AGR 1110 Nepal Project

Using micropropagation as a potential solution for the deforestation problem in Nepal

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Part I:

Nepal is currently facing a forest degradation by 1.7% annually, which is above the Asian, or even Global average (MFSC, 2008). The cause of the increase is due to logging, cultivation, agricultural expansion, encroachment, urbanization and industrialization (Leo et al., 2008).

Technology such as plant tissue culture could be highly beneficial for areas in need of plant growth and reforestation, using a process called Micropropagation. Micropropagation is the practice of quickly multiplying plant material using plant tissue to produce a large number of plants by in vitro method (Ahuja, 1993). AgriForest Bio-Technologies, based in Kelowna, British Columbia, is a company with a goal to supply their customers with tissue culture plants surrounded by top quality (AgriForest Bio-Tech).

Plant tissue culture technology has become a method of commercially breeding plants (Dodds, 1985). Tissue culture is simply a technique that involves exposing plant tissue to nutrients, hormones, and lights under sterile, in vitro conditions in order to produce a large number of new plants, all a clone of the mother plant. This allows for large production of different plants in a short amount of time (AgriForest Bio-Tech). The process of plant culture into plants can be divided into five stages: (1) selection and pre-treatment of suitable plants, (2) initiation, (3) exposure to culture for multiplication/proliferation of explants, (4) shooting and rooting of the plants and (5) weaning and hardening. The first stage is proper maintenance and management of the mother plants under conditions that are free of disease, insects and dust. The second stage is called the initiation stage. The plant tissue is established by in vitro by sterilizing and introduce it to culture. This can be done by the sterile instrument technique or surface

sterilization technique. The third stage is the multiplication stage. The in vitro plant tissue is re-divided and put into plant growth regulators. This leads to the reproduction of several shoots and is repeated until the number of plants wanted is fulfilled. The fourth stage is the root formation stage. Hormones are introduced to promote rooting and plants can fully grow (AgriForest Bio-Tech). Plants with strong, sturdy roots are a must for the plant to survive in the future. This stage requires the most labour, accounting for roughly 35-75% of the total production cost. The final stage is the weaning or hardening stage where the micropropagated plants are hardened gradually in a high to low humidity and a low to high illumination environment. The plans are then left in shade for 3-6 days to allow adaption to a new environment (IAEA, 2004). In 2000 square feet, millions of plants are able to be grown, which would take 20 acres to do conventionally (Steeves, 2005).

First, a well-designed facility is required to carry through these functions. To start up a micropropagation facility could cost more 1.3 million U.S. dollars or more. Since the establishment requires different systems to support a future successful company (Altman, 1997). The facility must provide media sterilization, cleaning, preparation, adequate storage, controlled environment for plant growth and an examination space for the plant cultures (White, 1965). Since plant tissue cultures are handled in a lab environment, various types of microscopes, fume hoods, incubators, plant growth chambers and refrigerators are some general necessities (Dodds, 1985).

Micropropagation abour and its associated costs are rather high. At AgriForest Bio-Tech, some of the positions available are Research and Development, Laboratory Production, Marketing and Sales and Greenhouse Production. Plant tissue culture results in cost savings for growers due to growing space, labour and time reduction to yield a product (AgriForest Bio-

Tech). Growing countries in Asia such as China and India want industries that are labour-intensive to ensure more employment opportunities (Altman, 1997), creating an industry that could have potential over there.

It will benefit the small Canadian company, and allow them to grow from their current 18 employees (Centre for Small Business Financing). Since the process of Micropropagation is labour intensive, more jobs would be available with the expansion of the technology. This technology and production of the product also does not impact the environment, but instead could have a great positive impact on the future of our environment. Also, more than just the biotech company is involved in the exportation of the product.

Part II:

The AgriForest Biotech Inc. ship their products in two different ways. For smaller orders, they ship using Greyhound or UPS. The small orders are packaged in custom boxes. With larger orders, they use common and safe transporters. With the larger orders, the plants are packaged on wooden pallets, which are then plastic wrapped. The plantlets are shipped at the purchaser's expense (AgriForest Biotech). The plantlets would then be shipped by plane or boat, though plane would be the best option. Some main shipping companies such as AllCargo Express Inc. are located by the water in Richmond, British Columbia (AllCargo Express Inc.). The plantlets could be transported from Kelowna to Richmond using a truck, and from there it could be shipped to Nepal in larger containers by air or water. According to Fedex Corporation, to ship a small container overseas would cost roughly 20,000 dollars depending on service type. Thousands of plants could be packaged in one container, allowing for efficient and easy transferring from one area to another. Once the plantlets reach the destination, the right storage

environment is needed to preserve the genetic stability, quality, viability and ability for photosynthesis. The plants should be stored in darkness, with some light stimulation and between 4-5°C. They are able to be stored in those conditions for about 2 months (Kubota *et al.*, 1996). For these plantlets to reach forests of Nepal, trucks could be used to get to those areas. Whatever regions are not accessible by truck, would have to be reached by human action. However, extra care must be taken when handling these plants. Plant losses during shipping is possible, especially when the plantlets are not fully hardened and rooted (IAEA, 2004).

Globally, the biotechnology business is around 150 billion U.S. dollars. Micropropagation makes up about 10% of that, with annual growth rate of 15%. The agri-business sector makes up about 50-60% of the total (Govil and Gupta, 1997). In developed countries there is a pause in the industry, since there are difficulties in finding cost-effective production. However, in developing countries, the wages are lower and plants are produced at cheaper rates. For example, in India the micropropagation industry has expanded exponentially from 5 million capacity to 190 million in an 8 year period. The micropropagation industry there started almost a decade later than main western countries such as the Netherlands and U.S. Since the North American and Europe are considered as the big competitors in the industry, there is not heavy competition for this technology in Nepal, but instead there is actually a global demand for this technology (Govil and Gupta, 1997). Since 1995, the market has entered China, resulting in plant tissue culture production increase by 14% in Asia (IAEA, 2004).

Plant tissue culture has the potential in increasing production in the agriculture industry and creating rural employment, and this is known by both policy makers and investors in the developing countries. The cost of the facilities and micropropagated plant production is high and the return on investment is not in line with the economic advantages. This problem could be

tackled by standardizing the agronomic practices to more precise practices and earning the highest profits for the crops (IAEA, 2004). The price is high to not only get this business started, but to run the operation, creating many limitations for this technology to adapt in Nepal. Unless, some kind of funding is put in place to start up a facility, the chances of the large, successful biotech business being established is not particularly high (IAEA, 2004).

The planting of trees have a large amount of benefits for Nepal and its people. As much as 93% of people depend on agriculture, while another 66% depend on the forests to supply them with their daily needs in order to survive (Adjikari *et al.*, 2004, Amatya and Newman, 1993). However, the deforestation problem has resulted in lack of necessities, medicinale plants, erosion of the soil, landslides, floods, lake and reservoir siltation and increase in peak water flow and decrease in the minimal water flow (Nepalese Ministry of Forests and Soil Conservation). In **figure 1.,** it highlights some of the determinant associated with the deforestation in Nepal (Holden *et al.*, 2013).

In Nepal, it is estimated that firewood is deficit at 2.6 million tons and timber is deficit at 0.25 million cubic meters every year. The ratio of firewood demand to supply is around 2.3:1in some areas, while other areas it is 4:1. It the routine for locals to walk all day to collect a load of firewood, with 1.13 hours per day in total labour for the collection for their daily needs (Nepalese Ministry of Forests and Soil Conservation).

Deforestation also encourages flooding and landslides causing human and animal death and damage to millions of homes. Every year, 300 lives are lost, 8600 homes are torn and 12,000-15,000 hectares of workable farmland is washed by these environmental factors (Nepalese Ministry of Forests and Soil Conservation).

Agriculture has been steady in Nepal with no real increase in production in the industry, even though effort has been put on improving those circumstances. Generally, old animal bedding and dung are used as compost to fertilize the fields, but these are now also used as a way to cook food. With the decrease in crop fertilization, the yield has decreased. It is also estimated that for farming to be sustainable on the hills of Nepal, more forests are needed to supply the local residents to retrieve enough fodder and leaf matter to increase overall production of the fields (Nepalese Ministry of Forests and Soil Conservation).

Deforestation also leads to loss of biodiversity, whether it is in the ecosystems or in the communities. The number animal and plant species are decreasing as a result, particularly in the plant category. Even though the species may still be present in that environment, the genetic variance would most likely still be decreasing (Nepalese Ministry of Forests and Soil Conservation).

As much as deforestation affects the physical environment, the problem also affects the culture and heritage of different people of Nepal. For example, the people in the Himalayas used to take their sheep and yak to different areas in Nepal for trading cereal, salt and clothes. But since deforestation has become a wide problem, different trading routes have to be mapped in order for those animals to have enough to graze. These people have to change their trading methods and adjust their lifestyle to fit the changing surroundings (Nepalese Ministry of Forests and Soil Conservation).

The forest in both Nepal and India have moved forest ownership to local communities that are responsible for maintaining the forests in their area. These forest community groups in Nepal are known as FUGS (forest user groups), which has become widespread throughout the

country. By 2009, about 1/3 of Nepal was involved with the group and ¼ of land has been put into the local hands of the people. That results in 14,439 forest user groups that are responsible for 1,229,669 hectares of forests. The average community forest size is 83 hectares, which provides for 116 households. Forest sizes under 100 hectares sustains roughly 63% of households, whereas the other 37% of households manage forests bigger than 100 hectares. These forests supply the local demand for different products such as firewood, grass and leaf matter, biggest one being firewood. The forests supply roughly 70% of the needed firewood for the locals. In a year, one household consumed 334kg of firewood, 16cu ft. of timber, 887kg of grass and 863kg of leaf matter. The class of the households resulted in little difference as to how much forest resources were used. It has been concluded that there is inequality with the distribution of the forests in these communities (Sharma, 2009).

These groups have allowed the members to create rules and regulations for the use of the forest for firewood and fodder, as well as promoting reforestation. Many studies have taken place on the impact of the forestry communities on using forest resources. Since establishing FUGS, there has been an overall 10-20% reduction in firewood use (Baland and Mookherjee, 2013). Even though the program has been successful, the success is only limited to certain areas of the country. About 90% of people that are involved with FUGS live in the hill area of Nepal, and 10% live in the Terai area (Holden, 2013). That being said, there is a basis for reforestation efforts in the country, with more emphasize in maintaining the current state and allowing locals to have power over their land. With the use of micropropagation, more emphasis could be laid on increasing and improving Nepal's forest structure. The target for the products could be these forest user groups and the resource-rich farmers. These people know the land, know the environment and the best way to grow vegetation. There are always those growers that are

prepared to risk investment in the high overall potential of the plants, if it means more advantages for the locals. For example, hybrid seeds of many crops cost 15-20 times more than the price of ordinary varieties. Yet there is a wide market for them, even in developing countries (Nepalese Ministry of Forests and Soil Conservation).

To ship any product, documentation is required to have access to a country. Nepal is listed as one of Asia's most open and trade dependant countries (World Bank Group). The shipments are also assessed for duties and taxes, according to the government of the importing country. The duties and taxes are put in place to retrieve revenue, protect local companies and industries against foreign competition. It could be based on the following: product value, trade agreements, country in which it was made, product use and the Harmonized System (HS) code. The duties and taxes must be paid before the goods are released in some countries. Typically when shipping a product the following customs documents must be attached: shipper's export declaration, origin certificate and commercial invoice, along with clearance documents. The export declaration must be the most recent version to avoid any government penalties. The Commercial Invoice must include a detailed description of the product, value, quantity, country in which it was made and total shipment value. The total shipment value must consider the duties, handling fees, taxes and other charges associated with customs. Each country has different requirements. Some countries may also require the original invoice, contract, packing list, shipper or supplier signature and power of attorney. Any documentation should be in English or have an English translation (Fedex Corporation).

AgriForest Biotech Inc. partners with several different groups in order to expand their research and production of more plant species. The company is supported by the Canadian Forestry Service and the B.C. Ministry of Forests. Together, they have carried out a project to

develop coniferous trees that are used in keeping the forests green in Canada (AgriForest Bio-Tech). In 2009, AgriForest Biotech Inc. got third place in the Commercialization of Agricultural Technology (CAT) competition and won $100,000 for their research and contribution to the industry (BCIC, 2010). The company also received $54,000 in government funding to further research and develop plant tissue culture procedures (Centre for Small Business Financing).

In conclusion, various types of biotechnologies present today, plant tissue culture has the most potential in improving forests. Many commercial growers use micropropagation to clone and multiply plants using plant tissue culture to produce thousands of viable plants. The technology continues to play a bigger role in forest and horticultural nurseries, capable of yielding high quality plants with reasonably high economic return. Much research and development is still being done to tackle unresolved problems to further improve the production of micropropagated plants. This type of technology has only been used for several decades, but it has grown in a fast growing industry (Huang *et al.*, 1993). Lastly, micropropagation may not be capable of reversing a long-term trend that lies deep in Nepal's history completely, but it brings opportunity and the possibility of improving the current state of Nepal's forests (Griffin *et al.*, 1988).

Figures:

	Model 1	Model 2	Model 3	Model 4
Household density	0.232**	0.220**	0.335***	0.288***
Area of forest	–0.002**	–0.001*	–	–
Number of households	–	–	–0.001	0.0004
Distance to market town	–0.022	–0.030	–0.033	–0.037
Distance to village	0.156	0.054	0.098	0.006
Distance to headquarter	0.028	0.033*	0.029	0.034*
Slope of forest land	–0.033	–0.029	–0.036	–0.029
Brahmin/Chetri HH ratio	0.092	–	0.196	–
Soil dummy	0.020	–	–0.014	–
Dang valley dummy	–0.198	0.149	0.065	0.308
Ratio of government managed forests in VDC	0.282	0.543	0.485	0.717
Constant	1.646**	1.198*	1.195	0.788
N	154	182	154	182
F	2.73	3.23	2.32	2.83
Prob>F	0.0043	0.0019	0.0145	0.0057
R-squared	0.1601	0.1298	0.1398	0.1156

Figure 1: Determining the biggest reasons for the deforestation problem Nepal. Retrieved from: http://books.google.ca/books?hl=en&lr=&id=IXchAQAAQBAJ&oi=fnd&pg=PA213&dq=deforestation+in+nepal&ots=AUBTwjuiY8&sig=Ex1DJu1shxoAq_7nhl0Iy16KIV8#v=onepage&q=deforestation%20in%20nepal&f=false

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