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Biofuels as an Alternative Energy Source for Sustainability

Rajamani Raman*

Department of Agronomy, Faculty of Agriculture, Annamalai University, India

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***Corresponding author:** Rajamani Raman, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar 608 002, Tamil Nadu, India

Abstract

Energy is one of the major inputs for the economic development of any country. Economic growth is desirable for developing countries and energy is essential for economic growth. The ever-rising cost of fossil fuel internationally has forced major world economies, which are also major importers of fossil fuel, to examine renewable and cheaper alternatives to fossil fuel to meet their energy demands. The importance of bio fuels (biodiesel and ethanol) is rapidly increasing which growing anxiety over crude oil supply and fast climate changes. Biodiesel is a safe and clean fuel. Bio diesel is environment friendly fuel prepared from edible and non-edible vegetable oils or animal fats. We can use it in our DIESEL engine today, with no modifications. We can even mix it with the petroleum diesel that's still in there. What's cool about Biodiesel is that it reduces greenhouse gases by 78 %. Biodiesel and bio ethanol have emerged as the most suitable renewable alternatives to fossil fuel as their quality constituents match diesel and petrol respectively. In addition, they are less polluting than their fossil fuel counterparts. Environmental concerns and the desire to be less dependent on imported fossil fuel have intensified worldwide efforts for production of biodiesel from vegetable oils and ethanol from starch and sugar producing crops. Both biodiesel and ethanol are clean, are methane (biogas) digesters that turn livestock, crop and food wastes into cooking and heating gas. Bio energy is a renewable energy and it is produced from biological materials (bio mass) such as crops, wood, and municipal wastes. Our planet is heating up and we've got to stop burning petroleum if we want to keep living here! All over the globe people are experimenting with solutions that will slow global warming and figuring out which ones work best. Biodiesel is a top choice is nearly every nation.

Keywords: Biofuels; Bio-diesel; Energy security; Sustainability; Ethanol

Introduction

Rapidly increasing world population, continuing energy crises, fast deterioration of non-renewable energy sources, exploding use of vehicles, pollution hazards from fuel emissions and the associated health disorders have warranted the immediate need for alternative source of fuel. The world energy demand is expected to grow further and further over the next couple of decades. Most of the energy requirements are currently satisfied by fossil fuels-coal, petroleum-based products and natural gas. The demand of these alternative fuels came into picture when the world recognized that it has a very limited supply of fossil fuel and burning it leads to various other environmental problems like global warming. Burning conventional fuels like petroleum leads to a lot of greenhouse gas emission. Biofuels are the best way of reducing the emission of greenhouse gases. They can also be looked upon as a way of energy security which stands as an alternative of fossil fuels that are limited availability. Today the use of biofuels has expanded throughout globe [1-3].

Biofuels

Biofuels are renewable liquid fuels coming from biological raw material and have been proved to be good substitutes for oil in the transportation sector. As such biofuels - ethanol and biodiesel are gaining worldwide acceptance as a solution for problems of environmental degradation, energy security, restricting imports, rural employment and agricultural economy. Ethanol is used as fuel or as an oxygenate to gasoline. Raw material used for producing ethanol varies from sugar in Brazil, cereals in USA, sugar beet in Europe to molasses in India. Biofuels can be easily produced through any carbon source: making the photosynthetic plants the most commonly used material for production. There are two methods currently brought into use to solve the above problems. In the first one, sugar crops or starch, are grown and through the process of fermentation, ethanol is produced. In the second method, plants are grown that naturally produced oils. These oils are heated to reduce their viscosity after which

they are directly used as fuel for diesel engines. This oil can be further treated to produce biodiesel which can be used for various purposes. Most of the biofuels are derived from biomass or bio waste. Most of the biomass is obtained from plants and animals and also include their by products [4-11].

Bio-disel

is a renewable energy that can be produced from a number of sources including vegetable oils, animal fats, algae sourced oil by a process known as lipid transesterification? It has some very similar properties to petroleum-based diesel and can be used as a complete replacement or as a mixture of petroleum and biodiesel. Because the biodiesel is a renewable fuel, can replace petroleum diesel in current engines and can be transported and sold using the current infrastructure, it is one of the most realistic candidates to replace fossil fuel as the world's primary transportation energy source. Biodiesel contains no petroleum, but it can be blended at any level with petroleum diesel to create a biodiesel blend or can be used in its pure form. Just like petroleum diesel, biodiesel operates in compression ignition engine; which essentially require very little or no engine modifications because bio-diesel has properties similar to petroleum diesel fuels. It can be stored just like the petroleum diesel fuel and hence does not require separate infrastructure

Unlike the burning of fossil fuels such as coal and oil, biodiesel does not give off any Sulphur dioxide. The exhaust fumes given from biodiesel are much cleaner smelling than regular diesel. It also has a other cleaner characteristics such as less carbon monoxide, unburned hydrocarbons and soot particles. Diesel engines are a lot more efficient than petrol engines and so less energy is wasted if we use biodiesel rather than petroleum. Biodiesel can be and is already mixed with regular diesel to form biodiesel blends. These blends are already sold at many filling stations. These blends can be in any proportion, but you will often find 5% biodiesel to 95% fossil fuel diesel.

Biofuel crops

Jatropha, Sugarcane, Sweet sorghum, Tapioca, Sugar beet, Maize and Pungam yield biofuel from starch, juice or from molasses.

Jatropha

Jatropha curcas is a multipurpose non edible oil yielding perennial shrub. It originated in Tropical America and belongs to the family Euphorbiaceae. It produces latex and hence animals do not browse the plant. It is a hardy and drought tolerant crop, can be raised in marginal lands with lesser input. It can be maintained for 30 years economically. The genus Jatropha has 476 species and 12 are found in India. Jatropha curcas is a promising one with economic seed yield and oil recovery. The oil of Jatropha can be used as biodiesel blend up to 20 %. Flowering starts from ninth month after sowing. Economic yield starts from the end of third year. The yield is 3 kg seeds per plant. Glycerine is a byproduct of seed processing and is an input in personal care preparations, cosmetics and pharmaceuticals. It has nearly 1500 known end uses as plasticizer, emollient, thickener, solvent, dispersing medium, lubricant, sweetener and anti freezing agent.

Jatropha oil and cake contains traces of toxins and can be denatured by heat. The oil cake cannot be used as animal feed because of the toxicity. The NPK content of oil cake is 4.4, 2.1 and 1.1 % respectively. The fixation of up to 10 t/ha of CO2 by Jatropha is an advantage. The oil content is 26 to 36 %.

Sugarcane

Sugarcane is composed of six species of perennial grasses of the genus Saccharaum L. of the Gramineae. Sugarcane cultivation requires a tropical or subtropical climate, with a minimum of 600 mm of annual moisture. Cane sugar is currently grown in tropical countries. Cane molasses is a byproduct of the manufacture or refining of sucrose from sugarcane. Molasses is a byproduct of the manufacturing of cane sugar. Approximately 2.7 % of a ton of cane can be extracted as molasses. Molasses can be used as fertilizer and stock feed. Molasses can be distilled and fermented to produce alcoholic distillate. Their main uses are in vinegar, cosmetics and pharmaceuticals, cleaning preparations, solvents and coatings. Other products from molasses are butanol, lactic acid, (solvents), citric acid (for food and beverages), glycerol and yeast.

Sugar beet

Sugar beet (Beta vulgaris spp.) is a biennial sugar producing root crop, grown in temperate countries contributing about 24% of the world's sugar production. Sugar beet and sugarcane are the two major sources of white crystal sugar in the world. Tropical sugar beet is gaining momentum in various parts of tropical regions.

Importance of sugar beet

a. The sucrose content is high. 14-18 %

b. Fits well in annual crop rotation

c. Harvest coincides with off-season

d. It Improves soil conditions.

e. High ethanol production/unit time/area viz., 13,000 - 15000 liters per hectare per year.

Sweet sorghum

Sweet sorghum, also known as sugar sorghum is currently developed for the simultaneous production of grain and cane. It was introduced in USA in 1950. Sweet sorghum has sweet juicy stem and is rich in stalk sucrose and sugars, may be used for forage and silage or to produce syrup. In Brazil, sweet sorghum is grown as a source of ethanol production. It is the chief source of ethanol in USA, Brazil, China, Australia and South Africa. Sweet sorghum has a potential yield of 4000 l/ha whereas corn, wheat and grain sorghum produce only 2290, 917 and 81 l/ha of ethanol respectively. Ethanol yield of sweet sorghum in different countries is 2639 lit/ha (Brazil), 7000 lit/ha (China), 3000 lit/ha (South

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Africa) and 4790 lit /ha (USA). The biomass yield is 35 -50 t/ha. Sweet sorghum produces a very high yield in terms of grains, sugar, and lignocellulosic biomass.

Cassava

Cassava offers immense scope as food, feed and industrial raw material. It can be used in industries for the preparation of alcohol, gums, dextrins and cold-water soluble starch. The yield of bioconversion and ethanol concentration was approximately 7.5 g ethanol / 25 g cassava chips.

f. Maize

Production of ethanol from corn created a byproduct, distillers' dried grains that must be sold to make the ethanol plants commercially viable. About half the protein in corn forms films readily and is insoluble in water. This alcohol extractable protein is called zein. Sale of zein isolate as a byproduct, in place of some of the distillers' dry grains should significantly reduce the overall cost of producing ethanol and enable corn producers to obtain and maintain higher returns from the non starch corn components. Maize is grown in Tamil Nadu both as irrigated crop and rainfed crop in an area of 2 lakh hectares.

g. Sweet potato

Sweet potatoes are now cultivated throughout tropical and warm temperate regions wherever there is sufficient water to support their growth. In nutritional terms, sweet potato, particularly the yellow fleshed varieties are good sources of vitamin A. A comparison with other food crops shows that it yields more calories per unit area than either maize or potato.

The roots are most frequently boiled, fried or baked. They can also be processed to make starch and a partial flour substitute. Industrial uses include the production of starch and industrial alcohol. They can also be sliced and fried and eaten just like potato chips. Sweet potato contains about 22% starch and 5 -6% sugars for a total of 27- 28% fermentable materials. A tone of sweet potato yields up to 40 gallons of alcohol. Ethanol from sweet potato is also an alternative source of alcohol production.

Bioethanol - using ethanol fuel for vehicles and other engines

Ethanol is alcohol produced from natural sugar and starch plant growth such as grains (it is sometimes known as grain alcohol), sugar cane and oil seed rape and it can be used to fuel vehicle engines. Ethanol is made from the processes of fermentation and distillation. When people talk about using ethanol as a source of energy, they sometimes refer to it as bioethanol. Ethanol is the type of alcohol that can be consumed (such as the alcohol in beer and wines). It is a clear, colorless liquid and its use as a fuel has a number of benefits over using petrol or oil-based diesel.

Ethanol has been used as a vehicle fuel in the United States for a number of years but on a very small scale. Recent growing concerns over the environmental effects of burning fossil fuels and the increasing price of oil have now forced governments and energy producers to consider biofuels such as biodiesel and bioethanol more seriously. Ethanol is commonly used as an addition to normal petroleum to form ethanol-blended petrol. These blends are commonly made up of around 10% ethanol and 90% petroleum, but now higher ratios of ethanol are being used in blends and further testing is being done on new types of blends. The US uses more than 15 billion gallons of ethanol blended petrol every year which makes up around 12% of the US' total fuel sales (Table1).

Table 1: Comparison of ethanol yield from various feed stocks.

Feed Stock	Crop	Crop yield (t/ha)	Ethanol yield (l/t)	Ethanol recovery (%)	Potential ethanol yield (l/ha)
Molasses	Sugarcane	100 - 120 (4000 kg molasses)	200 - 240	20 – 24	1000 -1200
Beet juice	Sugar beet	75 -80	75 - 90	8 – 9	6750 - 7200
Starch	Maize	6-May	400	40	2000 - 2400
	Sweet sorghum	50	40 - 45	44.5	2000 - 2250
	Cassava	30 - 35	80 - 90	9-Aug	2700 – 3200
	Sweet potato	20 - 25	150	15	3000 -3500
	Wheat	5	-	-	900
	Sorghum grain	4	-	-	800
Hemicellulose/ Cellulose	Paper, Wood chips, fibrous plant materials	Glucose based crop residue and stacks			150 -180 l/t
		Xylose based crop residue and stacks			60 - 80 l/t

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Benefits of ethanol as a fuel

a. There are lot of benefits of using ethanol as a fuel including both environmental benefits of ethanol and economic benefits of ethanol. A brief summary of these benefits is shown below

b. Reduced harmful exhaust emissions

c. Sustainable energy source

d. Reduced dependence on foreign sources of oil and gas

e. Biodegradable with no toxic effect on environment

f. Do not contribute to greenhouse effect due to growth / burning cycle

g. Cheap method of achieving high octane fuel

h. Many cars are capable of running on ethanol with no modifications

i. Can reduce levels of disease-causing emissions from petrol blends.

Ethanol Sources

a. In all, three different classes of sources can be used:

b. Starch as grain, corn and tubers like cassava

c. Sugar plants (sugar beet or sugar cane)

d. Cellulose plants (general tree and biomass)

Environmental Impact

All biofuel crops fix carbon by photosynthesis via the carbon cycle. Carbon is emitted back into the atmosphere where the biofuels are burnt. Hence, there is no net addition of CO2 with atmosphere due to burning of biofuels. If the biofuels were used to replace petroleum fuel, it would result in the net saving in CO2 emissions. It is estimated 1 t of biofuel produced or consumed, avoids emission of greenhouse gases equivalent to 3 t of CO2. Jatropha and Pongamia plantations on wastelands have the potential to improve the land and bring back these lands under agriculture production. Presence of tree cover is likely to improve the soil health through litter fall, recycling of nutrient from deeper layer and fixation in case of legumes (Pongamia). Besides soil fertility, addition of organic matter will improve the soil physical properties too. Once the plants have established and have fertilized the soil, their shade can be used for intercropping shade loving vegetable that can provide additional income to the farmers. The tree cover protects the waste and marginal lands from further degradation by water and wind erosion.

Benefits of biodiesel

a. The main environmental advantage of biodiesel is that it is carbon neutral, in other words using 100% biodiesel in our vehicle means we are not adding to the global warming crisis. Biodiesel does not add any carbon because it utilizes the amount of carbon which naturally circulates between the atmosphere and the biosphere.

b. Biodiesel reduces emission of carbon monoxide (CO) by approximately 50% and carbon dioxide by 78.45%

c. Biodiesel contains less amount of aromatic hydrocarbons.

d. It also eliminates Sulphur emissions (SO2), because biodiesel does not include Sulphur.

e. It has higher cetane rating (less knocking) than petrol diesel.

f. It is nontoxic and so we can spill it without creating hazardous zone. In fact, it is totally biodegradable.

g. Biodiesel is safe to handle.

Future potential

a. There is need to develop and disseminate eco-technologies for different climatic zones as well as hill and island areas, which have so far been bypassed by modern yield enhancement technologies.

b. Farming systems should be based on the resource availability and the intensification, diversification, and value-addition should be promoted.

c. Water conservation practices and sustainable management will require particular attention.

d. Develop and popularize crop mixtures based on considerations of ecology and economics, such as high value fruits, vegetables, and bio-fuel crops.

e. Future research on sorghum, therefore, is expected to work around primarily on genetic enhancement to promote productivity as a food crop, fodder and forage crop, industrial and bio-energy crop. Changing industrial needs and continuing research to constantly maintain the competitiveness of grain, improving the bio-energy potential and bye product utilization would assume greater importance.

Fossil fuels are not sustainable. Biofuels on the other hand are sustainable energy sources as they can have a continuous growth / burn / growth / burn cycle. Biofuels can easily be made at home and by local communities and farming groups. This can again make biofuels a cheap alternative to fossil fuels and can help to strengthen local communities both socially and economically. Biodiesel is a biofuel (made from non-fossil fuels) that can power regular diesel engines without any need for engine modifications.

Increasing awareness and importance of Biofuels

The world's energy demand continues to increase as we use more and more machines in our day to day lives. New high-level energy users such as China and India have emerged placing a higher demand on the already short supplies of fossil fuel energy. The available fossil fuel energy is declining day by day and price

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of fossil fuels increasing. The only option is to search for alternate energy for our regular uses. The biofuels is one of best source of alternate energy to overcome the future energy requirement. In respect to the environmental pollution alternate energy is the best option. How we supply our energy needs and with what fuels is becoming more and more of an issue, both economically and environmentally. Recently the US government recognized the need to be more self-sufficient in its energy supplies and reduce its 'addiction' to foreign oil. The European Union has set targets for biofuels to account for 5.75% of all fuel used in Europe by 2010.

Reasons to promote biofuels in Global level

a. Biofuels are renewable; hence, they can supplement hydrocarbon fuels, assist in their conservation, reduce GHGs as well as mitigate their adverse effects on the climate resulting from global warming

b. From the environmental point both Ethanol and biodiesel being superior fuels

c. Use of biofuels becomes compelling in view of the tightening of automotive vehicle emission standards and court interventions

d. The need to provide energy security, specially for the rural areas

e. The need to create employment, specially for the rural poor living in areas having a high incidence of land degradation

f. Providing plant nutrients to soil, checking soil erosion and thus preventing land degradation

g. Addressing global concern relating to containing Carbon emission

h. Reducing dependence on oil imports

i. Usability of biofuels in the present engines without requiring any major modification

j. The production of biofuels utilizing presently under-utilized resources of land and of molasses and, in the process of generating massive employment for the poor

k. The use of biofuels does not require many major or time-consuming studies or research

l. The programmes of production of biofuels in major places are more feasible, environmentally desirable and less injurious to health.

Conclusion

The use of biofuels as an alternative motor fuel has been steadily increasing for a number of reasons. The main three objectives for using of alternative energy - reducing emissions, reducing energy imports and improving the livelihood of farmers. Recent research breakthroughs and the promise of others is the key to exploiting underutilized biomass resources such as municipal solid waste and paving the way for energy crops and biofuels, especially ethanol, as substitutes for fossil fuels. Agricultural researches have demonstrated that the biofuel crops are cost - effective feedstock crops that may substitute fossil fuels. Furthermore, exciting new biotechnology involving saccharification and fermentation has made it possible to use readily available cellulosic material like wood and crop residue for ethanol production. Inspite of the vast scope and importance of biofuel crops as food, feed and fiber, they are poised to make important contribution to provide solution for the ever-growing demand of our nations.

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