

आज़ादी का अमृत महोत्सव
आज़ादी के 75 वर्ष

TECHNOLOGY

टेक्नोलॉजी फोकस

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BIOMASS AND BIORESOURCE : TECHNOLOGIES FOR SELF-RELIANCE



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From the Desk of Guest Editor



Energy security is vital for the economy of a country. Moreover, self-sufficiency in energy sector is an important determinant of the security of a country. The threats of depleting fossil fuel reserves and rapidly worsening air quality is compelling various stakeholders, viz., governments, corporate, scientists to search for viable alternate sources of energy. Biofuels, being liquid at ambient temperatures, offer attractive alternatives, because they can be used in most of present day vehicles and machineries without making any modifications.

Defence Institute of Bio-Energy Research (DIBER), a premier Bio-Energy R&D laboratory of DRDO has a major thrust area of processing of biomass to bio-energy and biofuels. In recent years, the institute has developed technologies for utilising pine forest residues for Combined Heat and Power (CHP) by gasification. The technology can successfully divert the pine forest residue for gainful utilisation, which is otherwise prone to catch forest fires during summer months in Uttarakhand. The institute has also developed another gasification process utilising pine needles as fuel, and steam as an oxidant for producing hydrogen rich syngas. From the point of view of biofuels and bio-energy, it is an excellent raw material to synthesise petroleum grade hydrocarbons, novel fuels like methanol and dimethyl ether, as well as purified hydrogen. The syngas itself can be used as a fuel in generator sets, engines and fuel cells. Utilisation of pine needles as biomass fuel is primarily hindered due to their low bulk density (<math><0.02 \text{ g/cc}</math>) compared to coal and wood. The institute has therefore developed techniques for energy densification by torrefaction as well as by biomass densification using briquetting. Both processes result into enhanced calorific value of the biomass per unit volume. The institute has developed unique formulation as well as process for development of pine needle briquettes. In the past, the institute has also developed briquettes from *Jatropha* fruit husk.

DIBER is also working towards utilisation of biomass to develop electro-chemical sources of energy like batteries and capacitors. The institute has been successful in developing a unique material by processing of waste biomass and plastic waste, which is otherwise a growing menace. This material has been used to develop secondary batteries. These batteries have been tested under low temperature conditions, and have shown resilience in performance under harsh conditions.

Another major thrust area of the institute is imparting Agrotechnology trainings and skill to native farmer population in border areas of Uttarakhand. This is being done with an objective of curtailing migration of civil population from far flung areas in the search of greener pastures. Populated and prosperous villages in border areas are always a boon for national security. Therefore to improve the socio-economic status of farmers in border areas, scientifically tested and meticulously planned agronomic practices are being introduced in these villages. So far, 3000 farmers have been registered for technological support from DIBER.

The institute has also contributed in a major way in developing superior *Jatropha* germplasm, its area-specific agrotechnologies, indigenized and superior transesterification process, and testing and trials of high quality *Jatropha* bio-diesel in vehicles and equipment of Armed Forces. DIBER has successfully executed trials of *Jatropha* bio-diesel in high altitude areas (>15,000 ft asl) in extreme winters (Temperature <-30⁰C), and in deserts in extreme summers (Temperature >45⁰C).

From time to time, the institute has also contributed in societal and national missions. For more than an year, the institute is also party to National Health Mission by actively participating in COVID-19 testing.

The present issue of *Technology Focus* highlights contributions made by DIBER during long history of its association with military units and civil population in frontier and inaccessible areas of Uttarakhand. I hope that the readers would enjoy the glimpses and snapshots of efforts of DIBER made in important areas of biofuel, bio-energy and curtailing migration from border areas.

Madhu Bala

Director, DIBER

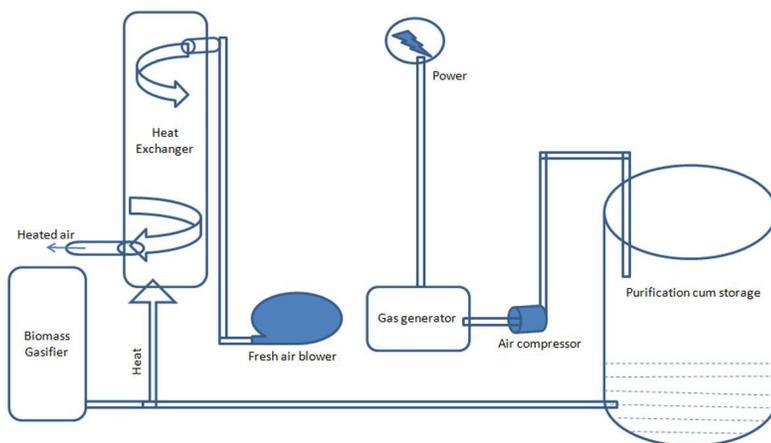
BIOMASS AND BIORESOURCE: TECHNOLOGIES FOR SELF-RELIANCE

COMBINED HEAT AND POWER

DIBER has developed technologies for combined heat and power using the gasification of pine needles. Pine needles are thermochemically treated at high temperatures in the

deficiency of oxygen, which leads to the production of combustible gases, called producer gas at temperatures above 300 °C. These gases can then be diverted to fuel a generator set for power production, or to

cooking stoves for heating purposes, or directed to a compressor for refrigeration, as may be the requirement. DIBER is utilising the gases for power production and space heating.



Conceptual diagram depicting harnessing of combined heat and power using pine needle gasification



A prototype of combined heat and power using pine needle gasification

AIR BLOWN GASIFICATION

Using air as an oxidant in a downdraft gasifier, DIBER has developed a process for the gasification of waste pine needles, a low-density biomass. While the availability of

pine needles is widespread in the Himalayas, and the calorific value (19.6 MJ/kg) is also desirable for biomass to be used as fuel, the lower bulk density (0.02 g/cc), makes it

difficult to use in a gasifier. DIBER has been able to gasify pine needles with specific process parameters like oxygen richness calculated in terms of air inlet rate, biomass packing factor,

operating temperature and biomass column. The quantity of the producer gas has been determined, while the efficiency of the process has been determined based on the equivalence ratio, reaction temperature profile, and other gasification parameters. Downdraft gasifiers produce lower content of tar in the gas (wt 0.1%), and

therefore the producer gas from these gasifiers can directly be used in an engine for the production of power or other uses. The process of gasification using a downdraft gasifier is suitable for remote high altitude locations with 2-4 months of snow cover for self-sufficient, self-reliant, small-scale decentralised power generation systems via the gas engine. It suits well in the CHP scenario as well, without the expense of fossil fuels.



— Mouth, for feeding biomass

- Air Inlet
- Gas outlet
- Main tank
- Grate

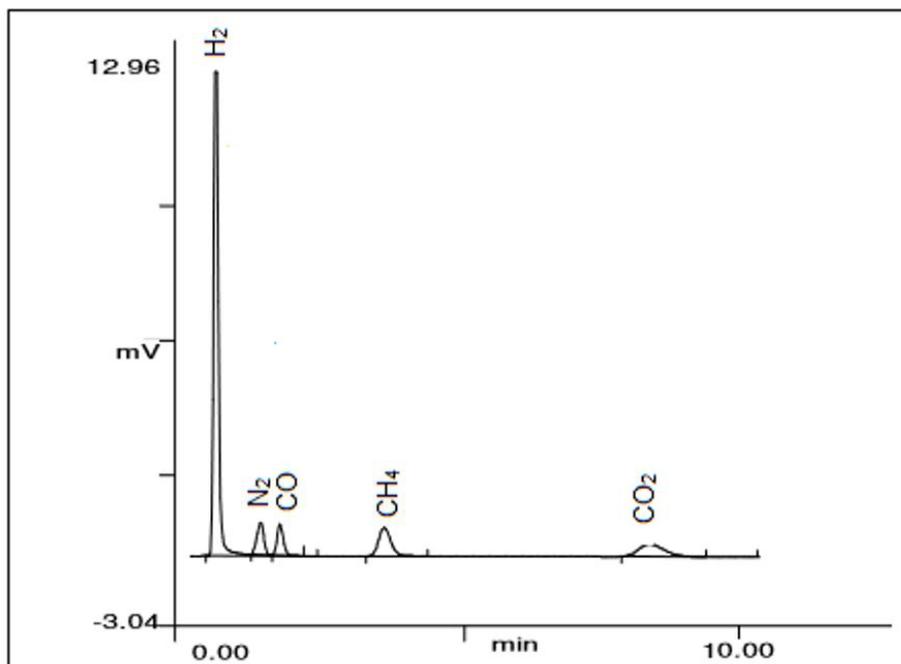


STEAM GASIFICATION

A process of gasification of pine needles has been developed using steam as an oxidant to lower the percentage of nitrogen in the producer gas as well as to obtain the

product with a higher heating value. Gasification using steam is carried out not only to obtain nitrogen-free

high calorific value syngas ($H_2 + CO$), but also to obtain an ideal ratio of H_2 and CO , which can then be utilised



for the production of liquid fuels, or to purify hydrogen gas for fuel. The development of liquid fuels would be a significant step towards achieving self-reliance in terms of energy security for an entire nation.

The developed steam gasification process is carried out at about 600 °C with a specific steam/biomass ratio. Pine needle biomass containing more lignin requires a higher temperature of gasification, and produces a

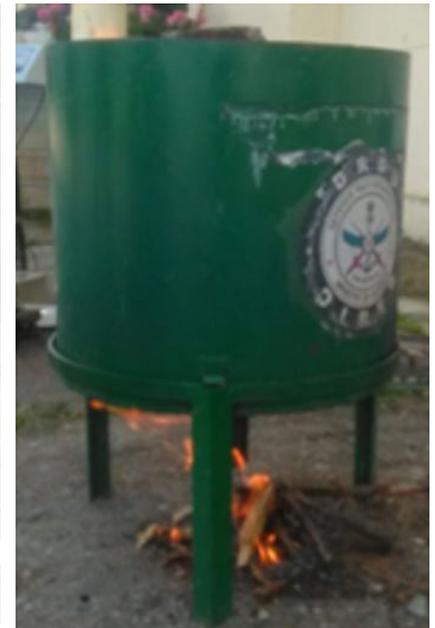
comparatively higher amount of bio-oil. The H₂/CO ratio better than 2:1 has been achieved, which is crucial for further conversion of syngas to hydrocarbons.

BIOMASS DENSIFICATION BY TORREFACTION

High altitude locations in Uttarakhand witness heavy rainfall, snowfall and low temperatures with high humidity. Besides that, the air density is low as well. Under such conditions storing as well as utilising the biomass for gasification and other purposes is quite difficult. Therefore, DIBER has standardised the

torrefaction process for pine needles for their subsequent use in gasification at high altitudes. Torrefaction of pine needles for 2 hrs at 200-300 °C would reduce the weight of the biomass to 2/3rd of the original due to partial loss of volatile matter and moisture. Thus, the biomass gets densified and becomes amenable to gasification.

Gasification of torrefied pine needles vs the raw pine needles resulted in more than doubling of retention time for torrefied pine needles in the gasifier. The biochar recovered from torrefied pine needles is <10 %, while in the case of untorrefied pine needles, only ash is formed.



Torrefied pine needles and the apparatus used for torrefaction at DIBER Fd Stn Auli.

BIOMASS DENSIFICATION BY BRIQUETTING

Pine needle briquettes are being prepared at DIBER with the use of an additive and a binder. The process

involves mixing the binder and the additive with the pine needle powder to prepare a semisolid mixture,

which is then added into the molds and allowed to harden. With the use of these additives and binders, the

density is improved to 1.49 g/cc. The energy density is enhanced to 3211

cal/g, which is 162% of the pine needle (powder). These briquettes are useful

for ensuring energy security at remote locations without any dependency on the imported fuel.



Pine Needle briquettes without additive



Pine Needle briquettes with additive

In addition, technology is also available in DIBER for densification of woody biomass. With the prunings of *Jatropha* plants, briquettes have been produced at a scale of about 200 kg/h.



Briquettes prepared from *Jatropha* prunings

GREEN ENERGY

BIOMASS BASED ENERGY GADGETS AND PRODUCTS

BPC/rGO Battery

As part of ongoing R&D, a unique bio-plastic char/condensate material has been produced (Patents filed). The material is heavily carbonized. This material has gainfully been utilised based on its properties such as dielectric constant, dielectric strength and conductivity, to produce 4.2 V batteries, with a rated capacity



BPC/rGO batteries of 4.2 V and weighing 45 g

of 1200 mAh. The advantage of these batteries includes their endurance in extreme climates of high altitude (tested at simulated pressure of 11.6 kPa), temperature extremes (from -20 to +72°C), etc.

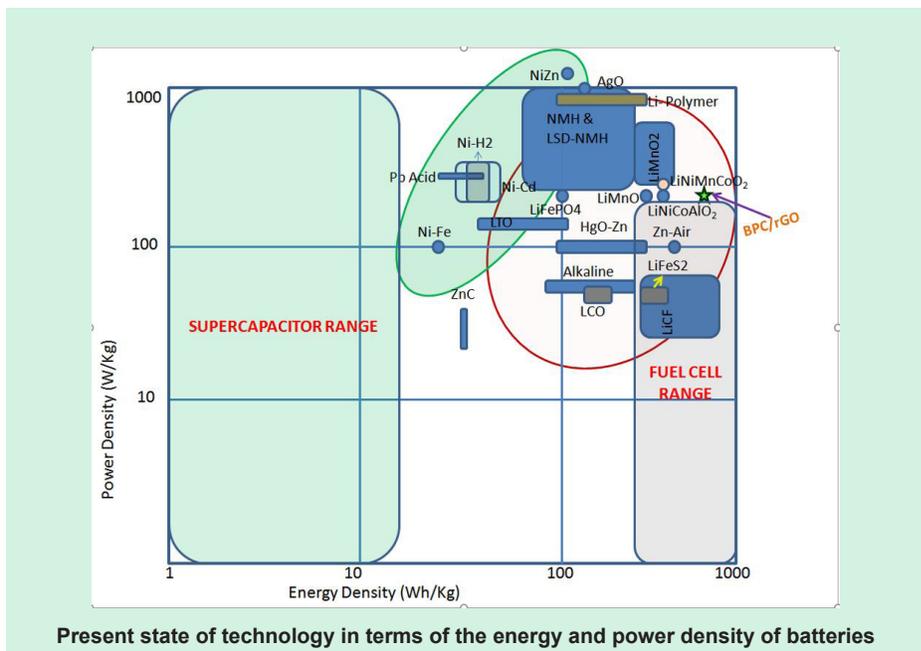
Having been prepared from waste biomass and other household polyolefin wastes, the batteries cut off the demand for costly Lithium and Cobalt, which is presently popular in preparing Lithium cobalt batteries. The battery is also superior to the present-day technology of Lithium-ion batteries in terms of energy and power densities.

Camelina-based Supercapacitor

DIBER has been instrumental in introducing Camelina to India in the year 2011. Technology for mass cultivation of Camelina at various altitudes and locations has been developed and standardised by DIBER. A part of R&D on Camelina involved chemical modification of C=C group in the alkyl chains of triglycerides to oxirane by epoxidation. The product thus obtained shows an oxirane oxygen content of 8.1 per cent. This product has been used in combination with silica and a commercial hardener to prepare a filler for the supercapacitors of various capacities- 4, 10, 20 and 36 μF . These capacitors have been tested by charging them for 30 s and then the terminals were contacted with each other, which created a spark.

High Functionality Bio-Polyol

Polyols are important as binders for rocket and missile propellants and explosives. To ensure self-reliance in



Supercapacitors developed at DIBER



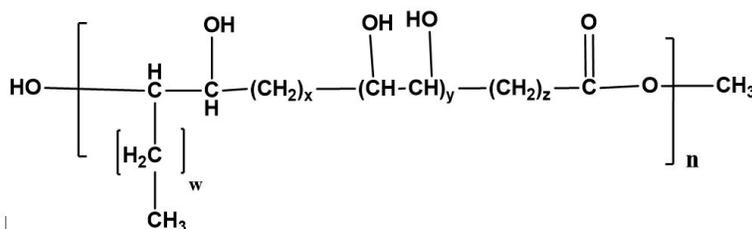
Spark from one of the capacitors

terms of the availability of polyols, the development of bio-based polyols is a niche area, which in addition can lead to the development of a cheaper alternative to conventional petroleum-derived polyols. DIBER has developed a bio-based polyol prepared from derivatives of natural vegetable oils that are under the green processes since it is synthesised from renewable sources, unlike petrochemical feedstock. The synthesis of natural oil-based polyol

for defence application is rarely available in the literature since the bio-based polyols are more difficult to design or synthesize for a specific application as compared to the one from its petrochemical equivalent.

The natural oil from suitable plants rich in C=C unsaturation has been modified to introduce -OH functionality followed by polymerization to obtain bio-based polyol with an average functionality

of 3.0-3.5 has been achieved. It is envisaged that such polyols are more suitable as binders and cross-linking agents for composite solid propellants and explosives.



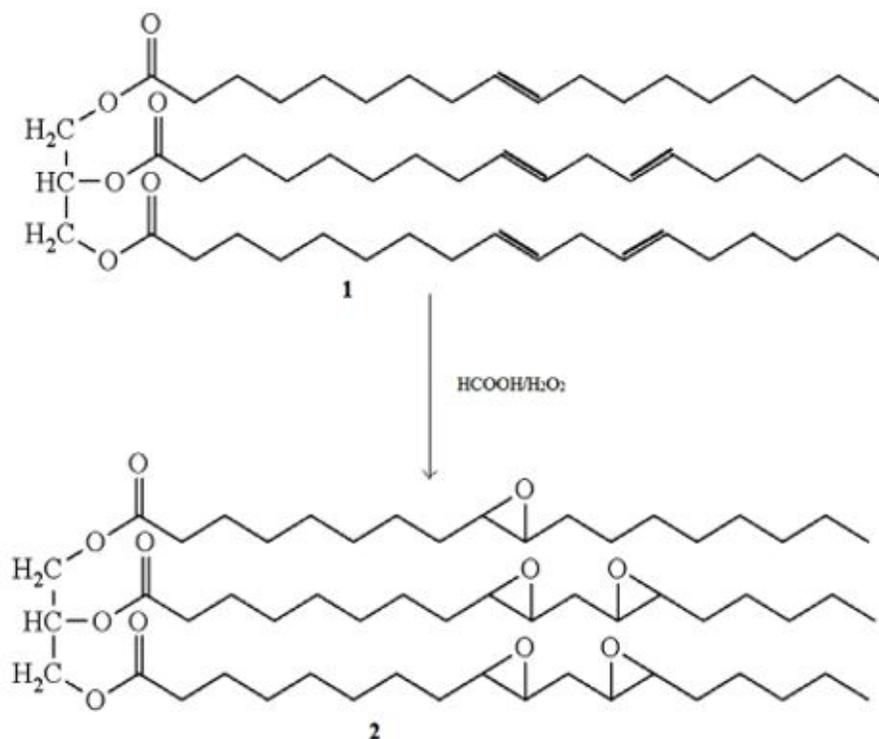
Probable structure of DIBER polyol

Bio-lubricants

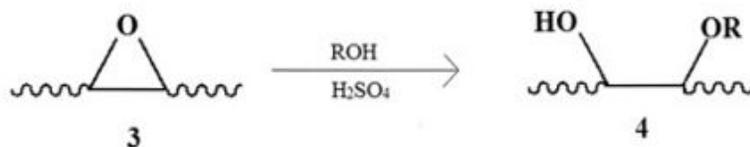
Technology has been developed for using epoxidation of certain vegetable oils rich in C=C unsaturation to convert them to epoxy and hydroxy functionalities. Chemically modified epoxidized or hydroxy-branching at the carbon chain of triglyceride improves the cold flow properties needed for bio-lubricant base stock. Ring opened product of these vegetable oils show a viscosity index of 192 at 0°C.

Low Cost Synthetic Growth Media for Microalgae with Biofuel Potential

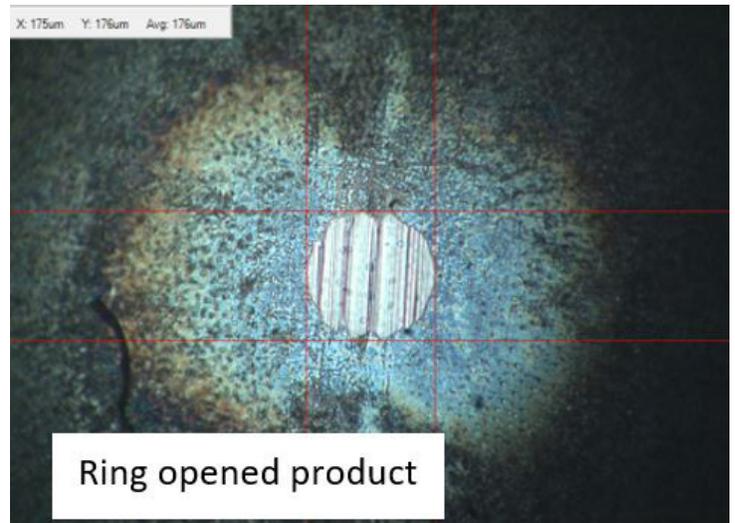
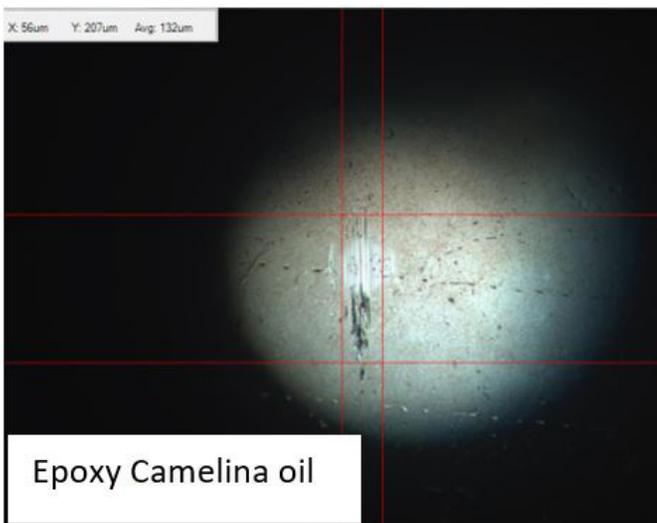
Microalgae hold tremendous potential for the development of future carbon-neutral biofuels, the major practical challenge in the commercialisation of microalgae-based bio-fuels is its economic cultivation. A simple and unique media combination has been developed for the culture of Indian freshwater microalgae with biofuel potential.



Epoxidation of triglyceride oil



Ring opened product



Wear scar diameter of epoxy Camelina oil and ring opened product

Microalgae cultivation using the low-cost synthetic media produces higher biomass coupled with higher net lipid productivity than the other reported media (Patent filed). The media is composed of Nitrogen, phosphorous, calcium and magnesium sources, and besides has been fortified with citric acid and ammonium iron citrate for commercial biomass production. The medium has been validated for induction of lipid accumulation under open and protected ponds in the produced biomass through subsequent culture on medium without nitrogen source.

The produced biomass has higher contents of saturated (15:00; 18:00; 20:00; 22:00; 24:00:00) as well as unsaturated fatty acid (16:02; 18:01; 18:02; 20:01). Besides, the medium composition is useful for the commercial production of biomass having higher chlorophyll and carotenoid contents.



Microalgae culture using novel medium combination under protected conditions at a scale of 200 lit.



Protected Pond

Open Pond

Microalgae culture with the novel medium at higher scale of culture (1000 Lit) under open and protected pond conditions.

BIO-RESOURCES FOR HUMAN HEALTH IN DIFFICULT AREAS

OPHICORDYCEPS SINENSIS: A STOREHOUSE OF USEFUL BIO-CHEMICALS

Ophiocordyceps sinensis earlier known as *Cordyceps sinensis*, popularly called Caterpillar Mushroom is a nontoxic, medicinal fungus growing at high altitude (13000 ft asl) in Himalayan hills in India, Nepal and Tibet region in China. It parasitizes Lepidopteran insect larvae *Thitarodes (Hepialus) armoricanus* Oberthuer of family Hepialidae under the soil. The grasslands below the snow line are a habitat for

Thitarodes armoricans and hence for *Ophiocordyceps sinensis*. In the higher hills of Uttarakhand, this fungus is locally known as *Yarsha Gamboo* or *Kira Ghas*. The local name *Yarsha Gamboo* is derived from the Tibetan words *Yartsa Gunbu*, meaning summer grass winter worm. It is well-known in the traditional Chinese medicine system but came to the limelight in India in the 1990s only.

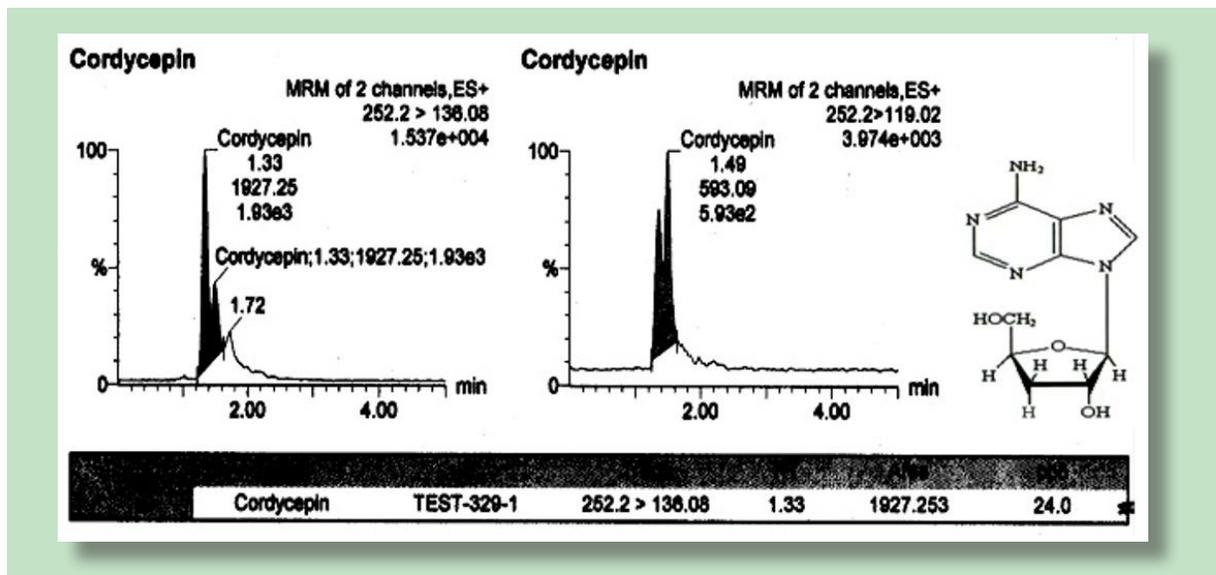
Cs and Cm. 2-Chloroadenosine was used as the internal standard for this assay. The precisions and accuracies were in the range of 1.5 % to 5.3 % and -3.5 % to 5 %, respectively. The limits of detection and quantification for nucleosides were 0.1-0.6 mg/ml and 0.5-2.0 mg/ml, respectively. The recoveries were in the range of 92 % to 107 %. With the developed method, the concentrations of nucleosides in Cs and Cm from different sources were determined. Cs, characterized with a far lower concentration of adenosine and cordycepin than Cm, can be very easy to distinguish from Cm. This reliable method would be useful for the study and quality control of *Ophiocordyceps sinensis* and its substitutes. Cordycepin, Cordycepic acid, Glutamic acid, Phenylalanine, Histine, Valine, Oxyvaline, Arginine unsaturated fatty acids like Oleic acid and Linoleic acid, Carbohydrates d-mannitol and Vitamin B12.

The most important active components in them are nucleosides. A highly selective, sensitive and accurate high-performance liquid chromatography method with photodiode array detection and mass spectrometric detection has been developed for simultaneous separation, identification and quantification of nucleosides in Cs and Cm using a mobile phase including (A) ammonium acetate (40 mM, pH 5.2) and (B) methanol with a gradient system on a 2.0 mm x 150mm Shimadzu VP-ODS column. The presence of each nucleoside in Cs and Cm was ascertained by comparison of MS data, UV spectra and retention time with standards. LC/ESI-MS in selective ion monitoring mode was used for the quantification of nucleosides in

DIBER has standardized the *in vitro* multiplication technology of this valuable fungus and transferred this technology to three industries so that the benefit of this highly medicinal fungus will reach the common man through their products in near future without interfering in its natural habitat.



Specimens of *Ophiocordyceps sinensis* (black filament like fungus) colonizing *Thitarodes armoricans* (brown coloured mummified caterpillar).



Mass spectrogram (MS) of Cordycepin, and structure of Cordycepin

IMPROVED VERSION OF ANTI-LEUCODERMA HERBAL PRODUCT (MARK-II)

Vitiligo or leucoderma is an idiopathic acquired disorder of the skin which causes pigmentary disfigurement in the skin. Patients with vitiligo develop white spots in the skin of varying sizes and locations. It is considered a social stigma in our country. DIBER has developed a herbal product for the cure of leucoderma. The technology of the product has been transferred to AIMIL Pharmaceuticals, New Delhi. The company has launched this product into the market by the trade name of LUKOSKIN. Further R&D on this product has been undertaken to enhance the efficacy of the product and to reduce recovery time and an advanced version of Lukoskin Anti-leucoderma Herbal Product Mark-II has been formulated. Taking into consideration the causes of leucoderma, drawbacks and limitations of existing remedies, a

poly component herbal formulation in the form of ointment and oral dose have been formulated by the institute. The ointment is composed of nine plants, two plants of which are rich in furano-coumarins are taken as skin sensitizer for initiation of erythema on the spots of vitiligo by the exposure to UV-A radiation. Oral dose plays a role in checking the emergence of new spots, is constituted of seven plants having furano-coumarins as main bio-molecules.

The toxicological studies of this herbal formulation have been carried out at Industrial Toxicological Research Centre (ITRC), Lucknow and DIBER Fd. Stn, Pithoragarh for acute oral toxicity, sub-acute oral toxicity, sub-chronic toxicity, Chronic toxicity, mucous membrane irritation test, skin sensitization test, etc. and found safe for human application.

The clinical trial of this herbal

formulation has been carried out on different age groups of patients with different ailment ages and extent of disease at Govt. Ayurvedic College and Hospital, Lucknow on 100 patients. The observations reveal that 52 patients have recovered completely and the rest patients showed various stages of recovery between 25 % to 75%. The clinical efficacy of this advanced version is 85-90.



Ailment age	No. of Patient	Recovery (%)				Time taken (days/months)
		Up to 24	25-49	50-74	75-100	
Female Below 40	33	1	2	8	22	120-365 days
Above 40	07	0	2	1	4	240-365 days
Male Below 40	38	4	5	9	20	120-365 days
Above 40	12	1	4	2	5	240-365 days
Patients not Responded	10	–	–	–	–	–
Total	100	6	13	20	51	120-365 days

HERBAL MEDICINAL FORMULATIONS

Amtooth

A herbal formulation for the treatment of toothache has been developed composed of ingredients from five plants. The toxicological studies of this herbal formulation for acute oral toxicity, sub-acute oral toxicity, mucous membrane irritation test, skin sensitization test, etc. have been carried out. The LD₅₀ of the product was more than 2000 mg/Kg body weight of a male rat. No significant symptoms of toxicity of the product were observed and found safe for human application.

According to the data of clinical efficacy the average effective toothache relieving time of this herbal product is 2 minutes to 10 minutes.

out and the efficacy of the product was found more than 95 %. The patients

got relief from ailment within 10 to 120 days, with no relapse of disease.



Before Treatment



After Treatment



Before Treatment



After Treatment



Before Treatment



After Treatment



Before Treatment



After Treatment

Clinical Trial on Anti-Eczema Ointment

Anti-Eczema Herbal Ointment

A poly component herbal ointment that is broad-spectrum effective, addresses all clinical features and contains ingredients of 10 plants that have been formulated. Toxicological studies indicate that the drug is safe for human application. The clinical trial of this product has been carried

Herbal Health Supplement

The herbal health supplement has been formulated from four Himalayan medicinal plants, which are a rich source of vitamins, minerals, amino acids especially essential amino acids, enzymes, glycosides, lignin, saponins, mono and polysaccharides. It has antioxidants, immuno-stimulant, memory enhancers and appetizer

properties. This herbal product is very helpful in the prevention of various body ailments, improving and maintaining good physical and mental health.

In this herbal health supplement, primary and secondary metabolites are present in ample quantities. Vitamin A, B₁, B₂, B₆, niacin, Vitamin



C and Vitamin D are present in very good quantities. Minerals like sodium, potassium, calcium, magnesium, copper, zinc, iron, manganese and cobalt are also present in this herbal formulation. It was found rich in microelements like iron, zinc and cobalt.

In the fast life of present time people having a lot of mental and physical stresses and don't have enough time to take vegetables and fruits in a balanced manner, therefore, this type of herbal health supplement has proven its significance. By consuming a little quantity of this product once or twice a day, one can fulfill daily nutritional requirements up to some extent. Apart from having rich in minerals, vitamins, protein, amino acids, carbohydrates, etc., it is an extremely effective intracellular antioxidant and free radical scavenger.

The immuno-stimulant property of this health supplement has been validated by the Department of Pharmacy, College of veterinary sciences, GB Pant Agriculture University, Pantnagar. For immuno-stimulant parameters like total erythrocyte, total leukocyte count,

erythrocytic indices, differential leucocyte count, delayed-type hypersensitivity, haemagglutination, immunoglobulin G (IgG), immunoglobulin M (IgM), total immunoglobulin and phagocytic index. The herbal health supplement was found superior in most of the above-cited immunological parameters than standard immuno-stimulant drug Levamisole. One patent on this product has been filed.

The toxicological studies of this herbal formulation have been carried out at Shriram Institute of Industrial Research, New Delhi and DIBER Fd. Stn, Pithoragarh for acute oral toxicity, sub-acute oral toxicity, sub-chronic toxicity. The LD₅₀ of this supplement is >2000mg/kg body weight. This health supplement is also free from heavy metals and found safe for human consumption.

CONSERVATION OF HIMALAYAN MEDICINAL PLANTS

Since time immemorial, Uttarakhand Himalayas has a reputation as the treasure of medicinal and aromatic flora. Nowadays, due to increasing demand and popularity of herbal products for health care as well as in cosmetics, there is tremendous pressure in the natural habitat of these plants. Himalayan Medicinal plants are getting unprecedented attention throughout the world. The occurrence of different climatic zones and soils of this region provides a very congenial climate to grow several medicinally important herbal species. But due to irregular, unscientific and over-exploitation of these herbs from their natural habitat these plants are

under severe threat of extinction. If no proper strategy for commercial-scale cultivation is formulated right now, the stage may come when almost each valuable medicinal species would be at the verge of extinction. Keeping this in view, the following attempts have been made by DIBER for the conservation of Himalayan medicinal plants.

DEVELOPMENT OF HERBAL GARDENS

By the extensive survey of Uttarakhand Himalayas, the medicinal plants were collected, identified and live herbal gardens have been developed at DIBER Field Station, Pithoragarh having 120 species and

DIBER Field Station Auli (Joshimath) with 60 species of economically and medicinally important medicinal plants. The aim of the development of an herbal garden is to conserve economically important medicinal plants in their natural habitat. The plants of the lower Himalayan region are being maintained at Pithoragarh, while high altitude medicinal flora is conserved at Field Station, Auli (Joshimath). These gardens are very useful for studying different plants' growth stages, as well as the biomass yield of medicinally active parts. The Germplasm of medicinal plants are being also provided to different NGOs and interested people for further multiplication.

AGRO-TECHNOLOGY OF ECONOMICALLY IMPORTANT MEDICINAL PLANTS

Agro-technology of twelve medicinally and economically important Himalayan medicinal plants, viz., *Artemisia annua*, *Ammi majus*, *Bergenia ligulata*, *Acorus calamus*, *Withania somnifera*, *Allium ampeloprasum*, *Saussurea coestus*, *Thymus serpyllum*, *Spilanthes acmella*, *Micromeria biflora*, *Cymbopogon citrates* and *Ocimum kilimandscharicum* have been developed. The cultivation techniques of these plants are being provided to the progressive farmers.

ESSENTIAL OIL YIELD OF IMPORTANT AROMATIC PLANTS

Thirty aromatic plants are being maintained in the herbal garden of DIBER Fd. Stn., Pithoragarh. The yield of essential oil was evaluated in different plant growth stages like before flowering stage, at the stage of flowering and after flowering stage to know the plant stage having maximum oil yield. These data are being provided to the growers of the aromatic plants.

CONSERVATION OF ENDANGERED HIMALAYAN MEDICINAL

PLANTS

Twenty-four endangered medicinal plants cited in the Red Data Book of IUCN are Ex-situ conserved in the Herbal gardens at Pithoragarh and Auli (Joshimath), for the development of their different measures of conservation. Keeping in view, the different factors responsible for the depletion of medicinal plants in Uttarakhand, The scientists of the institute are suggesting different measures of conservation to the people and generating awareness among people about this valuable herbal heritage from time to time.

BIORESOURCES FOR DOUBLING FARMERS' INCOMES

OUTREACH ACTIVITIES IN BORDER AREAS OF UTTARAKHAND

Uttarakhand is having a 650 km long international border with China and Nepal, which is manned by the army, ITBP, SSB, BRO in inaccessible climatically and geographically hostile remote locations. During winter and rainy months, land connectivity is a major issue due to remote locations, difficult terrain and frequent landslides. Seasonal and long-term migration of the local population in the border area is a major challenge for national security. According to a report published in 2016, about 1500 villages in border regions of

Uttarakhand had a population of less than ten. Primary reasons identified for migration include search for better livelihood, lesser productivity from agriculture due to changing weather and man versus wild animals conflicts.

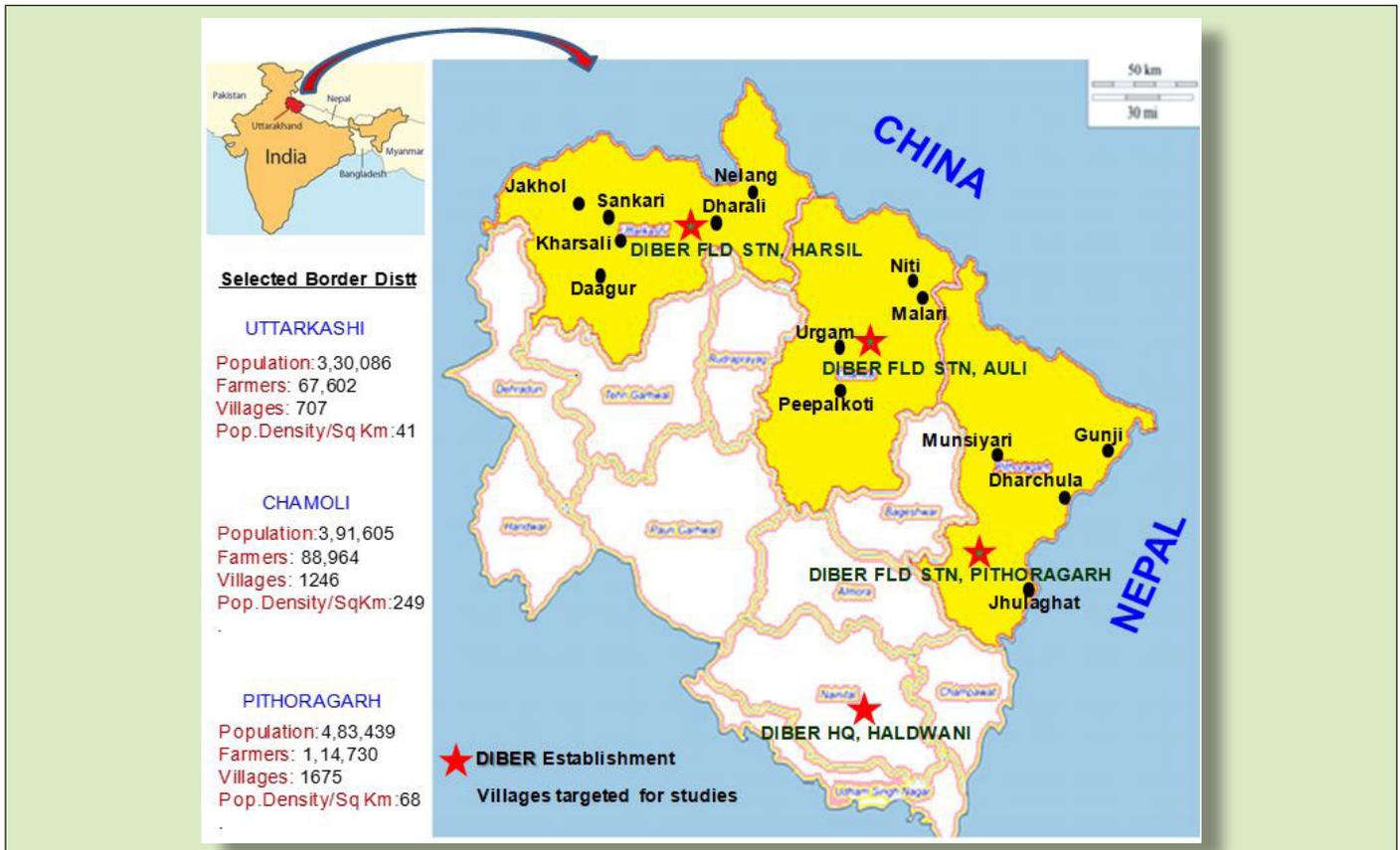
DIBER had already developed a large number of agro-animal technologies for border regions of Uttarakhand, while its existence as DARL. These mature agro-technologies (Hydroponics, Hydro-fodder, protective vegetable cultivation technologies, high-value exotic vegetable production, angora rabbit

farming, mushroom, medicinal plants cultivation, etc.) have been specialised to suit the climatic conditions of high altitude regions in Uttarakhand. The intervention of DIBER developed agro-technologies has shown great promise in increasing the farm income and livelihood opportunities for these marginal villagers. After successful completion of a pilot project with a few farmers of Pithoragarh district, DIBER has presently 1000 farmers from three districts of Uttarakhand (namely Uttarakashi, Chamoli and Pithoragarh) enrolled in an organised

campaign of doubling farmers income in border areas. Data has already been collected scientifically and assessed on user requirements which include land-use patterns, resource availability and technology

gaps. Based on this information, the potential area of intervention and impact of an intervention is being evaluated. Major steps in the outreach programme include survey and registration of farmers, training

need analysis and technology gap assessment, identification of potential and promising farmers, extending sustained support to farmers and collection of data for every crop season.



Uttarakhand districts shown in yellow colour where DIBER's outreach programme is ongoing

INCREASING FARMERS' INCOME AND NUTRITIONAL SECURITY IN BORDER AREA OF TAWANG (ARUNACHAL PRADESH)

Tawang is a strategically important district of Arunachal Pradesh state in India. It is surrounded by Tibet in the north, Bhutan in the southwest and Sella ranges separate it from West Kameng district in the east. The economy of the Tawang district is agrarian with more than 80 per cent of the population is dependent on

agriculture. Tawang is a high-altitude location with a very peculiar climate. It receives regular rainfall during the months from May to August with an annual average of 1700 mm and receives snowfall during the winter months (November to March) which makes crop cultivation very difficult. Therefore, only a few vegetables are

being grown locally in the Tawang region which includes local chili, potato, cabbage, leafy vegetables like spinach and lahi, radish and Manipuri beans, etc. Tawang is a snow-bound, land-locked area and the agriculture season is hardly 6-7 months. DRDO have undertaken a vital programme 'ARUNODAYA' to

demonstrate and disseminate the hi-tech agro-horticultural technologies in Tawang (Arunachal Pradesh) a remote location of North-East region. The laboratory has been tasked with standardisation of vegetable cultivation technology for around the year. A team of scientists and scientific staff has made untiring efforts and successfully demonstrated the year-round cultivation of vegetables in Tawang under protected conditions. Successful demonstration and standardisation of agro-technology for tomato, cucumber, bottle gourd and capsicum during March-April to July-August, and cultivation of broccoli, cabbage, cauliflower during September to March was done by DIBER. Introduction of European/

exotic vegetables such as packchoy, lettuce, celery, Chinese cabbage which adds to the cuisine of local people as well as a delicacy for tourists was also demonstrated to the local people as cash crops. Farmer field demonstration in collaboration with state agriculture department, Govt of Arunachal Pradesh was also carried out for quick transfer of modern agro-technology. These efforts have resulted in the doubling of farmers' income at villages of Audung, Ketchenga, Lemberdung and Changprong of Tawang.

The impact of the demonstrations has resulted in a remarkable increase in the production of vegetables due to the adoption of modern cultivation practices. Improvement



Exotic vegetable being demonstrated at Tawang. Local workers are being given practical training.



Snapshots of adoption of DIBER technologies for fresh food production in Tawang region

in productivity and profitability owing to the adoption of improved cultivation practices and efficient use of resources/inputs has been visible. Farmers were convinced that the agriculture sector is full of employment and income generation

opportunities provided modern technology is adopted scientifically. It is expected that many farmers will get encouraged to adopt modern vegetable cultivation after seeing the beneficial result of the demonstrations conducted in the fields of selected

farmers. Recently DRDO has adopted two villages of Tawang, i.e., Seru and Namet for the demonstration of various modern agro-technology to boost the productivity and cropping intensity in the region.

CONTRIBUTIONS TO FIGHT AGAINST COVID-19

PARTICIPATION IN NATIONAL HEALTH MISSION, UTTARAKHAND

Rigorous surveillance for COVID-19 in Uttarakhand is important as it shares a long border with China and Nepal. DIBER has responded to the call given by National Health Mission Uttarakhand for strengthening of diagnostic facilities in the state. Since March 2020, DIBER is working 24x7 with the team of VRDL, Govt. Medical College, Haldwani. All the tests are being carried out as per

SOPs of the Indian Council of Medical Research (ICMR). The most reliable gold standard diagnostic method of Nucleic Acid Amplification Test, using the Real-time Reverse Transcription Polymerase Chain Reaction (rRT-PCR) is being utilised to detect unique sequences, i.e., E-gene, RdRP gene, N gene in the swab-based Nasopharyngeal/ Oropharyngeal/ Nasal mid-turbinate/ Anterior nares/

Lower respiratory tract specimens. The operating team of VRDL and DIBER is performing for long hours in a specially recommended containment facility wearing Personal Protective Equipment (PPE). DIBER has also extended the infrastructure support by providing its calibrated functional CFX-96 RT-PCR machine and necessary peripherals to VRDL at Govt. Medical College, Haldwani.



COVID-19 facility at Govt Medical College Haldwani, fortified with instrumentation from DRDO (right); team of scientist (DIBER, DRDO) at work for detection of SARS-coV-2 in human samples (left)

TECHNOLOGY FOCUS

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MAJOR ACHIEVEMENTS UNDER DRDO ARMY BIO-DIESEL PROGRAMME

DRDO ARMY BIO-DIESEL PROGRAMME: BIO-DIESEL RECOMMENDED FOR USE IN ARMY BY HQ IDS

Under the DRDO army bio-diesel programme, DIBER has conducted rigorous bio-diesel trials in vehicles and equipment of armed forces under most demanding environmental conditions. Post completion of the trials, HQ IDS recommended Jatropha-based biodiesel (DIB JB20) for use in Army vehicles and gensets.

Requirement of a bio-diesel programme was initially projected by DDG MF in an Integrated Research Council in February 2006. It was suggested to have a collaborative project with QMG & MGO Br. DRDO-Army Bio-diesel Programme was sanctioned in June 2007 to DIBER as a nodal lab with VRDE Ahmednagar and other DRDO labs, academia and Services as partners of the programme.

MAJOR MILESTONES ACHIEVED UNDER THE PROJECT

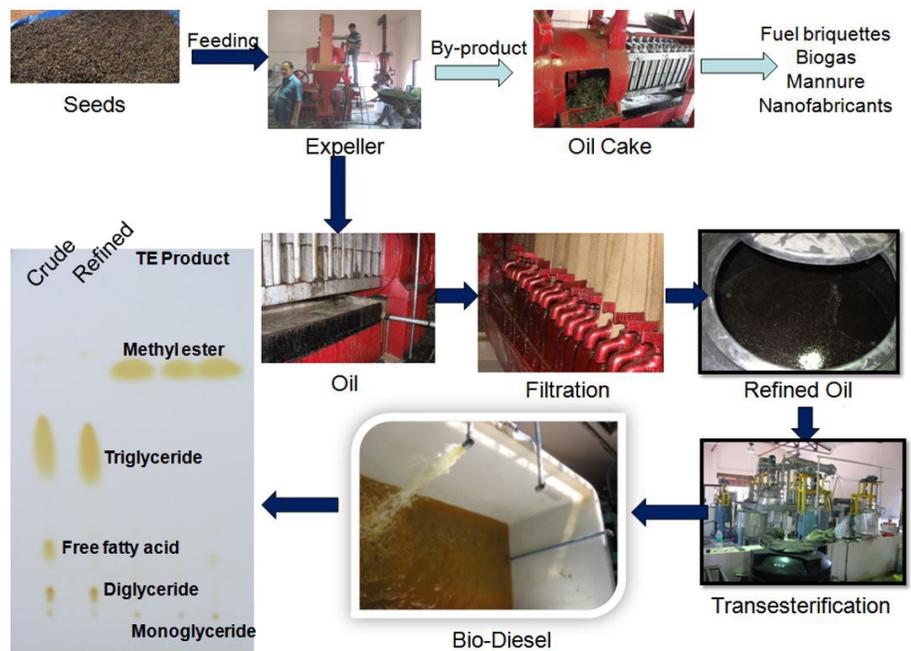
- The trans-esterification plant was installed at MF Secunderabad. The process was improved and modified to yield minimum wastes and ensure low acid value bio diesel (~0.1 mg KOH/g). The bio-diesel (B100) produced meets IS:15607 standards. No post processing is required for improving the quality of bio-diesel (Patent filed).
- A range of by-products and value added products are obtained

between fruit harvesting and transesterification including soap, glycerol, fertilizer (potassium sulfate), etc., which can be separately marketed.

- With anti-freezing agent, B100 could be stored in liquid state at temperatures up to -300°C .
- Detoxified Jatropha oil cake has been found suitable as animal feed. It can also be digested in a biomethanation tank, and the biogas produced can be channeled to meet various energy needs. The methanation sludge has been utilized as a bio-fertilizer and augmentation has been done using fungal species *Aspergillus awamori*, *Aspergillus*

nidulans, *Trichoderma viride*, *Phanerochaete chrysosporium* and bacterial species *Pseudomonas striata* and *Azotobacter chroococcum* for rapid decomposition

- Performance trial with B20, B50 and B100 were carried out at VRDE, Ahmednagar for power, specific fuel consumption, torque, CO, SC, NO_x, smoke and PM in Swaraj Mazda and BMP-II engine. The engine was found amenable for use of bio-diesel up to 20 per cent, as the performance was not affected. Decrease in hydrocarbon & carbon monoxide emission (by 4-8%), particulate matter (lesser by up to 14%) was recorded.





Test set up for Swaraj Mazda engine



Test set up for BMP-II engine

- High oil yielding cultivars (DARL-1 with 34.40% oil yield, IC NO. 569094 and DARL-2 with 36.5% oil yield, IC No. 569095) coupled with higher productivity were identified, based on the parental line performance. Achieved a grain yield $890 \text{ g} \pm \text{SE/plant}$ in IVth year.
- Biofuel parks were established in about 300 ha land distributed at MF Secunderabad, MF Mhow and MF Ahmednagar, with about 2,85,000 Jatropa plants.
- Genebanks were established at DIBER, Haldwani, GRTU, Raiwala and MF, Secunderabad.
- Standardised tissue culture protocol for true to type propagation and transferred the technology to TERI.
- Intercropping protocol was established with different location specific vegetable crops, viz., chilli,



tomato, capsicum, bean, bottle gourd, radish, fodder crops viz., maize and berseem, and fuel crop Camelina

Joint Users Trials with Indian Navy

Trials were conducted on a MT vehicle, DA set onboard Fuel Barge (yard craft), shore generator and fast interceptor crafts. The trial directives were drawn by Directorate of Marine Engineering, IHQ of MoD (Navy), and were monitored by HQ IDS. The

vehicles, equipment and operators of vehicles and equipment were provided by the host units where trials were performed, while bio-diesel (DIB JB100) and technical knowhow were provided by DIBER, DRDO. A 20 per cent blend (DIB JB20) was prepared with Low sulfur, high flash point diesel at the site of trial.

During the short term limited trials, combustion characteristics, performance and emission parameters were evaluated by the trial teams. The performance of the vehicle running on JB20 blend was found superior to performance of vehicle running on diesel. The fuel consumption of the vehicle running on DIB JB20 was found improved by 14.94 per cent, while the smoke density reduced to 19 per cent from 23 per cent. In DG set on board yard craft, specific fuel consumption of bio-diesel was



found higher by 13.89 per cent. While, specific fuel consumption of diesel was 238.3, the same was found to be 271.4 g/kW/h in case of DIB JB20. In the case of shore generator, bio-diesel consumption was found 4.99 per cent higher at maximum load. Nevertheless, emission benefits were recorded in terms of reductions in carbon monoxide (by 15 %), carbon dioxide (by 12 %) and unburnt hydrocarbon (by 50 %) levels, and increase in nitrogen oxide levels (by 4 %). Following the successful completion of these trials, IN conducted trials of bio-diesel provided by DIBER, on Fast

Interceptor Crafts (FICs), leading to the inclusion of bio-diesel powered FICs in Presidential Column during International Fleet Review (IFR) 2016, as Green Strike Force. In all, 4000 L pure bio-diesel (B100) was provided to Indian Navy for all the trials.

Notably, all the equipment, which were being used for the trials, were vintage, and post completion of trials, the trial equipment were shifted back to usage of normal diesel without any difficulty. Navy has already shown intent to use blended fuel JB-20 prepared by DIBER, DRDO in small crafts.

Joint Users Trials with Indian Army

Joint Users trials with Indian Army were carried out on Troop Carriers and DG sets circumscribing diversity of geographical locales and climatic conditions. The trials were conducted in four phases. Phase I (Technical trials) were conducted at VRDE, Ahmednagar. Phase II trials were carried out under peace and static conditions by MIRC Ahmednagar, during which vehicles were run for 8000 km on highway conditions and 2000 km in cross country. Performance of the vehicles was found

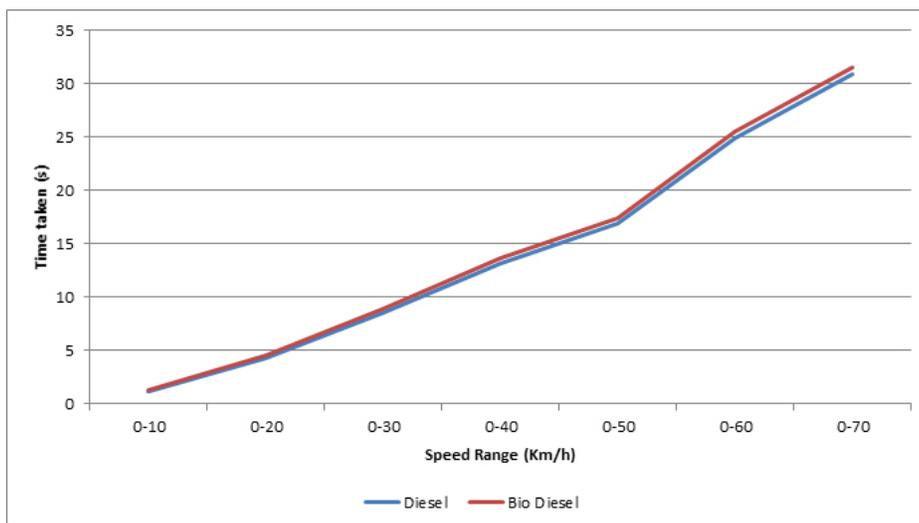


at par with each other, while emission benefits were recorded for the vehicle running on DIB JB20. During phase III trials vehicles were run for 8000 km in highway conditions and 2000 km cross country in desert conditions during peak summers with temperatures averaging about 45 °C, and at HAA during peak winters with temperatures dropping to -30 °C.

Generator sets too were run for 700 h in each of these conditions. The performance of vehicles and generator sets running on DIB JB20 were found at par with vehicles and generator sets running on normal diesel/zulu diesel. Phase IV trials were Maintainability Evaluation Trials (MET) and were run simultaneous to Phase III trials, and no additional maintenance requirement were reported for the vehicles/generator sets operating on DIB JB20.

The trials directives for all the trials with Army were drawn by MGO Br, and vehicles and generator sets too were provided by them. The vehicle and generator operators for running the vehicle/generator sets as well as engineers and technicians for maintenance were provided by the respective trial units. Bio-diesel

(DIB JB100) was provided by DIBER, DRDO and technical knowhow were provided by DIBER and VRDE, DRDO. A 20 per cent blend (DIB JB20) was prepared with DHPP(N) (or DHPP(Z) in case of high altitude trials) at the site of trial. All the trials were monitored by HQ IDS.



Performance of vehicles running on Diesel and Bio-diesel during Phase I Technical Trials was found comparative to each other. In the present graph, acceleration recorded by each of Diesel and bio-diesel powered vehicle is indicated

