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Review Article

JATROPHA THE NEW MONEY PLANT AS A BIODIESEL

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A] Introduction:-

Since biodiesel can be made from, among other things, food crops, there are those who believe producing them does not meet ecological, environmental, and human needs. Opponents also worry if the growth of plants is fast enough to accommodate fuel needs. Another category of potential feedstocks for biodiesel is microalgae. [(1)]

Biodiesel is an alternative fuel made from renewable biological sources such as vegetable oils both (edible and non edible oil) and animal fats. Vegetable oils are usually esters of glycol with different chain length and degree of saturation. It may be seen that vegetable contains a substantial amount of oxygen in their molecules. Practically the high viscosity of vegetable oils (30- 200 Centistokes) as compared to that to Diesel (5.8- 6.4 Centistokes) leads to unfavorable pumping, inefficient mixing of fuel with air contributes to incomplete combustion, high flash point result in increased carbon deposit formation and inferior coking. Due to these problems, vegetable oil needs to be modified to bring the combustion related properties closer to those of Diesel oil.

The fuel modification is mainly aimed at reducing the viscosity and increasing the volatility. One of the most promising processes to convert vegetable oil into methyl ester is thetransesterification, in which alcohol reacts with triglycerides of fatty acids (vegetable oil) in the presence of catalyst. Jatropha vegetable oil is one of the prime non edible sources available in India. The vegetable oil used for biodiesel production might contain free fatty acids which will enhance saponification reaction as side reaction during the transesterification process.

Classification:-

Kingdom: Plantae
Division: Embryophyta
Class: Spermatopsida
Order: Malpighialeas
Family: Euphorbiaceae
Genus: Jatropha
Species: curcas

Common names:-

English-physic nut, purging nut; Hindi- Ratanjyot Jangli erandi; Malayalam- Katamanak; Tamil-Kattamanakku; Telugu- Pepalam; Kannadakadaharanalu; Gujarati-Jepal; Sanskrit-kanana randa

Jatropha Plant:-

Jatropha curcas L. or physic nut is a poisonous, perennial, drought resistant large shrub or small tree, belonging to the Euphorbiaceae family, producing oil containing seeds. J. curcas is native in central Mexico and northeastern part of South America, but is now found abundantly in many tropical and sub-tropical regions throughout Africa and Asia. From the Caribbean, where the species was already used by the Mayas, J. curcas was most likely distributed by Portuguese ships via the Cape Verde Islands and Guinea Bissau to other countries in Africa and Asia [(6).]

The plant grows readily in swamps or shade and is quick growing. Survives in poor stony soil and is resistant to droug It reaches a height of 3-5 m and has annual seed yield of up to 5 tons per hectare [(5).]

Scope and importance:-

All countries are at present heavily dependent on petroleum fuels for transportation and agricultural machinery. The fact that a few nations together produce the bulk of petroleum has led to high price fluctuation and uncertainties in supply for the consuming nations. This in turn has led them to look for alternative fuels that they themselves can produce. Among the alternatives being considered are methanol, ethanol, biogas and vegetable oils. Vegetable oils have certain features that make them attractive as substitute for Diesel fuels.

Objective of praposed study:-

1) Biodiesel obtained from jatropha is alternative for natural fuel .
2) It is renewable source of energy.
3) Easy method for formation of biodiesel.
4) Economically good.

5) It helps in sum amount to solve the biggest problem of fuel.

6) It will also help full for farmer , to increase their economical strength by cultivating this crops.

B] Biology of *Jatropha*:-

Jatropha Curcas L., in this report referred to only as Jatropha, is a small tree or large bush belonging to the Euphorbiaceae family [2]. See Figure 1 for examples of two Jatropha plants. Normally the plant reaches a height of three to five meters but can reach up to eight to ten meters when grown under favourable conditions. It has a life expectancy of up to 50 years, maturing after four to five years, and grows into different shapes, with one stem with no or few branches, or with branches growing from below. The plant initially develops one central deep tap root and four lateral roots. [3] The tap root can stabilize the soil and prevent landslides while the more shallow roots are assumed to prevent soil erosion caused by wind and water. [2]

Figure 1: Examples of two Jatropha plants in Southern India

Jatropha is a plant of deciduous type and sheds its leaves during dry season and also under stressful conditions [2]. The leaves are green, smooth, 4-6 lobed and 10-15 cm in width and length [2]. The plant has separate male and female flowers which are organized in clusters, inflorescences. The plant carries more male than female flowers, the male-to-female ratio is 29:1.[2] report that the ratio may decrease with plant age implying increased fruiting capacity with age. Flowering normally occurs once a year, during rainy season, but in permanently humid areas or under irrigation it flowers throughout the whole year. [3] See Figure 2 for examples of a Jatropha leaf and Jatropha flower.

Figure 2: Examples of Jatropha leaves and flower

After pollination by insects, mainly honey bees, approximately ten green fruits having an ellipsoidal shape are formed by each inflorescence [3]. Each fruit is about 40 mm long and contains three seeds. Occasionally a fruit can contain four to five seeds. [4] It takes three to four months after the flowering for the seeds to mature. The seeds are black, measuring on average 18 mm in length, 12 mm in width, and 10 mm in thickness [4]. The seeds weigh between 0.5 and 0.8 grams and the average number of seeds per kilo is 1375 seeds [3]. The seed yield per tree is reported to range from 0.2 to 2.0 kilos per year [5]. The seed's shell and inner kernel account for on average 37 and 63 percent of the total weight, respectively. Oil content of the seeds range from 32 to 40 percent; the average is 34 percent. The seed contains toxins, such as phorbol esters, curcin, trypsin inhibitors, lectins, and phytates, which render the seeds, oil, and seed cake non-edible if not detoxified. [2] See Figure 3 for examples of fresh fruit and seeds.

Figure 3: Examples of fresh fruits and seeds

C] Geographical distribution of Jatropha:-

Jatropha grows in tropical areas all around the world. Its exact point of origin is still unknown, but located in the Central America and Mexico area. The plant was probably brought to Africa and Asia by Portuguese seafarers via Cape Verde, which is also where its first commercial use was reported during the first half of 20th century. Lisbon and Marseille imported the produced seed to extract oil for soap production, a significant contribution to the exporting country's economy. Today Jatropha is cultivated in Central and South America, South-East Asia, India and Africa. [6]

According to current knowledge, Jatropha is an easily established, drought-resistant plant, which grows relatively quickly. It is therefore well-adapted to semi-arid and arid conditions. Its characteristics make it suitable not only for cultivation for oil production, but also for use as a live fence and for reclamation of eroded land. [7]

Under stress, such as low sun radiation, drought and cold weather, Jatropha can retrieve and store the nutrients from its leaves, which then turn yellow and are shed. The stem remains photosynthetically active, and in this state the plant can survive without rain for over a year. [4] For a longer period of time it survives with an annual rainfall of 250 to 300 mm but at least 600 mm is needed for flowering and fruit yield. The ideal average annual rainfall for seed production is reported to be 1000-1500 mm and the most favourable temperature is 20-28:C. However, the crop has been reported to withstand a light frost. Very high temperatures can affect the yield in a negative way, but it is not preferable to grow Jatropha in shade since it is adapted to high light intensity. [5]

Regarding preferred soil type, Jatropha is said to be adaptable and can grow almost everywhere except on waterlogged land. It grows on gravelly, sandy, and saline soils and can be found in the poorest stony soil and even in the crevices of rocks. [3] The preferred soil pH is between 6.0 and 8.0/8.5. [5]

Jatropha is reported to be pest resistant. According to observations of free-standing older trees confirm this, but for monocultures pests and diseases are frequently reportedl[5].

D] History of J . c u r c a s Use -

Curcas

has been used for fuel starting in the 1930's in Mali. In 19 39, the French government that was ruling Mali ordered plant oils to be shipped to France for use as fuel (Jatropha World). However, after World War II, the use of plant oils was used in the production of soap [38]. The use of J. c u r c a s as a fuel source was researched for a second time in the 1980's at Cape Verde Islands as part of the Integrated Rural Development Project [39]. Petroleum based diesel fuel was still less expensive than biodiesel, so the project was shut down for economic reasons.

Since the 1980's Jatropha has been researched and used on a large scale in Nicaragua, and has been spreading in popularity in India and parts of Africa [39]. The use of J. c u r c a s has been most popular in developing countries, because it is inexpensive to grow and produce, and is able to give a stable fuel source for countries not able to afford the growing price of importing petroleum diesel. There is a major center for the research and development of J. c u r c a s oil in Rajasthan, India called the Centre for Jatropha Promotion and Biodiesel [40].

E] Cultivation of Jatropha:-

Depending on region and climatic conditions there are several different methods for cultivation of Jatropha: direct seeding, pre-cultivation of seedlings (nursery raising), transplantation of spontaneous wild plants, and direct planting of cuttings.

Plants propagated by cuttings do not generally live as long and have a lower resistance to drought and diseases than plants propagated by seeds. A reason for this is that these plants' taproots may only reach half to two-thirds of the soil depth compared to taproots produced by plants propagated by seeds. [3]. Spacing in plantations varies depending on what the purpose of the plantation is and how it will be managed.

A plantation of a rectangular shape, a block plantation, with a plant spacing of 2.5 × 3 meters is commonly used and generates 1333 plants per hectare. With this pattern the plant has the space it needs for growing and branching, and intercropping is possible the first and even the second year during which Jatropha is still growing slowly.

Wider spacing enables the plant to grow larger and higher, making pruning and harvesting more difficult. A more narrow spacing, such as 2 × 2 meters (2500 plants per ha) or 2.5 × 2.5 meters (1600 plants per ha), requires more labour due to the more extensive pruning needed in order for the plants not to grow into each other. This spacing also requires soil with good nutrient and water supply due to its intensity. [8] To optimize the yield for individual plants some recommend using a wider spacing, such as 4 x 2 and 4 x 3 meters, and agroforestry systems with a spacing of 5x2 and 6x6 meters. It has been observed in 2.5 year old plantations that increasing the spacing significantly increases the seed yield per tree but the seed yield per area decreases. [2] Estimates of yield vary depending on country and region; according to [3] estimates range between 0.1 and 15 t/ha/year. Other conditions affecting the choice of spacing are intercropping, mechanized agriculture, and whether the plants are to be used as live fencing.

For permanent intercropping the spacing between the rows should be sufficient for growing the other crop, most commonly 4 meters, and the spacing between Jatropha plants within a row is usually 2.5 to 3 meters. For mechanized agriculture, the spacing depends on the machines used. For example, if 2 meters is needed for the machine one should leave room for 1 meter of branches on either side, resulting in 4 meters between rows, and the spacing between plants can be less in this case, 1.5 meters. When using Jatropha as live fencing the spacing between plants should be 25 cm and single or double rows can be used. [8] Jatropha can also be planted in embankments surrounding fields, called bunds, which improves rainwater infiltration [5]. Jatropha plantations need to be managed. Weeding, pruning, and thinning are activities mentioned in the literature. [2] Weeding is especially important before the Jatropha plants mature and shade the ground, competing weeds should be controlled regularly. Pruning during the dry season when the plant is dormant is important, to increase branching and thereby the number of inflorescences on the branch tips. This also creates a lower plant which is easier to harvest. The first pruning should be done after six months and then once a year. After ten years the tree can be cut down to 45-cm stumps, which will improve yields. The tree will grow back quickly and bear fruit again within a year. [5] Thinning of the plantations is also recommended, reaching a final density of 400-500 trees per hectare when the trees are mature [2].

Most information available on Jatropha suggests that it is a low input crop, however, inputs of irrigation and fertilizers are needed in order to maintain a productive crop. When the rains are not sufficient irrigation is needed after planting but can be discontinued after approximately 3 months, when the plants have developed root systems. Further irrigation may enable higher yields but might not be economically viable depending on the market price of Jatropha and the costs of irrigation. (Fact Foundation 2009a) Additionally, if too much water is applied, using for example drip irrigation, there may be an increase in biomass at the expense of seed production . According to [5], sufficient data on fertilizer response is not available to give specific recommendations but a trial study performed by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) showed that fertilization to an optimal level increased yield while applying excess fertilizer had a negative impact on the yield.

The optimal time for planting Jatropha, regardless of use of seeds, seedlings, or stem cuttings, is at the onset of the rainy season. Land preparation usually involves clearing the land and preparation of planting pits. Under optimal conditions Jatropha can flower 3-6 months after being planted, when using seeds. Another 90 days are needed for the fruit to mature. [8] When the fruit colour has changed from green to yellow-brown it is time to harvest. In wet climates harvesting is done continuously during the year while in the semi-arid regions it may be limited to two months. However, the fruits do not ripen exactly at the same time requiring weekly picking which makes it difficult to mechanize. The fruits are either handpicked or knocked to the ground by beating the branches with sticks. [5] After harvest the plant either enters a dormant state or flowers again. [8]

F] By-products during production of biodisel: -

There are three important by-products from the production of biodiesel from Jatropha: the seed husk from the seed production, the seed cake produced in the oil extraction, and the glycerol from the transesterification.

The seed husks that are removed before oil extraction can be used directly for combustion, but also as feedstock for gasification. Fuel characteristics are reported to be comparable to those of wood [2],[12].

Remaining from the oil extraction from seeds and kernels is a seed cake, with an oil content that depends on the efficiency of the extraction method. The seed cake contains high quality proteins [2] but also various toxins which make it unsuitable as a fodder [13]. However, if detoxification methods become feasible, the use of the seed cake as animal feed becomes beneficial [2]. Studies show that the seed cake is rich in plant nutrients which make it valuable as an organic fertilizer [14]. The toxins make it work as a biopesticide [2]. Jatropha farmers commonly bring back seed cakes to the fields for fertilizing purposes [13]. But still there are few studies on long-term impact of the toxins on soil and crops, and more research is needed, especially if the cake is to be used as a fertilizer for food crops. It is also possible to combine the use of seed cake as a fertilizer with production of biogas, through anaerobic digestion of the cake before using it on agricultural soils. (2)

Glycerol is produced in the transesterification of Jatropha oil into biodiesel. The glycerol can be used to produce heat by combustion, but it can also be used in the cosmetic industry as a feedstock for production of soaps and other products. [2]

G] Environmental impact of jatropha biodiesel production:-

The environmental impact of the Jatropha biodiesel production has been evaluated by several studies applying the Life Cycle Assessment approach. This approach shows the total environmental impact for the production system during its whole life cycle. It determines the processes in the system that contribute most to environmental impact and where the possibilities for improvement are. These assessments show varying results, possibly due to differences in methodology.

1]Energy balance:-

If the energy output of a given system is greater than the energy input, the system has a positive energy balance. However, energy balance is affected by energy quality and the utility of different energy carriers. A high energy input can be acceptable if the input energy is low-quality and the output a high-quality energy carrier, such as a liquid fuel usable for vehicle operation. The production of Jatropha biodiesel reportedly has a positive energy balance . The largest differences in energy requirement between different production sites are derived from differences in cultivation intensity, as irrigation and use of fertilizers are energy intensive practices [15]. Higher cultivation intensity does not always pay off in higher energy production, and optimization of inputs and yield is required for maximized positive energy balance. Another energy intensive production step is the transesterification of Jatropha oil into biodiesel, which implies that the direct use of crude Jatropha oil would improve the energy balance. However, in the use phase, the combustion of Jatropha oil instead of biodiesel is less energy efficient and causes problems to the engine. Hence, possibilities for improvement of energy balance lie in the cultivation and transesterification steps. [2]

2]Global warming: -

Studies report that production of Jatropha biodiesel releases less greenhouse gas (GHG) emissions compared to production of fossil diesel . The largest GHG contributing phases of the production are use of fertilizers and irrigation, if applied in the cultivation process, and transesterification. Hence, intensification of cultivation will have a negative effect on the global warming potential of Jatropha biodisel production.

However,find the end-use phase of the biodiesel to be the main contributor of GHG emissions, responsible for 90 percent of total life cycle emissions , and therefore changes in production processes would only affect total emissions marginally.[16]

Further, Prueksakorn and Gheewala mention that GHG emissions from production and use of biodiesel are 23 percent of emissions from fossil diesel. The main reason for this is that biodiesel is produced from biomass, and its carbon dioxide (CO_2) emissions from combustion in the engine are considered GHG neutral. [16] Biodiesel in general releases less emissions than fossil diesel, except for emissions of nitrogen oxides (NO_x), where emissions are slightly higher [17]. Nitrous oxide (N_2O) emissions from the use of nitrogen fertilizers also need to be considered; IPCC estimates the emissions to be one percent of nitrogen input from fertilizers. As nitrous oxide is a potent GHG, with a global warming potential that is 296 times higher than that of carbon dioxide, it is important to optimize the input of fertilizer to the output from cultivation to reach a reduction in global warming potential for the system. Destruction of carbon stocks by removal of natural and semi-natural forest for plantation of Jatropha will have significant negative effects on the life cycle global warming potential, and pay-back of stocks through reduction of GHG emissions by the use of biodiesel will take a long time. [2] Jatropha may contribute to GHG savings by carbon fixation in the biomass, as only the seeds are harvested while the biomass may remain standing for a long period of time. Studies report carbon uptake by mature Jatropha plants ranging from 25 tC/ha on rainfed Indian wasteland to 40 tC/ha on irrigated land in Egypt. [19] An IFEU (Institute for Energy and Environmental Research) report estimates the carbon content of a 3.5 year old plantation on infertile Indian soil to 5 tC/ha [18].

Although spacing patterns vary, the number of plants per hectare is not likely to have significant influence on carbon uptake, since denser plantations demands increased extent of pruning which results in decreased biomass per plant [19].

3] Land use changes:-

The impact of Jatropha cultivation on land use changes will be influenced by several factors, the most important being the original use of the land, the used cultivation system, and cultivation intensity [2]. Expected positive impacts on soil include improvement on soil structure, prevention of soil erosion, and carbon sequestration. Intensification of cultivation methods is a driver toward negative impact on soil. [15]

The impact on biodiversity depends on what land use is replaced by Jatropha plantations and the methods for cultivating Jatropha. Cultivation on barren and unused wasteland can help restore local biodiversity [2], while replacement of natural or semi-natural vegetation will have negative effects on biodiversity, especially if Jatropha is grown as a monoculture [15]. No significant effect on biodiversity is expected if Jatropha is cultivated in intercrop or agroforestry systems, or planted for fencing. As Jatropha is a non-native crop in India, and relatively recently imported, its invasiveness and impact on native species in the local area are still uncertain [2].

4] Water related impacts:-

Water scarcity is a problem in large parts of India, and climate change and intensification of agriculture further increase stress on the scarce water resources. A growing demand for bioenergy creates increased requirements for water for irrigation of biofuel crops, and conflicts between water use for energy and use for other agricultural production are becoming an issue.

One of Jatropha's main mentioned advantages is its resistance to drought and its low water requirements. The ability to grow Jatropha under dry conditions and increase the vegetation cover on degraded land gives opportunities for channelling of water, which earlier evaporated from the ground, into positive transpiration. However, a possible negative impact from this is that the increased evapotranspiration from the plantations causes decreased water supply downstream.

The use of irrigation for Jatropha plantations puts stress on the limited resources in water-scarce areas; efficient water management is necessary for optimal use of the scarce resources. Calculations of the total water footprint of Jatropha exist, but they vary widely. According to the water use for Jatropha biodiesel in India is very inefficient, and the production of one GJ of energy requires 600 m3 of water, which equals 20,000 litres of water per litre of biodiesel. For comparison, the water footprint for sugar cane for production of ethanol is 110 m3/GJ. [20]

This high water footprint value is criticized by who claim the value is an overestimate caused by methodological errors and inappropriate use of data. Maes [21] estimate the water footprint at 65 m3/GJ, only 16 percent of the value calculated by [20]. To use water resources more efficiently, the amount of water for irrigation should be optimized relative to outcome, and waste water from industrial processes, such as oil extraction and transesterification, should be reduced.

Possible impacts of emissions to water, from for example use of fertilizers and combustion of fossil fuels, include negative effects on household water and acidification and eutrophication of water flows [18]

5] Controversy:-

Doubtful environmental impacts and the failures in reaching satisfying yields have brought criticism to the Jatropha programme. But what seems to cause more controversy, especially at the local level, is the appropriation of the land used for Jatropha plantations.

As mentioned earlier, a base for the whole Jatropha programme is the classification of wastelands, which determines the land available for plantations. These wastelands include large areas within forests, like degraded and under-stocked forest, and arid and semi-arid ecosystems. In the search for available wastelands, attention has been drawn to resources referred to as Common Property Resources (CPRs). CPRs include all natural resources where no individual has exclusive property rights, but that are collectively held and used by the inhabitants of a community. This includes grazing lands, different types of forest land, and several types of water resources.

Historically, CPRs constituted a large part of India's natural resources; these were controlled by local communities and available for the rural population's use. However, as state control over natural resources increased, the CPRs available for the population decreased, and today communities have limited rights to land and water resources. Nevertheless, CPRs are still important for the sustenance and livelihood of India's rural communities. Through the Indian government's classification of wasteland and identification of land suitable for Jatropha plantation, CPRs risk becoming even less available.

Also of great importance, especially to the poor and landless population, is land that is not private property but owned by government departments. This includes land categories such as barren land, land under non-agricultural uses, and degraded forests, which are classified as wasteland. [36] These areas are often inhabited and used by communities of indigenous and landless people, who do not consider the land to be wasteland. They rely on the land for food and energy and for grazing of animals. In many cases the plantation of Jatropha on wastelands has involved forceful methods of driving these communities from the lands they have inhabited for generations. (37)

G]The Indian context:-

India depends on imports of crude oil to satisfy energy demands. As the population and economy continue to grow, the demand will continue to increase. Concurrently, the pressure to reduce environmental impact and mitigate climate change mounts. The hope is that domestic production of biofuels will replace some of the fossil fuel use to reduce dependence on imported oil and address environmental issues. (14)

Production of biofuels can contribute to socio-economic development through secured energy supply and employment opportunities. However, it is also important to develop and enhance the agricultural system to ensure the supply of food and agricultural products. Cultivation of energy crops can conflict with agricultural activities for food production. To avoid the energy versus food conflict, it is important to take the existing agricultural system into regard and develop an energy production system that does not compete for the same resources. (22),(23).

H]Biofuel initiatives :-

In 2003 the Indian government declared a National Mission on Biofuels, to drive large-scale implementation of biofuel production. In 2008 the national mission was replaced by a new biofuel policy. However, when studying Jatropha biodiesel production it is important to consider the first national mission, since it determined the prevailing conditions during the large-scale implementation of the Indian Jatropha programme in 2003-2006.(24)

I] National mission on biofuels :-

The National Mission on Biofuels stated a five percent blending target of biodiesel in conventional diesel, with a 20-percent blending target for 2012. (24).

The mission also announced an expansion of the existing ethanol production to reach the same target. The programme aimed to contribute to energy security, especially in rural areas, and to reduce dependence on imports of crude oil. By introducing a fuel superior to conventional diesel from an environmental point of view, the programme sought to reduce environmental impact, address global pressure for reduction of carbon emissions and mitigation of climate change, and follow enhanced automotive vehicle standards. Cultivation of biofuel crops would also provide soil nutrients, reduce soil erosion and land degradation, and help rehabilitate degraded lands through greening. For socio-economic development, the programme sought to provide a more widespread energy supply and to create employment in rural areas. (14)

As the demand for edible oil in India is higher than the domestic production of the product, production of biodiesel from edible oil would cause competition with food production. Hence, there was a need for evaluation of crops suitable for production of non-edible oil. Studies found that Jatropha and Pongamia Pinnata were among the most promising for the prevailing conditions. The Planning Commission for the National Mission on Biofuels announced that Jatropha was found most suitable for the stated energy, environmental, and socio-economic purpose.

The following list, adopted from the Planning Commission's report, shows the reasons Jatropha was found most suitable (14):

- Oil yield per area is among the highest of tree borne oil seeds.
- It can be grown in areas of low rainfall (200 mm per year) and in poor soils. In high-rainfall and irrigated areas it can be grown with much higher yields. Therefore, it can be grown in most parts of the country.
- Jatropha is easy to establish, grows relatively quickly, and is hardy.
- Jatropha lends itself to plantation with advantage on lands developed on watershed basis and on low-fertility marginal, degraded, fallow, waste and other lands such as along canals, roads, railway tracks, on borders of farmers' fields as a boundary fence or live hedge in arid/semi-arid areas, and even on alkaline soils. As such it can be used to reclaim waste lands in forests and outside.
- Jatropha seeds are easy to collect as they are ready to be plucked before the rainy season and as the plants are not very tall.
- Jatropha is not browsed by animals.
- Being rich in nitrogen, the seed cake is an excellent source of plant nutrients.
- Seed production ranges from about 0.4-12 t/ha.

To produce a sufficient amount of biodiesel to achieve the 20 percent blending target, the Planning Commission for the national mission calculated that 13.4 million tonnes of biodiesel was needed, which would require 11.2 MHa of land for cultivation of Jatropha (see Table 1). Required land area is calculated based on plantation density of 2,500 plants per hectare and seed production of 1.5 kg per tree.

Table 1: Biodiesel demand and land requirements for 5 and 20 percent blending calculated by the Planning Commission.

Year	Diesel demand (MT)	Biodiesel demand (MT)		Area needed (MHa)	
		5% blending	20% blending	5% blending	20% blending
2003-04	44.51	2.23	8.90	1.87	7.48
2004-05	46.97	2.35	9.39	1.96	7.84
2005-06	49.56	2.48	9.91	2.07	8.28
2006-07	52.33	2.62	10.47	2.19	8.76
2011-12	66.90	3.35	13.38	2.79	11.19

Source: Planning Commission (2003)

The Planning Commission identified and estimated land areas available, concluding that 13.4 MHa of land was available and feasible for immediate plantation. An additional 4 MHa of wastelands could also be planted (see table 2).

Table 2: The Planning Commission's estimate of available land areas for Jatropha plantations

Type of land	Area (MHa)	Potential area for Jatropha (MHa)
Under-stocked forest areas	31.0	3.0
Protective hedge around agricultural fields	142.0	3.0
Agro-forestry		2.0
Cultivable fallow land	24.0	2.4
Wastelands under Ministry of Rural Development poverty alleviation programmes		2.0
Public land along railways, roads, and canals		1.0
Total		**13.4**
Additional wasteland		4.0

Source: Planning Commission (2003)

The Planning Commission acknowledged the need for demonstration of the viability of the programme before large-scale implementation and involvement of a large number of stakeholders, including private farmers, communities, industry, financial institutions and government institutions. Therefore, the National Mission on Biodiesel was proposed in two phases. Phase 1, from 2003 to 2007, consisted of a demonstration project.

The objectives of this demonstration project were - Lay a foundation for a self-sustaining and fast-growing stakeholder-driven biodiesel production programme - Produce a sufficient amount of Jatropha seeds - Test, develop, and demonstrate the viability of all components of the programme, and estimate its cost and benefits - Widely inform and educate all potential participants of the programme

The Planning Commission estimated that the demonstration project would generate 127.6 million person days of plantation work and 36.8 million person days in seed collection. On a sustained basis the employment generation would be 16 million person days per year.

The experiences from the Phase 1 demonstration project would provide the foundation for the second phase, where a self-sustaining expansion of the programme would lead to production of the biodiesel required to achieve the 20 percent blending target in 2012. The first demonstration phase of the mission was driven by the government through national and state government agencies and under already existing poverty alleviation programmes. As there was no awareness of short-term economic returns from Jatropha plantations, the funds could not be expected to come from the private actors; the mission stated that plantation investments had to be done by the government.

The second phase would rest more on initiatives from private farmers, communities, NGOs and industry with support from financial institutions. Here the government would act mainly as a facilitator for policy support and support in critical areas identified during the demonstration project. Experiences from the demonstration project were supposed to attract farmers to spend their own money, with support from subsidies and bank loans. [14] Sometime during the first phase of the National Mission on Biofuels, it became clear that the project was not successful; the production of biodiesel from Jatropha, initiated during the national mission, was not living up to the high expectations. The mission was heavily criticized as it failed to address important issues and because many parts were not implemented correctly. [25],[26].

This study reports on some of the problems encountered during the demonstration phase. As a consequence of the failure, in 2008 the National Mission on Biofuels was aborted. A new policy, the National Biofuel Policy, was introduced.

J] National Biofuel Policy:-

The National Biofuel Policy sets a 20 percent blending target of biodiesel to conventional diesel, to be achieved by 2017. Like the former national mission, the new policy aims to reduce environmental impact and contribute to energy security and rural development. It further emphasizes some of the issues that were criticized in the national mission. For example, the policy focuses more on avoidance of conflict between energy and food security. It is clearly stated that biofuels should be based on non-food feedstock raised on land that is not suitable for agriculture.

Plantations are to be created on government or community land classified as degraded, fallow, or wasteland in forest and nonforest areas. Private plantations and corporate contract farming can be established through a Minimum Support Price mechanism proposed in the policy. [27]

An important difference between the former National Mission on Biofuels and the new biofuel policy is that while the national mission stated that Jatropha would be used as feedstock for the required biodiesel production, the new policy does not put forward any certain crop as more suitable than others. Instead the potential and techno-economic viability for production of biodiesel of more than 400 indigenous species of trees bearing non-edible oilseeds will be exploited. The policy will support continuous research, development, and demonstration on all aspects of biofuel production, from feedstock production to end-use applications.

Support will also be given to development of new and second generation biofuel feedstocks and more efficient conversion technologies. [27]

Figure 4: Dr. APJ Abdul Kalam As a Observed Jatropha Plant

Figure 5: Dr. APJ Abdul Kalam As a Jatropha Plantation

K]The agricultural system in India :-

The development of large-scale biodiesel production impacts, and is affected by, the existing agricultural system. It is therefore essential to understand the importance the agricultural sector has to the rural population. India's agricultural system can be considered the country's largest private enterprise, with more than a 100 million farm holdings.

The agricultural sector contributes to 25 percent of India's national GDP, sustains the livelihoods of two-thirds of the Indian population, and provides direct employment to about 234 million people. (ICAR 2008) The most-produced crops are wheat, rice and different forms of vegetables [29].

The Indian agricultural sector has developed during the past decades, from need for food imports of 8-10 million tonnes annually in the 1960s to food self-sufficiency, buffer stocks, and food export in the 1990s. This development has been achieved by increasing the area under cultivation [30] and through gains in agricultural productivity. [28]

J]National Agricultural Policy:-

Increased agricultural productivity has contributed to reducing poverty. However, 250 million Indians still live below the poverty line and depend on continued agricultural development to raise their standard of living. (IARI 2010) In an attempt to face this challenge the Indian government announced the National Agriculture Policy in 2000.

The policy seeks to utilize the growth potential of Indian agriculture, support faster agricultural development by enhancing rural infrastructure, create employment in rural areas, secure a fair standard of living for the farmers and agricultural workers and their families, discourage migration to urban areas, and face the challenges arising out of economic liberalization and globalisation. [31] Continued development, economic growth and further population growth put high pressure on natural resources like land, water, and bio-diversity. [29].

The National Agriculture Policy acknowledges the strains on natural resources by aiming at agriculture growth "that is based on efficient use of resources and [which] conserves our soil, water and bio-diversity". The policy also aims at equal growth, divided across regions and farmers, and growth that is technologically, environmentally and economically sustainable. [31] An integral part of the National Agriculture Policy is the Farm Produce Price Policy that annually announces minimum support prices for the major agricultural commodities. The policy seeks to ensure farmers incomes that encourage increasing investment and production. [32]

L]Connection between agriculture and rural livelihoods :-

Agricultural development is closely connected to rural development as agricultural factors have large impact on rural poverty and hunger. One of these factors is farm size; studies show that 54 percent of the landless population in India live below the poverty line1, and that even small landholdings can have a great impact, as the number of poor is reduced to 38 percent for the population owning up to 0.5 Ha of land. Ownership of livestock affects the livelihood of rural farmers; the percentage of the population living in hunger, and poverty is lower among those who have a cow or buffalo than among those who have no livestock.

In the relation between poverty and agricultural practices, the use of irrigation is an important factor, and the concentration of poor are larger on rainfed lands than in irrigated areas. Apart from agricultural factors, literacy rate seems to have an impact on the livelihood in rural India; a larger part of the illiterate population live below the poverty line. The literacy rate has an important role in development of agricultural productivity and practices, and will become even more important with globalisation and further modernisation of the agricultural system. [29] See Appendix I for tables.

M]Development of rainfed farming and rural liveliohoods :-

One of the toughest challenges is for Indian agriculture to enhance conditions for rural farmers by transforming rainfed farming into more sustainable and productive agricultural systems.

A large part of India's poor rural farmers live on rainfed lands and are dependent on natural water resources for sustaining their plantations. Rainfed agriculture is characterized by low levels of productivity and low intensity in inputs, and variability in rainfall causes varied and instable yields. As climate change and increased stress on natural resources cause changes in agricultural conditions, the conditions for farmers on rainfed land become even tougher. [28] Facing the challenge of developing rainfed farming, the national government established the National Rainfed Area Authority (NRAA), to increase focus on the problems of rainfed areas [33].

Several government programmes aim at development of rainfed agriculture and enhancement of livelihoods for the rural poor. Among these are the Comprehensive Land Development Programme (CLDP), the Drought Prone Area Development Programme (DPAP) and the Integrated Wasteland Development Programme (IWDP).

For a sustainable development of rainfed farming, the Indian government has put high priority on implementation of the watershed approach, aiming at conservation and management of water. A watershed is defined as a geographic area that drains water to a common point, and can include one or several villages, arable and non-arable land, and various categories of farmers and land-holdings. The focus in water resource management is not only on creation of new water resources but also on more efficient utilization of existing resources, for example by adoption of efficient irrigation systems and substitution of high water requiring crops by low water requiring crops. Studies on impacts of watershed projects have shown increase in groundwater recharge, increased water resources, enhanced cropping intensity, higher yields, and reduced loss of soil nutrients. [28]

N]Jatropha in India :-

Jatropha may be more suitable than other crops for production of biodiesel, because of its stated properties. India is one of the leading countries in Jatropha plantations and expectations on the production of biodiesel from the crop have been high, not least because of the National Mission on Biofuels and the National Policy on Biofuels. However, Jatropha projects have not been as successful as expected, mostly due to difficulties in reaching satisfying yields

As Jatropha is a relatively new agricultural crop, it is hard to find reliable statistics on its performance.

O] Potential yields in India :-

Jatropha is put forward as a highly adaptable crop that can be cultivated in a wide range of ecological conditions. However, studies show that crop performance depends on the agricultural environment, which is why the potential yield differs widely among cultivation sites in different parts of India. Also, potential yield depends on cultivation techniques, with the main contributing maintenance factor seeming to be whether the crop is rainfed or irrigated.

For the rainfed case, reports show that most of the country could reach a potential seed yield of 1-3 t/ha, with somewhat smaller yields towards the Northeast. The most productive areas in India are the Eastern states and small parts of the Southern states of Tamil Nadu, Karnataka and Kerala, where potential seed yields are reported to peak at 5.2 t/ha . If irrigated, most areas in India can reach a productivity of 5.8 t/ha, and peak yields have been reported to be 6.9 t/ha [34].

P]Land requirements to reach blending target:-

According to the report preceding the now shut-down National Mission on Biofuels, an additional 11.2 MHa of Jatropha plantations was required to reach the 20 percent blending target by 2012 [14].

For the new target stated in the National Policy on Biofuels, to reach 20 percent blending by 2017, an additional 14 MHa is estimated to be required . Requirements estimated by [34] differ a little; they state that the land requirement is affected by the variation in potential productivity and calculate the required land to range between 9.5 and 41 MHa depending on if the cultivation sites are in high or low productivity areas. [34] also mention that land requirements can be further decreased if plantations are irrigated, and that the high productivity number can be as low as 7.9 MHa with the use of irrigation.

Out of India's total land area, 55.25 MHa are classified as wasteland or degraded land and could theoretically be available for plantation of Jatropha [35]. See Appendix II for categories and areas of wasteland. However, not all this land is optimal from an agricultural point of view, as the classification includes for example areas of bare rock and glaciers.

A large part of the area is land along roads and railways, which can result in widely spread plantations and demand for longer transports. Also, large parts of the land are not sufficient to produce satisfying yields, but here Jatropha cultivation might still have positive effects in hindering soil erosion and improve land fertility.

As a part of the National Mission on Biofuels, the Planning Commission identified and estimated the wasteland and other land available for Jatropha cultivation, and agreed on 13.4 MHa of land being available and feasible for immediate plantation of Jatropha. Thus, this was sufficient to reach the 20 percent blending target according to their own estimation of the required land.

Q] Jatropha biodiesel :-

The harvested Jatropha seeds are used for production of Jatropha oil and biodiesel. The first step is to extract the oil in the seeds, which can later be converted into biodiesel.

R] Methods and Devices for Jatropha Oil Extraction :-

Some of the methods that are usually employed forthe extraction of jatropha oil are as follows

1]Oil Presses:-

Oil presses have been used for the purpose of oil extraction as simple mechanicaldevices - either powered or manually driven. Among the different oil presses that are used for jatropha oilextraction, the most commonly used presses include the Bielenberg ram press.

The Bielenberg ram press involves the traditionalpress method to extract oil and prepares oil cakes as well as soaps. It is a simple device that yields around3 liters of oil per 12 kg of seed input. Since therecognition of jatropha as an alternative energy sources (namely, biofuel), jatropha oil extractionmethods have also gained due importance in themarket. Since jatropha oil is the primary ingredient required in the production of biofuels, the development of oil extraction methods and the optimization of existing methods of extracting the oilhave become significant.

S] Oil Expellers:-

Different kinds of oil expellers are used for the purpose of jatropha oil extraction. The most commonly used ones are the

1]The Sayari expeller: –

Is a diesel-operated oilextraction device that was originally developed in Nepal. It is now being developed for use in Tanzania and Zimbabwe for the purpose of jatropha oil extraction and oil cake preparation. The prototype included heavy parts made of cast iron. The lighter version has the cast iron replaced with iron sheets. A model driven by electricity is also available.

2]The Komet expeller is a single-screw :-

oil expeller that is often used for extracting jatropha oil from the seeds and also for the preparation of oil cakes.

3]Traditional Methods:-

Traditional methods by which the oil is extracted from the seeds by hand using simple implements are still practiced in ruraland less developed areas.

4]Modern Concepts:-

Methods like ultrasonication have been discovered to be effective in increasingthe percentage of jatropha oil that can be extractedusing chemical methods like aqueous enzymatictreatment. The optimum yield for such methods has been discovered to be around 74%. Jatropha oilextraction methods are still being researched. Thegoal of such researches is to discover methods toextract a greater percentage of jatropha oil from theseeds than the current procedures allow.

T] Oil Extraction:-

Oil Extraction may be done: Mechanically (by pressing the kernels) Chemically; and Enzymatically

Mechanical and chemical oil extraction:-

There are two different options for extracting oil from the Jatropha seeds: mechanical extraction and chemical extraction. In both cases the seeds have to be dried prior to extraction, either in an oven or in the sun. [2]

1] Mechanical oil extraction methods :-

Mechanical cold pressing of seeds is the conventional extraction method, due to its simplicity and affordable investment cost already at small scale (Aadrians 2006). For mechanical extraction either an engine-driven press or a manual press can be used, where the engine-driven option is reported to extract a higher percentage of the available oil, normally 75-80 percent compared to 60-65 percent for the manual press. The mechanical expeller can be fed with either whole seeds, kernels or a mix of the two [2].

2]Chemical extraction methods :-

Chemical extraction methods were developed in order to achieve a more complete extraction, where the amount of oil per ton of seed increased. The chemical extraction methods use a solvent. The most common solvent used in extraction of Jatropha oil n-hexane, which extracts 95-99 percent of the oil. However, the use of solvent-based oil extraction is only economical at large-scale production. Also, the use of n-hexane as a solvent generates large amounts of waste water, requires high energy consumption and causes emissions of volatile organic compounds, and affects human health by forcing operators to work with hazardous and flammable chemicals. [10] New production units for extraction with n-hexane as a solvent are more efficient and have a lower environmental impact, but research and development of alternatives, such as supercritical or bio-renewable solvents, could be useful. Environmental impacts can also be decreased by substitution of solvent based oil extraction with aqueous enzymatic oil extraction, but that would lead to decreases in the percentages of oil extracted. [2]

3]Conversion to biodiesel :-

The Jatropha oil can be used directly as a liquid fuel in older diesel motors, in generators and pumps running at a constant speed, or in newer engines with small modifications in the fuel system. The Jatropha oil can also be mixed with fossil diesel before use in the engine, which combines the properties of the fossil fuel with the lower environmental impact of the vegetable oil. [17], [2] However, Jatropha oil has a viscosity that is 20-25 times higher than the viscosity of conventional diesel, which causes problems when using the unmodified oil or blends with a high percentage of Jatropha oil in an engine.

Thus, there is a need for modification of the oil to reduce viscosity and make it more suitable as an engine fuel. [17] Methods for this are pyrolysis and micro-emulsification with solvents like methanol, ethanol, and butanol, but the most common method is to convert the Jatropha oil into biodiesel through transesterification. This method transforms an ester into another ester; in this case a reaction between Jatropha oil and methanol is used to produce a methyl-ester (biodiesel) with glycerol as a by-product. The biodiesel can be used directly in a diesel engine or in a blend with conventional diesel. [17], [2]

U]Production Process:-

1]Transesterification: -

Is the process of chemicallyreacting a fat or oil with an alcohol in a presence of acatalyst. Alcohol used is usually methanol or ethanolCatalyst is usually sodium hydroxide or potassium hydroxide. The main product of transesterification is biodiesel and the co-product is glycerin

2]Separation:_

After transesterification, the biodieselphase is separated from the glycerin phase; bothundergo purification .The chemical properties of jatropha oil are given below.

Table 3:

Item	Value
Acid Value	38.2
Saponification value	195.0
Iodine Value	101.7
Viscosity (at 31°C), Centistokes	40.4
Density (g/cm³)	0.92

Fatty acid composition

Palmitic acid (%)	4.2
Stearic acid (%)	6.9
Oleic acid (%)	43.1
Linoleic acid (%)	34.3
Other acids (%)	1.4

Figure 6: Jatropha curcas Plant

Figure 7: Jatropha curcas plant

Experimental procedure :-

3]Neutralization:-

The vegetable oil contains about 14-19.5 % free fatty acids in nature, it must be freedbefore taken into actual conversion process. Thepresence of about 14% of free fatty acid makesJatropha oil inappropriate for industrial biodiesel production.

The dehydrated oil is agitated with 4 % HCl solution for 25 minutes and 0.82 gram of NaOH was added per 100 ml of oil to neutralize the free fatty acids and to coagulate by the following reaction. $RCOOH + NaOH \rightarrow RCOONa + H_2O$. The coagulated free fatty acid (soap) is removed by filtration. This process brings the free fatty acid content to below 2 % and is perfect source for biodiesel production.

4]filtration:-

This process brings the free fatty acidcontent to below 2 % and is perfect source for biodiesel production.Biodiesel production: In this study, the base catalyzed transesterification is selected as the process to make biodiesel from Jatropha oil.

Transesterification-ion reaction is carried out in abatch reactor.For transesterification process 500 ml of Jatropha oilis heated up to 700C in a round bottom flask to drive off moisture and stirred vigorously. Methanol of 99.5% purity having density0.791 g/cm3 is used. 2.5gram of catalyst NaOH is dissolved in Methanol inbi molar ratio, in a separate vessel and was poured into round bottom flask while stirring the mixturecontinuously. The mixture was maintained atatmospheric pressure and 60°C for 60 minutes.

After completion of transesterification process, themixture is allowed to settle under gravity for 24hours in a separating funnel. The products formed during transesterification were Jatropha oil methylester and Glycerin. The bottom layer consists of Glycerin, excess alcohol, catalyst, impurities and traces of unreacted oil.

The upper layer consists ofbiodiesel, alcohol and some soap. The evaporation ofwater and alcohol gives 80-88 %pure glycerin,which can be sold as crude glycerin is distilled bysimple distillation.Jatropha methyl ester (biodiesel) is mixed, washedwith hot distilled water to remove the unreactedalcohol; oil and catalyst and allowed to settle under gravity for 25 hours. The separated biodiesel is takenfor characterization

5)Biodiesel production:-

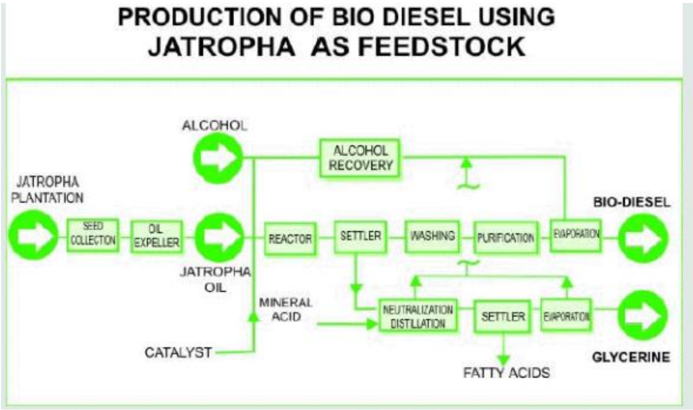

Figure 8: Bio - diesel Production Using Jatropha as Feedstock

In this study, the base catalyzed transesterification is selected as the process to make is carried out in a batch reactor.

For transesterification process 500 ml of Jatropha oil is heated up to 70°C in a round bottom flask to drive off moisture and stirred vigorously. Methanol of 99.5 % purity having density0.791 g/cm³ is used. 2.5 gram of catalyst NaOH is dissolved in Methanol in bi molar ratio, in a separate vessel and was poured into round bottom flask while stirring the mixture continuously. The mixture was maintained at atmospheric pressure and 60°C for 60 minutes.

After completion of transesterification process, the mixture is allowed to settle under gravity for 24 hours in a separating funnel. The products formed during transesterification were Jatropha oil methyl ester and Glycerin. The bottom layer consists of Glycerin, excess alcohol, catalyst, impurities and traces of unreacted oil. The upper layer consists of biodiesel, alcohol and some soap. The evaporation of water and alcohol gives 80-88 %pure glycerin, which can be sold as crude glycerin is distilled by simple distillation. Jatropha methyl ester (biodiesel) is mixed, washed with hot distilled water to remove the unreacted alcohol; oil and catalyst and allowed to settle under gravity for 25 hours. The separated biodiesel is taken for characterization

6]Biodiesel Characterization :-

The specific gravity reduces after transesterification,viscosity from 57 to 4.73 centistokes, which isacceptable as per ASTM norms for Biodiesel.

Flash point and fire point are important temperaturesspecified for safety during transport, storage andhandling. The flash point and fire point of biodiesel was found to be 128°C and 136°C respectively.Flash point of Jatropha oil decreases aftertransesterification, which shows that its volatile characteristics had improved and it is also safe tohandle.Higher density means more mass of fuel per unitvolume for vegetable compared to diesel oil.

The higher mass of fuel would give higher energyavailable for work output per unit volume.Higher viscosity is a major problem in usingvegetable oil as fuel for diesel engines. Cloud and pour point are criterion used for low temperatureperformance of fuel. The cloud point for Diesel is40C which is very low and the fuel performssatisfactorily even in cold climatic conditions. The higher cloud point can affect the engine performanceand emission adversely under cold climaticconditions. The pour point for Diesel is -40C. Ingeneral higher pour point often limits their use asfuels for Diesel engines in cold climatic conditions.

When the ambient temperature is below the pourpoint of the oil, wax precipitates in the vegetable oilsand they loose their flow characteristics, wax can block the filters and fuel supply line. Under theseconditions fuel cannot be pumped through theinjector. In India, ambient temperatures can go downto 00C in winters.Fuels with flash point above 660C are considered assafe fuel.

Manufacturing Process:-

1. Jatropha oil is filtered to remove any solid particles.
2. Jatropha oil is then heated to remove any water content (optional).
3. Titration is done to determine how much catalyst is needed.
4. Exact quantity of Potassium Hydroxide is then thoroughly mixed in Methanol till it dissolves completely to get potassium methoxide.
5. Jatropha oil is heated if required (during winter), and mixed in the potassium methoxide while with agitator running.
6. It is then allowed to settle and glycerin is removed from bottom.
7. Bio - diesel fraction is then washed and dried.
8. It is then checked for quality.

T] Conclusion:-

In the current investigation, it has confirmed that Jatropha oil may be used as resource to obtain biodiesel. The experimental result shows that alkaline catalyzed transesterification is a promisingarea of research for the production of biodiesel inlarge scale.Effects of different parameters such as temperature, time, reactant ratio and catalyst concentration on thebiodiesel yield were analyzed. The best combinationof the parameters was found as 6:1 molar ratio ofMethanol to oil, 0.92% NaOH catalyst, 600Creaction temperature and 60 minutes of reaction time The viscosity of Jatropha oil reduces substantially after transesterification and is comparable to diesel. Biodiesel characteristics like density, viscosity, flash point, cloud point and pour point are comparable to diesel.

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