

PROJECT COMPLETION REPORT

TECHNOLOGY SYSTEMS DEVELOPMENT (TSD) PROGRAMME

PROJECT TITLE

STUDY OF PERFORMANCE, COMBUSTION AND EMISSION CHARACTERISTIC OF A TURBOCHARGED DIESEL ENGINE FUELLED WITH SOME INDEGENOUS TREE SEED BASED BIODIESEL AVAILABLE IN NORTH EASTERN REGION OF INDIA.

SUBMITTED BY

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20th July, 2015

DST Reference No.

DST/ TSG/ AF /2011/156

PROJECT DURATION

From **08/04/2013** to **07/04/2015**

1. **DST File No:** DST/ TSG/ AF /2011/156
2. **Project Title:** Study of performance, combustion and emission characteristics of a turbocharged diesel engine fuelled with some indigenous tree seed based biodiesel available in North-Eastern region of India.
3. **Duration of Project:** From 08/04/2013 To 07/04/2015
4. **Principal Investigator (PI):**
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6. **Collaborating Organizations:** NIL

Part A - Summary Report

1. Project Objectives:

Sl no.	Objective as per the approved project.	Fully achieved/partially achieved	Reasons for partial achievement
1	Identification of new variety of biodiesel and their characterization for determining its similarity with normal diesel fuel.	Total 9 different types of seeds were identified for biodiesel production from them. Oils are now extracted from all the 9 identified varieties and biodiesels are produced. Finally properties of all these biodiesel samples are evaluated to compare them with conventional diesel fuel properties. Most of the biodiesels fulfill the biodiesel norms and properties are found similar to conventional diesel fuel.	
2	To characterize separately the various blends of all these ITSBD with normal diesel.	Various blends (10%, and 20%) of these biodiesels with conventional diesel fuel are prepared and their properties are also	

		separately evaluated.	
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2. **Deliverables:**

Sl no.	Deliverables as per the approved Project	Fully/Partially/Not Achieved	Reason for Partial/Non Achievement
1	Technical feasibility results of indigenous tree seed bio-diesel (<i>ITSBD</i>) available in Assam. It is anticipated that such outcome will ensure extensive use of some new variety of bio-diesel with the existing technology.	Biodiesels from total 9 different tree seeds (available in Assam) are produced and characterized. Some of them are totally new variety and biodiesel production and characterization for these varieties were not done before. Since most of these biodiesels fulfill the standard biodiesel norms, so these might be used as fuels in existing diesel engine technology at least in the blended form.	
2	Determination of oil content, fatty acid content in each variety of tree seed based oil.	Fully achieved	
3	Determination of free fatty acid	Fully achieved	

	profile of all these tree seed based oils.		
4	Results and specific information relating to trans-esterification of all these tree seed oils such as (i) reaction temperature and time (ii) reactant ratio (molar ratio of alcohol to oil) (iii) type of catalyst (iv) mixing intensity (v) presence of moisture and free fatty acid etc.	Fully achieved	
5	Determination of fuel properties of biodiesel obtained from all these tree seed oils	Fully achieved	

3. Specific Benefits/Outcome

i) **Patent:** NIL

ii) **Product/Process developed/ technology transferred:** Total nine (9) biodiesel varieties have been identified as potential sources of biodiesel out of which three (3) are totally new. Biodiesel production from all these 9 tree seeds has been performed and their characterization is done.

iii) **List of Publications arising from the Project:** One paper titled “Biodiesel Production from Kutkura (*Meyna spinosa Roxb. Ex.*) fruit seed, its characterization and performance evaluation of 10% blend in a Diesel Engine” has been communicated in an International journal which is under review.

One paper with the title "Characterization of biodiesel derived from Terminalia seed oil

and engine performance evaluation with 10% and 20% blending" has been submitted in an International Conference to be organized by Institution of Engineers, Tripura state centre and NIT Agartala which is now under review.

One more journal paper is under preparation which will be communicated shortly.

In the meantime a paper has been submitted to a conference

iv) **Linkages developed:** We have developed some linkages with the neighboring industries (NRL,Numaligarh) and also one research insititutes (NEIST,Jorhat and Punjab Biotechnology Incubator, Mohali) from this project.

v) **Manpower trained:** One JRF was appointed for the project. He has been trained to handle all the equipments (Bomb-calorimeter, combined Density-viscosity meter, Cloud point and Pour point apparatus, Flash point and Fire point apparatus, Vapour pressure apparatus, Carbon residue apparatus etc.) Most importantly the JRF is now fully trained for biodiesel production from seed oil using acid pre treatment and base catalyzed transesterfication.

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4. Summary of significant S&T Achievements:

- Biodiesels are produced from nine (9) different tree seeds available in Assam.
- All important fuel properties of these biodiesels have been evaluated.
- Almost all the properties of these biodiesels (except few) meet the standard biodiesel norms.
- Out of these, three (3) seeds are totally new from which biodiesel production and characterization were not attempted before.

- Properties of various blends (10% and 20%) of these biodiesels with conventional diesel are also evaluated.
- Further experiments are carried out with 10% and 20% blending of some of the biodiesel varieties as fuels in a single cylinder four stroke diesel engine for evaluating engine performance with the various biodiesel blends.

5. Project Budget (Final):

Sl no.	Sub-heads	Amount received (Rs.)	Amount spent(Rs.)	Unspent amount(Rs.)
1	Manpower	4,22,400.00	4,54,500.00	
2	Consumables	1,00,000.00	106,891.00	
3	Contingencies	70,000.00	70,000.00	
4	Domestic Travel	48,800.00	27995.00	
5	Other Costs	1,00,000.00	1,11,790.00	
6	Overheads	5,00,000.00	5,00,000.00	
7	Permanent Equipment	20,97,493.00	2066362.00	
Total*		33,38,693.00	33,37,538.00	1155.00
8	Interest earned			62,865.00
	Total balance			64,020.00

* As per original sanction order an Amount of Rs. 33,59,893.00 was sanctioned. In the first installment an amount of Rs. 27, 88, 693.00 was transferred to Registrar, Tezpur University (DST letter No. DST/TSG/AF/2011/156-G dtd. 22.08.2012). In the second installment an amount of Rs. 5,50,000.00 was transferred vide letter No DST/TSG/AF/2011/156 dtd. 25.06.2014.

Actual total amount received is Rs. 33, 38,693.00 (Rupees thirty three lakhs thirty eight thousand six hundred ninety three only).

6. Suggestions for Utilization of Project Outcome:

Outcome of this projects are 9 various biodiesels that have been produced and characterized. These bio-diesel varieties available in Assam have not been adequately explored, characterized and tested for engine performance. There is enormous potential of these bio-diesel varieties as fuel for diesel engine which is natural forest biomass resources. Therefore to properly utilize the outcome of this project, it requires further study in engines for evaluating their performance, combustion, emission in conventional diesel engines. Moreover, it is seen that biodiesel in blended form can be used in existing diesel engine technology without any modification. However biodiesel availability seems to be the problem and biodiesels should be produced from all potential sources. To this end Government should plan accordingly to plant biodiesel producing trees in the forest areas to make the fuel available for commercial use.

Part B – Comprehensive Report

1. Project Title: Study of performance, combustion and emission characteristics of a turbocharged diesel engine fuelled with some indigenous tree seed based biodiesel available in North-Eastern region of India.

2. Product/Process as an outcome of the Project, identify Beneficiaries:

- Biodiesels from nine (9) various Assam tree seeds have been produced simultaneously.
- Fatty acid compositions of these biodiesels are evaluated as a part of this project.
- All important fuel properties of these biodiesels have been evaluated as per the set objectives of the project.
- Evaluation of properties of few specific blends (10% and 20%) of these biodiesels with conventional diesel fuel is also completed as a part of this project outcome.
- Additionally performance of a single cylinder four stroke diesel engine is evaluated with 10% blending of some of the biodiesels including the three new varieties of biodiesel as fuels. Engine performance and fuel consumption characteristics of these biodiesel fuel blends are determined. The performance test shows better engine performance with some of the blended fuel (B10) in terms of fuel consumption and in engine efficiency.

The results will definitely be useful for bio-diesel producing industries as some new biodiesel sources have been identified as outcome of this project. Society will be benefited as large scale production of these oil bearing trees will increase the forest coverage of the region and also improve the

economy of the region. The promotion of bio-diesel renewable would reduce the fossil fuel dependence which has been the recognized as an urgent need of the society.

3. Scientific Description of the Product/Process, give Specifications/Standards for the same:

Biodiesel is basically monoalkyl esters of long chain fatty acids derived from plants or animal matters. It is the name given to transesterified vegetable oil to describe its use as a diesel fuel. Biodiesel produced from different vegetable oils has been accepted as a clean alternative fuel worldwide. It is an eco-friendly green diesel fuel which contains no petroleum, but can be blended at any level with petroleum diesel to create a biodiesel blend for use in compression ignition (CI) engines.

In this project oil content, fatty acid composition of nine different varieties of tree seed based biodiesels are determined. Important fuel properties of both the oil and fatty acid methyl ester are also evaluated. The fatty acid composition of various samples of seed oil is shown in Table 1. Fatty acid composition plays an important role in fixing some critical biodiesel properties such as cetane number, cold flow properties, viscosity, lubricity, oxidative and storage stability. Biodiesel with more saturated fatty acids is known to have higher cetane number and better oxidation stability; however the cold-flow properties (pour point and cloud point) are affected negatively. On the other hand, increasing unsaturation in the oil and decreasing chain length in the fatty acid chain causes reduction in some selected fuel properties such as viscosity, cetane number and calorific value. Fatty acid composition of the raw oil is not altered by transesterification; hence the composition is the same for both the oil and its methyl ester. Samples 1 to 4 and Sample 7 is mostly oleic while in Sample 6, 8 and 9 contain maximum amount linoleic acid followed by that of the oleic acid. Sample 5 almost have equal composition of palmitic, oleic and linoleic acids.

Table 1: Fatty acid compositions of various samples of seed oil

Fatty acid chain	% by wt									
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	
Caproic (6:0)	-	-	-	-	-	-	-	-	-	0.226
Caprylic (8:0)	-	-	-	-	-	-	-	-	-	0.406
Capric (10:0)	-	-	-	-	-	-	-	-	-	0.101
Myristic (14:0)	-	-	0.34	0.05	-	0.209	0.546	0.659	-	-
Myristoleic (14:1)	-	-	-	-	-	0.182	-	-	-	-
Palmitic (16:0)	14.2	11.30	5.030	18.03	32.80	6.622	5.189	8.586	7.187	-
Palmitoleic (16:1)	1.4	-	0.807	-	0.50	1.153	1.242	-	-	-
Heptadeconic (17:0)	-	-	-	-	-	0.970	-	-	-	0.206
Cis-10 Heptadeconic (17:1)	-	-	-	-	-	2.849	-	-	-	-
Stearic (18:0)	6.9	9.80	6.923	16.35	6.4	6.172	5.350	6.334	5.382	-
Oleic (18:1)	43.1	45.25	48.142	49.92	31.30	23.007	59.713	35.19	30.251	-
Linoleic (18:2)	34.4	24.75	31.372	13.28	28.80	32.938	23.649	37.142	52.553	-
Linolenic (18:3)	-	2.90	0.752	-	-	15.838	0.562	4.092	0.468	-
Arachidic (20:0)	-	1.75	3.675	1.41	0.30	0.985	2.223	0.502	1.449	-
Eicosenoic (20:1)	-	-	0.369	0.3	-	8.650	0.694	5.815	1.252	-
Behenic (22:0)	-	3.20	2.085	0.32	-	0.186	0.430	1.681	0.304	-
Tricosoneic (23:0)	-	-	-	0.05	-	-	0.064	-	-	-
Lignoceric (24:0)	-	-	0.504	0.13	-	0.240	0.358	-	0.214	-

The physical and chemical properties of the nine seed oils and their fatty acid methyl esters were evaluated. These include density, kinematic viscosity, calorific value, fire and flash point, pour point, cloud point, copper strip corrosion, carbon residue, vapor

pressure, acid value, sulphur content, distillation temperature and cetane index. The properties of the nine seed oils and its biodiesel are shown in Table 2 (a) and Table 2(b).

Table 2 (a): Properties of diesel, various seed oils and their biodiesels (Sample 1- Sample 5)

Properties	Diesel	Sample 1		Sample 2		Sample 3		Sample 4		Sample 5	
		Oil	FAME	Oil	FAME	Oil	FAME	Oil	FAME	Oil	FAME
Density at 15 °C (kg/m ³)	842.5	ND	884.2	ND	912.1	916.6	879.7	935.5	898.4	915.3	890.6
Viscosity at 40 °C (mm ² /s)	1.806	ND	5.74	ND	8.07	41.72	4.63	59.63	12.07	39.34	7.499
Calorific value (MJ/kg)	44.637	ND	39.861	ND	38.887	37.894	40.159	37.93	38.25	39.211	39.594
Fire point (°C)	48	ND	160	ND	164	ND	158	ND	190	ND	172
Flash point (°C)	44	ND	146	ND	154	ND	147	ND	178	ND	160
Pour point (°C)	-4	ND	-2	ND	4	3	5	5	3	7	-1
Cloud point (°C)	5	ND	8	ND	7	14	12	15	9	16	9
Carbon residue (wt. %)	0.140	ND	0.867	ND	1.22	ND	0.313	ND	0.387	1.08	0.208
Vapour pressure (kg/cm ²)	0.05	ND	0.04	ND	0.05	0.07	0.04	0.04	0.05	0.06	0.04
IBP/FBP (°C)	142/374	ND	341/406	ND	361/446	ND	343/419	ND	344/421	ND	342/417
Sulphur content (ppm)	340	ND	9	ND	15	ND	13	ND	7	ND	25
Copperstrip corrosion	1a	ND	1a	ND	1a	ND	1a	ND	1a	ND	1a
Cetane number/index	46.42	ND	56.4	ND	53.65	ND	68.3	ND	52.25	ND	54.92
Acid value (mg KOH/g)	0.035	ND	0	ND	0	ND	0	12.0	0.01	12.0	0.0
Ash content (wt. %)	0.01	ND	nil	ND	0.001	ND	0.04	0.02	0.01	ND	trace
Water content (vol. %)	0.014	ND	0.1	ND	0.45	ND	0.1	ND	0.035	ND	0.126

ND: Not determined

Table 2(b): Properties of diesel, various seed oils and their biodiesels (Sample 6- Sample 9)

Properties	Diesel	Sample 6		Sample 7		Sample 8		Sample 9	
		Oil	FAME	Oil	FAME	Oil	FAME	Oil	FAME
Density at 15 °C (kg/m ³)	842.5	944.2	903.2	917.6	884.2	960.4	924.0	923.8	886.5
Viscosity at 40 °C (mm ² /s)	1.806	67.7	6.645	42.98	4.891	291.2	18.36	27.47	5.646
Calorific value (MJ/kg)	44.637	38.469	39.051	39.583	40.224	36.521	36.909	38.16	39.717
Fire point (°C)	48	ND	155.0	ND	162	ND	ND	ND	148
Flash point (°C)	44	ND	145.0	ND	152	ND	ND	ND	136
Pour point (°C)	-4	5	2	ND	0	ND	-16	-2	-5
Cloud point (°C)	5	14	10	ND	5	ND	-4	5	4
Carbon residue (wt. %)	0.140	ND	0.769	ND	0.646	1.24	0.806	1.136	0.659
Vapour pressure (kg/cm ²)	0.05	0.07	0.05	0.06	0.05	ND	0.05	ND	0.04
IBP/FBP (°C)	142/374	ND	283/426	ND	353/542	ND	356/526	ND	345/434
Sulphur content (ppm)	340	ND	40.0	ND	5.0	ND	56	59	33
Copperstrip corrosion	1a	ND	1a	ND	1a	ND	1a	ND	1a
Cetane number/index	46.42	ND	49.24	ND	63.2	ND	53.3	45.33	59.38
Acid value (mg KOH/g)	0.035	32	0	ND	0	ND	0	6.00	0
Ash content (wt. %)	0.01	ND	0.2	ND	0.04	ND	0.09	ND	0.009
Water content (vol. %)	0.014	ND	0.1	ND	0.1	ND	0.2	ND	0.187

ND: Not determined

4. Methodology adopted for Development of the Product/Process:

The following methodology was adopted for production and characterization of biodiesels:

(i) Altogether nine (9) different seeds were identified for biodiesel production from them.

(ii) Oils from these oil bearing tree seeds were extracted.

(iii) Oil content of these tree seeds was measured which is shown in Table 3.

(iv) Free fatty acid (FFA) level of all the nine seed oils was determined to check whether it falls below 3%. In case of oils with FFA higher than 3%, acid pretreatment was done to bring FFA down to 3% and then base catalyzed transesterification was done to produce biodiesel from the vegetable oil methanol as reagent and NaOH as catalyst.

(v) The standard operating procedure was followed to produce biodiesels from these 9 different tree seeds.

(vi) After production of biodiesels, important fuel properties of these biodiesels were evaluated.

The following table (Table 1) shows the methods and standard used for investigation properties of oil and its fatty acid methyl ester (FAME).

(vii) The fatty acid composition of the seed oils were determined by Gas Chromatography (GC) technique using standard operating procedure in Punjab Biotechnology Incubator, an Agri and Food testing laboratory located in Mohali, Punjab, India.

Table 1: Methods and standard used for investigation properties of oil and FAME

Property	Apparatus, Model	Standard
Free fatty acid content	Titration method	ASTM D664
Kinematic viscosity and density	Combined viscometer and densitometer, LEMIS's VDM-300 Heat	EN 61326
Calorific value	Automatic bomb calorimeter, IKA	ASTM D240
Cloud and Pour point	Cloud & Pour point apparatus	ASTM D 2500 & ASTM D97
Fire & Flash point	Flash & Fire point apparatus	ASTM D 92
Copper strip corrosion	Copper Corrosion Test Apparatus	ASTM D 130
IBP/FBP (°C)	Distillation Apparatus	ASTM D-86
Cetane index	Calculated by four variable equation	ASTM D4737
Carbon residue	Ramsbottom Carbon residue apparatus	ASTM D 524
Vapour pressure (kg/cm ²)	Reid vapour pressure apparatus	ASTM D 323
Sulphur content (ppm)	X-ray fluorescence spectrometer	ASTM D4294/2622
Acid value (mg KOH/g)	Titration method	ASTM D664
Ash content (wt. %)	Muffle furnace	ASTM D874
Water content (mg/kg)	Distillation method	ASTM D287

Engine testing for evaluating engine performance with 10 and 20% blending of some biodiesels particularly the new varieties have also been performed in this project.

5. Scientific /Technological Formulation giving underlying Basis:

Biodiesel has been accepted as a clean alternative fuel by the World community. Biodiesel production and characterization from various plant resources are in progress in many countries. In India, biodiesel production from non-edible oil seeds is receiving significant research interest in the last decade. Controlled cultivation of plant species, seed procurement, oil extraction, transesterification, blending, research and development are vital for successful implementation of

National biodiesel Mission in India. . A number of unutilized oil bearing plant species are reported to be suitable for biodiesel production in India. *Jatropha curcas*, *Pongamia pinnata*, Mahua, Rubber seed oil are some of them. Assam, a part of North-East India is considered to be the hub of many plant resources. A number of tree bearing oil seeds such as *Mesua Fera* L, Koroch seed oil, *Terminalia* oil etc. are available here. Apart from these, there may be many other tree seeds which are yet to be explored for biodiesel production and used as fuel in diesel engine. The judicious exploitation of all such non-edible sources of biodiesel could be vital in addressing issues related to energy security, forest conservation and rural economy up gradation. If India has to attain the goal of even 10% substitution of diesel with fuel derived from plant sources, this will demand production and use of biodiesels from all potential sources and existing sources (*Jatropha*, *Karanja* etc.) alone will not be sufficient to meet this huge biodiesel requirement.

The utilization of these biomass resources as bio-fuel would definitely be able to address the national energy security problem. Considering the urgent need of exploring all possible sources of bio-diesel and potential strength of these oil seed bearing tree of this region (Assam), the present investigation was proposed to address the some specific problems related to biodiesel extraction and characterization of these tree seed based biodiesels. It was intended to bridge the research gap concerning the use of these biodiesels available in this region of the country. The project was proposed to address a problem of national importance (fossil fuel substitution) utilizing location specific natural resources (Bio-diesel available in Assam, North East India)

6. Further Work required, if any, to get full Benefits or enhance Utilization

Yes, with the production and characterization of these biodiesels completed, now it requires further investigation (engine testing) for confirming the suitability of these biodiesels as diesel engine fuel. Experiments in a single cylinder four stroke diesel engine was carried out with 10% and 20% blending of some biodiesels to evaluate the engine performance and combustion characteristics. However more research on biodiesel engine application is required so that it leads to development of dedicated engine for biodiesel use with higher percentage of blending. To this end, we submitted a new proposal to DST (copy attached) for consideration by the EAC members. The following were the objectives of this proposed new study. (However the project was later returned back by DST, TDT division)

- *To evaluate and compare the engine performance and fuel combustion of a two cylinder 4 stroke CRDI diesel under variable speed condition using various blends diesel and biodiesels.*
- *To measure engine simultaneously the smoke opacity and gaseous emissions using AVL engine analyzer with exhaust emission system (MDS 650)*
- *To provide ECU diagnostics with AVL (MDS 650) engine analyzer of the given engine with biodiesels and its diesel fuel blends.*
- *To determine the appropriate biodiesel and also the fuel blend for optimized engine performance based on analyses of performance, combustion and and emission results.*

Moreover following works are required to take full advantage out of the project outcome.

- To visualize the fuel spray pattern and in-cylinder combustion phenomenon in a single cylinder 4 stroke direct injection (DI) diesel engine operated with diesel and various biodiesel fuels at various engine operating conditions of load/speed and compression ratio (CR).

- To determine the spray cone angle, spray penetration length, spray uniformity of diesel and biodiesel fuel spray using photographic and high speed video recording at various operating conditions.
- To evaluate the fuel spray velocity, the spray droplet size and its distribution for all the above fuels at various operating conditions using Phase Doppler interferometer (PDI) system
- To determine the particle size and its concentration at the engine exhaust at various engine operating conditions using the diesel and biodiesel fuels.

This project proposal was also rejected by DST. However, the research with biodiesel now is saturated in so far as engine performance, combustion and emission study is considered. Only studies specific to biodiesel spray evolution, air fuel mixing, combustion visualization leading to development of engine combustion chamber development for biodiesel application may be the possible future works related to biodiesel.

7. OUT PUT:

A. Technology Development

- Technology developed at Lab scale/pilot scale/commercial scale:
 - Complete biodiesel production technology has been developed in the lab scale for all the 9 tree seeds considered including the 3 completely new varieties. Effect of catalyst and molar ratio of alcohol and vegetable have been evaluated to maximize the biodiesel yield for two new varieties of biodiesel.
- Technology demonstration in field setup - Yes/No: No
- Technology Transfer to industry: None
- Buyers/ end users of product: Not identified

- Creation of improved product: None
- Affordability: The cost-estimate of the developed prototype: Not studied

B. Knowledge creation:

- Research papers/publications/posters:

One Research paper “Biodiesel Production from Kutkura (*Meyna spinosa Roxb. Ex.*) fruit seed, its characterization and performance evaluation of 10% blend in a Diesel Engine” has been communicated in an Elsevier journal, one more in the pipeline.

- Patent filings: NIL

- Participation in conference/ training workshops attended:

Not participated, till now, however with the project findings (fuel property results); we are planning to submit paper to International conferences to be held in the year, 2015.

C. Capacity building

- Officers/faculty: Nil
- Temporary manpower recruited/trained: One JRF was recruited and he was trained to operate all the equipments installed under this project.

D. Added Value of project outcomes:

Additionally engine performance testing in a single cylinder 4 stroke diesel engine was done with 10% and 20% blending of some varieties of biodiesel which was produced and characterized in this project. The performance test results of a particular new biodiesel which is characterized in this project have also been reported in the manuscript that has been communicated in the International Journal which is under review at the moment.

E. Achievements/ highlights of the project:

- Biodiesels are produced from 9 different tree seeds available in Assam simultaneously at a time.
- The important fuel properties of these biodiesels including the fatty acid composition, oil content of the seeds are evaluated.
- Three new varieties have been identified as potential source of biodiesels in this project. Their properties are also evaluated and most of them conform to standard biodiesel norms.
- One JRF was appointed and trained on biodiesel production from tree seed oils. He is now fully trained on the use of various equipments related to biodiesel production and characterization.

F. Shortfalls/constraints faced:

Initially we faced some problems in producing biodiesels from some identified varieties (e.g. sample 10 in the photographs). Later on we had to skip some of them. After the oils from the 9 identified seeds were extracted, then we had to be dependent on some other agencies for evaluating its fatty acid composition and it took some time. Moreover all seeds are not available over the years which are seasonal and we had to wait for the matured seeds. Then again for evaluating some other properties (cetane index, sulphur content, ash content, water content etc.), we had to send the samples to Numaligarh Refinery Limited (NRL), Numaligarh, Golagahat, Assam and also to North Eastern Institute of Science and Technology (NEIST) Jorhat, Assam. Therefore it took some time to evaluate some specific properties of the biodiesel samples. We also faced some problems in extracting oil and producing biodiesel from one particular variety (Sample 8).

Signature of PI

Signature of Co-PI

Dr. Tapan kumar Gogoi

Dr. Dhanapati Deka

Name of PI

Name of Co-PI

Photographs of the equipments purchased from the project fund:



Viscometer and density meter



Automatic Bomb Calorimeter



Cloud and Pour point apparatus



Flash and Fire point apparatus



Distillation apparatus



Copper Corrosion test apparatus



Carbon Residue test apparatus



Reid vapor pressure apparatus



Transesterification plant



Oil expeller

Various Tree seeds collected for biodiesel production:



Sample 1



Sample 2



Sample 3



Sample 4



Sample 5



Sample 6



Sample 7



Sample 8



Sample 9



Sample 10

Men at project related works















Biodiesel production with samples and its blends











Supplier	Item	Quantity	Unit Price (Rs)	Total (Rs)
Jonomi	19,000.00			
Enterprize,	19,000.00			
Tezpur	19,000.00			
Grand Total (Cost (Rs))				19,000.00

Date: 19-03-2015





UTILISATION CERTIFICATE
(TO BE SENT IN DUPLICATE TO DEPARTMENT OF SCIENCE AND TECHNOLOGY)
For the financial year 2015 -2016
(Audited)

1.	Title of the Project/Scheme	STUDY OF PERFORMANCE, COMBUSTION AND EMISSION CHARACTERISTIC OF A TURBOCHARGED DIESEL ENGINE FUELLED WITH SOME INDEGENOUS TREE SEED BASED BIODIESEL AVAILABLE IN NORTH EASTERN REGION OF INDIA
2.	Name of the institution	TEZPUR UNIVERSITY
3.	Principal Investigator	Dr. Tapan Kr. Gogoi
4.	Dept. of Science and Technology sanction order no. and date of sanctioning of the project	DST/TSG/AF/2011/156 29 th August, 2012
5.	Head of the account as given in the original sanction order	Manpower: 4,22,400.00 Consumables: 1,00,000.00 Contingencies: 70,000.00 Domestic travel: 70,000.00 Other cost: 1,00,000.00 Equipment: 20,97,493.00
6.	Amount brought forward from the previous financial year quoting DST letter No. and date in which the authority to carry forward the said amount was given.	2,13,759.00
7.	Amount received during the financial year (Please give DST letter/order no. and date)	62,865.00 (interest earned)
8.	Total amount that was available for expenditure (excluding commitments) during the financial year (Sr. no. 6+7)	2,76,624.00
9.	Actual expenditure (excluding commitments) incurred during the financial year (up to 31 st March)	2,12,604.00
10.	Balance amount available at the end of the financial year	64,020.00

11.	Unspent balance refunded, if any (please give the details of Cheque No. etc)	64,020.00
12.	Amount to be carried forward to the next financial year 2014-15 (if applicable)	Not applicable

UTILISATION CERTIFICATE

Certified that the amount of Rs. 0.00 of grant sanctioned during the year 2014 -15 in favour of Registrar, Tezpur University vide sanction order no DST/TSG/AF/2011/156 Dated 5th August, 2014, and on account of unspent balance from previous year of Rs. **2,13,759.00** and interest earned of Rs. 62865 on project fund, a sum of Rupees 2,12,604.00 has been utilized for the purpose of Research project for which it was sanctioned and that the balance of 64,020.00 (including interest earned) remaining unutilized at the end of the year will be refunded to DST.

Name & Signature
of PI
Dr. Tapan Kr. Gogoi

B. Sharma
10/7/15
Name & Signature
of Accounts Officer with seal
Finance Officer
Tezpur University

B
Name & Signature of
Head of the Institution
With date and seal
Registrar
Tezpur University

(TO BE FILLED BY DST)

Certified that I have satisfied myself that the conditions on which the grant was sanctioned have been fulfilled/ are being fulfilled and that I have exercised the following checks to see that the money was actually utilized for which it was sanctioned.

Kinds of checks exercised

- i)
- ii)

Signature
Designation
Date :

Project Title: Study of performance, combustion and emission characteristics of a turbocharged diesel engine fuelled with some indigenous tree seed based biodiesel available in North Eastern part of India.
Sanction order no. DST/TSG/AF/2011/156

Date of closure of project: 7th April, 2015

FINAL STATEMENT OF EXPENDITURE

Sl. No	Sanctioned Heads	Funds allocated	Funds received					Total Fund Received	Expenditure Incurred					Total Expenditure	Balance as on date
			2012-13	2013-14	2014-15	2015-16			2012-13	2013-14	2014-15	2015-16			
1	MANPOWER	4,22,400.00	2,11,200.00	0.000	2,11,200.00	0.000	4,22,400.00	0.000	2,02,667.00	1,92,000.00	59833.00	4,54,500.00	-32100.00		
2	CONSUMABLES	1,00,000.00	60000.00	0.000	40000.00	0.000	1,00,000.00	0.000	59997.00	46894.00	0.00	1,06,891.00	-6891.00		
3	CONTINGENCIES	70000	30000.00	0.000	40000.00	0.000	70000.00	3874.00	29997.00	9633.00	26496.00	70000.00	Nil		
4	TRAVEL	70000	30000.00	0.000	18800.00	0.000	48800.00	0.000	13260.00	6000.00	8735.00	27995.00	20805.00		
5	OTHER COSTS	1,00,000.00	60000.00	0.000	40000.00	0.000	1,00,000.00	0.000	59990.00	51800.00	0.00	1,11,790.00	-11790.00		
6	EQUIPMENT	2097493	2097493.00	0.000	0.00	0.000	2097493.00	0.000	20,43,662	0.00	22700.00	20,66,362.00	31131.00		
7	OVERHEAD	5,00,000.00	3,00,000.00	0.000	2,00,000.00	0.000	5,00,000.00	1,50,000	0.000	2,55,160.00	94840.00	5,00,000.00	Nil		
8	INTEREST EARNED						62865.00						62865.00		
	TOTAL	33,59,893.00	27,88,693.00		5,50,000		33,38,693	1,53,874.00	24,09,573.00	5,61,487.00	2,12,604.00	33,37,538.00	64020.00		

Note:

1 Total balance as on date of completion of project =1155+ interest=1155+62,865.00=64020.00

Signature of PI

Signature of Finance Officer

3/9/15

Finance Officer

Tezpur University

Signature of Registrar

Registrar

Tezpur University