RESEARCH PAPER | International Journal of Agricultural Engineering | Volume 5 | Issue 1 | April, 2012 | 66 – 68

Economics of biodiesel production from jatropha oil

SAMODINI S. NEVASE, S.R. GADGE AND A.K. DUBEY

Received : 03.11.2011; Revised : 01.01.2012; Accepted : 14.02.2012

See end of the Paper for authors' affiliations

Correspondence to:

SAMODINI S. NEVASE
Department of Unconventional Energy Sources and Electricity Engineering, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, AKOLA (M.S.) INDIA
Email : samodininevase@rediffmail.com

Abstract **:** Present research work was undertaken to study economic feasibility of biodiesel production from jatropha oil. The biodiesel was prepared by the process of transesterification of the unfiltered jatropha oil, in presence of three per cent of KOH catalyst. Ethanol was added to oil by 30 per cent volume basis. The reaction temperature was kept at 60 ± 5°C for 1 h. The developed batch production unit of 5 l capacity at Central Institute of Agricultural Engineering, Bhopal was used for biodiesel production from jatropha oil. The 90.20 per cent of biodiesel recovery was obtained. The economic feasibility of prepared biodiesel was calculated by calculating the various economics of jatropha plantation, jatropha oil extraction, jatropha ethyl ester production. The cost of oil per kg and JEE production cost per litre was found to be Rs. 25.34 and 28.64, respectively.

Key words **:** Biodiesel, Transesterification, Jatropha oil, Economics

How to cite this paper **:** Nevase, Samodini S., Gadge, S.R. and Dubey, A.K. (2012). Economics of biodiesel production from jatropha oil. *Internat. J. Agric. Engg.*, **5**(1) : 66-68.

Energy is the driving force in the development of any country. There exist a strong relationship between economic growth and energy consumption. The socio-economic indicator drives the pace of economic development of any country. With regard to population, India is the second largest country in the world and has 17 per cent of the world population. The huge population, from 300 million in 1947 to over one billion people today, is putting strain on environment, infrastructure, employment and natural resources (Lodha and Singh, 2006). A programme for the development of energy from raw material, which grows in the rural areas, will go a long way in providing energy security to the rural people (Naik *et al.*, 2004). Even though many options like fuel cell run by hydrogen, electric vehicles etc. are being explored, use of biodiesel as replacement of petro diesel and ethanol in place of petrol are frontline alternatives as they can be used without any modification or change in the existing engines avoiding major additional investment. Recently, biodiesel has been receiving increasing attention due to its less polluting nature and because it is a renewable energy resource as against the conventional diesel, which is a fossil fuel leating to a potential exhaustion. Mostly biodiesel is prepared from oils like soybean, sunflower, safflower, rapeseed groundnut, and mustard etc. these oils are essentially edible in nature. Attempts have been made for producing biodiesel with non-edible oils like karanja and jatropha especially available in India. Considering the above facts, the present study was undertaken with the following objective to test the economic feasibility of biodiesel from jatropha oil.

Dorado *et al.* (2006) studied and approach to the economics of to vegetable oil based biofuels in Spain. This study identified that the price of the feedstock was one of the most significant factors. Also, glycerol was found to be a valuable by-product that could reduce the final manufacturing costs of the process up to 6.5 per cent, depending on the raw feedstock used. Biodiesel can only compete with diesel fuel prices. Planning Commission of India (2004) has calculated the cost of biodiesel for jatropha biodiesel considering seed at Rs. 6 per kg. and worked out the cost to be Rs. 20 per lit. (Which is expected at least after 4 years of plantation from then). Dindorkar (2006) studied production and energy balance of biodiesel and its performance in CI engine. Economics were calculated for biodiesel production using small scale domestic PKV Biodiesel processor. The cost of biodiesel was found Rs. 29.31 per lit of biodiesel considering seed cost Rs.5/kg.

METHODOLOGY

Mechanical oil expelling was done for jatropha oil extraction. CIAE, mini oil expeller was used for small-scale oil extraction of jatropha. Ethanol (C_2H_5OH) was selected as alcohol, as ethanol is produced from biomass and less

poisonous. Potassium hydroxide (KOH) was selected as catalyst, due to its high reactivity with oil in presence of ethanol. The batch production unit developed by CIAE, Bhopal used for production of biodiesel by processing 5 litre of jatropha oil by using KOH and ethanol in single stage trans-esterification method. Single stage transeterification method was used for the production of JEE from crude oil of jatropha. The general procedure adopted for the various trials was as follows:

- Known quantity filtered jatropha oil was taken
- The oil was poured in transesterification vessel.
- Potassium hydroxide was used about 3 per cent (w/v).
- Ethanol was added 30 per cent (v/v)
- Ethanol and KOH was mixed in stirrer
- Stirring was done slowly by 50 to 100 rpm
- Above mixture was slowly poured in the transesterification vessel containing jatropha oil
- Mixture thus got was heated at 65^0C in a closed vessel for alcoholsis
- The same temperature and speed was maintained up to one hour, to achieve complete transesterification
- After an hour the material was poured in semitransparent settling tank.
- It was kept at room temperature for 2-3 h for separation of the glycerin.
- Upper orange-brown ester was separated as bio-diesel from lower thick brownish glycerin by using siphon pump or other suitable means in separate tank.
- Ester was washed with water. The ester was mixed with water in 1:1 proportion followed by air bubble from the bottom of the vessel using air pump.
- Two washings of 1-2 h were given, so that pH of the bio-diesel decreases in the range from 6.5 to 7.5.
- Washed bio-diesel was separated from lower whitish washed water.
- Bio-diesel was heated up to 110^0C temperature for 1 hour for 10 m to remove the excess moisture in it.

After cooling, bio-diesel was ready for use in any diesel engine.

■ RESULTS AND DISCUSSION

Table 1 showed the economics of jatropha plantation cost per ha and per plant. Table 2 shows that the cost per jatropha plant Rs. 6.00 under rainfed condition. Same result was predicted by Planning Commission of India (2004). Table 2 showed the economics of jatropha oil extraction from Central Institute of Agricultural Engineering (CIAE) mini oil expeller. Capacity of the expeller assumed to be 100 kg per hour and life of plant assumed to be 10 years. And plant was supposed to run for 12 h/day and in one month for 25 days *i.e.* in one month for 300 h and in 10 years 3000 h. cost of oil estimated 25.34 by considering the seed cost Rs. 6/kg by considering profit @ 15 per cent the cost of oil was Rs 30 which was used for calculation of economics of JEE. This study showed that the price of the raw oil was one of the most significant factors. Also, seed hull and oil cake were by-product that could reduce the final production costs of the process up to 7.8 per cent. Same result was observed by Dorado *et al.* (2006). Table 3 shows the oil cost by using different seed cost. From Table 3 it seen that if the seed cost increases by Rs 2/- then oil cost increases by Rs. 8/-. Table 4 shows the economics of Jatropha ethyl ester production. Table 4 shows that if the jatropha oil cost was Rs. 26/kg then the cost of jatropha ethyl ester was Rs. 28.64/litre it seems that production of jatropha ethyl ester is economically feasible. Same observations was done by Dindorkar (2006).

Table 1: Economics of jatropha plantation

Sr. No.	Description	Cost
1.	Site preparation –10 MD	500
2.	Alignment and staking-5MD	400
3.	Digging of pits (2500 Nos.)	3500
4.	Cost of FYM (2 kg per pits)	2000
5.	Cost of fertilizer @ Rs. 6 per kg (50g per plant)	800
6.	Mixing of FYM, insecticides and refilling pits @ 100 per pit	1000
7.	Planting and replanting cost 100 plants per MD	2000
8.	Irrigation- 3 irrigation	1500
9.	Weeding and soil working	1000
10.	Plant protection measure	300
	Sub total	13000
	Contingencies @ 10%	1300
	Total	14300
	Cost per plant	5.75

Economics of jatropha biodiesel production in the biodiesel processor developed, starts with oil of jatropha. The cost of production for the processor was around Rs. 50000/- and life of plant was considered approximately 10 years. The cost of JEE was estimated to be Rs. 28.64/- by considering seed and Jatropha oil cost Rs. 6/kg and Rs. 26/kg, respectively. Biodiesel production was found to be affordable and comparable to the existing diesel prices.

Conclusion:

The cost of JEE was found to be Rs. 28.64 per litre (by reducing cost of byproducts) when the cost of jatropha oil was a Rs. 26/kg and that of seed cost was a Rs. 6/kg. Due to this the biodiesel is gaining worldwide acceptance as a solution for problem of environmental degradation, energy security, restricting imports, rural employment and attaining better agricultural economy.

Table 2 : Economics of jatropha oil extraction

Assumptions:
Capacity of the oil expeller was 100 kg/h of jatropha
Power requirement 20 Hp motor
Operation per day 12 hr
Production of oil cake 60 kg, oil 24 kg, hull 15 kg, 1 kg waste
Sale price of oil cake Rs. 2/kg, and hull Rs. 1/kg

Description	Nos.	Rate	Rs.
A) Fixed cost			
Machine cost:	1		
Power operated cleaner cum grader having capacity 150 kg/h	1	10000	10000
Dehuller with 1 Hp motor having about 100 kg/h capacity	1	10000	10000
Flanking unit	1	40000	40000
Oil filter press	1	15000	15000
Weighing scale, 100 kg capacity	1	10000	10000
Pretreatment of seed	1	10000	10000
Oil expeller	1	100000	100000
Total			195000
Housing, furniture @ 5%			9750
Total			204750
Salvage @ 10%			20475
Total			184275
Total per month			18427.5
Labor cost:			
Skilled operator	1	4000	4000
Helper	2	2000	4000
Total per month			8000
Electricity cost per month:			16000
Total fixed cost (a+b+c)			42427.5
B) Variable cost			
Seed cost	30000 kg	6/kg	180000
Miscellaneous @ 1%			184.27
Interest @ 2%			368.55
Total Variable cost (a+b+c)			180552.82
Total cost (A+B)			222980.325
C) Material cost:			
Oil cake per month	18000	2/kg	36000
Hull per month	4500	1/kg	4500
Total			40500
D) Total less byproduct cost [(A+B)-C]			182480.325
Oil cost per kg (D/seed weight)			25.34

Table 3 : Effect of seed cost on oil extraction economics

Sr. No.	Seed cost per kg (Rs.)	Weight of seed per day (kg)	Seed cost per day (Rs.)	Oil cost per kg (Rs.)
1.	4	30000	120000	17.01
2.	6	30000	180000	25.34
3.	8	30000	240000	33.67
4.	10	30000	300000	42.01
5.	12	30000	360000	50.34

Table 4 : Economics of jatropha ethyl ester production

Sr. No.	Description	Nos.	Rate	Rs.
Fixed cost				
Machine cost:				
1.	Cost of machine	1	50000	50000
2.	Depreciation @ 10%			4500
3.	Interest @ 2%			1000
4.	Maintenance @ 1%			500
	Total			56000
	Cost/day (Capacity 200 l/day)			28.00
Variable cost				
1.	Jatropha oil	200 l/day	26/kg	5200
2.	Ethanol	60 l/day	35/l	2100
3.	Catalyst	6 kg /day	10/kg	60
4.	Electricity	10 kW/day	4	40
5.	Labour	1	100/day	100
	Total			7500
Byproduct cost				
	Glycerol	30 l/day	60/l	1800
	Total			1800
	Total cost [A+(B-C)]			5728
	Total cost of JEE per litre			28.64

Authors' affiliations:
S.R. GADGE, Department of Unconventional Energy Sources and Electricity Engineering, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, AKOLA (M.S.) INDIA
A.K. DUBEY, Central Institute of Agricultural Engineering, BHOPAL (M.P.) INDIA

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