Bubble Bee: Exploring the Effectivity of Bubble Pollination

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Problem

Our project aims to find a more effective, cost-friendly and environmentally conscious approach to pollinating crops. This issue arises from the years of bee population decline in Canada (Claing, 2023), where there was a loss of 32% of bees in 2023. Bee population decline is a global issue as evidenced by population declines in China (Tang, 2023) where more than 266,17312 bee colonies were lost. The main factors in the decrease of bees include loss of habitat from urbanization, pesticide use, and parasites (Valkó, 2022). For these reasons, bees are not always the most reliable method of pollination. Therefore innovation in artificial pollination such as bubble pollination, has become a popular way to solve this issue of pollination scarcity. Pollination decline can have diverse negative impacts, such as an increase in food prices and a lower food supply for a growing population. As such, there has been research into alternative pollination methods. The three main artificial pollination methods are; pollinator drones, hand pollination, and mobile bees.

Currently, pollinator drones have received a lot of attention for a possible solution to the decline in pollinator bees. However, as effective as they are at pollinating crops they pose challenges. Firstly, the success rate of drone pollination is low which is concerning given the circumstances in which it was tested. Experimentation was conducted on liles, which are among the easiest plants to pollinate due to their large stigmas (Ghosh, 2017). Furthermore, drones can be extremely costly, around a hundred dollars per drone, which adds up quickly when evaluating them on a potential commercial scale. Additionally, these pollinator drones can be environmentally damaging. When operating within the vicinity of real bees, drones have the potential to scare bees away from crops or in the worst scenario, kill them. This can be problematic with the already declining bee population. Moreover, while depositing pollen onto plants and flowers, drones are usually rough and can cause damage to the plant. Additionally, the materials needed to create the drones use plastic, wires, and foils which are often costly (Hamlin, 2020). With these consequences in mind, pollinator drones are not environmentally friendly or applicable on a large scale.

Hand pollination is another method of artificial pollination that has been adopted by various Eastern countries in response to the dramatic decrease in bee population. However, it has also been evidenced to be an ineffective method to pollinate crops and plants in the long-term. In China, it has been used in apple and pear orchards, due to the loss of bees (Melvin, 2022). Although this technique may have high levels of effectiveness in the short-term, it is not a long-term viable solution. Firstly, it can be noted that it is a long, time consuming, and strenuous process, as it requires farmers to rub pollen on every individual flower. They must repeat this process around 5 times per flower, to ensure that there is successful pollination. When considering additional limitations where hand pollination can only be executed locally, and each individual worker must be paid by the hour, it is evident that hand pollination is not a viable long-term solution. As it has been stated, hand pollination "is a bandaid, not a cure" (Melvin, 2022).

Transported bees have become a popular method of pollination in fields and greenhouses. The bees are shipped around to different countries to pollinate different areas. Although it has been found to be effective at pollination, this shipping process can be harmful to both migratory bees and wild bees and is simply not a long term solution. Initially, it puts unnecessary stress on the honey bees, which in turn has made them more susceptible to pathogens and parasites. Despite the little research that had been conducted on the effects of moving honey bees, results have shown that the process can foster the transmission of diseases and pathogens. Out of the 16 studies conducted on this topic, 12 found a significant increase of pathogens in migratory colonies (Martínez-López, 2023). The stress imposed on the moving bees reduces their overall lifespan. It was proven to have decreased up to 20% of a worker bees' foraging life. These effects are then exacerbated in bee colonies which lead to the decline of bee populations as a whole (Simone-Finstrom, 2016). In addition to this, the migratory bees are shown to have a higher rate of transmitting parasites to the organisms, mainly bees, in the areas they travel to. This results in both the health of stationary bees and migratory bees being affected. Overall, the effects of transportation on bees, particularly honey bees, has shown to decrease their health and productivity through the transmission of pathogens.

Therefore, our efforts have been focused on the bubble pollination method that can be used to continue the supply of crops and food, while research and work is put into increasing bee populations. This technique is eco-friendly, affordable, and realistic on a grander scale. Although bubble pollination has only been tested once by Dr. Miyako and his colleagues, it is a promising solution. His concept was to use bubbles, containing pollen to pollinate crops. Once blown onto a flower’s stigma, pollen bubbles can effectively deliver pollen grains onto many plants. Through his experimentation, he discovered that it shows to be quite effective in pollinating plants, specifically pear plants.

Although, there have been concerns on the environment friendly nature of bubble solutions. In Dr. Miyako's research, he was able to present a solution he made safe enough for human consumption (Giaimo, 2020). In that respect, it is eco-friendly, not only for the environment, but for any organism. Moreover, the plants “do not sustain substantial physical damage from directly shooting soap bubbles because soap bubbles are lightweight, soft, and highly flexible.” (Miyako, 2023). Therefore, the bubble solution used for pollination is safe for use on organisms, including the plants being pollinated. The soap bubbles are also affordable in that they are simply a mixture of water and soap. This makes it also applicable on a commercial scale.

Dr. Miyako’s research has shown the possibility of a new pollination method that has the potential to be used to help mitigate the current bee population loss issues. Thus, through our experimentation, we hope to see whether Dr. Miyako’s bubble pollination method will continue to be successful even when tested in different environments.

Method

The experimental portion of the project is testing the effectiveness of bubble pollination in different environments. In our experiment, we emulated Dr. Miyako’s bubble solution using his 4 g/L ratio of pollen to bubble solution, where gold glitter was used in place of pollen. The experiment was executed using fake flowers, with black painted stigmas in order to contrast against the color of transferred glitter to help detect transferred amounts more accurately using the naked eye and camera.

Our experiment consists of four different manipulated environments for the bubble gun to be used in. (1) The first environment of our experiment was controlled where no variables were drastically changed, this provided a controlled trial for each flower to understand the effectivity of bubble pollination in the best circumstances. (2) The second experiment was altered so that pollination was tested at different distances from the flowers (30cm and 60cm). (3) In the third environment, we tested the effectiveness of bubble pollination on flowers after being watered. (4) In the fourth and last experiment, the variable of wind was changed, where we tested the effectivity of bubble pollination in windy conditions. The control variables in this experiment are the bubble solution concentration and number of bubble gun triggers. Distance, wind and water are the variables being manipulated. The responding variable is the status of our flowers being pollinated (with glitter transfer) or non-pollinated (without glitter transfer).

The materials used in this experiment include: microfine glitter of 0.1mm in size, Gazillion bubble solution, 9 fake flowers, bubble gun, scale, rubber bands, test tube holder, plastic bag, black paint, paint brushes, tape, measuring tape, containers and jars. The fake flowers used consist of three different types of flowers: Tulips, Jasmines, and Asters. Three identical flowers were used for each type. Manipulated variables include the environment in which flowers are pollinated where factors of distance, wind levels, and water levels are altered. The responding variables include successful glitter transfer and its amount. Controlled variables include the angle at which flowers are pollinated, the bubble solution concentration used for each session and the amount of triggers of the bubble gun.

(1) Our hypothesis in the control scenario was that, if a glitter bubble is blown onto the stigma of a flower, then the bubble will transfer glitter onto the stigma because the pollen bubble will pop and deposit its contents after making contact with the stigma.

1. Tape plastic bag onto desk and make a mark 15 cm away from the location of the test tube stand
2. Label each set of flowers 1 through 3
3. Place flower in 2nd test tube hole
4. Trigger bubble gun at marked 15 cm location 3 times to pollinate flower
5. Check flower for glitter transfer and take a photo
6. Wash stigma with water
7. Repeat for each flower

We conducted this experiment by first laying out a plastic bag on a desk and taping it to the table. We then marked the region in which the test tube holder would be placed and measured 15 cm away from the test tube holder, which is the controlled distance where we would trigger the bubble gun. Each of the three flowers from each type set were labeled 1 through 3 in order to ensure no flower would be accidentally pollinated twice. For the tulip round of pollination, the trial 1 tulip would be placed in the 2nd hole of the test tube holder and pollinated with 3 triggers of the bubble gun. After pollination, the trial 1 tulip would be checked for pollination, photographed and washed to remove any possible transfer. This process of flower pollination would then be repeated for each flower.

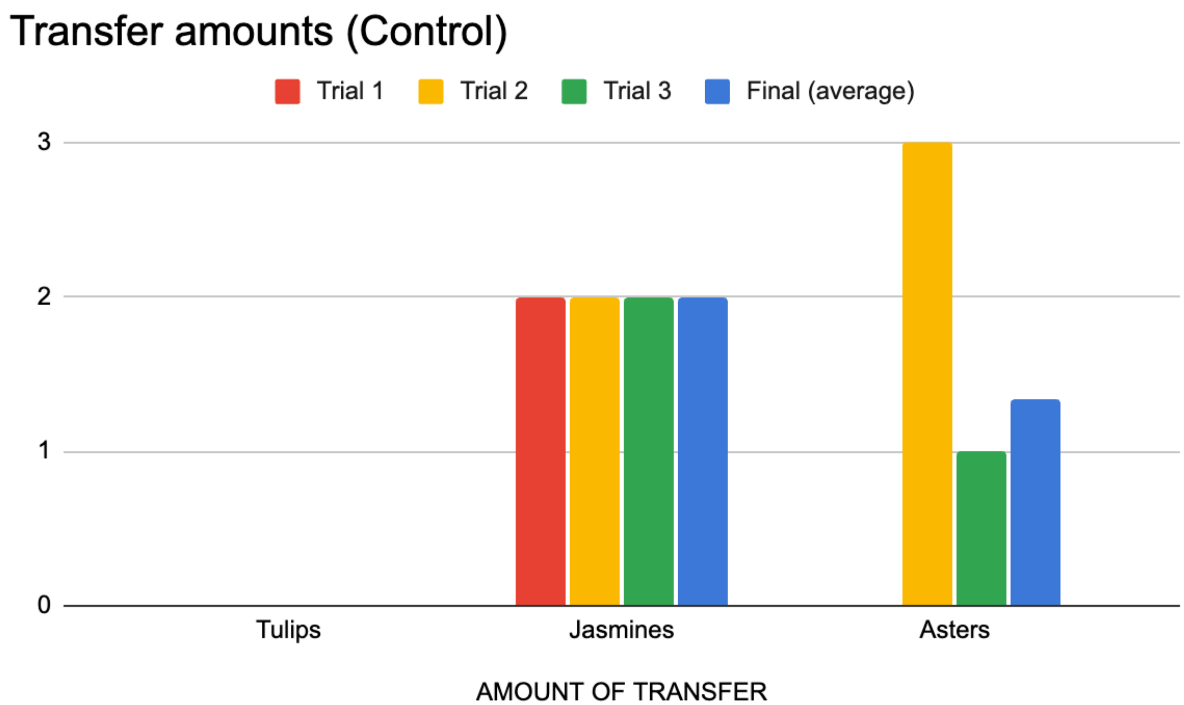
(2) Our hypothesis for the distance manipulated environment was that, if the distance away from the flower is increased, then the success rate of pollination will decrease because the bubbles will not be able to reach the stigma as easily. We conducted this experiment using the same method as described in the control variable with the only difference being the distance in which pollination was conducted at. There were two new

distances introduced: 30 cm away from the flowers and 60 cm away from the flowers. These distances were both marked out on the plastic bag using tape and sharpie.

(3) Our hypothesis for the water manipulated environment was that, if the flowers are watered before being pollinated, then the success rate of pollination will increase because the bubbles will stick onto the flower more easily as a result of cohesive forces between the soap bubble and water. The part of the experiment also followed the method described in the controlled experiment with the only difference being that the flowers were misted with water three time before pollination.

(4) Our hypothesis for the wind manipulated environment was that if the environment is windy, then the success rate of pollination will decrease since the bubble will be blown away from the flower. This portion of the experiment followed the control variable method but was conducted in a windy environment. A 10119 Model Seville Tower Fan was used on medium-low strength blowing in the same direction as the bubble gun.

Data



(1) Our hypothesis for the control variable was generally supported by our data. Transfer was recorded on jasmines and asters but not on tulips. Tulips had a 0% transfer rate with 0 glitter particles transferred. Jasmines had an average of 100% transfer rate with an average of 2 glitter particles transferred every pollination session. It is worth noting that transfer amounts in Jasmines were very consistent with 2 glitter particles being transferred every time. Asters had an average of 66.67% transfer rate with an average of 1.33 glitter particles transferred every pollination session.

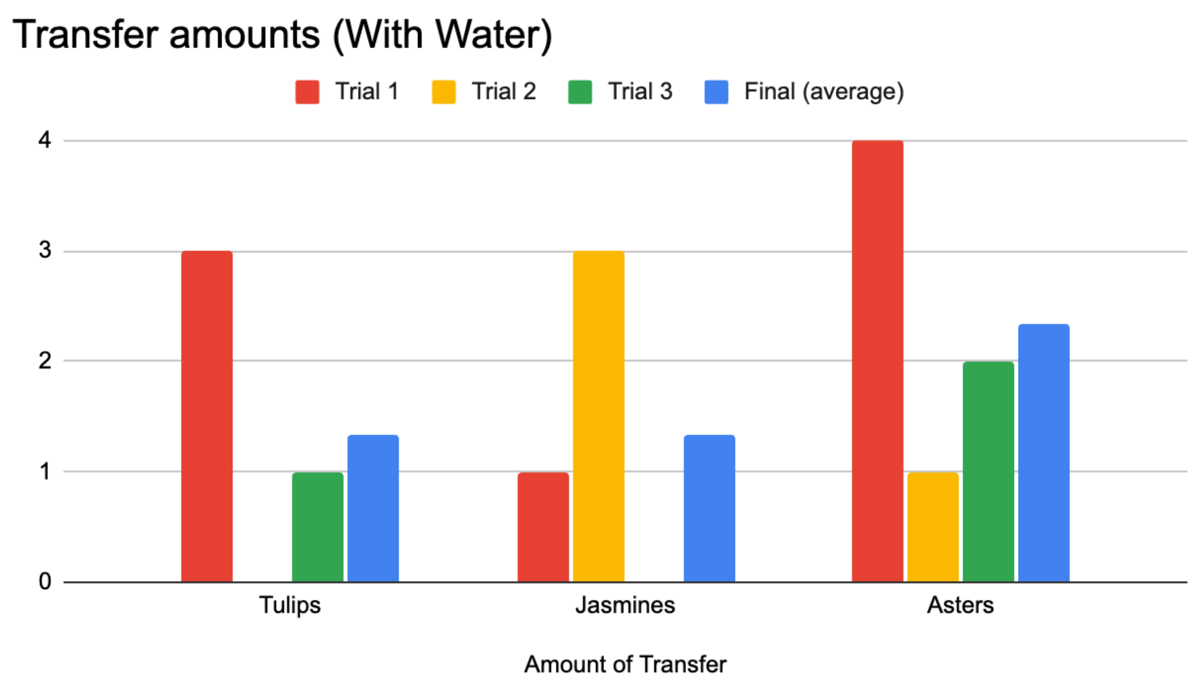
It was observed that Tulips had petals encasing their stigma which made it very hard for the glitter bubbles to make contact with the inside of the flower. Lots of glitter was observed to be on the external portions of the petals but not inside the flower which contributes to the low rate of pollination analyzed in this experiment. As for Jasmines, they were generally easy to pollinate since the flower had minimal petal interference and stigmas were plentiful. Asters were also generally easy to pollinate since there was minimal petal interference and the stigma was large and easily accessible for bubbles which contributed to successful transfer rates.

(2) Our hypothesis for the distance manipulated environment was supported in the 30 cm distance case and partially supported in the 60 cm distance case.

Figure 1 - Trial 2 Distance 30 cm for Tulips

In the 30 cm distance case, transfer was recorded on Jasmines and Asters but not on Tulips. Jasmines had an average transfer rate of 100% with an average of 0.67 glitter particles being transferred each session. Asters had an average transfer rate of 33.33% with an average of 1 glitter particle being transferred each session. Average transfer rate success was lower in Asters compared to the control and average glitter particle transfer was lower in both Asters and Jasmines compared to the controlled environment. Tulip transfer rates and amounts stayed constant.

In the 60 cm distance case, transfer was only recorded on Asters. Asters had an average transfer rate of 100% with an average transfer amount of 1 glitter particle per session. Average transfer rate success was higher in Asters, lower in Jasmines and constant in Tulips where the transfer rates of Jasmines and Tulips were 0%. Average transfer amounts were higher in Asters, lower in Jasmines and constant in Tulips where the average transfer amounts in Jasmines and Tulips were 0 glitter particles. It is possible that pollination of Asters were more effective at a longer distance since less petal interference occurred at further distances. Wind generated from the bubble gun can often blow up Aster petals and slightly block the flower from glitter bubbles. Increasing distance lessens the effects of bubble gun wind and allows for easier transfer.



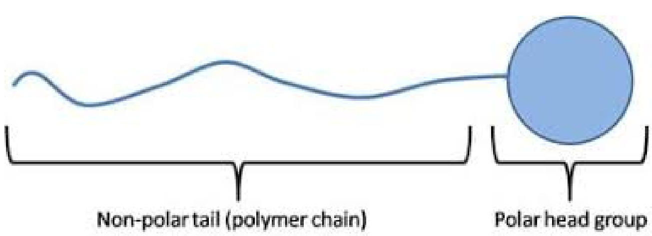
(3) Our hypothesis for the water manipulated environment was supported. Transfer amounts were recorded for all flowers. Tulips and jasmines had an average transfer rate of

66.67% and an average transfer amount of 1.33 glitter particles per session. Asters had an average transfer rate of 100% and an average transfer amount of 2.33 particles of glitter. Average transfer rates and average transfer amounts were higher in Tulips and Asters but dropped for Jasmines compared to the control.

Figure 2 - Trial 1 Water for Tulips

The water manipulated environment was particularly successful for tulips in comparison to the control. It was observed that by misting the flower, bubbles that would usually land at the top of the tulips were now able to slide into the flower when in contact

with water. This allowed the bubbles an entry way into the flower in order to pollinate the stigma.



DuPont, S., & Cates, R. (2010). [Digital Image] *The two distinct regions in an amphiphilic molecule.* Teach Engineering

Surfactants, also known as soaps, are composed of molecules with a polar head, and a nonpolar tail. They form a ring, with the polar heads facing out. Due to the polarity of the water, the soap adheres more easily. This explains our increase of pollination with the watered plants. The cohesive forces allow for higher pollination success rates.

(4) Our hypothesis for the wind manipulated variable was supported. Transfer amounts were recorded for Jasmines and Asters. Jasmines had an average transfer rate of 33.33% and an average transfer amount of 0.67 glitter particles. Asters had an average transfer rate of 66.67% with an average transfer amount of 1.00 glitter particles. Average transfer rates were lower in Jasmines and stayed constant in Tulips and Asters. Average transfer amounts were lower in Jasmines and Asters. Average transfer amounts in Tulips were consistent with the control, being 0 transferred glitter particles. The wind manipulated variable was among one of the least effective environments. It was observed that when the bubble gun was activated, bubbles were blown away from the flowers very quickly and reached well over 300 cm away from the flowers after a few seconds.

Individual Flower Data Analysis

Tulips had the best success rate and highest pollination after being watered. Due to the tulips' closed petaled nature, it proved difficult for the bubbles to enter the flower and pollinate the stigma. However, once the flower was watered, the petals became wet, and as previously stated the water and the surfactant make the bubbles stick to the flower. Where then it will pop, creating a higher likelihood of the flower being pollinated effectively.

Like tulips, the jasmines had a much higher success rate after being watered, for the same reason as the tulips. Furthermore, the distance of 30 cm also proved to increase the pollination rate. This is most likely because, if the bubble gun was too close then the bubbles would bounce off the soft petals, and too far (60cm) made it too long of a distance for the bubble to hit the stigma. Therefore, 30 cm of distance was a perfect middle ground resulting in a higher rate of pollination.

It seemed the 60 cm distance had the best effect on the Aster's pollination rate. This is most likely because its stigma is very flat and big, and the bubbles that were blown directly onto it bounced off rather than bursting on it. However, the bubbles that were blown further away from the flower, were able to lose the strong momentum and slowly float until it landed on the flower and popped. Since the stigma of the asters were much bigger, it provided more space for the glitter particles to land. Additionally, like the rest of the flowers the water was beneficial to the pollination rate of the flower. Finally, the wind factor seemed to show improvement as well in its pollination rate. Most likely , for similar reasons for its increase due to the 60 cm distance.

Conclusion

Having evaluated our experimental data, it can be concluded that the most effective environment for bubble pollination is after the plants are watered, shooting the bubbles at a distance of 15 cm away from the flowers.

With these results in mind, the best areas for the use of this pollination would be in greenhouses. As observed in the wind manipulated environment, wind hinders the bubble pollination process. These uncontrolled variables of wind and other more extreme weather in crop fields can lead to decrease the effectiveness of bubble pollination. As a result, greenhouse pollination serves as a better alternative to avoid these issues. Greenhouses also have the capabilities to allow for periodical and automated watering sessions. This makes it convenient to pollinate crops right after they are sprayed with water which increases the effectiveness of the pollination process. Additionally, the distance of pollination can also be accurately adjusted to 15 cm using technology.

In conclusion, bee population decline has shown to be a world crisis and multiple solutions have been attempted. One that has surfaced was bubble pollination; an understudied pollination method that has recently become popular for its ability to be a cost effective, environmentally friendly, and effective method in pollinating crops. Through experimentation, this method demonstrated success in controlled conditions and would be most successful when applied in a greenhouse setting.

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