Jatropha As Biodiesel: Potential And Problems

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***Abstract*— Biodiesel from Jatropha is one of the alternative sources of energy. It can be produced after transeterification process of vegetable oil and animal fat. In the context of Nepal, biodiesel from non-edible plant Jatropha can reduce the dependency on imported diesel to some extent. Jatropha has high potential in non cultivated land of the Terai districts and nominal feasible for mid hill area. It can be cultivated in proper soil condition, irrigation facility and with proper inter cropping also. Appropriate government policy, solving of the stakeholders problem are the key factors for the promotion of biofuel. This paper presents the findings of possibility and potential problems for the promotion of biofuel from Jatropha in the Nepalese context.**

***Index Terms*— Jatropha, Biodiesel, Cultivation**

I. INTRODUCTION

The consumption and demand for the petroleum products are increasing every year due to increase in population, living standard, industrialization and urbanization. The increased trend of petroleum oil import affects the country's economy and its development. Similarly, acid rain, global warming and health hazards are ill effects of increased polluted gases like SOx, CO and particulate matters in the atmosphere by the combustion of petroleum products. Today's diesel engines require a clean burning and stable fuel that performs well under the variety of operating conditions. Rising petroleum prices, increasing threat to the environment from exhaust emissions and global warming have generated an intense international interest in developing alternative non-petroleum fuels for engines (AJav & Akingbehin, 2002) Biodiesel is the only alternative fuel that can be used directly in any existing unmodified diesel engines. Among the various vegetable oil sources, non-edible oils are suitable for biodiesel production. Among the non-edible oil sources, *Jatropha curcas* is identified as potential biodiesel source and comparing with other sources, which has added advantages such as pleasant smell, or odorless and can easily mix with diesel fuel, rapid growth, higher seed productivity, suitable for tropical and subtropical regions of the world (Corner, 1979). Jatropha has similar properties to diesel fuel and its oil blending up to 40 to 50 per cent with diesel fuel could be used in engine without modifications (Kumar, Dixit, & Sharma, 2015)

II. JATROPHA BIODIESEL

Jatropha oil can be used directly in the engine. In general, it has been reported by most researchers that if raw vegetable oils are used as diesel engine fuel, engine performance decreases, CO and HC emissions increase and NOx emissions also decrease accordingly (Corner, 1979). However, Acrolein is high toxic substance released from the engine due to thermal decomposition of glycerol present in the oils (Ahmad, Teong, Zafar, & Sultana, 1981). Table 1 shows the problems observed in bio-diesel engines.

The problems encountered in raw oils are solved by forming biodiesel through transesterification process, which is non toxic, eco-friendly fuel, and have similar properties of diesel fuel (Krawczyk, 1996). Biodiesel is described as a fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats which is obtained after transesterification process. It is oxygenated, essentially sulfur-free and biodegradable (Moser, 2011) (Yuan, Y., 2004).

One environmental benefits of replacing fossil fuels with biomass-based fuels is that the energy obtained from biomass does not cause global warming. Fuels produced from biomass, releases carbon dioxide during combustion into the atmosphere. But, plants use carbon dioxide from the atmosphere to grow (photosynthesis); the carbon dioxide formed during combustion is balanced by that absorbed during the annual growth of the plants used.

Table 1. Problems in use of jatropha oil as fuel in diesel engine

Problems	Causes
Choking of injectors	High viscosity of raw oil, incomplete combustion of fuel. Poor combustion at part load with raw oil
Carbon deposits on piston and cylinder head of engine	High viscosity of oil, incomplete combustion of fuel.
Excessive engine wear	High viscosity of raw oil, incomplete combustion of fuel. Dilution of engine lubricating oil due to blow-by of raw oil

(PANDHARE & PADALKAR, 2013)

III. THE JATROPHA PROGRAMS IN NEPAL

A. Potential for Jatropha

Climatic conditions are favorable for Jatropha Curcas L. trees in around 30% of the country, so there is immense opportunity to enhance natural resources. Resource enhancement can promote economic enterprise in rural areas in cultivation, seed collection and processing as well as improvements in agricultural productivity, environmental protection and the quality and stability of marginal land (Boswell, 2003). Jatropha plants are available in about 70 districts of Nepal. Therefore, there is possibility to cultivate jatropha plants in these districts.

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Table 2. Land status in Nepal

S.N.	Area of utilization	%	Area, ha
1.	Agriculture	20.1	29,64,400
2.	Secured forest	19.7	29,05,400
3.	Other forest	18.4	27,13,700
4.	Not use in shrub and agriculture	11.4	16,81,300
5.	Parti/khark	11.9	17,55,000
6.	Other (Ice, rock, river etc.)	18.5	27,28,400
Total		100	1,47,48,400
Marginally used land from (From 3-6)		13.7	20,20,530

(CBS, 2011)

In the above table 2, marginally used land from 3-6 is 2,020,530 ha which can be used for jatropha cultivation. Feasibility of jatropha cultivation in the different districts has been categorized based on available land and climatic condition and is shown in table below

Table 3. Feasibility of jatropha cultivation in Nepal

Feasibility	Districts
Highly feasible districts	Kanchanpur, Kailali, Bardiya, Banke, Dang, Kapilvastu, Rupandehi, Nawalparasi, Chitwan, Makwanpur, Parsa, Bara, Rautahat, Sarlahi, Mahottari, Dhanusa, Siraha, Saptari, Rajbiraj, Udayapur, Sunsari, Morang, Jhapa
Nominal feasible districts	Sindhuli, Myagdi, Kavrepalnchowk, Sindhupalchowk, Jajarkot, Dailekh, Therathum, Gorkha, Nuwakot, Baitadi, Dhading, Dadeldhura, Darchula, Bhojpur, Bajura, Panchthar, Sankhuwasabha, Dhankuta, Dolakha, Rolpa, Baglung, Rukum, Ilam, Khotang, Taplejung, Okhaldhunga, Kalikot, Bajhang, Rasuwa, Accham, Salyan, Pyuthan, Lumjung, Kaski, Ramechhap, Doti, Parvat, Surkhet, Argakhanchi, Palpa, Tanahun, Gulmi, Syangja
Not feasible districts	Jumla, Mugu, Solukhumbu, Humla, Dolpa, Manang, Mustang Kathamandu, Bhaktapur, Lalitpur

(AEPC, 2010)

B. Conditions for cultivation

It can thrive well on stony, gravelly or shallow and even on calcareous soils having soil depth of about 2 feet. It can be grown under wide range of arid and semi-arid climatic conditions but cannot with stand heavy frost. It can be cultivated successfully in the regions having scanty to heavy rainfall with annual rainfall ranges from 500-1200 mm. Jatropha can grow in hot weather.

Quality of the soil: It can grow up well in sandy well-drained soils. It can even grow in very poor soils and in saline conditions. Fertile soil may lead to early fruiting and best result. The clay and flooded ground are not proper for plant growth.

Irrigation and weeding: Jatropha needs irrigation twice a year for non irrigated land in the early stage. Irrigation up to 1,500 mm rain fall is favorable for production of jatropha. For rain fall below 500 - 600 mm, production depends on the local water condition in the ground. It can stand without water - up to 2 years – and then grow again when rain occurs. Standard cultural practices are timely weeding (4 times a year), surface ploughing and pruning.

Use of fertilizer: Although Jatropha is adapted to low fertility sites and alkaline soils, better yields seem to be obtained on poor quality soils if fertilizers containing small amounts of Calcium, Magnesium, and Sulfur are used.

Satisfactory planting widths are 2m x 2 m, 2.5m x 2.5 m, and 3m x 3 m. This is equivalent to crop densities of 2500, 1600 and 1111 plants/ha, respectively. Distance of 2m×2m should be kept for commercial cultivation. Wider spacing is reported to give larger yields of fruit.

Pruning: The plants need to produce side shoots for maximum sprouting, flowers and seed. In order to facilitate the harvesting, it is suggested to keep the tree less than 2 meters. Therefore, the top of the plant should be cut cleanly such that 8 – 12 side branches are produced.

Inter-cropping: Specific intolerance with other crops has not been detected so far. On the contrary the shade can be exploited by shade-loving herbal plants; vegetables such red and green pepper, tomatoes, etc. Intercropping avoids dependency on single crop. This allows greater flexibility in the distribution of labor and helps to recover investments in much less time.

C. Government policy

Promotion of jatropha depends upon the government policy because at the initial phase jatropha cannot compete with imported petroleum fuel. Jatropha should be promoted to meet the local needs such as; cooking, soap making, running stationary engines and for blending with petro-diesel in transport sector.

Business strategy for production of jatropha oil should be adopted phase wise. In the first phase, conduction of public awareness program about potential benefits of jatropha plantation and associated technologies for extracting oil and its application should be implemented. Similarly, providing available public unused lands to farmers for jatropha cultivation on lease; providing high yield jatropha seeds to farmers; establishment of seed collection centers are important. Furthermore; demonstration program using blended kerosene with jatropha oil in cooking stove should be organized so that villagers will switch to jatropha blended fuel from firewood. Communities should be encouraged to establish soap making factories so that women will be able generate income. Similarly, the water pump can be run on biodiesel for irrigation or drinking water purposes at local levels.

In second phase, promotion for the operation of engines using blended petro-diesel at national level; development of bio-diesel refueling stations; establishment of Jatropha expelling plant and trans-esterification plants should be implemented.

In third phase, Inventive and subsidy policy are important for the promotion of jatropha. Exemption of duties and taxes on bio-fuels, encouragement of community management and biofuel projects, support for poor and backward families for the use of biofuel energy system, soft loan facility from financing agencies in the feasible areas, financial support for research and development of biofuel technologies,

distribution of quality seeds and guarantee for minimum price of seeds are also necessary(AEPC, 2008).

D. Potential problems/ constraints for the jatropha cultivation

Ideally, pH value of the soil for jatropha cultivation should be in between 6.5 to 8.5. The percentage of land favorable for its cultivation in various regions of Nepal has been summarized in the Table 4 below:

Table 4. pH status of soil in Nepal

Development Region	Less than 6.5	6.5-7.5	More than 7.5	Favorable for jatropha
Eastern	69%	22%	9%	31%
Central	88%	11%	1%	12%
Western	79%	15%	6%	21%
Mid-western	57%	38%	5%	43%
Far-western	38%	34%	28%	62%
Average	66.2%	24%	9.8%	33.8%

(Soil Directorate Pulchowk, 2006)

As seen from Table 2 that the potential land for jatropha is 2,020,530 ha and average favorable land for jatropha in Nepal is only 6,82,939 ha (Table 4). Thus, most of the land has not seen to be feasible for jatropha cultivation without additional investment.

On the other hand, adequate NPK (Nitrogen, Phosphorous and Potassium), Organic matter, Micro-nutrients, Phyto hormones, Phyto enzymes, microbial activities are necessary for high yield but unused and marginally used land lack these factors.

The better yield of Jatropha cultivation is achieved in irrigated lands than in non-irrigated plots. The existence of non irrigation practice could be due to the crop properties and value of water for the farmers in a context of water scarcity.

Agricultural scientists pointed out that the jatropha plant needs water during the first year and if it does not rain regularly, it is compulsory to irrigate fortnightly to ensure a year round production. The Jatropha curcas are giving yield in the areas where annual rainfall is above 500 mm. The Jatropha curcas can not tolerate frost and also the temperature below 0^0C. Jatropha curcas needs one or two life saving irrigation during summer season for better harvesting.

For wastelands, soil depth for jatropha plantation should be more than 2 ft and sufficient fertilizer and irrigation is necessary (Punia, 2007).

E. Current problems for Jatropha stakeholders

Biofuel Program has brought public awareness for jatropha cultivation. Small farmers and investors have been attracted for jatropha cultivation, establishment of jatropha expelling machines and biodiesel transesterification plants. But still there are various obstacles for stakeholders.

1) Problems for farmers

Most of the farmers have not sufficient knowledge about jatropha cultivation technology, although they are interested for jatropha cultivation. Most of the farmers do not have sufficient land for jatropha cultivation and there is no policy for the use of marginally used public land for cultivation of jatropha.

The farmer, who were involved for jatropha cultivation in previous years, had not adopted proper technology for jatropha cultivation, i.e. quality seeds and plants, proper spacing, use of fertilizers and chemicals, irrigation, pruning, weeding etc. Thus they are not getting result as expected on jatropha growth. They are not also sure about future yield from cultivation.

Poor farmers, who are suffering from low economic income and lack of land, are not interested for jatropha cultivation.

The jatropha plants which were transferred from lower to higher altitude have not seen proper growth as compared to plants that were transferred to same altitude.

Various communities have done plantation in the marginally used public land but these projects have not been successful due to lack of proper management and responsible person, lack of investment, lack of proper technology.

In various districts, people have collected jatropha from existing plant but harvesting process is very labor intensive due to low yield, scattered plant, large size of plant, need of repeated collection causing very high cost for collection of seed. They are not getting price as they have expected.

There is disagreement between farmer and biodiesel companies about price of seeds. Companies are neither offering a fair price nor do they promise to purchase seeds. Market is underdeveloped, and farmers are unorganized and do not have strong bargaining position.

Currently the market players are unknown, farmers are hearing different price of jatropha seeds so there is confusion about actual market price.

2) Problems for biodiesel companies

It was mentioned that jatropha oil can be extracted 30 to 46 % theoretically but the biodiesel companies are now extracting jatropha oil in the range of 20-25% only.

Biodiesel plants are not operating throughout the year, therefore companies are facing problem of high turnover qualified manpower.

Biodiesel companies neither want to lose the market nor take risk for the collection of seed at high price. This condition is discouraging seed collection from existing jatropha plants while biodiesel companies have remained in idle condition.

Biodiesel companies do not have fixed market and fixed selling price. The existing companies do not have sufficient vehicles so that they can consume biodiesel by themselves. Biodiesel companies have not taken initiation to settle this condition.

Oil content depends upon moisture content, process of drying and storage, altitude of seed collection and aging of seeds. Due to lack of experience and proper information, biodiesel companies are facing problems about seed quality.

Biodiesel companies have to pay high tax for the import of potassium hydroxide or sodium hydro oxide from India. Most of the alcohol is used in distillery purpose therefore to buy small amount alcohol, biodiesel companies have to pay more.

Biodiesel companies are situating in Palpa, Dovan, near Butwal and Ram Nagar, Bharatpur but jatropha seeds are produced in remote villages. Therefore, high transport cost and difficulty of delivery of jatropha seeds are a real financial and logistic burden for farmers.

IV. CONCLUSIONS

The organized plantation and systematic collection of jatropha can allow biodiesel as potential substitute to petroleum diesel which can reduce the import burden of petroleum substantially. This will help to solve energy security to some extent.

Jatropha oil will create job for rural community and will increase their living standard.

Problems are arising due to lack of proper technology of cultivation, channelized market mechanism, institution development and policy.

Biodiesel cannot compete with petroleum diesel in current market but increasing price trend of imported petroleum diesel may cross the price of biodiesel in the coming future so that government policy is urgent for the promotion of jatropha.

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