

## Thumba (*Citrullus colocyntis*) seed oil: A sustainable source of renewable energy for biodiesel production

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Thumba (*Citrullus colocyntis*) seed oil can be used for production of biodiesel. A comparative experimental study, carried out on a four cylinder, direct injection, water cooled diesel engine operating on diesel and biodiesel blends (B10, B20 and B30) of *C. colocyntis* and *Jatropha curcas*, showed that like *J. curcas*, biodiesel of *C. colocyntis* can be used as an alternative fuel with better performance and lower emissions compared with diesel.

**Keywords:** Biodiesel, Bio-fuel, *Citrullus colocyntis*, Engine performance, *Jatropha curcas*, Thumba

### Introduction

India is projected to become third largest consumer of transportation fuel in 2020, after USA and China, with consumption growing at an annual rate of 6.8%<sup>1</sup>. In India, 90% of imported oil is consumed for transportation and energy generation and its economy are highly depending on import of crude oil. Therefore, bio-fuel as a transportation fuel will play a very vital role in near future. Bio-fuels, produced as vegetable oils from plants, burning leads to a complete recyclable carbon dioxide (CO<sub>2</sub>), which reduces green house effect<sup>2</sup>. Biodiesel has a higher cetane number than petroleum diesel fuel, no sulphur, no aromatics, and contains O<sub>2</sub> (10–11% by wt), and therefore reduces emissions of carbon monoxide (CO), hydrocarbons (HC), and particulate matter (PM), sulphur dioxide (SO<sub>x</sub>) in exhaust gas compared with diesel fuel while nitrogen oxides (NO<sub>x</sub>) slightly increased<sup>3</sup>. Studies are available on vegetable oils (hemp<sup>4</sup>, *Jatropha*<sup>5-7</sup>, orange<sup>8</sup>, rapeseed<sup>9</sup>, sesame<sup>10</sup>, mahua<sup>11</sup> and a mixed vegetable oil<sup>12</sup> in a diesel engine for suitability as an alternate fuel.

This study presents Thumba (*Citrullus colocyntis*) seed oil as a sustainable source of renewable energy for biodiesel production.

### Experimental

#### Materials

Thumba (*C. colocyntis* Schrad.), a non-edible vegetable oil plant (Fig. 1), mainly grows in rain fed parts of Rajasthan and Gujarat. It is a creeper and grows well in sandy soil. Raw Thumba seed oil is presently consumed in large quantities by local soap industries. Comparing with *Jatropha* (*Jatropha curcas*), Thumba plant with small crop cycle and various uses can play a pivotal role for the progress of Indian rural economy (Table 1). Raw *C. colocyntis* (Thumba) oil, used for biodiesel production, was purchased from a soap industry of Jodhpur district of western Rajasthan (India) and commercially available diesel oil was purchased from nearby petrol pump.

#### Engine Test Setup

Performance and emission test was carried out in four cylinder, four stroke, water cooled, 39 kW at 5000 rpm, Model Tata Indica diesel engine, connected to eddy current type dynamometer for loading. It is equipped with necessary instruments for measurement of combustion pressure and crank-angle. Set control panel box consists of air box, fuel tank, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and engine indicator. Rotameters are used for cooling water and calorimeter

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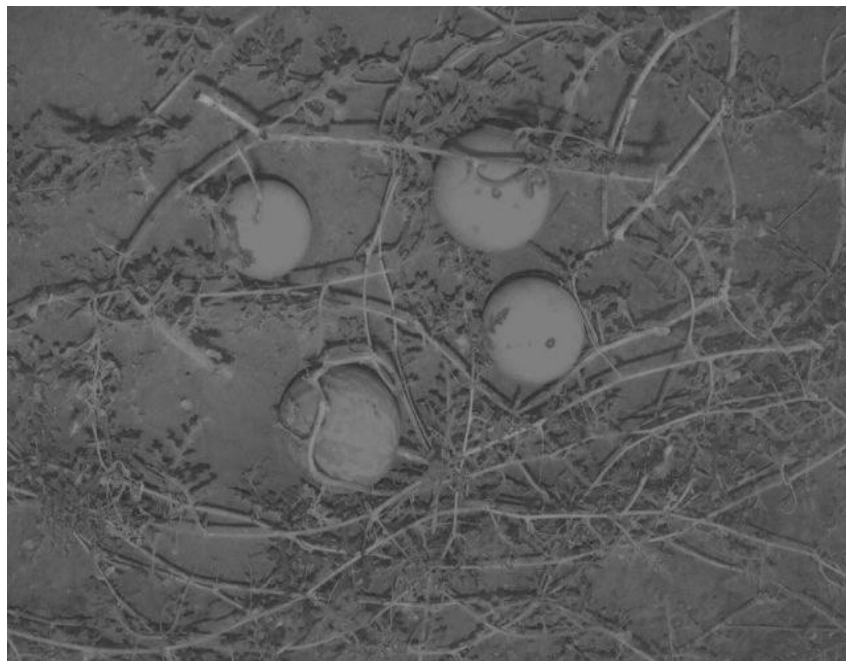


Fig. 1—Thumba plant with fruit

Table 1— Comparison between *Jatropha* and Thumba plants

| Sl No. | Characteristics          | Plant  |   |
|--------|--------------------------|--|---|
|        |                          | Ratanjyot ( <i>Jatropha curcas</i> )   | Thumba ( <i>Citrullus colocynthis</i> )                                   |
| 1      | Plant type               | Shrub (3-5 m)  | Creepers  |
| 2      | Crop cycle               | 3-30 years   | 6 months  |
| 3      | Plantation period        | July-August  | Monsoon season  |
| 4      | Soil type                | Any type of soil   | Dry desert soil   |
| 5      | Manure                   | 2 kg FYM per pit   | No special treatment requirement  |
| 6      | Irrigation               | 1 <sup>st</sup> year after planting<br>2 <sup>nd</sup> year after one year in summer as required   | Seeds are sown with bajra and no special treatment required               |
| 7      | Saplings                 | 1200 plants per acre (59.48 m <sup>2</sup> )   | Separate land is not required   |
| 8      | Insecticides, pesticides | Not required   | Not required  |
| 9      | Maturity                 | From second year plants will start producing and will reach maturity fully in 5 <sup>th</sup> year | 6 months  |
| 10     | Harvesting               | Oil with medicinal value, dyes, feed, insecticides, pesticides, alternative to diesel              | Same as <i>Jatropha</i> , but edible for animals and have medicinal value |
| 11     | Usage                    | Property is almost similar to the conventional diesel  | Similar to <i>Jatropha</i> but with low viscosity                         |

water flow measurement. Windows based engine performance analysis software package “Enginesoft” is used for on-line performance evaluation.

#### Preparation of Biodiesel Blend

Biodiesel is prepared by hydrodynamic cavitation technology with raw Thumba oil at Delhi College of

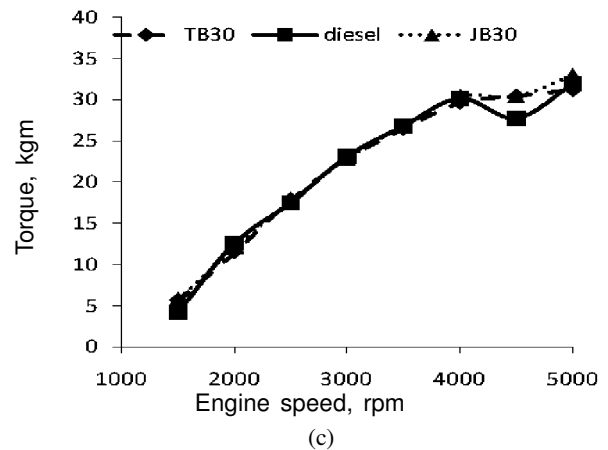
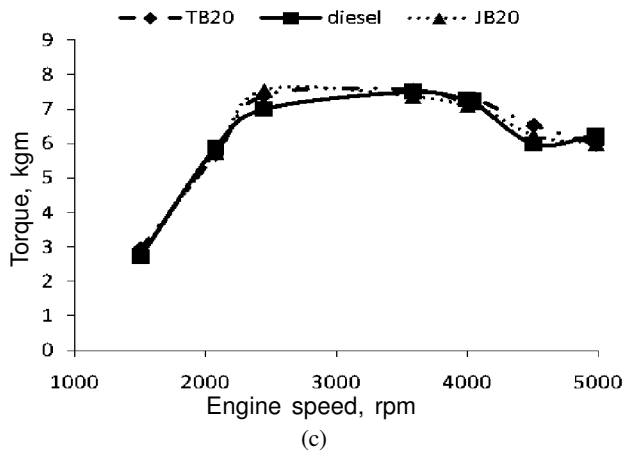
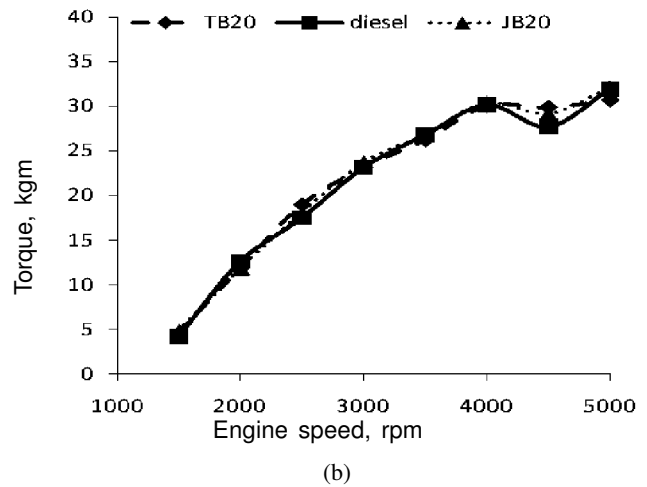
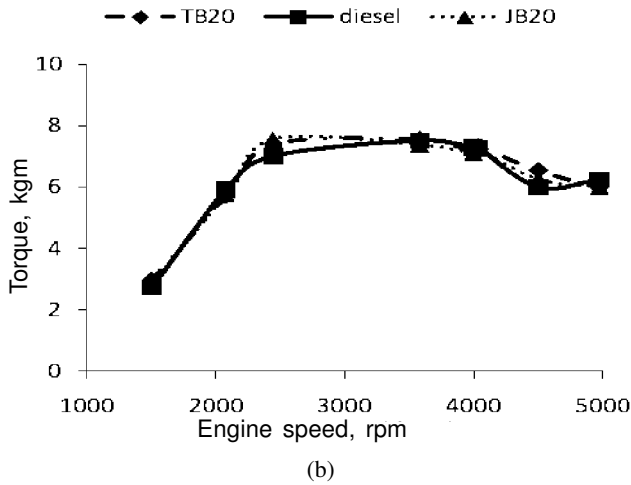
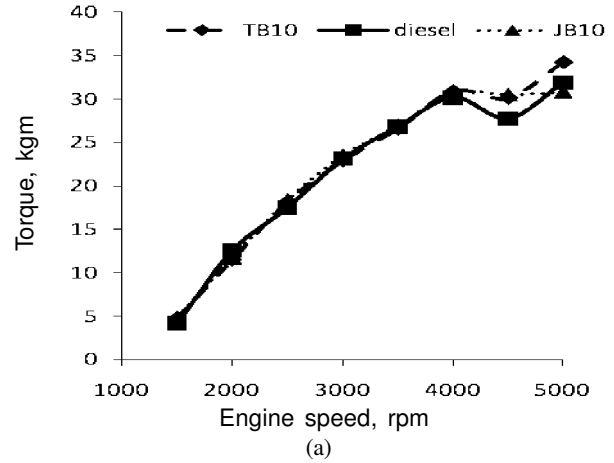
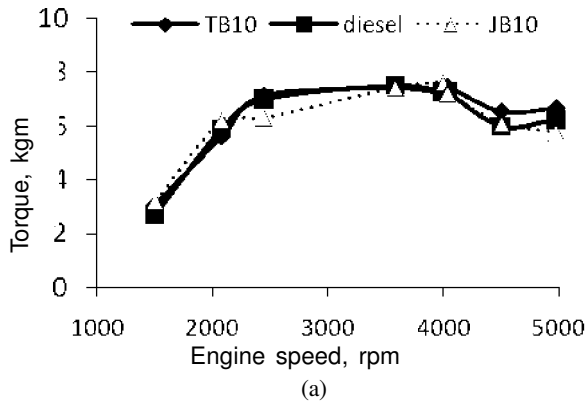


Fig. 2—Comparison of torque vs speed for biodiesel blends of diesel with Jatropa and Thumba oil at: a) 10% b) 20%; and c) 30%

Fig. 3—Comparison of brake power vs speed for biodiesel blends of diesel with Jatropa and Thumba oil at: a) 10%; b) 20%; and c) 30%

Engineering laboratory and blended (10%, 20% and 30%) with diesel.

**Results and Discussion**

Variation of parameters of load test with respect to speed (1000-5000 rpm) at an interval of 500 rpm and a

gap of 5 min of engine for pure diesel, Thumba biodiesel (TB) and Jatropa biodiesel (JB) include torque (2.5-7.7 kg-m), brake power (BP, 3-35 kW), brake thermal efficiency (BTE, 19-27 %), brake specific fuel consumption (BSFC, 0.33-0.46 kg/kWh), and smoke opacity (5-60%).

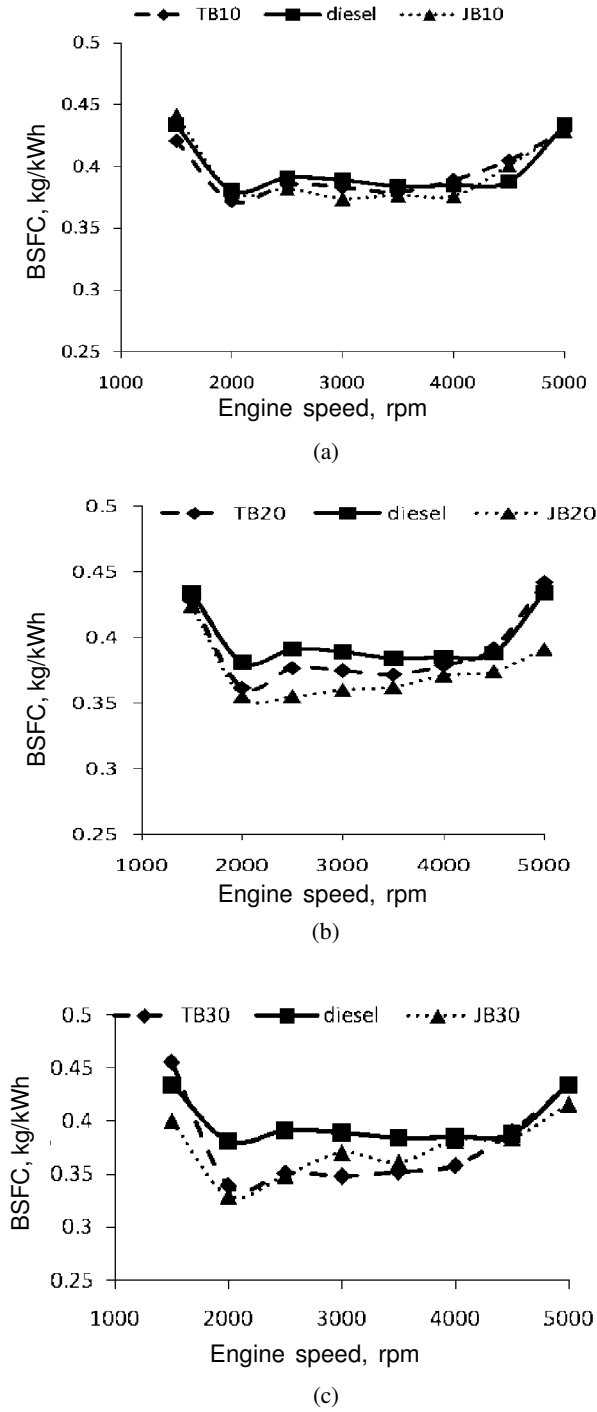


Fig. 4—Comparison of BSFC vs speed for biodiesel blends of diesel with Jatropha and Thumba oil at: a) 10%; b) 20%; and c) 30%

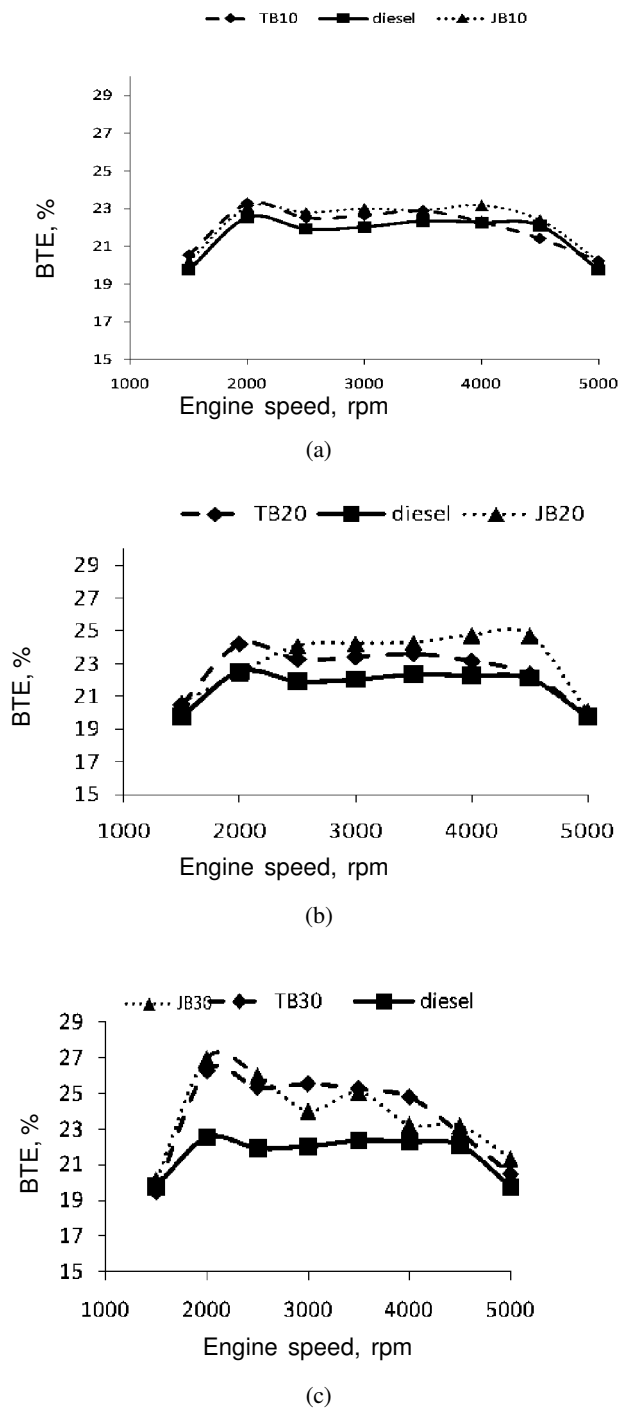


Fig. 5—Comparison of BTE v/s speed for biodiesel blends of diesel with Jatropha and Thumba oil at: a) 10%; b) 20%; and c) 30%

**Variation of Torque vs Engine Speed**

Variation of torque for different blends and pure diesel at a particular engine speed is within a very narrow range (Fig. 2). In case of both biodiesel blends and pure diesel,

initially torque rises sharply with increase in engine speed up to 2500 rpm, thereafter variation of torque with speed (2500-4000 rpm) remain almost constant. Further increase in speed causes decrease in torque.

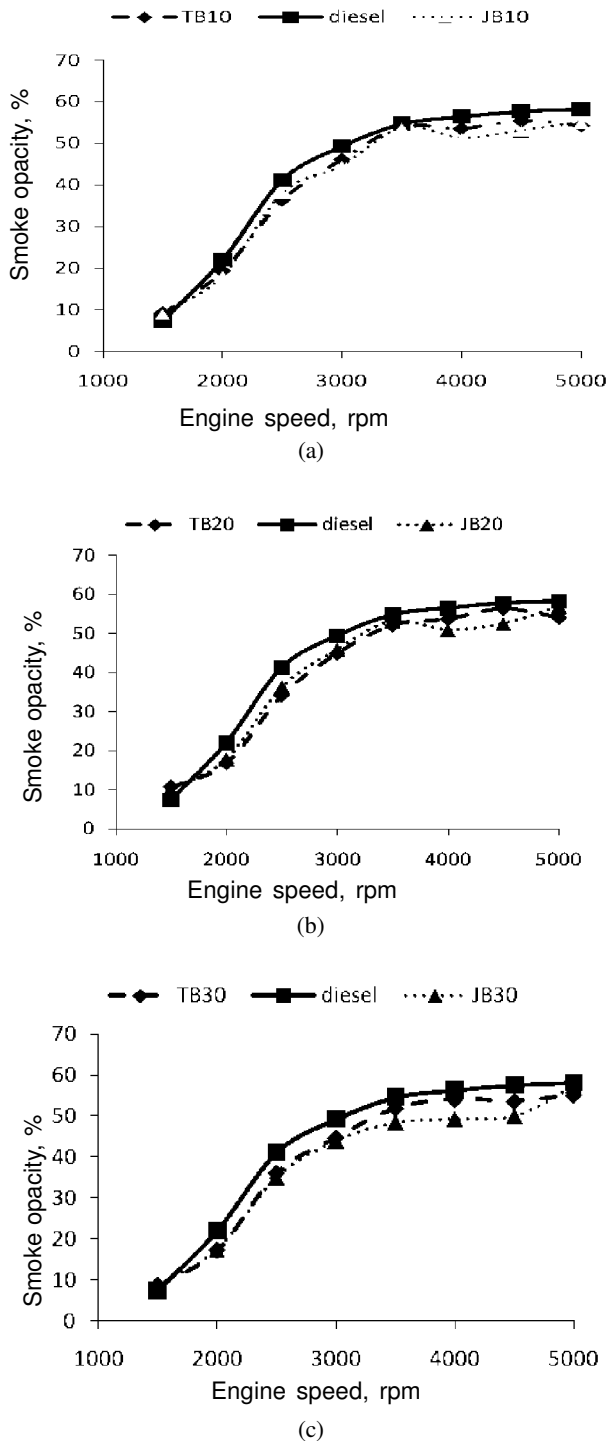


Fig. 6—Comparison of smoke opacity v/s speed for biodiesel blends of diesel with Jatropha and Thumba oil at: a) 10%; b) 20%; and c) 30%

Pattern is almost same for all blends. Maximum torque achieved in case of TB20 was 7.5 kg-m at 2500 rpm.

#### Variation of Brake Power (BP) vs Engine Speed

BP (6-32 kW) increases proportionally to engine speed (2000-4000 rpm); for speed above 4000 rpm, there is fluctuating variation in BP among biodiesel blends (Fig. 3). Maximum BP achieved for TB10 was 35 kW at 5000 rpm.

#### Variation of brake specific fuel consumption (BSFC) vs Engine Speed

For all cases, BSFC initially decreases sharply with increase in speed up to 2000 rpm and between 2000-4000 rpm remains approximately constant; for more than 4000 rpm BSFC increases sharply with speed (Fig. 4). BSFC for JB30 of Jatropha oil is lowest (0.32 kg/kWh to 0.44kg/kWh) at speed between 2000-4500 rpm. In case of all Thumba and Jatropha biodiesel blends, BSFC values are significantly lower as compared to pure diesel for a wide range of engine speed.

#### Brake Thermal Efficiency (BTE) vs Engine Speed

Maximum value of BTE for all blends and pure diesel is at 2000 rpm (Fig. 5). For all blends of both oils, variation of BTE is higher as compared to pure diesel for wide range of engine speed. Maximum BTE achieved by using JB30 blend is around 26.9% at 2000 rpm, which is 5% higher as compared to pure diesel. BTE is almost constant between 2000-4000 rpm, and decreases sharply with further increase in speed. With increase in percentage of biodiesel blending, BTE increases for wide range of engine speed. Both Jatropha and Thumba oil exhibit comparatively higher efficiency than pure diesel with all blends.

#### Smoke Opacity vs Engine Speed

Smoke opacity for pure diesel is slightly higher than all type of blends for wide range of engine speeds (Fig. 6). For all biodiesel blends, opacity increases (10-60%) with increase in speed (2000-3500 rpm); thereafter (>4000 rpm) no significant change was observed in opacity.

#### Conclusions

*C. colocyntis* that grows as creeper in sandy soil with in a six month crop cycle has enormous potential for biodiesel production. Variation of performance parameters for wide range of engine speed are similar for biodiesel blends of Thumba and Jatropha with pure diesel and do not show any sign of deterioration as compared to pure diesel. Brake thermal efficiency improves significantly with increase in percentage of

biodiesel blending. Smoke opacity results show that biodiesel blending is relatively less pollutant as compared to petroleum diesel. Thus, Thumba and Jatropa can be successfully used for biodiesel blending for C I engine.

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