Project Identification

1. **Project Title:** 20190424
2. **Project Number:** Demonstration of Efficacy of Bumble Bee (*Bombus huntii*), Honeybee (*Apis mellifera*) and Leafcutter Bee (*Megachile rotundata*) on Pickling Cucumbers
3. **Producer Group Sponsoring the Project:** Saskatchewan Vegetable Growers' Association (SVGA)
4. **Project Location(s):**
    - Canada-Saskatchewan Irrigation Diversification Centre (CSIDC), RM of Rudy
    - Conservation Learning Centre (CLC), RM of Prince Albert
5. **Project start and end dates (month & year):**
    - March 2021 to February 2022
6. **Project contact person & contact details:**
    - Cara Drury PAg, CIB, MOA
    - Kelly Farden PAg, CIB, MOA

Objectives and Rationale

7. **Project objectives:**
    - Compare the efficacy of three commercially available pollinator species for improved fruit set, size, evenness, and quality on a pickling cucumber crop.
    - Demonstrate the benefit and practice of incorporating commercially available pollinators to pickling cucumber production.

8. **Project Rationale:**

    The market for Saskatchewan grown pickling cucumbers is growing. Federated Co-operative Limited (FCL) has a newly developed line of Saskatchewan grown and processed pickles, which will be supplied to their Western Canadian stores. To meet the demands for current production, and realize the potential for product expansion and export, Saskatchewan producers need to grow pickling cucumbers in the most efficient way possible. Unmarketable oversized and misshapen cucumbers due to poor pollination is a waste of time, labour and inputs for these producers. A demonstration of the best pollinator species for large scale, high value horticultural crops will help increase both quality and efficiency of the producer's product.

Methodology and Results

9. **Methodology:**

This project took place at two locations, the Canadian-Saskatchewan Irrigation Diversification Centre (CSIDC) in Outlook and at the Conservation Learning Centre (CLC) near Prince Albert.

Both locations prepared the sites with tillage, incorporating fertilizer to achieve 100 lbs N/ac and 120 lbs P/ac. Both sites used Jackson Supreme pickling cucumber seed, treated with Farmore D1400, Thiamathoxamine, 420xystrobin, mefenaxam, feudioxonie, thiam seed treatment. The CSIDC site was seeded on June 2, 2021, with a Stanhay seeder. The CLC site was seeded on June 14, 2021, by hand. Row spacing was 20 inches, with 4 rows per plot, only harvesting the centre two rows. Plot length was three meters. At both sites water was supplied through trickle irrigation and managed to keep soil moisture at 75%.

There were five treatments, replicated three times per site:

(1) Honeybees

(2) Leafcutter bees

(3) Bumble bees

(4) Background pollinators

(5) No pollinators (pollinator exclusion)

Pollinator treatments were added to the trial once flowering of the pickling cucumbers started. This occurred during the week of July 19, 2021. To keep treatments separate, each treatment was maintained under an inclusion or exclusion tent (Figure 1), except for treatment 4, background pollinators. The treatment "Background Pollinators" used whatever pollinators were occurring close to the demonstration project. The CLC location is in a mosaic of good to excellent wild pollinator habitat with wetland, some woodlands, annual and perennial crops and hay land nearby. As well a commercial beekeeper has a yard of bees approximately 800 m from the cucumber plots. The CSIDC site has fair to good wild pollinator habitat adjacent with urban area, shelterbelt and irrigation research plots adjacent. Small scale beekeepers had approximately 6 colonies roughly 800 m from the cucumber plots. Tents were covered with 17 gr ProtekNet, from Dubois. This netting has a mesh size of 0.85 mm X 0.85 mm.

Treatment 1 housed 5 frame nucleus honeybee colonies (Figure 2), supplied by cooperating local honeybee keepers. Treatment 2, housed approximately 110 g of leafcutter bee cocoons incubated to the emergence stage at the time of flowering with a small nesting block of approximately 600 tunnels, 3 inches deep (Figure 3), supplied by cooperating local alfalfa seed producers. Treatment 3 housed commercially available bumble bee colonies (Figure 4) purchased from the company BioBest, in Leamington Ontario. The exclusion treatment had no pollinators added and nets placed overtop, while the background pollinator plots were not netted and open to the environment.

Figure 1. Inclusion/exclusion pollinator tents

Figure 2. Honeybee sub hive

Figure 3. Leafcutter cocoons and nesting block

Figure 4. Commercially available bumble bee colony

It was initially planned to open pollinator tents on a rotating basis, allowing the pollinators to have a larger foraging area. Tents would be opened at 6:00 am, while the temperature was still cool, and the pollinators were not active. Tents would be left open until sunset, when temperatures would drop, and the pollinators would return to their respective nests/hives. It was planned that each pollinator species would have their tents opened one day a week: honeybees Tuesday, leafcutters Wednesday and bumble bees Thursday.

The CSIDC site cycled through one week of tent opening. It was found that many pollinators were returning to their respective nests/hives, but not all. There was concern that if tent opening continued that there would not be adequate pollinator populations left in the tents, or that pollinator populations would start mixing. It was decided to keep the tents closed and ensure that adequate supplemental food (sugar water or honey) and water was available for each treatment. Because of the concerns found at CSIDC, the CLC site did not open their tents.

Cucumber harvest took place approximately twice a week, at 6:00 am. The temperature at 6:00 am was found to be sufficiently cool and the pollinators were not active at that time. Tents were opened at the time of harvest and securely closed afterwards. The first harvest at CSIDC was on August 4, and the last was August 26. The first harvest at CLC was August 5, and the last was August 31. Harvest intervals varied due to weather events or other challenges which varied the schedule. Once fruit was harvested it was sorted, graded and weighed. The fruit grades were marketable (1.75” - 6.0 long and straight), oversized (>6.00” and straight) and misshaped (Figure 5).

Table 1. Harvest Intervals

Harvest number	Outlook	Interval	Prince Albert	Interval
1	4 August	3.66	5 August	4.3
2	9 August	5	9 August	4
3	12 August	3	12 August	3
4	16 August	4	17 August	5
5	19 August	3	20 August	3
6	23 August	4	25 August	5
7	26 August	3	31 August	6

Figure 5. Cucumbers on the right misshapen due to the C curve while on the left misshapen due to globular shape.

Once the fruit was harvested, the results were analysed to compare fruit set, fruit evenness and fruit quality at each site and among the pollination treatments. Fruit set was measured as total fruit count by treatment. Since cucumbers are dioecious and male and female flowers are separated, any fruit must be the result of insect transfer. Fruit evenness was fruit weight among pollinator treatment groups by harvest date. Fruit quality was measured by total marketable fruit weight by treatment. The total weight, total count and total marketable weight between sites were analysed by an ANOVA as well as within sites by pollinator treatment. If a result was significant within pollinator treatments, a post hoc uncorrected student T-test was performed between each treatment. The decision to use uncorrected T-test was chosen as the sample size of three was relatively small, contained large differences within treatment values and the relatively large amounts of comparisons made. The less rigorous use of uncorrected T-test was thought to be more appropriate given these demonstration considerations. As the harvest intervals were not always the same number of days, fruit evenness within treatment was calculated to be an average daily fruit yield for a given harvest interval. On the first harvest date, where no interval could be calculated, the average harvest interval was calculated for each site and applied to the first day's harvest.

10. Results

The total weight of fruit, which included both marketable and unmarketable weight, was not significantly different between sights, ($F = 1.1415$; $df = 1,28$; $P = 0.2945$) but total fruit count was ($F = 77.15$; $df = 1,28$; $P = <0.0001$) and total marketable weight were ($F = 21.627$; $df = 1,28$; $P = <0.0001$).

At the Outlook site there was no significant difference between pollinators on fruit set as measured by total fruit set ($F = 1.7501$; $df = 4,10$; $P = 0.2154$), evenness within pollinator treatments (see Table 2) or fruit quality

(F = 0.9695 df = 4,10; P = 0.4656). At the Prince Albert site pollinator treatment had a significant effect on fruit set (F =7.13329; df = 4,10; P = 0.00554) fruit evenness within pollinator for all treatments but the pollinator exclusion (see Table 2) and fruit quality (F = 9.61246; df = 4,10; P = 0.00186).

Table 2. Fruit Evenness Statistical Significance

Effect	F	df	P Value
Outlook, All Pollinators	0.62318	6,14	0.7094
Outlook, Bumble Bee	0.8249	6,14	0.5693
Outlook, Honeybee	1.98341	6,14	0.1365
Outlook, Leafcutter	0.4542	6,14	0.8304
Outlook, No pollinators	0.42164	6,14	0.85257
Prince Albert, All Pollinators	15.3587	6,14	**<0.0001**
Prince Albert, Bumble Bee	13.0413	6,14	**<0.0001**
Prince Albert, Honeybee	73.847	6,14	**<0.0001**
Prince Albert, Leafcutter	22.7385	6,14	**<0.0001**
Prince Albert, No pollinators	0.90492	6,14	0.5186

Since pollinator was determined to be a significant factor at the Prince Albert Site, the post hoc t-test were used to determine which treatments differed. The three treatments which used the bumble bee, honeybee and leafcutter bees were significantly different from the pollinator exclusion treatment for fruit set but not different from the open pollinated treatment (Table 3). For marketable fruit weight, the treatments including open pollination, bumble bee, honeybee and leafcutter bees were significantly different from the pollinator exclusion treatment (Table 3).

Table 3. Post hoc T-test for the Prince Albert Site

Parameter	Comparison	P-Value	Significant
Fruit Set (Count)	All vs Bumble	0.110866	No
	All vs Honey	0.341129	No
	All vs Leaf	0.45326	No
	All vs none	0.060334	No
	Bumble vs honey	0.230226	No
	bumble vs leaf	0.443536	No
	bumble vs none	**0.00204**	**Yes**
	honey vs leaf	0.980025	No
	honey vs none	**0.007485**	**Yes**
	leaf vs none	**0.025529**	**Yes**
Marketable Weight	All vs Bumble	0.575372	No
	All vs Honey	0.613364	No
	All vs Leaf	0.92315	No

	All vs none	**0.006679**	**Yes**
	Bumble vs honey	0.232818	No
	bumble vs leaf	0.593234	No
	bumble vs none	**0.008136**	**Yes**
	honey vs leaf	0.79561	No
	honey vs none	**0.001723**	**Yes**
	leaf vs none	**0.014892**	**Yes**

11. Conclusions and Recommendations

The results make it apparent that there was a big difference between the two sites in terms of their effectiveness of pollination. While the two sites did not significantly differ in the total weight of fruit production, there was a significant difference in both the fruit set as measured by fruit count, as well as the total marketable fruit weight.

The supplemental pollinator treatments (honeybee, leafcutter bee and bumble bee) at CSIDC produced more misshapen cucumbers than marketable. Misshapen cucumbers are caused by an error in pollination. This results in C or S curves, or a globular shaped fruit. Errors in pollination can be attributed to different factors: infrequent or ineffectual visits from a pollinator, heat stress, moisture stress or physical damage. Seeded pickling cucumber female flowers need eight to twelve pollinator visits in a single day to set marketable fruit. The results from this trial indicate that the conditions (supplemental pollinators and environmental) at the CLC produced a larger ratio, and a larger volume, of marketable pickling cucumber than at CSIDC.

Looking at total cucumber production, over the entire growing season the No Pollinator treatment produced the fewest cucumbers at each site. The fact that some cucumbers were produced in these treatments can be accounted for by small, native pollinators that were unseen at the time, but trapped in the exclusion tents. As well the tents may have had small gaps or holes that allowed access to insects in and out of the nets at some points throughout the demonstration.

Comparing the total count of cucumbers, per treatment, per site to the total weights of cucumbers, per treatment, per site it is noted that there are marked differences per site. The CLC treatments produced over double, CSIDC's total count of cucumbers for each treatment; but each site produced similar total weights for each treatment The difference in counts and weights may be accounted for by differences in harvesting practises at each site. The CLC site picked a larger number of small cucumbers, while the CSIDC site picked a smaller number of large cucumbers. Causes for these differences are likely varied, from harvesting experience of the pickers to environmental conditions that allowed fruit to size-up at differing rates.

The three different pollinator species did not significantly differ in their ability to pollinate a pickling cucumber crop. Overall, a similar pattern occurred where bumble bees were the best pollinators, followed usually by honey bees, open pollination and leafcutter treatment but this pattern was only a trend. That result fits well with the expectation of bumble bees being well suited for cucumbers and honeybee and leafcutters less so based on size and temperature tolerance. Supplemental pollination is recommended for commercial production of fruit and vegetable crops that rely on insect pollination. When choosing a pollinator species to use for supplemental pollination it is recommended to choose the one that is best suited to your individual operation or chose a multiple pollinator approach. Each pollinator has its own set of pros and cons and using a full suite of pollinators can guarantee excellent pollination. If that is not practical or possible, picking the best option available to producers is also an excellent management option. It should be noted here that the number of pollinating insects was not the same in all treatments and no effort was made to make them the same. A standard number of pollinating insects is not a realistic goal for pollination in this context. Colonies of bumble bees are almost always smaller in population number than commercial beehives, and leafcutters

are solitary but gregarious bees which can have any number of cocoons placed in the same location.

The difference in fruit evenness, as measured by weight per harvest period was not significantly different for Outlook but was for Prince Albert. Considering that there was no significant effect of pollinators in Outlook, the pollination, in addition to specific site conditions likely played a role in this. For some harvest purposes, it is preferred to have much more fruit ripen all at once. A one-time mechanical harvest for instance would benefit if all the fruit were at the highest marketable value at the same time. However, if there are logistical considerations like spreading production over a longer time period for harvest, access to trucking and harvesting equipment or u-pick operations, a more spread-out harvest may be preferred. A common benefit of good pollination is early and even ripening of crops, usually for mechanical harvest at one time. The Prince Albert site had a much higher fruit production on the first harvest date but tapered off through subsequent harvests. This also could be a result of decreasing pollinators as their surviving number decreased through the harvest month. The Outlook site did not have a significant effect of pollinator, nor a significantly different yield through harvest intervals. This could have resulted from the different tent management for the first week of the trial. As well extremely hot days and disease issues at Outlook may have contributed to poor performance of the cucumbers, regardless of pollinator management.

Honeybees are easy to access, have well established management practises and produce honey as a marketable product. On the downside, of the three pollinator species demonstrated honeybees are the most aggressive, require the most management and require the most equipment. Producers with U-pick operations, on farm stores or fearful labourers may want to consider a different pollinator species.

Leafcutter bees are the least aggressive species from this demonstration. Leafcutters are physically quite small, and their stings are less painful than honeybees or bumble bees. They are the least intimidating pollinator species that was demonstrated and because of this, they are well suited to operations that are frequently accessed by the general public. Leafcutters do have limitations, because of their small size they are a “fair weather” pollinator. Leafcutters do not stand up well to extreme weather conditions. They require habitat that is protected by the wind and are less likely to be out pollinating in unfavourable conditions.

The opportunity to purchase the native bumble bee species, *Bombus huntii* commercially is relatively new for Saskatchewan. The company BioBest has a subsidiary in Ontario which offers a variety of hive and colony options to provide supplemental pollination for horticulture crops. A benefit of these purchased hives is the included food source. The supplemental glucose water ensures that the colony has adequate nutrition while pollinating horticulture crops. Bumble bees are less aggressive than honeybees, but more aggressive than leafcutters. They do have the ability to sting multiple times and their large size maybe intimidating to some people. A benefit of bumble bees is their robust nature, they have the ability to provide pollination in weather conditions that leafcutters and honeybees would not tolerate.

For future work that incorporates the use of pollinators and inclusion/exclusion tents it is recommended to maintain the tents as closed, and not plan for a larger foraging area. Instead of larger foraging areas, supplemental sugar water should be made available to the colonies. It is also recommended to look at different crops’ performance with these pollinators. Flower size and shape can change the efficacy of a pollinator species.

Supporting Information

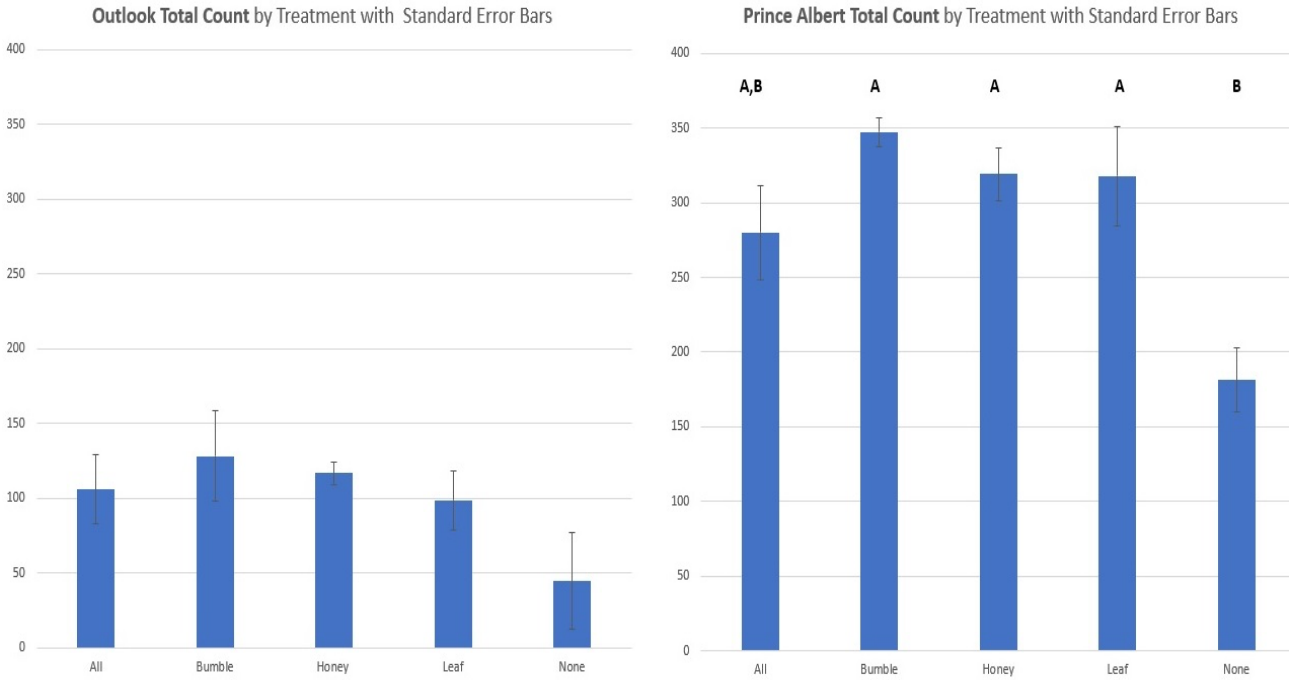
12. Acknowledgements

- Angela Stoppler, ICDC Acting Horticultural Research Technician, for project implementation and plot maintenance
- ICDC staff for assisting in setup and field work

- Brooke Howat, CLC Temporary Manager, for project implementation and project maintenance
- CLC staff for assisting in setup and field work

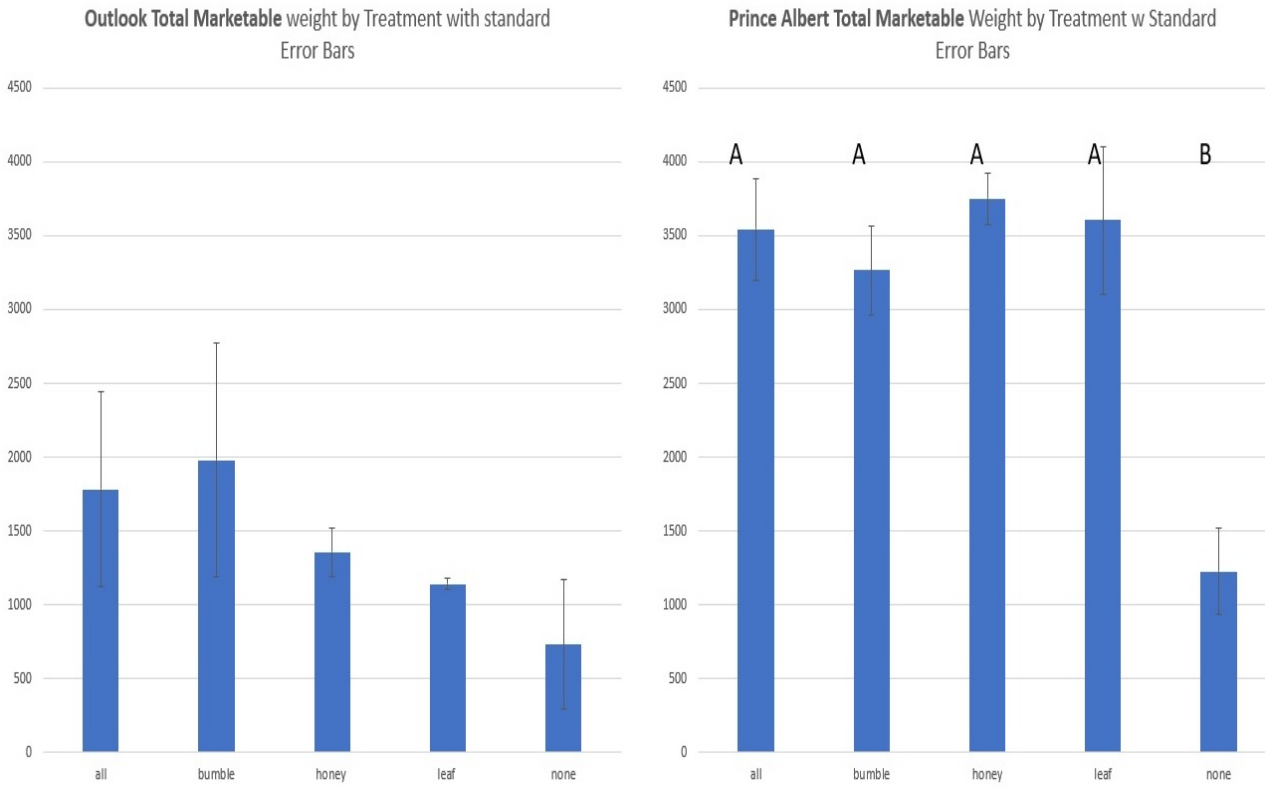
13. Appendices

Table A1. Total cucumber production weight by treatment, per site with standard error bars



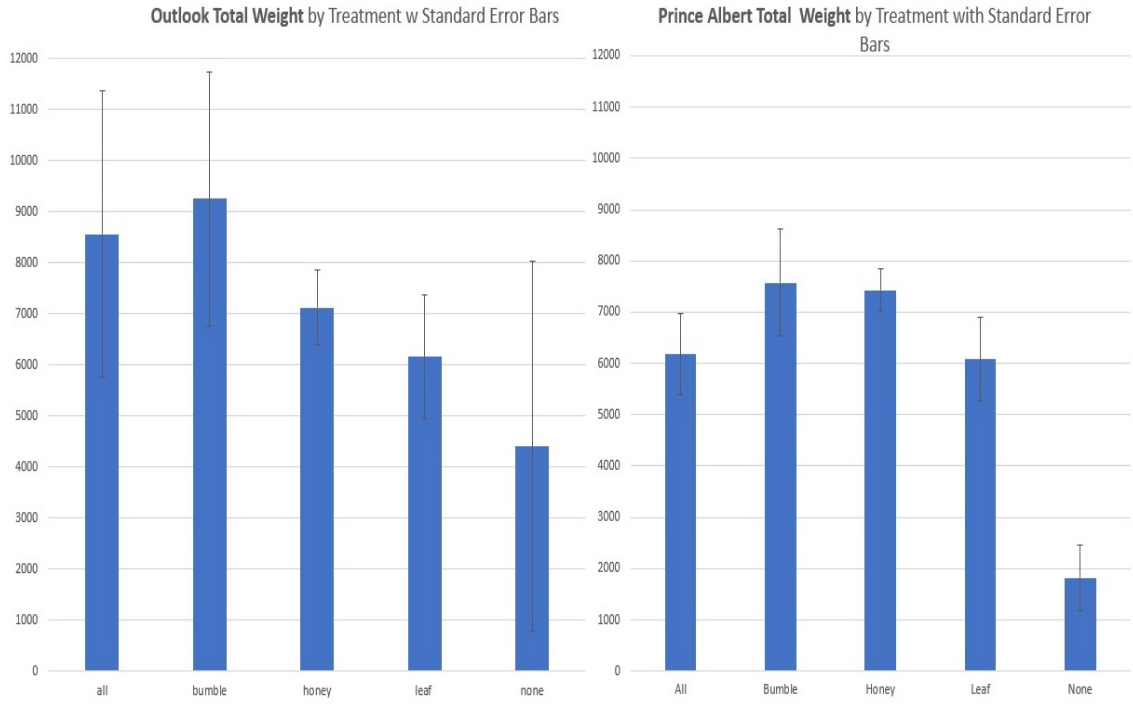
Total Fruit Count was significantly different between the two sites (F = 77.15; df = 1,28; P = <0.0001). Within each site pollinator had no significant effect in Outlook (F = 1.7501; df = 4,10; P = 0.4656) but there was a significant difference between pollinators in Prince Albert (F = 7.13329; df = 4,10; P = 0.00554). Within the Prince Albert site. Treatments with the same letter above are not significantly different.

Table A2. Total cucumber production count by treatment, per site with standard error bars



Total Marketable Weight was significantly different between the two sites ($F = 9.6124$; $df = 4,16$; $P = 0.00186$). Within each site there no significant difference between pollinators in Outlook ($F = 1.7501$; $df = 4,10$; $P = 0.2154$), but there was a significant difference in Prince Albert ($F = 7.1339$; $df = 4,10$; $P = 0.00554$). Treatments at the Prince Albert location with the same letter are not significantly different (see Table 3)

Table A3. Total cucumber marketable weight by treatment, per site with standard error bars



Total Fruit weight did not significantly differ between Outlook and Prince Albert (F = 77.15, df = 1,28; P = 0.2945)

Abstract

14. Abstract/Summary

The market for Saskatchewan grown pickling cucumbers is growing. To meet the demands for current production, and realize the potential for product expansion and export, Saskatchewan producers need to grow pickling cucumbers in the most efficient way possible. Unmarketable, undersized and misshapen cucumbers due to poor pollination is a waste of time, labour and inputs for these producers.

This trial demonstrated the use of three different, commercially available pollinators (bumble bee *Bombus huntii*, honeybee *Apis mellifera* and leafcutter bee *Megachile rotundata*) for providing supplemental pollination on a pickling cucumber crop. The three different pollinator species did not demonstrate significant differences in their abilities to pollinate a pickling cucumber crop but did show an increase in fruit production over no pollinators.

Supplemental pollination is recommended for commercial production of fruit and vegetable crops that rely on insect pollination. When choosing a pollinator species to use for supplemental pollination it is recommended to choose the one that is best suited to your individual operation as each pollinator has its own set of pros and cons.

This project was presented at:

- CLC Field Day (video available on CLC's YouTube Channel here)
- https://www.youtube.com/watch?v=nSjuNYzfV1w
- CSIDC Virtual Field Day
- Saskatchewan Irrigation Projects Association (SIPA) AGM and Conference