Atlantic Tech Transfer Team for Apiculture

Wild Blueberry Pollination Research 2019

Project Number: C1819-0280-Y2 Optimizing Pollination in Wild Blueberry

Applicant: Perennia on behalf of the Atlantic Tech Transfer Team for Apiculture (ATTTA)

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April 01, 2019- March 31, 2020

Year Two Final Report

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Project Overview

The Atlantic Tech Transfer Team for Apiculture (ATTTA) implemented a multi-year pollination project in both New Brunswick and Nova Scotia in 2018 to build on previous research (http://www.perennia.ca/wp-content/uploads/2018/04/02-effect-of-hb-stocking-density-on-wb-eng.pdf). The 2019 field season marked the second year with funding assistance from the Enabling Agriculture Research and Innovation (EARI) Project, through the Canadian Agricultural Partnership (CAP).

Project Objectives

The five-year overarching project objectives include:

1) Optimize pollination of wild blueberry
2) Evaluate the effect of honey bee hive stocking density on wild blueberry production and hive health
3) Evaluate the effect of moving hives during pollination on blueberry fruit set
4) Determine the optimal strength of honey bee hives entering wild blueberry pollination
5) Determine the optimal timing of placing honey bee hives in wild blueberry fields
6) Evaluate the effect of sending honey bee hives to blueberry pollination with pollen patties on hive health and blueberry production
7) Create Best Management Practices (BMPs) for pollination of wild blueberry

For the 2019 field season, we focused on the following two objectives: a) evaluating the effect of stocking density of honey bee colonies on wild blueberry production and hive health, and b) evaluating the effect of sending honey bee hives to blueberry pollination with pollen patties on hive health and blueberry production. The first objective was repeated in 2019 from 2018 due to the severe frost experienced in June 2018 and includes data from 2017 work in New Brunswick. Including data from multiple years allows us to see overarching trends of stocking density and allows us to make better recommendations for beekeepers and blueberry growers.

Additionally, we continued creating our Best Management Practices (BMPs) document for pollination. Our plan is to complete our proposed research projects to include in the BMP document before releasing it to industry.

Project Deliverables

The proposed research (2018-2023) will provide answers to:

1) The effect of honey bee hive stocking density on wild blueberry production and hive health
2) The effect of moving hives during pollination
3) The optimal strength of honey bee hives entering wild blueberry pollination
4) The optimal timing (percent bloom) of placing honey bee hives in blueberry fields

5) The effect of sending honey bee hives to blueberry pollination with pollen supplementation
6) Best management practices for pollination of wild blueberry

This year (April 01 2019-March 31 2020), an interim and final report will be submitted to the New Brunswick Department of Agriculture, an annual progress report will be prepared and shared through ATTTA, and preliminary findings will be shared at industry meetings (e.g. beekeeping and wild blueberry meetings throughout the Maritimes). Additionally, the creation of a Best Management Practices guide for wild blueberry pollination will continue. This document includes two project summaries: one for our stocking density project, and one for our pollen substitute project.

Summary of Progress- Stocking Density Project

Materials and Methods

The study was carried out in Gloucester, Northumberland, Kent, and Westmorland counties in New Brunswick, and in Colchester County, Nova Scotia, over three years (2017-2019). A completely randomized design was used with one factor (honey bee hive stocking density) at three levels: 2, 3, and 4 hives per acre. All colonies were housed similarly, with at least two to three boxes (e.g. two brood chambers or one brood chamber, one honey super). In 2019, we began the trial with 11 fields (3 at 2 hives per acre, 4 at 3 hives per acre, and 4 at 4 hives per acre). Due to grower decisions (described further in discussion), our field sites in 2019 changed to 0 fields at 2 hives per acre, 3 fields at 3 hives per acre, and 6 fields at 4 hives per acre. In 2018, we began the trial with 11 fields, but due to the severe frost in June 2018, we were left with four fields to measure bee growth (2 fields at 2 hives per acre, one field at 3 hives per acre, and 1 field at 4 hives per acre). This is because in fields severely impacted by frost, beekeepers moved hives out of blueberry fields. Hives remained in fields that were less severely impacted by frost. We also had 9 fields to measure all other endpoints (2 fields at 2 hives per acre, 5 fields at 3 hives per acre, and 2 hives at 4 hives per acre). Where appropriate, statistics from our 2017 field season are included in this report.

Growers were selected based on their isolation (isolated from other study sites by at least 3 km, and only in fields with nearby fields stocked at the same honey bee stocking densities being studied). Permission was granted from individual beekeepers to assess colony strength. Colony strength was quantified at the beginning and end of blueberry bloom by recording the number of seams of bees (Nasr et al. 1990). The first sampling period occurred within three days of the hives being placed in blueberry fields, and the second sampling occurred within three days of the colonies being removed from blueberry fields. The hives studied were in their first blueberry pollination to reduce variability. Thirty stems within each study field were randomly selected before flowering (early May) by walking slowly through the fields in a zig-zag pattern (Chiasson and Argall 1996; Drummond 2002). Each stem was 1m apart and tagged with flagging tape with a corresponding sample number in order to track number of flowers (May), fruit set (July), and harvest (August). In 2017, 50 stems per field were tagged and in 2018 and 2019, 30 stems per field were tagged.

In 2019, we introduced transects to conduct bee surveys. These transects were constructed approximately 20 m from honey bee hive locations, and were 2 m wide by 30 m long. The transects ran in an East-West orientation. Thirty minute bee walks were conducted during pollination in each study field, and observations were recorded for all honey bees (*Apis*) and native bees (non-*Apis*). Transect walks were done as inconspicuously as possible to avoid startling pollinators.

Statistics

Analysis of variance (ANOVA) using a general linear model was used to detect any differences among the following measured endpoints: 1) colony growth during blueberry pollination (final seam count – initial seam count) (colony growth), 2) pollination success at different stocking densities, 3) mean berry mass at different stocking densities, 4) yield at different stocking densities, and 5) effect of stocking density on honey bee and native bee abundance and diversity. The model assumptions of normal distribution of error terms and constant variance of the residuals were met for all analyses except bee abundance and diversity, which underwent a square root transformation. Letter groupings were produced to show significant differences among means using $\alpha = 0.05$ and generated using Fishers LSD. All statistical analyses were carried out using Minitab (Minitab 2018).

Data from 2018 and 2019 were included to analyze the effect of stocking density on colony growth. The average hive growth per field was used as a replicate and the individual hives were used as a pseudo-replicate. Since different number of hives were used among fields and among years, and there were different numbers of stems between 2017, and 2018-2019, we used the average growth of hives per field, or average number of berries per stem per field, as a metric for more accurate comparison. Data were collected in 2017 on colony growth, but due to variability in colony size and management, were excluded for analysis (more information provided in discussion).

To analyze the effect of stocking density on pollination success, the average success rate per field (number of flowers divided by the number of berries in August, multiplied by 100%) was used as a replicate, and individual stems were used as a pseudo-replicate. Data from 2017 and 2019 were included, while data from 2018 was excluded due to the severe frost experienced in June 2018.

To evaluate the effect of stocking density on berry mass at harvest, the average berry mass per field was used as a replicate, while individual berries were used as a pseudo-replicate. Tagged stems were picked individually and berries were harvested. The total weight of all the berries per stem was calculated, and then divided by the total number of berries per stem to get an average weight per berry per stem. Data were included from 2017, 2018, and 2019.

To evaluate the effect of stocking density on total yield at harvest, we used blueberry hand rakes (34 cm wide by 23 cm long) to collect yield data from 1m^2 plots. We harvested 5 replicates of blueberry transects per field (in random locations throughout study fields) and then took the blueberry yield from each quadrat and multiplied the weight per quadrat (kg/m^2) harvested by 8921.79 to convert units to lbs per acre. Data for this analysis were only collected in 2019.

In 2019 we added an experiment to evaluate the effect of honey bee stocking density on honey bee and native bee abundance. We also examined the impact of honey bee stocking density on honey bee (*Apis*) and native bee (non-*Apis*) abundance.

Results

Effect of Stocking Density on Colony Growth

The effect of honey bee stocking density (hives per acre) on colony growth (seams of bees) was tested in New Brunswick and Nova Scotia wild blueberry fields across two years (2018 and 2019). Three different stocking densities were compared: 2 hives per acre (n= 2 fields), 3 hives per acre (n= 2 fields), and 4 hives per acre (n= 7 fields). There was no significant effect of honey bee stocking density on colony growth during pollination ($F_{2,8} = 0.48$; $P = 0.634$) (Figure 1).

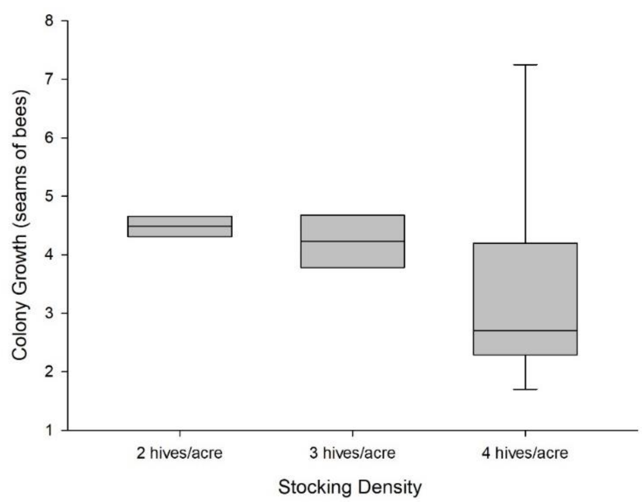

Figure 1. Boxplot demonstrating the effect of honey bee hive stocking density (hives per acre) on colony growth in New Brunswick and Nova Scotia study fields, 2018-2019.

Colonies stocked at 2 hives per acre grew an average of 4.5 (SE ± 0.18) seams of bees, while colonies stocked at 3 hives per acre grew an average of 4.2 (SE ±0.45) seams of bees. Colonies stocked at 4 hives per acre grew an average of 3.4 (SE ± 0.71) seams of bees.

Effect of Stocking Density on Pollination Success

The effect of honey bee stocking density (hives per acre) on pollination success (number of berries at harvest time divided by the number of flowers during pollination) was tested in New Brunswick and Nova Scotia wild blueberry fields across three years (2017-2019). Due to the severe frost and its impact on pollination success in 2018, only data from 2017 and 2019 are presented. Three different stocking densities were compared: 2 hives per acre (n= 2 fields), 3 hives per acre (n= 5 fields), and 4 hives per acre (n= 6 fields). There was no significant effect of honey bee stocking density on pollination success ($F_{2,11}$ = 2.29; P = 0.147) (Figure 2).

Fields stocked at 2 hives per acre resulted in a pollination success rate of 50.5% (SE ± 15.2) on average, while colonies stocked at 3 hives per acre had an average pollination success rate of 66.4% (SE ± 5.0). Colonies stocked at 4 hives per acre had an average pollination success rate of 72.5% (SE ± 4.2).

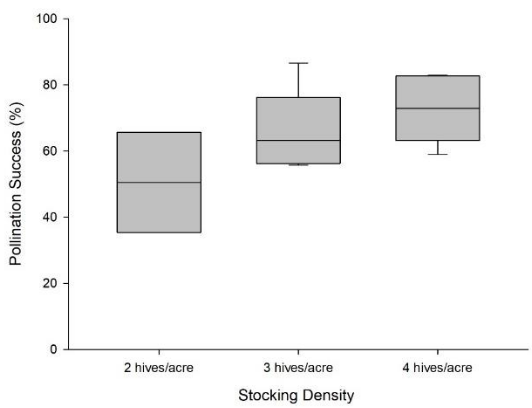

Figure 2. The effect of honey bee hive stocking density (hives per acre) on pollination success (%) in New Brunswick and Nova Scotia study fields, 2017 and 2019.

Effect of Stocking Density on Berry Mass at Harvest

The average berry mass at harvest was compared among three different stocking densities: 2 hives per acre (n = 4), 3 hives per acre (n= 11) and 4 hives per acre (n= 7) and across three years: 2017-2019. There was no significant effect of honey bee stocking density on average berry mass at harvest ($F_{2,20}$ = 0.39; P = 0.684) (Figure 3).

Fields stocked at 2 hives per acre produced berries weighing on average 0.30 g (SE ± 0.03) while fields stocked at 3 hives per acre produced berries weighing on average 0.39 g (SE ± 0.04). Fields stocked at 4 hives per acre produced berries weighing on average 0.39 g (SE ± 0.07).

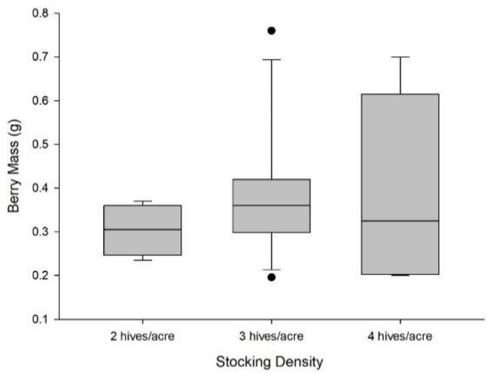

Figure 3. Boxplot demonstrating the effect of honey bee hive stocking density (hives per acre) on average wild blueberry mass (g) in New Brunswick study fields in 2018 and 2019.

Effect of Stocking Density on Berry Yield

Wild blueberry yield at harvest (lbs per acre) was compared among two different stocking densities (3 hives per acre (n = 3) and 4 hives per acre (n= 6)) in New Brunswick in 2019. There was no significant effect of honey bee stocking density on yield at harvest ($F_{1,7}$ = 0.24; *P* = 0.639) (Figure 4).

Fields stocked at 3 hives per acre produced on average 6,654 lbs (SE ± 878lbs) per acre, while fields stocked at 4 hives per acre produced on average 7,143 lbs (SE ± 565 lbs) per acre.

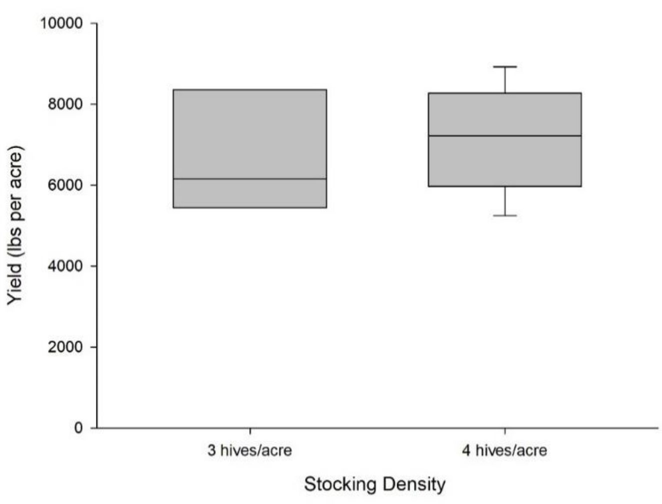

Figure 4. Wild blueberry yield in the two honey bee stocking density treatments tested in New Brunswick in 2019: 3 and 4 hives per acre.

Effect of Stocking Density on Bee Abundance and Diversity

We found no significant interaction of honey bee stocking density and bee type (*Apis* or non-*Apis*) ($F_{1,14} = 0.02$; $P = 0.899$) (Figure 5). There was no significant effect of honey bee stocking density on bee abundance ($F_{1,14} = 0.22$; $P = 0.643$) nor bee type ($F_{1,14} = 1.28$; $P = 0.276$) observed during our thirty minute transect surveys. In fields stocked at 3 hives per acre, we observed on average 40 (SE ± 5.29) honey bees and 25.33 (SE ± 6.36) other bees. In fields stocked at 4 hives per acre of honey bees, we found 33 (SE ± 14.8) honey bees and 21.33 (SE ± 4.28) other bees.

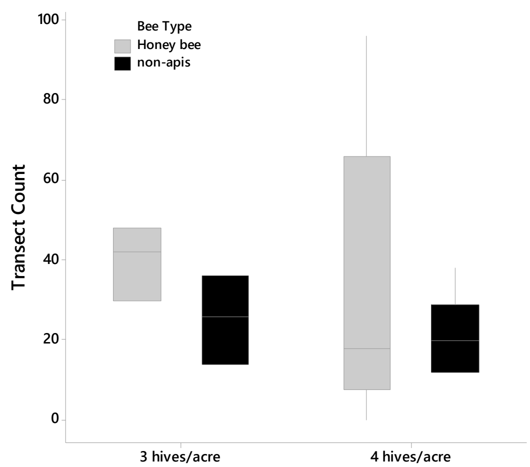

Figure 5. The effect of honey bee stocking density on abundance of honey bees (*Apis*) and other bees (non-*Apis*) in New Brunswick wild blueberry fields in 2019.

Discussion

Effect of Stocking Density on Colony Growth

We found that colonies stocked at 2 hives per acre displayed the greatest growth, although not significantly more than hives stocked at 3 and 4 hives per acre.

The New Brunswick pollination standard is (https://www2.gnb.ca/content/gnb/en/departments/10/agriculture/content/bees/pollination.html):

- At least 2 boxes or supers
- Contain a laying queen and brood
- 25,000-30,000 honey bees

The Nova Scotia pollination standard is (http://www.nsbeekeepers.ca/newBeekeepersDetail.php?Pollination-Standard-12):

- 4 frames of brood with 100% brood coverage (or equivalent)
- 8 frames of bees with 100% bee coverage (or equivalent)
- 2 frames of honey
- 1 laying queen

Our findings suggest a trend of decreasing colony growth as stocking density increases, but when hives are sent at the pollination standard, they display optimal growth without swarming. Regardless of stocking density, it is important that all hives meet the pollination standard. When hives are stocked at high densities, it may be even more important to send colonies with high populations, and extra honey and pollen reserves. Colonies sent below pollination standard to high stocking densities may be negatively impacted by pollination and may even shut down egg-laying to conserve resources. We observed decreased growth at higher stocking densities (3 and 4 hives per acre) compared to 2 hives per acre, although not significantly so. Based on pollination success data of 73% at 4 hives per acre, it may not be in the best interest of colony health to stock at densities higher than 4 hives per acre, particularly as it may not be possible to achieve pollination success rates higher than 73%.

Hives that were sent to pollination weak (did not meet the standard) did not grow during pollination and were excluded from analysis. Hives that were sent too strong (many of the hives in 2019) swarmed and potentially negatively impacted pollination. When hives are sent too weak, there is an inadequate foraging force available to pollinate. When hives are sent too strong, the hive is not at its optimal strength and does not have the same capacity or ability to pollinate (e.g. egg-laying slows down before swarming, and with reduced young bees "brood" to feed, there is a decreased need to forage for pollen (Sammataro and Avitabile 2011; Schneider 2015). This also negatively impacts the beekeeper; when hives swarm in blueberry fields, there are reduced populations of bees to forage for honey after pollination or divide colonies to make up new colonies for sale or replacement. When hives are sent at the standard, an adequate foraging force is available to pollinate, the hive can maximize its potential growth in blueberry fields, and provide increased populations to collect honey after pollination or be able to be divided (split) after pollination, providing increased hive numbers or revenue for beekeepers.

Effect of Stocking Density on Pollination Success

Although we did not detect significant differences in pollination success among different stocking densities, we did notice a positive trend in pollination success as stocking density increased. At the current industry standard of 2 hives per acre, pollination success rates of 50.5% were achieved. By increasing stocking density to 3 hives per acre, pollination success rates of 66.4% were achieved, and increased at 4 hives per acre to 72.5%. It is unknown what the pollination success limit was in these study fields, as pollination success can depend upon genotype, weather, pollinator abundance, degree of self-sterility, and proportion of other clones, among other factors (Drummond 2002). In New Brunswick, pollination success rates of 40-50% are considered "very good", while rates of 50-60% would be considered "excellent" (Chaisson 1996). Using these results, stocking hives at 3 and 4 hives per acre achieved above excellent pollination success in our study fields. Weather during the 2019 pollination season was optimal for pollinator foraging, and weather during the 2017 pollination season was also ideal; this factor may have improved the pollination success results observed.

Effect of Stocking Density on Berry Mass at Harvest

We did not detect a significant difference in berry mass at harvest among different stocking densities tested (2, 3 and 4 hives per acre). Fields stocked at 3 and 4 hives per acre did produce heavier berries than fields stocked at the current industry standard of 2 hive per acre, although not significantly so. We found that at 4 hives per acre, berry mass was more variable. For example, some berries were large (indicating better pollination), but some berries were smaller and more variable.

Effect of Stocking Density on Berry Yield

We found that fields stocked at 4 hives per acre did not produce significantly more yield than fields stocked at 3 hives per acre in New Brunswick. However, the difference in yield at 4 hives per acre, compared to 3 hives per acre, allowed for more than an additional pollinating unit, based on $0.45 per pound for blueberries. We also found less variability in yield at 4 hives per acre; fields stocked at this density produced more consistent crops than fields stocked at 3 hives per acre. Yield information was only collected in 2019 in New Brunswick, which allowed for comparison of similar fields and reduced variability. However, this also means our recommendations need to be tailored to specific growers and regions. For example, what makes sense in New Brunswick fields (with typically higher yield potentials) may not make sense in other parts of the Maritimes (e.g. fields with lower yield potentials). If fields are not consistently producing above 6,500 lbs per acre, stocking at 4 hives per acre may not be economically viable, based on our data. This experiment should be repeated in additional regions including Nova Scotia and Prince Edward Island.

In Nova Scotia, Eaton and Nams (2012) saw a linear increase in blueberry yield up to 4 hives per hectare (1.6 hives per acre). However, the highest yield they cited in the study was 5000 kg/ha (approximately 4500 lbs per acre) (Eaton and Nams 2012), meaning their upper yield limit of fields studied would be considered relatively poor producing fields in our study in New Brunswick. In this Nova Scotia study, the authors suggested that variability was too high above 1.6 hives per acre to make recommendations on stocking density; in our study, we are now able to make recommendations up to 4 hives per acre. This emphasizes the need for regional decisions based on regional research, individual fields, and yield potential.

Effect of Stocking Density on Bee Abundance and Diversity

Honey bee stocking density did not significantly impact the number of honey bees or native bees we observed in the same fields. There was greater variability in the number of honey bees detected in fields stocked at 4 hives per acre, but this could be due to increased competition for floral resources, and honey bees using their large foraging range (up to 5 km) to access floral resources elsewhere. We found no evidence for competition between honey bees and native bees at higher honey bee stocking densities, suggesting using managed pollinators at these stocking densities (up to 4 hives per acre) does not displace native bees that provide base pollination, potentially due to the short pollination window that managed bees are placed in blueberry fields.

Challenges

As with most field research, we encountered challenges during the three years of study. There were major challenges surrounding grower and beekeeper communication. For example, each year we carefully designed an experiment that considered adequate replication for statistics (e.g. number of fields with the same stocking densities of honey bee hives). Each year, we encountered situations where we lost replication due to stocking densities changing, or hives moving in and out of fields prematurely. We also encountered challenges with honey bee colony strength. For example, colonies monitored for growth during pollination in 2017 were excluded from all analyses as many of the colonies did not meet the New Brunswick recommended pollination standard or were not managed similarly (e.g. different hive configurations, from different sources in and outside of New Brunswick). Hives studied in 2018 and 2019 were from fewer beekeeper sources that generally followed similar management practices. These hives consistently met the recommended pollination standard, and were stronger, except for one field studied in 2019 (these weak hives were omitted from statistical analyses).

These challenges also highlight the importance of studying the optimal strength of honey bee hives entering wild blueberry pollination, a future goal of our project. For the past three years of study, we omitted hives from statistical analyses if they did not meet the pollination standard or were managed very uniquely. We also tried to work with fewer beekeepers to reduce variability and ensure we met the pollination standard. In future work, we will also examine if there is a correlation between starting strength of hives and colony growth as well as pollination success, berry mass, and yield. This information could allow us to determine if the current pollination standard is adequate, or if new recommendations should be made.

Moving forward, grower and beekeeper communication is key with researchers, but we also advocate this is a two-way street. We aim to design high-quality experiments and work with farmers as best we can to ensure accurate data are collected. We as researchers, however, are also responsible for sharing results in a timely manner.

General Recommendations

Our study shows that increasing honey bee stocking densities can reduce variability in pollination success and yield but may only be economically viable in fields with higher yield potential, and when blueberry prices are optimal.

Colony growth decreased as stocking density increased, although not significantly so. More importantly, hives sent to pollination meeting the pollination standard grew well and did consistently better than weak hives. There are benefits to the blueberry grower and beekeeper to send hives at the pollination standard, at least up to 4 hives per acre as we studied, at the yield potentials that we studied. Communicating the pollination standard and its benefits more clearly to both parties, as well as sharing tips to achieve the standard may be helpful for this industry. For example, we would recommend beekeepers send hives to pollination with enough room to grow; this enforces sending hives at the correct strength but allows for potential growth and swarm prevention. Factors that need to be considered include colony strength, yield potential, weather forecasts and projected price. If high-potential fields are stocked at high stocking densities (e.g. 4 hives per acre and above), there are steps to take to protect colonies including meeting the pollination standard and sending hives with pollen substitute. Good communication between beekeepers and blueberry growers to prepare for pollination is essential to achieving high pollination success rates and healthy colonies.

Grower and beekeeper participation and collaboration in our study is fundamental in what we can achieve. We appreciate those who worked with us to gather this information.

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Summary of Progress- Pollen Supplementation Project

Project Title: Evaluating the effect of feeding pollen substitute to honey bee colonies destined for wild blueberry pollination in Colchester County, Nova Scotia
(published as a fact sheet on our website: https://www.perennia.ca/portfolio-items/honey-bees/)

Introduction

Wild blueberry (*Vaccinium angustifolium* Aiton) is a regionally important crop in eastern Canada that requires insect-mediated cross pollination for fruit set. Many blueberry growers rely on honey bees (*Apis mellifera*) as the dominant pollinator for their crops due to their versatility, efficacy, and convenience. Wild blueberry pollination is a significant source of income for beekeepers in eastern Canada, however, there has been a recent surge of reports from local beekeepers regarding the health of their honey bee colonies once they return from pollination. Anecdotal reports from beekeepers suggest that hives that return from blueberry pollination are typically weaker than when they were sent to fields. Many of these reports suggest that colonies reduce in size during pollination, and some report that hives develop European foulbrood (*Melissococcus plutonius*) (EFB) during blueberry pollination. EFB is often cited as a stress related disease and is considered more problematic when forage is sporadic or limited, or when other stressors including hive movement, climatic conditions, or poor nutrition are at play (Bee Aware, n.d; Forsgren, 2010). Honey bee colonies may experience these negative conditions in certain blueberry fields in eastern Canada. It is therefore of interest to test potential solutions to help ensure that colonies sent to wild blueberry pollination return strong and disease-free.

The objectives of this trial were to 1) determine the effect, if any, of providing pollen substitute to honey bee colonies during blueberry pollination on the growth of colonies, and 2) to determine the prevalence and severity of EFB of colonies fed different amounts of pollen substitute during blueberry pollination.

Methodology

This trial was conducted in the spring of 2019 in three wild blueberry fields in Colchester County, Nova Scotia during pollination. Sixty hives belonging to the same beekeeper were used in the trial. The test colonies were housed in wooden Langstroth hive boxes and were sent to blueberry pollination as two deep brood chambers and a medium honey super.

The trial was constructed as a randomized block design. Each of the 60 test colonies were randomly assigned to one of three equally proportioned treatment groups. Blueberry field was used as a random blocking factor to account for variation among fields. The trial was set up as an imbalanced design, where 12 hives (four replicates of each treatment) were present in the first field, 12 hives (four replicates of each treatment) were present in the second field, and 36 hives (12 replicates of each treatment) were present in the third field. The imbalance of the design was due to the different sizes of blueberry fields since hives were stocked in each field at approximately two hives per acre.

On the evening of 3 June 2019, the host beekeeper delivered hives to the blueberry fields for pollination. On 4 June 2019, the initial colony strength assessments were conducted by counting the seams of bees in each hive (Nasr et al., 1990). At the same time, three frames of brood in each colony in the top brood chamber were observed for the presence of EFB, and rated based on the severity observed (low: 1-4 infected larvae per brood frame, moderate: 5-9 infected larvae per brood frame, high: 10+ infected larvae per brood frame). The frames that were observed for the trial were marked with an 'X' using a permanent marker so that the same three frames could be examined again at the end of pollination, and three weeks post-pollination. After the colony assessment, colonies either received no pollen patty which served as the control, 1 lb of pollen patty, or 2 lb of pollen patty. For colonies receiving pollen patty, the patty was placed on the top of the second brood chamber and below the honey super. The pollen patty brand used in this trial was Ultra Bee™ (Mann Lake Ltd., Minnesota) due to its wide spread use in Maritime beekeeping operations, representing a "standard" pollen substitute.

During blueberry pollination, bottom mount pollen traps (Pollen Depot, Port Hope, Ontario) were deployed on colonies in each treatment group in each field to determine if the amount of pollen and the percentage of blueberry pollen collected per treatment varied among treatments. Pollen traps were deployed on 17 June 2019 for 24h. On 18 June 2019, the pollen traps were removed from the colonies, and the pollen was collected, cleaned and stored in a -18^{0}C freezer. Pollen analysis will take place during the winter and ATTTA will share results once completed.

Just before the hives were removed from the fields at the end of pollination on 19 June 2019, final seam counts were conducted and the three frames that were previously marked were assessed for the presence and severity of EFB infection. Except for a few hives, hives that were fed either 1lb or 2lb of pollen patty had consumed all that was fed during pollination. Any hives that swarmed or became queenless during pollination were removed from the trial (one in control, two in 2lb group).

Approximately three weeks after hives were removed from the blueberry fields and placed in summer bee pasture (11 July 2019), colonies were further assessed for presence and severity of EFB. Colony growth was not assessed at this time due to the host beekeeper splitting hives immediately after blueberry pollination. The frames marked for EFB inspection were not removed from the parent colonies when hives were split after blueberry pollination.

Colony strength data were analysed using a general linear model in Minitab 18 (Minitab, 2018) using treatment as a fixed factor, and blueberry field as a random blocking factor. The prevalence of EFB was calculated by dividing the number of hives that displayed EFB symptoms by the number of hives in the treatment group and multiplied by 100.

Results

There was no significant difference in the growth of colonies that were fed 2lb of patty (mean = 5.83 seams, SEM = 0.63, range = -0.17 – 9.69 seams, n = 18), 1lb of patty (mean = 4.38 seams, SEM = 0.79, range = -2.00 – 7.23 seams, n = 20), or control colonies that were given no pollen patty (mean = 4.34, SEM = 0.57, range = 1.00 – 9.36 seams, n = 19) during the blueberry pollination period ($F_{2,52}$ = 0.63, P = 0.537) (Figure 1).

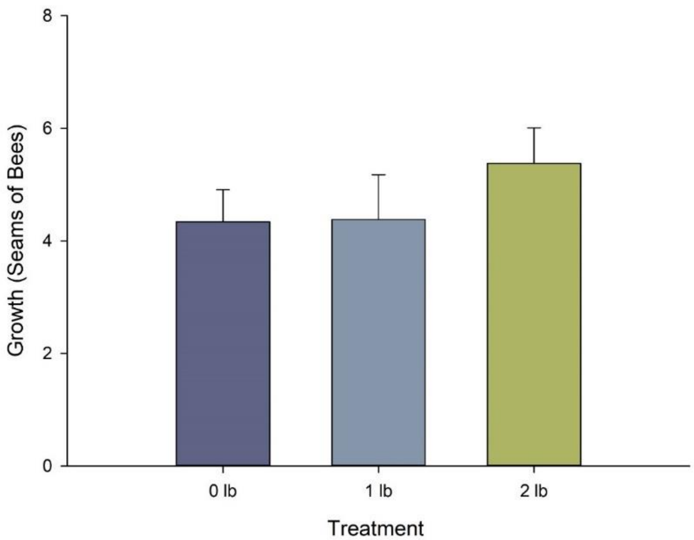

Figure 1: Mean honey bee colony growth during blueberry pollination in Colchester County, Nova Scotia, 2019 among groups fed 0, 1, or 2lbs of pollen. Error bars represent standard error.

At the onset of the trial, none of the hives were observed to have visual symptoms of EFB infection. By the end of pollination, there were only 2 out of 57 hives (3.5%) that displayed any symptoms of EFB, both with a low severity rating (1-4 infected larvae per brood frame) (Figure 2). One of these hives was in the control group, and the other was in the 2lb treatment group. Three weeks after blueberry pollination, additional hives displayed EFB symptoms, and the level of severity was much higher. Three weeks post-pollination, 4 out of 57 hives (7.0%) displayed symptoms of EFB with a high severity level (10+ infected larvae per brood frame) (Figure 2). Of the hives that were observed with EFB symptoms 3 weeks post-pollination, three of the hives were from the control treatment group (15.7%), and one hive was observed in the 2lb treatment group (5.5 %).

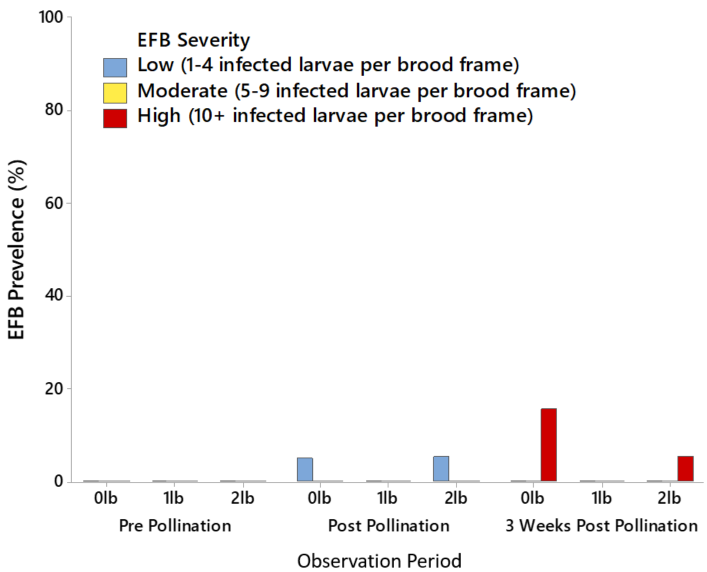

Figure 2: European Foulbrood prevalence and severity rating of honey bee colonies pre-pollination, post-pollination and three weeks post-pollination in Colchester County, Nova Scotia, 2019.

Discussion

This trial aimed to evaluate the effect of feeding pollen substitute to honey bee colonies on the growth of colonies and the prevalence and severity of EFB. Our data show that feeding pollen substitute to colonies during blueberry pollination did not influence colony size and did not have an appreciable impact on reducing the prevalence and severity of EFB either post-pollination or three weeks post-pollination.

Although these results suggest that there is no economic benefit of sending bees to blueberries with pollen patty with respect to colony growth, beekeepers should be aware that surrounding floral resources and weather can impact colony growth and therefore beekeepers must make management decisions based on a variety of factors. For example, wild blueberry pollination in 2019 was completed in a relatively short time frame compared to other years. The pollination period lasted 16 days for this trial while in some years, pollination can last 21-24 days, depending on weather conditions. The weather in 2019 was favorable for foraging activity for most of the days that the hives were in pollination. In other years, poor weather during pollination can result in bees remaining inside hives, limiting foraging activity. In cold wet years, pollen substitute may give hives an added advantage of protein inside the hive so they can continually rear brood during times of poor weather. The blueberry fields that were used in this trial were coincidentally located in areas with a variety of alternative forage (apples, cherries, dandelion, etc.) surrounding the fields, giving bees sources of attractive, nutritious pollen to balance the incomplete diet gathered from blueberry pollen (Colwell et al., 2017). Furthermore, the cold wet start to spring in 2019 resulted in a delay in bloom of many flowers, and therefore the bloom of many alternative flowers coincided with blueberry bloom for this season. This meant that the bees had access to many other sources of nectar and pollen to collect along with blueberry pollen. These factors may explain why there was no apparent benefit of colony growth during pollination. At the end of the trial, the host beekeeper had to split colonies right away to attempt to prevent swarming. Despite being fed pollen sub or not, hives in the trial grew very well during the short pollination period this season. The trend commonly reported by beekeepers that hives do not grow, or reduce in size during pollination, was not observed during this trial. This may be a result of optimal foraging conditions during pollination, or due to the abundance of alternative forage surrounding the blueberry fields used in the trial. The host beekeeper sent hives to pollination meeting or exceeding the recommended pollination standard for Nova Scotia (Nova Scotia Beekeepers Association, 2012). If hives do not meet or exceed this standard, they may require additional resources such as pollen patty in order to reduce the potential negative effects during blueberry pollination. It is possible that if hives were sent below the pollination standard, there may have been a positive effect of feeding pollen patty (e.g. colonies had a greater need for pollen and responded as such). Furthermore, weaker hives may have a higher occurrence of EFB post-pollination and three weeks post-pollination due to stress associated with pollination.

During this trial we did not notice many hives that were infected with EFB. Immediately after pollination, only 2 hives out of 57 were found with any EFB symptoms, both of which were not severe (1-4 infected larvae per brood frame). Interestingly, we did notice more EFB once the hives were placed in summer pasture three weeks after blueberry pollination, and the level of severity was much higher (10+ infected larvae per brood frame). During the three-week post-pollination period, two additional hives that were from the control group were found with high levels of EFB. However, only 4 hives out of 57 hives total were found with any level of EFB three weeks post-pollination. All the hives that contracted EFB during pollination or after pollination were from the same blueberry field, and all of the hives with EFB also showed signs of a moderate level chalkbrood infection as well. The data from this trial suggest that there may be a benefit of adding pollen patty to hives for blueberry pollination to reduce the chances of developing EFB symptoms during or after pollination based on the higher incidence of EFB found in the control colonies. However, it is difficult to draw conclusions based on such a small sample of hives that contracted EFB. It is also interesting that all of the hives that developed EFB were from the same blueberry field and these hives were also exposed to stressors from chalkbrood as well. This may suggest that hives placed in certain fields may be more prone to developing EFB than others based on environmental stressors such as a lower abundance of alternative forage. It is also possible that because EFB is a nutritional and stress-related disease, that the colonies which had chalkbrood may have developed EFB due to the added stress of dealing with chalkbrood. Further research is required in fields with poor alternative forage surrounding the blueberry fields to determine if there is a benefit of sending bees to pollination with pollen patty.

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