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Comparison of Insecticide and Trap Crop Management Practices for the Control of *Acalymma vittatum* (Coleoptera: Chrysomelidae) in Cucumbers

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Abstract

The striped cucumber beetle (*Acalymma vittatum* (F.)) is a specialist herbivore pest, feeding on plants in the Cucurbitaceae family across North America. Adult beetles migrate into cucurbit fields from the field edges to feed on the emerged plant parts. Control methods can include insecticides, cultural practices, and some biological control species, or a combination of multiple methods, each having their own advantages and disadvantages. A push-pull trap crop management system using blue hubbard squash (*Cucurbita maxima* Duchesne) and nasturtiums was established and compared to a lambda-cyhalothrin (Matador 120EC) foliar insecticide control approach in a cucumber crop. Lambda-cyhalothrin, applied at local threshold, demonstrated acceptable defoliation and *A. vittatum* adult beetle counts 22 DAA (days after application). However, there were no other arthropod species present in the treatment plots until 14 DAA. The cucumbers in the trap crop treatment had high levels of defoliation and adult *A. vittatum* beetles until 14 DAA when the blue hubbard squash trap crop began to outcompete the cucumber crop resulting in inaccurate data collection. A plethora of arthropods could be observed in the trap crop treatment at all assessment timings. An effective trap crop could reduce the quantity of insecticide applications in a commercial crop, as well as providing everyday gardeners with a management tactic for controlling *A. vittatum* at home.

Introduction

The striped cucumber beetle, *Acalymma vittatum* (F.) (Coleoptera: Chrysomelidae), is a phytophagous insect commonly found in North America (Haber et al. 2021). It is a specialist herbivore, feeding on plants in the Cucurbitaceae family (Weber 2018). Adult beetle feeding is exhibited on the exposed plant parts which can kill young seedlings, reduce fruit set, and render harvested fruit unmarketable (Weber 2018). *A. vittatum* larvae are found underground, feeding on cucurbit plant roots which can hamper root development (Cline et al. 2008). Along with the direct feeding damage to the plant, *A. vittatum* adults can vector the pathogen *Erwinia tracheiphila,* causing bacterial wilt of cucurbits (Weber 2018). *A. vittatum* is not only a pest for commercial growers but is just as destructive for everyday gardeners. Control methods can include insecticides, cultural practices (crop rotation, mulches, trap crops, intercropping, companion planting, etc.) as well as some biological control species, or a combination of multiple methods known as integrated pest management (IPM).

The use of perimeter trap crops is a cultural control method used as a part of an IPM system (Adler and Hazzard 2009). The idea of perimeter trap crops is to provide *A. vittatum* with a more attractive food source compared to the commercial crop (Cavanagh et al. 2009). By planting the trap crop around the perimeter of a commercial crop, it is physically in the way of *A. vittatum* when they migrate inwards to the field (Cavanagh et al. 2009). By planting a crop with a more attractive olfactory signature, the *A. vittatum* adults are more likely to remain feeding on the trap crop instead of continuing onto the commercial crop (Cavanagh et al. 2009). Previous studies have shown that *A. vittatum* has a high affinity for blue hubbard squash (*Cucurbita maxima* Duchesne) with increased feeding observed and therefore has the potential to be an effective trap crop (Adler and Hazzard 2009). In addition to the trap crop, a companion plant can be used as well with the goal of deterring the pest from the crop. Plants such as radish, nasturtium, and tansy are companion plants to cucumbers (Agriculture and Agri-Food Canada 2022). By planting companion or trap crops, the number of plant species in the area is increased from one to multiple allowing for a more diverse and healthier ecosystem.

Trap cropping of *A. vittatum* has been a recognized approach towards controlling this pest for the past century (Gardner et al. 2015). Within the last 30 years, there has been more interest in how to increase the efficacy of this system due to increased interest in pollinator sustainability, organic agriculture production, risk of resistance, and IPM tactics (Gardner et al. 2015). Research by Cline et al. (2008) showed that plots containing repellent plants and plots containing beneficial plants significantly reduced the number striped cucumber beetles in a watermelon crop, compared to the untreated check.

More recently, research has been done by Agriculture and Agri-Food Canada (AAFC) in Nova Scotia, Canada in 2020 on implementing a push-pull strategy using baby blue hubbard squash and nasturtiums for the control of *A. vittatum* and spotted cucumber beetle (*Diabrotica undecimpunctata*) in squash. Observations with moderate *A. vittatum* pressure showed that the squash crop received less feeding damage compared to the trap crop (Agriculture and Agri-Food Canada 2022).

There are also a number of chemical pesticide options for the control of *A. vittatum*. Organophosphates, carbamates, pyrethroids, and neonicotinoids insecticide classes are often used in a chemical control program (Haber et al. 2021). Chemical insecticides can be used at planting, as seed treatments, soil drenches, and/or as foliar applications (Haber et al. 2021). Despite the effectiveness of insecticides, there are drawbacks to their uses. Repeated applications of the same chemistries increases the chance of resistance development (Haber et al. 2021). Cucurbit crops, especially cucumbers, rely heavily on insect pollination so the use of some insecticide chemistries can cause off-target harm towards these pollinator species (Haber et al. 2021).

The trial as part of this research project aims to compare the successes and drawbacks of a common insecticide program to a trap crop for the control of *A. vittatum* in cucumbers. Treatment efficacy as well as impact on off-target insects will be explored.

Materials and Methods

The study was set up in a randomized complete block design with three replicates (Figure 1). The trial was established at an agricultural research farm field located in Bright, Ontario, Canada (43.261734, -80.634100). The ground at the site was disced, fertilized, and cultivated on 25-May-2023. Plastic mulch was put down on the bed in rows for plot set up. The plastic mulch was used to reduce weed control issues and to conserve moisture. Drip tape irrigation was laid under the plastic mulch layer to water the plants as necessary. Each plot was 1.5m wide by 6m in length. There was 20m between the plastic rows and 5m alley between the replicates (Figure 2).

There were three treatments in this study. Treatment 1 was the untreated check (control). Treatment 2 was a standard foliar insecticide maintenance program consisting of one application of lambda-cyhalothrin (Matador). Treatment 3 was a push-pull trap crop using nasturtiums (repellent) and blue hubbard squash (attractant).

The fallow ground between the plastic mulch rows received a pre-emergent bare ground herbicide application of Dual II Magnum (s-metolachlor at 915 g ai/L) on 11-June-2023. Spot treatments of Roundup WeatherMAX (glyphosate at 540 g ae/L) and manual pulling of weeds were used to control weed escapes during the study. A preventative fungicide application of Orondis Ultra (oxathiapiprolin at 30 g ai/L and mandipropamid at 250 g ai/L) for downy mildew control was applied on 6-July-2023.

Cucumber (variety "Talladega") and blue hubbard squash (variety "Blue Magic Hybrid Squash") seeds were planted into biodegradable 2" square cell trays filled with Miracle-Gro Potting Mix. The trays were maintained in a hoophouse style greenhouse and were watered and fertilized (Miracle-Gro water soluble 24-8-16) as needed until transplanting. Nasturtiums (varieties "Whirlybird Mix" and "Empress of India") were purchased from a local commercial greenhouse in 3" square cell containers. The blue hubbard squash (3-leaf stage) and nasturtiums (vegetative growth) were transplanted on 9-June-2023 into treatment 3 plots only. There were six blue hubbard squash plants planted evenly around the plot (~1m border) and three nasturtiums planted within the plot. The cucumber transplants were planted into all plots at the 2-leaf stage on 27-June-2023. Each plot had eight cucumber plants planted in two rows spaced 50cm apart with 75cm plant spacing within each row.

Treatment 2 (lambda-cyhalothrin) was applied 12-July-2023 when the local threshold for *A. vittatum* was reached; one adult *A. vittatum* beetle per plant. Matador 120EC (lambda-cyhalothrin at

120 g ai/L) insecticide was applied at the high label rate of 28 g ai/ha (233 mL fp/ha). The foliar application was completed using a 1.5m handheld spray boom calibrated to deliver 200 L/ha spray volume at 40 PSI using CO2 as the propellant. AIXR 11002VP nozzles were used for the application. Treatments 1 and 3 did not receive an insecticide application.

Efficacy evaluations were completed at 0, 2, 7, 14, and 22 DAA (days after application). Prior to the first evaluation, three cucumber plants in each plot that had *A. vittatum* feeding damage and/or an adult present were flagged and used for all efficacy evaluations. At each assessment, the number of living *A. vittatum* adults were counted and the percent visual defoliation damage was assessed. A 0-100 scale was used where 0 percent defoliation was used for plants that had no feeding damage on its foliage and 100 if the entire emerged plant foliage had been eaten.

The data collected was entered into ARM (Agricultural Research Manager revision 2023.3) software and a 1-way ANOVA (analysis of variance) test using Tukey's HSD (P=.05) was performed on treatment means.

Results

Defoliation

At the 0 DAA evaluation, all three treatments exhibited visual defoliation on cucumber plants due to *A. vittatum* feeding. There was significantly higher defoliation on cucumber plants in the trap crop treatment (39.8%) compared to the untreated check (5.3%), and the lambda-cyhalothrin treatment (4.1%).

The same trend was observed at the 2 DAA evaluation, with significantly higher cucumber plant defoliation in the trap crop treatment (28.2%) compared to the untreated check (4.4%), and the lambda-cyhalothrin treatment (3.4%).

The mid-season evaluation did not have any significant differences between any of the treatments. Numerically, the trap crop treatment continued to exhibit increased *A. vittatum* cucumber plant feeding damage (19.9%) compared to the untreated check (9.8%), and the lambda-cyhalothrin treatment (2.1%).

The 14 DAA evaluation did not have any significant differences between any of the treatments. Numerically, the untreated check had the highest cucumber defoliation damage (7.7%) compared to the lambda-cyhalothrin treatment (1.6%), and the trap crop (3.0%).

Similar trends to the 14 DAA evaluation were observed at the 22 DAA final evaluation. There were no significant differences between any of the treatments. Numerically, the untreated check had the highest cucumber defoliation damage (6.7%) compared to the lambda-cyhalothrin treatment (1.4%) and the trap crop (2.1%).

Insect Counts

At the first assessment timing, 0 DAA, all three treatments had living adult *A. vittatum* present.

At the 2 DAA evaluation, there were no observed living *A. vittatum* adults in the lambda-cyhalothrin treatment (treatment 2). The untreated check and trap crop treatments were relatively unchanged from the 0 DAA assessment (0.8 and 1.1 adults, respectively). There were no significant differences between any of the treatments.

At the 7 DAA evaluation, there were no significant differences between any of the treatments. The number of living *A. vittatum* adults increased in the untreated check (5.1). There were minimal *A. vittatum* adults observed in the lambda-cyhalothrin treatment (0.3). The number of *A. vittatum* adults on the cucumbers in the trap crop began to decline (0.3).

Trends continued from the 7 DAA to the 14 DAA assessment timing. However, there were no significant differences between the treatments. The untreated check and lambda-cyhalothrin treatments continued to have an increase in the number of *A. vittatum* adults (7.8 and 1.4, respectively). The trap crop did not have any observed *A. vittatum* adults present on the cucumber plants.

At the final evaluation, 22 DAA, both the lambda-cyhalothrin and trap crop treatments exhibited significantly less *A. vittatum* adults (0.7 and 0.4, respectively) compared to the untreated check (3.1).

Yield

Yield was not completed for this study.

Discussion

The main objective of this study was to compare the successes and drawbacks of a common foliar insecticidal program (lambda-cyhalothrin) to a trap crop (blue hubbard squash + nasturtiums) for the control of *A. vittatum* in cucumbers.

Efficacy

The untreated check plot performed as expected. The cucumber defoliation damage and *A. vittatum* insect counts in these plots increased as time went on. The end of the *A. vittatum* life cycle began towards the end of July. This is shown in the 22 DAA *A. vittatum* counts as the number of observed adults decreased in both the untreated check and lambda-cyhalothrin plots. Two plants in the study died due to bacterial wilt (*Erwinia tracheiphila*). This disease is transmitted directly from *A. vittatum* feeding on the cucumber foliage. The affected plants were appropriately from untreated check plots. This further confirms the need to employ a management strategy to grow a successful cucumber crop.

The lambda-cyhalothrin treatment was effective in reducing the number of living *A. vittatum* adults on the cucumber plants. The initial knockdown of *A. vittatum* at the 2 DAA evaluation followed by a slow population re-growth is as expected. The cucumber plants were able to grow at a pace that kept the defoliation damage at a minimum through to the end of the evaluations. Overall, the lambda-cyhalothrin treatment effectively allowed for the successful growth of cucumbers. The trap crop treatment was planted approximately 2.5 weeks prior to the cucumber transplants (9-June-2023 and 27-June-2023, respectively). This was to let the trap crop establish and to allow for *A. vittatum* to become attracted to the blue hubbard squash prior to introducing the cucumber crop plants. The first *A. vittatum* adult was observed on the blue hubbard squash on 20-June-2023. The population began to build, and the cucumber crop was planted on 27-June-2023. The initial evaluation, 0 DAA, demonstrated that the *A. vittatum* did not remain attracted solely to the more attractive blue hubbard squash. Despite the blue hubbard squash having a 1m perimeter around the cucumber crop, the rapid growth of the squash was severely underestimated. At the time of the 0 DAA evaluation, there was only 50cm space remaining between the trap crop perimeter and cucumber crop, from the original 1m spacing. The combination of cucurbitacin released by both the cucumber and hubbard squash crops resulted in little effect of the lure crop due the high amount of cucurbitacin present negating the effects of the lure crop versus commercial crop. Although there were no visual observations of *A. vittatum* presence on the nasturtiums, their repellent properties were not enough to push the *A. vittatum* away from the cucumber crop. Again, this could be due to the confined space of the trap crop system, or that the nasturtiums were not in flower and did not provide enough repellent property. The rapid growth of the blue hubbard squash eventually caused competition for resources with the cucumber crop. Being less established, the cucumbers next to the hubbard squash began to develop morphologically different compared to the cucumbers in the other treatments. These morphological differences either led to only vegetative growth in the cucumber plants and/or plant death. Efficacy evaluations completed at 14 and

22 DAA had a minimal number of cucumber plants remaining for data collection and may not be truly representative of treatment effectiveness.

Effect on Off-Target Species

Insecticide use is an important component of an integrated pest management program; however, its incorrect usage can be detrimental to many off-target insect species.

From the time of application (0 DAA) to the 14 DAA evaluation, the lambda-cyhalothrin treatment did not have any other insect species besides *A. vittatum* present on the cucumber crops. By the end of the evaluation schedule, there was an aphid (*Myzus persicae*) colony beginning to form on the underside of cucumber leaves. Fortunately for this study, the *A. vittatum* threshold was reached prior to cucumber flowering, this reduced the chance of impacting or spraying pollinator species.

Contrary to the lambda-cyhalothrin treatment, the trap crop treatment had a plethora of other insect species present in the plots across all evaluation timings. *A. vittatum,* aphids (*Myzus persicae*), tarnished plant bugs (*Lygus lineolaris*), squash bugs (*Anasa tristis*), katydids (Tettigoniidae), mosquitoes (Culicidae), and bees (Apoidea) were among the most prevalent insect species observed in the plots. The polyculture design of the plot increases biodiversity and creates a healthier ecosystem compared to the monocrop of the untreated check and lambda-cyhalothrin treatments.

Yield

Due to the number of cucumber plant deaths in the trap crop treatment, yield data was not completed. Any yield data collected would not be representative of treatment effectiveness.

Importance

Management strategies used to control *A. vittatum* in a cucumber cropping system are key in order to grow a successful crop. When used appropriately, lambda-cyhalothrin works well at controlling

A. vittatum however, its impact on other insect species is not desirable. The crop ecosystem is not as healthy and the risk of negatively affecting pollinators can impact cucumber fruit set, and therefore yield. The use of a trap crop creates a more dynamic ecosystem where other insect species can thrive. Plant growth rate differences means having pollen and nectar sources for an extended period of time, allowing for prompt cucumber pollination. However, by not controlling *A. vittatum* as effectively as lambda-cyhalothrin, the risk of plant death, pollination disruption, and reduced fruit marketability can become an issue.

For commercial growers who have cucumber crops planted across large acreage, the use of trap crops around the field perimeter could be an effective *A. vittatum* management addition. If used correctly, the trap crop could delay the need for an insecticide application and promote crop pollination, leading to higher yields. For the everyday backyard gardener who do not wish to use or have access to insecticides, the use of a trap crop could help control *A. vittatum* damage. Proper placement of the trap crop is crucial to its effectiveness; however, the use of patio pots allows for spatial distance between the cucumbers and trap crop. There are both positive and negative aspects of any management tactic used to control *A. vittatum* in a cucumber crop. The grower must decide what approach best fits their operation and end goals.

Future Direction

Due to the trap crop being planted too close to the cucumbers, it is suggested to do another trial with a wider perimeter. Another treatment could be added that combines both the trap crop and lambda-cyhalothrin treatment to observe the effects of a IPM system. This information would be beneficial to the grower in determining how much of a benefit the trap provides in controlling *A. vittatum*.

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Figures

Figure 1: Trial randomization.

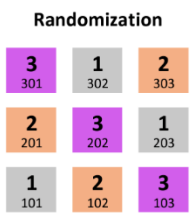


Figure 2: Plot diagram (not to scale).

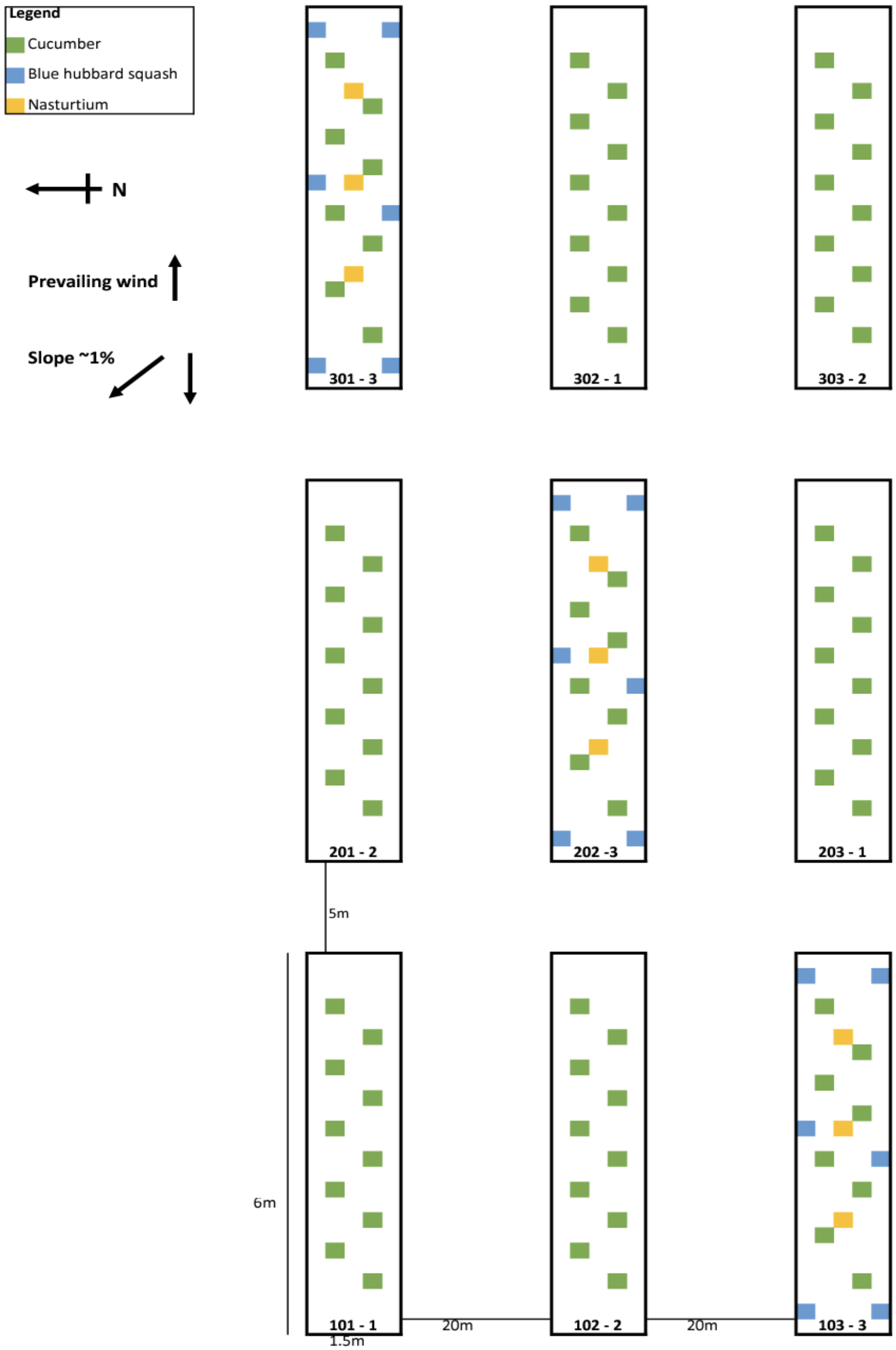


Figure 3: Cucumber defoliation damage evaluation data.

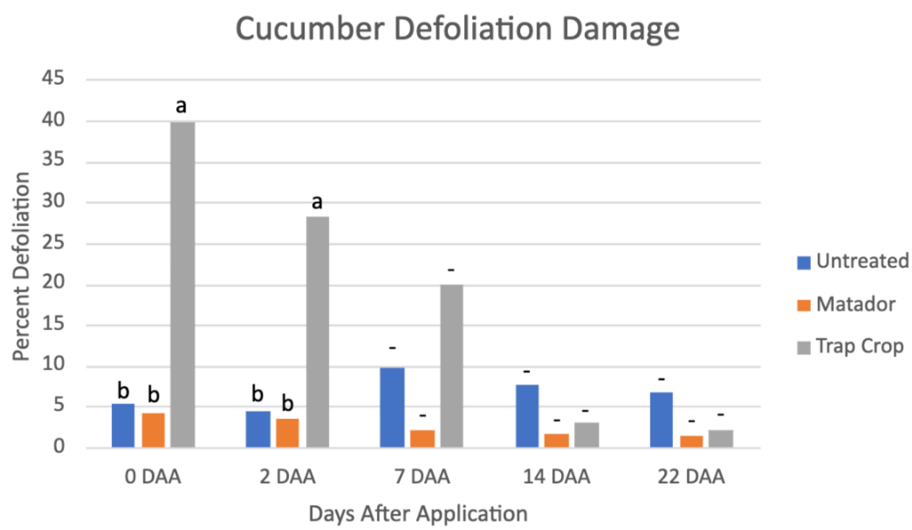
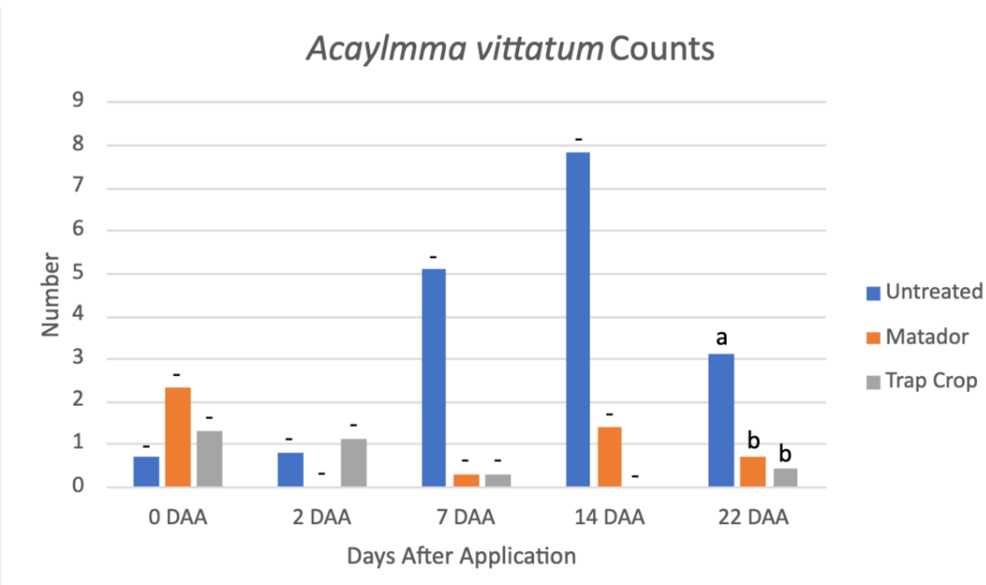


Figure 4: *Acalymma vittatum* living adult counts evaluation data.



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