Proposal for the Export of a Canadian Neem Oil-Based Insecticide to Nepal

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Introduction

This paper outlines the advantages of potentially exporting a Neem oil-based insecticide from Canada to Nepal. Currently, the manufacturing of any Neem oil related insecticides is banned in Canada, due to an issue in policy over registering the components of Neem Oil. This subject will be addressed however, the potential benefit a Neem oil insecticide could have will also be evaluated for both countries. The paper will outline the advantageous characteristics of Neem, the product itself, and any benefits for the countries involved. Additionally, the methods for manufacturing, costs, and transportation will be evaluated in depth. In analyzing the product, conclusions will be made as to whether or not this product would be a sufficient export for the improvement of Nepalese agriculture.

Part 1: Outline of Product and Benefits to Canadian Agriculture

Neem Oil Background

Neem oil is a product of the Neem tree, an evergreen tree that is native to India and other Southeast Asian countries (Schmutterer, 1990). The Neem tree possesses the ability to grow in various climates and soil types including clay, alkaline and stone soils (Atabani et al., 2013). The tree has also been adapted to higher temperatures and can withstand temperatures ranging up to 49 degrees Celsius in regions of low rainfall between 150 and 250 millimeters (Girish and Bhat, 2008). The tree reaches maximum productivity around 15 years of age and can live to be between 150 and 200 years old

(Atabani et al., 2013). Oil can be obtained from both the leaves and the seeds with the leaves growing up to 30 centimeters in length (Schmutterer, 1990). The seed can provide oil through extraction from the kernel with the seed yielding between 20 and 30 percent oil in weight (Atabani et al., 2013). Furthermore, the trees can be propagated through seeds or cuttings making for easy transplantation (Atabani et al., 2013).

Azadirachtin for Pest Control

Neem oil contains the secondary metabolite Azadirachtin, a chemical with a variety of insect repellent properties in the pest control of up to 350 species (Girish and Bhat, 2008). Azadirachtin has the ability to control growth and food intake, specifically by causing birth defects in larvae during metamorphosis, as well as delayed growth, mortality, and infertility (Schmutterer, 1990). This paper will focus on the effects of Azadirachtin on the rice weevil, rice brown plant hopper, and mosquito varieties as these pests are native to Nepal and will pertain to the use of the product to be introduced later.

Both the rice weevil and the rice brown plant hopper are pests that target rice crops by attacking the base of the plant and competing for plant nutrients (Kartohardjono and Heinrichs, 1984). Research has shown that when rice crops were applied with Neem oil, the rice brown plant hoppers exhibited reduced food intake and less than 50% of the population survived the spray application (Saxena et al., 1984). In Southeast Asia, mosquitoes are also of major concern for pest control as they not only cause a reduction in agricultural yields, but also pose health threats to the human population (Vatandoost and Vaziri, 2004). In mosquitoes, studies have shown that when Neem was applied to rice crops, larvae births and breeding were reduced, with an 80-100% reduction over the study period (Dua et al., 2009). In addition, the application of the oil possessed the ability

to weaken the larvae's' immune system by making pathogen transfer more difficult, an effective strategy for disease vector control (Dua et al., 2009). Other traits that have been observed include, decreased egg hatchability and shortened life span both which could be due to the antifeedant properties possessed by Azadirachtin (Ascher, 1993).

Uses of Neem Oil in Industry

Aside from being used as an insecticide, other parts of the Neem tree have been used for agricultural and forestry purposes. In forestry, the bark and wood obtained from the tree have been used in afforestation and fuelwood production (Koul et al., 1990). Neem wood is commonly used as the main material in furniture production, as a source of fuel for heating, and as a material in infrastructure foundation as the bark is termite resistant (Koul et al., 1990; Girish and Bhat, 2008). Additionally, Neem cake, the solid extract in oil production, can be used in crop production as the cake can be applied to the base of a crop to act as a natural fertilizer as it adds nutrients to the soil and can increase nitrogen fixation in the roots (Girish and Bhat, 2008). Other agricultural uses include planting Neem trees to act as a shade cover for crops and in livestock production as the leaves can be fed to buffalo, sheep, and camel as feed (Girish and Bhat, 2008).

Oil Components and Environmental Impact

In comparison to other oilseeds, Neem trees yield about 2,670 kg of oil per hectare whereas other oilseeds such as the rubber tree and the castor tree yield 50 kg of oil per hectare and 1,188 kg of oil per hectare respectively (Atabani et al., 2013). The seed kernel yields approximately 45% oil which in weight is 2.5 kg (Koul et al., 1990).

When considering the environmental impact of the growth and production of Neem oil, one benefit that has been scientifically proven is that Neem is completely non-

toxic to humans; therefore any applications on crops for human consumption would have no negative health impacts (Isman, 1997). The growth of the Neem tree is environmentally friendly as the tree has an increased capacity to release high quantities of oxygen (Raval et al., 2003). Additionally, the seeds, leaves, bark and seed cake from Neem are biodegradable and can act as natural pesticides, supplying additional nutrients to any crops applied with the oil (Isman, 1997). The application of Neem does not impact the survival of native pollinators and as well can maintain the ecosystem balance as Neem favours natural predators, therefore, it will not introduce new pests into the environment (Isman, 1997).

Health Benefits

In addition to pest control, Neem is also effective in the prevention and control of diseases such as HIV, and certain cancers (Roy and Saraf, 2006). Neem also contains many antimicrobial and anti-inflammatory compounds to combat diseases such as malaria, and bronchitis **(**Girish and Bhat, 2008). In chemotherapy, Neem has been used as it contains limonoids, which are naturally occurring chemicals that inhibit the growth of breast cancer cells and can also stop the production of neuroblastoma cells (Roy and Saraf, 2006). As previously mentioned, Neem is also effective in controlling pest populations of mosquitoes, a benefit to the control of malaria, a disease that is affecting millions worldwide (Roy and Saraf, 2006). Neem has also been used in inhibiting the replication of HIV-1, the gene that transmits HIV (Roy and Saraf, 2006). Certain soaps and shampoos also contain Neem as the oil contains a high quantity of fat, which is ideal for production purposes (Ahmed and Grainge, 1986).

Table 1: Breakdown of Neem Components based on Medicinal and Biological Properties (Girish and Bhat, 2008)

Table 1. Some bioactive compounds from neem [25].

Neem compound	Source	Biological activity
Nimbidin	Seed oil	Anti-inflammatory, Antiarthritic, Antipyretic, Hypoglycaemic Antigastric ulcer, Spermicidal Antifungal, Antibacterial Diuretic
Sodium nimbidate		Anti-inflammatory
Nimbin	Seed oil	Spermicidal
Nimbolide	Seed oil	Antibacterial Antimalarial
Gedunin	Seed oil	Antifungal Antimalarial
Azadirachtin	Seed	Antimalarial
Mahmoodin	Seed oil	Antibacterial
Gallic acid, (–) epicatechin and catechin	Bark	Anti-inflammatory immunomodulatory
Margolone , margolonone and isomargolonone	Bark	Antibacterial
Cyclic trisulphide and cyclic tetrasulphide	Leaf	Antifungal
Polysaccharides		Anti-inflammatory
Polysaccharides GIa , GIb	Bark	Antitumour
Polysaccharides GIIa , GIIIa	Bark	Anti-inflammatory
NB-II peptidoglycan	Bark	Immunomodulatory

Table 1 provides data with respect to specific components of Neem and the variety of medicinal properties including anti-inflammatory, antibacterial, spermicidal and immunomodulatory properties (Girish and Bhat, 2008).

Product and Company Overview

Prior to the ban of Neem oil in Canada in 2012, Ultra-Bio Logics Inc., a Canadian company based in Chateauguay Quebec, was manufacturing Neem oil insecticides. The manufacturing company that employs between 20-50 employees at a time, produces insecticides, livestock feed additives, and soil modifiers (Ultra-Bio Logics Inc., 2013). Their product, Neem Azadirachtin was a Neem oil-based insecticide from seed kernel oil

extraction (Ultra-Bio Logics Inc., 2013). The insecticide can be applied to crops such as rice, wheat, sorghum and maize and is typically applied four times annually (Primal Group, 2016). The insecticide existed as a foliar spray that could be applied to seedlings between 15-18 days after germination and was sold in quantities ranging from 500 mL to 210 L (Ultra-Bio Logics Inc., 2013). Although this product is banned in Canada, the data assembled for this paper is based on similar Canadian products and as well draws a comparison to Neem oil products in the US as the country has not placed a ban on any Neem derivatives. Additionally, processing methods were determined based on information obtained on the Ultra-Bio Logics website as the information regarding the product still exists online.

Extraction Process

The method used by Ultra-Bio Logics to process the Neem oil insecticide was a combination of mechanical pressing and solvent extraction. Table 2 outlines three commonly used methods of oilseed extraction as it pertains to Neem oil specifically. It should be noted that oilseed extraction is sensitive to temperature as high manufacturing temperatures can degrade oil quality (Ofori-Boateng et al., 2012). High temperatures during production can increase saponification, peroxide content and pH making the oil more acidic and in addition can decrease iodine content (Liauw et al., 2008). Mechanical extraction with a solvent is more efficient than simply using mechanical extraction, as the action of applying the solvent after pressing allows for a higher quantity of oil to be extracted (Rosenthal et al., 1996).

Table 2: Comparison of Oilseed Extraction Methods; Mechanical Pressing, Supercritical Fluid Extraction, and Solvent Extraction

Type	Oil quality and yield	Process and equipment	Other Details
Mechanical pressing	The oil produced is cloudy and contains a high proportion of water and metals, with oil yields of 75-85% (Liauw et al., 2008; Ofori-Boateng et al., 2012). Oil quality can also be lowered by a loss of heat to the surrounding environment due to friction (Ofori-Boateng et al., 2012).	Extraction is done using a screw press or an oil expeller and requires the use of technology such as an acidic or enzymatic material to weaken cell walls prior to extraction (Mercer and Armenta, 2011).	This method of extraction is the most commonly used and has been used for centuries, originating in Greece for the purpose of extracting olive oil (Ofori-Boateng et al., 2012). This method has a very low investment cost yet a high operational cost for the replacement of machinery (Ofori-Boateng et al., 2012).
Supercritical fluid extraction	This method extracts between 36-43% of oil content (Bulley et al., 1984). Additional purification using gasses such as CO_2 removes any impurities and gumming materials, yielding a high concentration of raw material (Bulley et al., 1984).	Material for extraction is placed in an apparatus such as the Soxhlet with the solvent added in small amounts (Hedrick et al., 1992; Reverchon, 1997). CO_2 is often used as a solvent material as it is completely non-toxic and does not require intense pressure or temperature conditions for extraction (Reverchon, 1997).	This type of extraction requires a large amount of power for processing and time, up to 72 hours (Hedrick et al.,1992). Additionally, it is non-toxic as there is no requirement of organic solvents for extraction, which leaves harmful residues. (Mercer and Armenta, 2011). In terms of cost, this method is relatively cheap as it costs less to obtain the gaseous solvent (Bulley et al., 1984).

Solvent Extraction	Oil contains lower solid components however, the oil produced is not as pure as that of supercritical fluid extraction. This method extracts 99% of oil content (Liauw et al., 2008; Ofori-Boateng et al., 2012; Mercer and Armenta, 2011).	Extraction requires the use of an organic solvent, with the most common choices being n-hexane or ethanol (Johnson and Lusas, 1983). The solvent is mixed with the seed and then extracted using a centrifuge (Ofori-Boateng et al., 2012).	In the past decade the cost of obtaining the n-hexane has increased 6-8 fold making this process expensive along with the operational costs (Johnson and Lusas, 1983).

Figure 1: Breakdown of Steps in Oilseed Extraction Using Mechanical Extraction with Solvent (Rosenthal et al., 1996; Lamsal et al., 2006; Ofori-Boateng et al., 2012)

Table 2 outlines the processing steps required for the production of oilseeds through mechanical extraction using a solvent. The seeds are typically washed first to remove impurities and then are dried to remove moisture (Rosenthal et al., 1996; Ofori-Boateng et al., 2012). The process of flaking is not always compulsorily used in manufacturing, however, it is recommended to provide uniform seed shape (Lamsal et al., 2006). After the extraction is done, further filtration is used to ensure that no large solid components remain in the oil (Rosenthal et al., 1996; Ofori-Boateng et al., 2012).

Benefits to Canada

The introduction of Ultra-Bio Logics' Neem oil insecticide to Nepal could benefit Canada primarily through the creation of jobs in addition to Canada's international trade. Based on 2013 data, Canada imported $11.7 million dollars worth of Nepalese imports in comparison to only $7.1 million dollars of Canadian exports to Nepal (The Government of Canada, 2014). By exporting the insecticide, this could benefit Canada by balancing the imports and exports between the two countries, in turn positively impacting Canada's economy. Due to a financial recession in 2009, the number of Canadian exports decreased from $480 to $420 billion dollars, which could have contributed to low exports between Canada and Nepal (Export Development Canada, 2012). In the last decade the export of manufactured goods has fallen from 68% to 53% however, this can also likely be correlated to the 2009 recession (Export Development Canada, 2012). If the product were to be distributed on a larger scale, this could create the potential for business expansion for Ultra-Bio Logics Inc. increasing the number of jobs available to Canadians and lowering the unemployment rate. In addition to stimulating the economy, the increased production of Neem oil insecticides would create an opportunity for research

and development of Canadian agriculture. At the Quebec Research and Development Centre there is a focus on developing crop systems for the Canadian climate and in utilizing an association such as this, Ultra-Bio Logics Inc. could potentially increase sales for both international and national consumers in addition to creating a product that is multi-functional for increasing crop yields in varying climates.

Competition in Canada

There is only one Canadian company currently selling Neem oil for agricultural use however, it is not available for purchase in Canada. Terramera Inc. is a British Columbia-based research and development company that produces a Neem oil insecticide for purchase in the US and internationally (Terramera Inc., 2016). Recently, Terramera Inc. acquired the Indian-based company Plasma Neem that is used as the manufacturer for the product (Terramera Inc., 2016). The advantage of manufacturing the insecticide in India is that it would be more cost effective, as it could be directly distributed from the plant, which requires minimal transportation. On the other hand, the use of an international manufacturer significantly decreases opportunity for Canadian employment and therefore contributes little to the development of Canadian agriculture.

Marketing Strategy

When considering a marketing strategy for this product, it is first important to consider the consumer preferences in Nepal. In terms of agriculture, many farmers are looking for solutions to combat climate change and are willing to use technology in order to increase crop yields and limit water loss (Chhetri et al., 2012). Based on 2004 statistics, 60% of Nepalese rice farmers have only a basic education whereas 20% do not have any education at all which indicates a need to increase educational support in the

country's agri-food system (Dhungana et al., 2004). The highest input cost for farmers is land, with the second highest input cost being human or mechanical labour (Dhungana et al., 2004). The average worker gets paid 65.52 rupees per person per day, which is roughly 0.81 cents Canadian (Dhungana et al., 2004). With increased pest control there is less required physical labour as research has shown that rice farmers can reduce the physical labour required by 24% and still maintain the same level of production (Dhungana et al., 2004). Farmers often purchase fertilizers and insecticides but often do no know how to use them properly or to the full extent, as they are afraid of the potential risks that the use of these products could have on their production outputs (Dhungana et al., 2004). When insecticides are marketed to developing nations, there is often a false perception that there are no alternatives to the products that a company is trying to sell which in turn uses fear to sell the product (Palikhe, 2002).

For this product specifically, it would be ideal to educate the targeted customers, in this case, rice farmers in Nepal, on the properties contained in Neem oil and how they could benefit crop production. As traditional marketing cannot be used to target farmers in rural Nepal, marketing could be done through farmer groups or associations that promote international products for implementation on a large scale. Organizations such as PACT (Project for Agriculture Commercialization and Trade) in Nepal could be used as a platform to promote the product as they work to improve Nepalese agriculture but also could help eliminate the fear that is often felt with respect to the use of fertilizers and insecticides. On the Canadian side of the business, the company could employ Nepalese-Canadians to work as salespeople to go to Nepal to promote the product which would not

only employ Canadians but would also convey trust in the customers by creating a sense of familiarity and understanding.

Part 2: Export Strategy for Nepal and Benefits to Nepalese Agriculture

Introduction to Nepal

Nepal is a small landlocked country located between India and China (Karki and Gurung, 2012). The population of Nepal is extremely poor with 25% of the citizens living on less than $1.25 US dollars daily (Karki and Gurung, 2012). The country is comparable to the size of Arkansas with 140,800 square kilometers of land (Baral et al., 2003). Agricultural land is divided into three regions; the Terai region, the Hill region and the Mountain region with the Terai region accounting for the majority of the agricultural land (Shrestha et al., 2007). Agriculture is particularly important to Nepal as it employs over 80% of the population and accounts for 42% of the GDP (Upadhyaya et al. 1996).

Concerns for Nepalese Agriculture

There are many problems regarding agriculture in Nepal as of late, with the majority of these problems arising as a result of an increase in population. A larger portion of the population is opting to live in urban regions directly impacting the agricultural sector and the country's economic stability (Malla, 2008). The increase in population has also resulted in higher emissions of greenhouse gasses with methane emissions rising by 3% a year (Malla, 2008). Furthermore, the overall temperature is also rising with a recorded increase of 1.8 degrees Celsius in the past 32 years (Malla, 2008). In addition to the environmental impacts of a rising population, there has also been an increase in food insecurity as a byproduct of drought, flooding, and nutrient depletion impacting crop production (Palikhe, 2002). Pests and pathogens are able to live longer

and can thrive in different climatic regions, for instance, recently it has been discovered that certain mosquito varieties have had an increased ability to live in the Hill region due to favourable climate (Malla, 2008). Nepalese agriculture loses up to 35% of crop production due to pests, which could also be due to insufficient use of resources (Palikhe, 2002).

Figure 2: Projected Temperature and Precipitation Patterns for Southeast Asia from 2071 to 2100 (Shreshtha and Aryal, 2011)

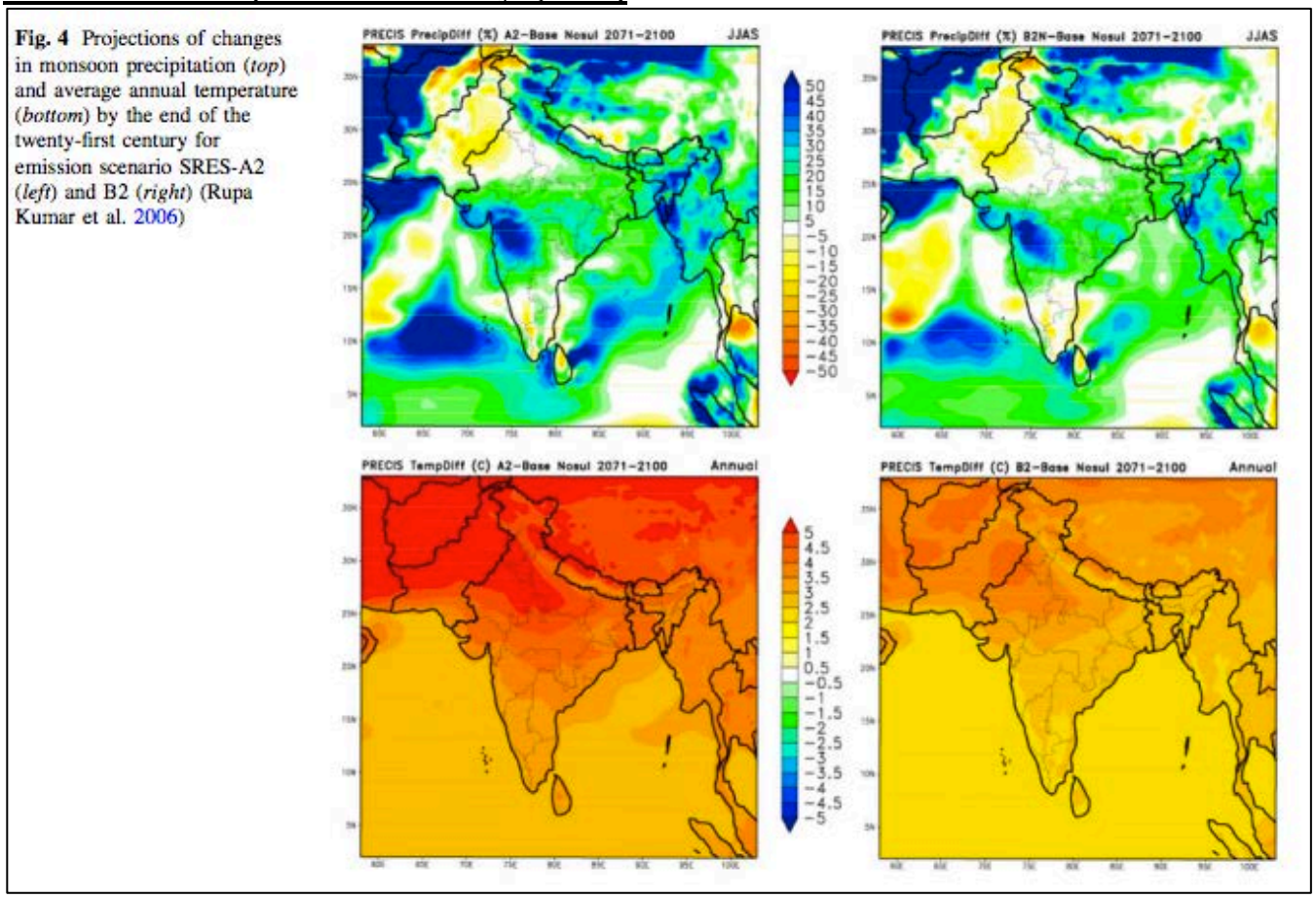

Fig. 4 Projections of changes in monsoon precipitation (*top*) and average annual temperature (*bottom*) by the end of the twenty-first century for emission scenario SRES-A2 (*left*) and B2 (*right*) (Rupa Kumar et al. 2006)

It can be observed based on Figure 2 that the average temperature and precipitation is projected to increase significantly in Southeast Asia over the next 100 years (Shreshtha and Aryal, 2011). Temperature could increase by as much as 5 degrees Celsius in direct correlation with precipitation, which is predicted to decrease to 20% annual rainfall in Nepal (Shreshtha and Aryal, 2011). It is necessary that Nepalese

agriculture develop methods to combat climate change in the form of drought and pest resistant crops, which is why a Neem oil insecticide could be favourable.

Advantages and Target Consumers for Neem Oil Insecticide

As previously mentioned, this product would be beneficial to the Nepalese for a variety of reasons. Neem oil is able to withstand severe drought, infertile soils and will significantly reduce pests by application (Upadhyaya et al. 1996). The product's heat resistant capacities would be favourable to increase yields of crops such as rice and wheat, both staples in Nepal, in turn meeting the needs of the food insecure nation. Neem oil insecticides come from a completely renewable source with both the oil and cake from extraction possessing the ability to decompose (Koul et al., 1990). The oil contains polysaccharides, which provide additional energy to increase crop growth and as well can be used to control the transmission of diseases such as malaria or rice seedling infections (Koul et al., 1990).

The target consumers for this product would be rice farmers living in the Terai or Hill regions, as the climate in these regions would be ideal for insecticide productivity as the insecticide can be applied to crops in arid regions with low soil fertility. Pests that are targeted by Neem oil are less likely to develop resistance as the oil contains multiple different control functions to manage pest populations (Govindachari, 1992). A Neem oil insecticide could replace the use of synthetic pesticides that can be toxic to the farmers that work with them (Girish and Bhat, 2008). Studies have shown that synthetic pesticides are the cause of up to 220,000 deaths per year as a result of misuse or dangerous exposure levels (Girish and Bhat, 2008).

Rice Farming in Nepal: Overview

Rice farming is extremely important to Nepalese agriculture as it is the number one agricultural sector and employs a large portion of the population (Upadhyaya et al. 1996). Rice is grown on 1.5 million hectares in Nepal, which is approximately half of the agricultural land and supplies over half of the dietary energy for the population (Dhungana et al., 2004). Additionally, research has shown that the application of Neem oil insecticides on rice crops has increased yields by 22 to 24% (Saxena et al., 1984). Neem also possesses nitrogen fixation properties with studies proving that rice crops applied with Neem showed a 10 fold increase in nitrogen fixation, a property that is ideal for nutrient accumulation in the roots (Saxena et al., 1984; Koul et al., 1990).

Neem Oil Source and Manufacturing

The insecticide would be manufactured at the Ultra-Bio Logics plant however, it is unclear as to whether their previous manufacturing processes required a Neem oil extract or Neem oil that was obtained directly from trees grown at the facility. Assuming the trees were grown on site, it would require a minimum of 15 years for the trees to reach productivity at which point the seeds can be harvested for oil production (Schmutterer, 1990). Seed propagation can occur as early as 9 to 12 months in the nursery and can then be transferred to the field through transplanting (Koul et al., 1990). The climate in Canada would be appropriate for growth of the trees, as they possess the capacity to grow at low temperatures between 50 m to 100 m in altitude (Koul et al., 1990).

Cost Analysis and Export Pathway:

Table 3:Manufacturing Costs for Ingredients and Equipment (Alibaba, 2016)

Name of Equipment	**Estimated Cost (Quote)**
Wash machine for seeds	Between $2,900-$5,300 to process 7,500 kg/hour.
Industrial Oven	Between $2,878-$6,896 to process 300-500 kg. This machinery can reach temperatures of between 50-150°C using steam.
Flaker	Between $10-$1,500 to process 180-520 kg.
Mechanical Press	Between $2,000-$3,000 to process 400-800 kg/hour. The machinery has the option to extract with or without heat.
Organic Solvent (n-hexane)	Between $10-$50 depending on the required amount for processing (options for 1, 25, and 100 kg packages).
Receiving Tank	Starting at $1,000 to hold upwards of 100 L although there are more expensive alternatives with larger capacities.
Centrifuge	Starting at $1,000 to hold upwards of 1500 kg of liquid.
Filter	Between $500-$900 with a holding capacity of 150 kg.
Neem source (either seeds or extract)	Seeds: $20-40 Extract: $50-200

As this product is currently not in production, the assumption was made that the product was produced on a small scale, with no more than 1,000 L of insecticide being produced daily, although this assumption cannot be confirmed or denied as Ultra-Bio Logics would not provide any information on previous manufacturing practices.

Transportation Costs and Pathway

To approximate costs for transportation, a comparison was made between a 3 L container of Wilson's Home Pest Control Insecticide, which is sold in Canada. The dimensions for the 3 L container had to be adjusted from 4x9x10 inches at 11 pounds to 5.3x12x13.3 inches at 15 pounds to account for a 4 L container, as it would make more sense for a farmer to purchase a large enough quantity to apply for an entire year. A crate could be transported from the manufacturing facility to Montreal-Mirabel International

Airport via Services De Port Quad City Inc. a freight distribution company based in Chateauguay Quebec. It would cost approximately $302 to transport a crate from Montreal to Kolkata via air freight through A1 Freight Forwarding (A1 Freight Forwarding, 2016). After arriving in Kolkata, the rest of the transportation would depend on the preference and location of the customer in Nepal. One option could be to use FedEx to transport from Kolkata to Kathmandu however, this method is expensive, as it would cost around $824 in Canadian dollars to transport 150 pounds, around 10 containers per crate (FedEx, 2016).

Application Costs

The average Nepalese rice farm is approximately 1.56 acres (Dhungana et al., 2004). When considering the cost per 1 L of insecticide, the price is around $13.40 Canadian or 1067 Nepalese rupees, the conversion being based on the data seen in Table 3 (Primal Group, 2016). In terms of application, it costs around $60 Canadian or 4780 rupees per acre and the insecticide is applied at a 0.5 L/acre rate (Primal Group, 2016). The insecticide is applied 4 times a year; therefore, the overall cost is around $480/per year Canadian if the average farm is 2 acres meaning 38,985 rupees. The GDP per capita in Nepal is $958.70 Canadian making the product expensive for the average Nepalese farmer (The Government of Canada, 2015).

Ban on Neem Oil in Canada

In 2012 there was a ban placed on the import and export of Neem oil and related products due to the fact that Neem oil was never registered as a pesticide in Canada (Celli, 2016). According to the Canadian government, there were never any submissions regarding Neem oil as a pesticide, therefore no data analysis could be made to conclude

whether or not any related products would be safe within Canadian chemical parameters (Celli, 2016). There is however, a Canadian Neem oil product being sold by the name of TreeAzin, which is produced by Bio Forest Canada and is used specifically for the control of the invasive Emerald Ash Borer (Celli, 2016). It is likely that this product is exempt from Ontario's Cosmetic Pesticide Ban Act, as the chemical is not applied to crops that could be consumed by humans; therefore, the acceptable levels of toxicity are higher (Celli, 2016). It costs around $250,000 US to register a new insecticide ingredient and Neem oil insecticides were easily accepted for they contained harmless components to consumers (Isman, 1997). In Canada, a question of standardization is asked, as the process of simply proposing a new ingredient for an insecticide or fertilizer requires the screening of each component, a lengthy and costly process (Isman, 1997).

International Competition

As Neem oil is still available in the US, a comparison can be made to similar products sold in the US and internationally. Internationally, National Exports Private Ltd. is the only company in Nepal to be selling Neem oil, however; the product does not come as an insecticide and is sold through a private wholesaler (National Exports Private Ltd., 2016). In India, there are multiple companies manufacturing Neem oil including Apex International, a company that sells a Neem oil insecticide for between $2-7 US dollars with the price varying based on the quantity purchased (Alibaba, 2016). In the US, there are also a variety of companies selling Neem oil insecticides including the patented Neemix® product from Certis USA (Certis USA, 2016). Safer Brand is another company that sells a Neem oil insecticide with their product BioNEEM® costing around $14.99 US dollars per 16 ounces which is around $30 per acre in US dollars (Safer Brand, 2016).

The price indicates that it costs around $30 less to buy Neem oil in the US compared to in Canada making any products distributed from the US more competitive and more preferable for overall cost.

Conclusion and Recommendations

In conclusion, it is not recommended that this product be exported to Nepal, as the overall cost would outweigh the benefits. Although this product shows benefit for aiding agricultural yields to combat food insecurity in Nepal, the customer would have to pay almost $1,000 Canadian (CAD) as an additional cost to simply ship the product which in retail value would only be around $60 CAD for the product itself. The insecticide would be highly beneficial to increasing crop yields and regulating pests however it is unlikely that a struggling farmer would have the means to be able to afford the product unless it was funded by the government. On the other hand, if the ban were to be lifted in Canada, this could result in research and development opportunities not only for international export products but also for Canadian agriculture. Research would need to be done to investigate more cost efficient ways to sell and transport the product in order to be beneficial to both countries.

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