UNIVERSITY OF GUELPH

The Potential Use of Soybean Inoculant in Nepal

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This document looks at agriculture in Nepal focusing on the legume soybeans and the potential use of the soybean inoculant SoyRhizo developed by Xitebio as a method to help improve agriculture productivity in Nepal.

Nepal

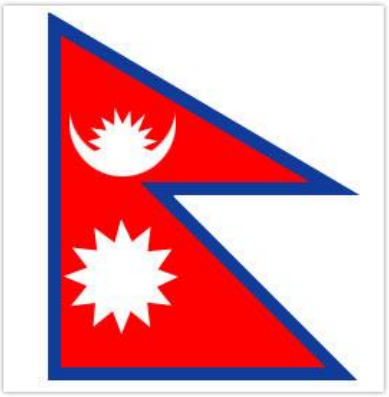

Figure 1: The Official Flag of Nepal

Nepal is a small landlocked country between India and China and occupies 0.1% of the earth's total land area at 147 181km^2. The country has a population of 23 200 000 people in which most of them live in the Kathmandu valley near the capital city of Kathmandu (Nepal Information, 2012). Nepal is divided into three main regions, the Terai, the Middle Hills and the Mountains (Geography, 2012) and has five main seasons; winter, spring, summer, monsoon and fall with an annual rain fall of 1600 mm(Climate, 2012). The Himalayan Mountains act as a barrier to the cold Central Asia winds but also form a boundary in the north for the monsoon winds. The climate varies throughout depending on geographical location; in the north, the winters are severe and the summers are milder while in the south the summers are tropical and the winters are temperate; for every 1000m of elevation change, there is a 6°C change in temperature (Climate, 2012).

The Terai has a width ranging from 26-32 km with an altitude ranging from 60-305 m and occupies approximately 17% of the total land area of the country (Geography, 2012). The temperature in this area reaches 37°C in the summer or higher depending on location and has a winter temperature range of 7-23°C (Climate, 2012). The Northern Terai region has very coarse soil, with a low water table and quick soil percolation making it to be a very unproductive area for agriculture where in the Southern Terai the soil is a mixture of silt, sand and clay and is much more agriculturally productive (Dahal, 2005).

Agriculture in Nepal

Nepal is country primarily based on agriculture; 88% of the population lives in rural Nepal with approximately 78% of adults being in agriculture. In a 2001 census, approximately 61 % of the population was involved with agriculture and 78% of farming households have their own land. The average farm size is 0.8 ha (Joshi, Conroy, Witcombe, 2012) which is too small to generate income above the poverty line and there is currently has 3.2 million ha used for cultivation with an additional 1.0 million ha are available. A total of 56% of the available land for cultivation is in the Terai, 38% is in the Middle Hill and 6% is in the Mountain region (Rijal, Bansal, Grover, 1990). In the Terai region it takes 0.42 ha to feed a family of six, in the Middle Hill it is 0.52 ha and in the Mountain region it is 0.64 ha. As these facts show, Nepal has very low productivity and with only 17% of the land being irrigated with the potential for 42% irrigation, the country is missing out on huge productivity (Joshi, Conroy, Witcombe, 2012). This is caused by a variety of factors but mainly topography and road infrastructure (World Bank, 2013) makes it difficult to improve agriculture including the use of agriculture mechanization.

The growing season in the mountain and middle hill regions are much longer than the Terai. In the Terai, a variety of crops can be grown including; wheat, maize, and sugar cane. Only 10% of the land in the Middle Hill region is suitable for agriculture and the location where crops such as: maize, millet and potatoes are grown; in the Mountain region 2% of the land is suitable for agriculture with the crops potatoes, millet, maize and barley grown here. Terracing was introduced in the 12th century being used as a

Figure 2: Terracing in Nepal on the side of Hills

method for farming of barley, millet, rice and legumes. Maize and potatoes were introduced in the 18th century to help intensify cropping. In the Middle Hill and Mountain regions terracing is the method of farming, it makes it difficult for mechanical equipment to be used, but makes the best use of the land as possible (Joshi, Conroy, Witcombe, 2012).

When looking at the total crop production of Nepal, 90% of crops produced by a farmer are kept as food crops while the remaining 10% are sold as cash crops (Rijal, Bansal, Grove, 1990). The extreme climate variation and natural disasters have contributed to an escalation in food prices as well as food insecurity. As mentioned, Nepal is a very food insecure country; it is one of the most food insecure countries in Asia and is the only country where the population growth rate surpasses the cereal crop production (Joshi, Conroy, Witcombe, 2012). It is estimated that almost 31% of the country lives below the poverty line with 41% of the country consuming less than the recommended minimum calorie requirement in 2010, but according to the Multidimensional Poverty Index, the number of people who are living below the poverty is actually more that 66% of the country or 18 million people; Nepal ranks 20.6/30 on the Global Hunger Scale and 57/88 of developing/ transitioning countries in the world. 78% of these people have a daily income of less than $2/ day in which 67% of people in this statistic are involved with agriculture and 11% of the 67% are agricultural labourers (Joshi, Conroy, Witcombe, 2012).

The agriculture industry alone accounts for 1/3 of Nepal's GDP, but has a very low return per capita GDP at only $140/ worker (Joshi, Conroy, Witcombe, 2012). Over the past ten years, the government investment in agriculture has declined from 3.7% to 2.6% in 2013 (SyndiGate Media, 2013). The bank lending has had the opposite occur; the lending to the agriculture industry has in increased to 6.16% of the banks total credit portfolios compared to the hydropower industry (Global Banking News, 2014). This means that banks want farmers in

Nepal to be successful and are trying to assist them by increasing the number of loans they give to farmers. This would greatly assist farmers in helping them improve upon their livelihoods and become profitable to help improve their country and make it a better place.

The Ministry of Agricultural Development (MOAD) has a total of 378 offices spread throughout Nepal, each office manages 11 000 farms and for each technician there is 1500 farms for him/her to be responsible while in developed countries, one technician is only has 400 farms to look after (Trouble in Nepal, 2013). This is a lot for one person to manage, in a country that is very dependent on agriculture, there needs to be more resources available to help improve the industry and make for more efficient farming in order to best utilize the technicians. One factor that makes it difficult for the technicians to do their jobs is the poor road conditions in the country. In the Mountain region, technicians are not able to reach remote communities that would probably benefit greatly from the technician very easily; there are five district headquarters that unreachable by road (World Bank, 2013).

The difficult terrain in Nepal greatly affects the lives of all the Nepalese people, the two major sources of transportation are by road and by plane. Unfortunately only 43% of Nepalese have access to all weather and more than 60% of the all-weather roads are in the Terai region, this is shown in the map to the right. As of 2007, there is a total of 17 282 km of roads, in which 60% of development is made possible by private donors and because of the lack

Figure 3: Map of Nepal with Roads and Airports

of money from the government, maintenance of the roads is difficult and is not often done; this causes a back logging effect and ceases the development of new roads (World Bank, 2013). When looking at importing goods into Nepal by road there are only two points of entry, one is at the India-Nepal border in Mahendrange and the other one is at the China-Nepal border in Kodari (Travelling by Roads, 2012). This makes it difficult to import large goods that need to be shipped by boat and transported by road to get into Nepal. Between being a landlocked country and rough terrain, it is very difficult to make many improvements in order to make the lives of the Nepalese people better. Trains would be of a great benefit to Nepal, currently there is only 57 km of railway systems with 53 km owned by government agencies, this plays a factor in trying to import goods, with an expansion of the railway system, the ability to transport goods to neighbouring countries and transport people would greatly improve. Domestic airports have become an important method of transportation in order to reach remote regions (World Bank, 2013) there are over 18 domestic airlines serving Nepal (Transportation, 2012), not only do they provide a method of transportation for tourists, but airplanes also play a vital role in reaching remote regions.

Transportation and terrain have played major roles in agriculture in Nepal. Terracing, as previously stated has made it difficult for small equipment to be used in the Middle Hill and the Mountain regions; the use of agricultural mechanization would greatly improve upon on the lives of farmers in these area. In the Terai region, small equipment has greatly improved the lives of farmers because the equipment has become more available at a cheaper cost and has allowed to farmer to create more business as they have begun to do more custom work in order to make more money (Joshi, Conroy, Witcombe, 2012). Back in the Middle Hill and Mountain region, animals such as oxen are used as labour for farming; the most intense practice for the animal is

plowing; plowing utilizes 35-60% of the animals total energy requirement for the crop. In these regions, the manure from the animals are primarily used a fertilizers for the soil and in the Terai, the manure is used as a source as fuel for cooking (Rijal, Bansal, Grover, 1990). The farmer in the Middle Hill and Mountain regions need to the nutrients from the manure in the soil in order for crops to grow in the tougher climates.

Soybeans in Nepal

Soybeans are the fifth most important legume in Nepal (Dhami, Prasad, 2005); for many centuries they have been grown in the Middle Hill region at altitudes ranging d from 915-1525m, but in the late 1970's soybeans began to be grown in other parts of the country (Shurtleff, Aoyagi, 2007), they are now grown from the Southern Terai to an elevation of 2000 m in the mountains (Adhikari, Kaneto, Itoh, Suyama, Pokharel, Gaihre, 2012). Soybeans are traditionally intercropped with corn, millet, rice or pigeon pea (Shurtleff, Aoyagi, 2007) or can be grown be grown solo and has a yield average of 4.5t/ha intercropped and 2.0t/ha when grown solo; the national average is only 770kg/ ha which is low but shows there can be a huge improvement that have a huge potential in terms of improving the lives of farmers in Nepal. One of the largest issues with soybeans in Nepal, is the effectiveness of the native *Bradyrhizobia* (rhizobia) in the soil, as the quantity may not be sufficient or as efficient as they should be in fixing nitrogen. Nitrogen fixation refers to the *Bradyrhizobia* utilizing the nitrogen from the soil that has been come from the atmosphere via lightning and transforming it into a form that the plant can use (Linderman, Glover, 2003). It has been found that areas with continuous soybean cultivation have higher rhizobia where areas that do not have soybeans commonly grown have less

rhizobium in the soil. This relationship proves how important the symbiotic relationship between the rhizobia and the soybean crop is and how it impacts the crop (Dhami, Prasad, 2005).

Soybeans contain 40% protein and 20% oil making them an important source of protein for both humans and animals (Krishan, Natarajan, Mahmoud, Bennett, Krishan, Prasad, 2006). A few examples of food sources for humans are soymilk, soysprouts and and wok-roasted soybeans; soysprouts and wok-roasted soybeans are a quick meal to make only taking five minutes to prepare (Shurtleff, Aoyagi, 2007). In Nepal, the most common soybean species is *B. japonicum*, a slow growing and diverse species as soybeans are greatly impacted by the pH level in the soil ranging from 3.4-7.4 (Adhikari, Kaneto, Itoh, Suyama, Pokharel, Gaihre, 2012). When comparing North American varieties to the indigenous soybean varieties of Nepal, Sathia, Seti, Kavre, and Soida Chiny have significantly higher protein content at 42-45% when compared to the North American variety Williams 82 at 39% and in terms of arginine content- the amino acid responsible for protein quality, the Nepalese varieties have an arginine content of 7.7-8.1% compared to the Williams 82 at only 7.4%; this is a 5-10% increase (Krishan, Natarajan, Mahmoud, Bennett, Krishan, Prasad, 2006). This proves although the crop is low yielding, it is high in protein which is very important as many countries in similar situations lack in getting enough protein and with a little assistance, the crop would make a significant difference to farmers. In a study performed by N. Dhami and B.N Prasad of Tribhuvan University in Kathmandu Nepal, the soybean variety Sathiya saw a 303% yield increase when inoculated compared to the plants not inoculated (Dhami, Prasad, 2006). Soybean inoculant would make a huge difference in terms of the yield of the crop in Nepal and from there, creating a larger profit margin for the farmer who pays taxes that helps to build new roads and maintain

existing roads that help import good from other countries, transport people to remote areas and make it easier for small farm equipment to be used.

Xitebio and SoyRhizo Soybean Inoculant

Xitebio is a privately owned company located in Winnipeg Manitoba. The President/CEO is Dr. Manas Banerjee and the Director, Sales and Marketing is Garry Van Den Bussche. Xitebio currently serves Canadian, US, European and South American markets with a mission "To build relationships with farmers everywhere by consistently providing easy to use microbial innovations that increase production and reduce input costs" and has a "Go Green" (Xitebio, 2013) perspective which would appeal to the Nepalese farmers. Xitebio created the product SoyRhizo a liquid soybean inoculant that would greatly benefit the farmers of Nepal. SoyRhizo uses the optimum number of *Bradyrhizobium japonicum*- 2 billion into the soil and uses Advanced Growth Promoting Technology (AGPT) which helps to invigorate the native microflora including the natural rhizobium by creating a synergy between them. This versatile liquid inoculant works under different soil and environmental conditions and can be applied on seed or in the furrow. It is available in 2.5L jugs and is shipped in 4 cases of 50 units and is available in 10L jugs in a case with 200 units. The application rate of the product on seed is 2.0 fl oz/ 60lbs or 60 mL/ 27kg of seed. In field trials conducted in 2011, the average yield

Figure 4: Field Trial of SoyRhizo with a Control

increase was 9 bu/ac or a 21% increase. The versatility of SoyRhizo allows it to be compatible with most soybean seed treatments (SoyRhizo, 2013).

For the Nepalese people the best method of application would be on seed application using the Soybean Inoculant Applicator manufactured by Horvick in Fargo North Dakota, but is sold in Canada by Novozymes in Saskatoon Saskatchewan, this product can be completely custom made to fit the needs of the farmers of the Nepalese farms. It is available in 15 or 30 gallon cone bottom tanks; it features a 3.8 gpm 110V AC pump, has a magnetic nozzle holder and has a stand for easy maneuvering (Novozymes, 2012). The stand would make it easy for farmers to move the product to where they need it and makes it easier to be used in on Terraces and on the different levels on the terraces. When comparing it to other applicators with similar jobs, running around $430 US for the Liquid and wettable powder applicator manufactured by Enviropac in Compton Illinois, and is sold by the same company in Canada. This price may deter some farmers from purchasing one on their own, but may inspire a group of them to share one and split the cost making it more economical for all involved.

In order to benefit the farmers of Nepal the most, using the indigenous species with the soybean inoculant would greatly improve the yield of the crop as well as the quality. As previously stated, the native Nepalese varieties have higher protein content when compared to the North American varieties. SoyRhizo, increases root nodulation in the plant, creating stronger and longer roots as well as a healthier crop by helping the soybean plant cope with environmental stresses (SoyRhizo, 2012). In a country that have a very diverse climate this would prove to be greatly beneficial allowing for better crops to be grown in the Mountain region, possibly at a higher altitude and be more efficient in the Southern Terai.

A similar product to SoyRhizo is Juxinlong Soybean Inoculant originating in Henan China from Anyang Juxinlong Metallurgical Refractories Co. LTD., this product ranges from $1500- $3000/ metric ton in a minimum order of 20 metric tons in 25 kg bags with a delivery being able to be made with 45 days of the contract being signed this product is very convenient for important. The distance from Henan, China to Kathmandu Nepal requires a plane at 7 hours and 55 mins with one possible connection using China Air (Google Flights), since there is no water, there would be the possibility for roads to be used.

Figure 5: Location of Henan China in Respect to Nepal

When looking at potential flights from Winnipeg, the flight would take 29 hours and 55 minutes using Unites and Dragonair with two stops (Google Flights) which is much longer when it comes to importing good into the country and it could take up to 41 hours with three stops (Google Flights). In terms of jobs for the people of Nepal, many people would be needed in order to set up a distribution center in Kathmandu, and having several small distribution centers across the country where farmers in more isolated areas would be able to go to get the product. A potential buyer in Kathmandu would be Multi Tech International (P) LTD., this country sells seeds, carpets and pashmina shawls and offers agriculture research and development. Using a company such as this that already works in agriculture would give the power to the people of Nepal in empowering them to want to change their country in order to make it a better place for them and their families.

The SoyRhizo inoculant needs to be stored at a temperature between 7°F-37°F (Xitebio,2011) and in knowing this, there would need to be proper training of the Nepalese who are hanging the product in how SoyRhizo is supposed to be stored and transported. This is where Canada comes in; Canada has used soybean inoculant for many years and has developed many successful products including Nodulator Granular Inoculant- Soybean, an in-furrow applied granular inoculant with storage between 1°C-20°C developed by Becker Underwood Canada in Saskatoon Saskatchewan (Government of Saskatchewan, 2012). Canadians could be brought in to Nepal to train the Nepalese people on how to handle the soybean inoculant, how it should be stored and be crop scouts and assist the Nepalese on what to look for in a healthy soybean crop and how to identify diseases.

In conclusion the use of soybean inoculant such as Xitebio SoyRhizo would greatly impact the agricultural industry of Nepal. Soybeans are a very diverse crop with many uses and are an important source of protein for not only humans but animals as well. By improving yields, the soybean inoculant allows the farmer to sell the healthier crop to help improve the livelihood of him/herself as well the his/her family and gives the opportunity to potential send their children to school, pay more taxes to help improve road infrastructure, make more isolated areas easier to access and from there inspiring a nation to make their lives better and make a difference in their country.

Be the Change You Want to See in the World- Gandhi

Additional Information Not Found:

- Price of SoyRhizo
- Shipment Price
    - From Winnipeg to Kathmandu
    - Hanen China to Kathmandu
- Size of shipment container
- Available buildings for storage in Kathmandu
- What sort of building is needed for storage

Contact Information for Companies

1-888-744-5662 or visit

www.bioag.novozymes.com.

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Figure 3: Terracing in Nepal (n.d.). Retrieved November 23, 2014, from http://www.asianhikingteam.com/images/trekking/agriculture-trek.jpg

Figure 4: Field Trial of SoyRhizo (n.d.). Retrieved November 23, 2014, from http://www.seedquest.com/visuals/image/2011/xitebio4.jpg

Figure 5: Map of China in approximation of Nepal (n.d.). Retrieved November 23, 2014, from http://www.ssqq.com/archive/images/guoliangcun tunnel map 87.jpg