Analysis of the Exportation of Bee Vectoring Technology to Nepal

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The world's population is expected to reach 9 billion people by the year 2050, placing extreme pressure on agriculture practices to create enough food in a sustainable manner (United Nations, 2013). BVT Inc. is taking many steps in the right direction to reduce the amount of pesticides used in oilseed and vegetable production (Bee Vectoring Technology, 2015).

Part I: Bee Vectoring Technology

i) What is it?

Bee Vectoring Technology uses the natural process of pollination as a delivery system of pesticides directly to the crop (Bee Vectoring Technology, 2015). The product uses Bumblebees to deliver pest controlling Vectorite as a substitute for traditional spraying methods (Bee Vectoring Technology, 2015). The bees live in a hive, as normal, but the hive has an add-on created by BVT. Their dispenser system, directs the bees to the one exit out of the hive. Bees fly through the inner tray containing the bio-pesticide powder (Vectorpak™), that sticks to their legs as they exit. The process then mimics pollination, bees fly from flower to flower, leaving behind the biological agent (Bee Vectoring Technology, 2015). The whole process is organic, reducing the amount of chemicals needed for a field, requiring no machinery, and uses no water (Bee Vectoring Technology, 2015).

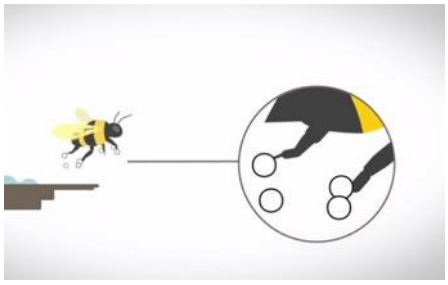

Figure 1: The inoculant contained in the Vectorpak ™ sticks to the legs of the bees as they exit the hive. When they land on the flowers, the inoculant is left on the flower.

http://www.trendhunter.com/trends/bee-vectoring-technology

Figure 2: The Bumble Bee walks through the Vectorite powder as it exits the hive. (http://www.beevt.com/media/image-library/)

Figure 3: The bees exit the hive through a one-way system, after picking up the inoculant. http://www.beevt.com/media/image-library/

Disease and Pest Prevention:

i) Clonostachys rosea

Contained in BVT's Vectorpak™, a biocontrol BVT-CR7 (Bee Vectoring Technology 2015). BVT-CR7 is a powdered form of an organic strain of a fungus that is commonly found in nature, *Clonostachys rosea* (Bee Vectoring Technology). *Clonostachys rosea* (C. *rosea*) can be used as a pesticide to fight against grey mold, a common disease in fruits cause by *Botrytis cinera*, that can result in loses of 50% (Jarvis, 1962). This disease has been a serious pathogen threatening soft fruit since 1914 (Jarvis, 1962). In many plants, the fungus infects the floral organs, invading the fruit through the stamen and/or stigma (Yu et al, 1997). This results in the most damage being done to the plant during flowering (Cota et al, 2008). The signs of Botrytis are not apparent until ripening, where it covers the fruit in a grey, fuzzy, mold (Cota et al, 2008). This has caused growers to adopt a calendar spraying system, where they spray for diseases or pests often, regardless of if the pest or disease is present (Bee Vectoring Technology,

Figure 4: The physical effects of Botrytis at ripening. (Bee Vectoring Technology, 2015).

2015). *C.rosea* targets the grey mold directly, suppressing sporulation on the reproductive organs of the plant, and growing to fill the gap where the fungus might grow (Kapongo et al, 2008). Within hours of application, the *C.rosea* spores germinate and form a barrier between superficial plant cells (Bee Vectoring Technology, 2015). Any spores that fall off, or don't make it to the flower, germinate and have the same effect on the leaves (Bee Vectoring Technology, 2015).

Figure 2 shows the results of a study done by Cota and his colleagues (2008) on the ability of *C.rosea* to suppress Botrytis in more flowers. It showed *C.rosea* to be more effective in controlling Botrytis than Captan (a fungicide) (Cota et al, 2008).

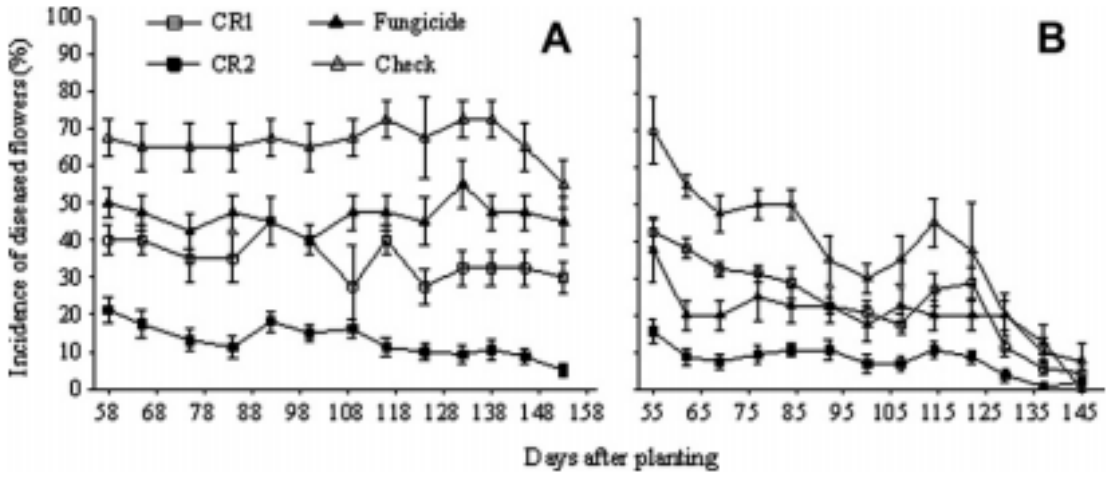

Figure 5: The average of four tests of C.rosea were conducted. In one test, C.rosea was applied once, and another twice a week, another was tested with fungicide (captan), and a check (water sprays) (Cota et al, 2008).

ii) Pest Prevention

Bee Vectoring Technologies is currently researching ways of integrating a pest control ingredient into the Vectorite powder (Bee Vectoring Technology, 2015). The system has been tested to incorporate more than one type of inoculant so it can be personalized to the needs of the field and crop (Bee Vectoring Technology, 2015). Some consideration has been put into the addition of *Beauveria bassiana* to *C.rosea* (Bee Vectoring Technology, 2015). There have been trials done that have shown this inoculant to be successful in the control of pests (Kapongo et al, 2008).

Effects on Bumble Bees

Bees are a necessity to the success of many crops across the globe, but they are beginning to decrease in population (Bee Vectoring Technology, 2015). This can be because of habitat loss, pathogens, climate change, etc, but a major player is agrochemicals (Potts et al, 2010). Pesticide use is resulting in the loss of a large percentage of bee populations (Potts et al, 2010). When sprays are used on a field the bees go to pollinate and get the chemicals on them, bringing them into the hive (Bee Vectoring Technology, 2015).

BVT uses bees that are commercially reared, and bred specifically for the job of pollination and dispersal of the product (Bee Vectoring Technology, 2015). The bees do not consume the product, only carry it around to the flowers (Bee Vectoring Technology, 2015). Bumble bees forage regularly regardless of delivering the inoculant, therefore the delivery system follow the natural process of pollination (Yu et al, 1997). The set-up of the Vectorpak™ protects the rest of the hive from contamination (Yu et al, 1997). The inoculant is only in the Vectorpak™, which they only pass through as they leave the hive, so bees aren't exposed to the inoculant for long periods of time (Yu et al, 1997). If a spray needs to be applied to the field, a cover can be put in place to only allow the bees to enter the hive, not exit (Bee Vectoring Technology, 2015). Thus protecting the bees from the chemicals (Bee Vectoring Technology, 2015).

Traditional Spraying Methods vs Bee Vectoring Technology

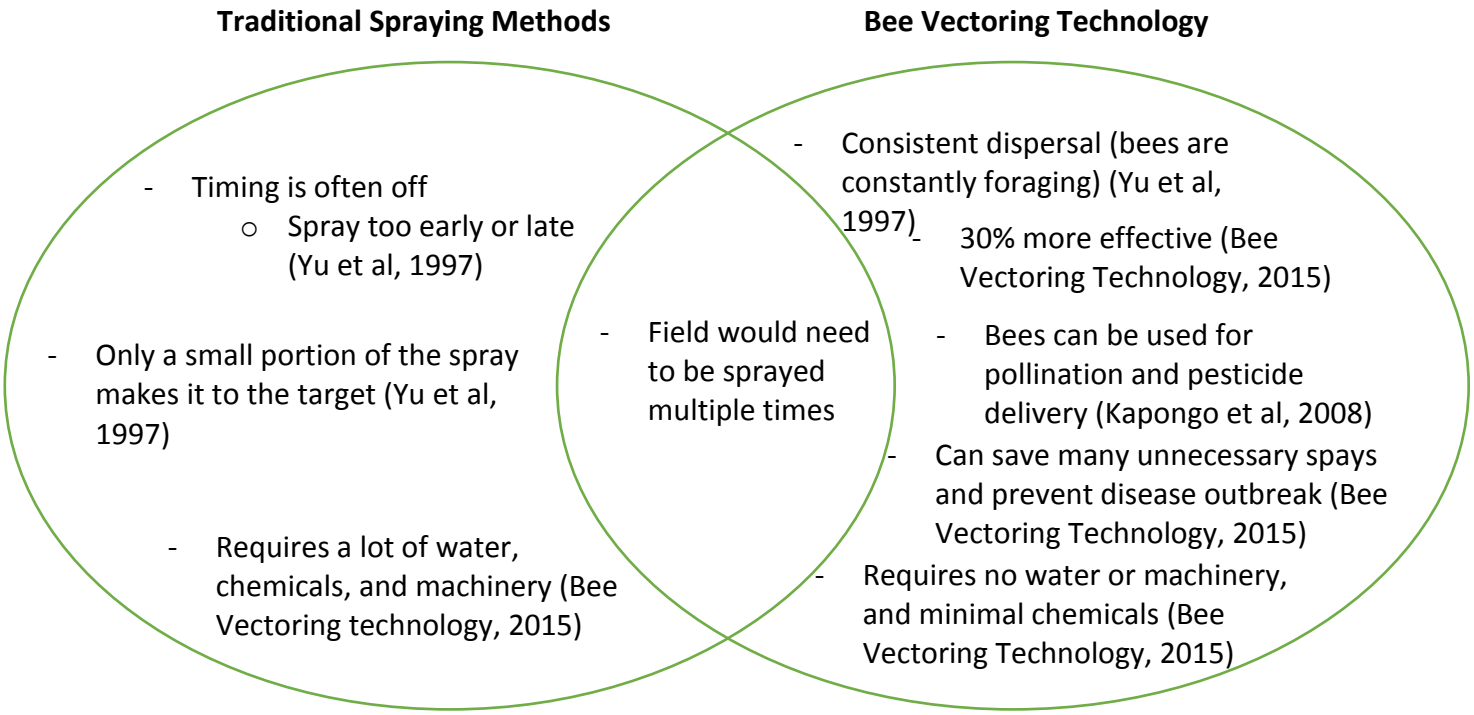

Figure 6: A comparison between tradition spraying methods and the BVT system.

Benefits

Bee vectoring follows a natural process which results in a low impact on the environment (Bee Vectoring technology, 2015). There is no machinery or water required for the process, and very little chemicals used (Bee Vectoring Technology, 2015). The use of pollinators to deliver the inoculant not only reduces the pressures of pests and pesticides on plants, but also improves pollination (James et al, 2008). It has also been seen to result in higher yields because of the improved seed quality and germination (James et al, 2008). The better quality of the fruit results in a longer shelf life which decreases the amount of food waste (Bee Vectoring Technology, 2015). Farmers to be able to minimize their use of sprays with the product, resulting in less water usage, and decreased amounts of chemicals that make it into the waterways (Bee Vectoring Technology, 2015).

Manufacturer

Bee Vectoring Technology is only made by Bee Vectoring Technologies Inc. which is a Canadian company based in Mississauga, Ontario (Bee Vectoring Technology, 2015). The company recently opened a state of the art facility in Mississauga where their research and production occurs (Bee Vectoring Technology, 2015). This facility will allow the production of $100 million dollars worth of product in a year (Bee Vectoring Technology, 2015).

Production

In creating the Vectorpak™, large quantities of the *Clonostachys rosea* are produced in the BVT lab and put into the plastic Vectorpak™ container and sealed (Bee Vectoring Technology, 2015). To make the dispenser systems, it costs about $2 CAN to produce (personal communication, November 28, 2016). Since Bee Vectoring Technologies Inc. is still an up and coming company, there is no set cost for the product if bought by a farmer (personal communication, November 28, 2016). Usually farmers that are interested in the product, have bees of their own already, but some bees come from other bee suppliers in that area (personal communication, November 28, 2016).

Figure 7: One step in the process in producing the product. The Vectorite powder is being placed into the Vectorpak™(Bee Vectoring Technology, 2015).

Patent restraints

Bee Vectoring Technology has applied for patents in about 40 countries around the world (Bee Vectoring Technologies Inc., 2016). This includes three patents; the dispenser system, the Vectorite™ brand, and the active ingredient required for the product (BVT-CR7) (Bee Vectoring Technology, 2015). The company has recently gained 2 of 3 patents in the U.S, and is awaiting the result of the third patent for the active ingredient in the system (Bee Vectoring Technologies Inc., 2016). The company has gained approval for the patents in Canada, China, Russia, and

Australia, and is awaiting the results from the other countries (Personal communication, November 28, 2016).

Benefits to Canada

i) Creation of Jobs

Though there are only about 6 people employed at the facility in Mississauga at the moment, the company has tremendous potential to expand. At their new state of the art facility in Mississauga, many scientists, researchers, and other employees will be hired as the company grows to make and research the product (Bee Vectoring Technology, 2015). The Canadian company will be able to produce $100 million of BVT products in a year (Canada NewsWire, 2015). In 6 months BVT raised $4.2 million to go toward the new facility, sales, and marketing (Canada NewsWire, 2015). Also, the production of this product would benefit the transportation industry (ie. Trucking). With the Vectorpak™'s needing to be replaced every few days in the flowering season, the company will need to be continuously making product, as well as the trucking would need to be transporting the product. Additionally, this would contribute to Canada's GDP and support domestic production of products.

ii) Strengthen Trade Relationship Between Canada and Nepal

Canada and Nepal, for a long time have had an established relationship (Government of Canada, 2013). Trade and investment between the countries are modest (Government of Canada, 2013). Exports from Canada to Nepal was $7.1 million, and imports from Nepal accounted $11.7 million (Government of Canada, 2013). Canada mainly exports machinery, paper, vegetables, etc to Nepal with particular interest in energy equipment, irrigation and engineering, transportation, etc (Government of Canada, 2013).Though Bee Vectoring Technology does not fall under any of these main categories, adding this technology to the list of Canadian exports would help continue to build strong trading ties with Nepal (Government of Canada, 2013).

Part II: Export Potential to Nepal

Nepal is a landlocked country, located between India and China with a population of 29 million people (Central Intelligence Agency, 2011). It is a rectangular shaped country that has an area of 147,181 km^2 (Central Intelligence Agency, 2011). The terai, hill, and mountain region make up Nepal's landscape (Figure 5) (Nepal Economic Agriculture, and Trade Activity, 2011). Agriculture accounts for 21% of the land, and employs 66% of the population of Nepal (Nepal Economic Agriculture, and Trade Activity, 2011). Since agriculture accounts for 36% of Nepal's GDP, it is a major contributor to the country's economic development (Nepal Economic Agriculture, and Trade Activity, 2011). The capital of Nepal is Kathmandu, with a population of 1.1 million (Central Intelligence Agency, 2011).

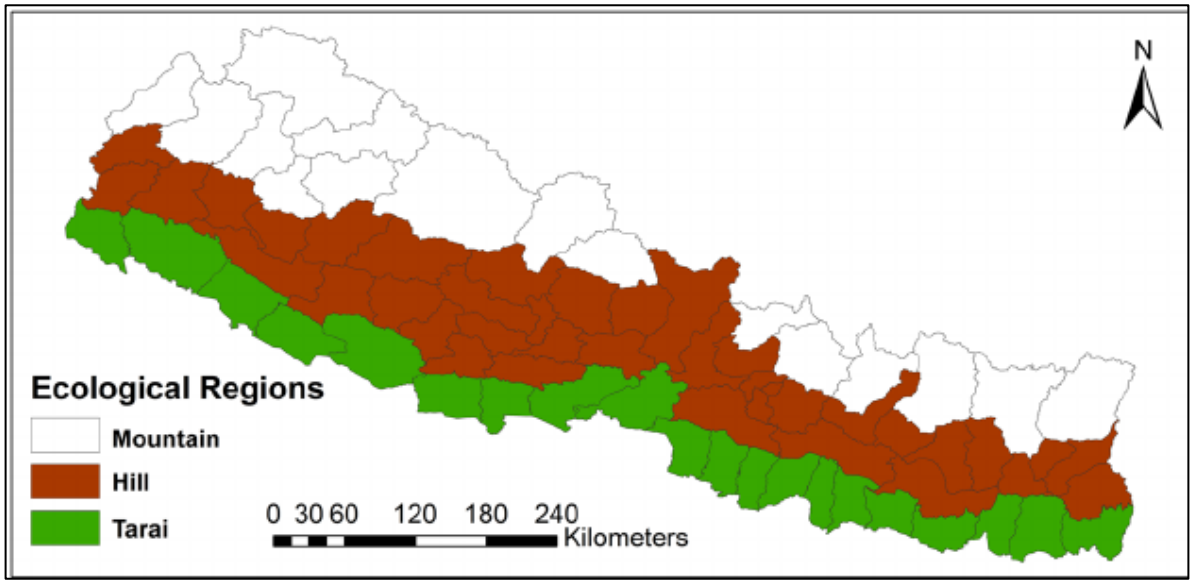

Figure8: The variations in the topography of Nepal; terai, hill, and mountain regions.
https://www.researchgate.net/figure/281202065_fig1_Figure-1-Ecological-regions-in-Nepal

Vegetable Production in Nepal

i) Overview

Vegetable production in Nepal has rapidly increased over the last 10 years, using 7.3% of the total land, accounting for about 14% of the country's GDP (Nepal Economic Agriculture, and Trade Activity, 2011). In the last decade some farmers have started to move away from the staple crops, such as rice, maize, etc (SAMARTH, 2015). Horticulture crops have become an important and popular aspect to Nepalese agriculture not only benefiting the commercial farmer, but also low income citizens (Ghimire et al, 2013). Approximately 69% of all households in Nepal are involved in vegetable production, however the majority are small production, growing on less

than 0.5 hectares (SAMARTH, 2015). The major off-season crops in Nepal are cauliflower, tomatoes, cucumber, cowpeas, etc which are grown in the terai and hills region (Ghimire et al, 2013). The terai region produces and sells the most vegetables, though the hill region vegetables are more profitable because they're grown in the off season (Ghimire et al, 2013). The high nutritional value of vegetables is very beneficial to human health but they are not consumed as much in Nepal because of the imperfections in production, and cost (Singh et al, 2013). A large portion of the vegetables produced are transported to cities and towns such as Kathmandu, where there is a large market (SAMARTH, 2015).

ii) Pesticide Use

Pesticide use in Nepal is a major concern for human health and the environment (Tiwari et al, 2008). Many pesticides that are older and more toxic are still being used in developing countries, Nepal included (Atreya, 2007). A current priority to Nepal is to find a new way to get the pesticides to the plant in an environmentally friendly manner (Palikhe, 2002). Many farmers know of the environmental and health impacts, but continue to heavily apply pesticides to their crops (Tiwari et al, 2008). Around 35% of crops in Nepal are damaged or lost because of pests and storage means, which causes Nepalese farmers to result to excessive use of pesticides (Palikhe, 2002). Vegetable production is known to a use the most pesticides when compared to the other crops (Bhatta et al, 2010), with many studies have showing how the vegetable industry is indiscriminate in its pesticide use (Tiwari et al, 2008). As the intensification of production increased, pests and diseases did as well resulting in the need for larger quantities of sprays (Bhatta et al, 2010), with only 50% of chemicals applied making it to the target (Ranga Rao et al, 2009). Pesticides that are applied heavily or inaccurately can result in pest resistance, increase water, air, and soil pollution, and also cause carcinogenic effects on human health (Palikhe, 2002). The effects on human health through the consumption of these vegetables and crops have been researched, finding that the direct and indirect exposure leads to pesticide residues in milk and blood (Ranga Rao et al, 2009). With pesticide consumption increasing by 10-20% each year, and vegetable production becoming a more prominent industry, Nepal is going to be seeing major environmental and health impacts (Diwakar et al, 2008).

How BVT Can Help

i) Decrease Pesticide Use

Bee Vectoring Technology has the potential to help greatly reduce the amount of pesticides used as well as deliver the pesticides in a more targeted, efficient manner. In Nepal, 35% of crops are damaged or lost because of pests and storage means, causing farmers feel the need to apply a larger amount of pesticides on the crop (Palikhe, 2002). The use of bee vectoring technology has been tested and shown to increase crop quality and yields by >10% (Bee Vectoring Technology, 2015). This would decrease the amount of produce grown in Nepal, allowing for a greater income to Nepalese farmers. The BVT system uses 0.5 kg per acre per season, compared to the 7.5kg of chemicals in traditional methods (Bee Vectoring Technology, 2015).

In Tomatoes for example, studies have shown that consumers, are more willing to pay 10% more for pesticide free tomatoes, which would benefit Nepalese farmers if they had a means of growing pesticide free crops (Bhatta et al, 2009). The use of the BVT system organically uses bees to continuously apply the inoculant to the flower throughout the who flowering season, only transporting a small dose at a time to get decrease the amount of waste (Bee Vectoring Technology, 2015). Many diseases that target crops, cause the plants to not show physical signs until it is too late (Bee Vectoring Technology, 2015). A study by Kapongo et al (2008) was conducted to evaluate the success of bee vectoring, and found that the *C. rosea* innoculant was found in 82% of the tomatoe plants tested. Tomatoes being one of the most popular off-season crops being grown in Nepal, could potentially benfefit from this technology, similar to Kapongo's (2008) findings.

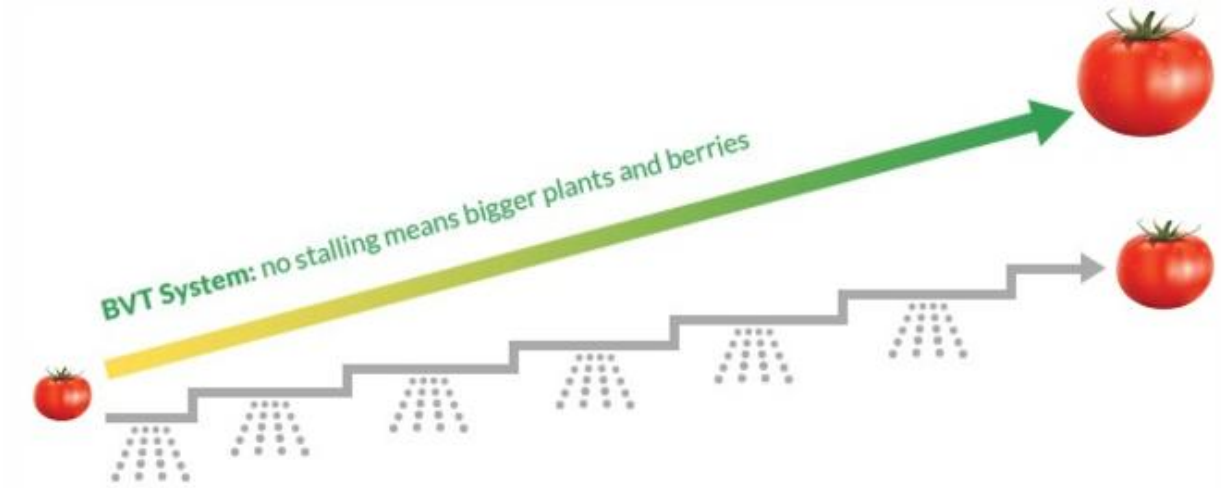

Figure 9: Comparison of the BVT system to traditional spraying methods. [http://www.beevt.com/crops-we-help/tomato-mold-botrytis/)](http://www.beevt.com/crops-we-help/tomato-mold-botrytis/)

ii) Environmental Benefits

The BVT system has been designed to require, no water or machinery, and greatly reduce the use of pesticides on the crops (Bee Vectoring Technology, 2015). The dispensing method uses 0.5 kg per acre as opposed to 7.5 kg per acre used by traditional spraying (Bee Vectoring Technology, 2015). This minimizes the amount of pollutants that make it into water ways (Bee Vectoring Technology, 2015). The process mimics pollination to deliver the inoculant directly to the plant (Bee Vectoring Technology, 2015). The use of bee vectoring allows the plant to be constantly regenerated with the inoculant, instead of spraying on a calendar schedule (Cota et al, 2008). The whole process allows farmers to be able to minimize their use of sprays, resulting in

less water usage, and decreased amounts of chemicals that make it into the waterways (Bee Vectoring Technology, 2015).

Transportation.

Table 1: A layout of the transportation steps and prices to get the BVT technology to Nepal.

Step #1: FedEx	**Step #2: A1 Freight Forwarding (Air Freight)**
From BVT, Mississauga, ON, CAN → A1 Freight Forwarding Warehouse, Maple, ON, CAN via: FedEx FedEx 25 kg box containing ~50 Vectorite™ trays **Base Rate: $**49.21 CAN **HST:** $6.48 CAN	**From Maple, ON, Canada → Kathmandu, Nepal via: A1 Freight Forwarding** FedEx 25kg box containing ~50 Vectorite™ trays **Base Rate:** $330.93 CAN **HST:** $43.02 CAN
TOTAL: $56.29 CAN	**TOTAL:** $373.95 CAN
GRAND TOTAL: $430.24 CAN (35,280.10 NPR)	

The product does not require refrigeration unless it is anticipated that the package will reach very warm temperatures. In which case, cool packs would be sent. Overall, the trip would take about 5-7 business days. Once the product got to Kathmandu, Nepal, it would then be picked up by either a member of the community, or Trans Nepal Freight Services Pvt. LTD to be taken to a community or co-op.

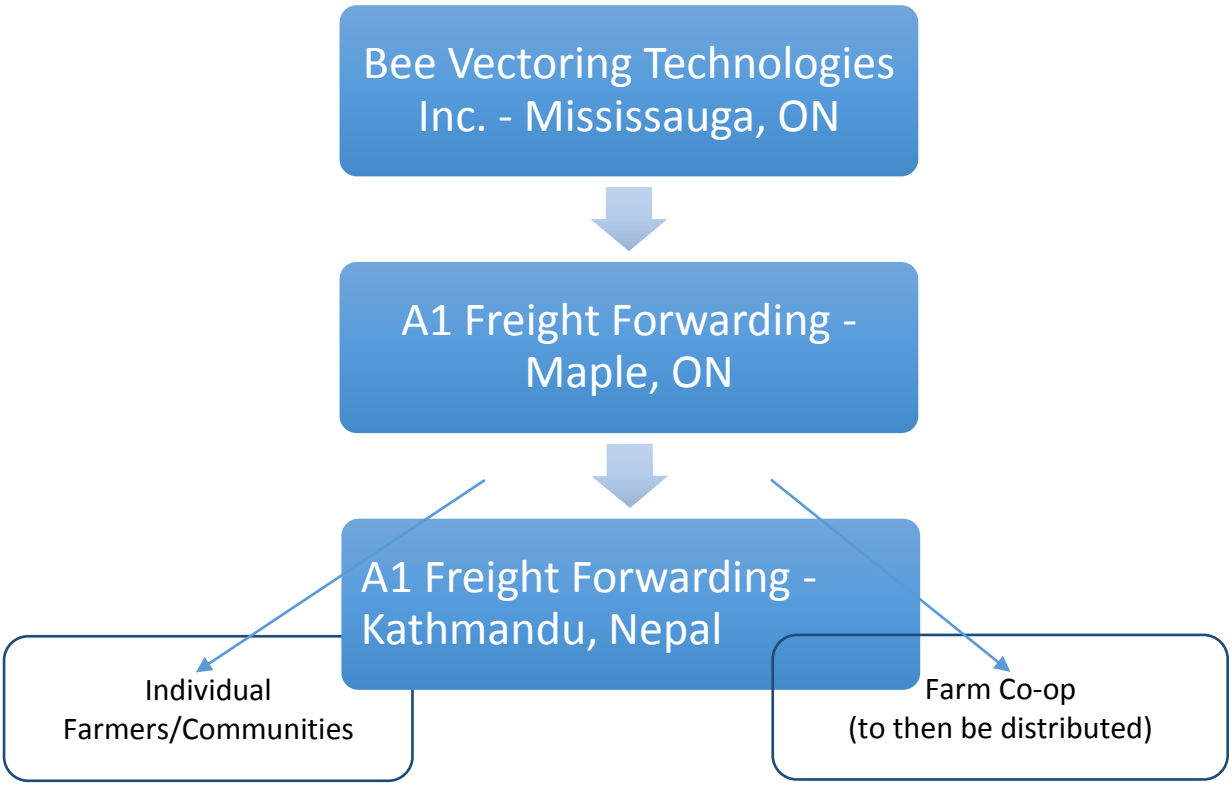

Figure 10: A visual representation of the pathway the product would be taking to get to Nepal.

Cost Analysis

Bee Vectoring Technologies Inc. is a young company that is still building up and establishing their identity (Bee Vectoring Technology, 2016). Because of this, there is no set cost per unit, or for a large order (personal communication, November 28, 2016). The cost to produce the item is ~$2 per tray (personal communication, November 28, 2016). To use the product on a field, would not cost any more than what farmers already pay to spray crops traditionally (personal communication, November 28, 2016).

The cost of the product depends on a few different factors; the crop, the duration of flowering season, etc (personal communication, November 14, 2016). The longer the flowering season, the longer the product is needed for the crop (personal communication, November 28, 2016). Strawberries in Canada for example, have a 6 month growth rate, which would require the BVT system for 1 month (personal communication, November 28, 2016). Different crops would have different lengths in the flowering period which would result in different prices (personal communication, November 28, 2016).

Market Analysis in Nepal:

This product could be very beneficial to vegetable farmers, as well as other crop producers in Nepal. Though vegetable farming in large amounts for market only take up 18% of total vegetable producers, the product would promote changes to the large producers that use tremendous amount of pesticides (SAMARTH, 2015). Many vegetable farmers only have about 0.5 ha of land that is used for vegetable production (SAMARTH, 2015). There is a service set up in Nepal called the payment for ecosystem services (Khanal et al, 2013). This program is designed to help farmers that support and practice sustainable agricultural practices, by providing them incentives (Khanal et al, 2013). Of the farmers that are aware of the hazards of pesticides, 80% are willing to pay the contribute toward PES (Bhatta et al, 2010). This program promotes sustainable agricultural practices, specifically through decreased pesticide use (Bhatte et al, 2010). There is potential for BVT to become a contributing method that helps promote less pesticide use in vegetable production.

Marketing Strategy

To market the product, since it is still an up and coming technology, there could be trials done in Nepal to show farmers how the product works, and that it can work better than their current methods (Bee Vectoring Technology, 2015). This could benefit the company itself in developing their product to different ecosystems, and also Nepalese farmers, giving them a method of decreased pesticide use. Larger vegetable producers should be marketed to first, conducting trials or purchasing the product. Pesticides were first introduced to Nepal in small amounts, and when people saw the effects, pesticides became a widely used product (Diwakar, 2008). By bringing Bee Vectoring Technology into Nepal, it will reduce the amount of pesticides used, thus reducing the environmental impact, and reducing health risks (Bee Vectoring Technology, 2015). The introduction the product through running trials it will educate and introduce the idea to Nepalese farmers, without having to have a salesman going door to door to support the product.

Competitors

The only competitor with Bee Vectoring Technologies Inc. is Biobest's Flying Doctor (personal communication, November 28, 2016). This product does the same thing as BVT's dispenser system, using bees to deliver a bio pesticide directly to crops (Biobest, n.d). The company based out of Belgium, supplies not only the dispenser system but also the bees themselves (Biobest, n.d). Biobest has been in the bee business for 25 years, and have developed many different methods for pest control (Biobest, n.d). There was no price displayed for the Biobest product either, because of the many factors that go into the total price. This company has been in the bee business a long time and has a presence on the bio pesticide stage (Biobest, n.d).

Figure 11: http://www.ipmsupportethiopia.org/index.php/145-flying-doctors-biological-fungicides-now-available-in-holland

i) Contact Info

Biobest	**Bee Vectoring Technologies Inc.**
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Documentation Requirements

Table 2: List of the required documentation to import a product to Nepal (International Trade Administration, 2016).

Required Documentation For Import Clearance
- Customs Declaration Form - Certificate of Origin - A package that is clearly marked and correctly labeled - Copy of export license - Commercial invoice - Foreign exchange declaration form - Airway bill - Authorization Letter

Recommendations and Conclusion

As BVT continues to grow and establish as a company, it will become more suitable for export to Nepal. Unless there are trials done in Nepal to show the producers the benefits, and educate them on the product and method itself, it is unlikely that the product would ever take off in Nepal. In Nepal 55% of the population is below the poverty line, earning as little as $1.25 a day (Singh et al, 2013). This product, though the cost is unknown, may be too expensive for a vegetable producer in Nepal. Lastly, the documentation required to send the BVT dispenser system to Nepal, needs to be researched further as BVT continues to gain patents in other countries.

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