Agricultural Economics Research Review
Vol. 24 January-June 2011 pp 99-108

Economic Benefits and Costs of Jatropha Plantation in North-East India[§]

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Abstract

Energy security, emissions control and environmental concerns are some of the issues that drive India to search for bio-fuels in general and bio-diesel in particular as an alternative source of energy. The inception of National Biofuel Mission in 2003 has resulted in expansion of jatropha plantations in different states of the country. In North-East India, jatropha plantation was started in 2007, mostly at small farmers' level with direct and indirect initiatives of the government and the private sector. However, adoption and expansion of jatropha plantation in the rural areas largely depend on profitability from such plantations at farmers' level. The present study has assessed the profitability of jatropha plantation in four states of North-East India, viz. Arunachal Pradesh, Assam, Nagaland and Tripura, through cost-benefit analysis. The study has shown positive returns from the investment on jatropha plantation, making it an economically viable venture for the growers of the region. The investment on such plantation has shown a payback period of five years under the scenario of higher seed yield and accordingly requires adequate state funding support for operation and maintenance of such plantations at least during the initial years.

Key words: Jatropha, Bio-fuels, Bio-diesel, North-East India, Cost-benefit analysis

JEL Classification: Q16, Q42, Q49

Introduction

Production and use of bio-diesel are becoming an important concern across different countries of the world including India. A limited stock of fossil fuels, problems of global warming, generation of employment and income opportunities, etc., are a few driving forces for increased use of bio-diesel (Mathys, 2008). Along with higher economic growth and changing living standards of people, the demand for energy is fast increasing in India (Worldwatch Institute, 2008). As India meets her major energy requirement through the consumption of diesel, the demand for diesel will increase further in the coming years and, by 2025, almost 90 per cent of India's fuel requirement will be fulfilled only through import (CSIS, 2006). The blending of bio-diesel with diesel can reduce the quantum of such import. The Government of India has launched a National Biofuel Mission in the year 2003, which mandates blending of bio-diesel with high speed diesel at 5 per cent by the year 2012, 10 per cent by 2017 and 20 per cent after 2017 (Shinoj *et al*., 2010). Therefore, interest on Jatropha as the primary source of bio-diesel is increasing in the country.

Jatropha seed is a good feedstock for the bio-diesel industry and plantation of jatropha is beneficial to poor growers in areas where there are few opportunities for alternative farming strategies and livelihood options

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§ The paper is based on the research project entitled 'Economic Value Addition of Jatropha Based Products in North-East India', supported by the National Oilseeds and Vegetable Oils Development (NOVOD) Board, Ministry of Agriculture, Government of India.

(Freim, 2008). Although the higher economic growth has lifted many people out of the poverty in the country, millions more remain marginalized from the booming economy, which is a difficult task to achieve without alternative employment opportunities in the agricultural sector (Rhoads, 2007). Besides energy security and environmental benefits, jatropha offers a potential opportunity to address the issues of rural livelihoods and poverty (Brittaine and Lutaladio, 2010).

Adoption and expansion of any agricultural activity mostly depend upon the profitability in such investment besides other factors. In the case of jatropha, there are uncertainties involved in profitability from plantation at farmers' level. Growers here are engaged in the feedstock production as the first component of bio-fuel value chain (Tomomatsu and Swallow, 2007), which may be a risky enterprise with low profitability (Messemaker, 2008). The possibility of over-estimation of yield and profitability are the issues of concern in India (Singh *et al*., 2006). Proper investigations that take into account the costs and benefits resulting from jatropha plantation are needed, which may help in reducing economic risks and influence in adoption and expansion of such plantations. Therefore, there is a need to investigate the potentials of jatropha plantation by examining its economic viability through costs and returns in such plantations. The present study has analysed the viability of jatropha plantation in North-East (NE) India through cost-benefit analysis (CBA).

Location, Database and Methodology

The National Policy on Biofuels permits cultivation of jatropha only in wastelands (GoI, 2008). As per the National Remote Sensing Agency (NRSA), the total wasteland available in the NE India (excluding Sikkim) was 58,298.43 sq km in 2003 (Wastelands Atlas of India, 2005). However, out of this total wasteland available in the region, jatropha can easily be grown on about 70 per cent area, which includes wastelands with and/or without scrub, land under shifting cultivation, and underutilized/degraded notified forest land. Because of the availability of wasteland, in recent years different organisations such as D1 Williamson Magor Bio Fuel Limited (D1WMBF Ltd), Smriti Herbs and Bio-Fuel farm, etc. are actively engaged in expansion of jatropha plantation at small growers' level in the region. Keeping in mind the expansion of such activities, the study has considered four leading NE states of the region for analysis; these are: Arunachal Pradesh, Assam, Nagaland and Tripura.

The data for the study were collected from both primary and secondary sources of the selected states. The selection of the places was done through purposive sampling, depending upon the intensity of plantations, and random sample method was used to select the growers. Primary data were collected from 279 jatropha growers through uniformly designed structured interview schedule during the period May 2009 to June 2010. Focus group discussions (FGDs) were also carried out to collect in-depth information and cross verify a few parameters. Secondary data and information were collected from D1WMBF Ltd, National Bank for Agriculture and Rural Development (NABARD), National Oilseed and Vegetable Oils Development Board (NOVOD), NRSA, Rural Development Departments of the states, and internet sites of different agencies/organizations.

The cost-benefit analysis was carried out using the concepts of net present value (NPV) and benefit-cost ratio (BCR) to evaluate the viability of jatropha plantation in NE India. The present value (PV) is calculated using Equation (1):

$$PV = \frac{C_t}{(1+r)^t} \qquad \ldots(1)$$

where, t = Time of the cash flow; C_t = Cash flow at that point of time; and r = Discount rate.

If the total time period of the project, i.e. total economic life of jatropha plantation is 'n', then the sum of all cash flows in each time period, discounted to the present by using the time value of money, represents the NPV of the project. Thus, the NPV indicates the overall economic feasibility of the project in its entire life span as mentioned by Equation (2):

$$NPV = \sum_{t=0}^{n} \frac{C_t}{(1+r)^t} \qquad \ldots(2)$$

The BCR is a profitability index, which is the ratio of the present value of the cash flows generated to the present value of the cash flows consumed (Crundwell, 2008). It is a ratio of discounted benefits and discounted costs of an investment project, and is given by Equation (3):

Table 1. State-wise average establishment cost of jatropha plantation in NE India

(₹/ha)

State	Seedling cost	Labour cost	Total establishment cost
Arunachal Pradesh	7025	6347	13372
Assam	7454	8137	15591
Nagaland	7095	4430	11525
Tripura	7121	8173	15294
NE India	7174	6772	13946

$$BCR = \frac{\sum_{t=0}^{n} \frac{B_t}{(1+r)^t}}{\sum_{t=0}^{n} \frac{E_t}{(1+r)^t}} \quad \ldots (3)$$

where,

B_t = Benefit at time‘t’;

E_t = Cost at time‘t’; and

r = Discount rate.

Plantation of Jatropha and Associated Costs in NE India

Cost of jatropha plantation varies depending upon its geographical location, agro-climatic condition, input-use, other operational practices, etc. The per hectare estimated cost, associated with different stages of jatropha plantation are discussed in brief below.

(a) Establishment Cost

The establishment cost of jatropha plantation includes the costs on seedlings, farm yard manure (FYM), labour on various activities, farm building, etc. However, seedling and labour costs were found as the only two components of establishment cost in NE India.

In NE India, farmers establish their plantations mostly from seedlings. The recommended number of seedlings per hectare varies from 1,500 to 2,500, depending upon the plant spacing followed in such plantations. The cost of seedling was found as ₹ 3 in most of the sampled states. Labour cost was another component incurred during the period of establishment. The state-wise per hectare average establishment cost of jatropha plantation in NE India is given in Table 1.

A perusal of Table 1 revealed that there was a variation in the establishment cost across the states in the region. This was mainly due to the variations in labour cost across the states. Depending upon the plant spacing followed, method of establishment, etc., the per hectare labour requirement for establishment of jatropha plantation varied across the states in the region. The per hectare average establishment cost of jatropha plantation in NE India was ₹ 13,946 which included the costs on seedling (₹ 7174/ha) and labour (₹ 6772/ha). The labour cost was largely incurred in three different activities, namely land preparation (41%), digging (34%), and planting (25%). In NE India, the planters need to clear their plantation areas which are often covered by shrubs, tall elephant grass, etc. This increases requirement of labour in land preparation.

Use of fertilizers, irrigation water, and insecticides and pesticides was not found in the region. However, a small portion of the farmers used cow dung manure, which was available free of cost. Though the use of irrigation is recommended to boost plant growth and crop yield during dry season, it is not so important in NE India, as the region receives heavy rainfall spread over seven months in a year.

(b) Operation and Maintenance Cost

Operation and maintenance cost of jatropha included the costs incurred on post plantation management operations. These operations include soil working and weeding, FYM and fertilizer application, pruning, application of insecticides and pesticides, etc. However, in NE India, pruning, weeding, and replanting were the major post-plantation operations. The major component of cost in these operations was the cost on labour. However, these costs varied from state to state as scale of operation varies across states.

The fruiting in jatropha takes place at the top of its shoots. The pruning ensures increase in branching and thus availability of more fruits. Another aspect of pruning is that it keeps a plant in an appropriate size and shape.

Under natural conditions, the height of a jatropha plant often makes harvesting uneconomical. The height should be kept low in order to facilitate manual harvesting. This is of considerable importance as mechanised harvesting in the hilly areas is not possible, mostly because of slopy terrains. It is ideal to keep the plant height less than 2 metres for easy harvesting (Reddy and Naole, 2009).

The first pruning of jatropha is needed within six months when cutting is done at a height of 30 cm to 40 cm from its base. After one year, a second pruning is needed when plants grow extensively after the first pruning. The same procedure is repeated thereafter, maintaining a gap of two years between two successive prunings (Reddy and Naole, 2009; Franken and Nielsen, 2010). However, time gap, frequency, and procedure of pruning may vary from state to state, depending on the growth of the plant. In order to maintain the plant height around 2 metres, the operation needs to be done at a constant and regular time interval. For the present analysis, after three years of plantation, it was assumed that growers bear a constant expenditure for pruning, maintaining a gap of one year between two successive prunings. It was assumed keeping in mind the high rainfall pattern of the region which facilitates higher vegetative growth of the jatropha plant.

The soil working and weeding are the other two important post plantation management operations. These operations are necessary in NE India as the region gets a high amount of annual rainfall, leading to faster growth of weeds. Once the plant is well established, it can survive even under the weed infestation. However, in the later stages of growth, some creepers mostly *Mikania micrantha* adversely affect production of this plant. Therefore, it is important to keep a jatropha field free from weeds and creepers. Weeds should be removed at regular intervals and left on ground as mulching materials, which helps in reducing soil erosion common in undulating plantations. Canopies of jatropha become dense only after one to three production seasons (depending on the agro-climatic conditions) and subsequently the growth of weed is suppressed (Nielsen, 2009; Franken and Nielsen, 2010). Therefore, the cost on weeding usually goes down after two to three years of plantation. In NE India, weeding in jatropha plantation is labour-intensive, and is often done twice in a year.

Apart from pruning and weeding, replanting is another post plantation operation found in NE India. It is done to fill the gaps in the plantation area where existing plants become dead. However, the mortality rate of jatropha plant in the region being low, the cost on replanting is also low.

Other activities such as application of irrigation, FYM, fertilizer, etc. are not common in the region. The state-wise annual average labour costs for operating and maintaining one hectare of jatropha plantation in NE India given in Table 2, reveal that these were lowest in Arunachal Pradesh (₹ 1,535) and highest in Tripura (₹ 3,219).

Table 2. State-wise annual average labour cost for operating and maintaining one hectare of jatropha plantation in NE India

(₹/ha)

State	Labour cost	Standard deviation
Arunachal Pradesh	1535	578
Assam	2052	1034
Nagaland	1605	901
Tripura	3219	1698
NE India	2103	779

Among the three activities, the total labour cost was maximum on cleaning and weeding (57%), followed by pruning (22%) and replanting (21%). In Tripura, most of the farmers reported weed infestation to be a major problem requiring a good number of labour days.

(c) Other Associated Costs

The other associated costs in jatropha plantation included costs on harvesting, seed separation, transportation and marketing. Harvesting and seed separation practices require labour as the operations are done manually. The primary data on harvesting and seed separation in NE India were not considered in the study as commercial production is yet to start in the region. However, Kureel *et al*. (2007) have revealed that two man-days can harvest 100 kg of jatropha seeds, i.e. about 6 kg of seeds per hour. Similarly, Nielsen (2009) has found that one person can harvest 1-3 kg of jatropha seeds per hour, including decortications and more than 5 kg per hour without decortications. Thus,

the finding of Kureel *et al*. (2007) is closer to that of Nielsen (2009) in harvesting without decortications. However, Nielson's finding of one person harvesting 2 kg seeds per hour including decortications shows that jatropha plantation in NE India may be uneconomical if we consider employment under the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) at the wage rate of ₹ 100 per day. Because, assuming 8 working hours in one man-day, a person can harvest and decorticate 16 kg seeds that generate an income of ₹ 80 per day at the current market price of ₹ 5 per kg. However, the economics of cost on labour were quite different in this region. Firstly, in early years of plantation, jatropha growers use their unemployed family members (under MGNREGA only one member gets employment) for harvesting and decortications. Secondly, the decortications are often done during leisure hours.

Considering the other possibility of two-man days harvesting 100 kg of jatropha seeds, the per hectare annual average labour costs on harvesting and seed separation were calculated at a daily wage rate of ₹ 100. Two production scenarios were considered. The Scenario I was based on observations of Kureel *et al*. (2007) and of NABARD Consultancy Service (2007) and Scenario II was based on observations of D1WMBF Ltd (2010). As per Scenario I, under rain-fed conditions, the expected per hectare annual average seed yield of jatropha from the sixth year onwards varies from 2.5 tonnes to 5 tonnes depending upon the fertility of soil, viz. poor or average (NABARD Consultancy Service, 2007). The Scenario II presumes the per hectare annual average seed yield from the sixth year onwards of plantation to be 7.5 tonnes. The per hectare annual average labour cost of harvesting associated with the two production scenarios in different years of jatropha plantation is given in Table 3.

It is evident from Table 3 that the harvesting cost was another important cost component in jatropha plantation. In NE India, although the data on actual harvesting cost were not available, the cost is expected to be high as mechanized harvesting is not possible and labour efficiency is low in the region. The expenditures on storage, marketing, etc. are not significant in jatropha plantation in the region, as most of the companies collect jatropha seeds from the residence of the growers in the region.

Expected Returns from Jatropha Plantation

Field information on large-scale jatropha seed production in NE India was not available as most of the plantations were on small-scale. Jatropha plantation on a commercial scale started in the region in 2007 and many rural households expanded their plantation area in subsequent years. These plantations are being done largely under the initiative of D1WMBF Ltd. Thus, in NE India, the oldest plantations are hardly four years old. A jatropha plant gives best seed yield only from the sixth year of its plantation (Kureel *et al.*, 2007; NABARD Consultancy Service, 2007). Therefore, instead of using field data, analysis was carried out using the available information on jatropha production scenarios. Also, other income associated with jatropha such as selling of shells, oil cake, etc. was not considered in the present analysis.

Based on per hectare seed production and market price data, the returns from one hectare of jatropha

Table 3. Annual average yield of jatropha seed and labour costs of harvesting in different years under rain-fed condition in NE India

(kg/ha and ₹/ha)

Age of plantation	Scenario I		Scenario II	
	Seed yield	Harvesting cost	Seed yield	Harvesting cost
Second year	250	500	-	-
Third year	500	1000	2500	5000
Fourth year	1000	2000	3750	7500
Fifth year	1600	3200	5000	10000
Sixth year	2500	5000	7500	15000

Scenario I: Harvesting on poor fertility soil (Seed yield of jatropha = 2.5 t/ha)
Scenario II: Harvesting on fertile soil (Seed yield of jatropha = 7.5 t/ha)

plantation during initial six years were calculated and have been presented in Table 4. The returns over the years show that jatropha generates income from the second year onwards. It was also found in our primary survey in the region. However, the plants were not matured enough to realize the production fully. The data reported in Table 3 reveal that production increases till sixth year of plantation. Therefore, for this analysis, plants were assumed to become fully matured in the sixth year of plantation, providing a stable production thereafter. Based on the two production scenarios and current market price, the potential annual income from the sixth year onwards of plantation has been found to range from ₹ 12,500/ha to ₹ 37,500/ha (Table 4).

Table 4. Potential annual income from jatropha during initial six years in NE India

(₹/ha)

Age of plantation	Income assuming low yield (Scenario I)	Income assuming high yield (Scenario II)
Second year	1250	-
Third year	2500	12500
Fourth year	5000	18750
Fifth year	8000	25000
Sixth year	12500	37500

Cost-Benefit Analysis of Jatropha Plantation in North-East India

Based on costs and returns of jatropha plantation, the net income from one hectare of jatropha plantation was calculated under the two production scenarios for the initial 10 years. Total expenditure was calculated by adding costs on establishment, operation and maintenance, and harvesting and seed separation. For calculating gross income, the per hectare annual average seed yield was considered as 2.5 t/ha under Scenario I, as it was the lowest projected annual yield in poor quality soil. The total expenditure and gross income from jatropha plantation during the initial 10 years were found as ₹ 58,285/ha and ₹ 79,250/ha, respectively (Table 5) providing a net income of ₹ 20,965/ha under Scenario I. The cumulative net cash flow has depicted the payback period as 7 years.

The profitability of jatropha cultivation cannot be compared with other plantation crops as these plantations, in principles, are promoted on wastelands that are not suitable for other crops. A perusal of Table 5 shows jatropha cultivation not profitable at the presumed yield of 2.5 t/ha because of negative returns in the initial 6 years and meagre positive returns thereafter till the 8th year. However, jatropha plantation requires a lower investment in comparison to other plantation crops such as rubber and tea, wherein establishment costs are as high as ₹ 85,000/ha (Bhowmik, 2006) and ₹ 136,900/ha (http://planning.up.nic.in/innovations/inno3/ph/tea.htm), respectively. In NE India, the prevalence of low yield may not be very common because of fertile land and suitable climatic conditions. From the current growth of jatropha plant in the region, the annual production is expected to be much higher than 2.5 t/ha from the sixth year onwards. A similar set of economic values, obtained for Scenario II assuming the annual production as 7.5 t/ha from the sixth year onwards, is presented in Table 6. The total expenditure and gross income from one hectare of jatropha plantation during the initial 10 years were found as ₹ 124,085 and ₹ 243,750, respectively, providing a net income of ₹ 119,665. The payback period, shown by the cumulative net cash flows, was found as 5 years.

The costs and returns from one hectare of jatropha plantation during its entire lifespan, considered as 40 years (Freim, 2008), were calculated under both the presumed scenarios of production and are given in Table 7. As expected gross income and net income were both higher in Scenario II than Scenario I.

A higher price level of jatropha seed will also ensure a shorter payback period and increase the net return. Recently, the Confederation of Indian Industry (CII) has submitted a proposal to the Ministry of New and Renewable Energy, Government of India, New Delhi, wherein it is mentioned that the procurement price could be increased from the current level of ₹ 26.50 per litre to ₹ 36 per litre (*The Statesman*, 2011). The government should accord more attention on procurement price of seeds and take necessary action to support the resource-poor growers of this region to help in sustained production of jatropha seeds to make the bio-diesel industry sustainable.

Net Present Value of Jatropha Plantation

The net cash flows, calculated for 10 years and 40 years (as mentioned in Tables 5, 6 and 7) did not reveal

Table 5. Costs and returns from one hectare of jatropha plantation during the initial 10 years (under Scenario I) in NE India

Costs and returns (₹)	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year	9th year	10th year
1. Establishment cost	13945	0	0	0	0	0	0	0	0	0
a. Seedling costs	7174	0	0	0	0	0	0	0	0	0
b. Labour costs on various operations	6771	0	0	0	0	0	0	0	0	0
i. Land preparation	2799	0	0	0	0	0	0	0	0	0
ii. Digging	2303	0	0	0	0	0	0	0	0	0
iii. Planting	1669	0	0	0	0	0	0	0	0	0
2. Operation and maintenance cost	1907	2417	1907	691	1215	691	1215	691	1215	691
a. Cost on cleaning and weeding	1383	1383	1383	691	691	691	691	691	691	691
b. Cost on pruning	524	524	524	0	524	0	524	0	524	0
c. Cost on replanting	0	510	0	0	0	0	0	0	0	0
3. Other associated costs	0	500	1000	2000	3200	5000	5000	5000	5000	5000
a. Cost on harvesting and seed separation	0	500	1000	2000	3200	5000	5000	5000	5000	5000
4. Total costs on establishment, maintenance and harvesting	15852	2917	2907	2691	4415	5691	6215	5691	6215	5691
5. Production of seed (kg)	0	250	500	1000	1600	2500	2500	2500	2500	2500
6. Gross income	0	1250	2500	5000	8000	12500	12500	12500	12500	12500
7. Net income	NA	-1667	-407	2309	3585	6809	6285	6809	6285	6809
8. Cumulative net cash flow	-15852	-17519	-17926	-15617	-12032	-5223	1062	7871	14156	20965

Notes: Fertilizer, FYM and irrigation are important inputs, but in NE region there were no expenditures on these inputs initially or under operation and maintenance; hence these have not been shown in the table. Similarly, no costs were being incurred on storage, transportation and marketing; hence these have also not been shown in the table.

Table 6. Costs and returns from one hectare of jatropha plantation during the initial 10 years in NE India (under Scenario II)

Costs and returns (₹)	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year	9th year	10th year
1. Establishment cost	13945	0	0	0	0	0	0	0	0	0
a. Seedling costs	7174	0	0	0	0	0	0	0	0	0
b. Labour costs on various operations	6771	0	0	0	0	0	0	0	0	0
i. Land preparation	2799	0	0	0	0	0	0	0	0	0
ii. Digging	2303	0	0	0	0	0	0	0	0	0
iii. Planting	1669	0	0	0	0	0	0	0	0	0
2. Operation and maintenance cost	1907	2417	1907	691	1215	691	1215	691	1215	691
a. Cost on cleaning and weeding	1383	1383	1383	691	691	691	691	691	691	691
b. Cost on pruning	524	524	524	0	524	0	524	0	524	0
c. Cost on replanting	0	510	0	0	0	0	0	0	0	0
3. Other associated costs	0	0	5000	7500	10000	15000	15000	15000	15000	15000
a. Cost on harvesting and seed separation	0	0	5000	7500	10000	15000	15000	15000	15000	15000
4. Total costs on establishment, maintenance and harvesting	15852	2417	6907	8191	11215	15691	16215	15691	16215	15691
5. Production of seeds (kg)	0	0	2500	3750	5000	7500	7500	7500	7500	7500
6. Gross income	0	0	12500	18750	25000	37500	37500	37500	37500	37500
7. Net income	NA	-2417	5593	10559	13785	21809	21285	21809	21285	21809
8. Cumulative net cash flow	-15852	-18269	-12676	-2117	11668	33477	54762	76571	97856	119665

Notes: Fertilizer, FYM and irrigation are important inputs, but in NE region there were no expenditures on these inputs initially or under operation and maintenance; hence these have not been shown in the table. Similarly, no costs were being incurred on storage, transportation and marketing; hence these have also not been shown in the table.

Table 7. Costs and returns from one hectare of jatropha plantation under two scenarios during a period of 40 years

(in ₹)

Costs and returns	Scenario I	Scenario II
Total costs on establishment, maintenance and harvesting	236467	602267
Gross income	454250	1368750
Net income	217783	766483

a clear picture about the actual returns. Moreover, cash flows occurring after 10 years or 40 years may have different meaning today. Therefore, net present value and benefit-cost ratio were calculated for these two periods by discounting the future cash flows. However, the choice of discounting factor or discount rate in such calculations plays an important role. In these calculations presented in Table 8, the assumed rate of return was available from an alternative venture.

The net present values and benefit-cost ratios were calculated for the plantation period of 10 years and 40 years under both the production scenarios assuming the discount rates of 6.5 per cent (which is the interest rate provided by Post Offices), 7.75 per cent (interest rate of State Bank of India) and 8 per cent (interest rate on long-term deposits). The net present values of jatropha plantation for both periods of 10 years and 40 years have been found positive for all the three discount rates under both assumed scenarios. However, as expected, returns would be higher under production Scenario II than Scenario I.

The benefit cost ratios in both the periods and under both the production scenarios have been found more than one for all the discount rates. It indicates that the return from jatropha plantation is higher than per rupee invested in such plantations. The B-C ratio improves, indicating higher profitability, when there is an increase in the yield and/or decrease in the interest rate. Furthermore, the B-C ratio also increases with an increase in production years, because as production period increases, additional expenditures involved in plantation decrease.

Conclusions

The study has revealed that jatropha plantation in NE India is economically viable, though not highly profitable at the present. Since the cost needed for plantation is relatively lower for jatropha than other plantation alternatives in the region, resource-poor growers may look for investment in jatropha plantation. The major cost component of jatropha plantation is labour cost, which is incurred on operation and maintenance, harvesting and seed separation activities. Among these, cost on cleaning and weeding has been found the highest in the region, followed by costs on pruning and replanting. The plantation activities would become attractive for the growers, if they get adequate financial support for operating and maintaining their plantation sites. In this context MGNREGA can help the growers by creating employment opportunities in various operations, needed during a year.

Further, research and development efforts on new seed varieties, post management operations, better market price, etc. will make jatropha plantation more attractive. The analyses so far are based on the assumption that price would remain constant over the years. But, it does not seem to remain so as there is an increasing demand for fossil fuel (oil) in the world market. The rising demand for fossil fuel along with its limited stock will increase fuel price further, which in turn will result in a higher market demand for bio-diesel. Under such a situation, one may expect that the price of bio-diesel would increase in the near future. Accordingly, any future step to increase the procurement price of jatropha seeds will support the growers.

Table 8. Net present value and benefit-cost ratio of one hectare of jatropha plantation at different discount rates

Discount rate	Plantation period 10 years				Plantation period 40 years			
	Scenario I		Scenario II		Scenario I		Scenario II	
	NPV	B-C ratio	NPV	B-C ratio	NPV	B-C ratio	NPV	B-C ratio
6.5% (Post Office saving rate)	11990	1.25	87764	1.88	57563	1.64	237617	2.13
7.75% (SBI interest rate)	9870	1.21	80444	1.86	45859	1.58	198752	2.10
8% (from long-term investment rate)	9647	1.21	79636	1.86	34358	1.57	192594	2.09

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Received: March 2011; Accepted: April 2011