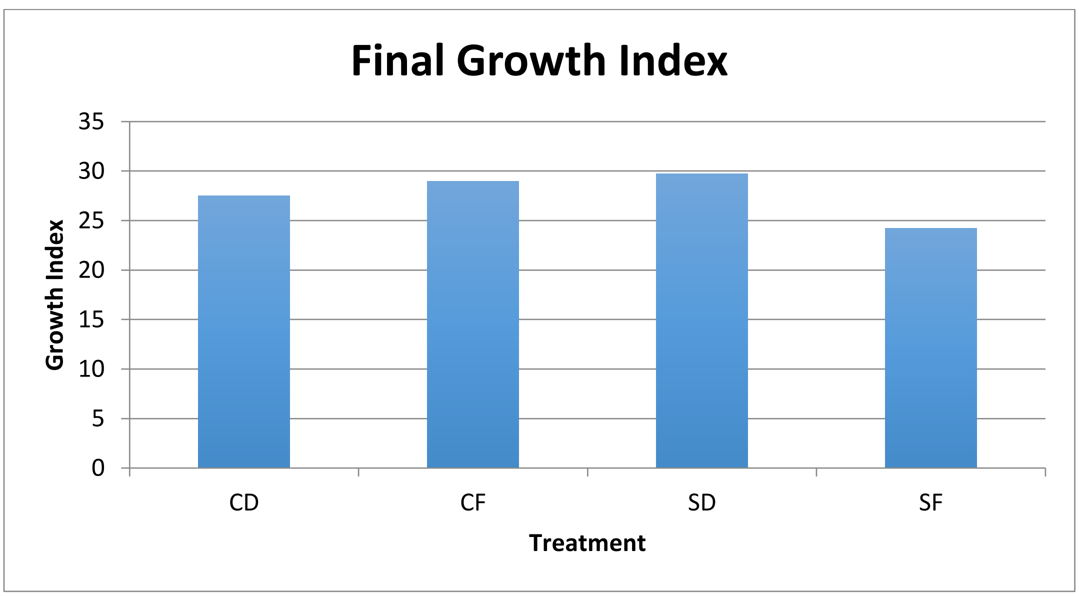

Figure 6: Growth index evaluated on January 8, 2018 for three representative plants per treatment for the Control Drench (CD), Control Foliar (CF), Silamol® Drench (SD) and Silamol® Foliar (SF) treatments.

Over time, Growth Index steadily increased for plants in all treatments **(Figure 5)**. When Growth Index was evaluated at the end of the study on January 8, 2018, minimal variation in Growth Index among treatments was observed **(Figure 6)**. For this study, Verbena plants were grown from seed, which may have accounted for some of the variability in growth observed for plants within treatments **(Figure 7)**.

Figure 7: Five representative plants per treatment at the completion of the study on January 8, 2018.

Results: Shoot Dry Weight

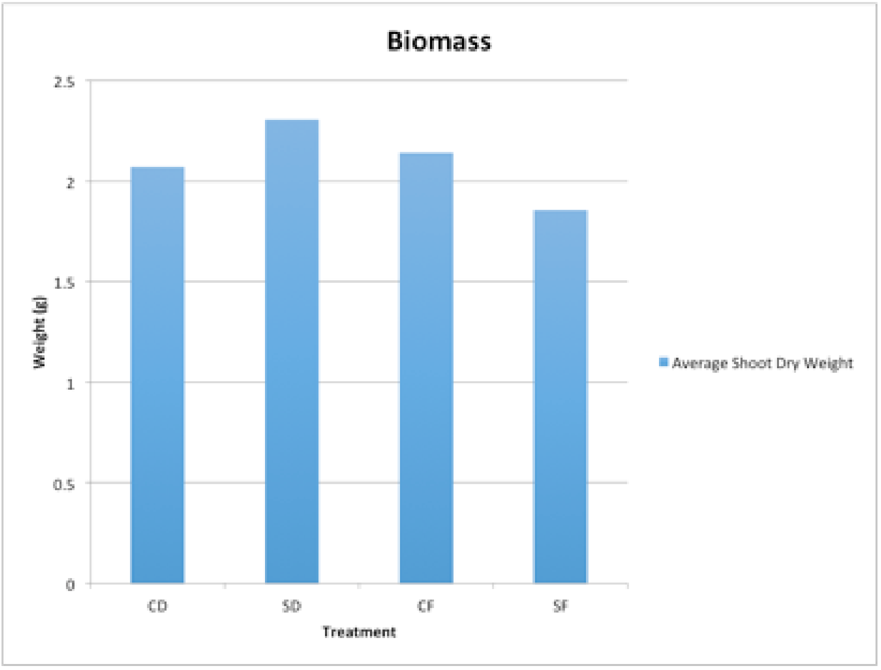

Figure 8: Average shoot dry weight evaluated on January 19, 2018 for three representative plants per treatment for the Control Drench (CD), Control Foliar (CF), Silamol® Drench (SD) and Silamol® Foliar (SF) treatments.

Figure 9: Representative plants on January 8, 2018 for the (Left to Right) Control Drench (CD), Control Foliar (CF), Silamol® Drench (SD) and Silamol® Foliar (SF) treatments.

The greatest average shoot dry weight was observed for the Silamol® Drench treatment (2.19g), while the Silamol® Foliar treatment had the lowest average shoot dry weight (1.85g). The average shoot dry weight for both the Control Drench (2.07g) and Control Foliar (2.11g) treatments were mid-range for the plants in this study **(Figure 8).** By January 8, 2018, plant growth had filled in the containers and some plants were beginning to flower **(Figure 9).**

Results: Flowering

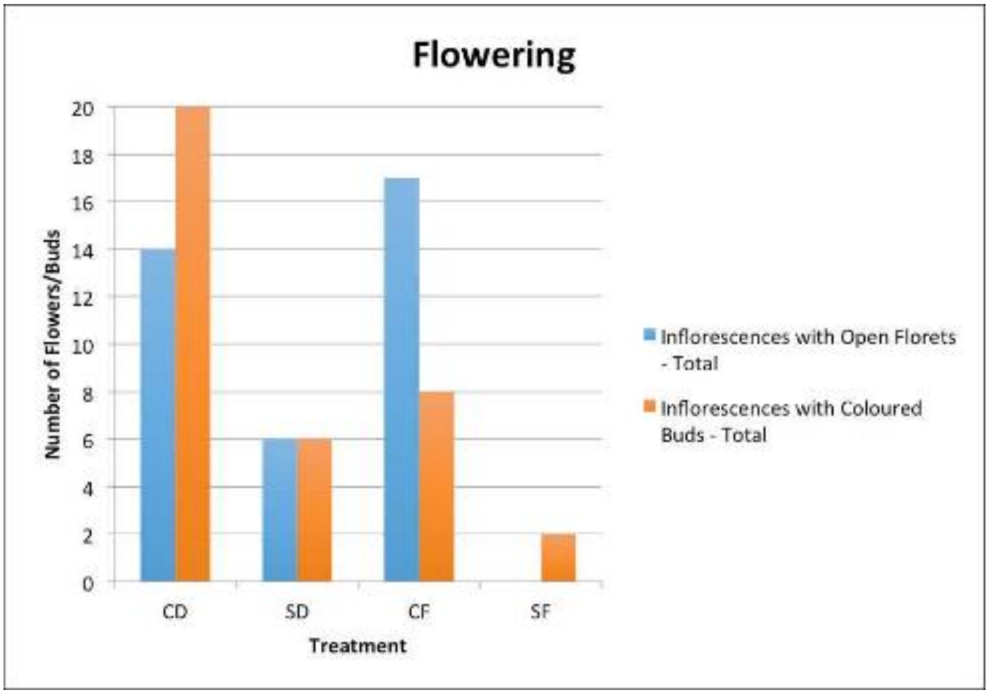

Figure 10: Total number of inflorescences with open or coloured bud-stage florets counted on January 8, 2018 for all plants per treatment for the Control Drench (CD), Control Foliar (CF), Silamol® Drench (SD) and Silamol® Foliar (SF) treatments.

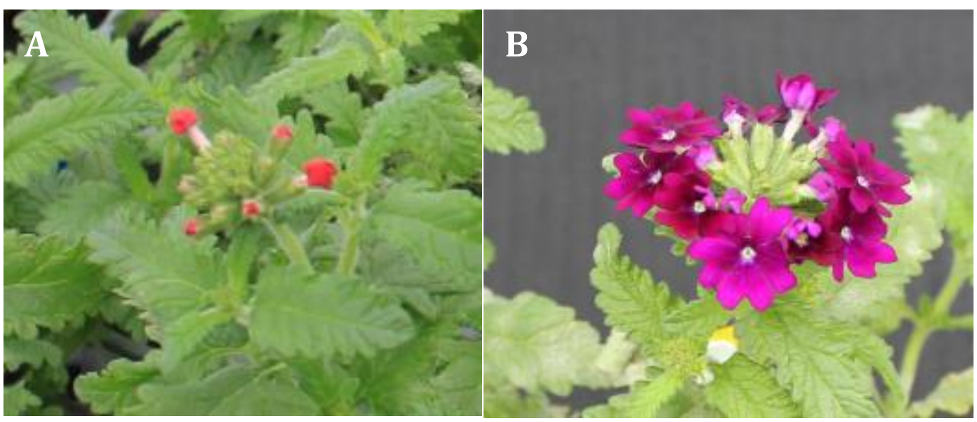

Figure 11: Verbena inflorescences considered to have coloured bud-stage florets (A) and open florets (B).

On December 7, 2017, flower bud formation was first observed on plants in all treatments. At the end of the study (January 8, 2018), considering all plants per treatment, the Control Drench treatment contained the greatest number of inflorescences having open florets, while the Control Foliar treatment contained the greatest number of inflorescences with coloured-bud stage florets **(Figure 10, Figure 11)**. Plant stress may have triggered greater flowering in the two Control treatments, compared to the Silamol® treatments. Of all treatments, the Silamol® Foliar displayed the least amount of generative growth, which may have resulted from low plant stress.

Results: Disease and Pest Symptoms

Figure 12: Verbena leaves showing symptoms of powdery mildew infection (A), brown spot on leaf margins (B, red circle) and thrips damage (B, yellow circle).

During the 2017 growing period, Verbena leaves displayed powdery mildew symptoms, brown spots and symptoms of thrips damage **(Figure 12A and B).** Symptoms of thrips damage appeared early in the trial (October 30, 2017 for all treatments) and symptoms were observed less frequently after the first few weeks; symptoms appeared as irregularly-shaped silver spots on the tops of some leaves. The damage was minor, and warranted no corrective action.

Brown spots on leaves **(Figure 12B)** were first observed on December 4, 2017 for all treatments. When first observed, brown spots appeared on the margins of older leaves. Over time, additional brown spots also appeared toward the centre of leaves and were observed on both old and new leaves. The brown spots were approximately 1-2mm in diameter, and occurred on leaves of both Silamol® Foliar and Silamol® Drench treatment plants more often than on leaves of plants in either of the Control treatments. Further testing is required to determine a cause of these brown spots.

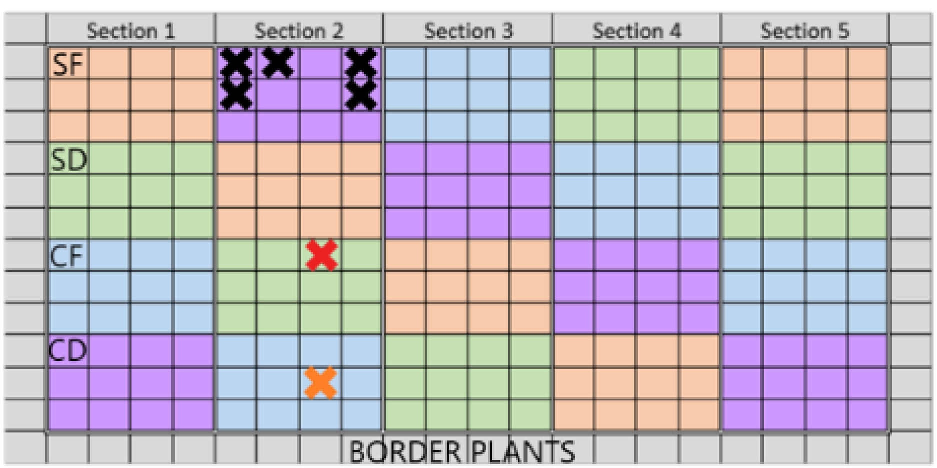

Figure 13: Niagara College greenhouse bench layout showing the locations of the first plants per treatment infected with powdery mildew in 2017, including the Control Drench (black X, purple), Silamol® Drench (red X, green) and Control Foliar (orange X, blue) treatments.

Results: Disease and Pest Symptoms

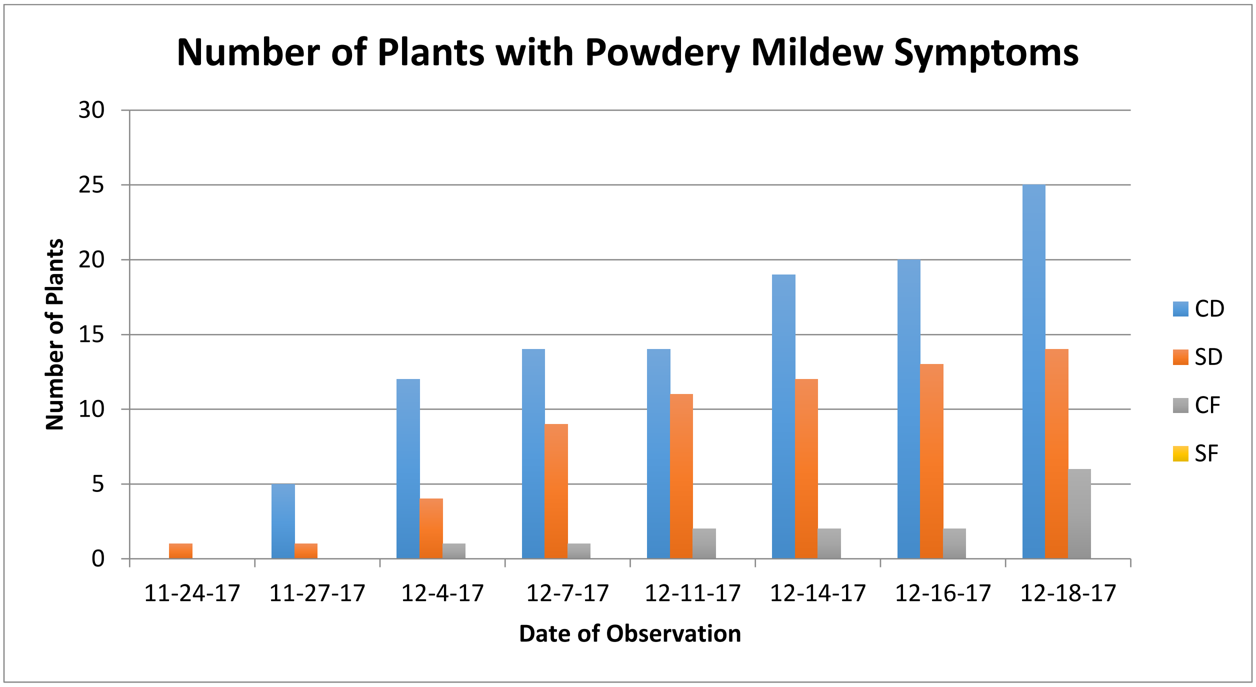

Figure 14: Total number of plants showing powdery mildew symptoms at eight time points between November 24 and December 18, 2017, evaluated per treatment for the Control Drench (CD), Control Foliar (CF), Silamol® Drench (SD) and Silamol® Foliar (SF) treatments. No symptoms were observed for the Silamol® Foliar (SF) treatment during this observation period.

Of all symptoms observed on Verbena leaves, powdery mildew symptoms were the most notable. Between October 4 and December 18, 2017 powdery mildew symptoms were observed on Verbena plants in three treatments (i.e., Silamol® Drench, Control Drench and Control Foliar), which appeared as white powdery spots on leaf surfaces **(Figure 12A).** The first incidence of powdery mildew symptoms was observed on November 24, 2017 on a Silamol® Drench plant located in Section 2 of the greenhouse bench **(Figure 13, red X).** Infection of Control Drench treatment plants quickly followed three days later (November 27, 2017), with four plants in Section 2 of the greenhouse bench simultaneously showing powdery mildew symptoms **(Figure 13, black X markers).** The first Control Foliar treatment plant to display powdery mildew symptoms was also in Section 2 of the greenhouse bench, and was observed on December 4, 2017 **(Figure 13, orange X).** No powdery mildew symptoms were observed for any Silamol® Foliar treatment plants during 2017.

The number of plants with visible powdery mildew symptoms increased over time for the Control Drench, Control Foliar and Silamol® Drench treatments during 2017 **(Figure 14).** By December 18, 2017 the Control Drench treatment tended to have the greatest number of plants showing powdery mildew symptoms.

Results: Disease and Pest Symptoms

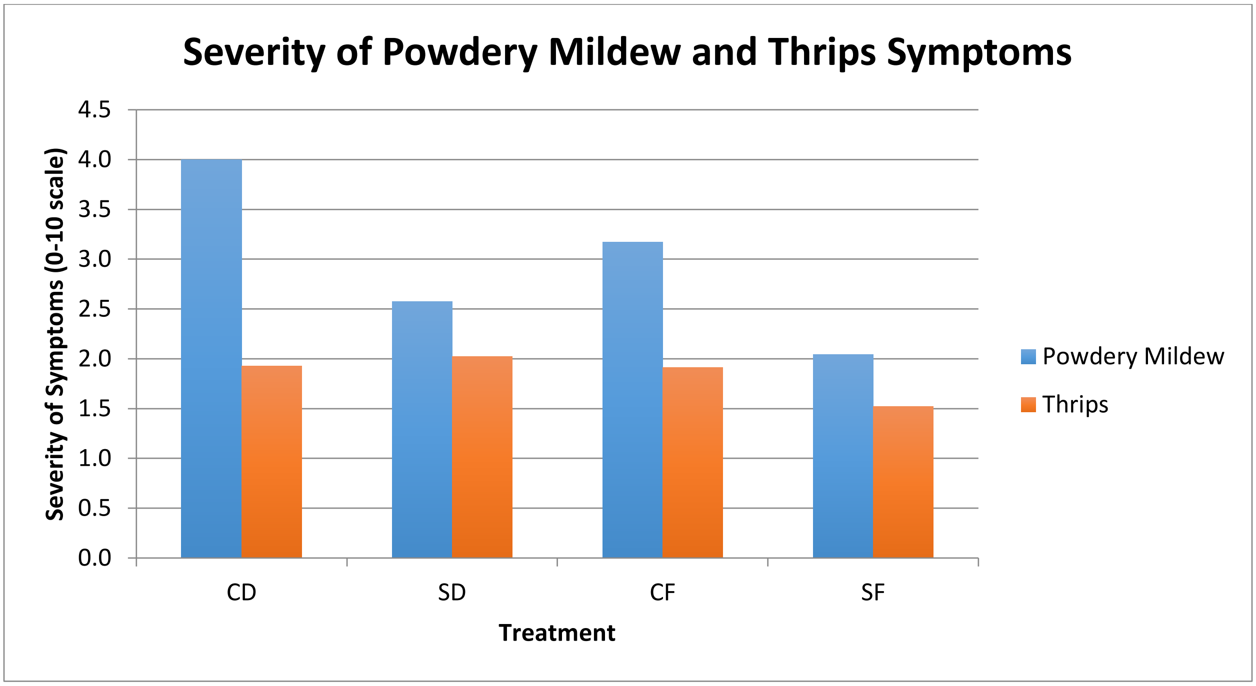

Figure 15: Visual ranking of powdery mildew symptoms and symptoms of thrips damage on Verbena leaves on January 8, 2018 for plants in the Control Drench (CD), Control Foliar (CF), Silamol® Drench (SD) and Silamol® Foliar (SF) treatments. A score of 0 indicates no damage and 10 indicates symptoms completely covered all plant leaves. Values are an average of all plants per treatment.

At the end of the study (January 8, 2018), powdery mildew symptoms and symptoms of thrips damage were observed on plant leaves of all treatments **(Figure 15)**. Minimal variability was observed among treatments for symptoms of thrips damage, while powdery mildew symptoms tended to be greater in both Control treatments, compared to both Silamol® treatments.

Summary

In summary, of the four treatment methods, a weekly foliar spray application of Silamol® seemed to offer the best protection of greenhouse-grown Verbena foliage from initial incidence as well as severity of powdery mildew symptoms. When compared to the Control treatments, a substrate drench application of Silamol® also displayed better powdery mildew symptom protection.

Further research using Silamol® for greenhouse production of Verbena is needed to determine Silamol® efficacy when pH and EC levels are maintained at more consistent levels, and when plants are grown under higher light conditions, than occurred in the current study. In addition, further research is needed to explore the relationship between Silamol® and flowering. Specifically, future work should determine if the lower flower numbers observed in January for Silamol®-treated Verbena, compared to Control treatments, were in response to the Silamol® product or in response to low plant stress reducing plant reproduction urgency.

Overall, this study indicates weekly foliar Silamol® applications could be useful for greenhouse Verbena growers to prevent the incidence and severity of powdery mildew symptoms within the crop.

References

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