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Comparative Evaluation of Bioproductivity Studies of Simarouba, Pongamia and Jatropha for Biodiesel Parameters

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ABSTRACT

The vegetable oils (non-edible) have proved to be promising feedstock for the biodiesel production. The present study deals with the evaluation of Simarouba , Jatropha and Pongamia for their growth performance from the seed germination to the first bearing, production and characterization of oil and biodiesel as they are considered as biofuel crops capable to grow on waste lands. Variations in bioproductivity of the plants were compared every six months for four years of investigation and biodiesel parameters were also studied and analyzed statistically. Identification of better genotype or superior phenotype having better yield and oil content is the important step in the tree improvement strategies involved in the biofuel program. The results obtained from the studies on the bioproductivity traits, their correlation and satisfying biodiesel quality has proved a *Simarouba species* as a potential candidate to provide sustainable feed stock for biodiesel industries.

Key Words: Bioproductivity, Biodiesel, Feedstock, Crop improvement

INTRODUCTION

The gradual depletion of petroleum reserves and the increasing environmental concerns have created great demand for alternative source of petroleum based fuel. Energy consumption, economic growth and industrialization have lead to higher energy demand**.** Vegetable oils (triglycerides) are promising feedstock for biodiesel production, since they are renewable in nature and can be produced on the large scale and are environmental friendly (18). Numbers of studies have shown that triglycerides hold promise as alternative diesel engine. In the countries like India usage of edible oil for biodiesel production causes problems such as the competition with edible oil market which increase cost of oil and biodiesel (9). Based on global crop production statistics, the country will require tenfold increase in agricultural production if its total energy demands are to be met using biofuel crops (17). This will cause deforestation in some countries and slowdown food production. The waste land areas are considered as potential niches for promotion of perennial non-edible crops for biofuel, that aid in restoring afforestation, conservation and environmental friendly energy production. Approximately 68.35 million hectares area of the land is lying as wastelands in India as reported by Government of India Ministry of Rural Development Department of Land Resources New Delhi, India. It is estimated that, India has the potential to produce about three million tons of vegetable oil from nontraditional oil seeds, minor oil seeds and oil seeds of tree origin. It is estimated that potential of biodiesel production from non traditional sources is 1.38 million tons and about 75 percent of domestic production is consumed for industrial purpose (16).

More than 300 trees borne oil seeds that include edible and non-edible oil have been identified as a suitable raw material for biodiesel industry. In India more than 100 plant species found in the wild or in cultivated conditions have been iden-

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tified to bear oil seeds in commercially extractable proportion (5)Several potential tree borne oil seeds (TBOs) and non-edible crop source have been identified as suitable feedstock for biodiesel (19, 20). The National Oilseeds and Vegetable Oils Development (NOVOD) Board, Gurgaon, India, has initiated a tree improvement programme for tree borne oil-yielding species (TBOs) in different states with mandate for population identification, selection of superior genotypes and establishment of seed orchards to produce high-quality fruits / seeds for oil extraction.

It is recorded that non-edible crops can be grown in waste land and cost of cultivation is much lower because these crops can still sustain reasonably high yield without intensive care (8,12). Several plant species like *Jatropha curcas*, *Pongamia pinnata, Simarouba glauca, Calophyllum inophyllum, Maduca indica, Hevea brasilinsis, Azardirachta indica, Ricinus communis, Shorea robusta, Mesua ferra, Mallotus phillippinensis, Salvador, Garcinia indica* are considered as fuel crops for biodiesel production. These species are resistant to drought, non-grazing, high seed yield, and sustain their growth in arid and semiarid agro climatic conditions. Preliminary evaluation of several oil seed crops for their growth, and utilization under agroforestry system has been recorded (14) most of these plants have multiple uses such has commercial, pharmaceutical, pesticidal properties and have capability to grow in the arid and semiarid regions. There is need to introduce the area under waste land with oil yielding tree species. Research and development on germplasm resources and identification of elite cultivars becomes necessary. Preliminary evaluation of several non-edible oilseed crops for their growth, feedstock and adaptability show that these feed- stocks should have the following advantages (1,17,20).

Aim

The aim of the present investigation is to compare bioproductivity parameters of three important biofuel plants *Simarouba gluaca, Pongamia pinnata* and *Jatropha curcas* from the phase of their seed germination to seed maturity and select a candidate clone that will serve as a potential and sustainable feedstock for biofuel industries. The characterization, evaluation and selection of desirable genotype for economic value will been done by considering few important bioproductivity characteristics, which will help in selection of high yielding cultivar that are capable to grow on waste land areas and aid in the rural development programs.

Methodology

The candidate plus trees were identified after a detail survey and inspection. The selection process for high nutlet yield for oil production was considered based on their superiority with respect to fruit yield, seed quality. The seedlings of *J. curcas* and *P. pinnata* and S. *glauca* were raised in beds (Black soil: sand: farm yard manure in 2:1:1 ratio) in three replicates. At 8- 9 months the seedlings were transferred to field trials in 2×2ft pits with 4feets spacing between the plants of *J. curcas*, 5ft spacing between *P. pinnata* and *S. glauca.* The study was conducted in the biodiesel technology park, Gulbarga University Gulbarga India, located on the latitude 17^{o} 12 ‘ to 17^{o} 46’ N, longitude 76^{o} 04’ to 77^{o} 42’ E and altitude 391 to 472 meters. The area have mainly black soil with annual rain fall measured is less than 750mm, while the mean area temperature is 38 to 42^{o}C with 35 to 62% humidity.

Bio productivity analysis

Simarouba glauca*, Jatropha curcas* and *Pongamia pinnata* were evaluated for their growth performance from seedling stage to first bearing in field. Some of the bioproductivity parameters like germination count, plant height, canopy growth, collar diameter, number of branches per plant, number of leaves per branch, number of flowers per bunch, number of pods per branch and number of seeds per branch were recorded following (6, 13, 14). 100 seed weight and 100 pod weight was recorded by the using electronic balance. Total oil content (OC) of seeds was estimated by the soxhlet extraction method using n-hexane as the solvent (10). The biomass assessments of the plants were carried out till the end of experimental period. The biodiesel was produced from the process of alkaline catalyzed transesterification. Important fuel properties like viscosity, flashpoint and copper strip corrosion of biodiesel were performed as per ASTM standards ASTM D130, ASTM D445 and ASTM D93, respectively to test the quality of the biodiesel.

Data analysis

The comparative analysis of Bioproducivity assessment of *Simarouba glauca*, *Jatropha Curcas*, and *Pongamia pinnata* was done by subjecting the recorded data to the statistical analysis using statistical software Origin 6 following appropriate methods.

Result

The mean value calculated on data collected for every six months by field studies on bioproductivity were subjected to the origin 6 software for graphical representation. The gradual increase in plant height, canopy growth, collar diameter, number of branches per plant and number of leaves per branch in *Simarouba glauca*, *Jatropha* curcas and *Pongamia pinnata* was observed. *Simarouba glauca* produced tall trees with the mean height of 34.63±1.567 cms (6 months), to 295.482±2.517cms (48 months). *Pongamia pinnata* produced progeny with plant height of 30.889±2.057cms at 6 months to 241.908±4.353cms at 48 months and lowest plant height that is 18.128±1.300cms to169.845±4.285 cms of mean values was seen in plants produced by *Jatropha curcas*(Fig 1.). While considering the canopy growth, *Simaroba glauca* had larger canopy growth that is 33.347±1.795cms to 244.549±2.135 cms of mean value, *Pongamia pinnata* had canopy growth of 20.899±0.9828 cms to 211.333±5.585 cms of mean value, where as smaller canopy growth was observed in Jatropha that is15.403±0.6729 cms to181.724±3.466 cms of mean value (Fig 2.).Collar diameter parameter showed highest growth in Simarouba 1.97±0.1252 cms to 17.545±0.3957 cms followed by Pongamia and Jatroph that is of 0.788±0.1136 cms to 13.857±0.4083 cms and 1.115±0.1080 cms to 16.144±0.4868 cms respectively (Fig 3.). Considering number of branches (Fig 4.) *Simarouba glauca* bares low number of branches from 2.5±0.2236 to 24.7±0.7895 where as *Pongamia pinnata* bears 3.6±0.3055 to 32.2±0.7272of branches and *Jatropha Curcas* showed highest number of branching patterns that is about 3.9±0.3145 cms to 42.2±0.8138 cms. Figure 5 shows enormous high growth in number of leaves per branches *Simaroba glauca* that is 45.6±2.845 to 1142.4±30.254 mean value compared to *Pongamia piñatas* (10.6±1.147 to 309.6±11.259) and *Jatropha curcas* (6.0±0.6142 to 212.7±8.046) which showed lower number of leaves. *Jatropha curcas* plants have shown early flowering during their growth. *Simarouba glauca* plants showed higher flower count 105.8±4.95 of its mean value where as Pongamia and Jatropha has flower count of 24.8±2.439 and 13.8±74.24 respectively (Fig 6.). Jatropha excelled in count of number of seeds per bunch that is 239.1±9.930 of mean value followed by Simarouba 42.8±1.162 where as Pongamia showed least number of seed count that is of 38.8±3.116 (Fig 7.). Maximum 100 seed weight is seen is Pongamia 164.56±0.72 gm, Simaroba showed 94.67±0.97 gms of seed weight and minimum seed weight was observed in Jatropha 63.82±0.61gm.(Fig 8.). Bar graph has shown highest oil content in Simarouba (67.06±0.54) compared to Jatropha (34.24±0.91) and Pongamia (31.16±0.86) (Fig 9.).

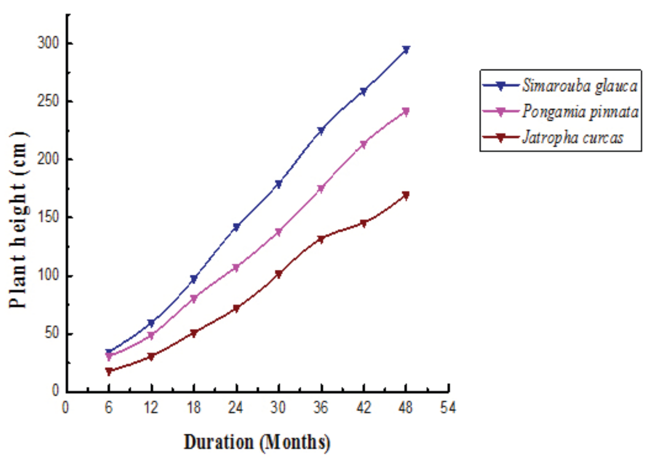

Figure 1: Graph showing comparative analysis Plant height of *Simarouba glauca, Pongamia pinnata and Jatropha curcas.*

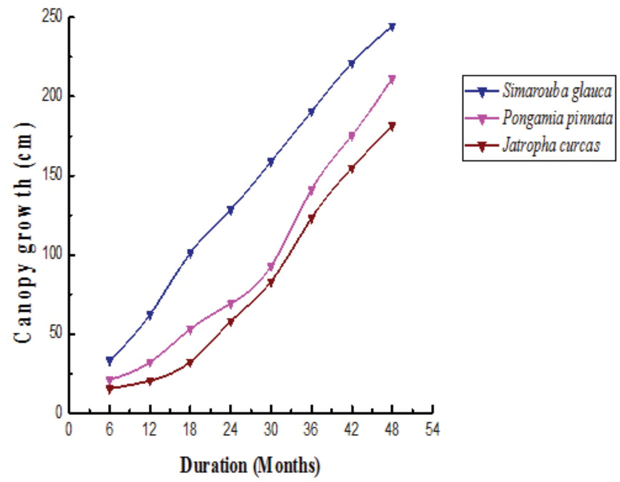

Figure 2: Graph showing comparative analysis of canopy growth of *Simarouba glauca, Pongamia pinnata and Jatropha curcas*.

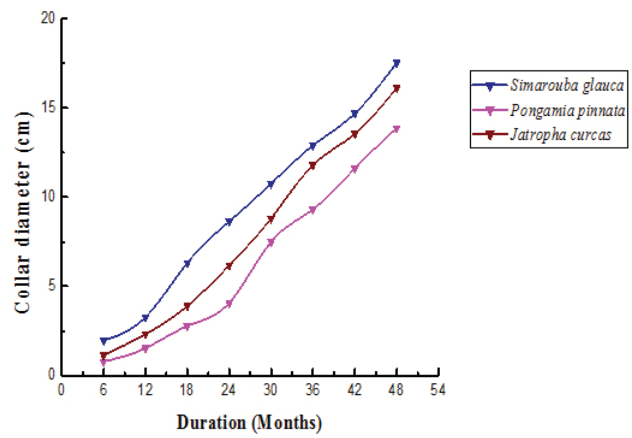

Figure 3: Graph showing comparative analysis of Collar diameter of *Simarouba glauca, Pongamia pinnata and Jatropha curcas*.

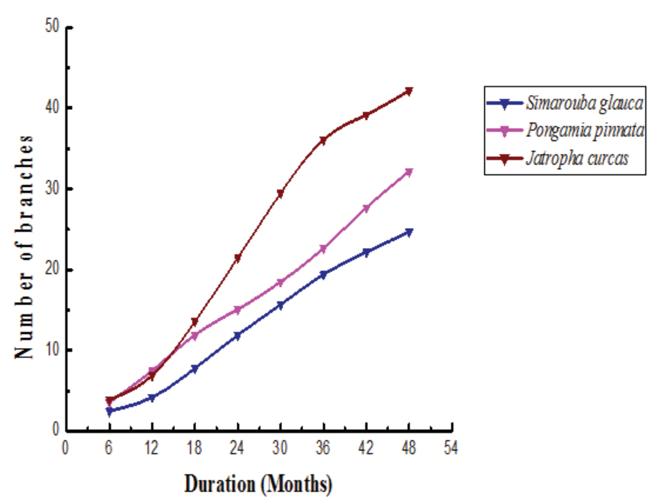

Figure 4: Graph showing comparative analysis of Number of branches of *Simarouba glauca, Pongamia pinnata and Jatropha curcas.*

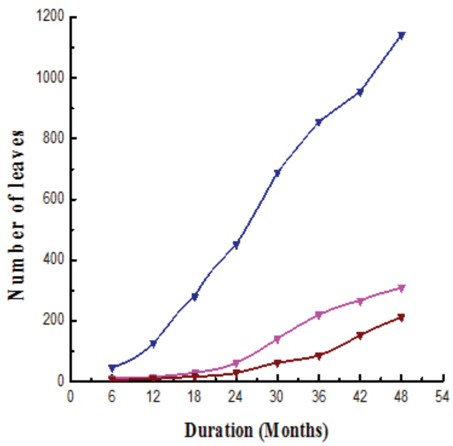

Figure 5: Graph showing comparative analysis of number of leaves of *Simarouba glauca, Pongamia pinnata and Jatropha curcas.*

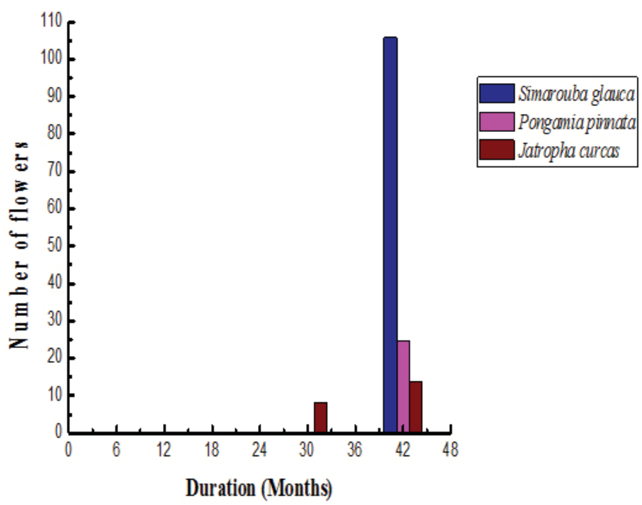

Figure 6: Graph showing comparative analysis of Number of flowers of *Simarouba glauca, Pongamia pinnata and Jatropha curcas.*

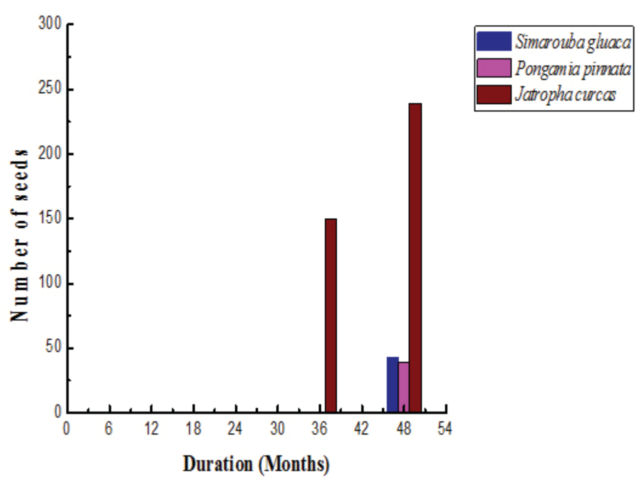

Figure 7: Graph showing comparative analysis of Number of seeds of *Simarouba glauca, Pongamia pinnata and Jatropha curcas.*

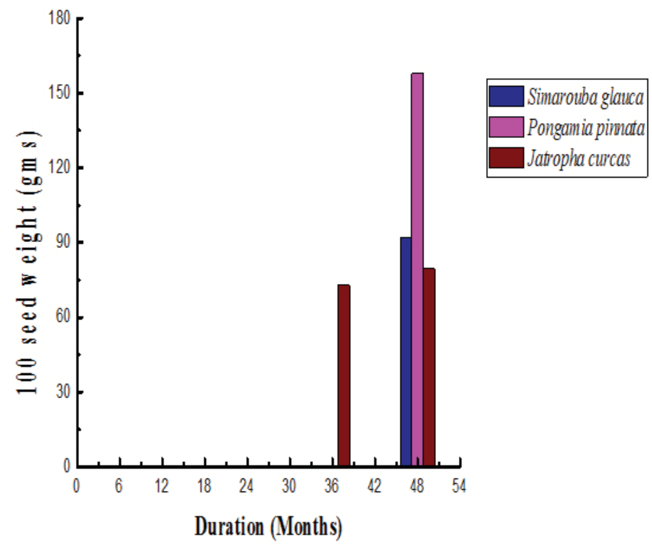

Figure 8: Graph showing comparative analysis of seed weight of Simarouba glauca, Pongamia pinnata and Jatropha curcas

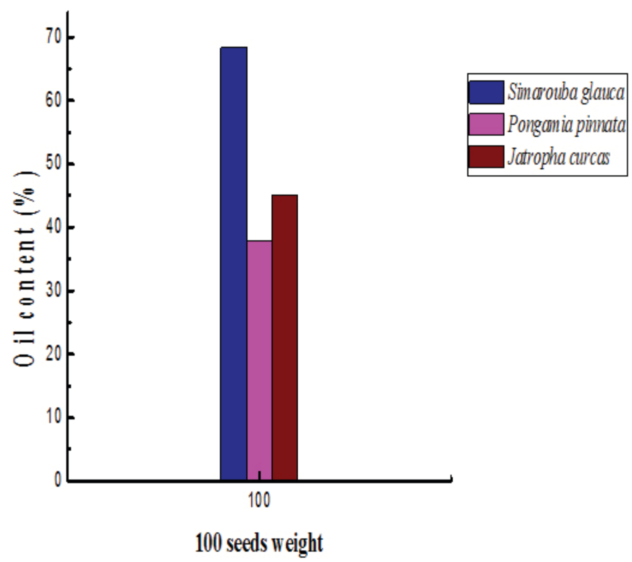

Figure 9: Graph showing comparative analysis of oil content of Simarouba glauca, Pongamia pinnata and Jatropha curcas

Seed traits

High germination rate (84.48%) was observed in *Simarouba glauca,* compared to *Pongamia pinnata* (71.54%) and *Jatropha curcas* (43.31%). 100 pod weight (304.14gm) and 100 seed weight (164.56gm) of *Pongamia pinnata* is high compared to *Simarouba glauca* which showed 100 pod weight (113.27gm) and 100 seed weight (94.67gm) . *Jatropha curcas* has 100 pod weight (108.39gm) and 100 seed weight (63.82gm). It is observed that the percentage of oil content (67.6%) in *Simarouba glauca* is almost double compared to percentage of oil content in *Jatropha curcas* (34.34%) and in *Pongamia pinnata* (31.16%). In *Simarouba* the amount of seed cake observed per kg of seed is 552.34gm, where as

624.08gm in *Jatropha* and 697.82 gm in *Pongamia pinnata*. The mean values of the seed traits are shown in Table.1.

Biodiesel quantity and quality

It is observed that 4.32kg of seeds are required to produce one liter of crude oil which yields 865.43ml of biodiesel in Simarouba, where as 6.23kg of seeds are required to procure one liter of crude oil which yield 677.54ml of biodiesel in *Jatropha curcas*. In case of *Pongamia pinnata* 6.74kg of seeds are required for per liter of crude oil which yields 639.52ml of biodiesel. The amount of glycerin per liter of biodiesel is observed is 194.52ml in Simarouba where as it is 317.03ml in Jatropha and 221.48ml in Pongamia respectively. Biodiesel quality tests as per ASTM standard showed, viscosity (4.16 cSt) of *Simarouba* which is less compared to the viscosity (5.22 cSt) of Jatropha and viscosity (5.81 cSt) of Pongamia. Flash point (162.17 cSt) of Simarouba is less as compared to flash point (161.41) of Jatropha and flash point (163.55) of Pongamia when tested as per ASTM standard methods ASTM D130, ASTM D445 and ASTM D93 respectively and the biodiesel quality meets the ASTM D6751 standards for biodiesel. The values of biodiesel parameters are shown in Table 1.

Table 1: Seed traits and biodiesel parameters of *Simarouba glauca, Jatropha curcas* and *Pongamia pinnata*

Characters	*Simarouba glauca*	*Jatropha curcas*	*Pongamia pinnata*
1. Germination rate (%)	84.48±0.78	43.31±0.98	71.54±0.94
2. 100 pod weight (gm)	113.27±0.81	108.39±0.74	304.14±1.65
3. 100 seed weight (gm)	94.67±0.97	63.82±0.61	164.56±0.72
4. Percentage of Oil (%)	67.06±0.54	34.24±0.91	31.16±0.86
5. Weight of seeds/liter of oil (kg)	4.32±0.08	6.23±0.09	6.74±0.07
6. Amount of biodiesel/liter of oil (kg)	865.43±1.03	677.54±0.97	639.52±0.60
7. Amount of glycerin/ liter of biodiesel (ml)	194.52±0.80	317.03±0.71	221.48±0.78
8. Amount of seed cake/kg of seeds (gm)	552.34±0.86	624.08±0.87	697.82±0.73
9. Viscosity of biodiesel (cSt at 40^{o}C)	4.16±0.04	5.22±0.08	5.81±0.06
10. Flash point of biodiesel (at 40^{o}C)	162.17±0.61	161.41±1.01	163.55±0.68

DISCUSSION AND CONCLUSION

The results of the present study shows that *Simarouba Species* performed better with respect to seedling growth and biodiesel parameters compared to *Jatropha* and *Pongamia*. The seed oil content is very high in *Simarouba glauca* as compared to *Jatropha* curcas and *Pongamia pinnata*, it is observed that the percentage of oil content (67.6%) is almost double compared to percentage of oil content in Jatropha curcas (34.34%) and in *Pongamia pinnata* (31.16%). Identification of better genotypes or superior phenotypes having better yield and oil content is the initial step in any tree improvement strategies (20)involved in the biofuel program. Compared to *Jatropha sp* and *pongamia sp* only 4.32kg of seeds are required to produce one litre of crude oil which had produced 865.43ml of biodiesel in *Simarouba sp*. The biodiesel properties were found to be within the ASTM D6751 standard. Simarouba biodiesel should less viscous property that is about 4.16 cSt .It is one of the important fuel property that is responsible for the free flow of the fuel. The flash point observed is 162.17 which will help in the safe handling of the fuel. Thus, according to the results obtained from the studies on bioproductivity traits, and satisfying biodiesel quality has made *Simarouba glauca* a potential candidate to provide sustainable feed stock for biodiesel industries.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

REFERENCES

1. Ahmad AL, Yasin NHM, Derek CJC, Lim JK. Microalgae as a sustainable energy source for biodiesel production: a review. Renewable and Sustain- able Energy Reviews 2011;15(1):584–93.
2. ASTM D6751-076 (2007) Standard Specification for Biodiesel Fuel (B100) Blend Stock for Distillate Fuels. West Conshohocken, PA: American Society for Testing and Materials.
3. ASTM Standard D93, 2008, "Standard Test Methods for Flash Point by Pensky-Martens Closed Cup Tester," ASTM International, West Conshohocken, PA, 2008.

4. ASTM D445, 2006, "Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)," ASTM International, West Conshohocken, PA, 2006.
5. Azam MM, Amtul-Waris, Nahar NM. 2005. Prospects and potential of fatty acid methyl esters of some non-traditional seed oils for use as biodiesel in India. Biomass and Bioenergy, 29: 293–302.
6. Divakara BN, Rameshwar Das. 2011. Variability and divergence in Pongamia pinnata for further use in tree improvement. Journal of Forestry Re- search, 22(2): 193–200.
7. Government of India Ministry of Rural Development Department of Land Resources New Delhi, India.
8. Gui MM, Lee KT, Bhatia S. Feasibility of edible oil vs. non-edible oil vs. waste edible oil as biodiesel feedstock. Energy 2008;33:1646–53.
9. Kansedo J, Lee KT, Bhatia S. Cerbera odollam (sea mango) oil as a promising non-edible feedstock for biodiesel production. Fuel 2009; 88:1148–50.
10. Kaushik N, Kumar S, Kumar K, Beniwal RS, Kaushik N, Roy S. 2007. Genet- ic variability and association studies in pod and seed traits of Pongamia pinnata (L.) Pierre in Haryana, India, Genetic Resources for Crop Evolution, 54: 1827–1832.
11. Knothe G, Sharp CA, Ryan TW. Exhaust emissions of biodiesel, petrodiesel, neat methyl esters, and alkanes in a new technology engine. Energy Fuels 2006; 20:403–8.
12. Kumar Tiwari A, Kumar A, Raheman H. Biodiesel production from Jatropha oil (Jatropha curcas) with high free fatty acids: an optimized process. Biomass Bioenergy 2007; 31:569–75.
13. Kumaran K. 1991. Genetic analysis of seed and juvenile seedling attributes in neem (Azardirachta indica A. Juss.) and pungam (Pongamia pinnata (Linn.) Pierre). M.Sc. Thesis. Tamil Nadu Agricultural University, Coimbatore, India.
14. Mukta, N. Sudhakara Babu, S.N., Nagaraj, G. and Ranganatha, A.R.G. (2000).
15. National Biodiesel Board. Fuel quality policy. National Biodiesel Board. Available at: www.biodiesel.org; 2009.
16. Neelakantan, K.S. (2004) Tree Borne Oilseeds - an Over view. Strategies for Improvement and Utilization of Tree Borne Oilseeds.
17. Nonhebel S: Renewable energy and food supply: Will there be enough land? Renewable and Sustainable Energy Reviews, 9 (2):(2005)191-201.
18. No SY. Inedible vegetable oils and their derivatives for alternative diesel fuels in CI engines: Renewable and Sustainable Energy Reviews 2011;15(1):131–49.
19. Patil PD, Deng S. Optimization of biodiesel production from edible and non- edible vegetable oils. Fuel 2009; 88:1302–6.
20. Razon, L.F. Review Alternative crops for biodiesel feedstock. 2009 [cited 8 February 2011].
21. Surendran C., Sehgal R.N. and Paramatma M. Texbookof Forest Tree Breeding. Indian Council of Agricultural Research,New Delhi, India 2003;24.
22. Syers JK, Wood D, Thongbai P. The proceedings of the international technical workshop on the ''feasibility of non-edible oil seed crops for biofuel production. Chiang Rai, Thailand: Mae Fah Luang University; 2007.