Biodiesel Conference Towards Energy Independence – Focus on *Jatropha*

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Contents

Quality Planting Material

Land Availability

Production Practices

Extraction and Transesterification

Linkages

BIOFUEL POLICY

Preface

'Energy Independence' is one of the vital areas to make India a developed nation. Among different types of energy sources bio-energy through plant/animal route has to play a great role as the end of fossil fuel age has already began. Among the bio-energy, plant route is considered very promising because of its renewable nature. Plants yielding oil are considered suitable for production of bio-fuel particularly biodiesel. Because of heavy requirement of edible oil, non-edible oil yielding plants are considered ideal for Indian condition for production of biodiesel. Planners and scientists in this context have rightly focused on non-edible oil yielding plant/tree/bush, *Jatropha curcus*, the Physic nut.

The programme on *Jatropha* plantation, processing etc was taken up in almost in all the states but there seems to be hurdles in production and processing etc. at every stage being a new venture with a new crop.

In above context, this biodiesel conference has been convened by The President of India to have first hand information from framers, processors, Govt. and private agencies. The deliberations are expected to address some of the hurdles.

In organization of the conference help and assistance have been taken from different agencies, such as Ministry of Agriculture, Ministry of Rural Development, Ministry of Forest and Environment, Dr. Kureel, Director NOVOD Board, Dr. Panjab Singh, VC, BHU and others. We are thankful for their assistance and constructive suggestions. We are also thankful to all the contributors and participants who at a very short notice have submitted manuscript and agreed to attend the conference.

We shall be failing in our duty if we do not put on record the guidance and assistance provided by the President's Secretariat, Rashtrapati Bhavan particularly by Shri P.M. Nair, Secretary to the President; Shri A.K. Mangotra, Joint Secretary to the President; Shri Satish Mathur, Director A&E; Smt. Rasika Chaubey, IFA; Shri S. M. Khan, Press Secretary, Shri Barun Mitra, Director, CA–I and CA–II and Shri Nitin Wakankar, Dy. Press Secretary. We acknowledge the untiring efforts made by Dr. A.L. Moorthy, Director, DESIDOC; Shri S.B. Gupta, Scientist, DRDO HQrs; and Shri A. Saravanan, Scientist, DESIDOC for their help in editing, designing and producing this publication in a very short time.

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06.06.2006

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Purpose of the Conference

His Excellency, The President of India, Dr. A.P.J. Abdul Kalam, Distinguished Participants to the Conference, Media Persons, Organizers, Ladies and Gentlemen, on behalf of the President's Secretariat and on my own behalf it is my proud privilege to welcome you all to the two days conference on **"Biodiesel Conference : Towards Energy Independence – Focus : *Jatropha*"** at Rashtrapati Nilayam, Bolaram, Hyderabad. Hope you are reasonably comfortable.

This Rashtrapati Nilayam was built in 1896 which was taken over from the Nizam of Hyderabad after India attained Independence. Like Rashtrapati Bhavan, New Delhi, this Nilayam is also the soul of the Country and belongs to the General Public of the great nation, the India/ The Bharat.

The aim of the Conference is to achieve "Energy Independence or Energy Self Reliance or Self Sufficiency". As you all know fossil fuel, one of the major contributors to energy is not only expensive but is going to be not available shortly because of its finite quantity. The alternatives to it, being attempted are many separately for petrol, diesel, electricity etc. Diesel through bio (plant of animal) route is one of the most promising and strong renewable alternatives. Mr. Rudolf Diesel developed first engine to run on peanut biodiesel. *Jatropha*/Ratanjyot/Physic Nut is considered to hold promise to be major contributor because of its several favourable characteristics. Of late *Jatropha* has not only been projected to hold promise for biodiesel but also solve host of other national problems like utilization of waste/barren/forest land, rural employment, carbon credit, availability of bio fertilizers etc. At present public and private sectors are promoting *Jatropha* production, processing and marketing.

But desired/proportionate results are not visible. All the players in the *Jatropha* production, oil extraction, esterification, marketing and other associated ventures don't seem to be very comfortable. Some of them have started making sound; others are quietly trying to correct if something has been found missing at some stage. This concern and discomfort about *Jatropha* venture for biodiesel/biofuels has reached the President's House. There are complaints and concern by farmers and others. The President's House being an advocator of *Jatropha* as potential tree to yield biodiesel at commercial scale, felt very concerned. Someone out of you have mentioned that remarkable progress in *Jatropha* venture has been made inspite of your hands, legs and eyes being tied down. The purpose of this Conference therefore is to create a feeling of your hands, legs and eyes unshackled. His Excellency, The President of India, Dr. A.P.J. Abdul Kalam, who is present with you all here, was pleased to convene this conference involving all concerned (farmers, industries, scientists, govt. agencies, automobiles industries etc.) at Rashtrapati Nilayam, Hyderabad to take stock of the present position and deliberate corrective measures to boost up steps towards achieving the goal of energy independence. The importance of the Conference can hardly be over emphasized. The President himself is present and would participate in the deliberations.

Ratanjyot/Jatropha curcas is a plant, which has come in prominence in India in past couple of years. Earlier forest and agriculture scientists were researching it upon in a routine manner. *Jatropha* was mainly known in India among herbalists for its several medicinal properties. This is a unique plant owned/disowned by everyone in Agriculture, Rural Development, Forest and Environment, Petroleum Non-Conventional Energy, Panchayati Raj and Finance Ministries. It is not a food, fodder, forest, fiber but a fuel crop. On fuel crops in our country there are very few research institutes. With the result improved/high yielding varieties of *Jatropha* for different regions in the country are not available. Region specific agro technology packages for *Jatropha* cultivation are not ready. Elite planting material, nurseries/certified seeds etc. are not there. Extraction and esterification of oil from *Jatropha* seed have lot many hassles. Continuous biodiesel production unit and technology perhaps are not available in the country. *Jatropha* seeds shelf life, continuous supply of seeds for extraction and esterification throughout the year seems to be a problem. Price of seed offered to the farmers and diesel price to the industrialists do not seem to be based on authentic input/output data. There are several other gaps in the venture requiring immediate attention. In view of above and other prevailing *Jatropha* biofuels scenario this conference at the highest level in the country is very timely, in the expectation of overcoming obstacles faced in *Jatropha* biofuel promotion. Since it is “The President, Public and Private Participation Conference” its outcome is definitely expected to be a step forward towards achieving energy independence.

Now I request His Excellency The President of India, Dr. A.P.J. Abdul Kalam, to address the Conference.

FARMERS' EXPERIENCE

Farmers' Observations : Maharashtra

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Since you are all well aware about the subject of *Jatropha* and the alarming oil situation, therefore I will not be repetitive. Instead I will tell you a story of sheer grit and determination. It is our own story about the remarkable progress we made in cultivation of *Jatropha* in spite of our hands, legs and eyes being tied down.

I wish to make a disclosure here that I'm neither a technocrat nor an academic. I'm a simple farmer who has given three invaluable years of my life in growing and researching *Jatropha* and today I'm here to share my experiences with you now that we've already grown *Jatropha* on 300 acres with drip irrigation and with immediate expansion plans of growing by leaps and bounds.

We at Noble Explochem Ltd are actually manufacturers of explosives and specialty chemicals and we are in possession of 1500 acres of land near Wardha, which is required as a safety buffer zone. Three years ago after the new management took over this company we started utilizing our valuable land resource by commencing Horticulture activities. One thing led to another and we chanced upon *Jatropha*, which was then totally unknown. Even then we had a strong gut feel about *Jatropha* and we started working steadily on it.

Although we have now covered 300 acres with *Jatropha* under drip irrigation I want to inform this august gathering that our path was filled with thorns but we overcame each time and I want to present you with the ground realities.

- During the last three years I have visited almost every known Institution supposed to be working on biofuels. Since my knowledge was then zero I was eager for some opening on the subject. However every visit of mine was a let down. I saw a complete decay in people and the Institutions. Beyond back patting and self-promotion there was complete emptiness everywhere.

  Realizing that we were left to fend for ourself, we started from A B C D and slowly but surely we did a wonderful job. However it involved three years of hard labour, involvement and investment. And today we possess a valuable data bank alongwith elite plant varieties.

- Secondly, the profitability of *Jatropha* cultivation was in question. In absence of availability of authentic data and judging by observation and enquiries it was clear that cultivation of *Jatropha* <u>singularly</u> was not a very attractive proposition. Further, our investment in costly drip systems was further ballooning the project cost.

  Intercultivation was the answer. We investigated tirelessly over the years to develop a intercropping model of different but complementary crops tolerant to each other and as result of which today we have a successful formula of four different crops standing simultaneously thus making *Jatropha* farming a very attractive farming proposition with – short term – medium term and long term gains.

- Once our goal was set we pushed ourselves with dedication however there were many questions, which were nagging us continuously.

  a) Subsidy support was one important issue. We were disappointed to learn that subsidy comes with an upper limit. Nobody has correlated that if we are to achieve enough biodiesel production for just 5% blending with fossil diesel, even then we require plantations on millions of acres which will not be possible without the entry of big Corporates. Therefore we need to think big. It is time that our subsidy agencies rewrite the rule books by saying that subsidy will be available subject to a minimum of so many acres.

b) We were equally disturbed with the absence of a clear-cut policy on biofuels. Till date there is darkness in areas related to – licensing, taxation, excise, etc. Even the recently announced support price of Rs 25/- per litre is a joke as the cost of production is definitely more than the support price.

   Even in spite of these nagging uncertainties we marched on as we continue to believe in biofuel and we know that reason will prevail ultimately.

- Then came the question of economy of scale. Long ago we realized that for Biofuels to be successful, large-scale plantations were necessary and we worked on several models to achieve this. But we were in for a rude shock each and every time.

1. We thought of Contract farming options and we tied up with the leading Bank of our country to bring all round prosperity and energy Independence to our country. However that was not to be. In spite of investing huge amounts of money and time in readying farmers through awareness programmes, in spite of developing teams of people fanned out in several districts encompassing more than 25,000 acres, in spite of everything that we did, the whole structure came tumbling down.

A few months ago we were taken totally unaware when we rudely received the new parameters by the Bankers. The new parameters had been unilaterally reworked upon by enthusiastic and impractical babus and which was so impractical and so unworkable that in a single stroke of madness the entire hopes and hard work put in by thousands of people ground to a complete halt.

2. Then we had the brilliant idea of taking leased forestlands for cultivating *Jatropha*. After spending months in various Government offices we finally managed to reach the top brass who after much convincing agreed to favour us with allotment of lands. But then, there was a catch – even though the investment was totally to be ours, however we were not entitled to the harvest.

We were shell-shocked. I could not believe that in this age we are still governed by such impractical rules and thought process.

3. Simultaneously we had begun our quest of buying large tracts of land to achieve economies of scale. This time we were confident that nothing could go wrong. Thus armed with money we started the land hunt.

However once again we were in for a complete shock. Our country's rules do not allow large land holdings in order to "protect the interests of the poor". How on earth are we protecting the poor with his land lying barren? In fact the farmer will benefit by selling his land to a stronger entity with resources to pool large land holdings with proper systems. Not only will the farmer get immediate returns but will also benefit on continuous basis with gainful employment for his entire family. Benefits to our country and to ecology are further gains. How can India hope to be a super power when we are still stuck up with self-defeating rules? Hasn't anybody learnt the lesson of successful farming from their numerous foreign visits? We are repeatedly taught in school that small land holdings are the curse of Indian agriculture. Why can't we be courageous and practical in action? On the contrary our Government must make every attempt to ensure that barren lands are utilized immediately.

It is more frustrating when small countries like Israel without natural blessings have converted themselves into lush green paradises. Whereas our country, which is blessed with one of the most favorable, and most bio-diversified systems continues to rank at the bottom most in agriculture production. It is not that people of other countries are superior as I observed first hand in Israel. It is simply that our prehistoric rules and bureaucracy restrict every growth.

While on the same subject I wish to point out that land ceiling exemptions have been granted to coffee and tea plantations however no similar thought has been given to the economics of *Jatropha* cultivation. I am afraid if immediate rectifications in laws are not made then the biofuel dream of India is destined to remain a dream.

However we refuse to give up so easily in our quest for economy of scale. We are determined to grow and we are now exploring others norms of controlling land holdings.

Your Excellency, I want you to know that your periodic support for *Jatropha* has been a great succor for me in times of crisis, which have been many. When you addressed our Nation on 14th August 2005 by stating that *"by 2020 the nation should achieve comprehensive energy security and by 2030 energy independence through solar power and other forms of renewable energy, courtesy large scale energy plantations like Jatropha,"* I am sure you must have inspired many more to venture into unchartered territory.

However it is very important to understand how many can sustain apathy and indifference? Why are things made so difficult when they could be simple? Why does the system enjoy harassment? I am sure many of you are burning with similar questions.

Sir, my humble suggestion to you is that if we are to allow biofuels to see light of the day then a *Jatropha* Board must be immediately formed and which must be manned by achievers from private and government sectors and be empowered with extra judiciary authority to ensure single window clearances. From chaos we must create order.

The Government's job must only be to provide a clear-cut policy based on bold changes and decisions and then to leave it to the people of India who are amongst the most resourceful in the world. Once allowed to function "we the people" can bring in the biofuel revolution so urgently required by our country. And if this happens then I can assure you that very soon *India will be farming biofuels instead of digging for it.*

The *Jatropha* Experience : Andhra Pradesh

Naageshwar Sharma
Secretary-General, The Panacea

1. Introduction

Through the vast researches conducted for over a decade under the aegis of the National Oil Seeds and Vegetable Oils Development Board (NOVOD Bd.), Ministry of Agriculture, Government of India and on the basis of a wide consultation process involving a cross section of the society comprising Automobile manufacturers, Botanists, Agronomists, Foresters, Petroleum Technologists, farmers, NGOs etc. *Jatropha curcas* has been adjudged the most suitable Tree Borne Oil (TBO) Seed for production of Biodiesel on a large scale under Indian conditions.

By virtue of being a member of the Euphorbiaceae family, *Jatropha* has a high adaptability for thriving under a wide range of physiographic and climatic conditions. It is found to grow in all most all parts of the country up to an elevation 3000 feet. However frosty weather prevented it from flowering.

Though categorized as a TBO, it is a perennial shrub, growing vertically and occupying limited space. The gestation period is so short that some of the saplings, especially those raised from shoot cuttings, start flowering even at the nursery stage.

The special advantages of *Jatropha* as a source of biodiesel are:

- It is suitable for all soils including the degraded and barren lands
- It has a short gestation period of two years.
- It is a perennial occupying limited space and as such suitable for intercropping

- It can be grown as a fence around existing plantations and crops with the dual benefits of protection as well as yielding perennial income.
- It helps soil to retain moisture and creates a lush green ambience to hither to barren ambience.
- It has multiple uses: the oil cake left behind can be used as organic manure and the pods after removal of seed can substitute for fire wood as a cooking fuel, thereby conserving trees. The residual oil left in the cake, when dispersed in water can be a good bio-pesticide for orchards and vegetable gardens.
- Raising *Jatropha* plantations and their maintenance, harvesting of seed, its transportation, and storage and crushing for oil creates jobs for the rural poor and the landless.

2. The Panacea and Its Mission

The Panacea, a NGO working on sustainable developmental alternatives for the past one decade has adapted "Operation Biodiesel" as its mission to spread awareness on cultivation of *Jatropha* among the public general and land owners in particular with the goal of achieving cent percent coverage of all barren patches of land colonized by *Jatropha*.

Accordingly, as a first step, a *Jatropha* Demonstration farm and Nursery was established at Anandapuram village of Visakhapatnam district with financial support of NOVOD Board Govt. of India in the year 2004.

I shall place before you some of our experiences based on the studies under taken at the farm.

3. Nursery Raising

Initially, we resorted to stem cutting method of vegetative propagation by procuring a few thousands of 6-inch long twigs from naturally growing *Jatropha* curcas from the forests of Narsipatnam. Sprouting was late (after ten days) with percentage of sprouted shoots as low as 30% in the nursery beds and 40% in polyethylene bags. The shoots developed adventitious root system and took a long time to consolidate. However, some of the sprouted shoots flowered with in six months.

Then, I picked up some seed from *Jatropha* shrubs being grown as a hedge by the tribals of Arunachal Pradesh, during one of my visits to the North East and raised seedlings in poly-bags. The germination percentage was as high as 80%. But, the growth of saplings was found to be slow taking as much as four months to harden.

Finally, seeds have been dibbled in well-prepared seedbeds under shade with a spacing of 2 inches and profusely watered for a week. This sample gave us almost 100% germination. The saplings grew fast and endured transference to poly bags with in a month.

Accordingly, we found the dibbling method to be the most effective for raising nursery stock.

But the seeds when preserved lost their fecundity with passage of time. Freshly harvested seed is found to be most suitable for nursery raising.

4. Transplantation

Four to six month old saplings have been transplanted in one foot deep and one foot wide pits filled with farmyard manure under four modules viz., hedge, intercropping, agroforestry and block plantation.

4.1 Hedge module

Six month hardened saplings have been planted all around the farm at a spacing of 1 metre in the month of June ahead of the onset of monsoon. The transplanted saplings have been watered manually on alternate days for a fortnight by which time monsoon had set-in giving intermittent showers over a period of two months.

Most of the saplings got consolidated and put up new sprouts by the end of the monsoon. However when monsoon has ended and watering has been discontinued growth has been slow down. During the months November-December *Jatropha* plants left unirrigated had shed leaves with the green elongated stems remaining dormant along with a terminal bed. As a member of the *Euphorbiaceae* family, it is a natural way of adapting to drought conditions for this species.

None of the plants under this module flowered even at the end of 2nd year.

4.2 Inter cropping

We have raised vegetables and flowers in separate beds under irrigated condition by lifting subsoil water with the help of an energized bore well. Shallow irrigation channels have been created between two rows of flowerbeds. Each bed with 4 rose plants/Zinnia, interspersed with a *Jatropha* at the centre, when irrigated, all the flower plants as well as *Jatropha* got flooded, with no special efforts required for the irrigating *Jatropha* in particular.

Alternately, *Jatropha* was planted at a spacing of 3 metres between the rows and 2 metres between the plants allowing enough space for inter-cultivation and ploughing activities connected with raising of vegetables/flowers/pulses according to local preferences.

Thus, *Jatropha* has been treated as the main long-term crop providing for rotation with seasonal crops.

Watering was done once a week or as required by the seasonal crops. The *Jatropha*s registered luxurious growth with profuse branching in the first year. By March next year, flowering started with pod formation by the month of May.

Second flowering had set in by November and pods formed by January.

4.3 Agro-forestry

Under this module, *Jatropha* has been raised in the irrigation channels meant for sending water into vegetable and flower crops. The plants absorbed water during brief periods when water passed through the channels and registered good growth at par with the flooded plants under the earlier module.

Jatropha, being a bush growing vertically rather than horizontally, did not interfere with the growth of regular crops.

Except for the farmyard manure mixed with soil for bagging and nursery bed preparation, no other fertilizer doses have been applied for *Jatropha* cultivation at this demonstration centre. Yet, plant growth has been found to be good, as long as periodical irrigation was provided.

5. Block Plantation

A small plot was chosen as a control and *Jatropha*s planted with spacing of one metre between the plants and rows as well, during the rainy season. The saplings, which registered a growth of half-a–metre by August/September were left to fend for themselves with out further watering.

The project area being located in an arid zone, rainfall was very sparse and growth of the saplings was found to be stunted with out regular irrigation. By November/December instead of flowering, leaf shedding was noticed with the stems remaining dormant.

6. Growth Pattern

Branching started after one-foot height in most of the irrigated plants, while the un-irrigated plots under block plantation method took longer time to start branching. However, those under the hedge module produced elongated stems with out branches.

Under irrigated conditions it has attained height of 1 metre in the 1st year and went bushy by the second season, reaching a height up to 2 metres. Inflorescences started appearing in dozens of lateral meristems

Flowering started in the 2nd year during the month of March. Pods produced in clusters of 3–6 had become dry by mid May.

Harvesting of dry pods started in the 3rd week of May and went on up to end of July. Seeds separated and preserved in dry tins. Each bush produced from 70 to 100 pods in the second year, which increased up to 150 in the 3rd year.

7. Suggestions

Since, diesel constitutes 50% of petroleum products consumed in India. Currently diesel is the lifeblood for public transportation in urban as well as rural areas. But now, with the concept of globalisation and modernisation picking up with the rural masses also energizing pump sets for lifting subsoil water and tractors for cultivation along with power generating sets in remote rural areas also add to the demand for diesel.

Jatropha holds immense potential in supplying the raw material for production of Biodiesel to meet the fuel requirements of the entire rural tracts of India, in addition to containing the automobile exhausts in urban areas as per our obligations under the Kyoto-protocol.

As such it is imperative that *Jatropha* plantations are created in vast areas through people's participation rather than governmental fiat.

A few lakh of hectares under *Jatropha* in each district is a pre-condition for production of Biodiesel. This can only be achieved through non-governmental efforts at motivating bulk of the rural populations on one hand and making available robust seedlings at the doorstep of rural folk.

On the part of Government, instead of centralised subsidies, micro-credit may be provided through NGOs, Cooperative and Grameen Banks at a nominal interest under the supervision of NABARD.

It is considered desirable that *Jatropha* cultivation be popularized among house owners, real estate owners, educational institutions, industry and commerce along with government organizations by utilizing all available spaces.

8. Modus Operandi

Since the cost of plantation has been tentatively worked out @ Rs. 30,000 per ha. by the Planning Commission, micro-credit up to Rs. 25 lakh may be made available to KVKs and Agro-based NGOs like the panacea to promote *Jatropha* cultivation on a time bound schedule.

To this end, the panacea has already taken up "*Jatropha growing on a mission mode*" through taking the art and science of Jatropha to the doorstep of people.

The *Jatropha* Hype: Promise and Performance

Dr. V. Ranga Rao
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Jatropha which until recently, a less known and neglected plant like its other tree borne oil yielding counterparts has overnight become the star center of attraction - thanks for the recommendations of planning commission's special committee on biofuels and the spree of ambitious plans unleashed by various State as well as Central Governments for its large scale promotion and development and the exciting business opportunities they opened to agri-entrepreneurs. The result — mushrooming of a plethora of Biodiesel processors, scientists' and farmer turned seedsmen, self appointed consultants with promise of incredible yields (10-12 t/ha or more at crops peak bearing phase) and income (of Rs.1 to 1.5 lacs/ha/year in some cases) often backed up by irresistible temptations (*Jatropha* – a Kalpataru/a Bhagyarekha/Panacea) leading to country-wide euphoria in the crop right from small to large farmers irrespective of their specific agro ecological and crop growing situations. This is obvious from the spate of calls ETV's regional network of channels received through *Annadata's* toll free helpline. What is more, a number of over enthusiastic farmers even took up *Jatropha* in their agricultural fields often under high input conditions and in preference to their traditional crops. The paper in question highlights the wide gaps that exist between the current hype and the actual field realities at ground level based on ETV Annadata's extensive video recordings of already established plantations shot from a wide array of soils (i.e. rich and poor), growing situations (scanty and assured moisture; high and low inputs), production systems (block plantations and as a component of agro forestry systems), plantations (i.e. research farms, farmers fields and those of NGO's and seed companies) spread over different states right from Kanyakumari in the South to Haryana in the North on one hand and Costal Andhra in the East to Gujarat in the West on the other.

Quite contrary to the widely publicized claims, none of the plantations of 3 years or more videographed exhibited either the kind of productivity levels promised or the fruiting potentials (i.e., bunch number and size etc) expected of plants capable of yielding one kg/year under the system of block plantations. Far from the reported bumper yields, extension of *Jatropha* into situations which are totally alien to it namely fertile soils with favorable moisture and input regime only led to very luxuriant and unproductive vegetative growth. What is more, the crop turned out to be as vulnerable as any other crop to insect pests and diseases (eg. collar rot, bark eater, defoliators, powdery mildew, leaf spots, termites, leaf minor etc.,) once it is removed from its original habitat and put under high density and intensive cropping system. If results so far available from either the latest field trials of some research centers/institutes (viz., CRIDA-Hyderabad, GAU-Dantiwada, Dr. PDKV-Akola) and private companies (eg. Tree Oils Limited, Hyderabad) as well as the earlier experiences of a large number of Maharastra farmers with massive field plantations - courtesy Nashik Agro Forestry and Waste Land Development Foundation, the average yields from the currently available planting materials in drylands are unlikely to exceed 400 kgs per/ac/year (or = 1 t/ha/yr).

Judging from these and conspicuous absence of any authentic data base, the current hype and euphoria naturally traces back to international reports of 5-10 t/ha/yr based on extrapolation of yields from per meter length of hedge grows in countries like Cape *varde and Nicaragua (Central America); Zimbabwe (South Africa), Mali (West Africa)* and the resultant publications viz "*Oil Gloom to Oil Boom – Jatropha*" of

Mr.Vinayakrao Patil (Maharashtra Agro Forestry and Wasteland Development Foundation) of early 90's and its republished version "*Jatropha*" of Indian Council Forestry Research and Education (ICFRE), Deharadun as well as "*Jatropha*" of Directorate of Oil Seeds Research, Hyderabad. Interestingly, the original authors of both the above publications have either denied of any database of their own or drastically toned down their earlier figures through issue of revised publication "*Jatropha – 2003*" (i.e., Mr.Vinayakrao Patil, Nashik).

The situation is no better with respect to availability of superior planting materials, production systems and matching agro production techniques for harnessing the crops full productivity potentials under varied situations. Barring publicity krieg, no proven, farm-worthy and promising varieties with either high oil content of 40-48% (actual average seed oil content = or <30%) and/or superior response to inputs and management could be noticed any where in the country. Equally lacking are any valid and reproducible information on either *Jatropha* culture and management in sole and intercropping situations or its scope in various production systems, their feasibility and relative economics, etc., Whatever recommendations are currently available from various governmental and non governmental agencies in the country are on the basis of experiences from similar other situations/species rather than any specific experimental testing of their own.

Notwithstanding the reported versatility of *Jatropha* owing to its short gestation period, excellent re-generation capability, long productive life, adaptability to fragile and harsh environments etc., any such plans for large scale commercialization are unlikely to succeed without back up of appropriate and relevant region and situation specific planting materials and agro production techniques. In the light of these and the limitations associated with the available non descript genetic materials and half baked and assembled technologies/informations, any indiscriminate and hasty expansion of *Jatropha* into all conceivable agro ecological and crop growing situations may cause irreparable damage to an otherwise “Golden Goose” and harm the immense opportunities it otherwise offers in the long run. This therefore, calls for a strategic shifts in priorities and direction with appropriate short/medium (viz. exploitation of wider basket of Biodiesel species, besides *Jatropha*; concentration of all current promotional and developmental efforts to waste, underutilized and barren lands) and long term (eg. intensification of breeding programmes for total restructuring of the available plant types into more input responsive, biologically efficient and high oil forms with a very favourable male-female sex ratio as in case of its closely related family member namely castor, development of viable technologies for production of ethanol from alternate sources such as leftover straw/cellulose materials, other than current sugarcane and sweet sorghum routes) if the country is to achieve the much elusive energy self reliance in the crucial sector devoid of the associated environmental penalties and resource crunch from fossil fuels and emerge as the world’s major green power. Given the rich wealth of oil yielding plant species, the country is endowed with vast stretches of waste, barren and underutilized lands and the opportunities it offers for year round cultivation, the above dream is certainly not an impossible task.

Brief Profile of Dr. V. Ranga Rao

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A Post Graduate in Agriculture (B.Sc. 'Ag.' 1963, M.Sc. 'Ag.' 1965 and Ph.D – from IARI, 1968) with specialization in genetics and plant breeding; Hails from a rural agricultural family background in Andhra Pradesh. For over more than 3 and a half decades actively engaged in a widely diverse and highly challenging areas of productive R and D viz. dryland research and development including on-farm researchers (=10 years), National Oil Seeds R and D (=10 years), Agricultural Print and electronic media (= 6 years) involving Governmental (more than 20 years) and non Governmental (=13 years) as well as corporate sector (ITC). Also held key managerial positions/responsibilities at National level (Co-ordinator as well as Director, Oil Seeds Research ICAR) as well as corporate sector (head seed business, ITC and Chief, agricultural, educational print and electronic media); Also widely travelled both within and outside the country in different capacities, both National and International assignments.

Jatrapha Cultivation in Punjab

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1. Introduction

The ever increasing demand of diesel and continuous rise in prices has forced us to search for ecologically sustainable alternative energy source. In this search biodiesel from vegetable oil has emerged as a viable alternative, particularly non-edible vegetable oil from *Jatropha*.

My talk is focused on prevailing situation in the farm sector in Punjab and how the Punjabi farmer is affected. The MSP the farmers get for their produce is not increasing at the same rate as the cost of inputs is increasing. Therefore, there is financial gap which leads to debt trap and resultant suicides. Now how to cover this gap one simple method is to keep increasing MSP to off set the increase in input cost ,this is not possible for Govt for different reasons, the other way out is to help the farmer to reduce the cost of inputs and thus generate additional income indirectly to cover the gap. This I feel is a viable solution.

It is a well known fact that the density of farm machinery specially the Tractors, Gen sets and harvesters is the highest in Punjab and all this machinery operates on diesel. Therefore if we can provide biodiesel to the farmers and give them the capability to produce their requirement of diesel in their own farms we would have indirectly provided them the ability to reduce input cost and also achieve energy security and freed them from market pressure of frequent rises in diesel prices.

At the National level also the domestic production only covers 22% of the total demand the rest is imported which is a heavy drain on our foreign exchange which if saved can be effectively utilized for development schemes.

Therefore, in biodiesel the country has a ray of hope and especially Punjabi Farmers who need the Biodiesel the most to run their farm operations.

2. Situation in Punjab

At present cultivation in Punjab has not found favor with the farmers due to lack of awareness and lack of support from the state Govt. This situation needs to be corrected.

2.1 Own efforts

I will briefly touch upon my individual effort. I belong to a farming family who has traditionally served in the army for generations and also carried on farming, I after retirement got into farming apart from traditional farming I got into diversification to arrest financial gap which I had mentioned earlier. I introduced Turmeric farming as commercial crop and setup processing plant where the produce is processed and marketed I buy the crop from the farmers and save them of problem of processing and marketing this venture is proving a success. Similarly I have undertaken *Jatropha* cultivation on my farm now I have setup oil extraction unit and Trans- Estrification plant to prepare better quality Biodiesel for my own requirement and also to demonstrate to the farmers and motivate them to adopt *Jatropha* cultivation. A little success has been achieved but lot needs to be done which is only possible if the Govt steps in which has bigger resources.

2.2 Viability

Now coming back to another important aspect how viable is biodiesel visa-vise petro diesel. It is only viable if the seed price is around Rs. 5-6 per Kg but it is not so in Punjab whereas it may be in other States. Therefore there is requirement of providing help by the Govt to stabilize the procurement price till the production of seed increases.

To ensure farmers in Punjab do not use fertile land for bloc cultivation of *Jatropha* they can plant *Jatropha* on the periphery of the fields which will provide good hedge and income similarly the Panchayat waste land in the village can be used for plantation which will provide additional income to the village Panchayat, similarly waste forest can be used for plantation this will generate employment for plantation, collection of seeds and running of extraction plants,

It is not possible for each farmer to setup oil extraction and purification plant therefore such facility should be setup at Block HQ level.

3. Recommendations

It evident that Production of Biodiesel in Punjab is the only hope of farmers to generate additional income but at present the State Govt has not given the required support that it needs. Therefore my suggestions are –

- Punjab Govt should be asked to promote cultivation of *Jatropha* as National requirement.
- Central Govt should extend all schemes that being implemented in other states on *Jatropha* to include Punjab
- Financial help or grants be provided to setup processing facility.
- Make available latest technology and know-how

- Provide subsidy on seed procurement to stabilize the price.
- Provide subsidy to farmers for *Jatropha* cultivation.
- Agriculture Dept at State level should be made the nodal agency to implement the schemes as the have the necessary infrastructure down to village level,
- There should be tax free inter state movement of seeds and biodiesel

4. Conclusion

In the end it is worth mentioning that to day it is hard to find any negative point about Bio-fuels, they are green and farmer friendly, Govt's desire to reduce import dependency has a good cause to provide necessary support to farmers to adopt *Jatropha* cultivation for biodiesel production.

I feel honored that I have been given an opportunity to put across my views on *Jatropha* cultivation in Punjab .I hope necessary help will be forthcoming from the centre to give boost to the project in Punjab.

Farmers' Observations : Tamil Nadu

Rakesh Gupta

Director, Sadhna TV Channel and Sadhna Bio-oils Pvt. Ltd.

I introduce myself as Rakesh Gupta, Promoter and Managing Director of Sadhna TV Channel. I am also a promoter of Sadhna Bio-oils Pvt. Ltd, which has invested in *Jatropha* plantations on a large scale. We have already cultivated thousands of acres of land in southern India with *Jatropha* and endeavor to constantly invest more and more for the purpose.

We learnt from the NOVOD board and others in the society that *Jatropha* is a drought resistant wonder plant that can survive well in marginal or poor soils also. India has millions of acres of wasteland throughout the country and we plan to cultivate *Jatropha* extensively on such unused lands for achievement of the company's goals.

We started Sadhna Bio-oils with specific goals in mind. During one of our visits to Madurai, we realized that thousands of farmers commit suicide every year as their crops get destroyed due to draught and lack of proper irrigation. Moreover these farmers are heavily burdened under debt that they take to purchase seeds, fertilizers, pesticides etc. for cultivation. And their inability to payback these loans and incapability to sustain their families, forces them to take such drastic steps.

This dreaded situation motivated us come up with a solution that can help my fellow citizens live with pride. Since *Jatropha* grows on lands that are not irrigated well, it is a boon for these farmers. It is our company's main goal to guide them and providing them with a new world of opportunities by growing *Jatropha*. This will help these small farmers in sustaining their families with self-esteem.

Large-scale *Jatropha* plantations are also going to generate big employment opportunities for the labor class. These sites offer jobs at various steps like sowing, planting, irrigating, weeding, monitoring etc. And since these tasks are not temporary, but ongoing, they provide long term jobs opportunities. This way Sadhna is achieving the goal of empowering the poorer sections of the society and helping them live happily as well. This also helps in preventing the rural people, especially the younger generations from migrating to cities in search of employment and over crowding them.

Converting waste and barren lands to *Jatropha* sites has multiple benefits to the environment as well. On one hand it converts green house gasses to Oxygen as they grow and on the other hand, the use of seed oil as bio diesel significantly lowers harmful emissions. Carbon monoxide emissions can be reduced by up to 50% and particulate emissions by up to 30%. Biodiesel is virtually free of sulfur and does not contribute to acid rain. The release of unburned aromatics in the air is also significantly reduced. According to a research conducted by the United States Department of Energy and United States Department of Agriculture, this overall impact can reduce CO2 emissions by up to 78%. This settles our company's commitment that it has made to Mother Nature.

On the economic front, the Growth of this plant helps my country in self-sustenance. With more and more plantations coming up in the country, more and more diesel will be produced in-house putting less burden on the already constraint Government Budget and foreign exchange imbalances. Currently, India fulfils the oil needs by importing 73% of the total requirement. In the year 2005-06, we imported oil worth US $ 43 billions from abroad. With increase in number of plantation sites and increase in use of bio –diesel, this figure can be limited from increasing and in times to come, it may even decrease. Likewise, we can say that "*Ab Tail Kharhi se Nahin Jharhi Se Ayega*" that is, (now oil will not come from gulf, but from bushes i.e. *Jatropha*)

Even as an entrepreneur, *Jatropha* plantations are a big success. According to financial estimates, by investing just Rs. 15,000/- in 1 acre of land, one can expect to earn about Rs. 25000/- per annum starting from 3rd year and up to 40 years with negligible further expenses. Having large scale Plantations also helps companies earn carbon credits or Certified Emission Reduction Certificates commonly known as CERs that can be converted in cash from various Green-House-Gas emitting organizations worldwide under the Kyoto Protocol. One earns about 8 CERs from just 1 acre of *Jatropha* plantation that can be sold internationally gaining additional valuable foreign exchange for the country.

This means that on one hand, we are doing a service to the nation and on the other; we are making profit out of it as well. It is a win-win situation for all.

But, as everyone knows that seeing-is-believing, we are also waiting to see the real results of *Jatropha* Plantation. So far, large-scale *Jatropha* plantations have been undertaken merely 2 to 3 years ago only. This means that the real results of the plantation in terms of actual crop, oil extraction, bio diesel productions etc. are yet to be seen. Especially, actual costs and selling prices will be big factors in determining the real growth of this sector.

We, at Sadhna, have identified and experienced few obstacles in growth of this sector that we expect our government to remove. One faces difficulties in procuring the seeds for growing *Jatropha* and whatever one gets, is not of a good quality. The germination ratio is far below expectation. We face this problem, as there is no central body to check and certify the quality of seeds. We request the government to take steps to setup a central body of agronomists that will make available the quality seeds with respect to their oil content, moisture content, germination ratio etc. With these important facts in hand, people will be able to choose the appropriate material as per their requirement.

The second problem that we face is related to land. The land is not available in bulk. The farmers, who sell their lands, have it in smaller sizes. If we are to setup a site with 1000 acres, we have to deal with and buy land from more than 200 farmers. This is a big problem. Also, many times, their sites are scattered and hinder our economies of large scale. As an example, for every scattered land, we are forced to reinvest in irrigation systems and bore wells. Also, we have to pay heavy charges for stamp duty at the time of purchase of land, which, in my opinion, should be abolished if land purchase is for *Jatropha* cultivation. This will help boost large investments in the sector by corporate houses.

The 3rd problem is that the banks also refuse to give loan for purchase of land for *Jatropha* cultivation. The support from the banks is very critical as small farmers rely on banks to start a plantation. If these farmers are not supported by the banks, then, they are forced to take money from private moneylenders at much higher interest rates that range from 20% to 30% thereby putting additional burden on them. We request the government to make necessary provisions and direct the banks to provide financial support for purchase of land for *Jatropha* cultivation.

The 4th problem that we face is of subsidy provided on land purchase for *Jatropha* cultivation. Currently, 30% subsidy is provided if land is purchased for *Jatropha* cultivation, but with limit of up to rupees six and a half lakh only. This means, a person investing in 1000 acres of land will get equal subsidy to someone investing in just 200 acres of land. I believe that this limit should be abolished to encourage large corporate houses in entering this field.

The 5th problem that we face is of expert know-how. Though our country is blessed with millions of farmers, we still don’t have expert agronomists available that we can hire or take guidance from. We are forced to adopt the hit and trial practice only that yield low results. With the help of experts, more output can be gained from the existing sites only without putting more land under cultivation thereby increasing the profit per acre ratio. This will induce more and more investments in this field.

And last but not the least, we can foresee problem in selling the final product to end customer i.e. selling bio diesel to oil marketing companies like Indian Oil, Bharat Petroleum Corporation Limited etc. As per the Bio Diesel Purchase policy released by Ministry of Petroleum and Natural Gas on October 9 2005, the purchase price was fixed at Rs. 25/- per liters. This is far below the prevailing cost price of bio diesel production; forget about making profit out of it. Even in the international market, the prevailing prices of biodiesel are much higher than Rs. 25/- per liters. The petroleum diesel is currently being sold in the Indian market at a loss that is being borne by the oil marketing companies. The purchase price of petroleum diesel is much higher than Rs. 35/- per liters. According to me, the purchase prices of biodiesel should not be fixed and should be allowed to increase and decrease with market fluctuations with a minimum cover price to support small farmer's interest.

We request and expect the government to help in growth of the *Jatropha* plantation by resolving all these matters. With support from the government, many entrepreneurs like me will further invest in the plantation sites thereby giving a big boost to the expansion and investment in this sector.

Honorable President Sir! We have a good team of enthusiastic and efficient experts who are already visiting villages and campaigning for *Jatropha* plantation among poor farmers. We are also providing seedlings/ seeds for the benefits of the farmers at our actual cost price. Our nurseries are ready near Madurai and we are also ready to start plantation on

10,000 acres of land. We have above 1 crore seedlings at our nursery. We request you to kindly bless us for the overall success of our project. We started this project only because of your motivation and inspiration for *Jatropha* Plantation.

Biodiesel through *Jatropha* Curcas A Critical Analysis

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1. Preamble:

Biodiesel is an eco-friendly, alternative fuel prepared from renewable resources i.e. vegetable oil (edible or non edible) and animal fat. These natural oil and fat is made of triglycerides. The triglycerides when treated have striking similarly to petroleum-derived diesel and are called “Biodiesel”. As India is already deficit in edible oil requirement, non-edible oil may be material of choice for producing biodiesel. For this purpose *Jatropha curcas* considered as most potential source. Biodiesel is produced by transesterification of oil obtains from the plant.

Jatropha curcas has been identified by planning commission’s Task Force as the most suitable Tree Borne Oil (TBO) seed plant for production of biodiesel both in view of the non-edible oil available from it and its presence throughout the country. The capacity of *Jatropha curcas* to rehabilitate degraded or dry lands, from which the poor mostly derive their sustenance, by improving water retention capacity, makes it additionally suitable for up-gradation of land resources. With the agricultural correlation *Jatropha curcas* is seen as the solution for pollution. It is a non-toxic, 100% natural, bio degradable supplement for diesel, excited by the possibility of its wide-scale use in transport, electrical equipment and other machines that runs on diesel.

CBMD is an organization, which is promoting the Biodiesel issue since its inception; to provide technical knowledge to the stakeholders (like scientists, farmers, students, Entrepreneurs etc.) by organizing need based conferences, seminars, workshops and training programs. We have also partnered in plantation of the *Jatropha curcas* by farming, across the country. The tests on these plants revealed their significance on growth; yield, disease resistance, dormancy etc. in these areas. CBMD's plantations span in different agro climatic zones, comprising the Chhattisgarh Plain Zone, Arid Western Plain Zone, Malwa Plateau Zone and Southern area in the country. On the basis of these programs, trainings and plantations team of experts conducted **SWOT-** analysis.

2. SWOT Analysis

(i) Strength

Biodiesel

- It is a Renewable energy source.
- It Balances Carbon dioxide in Environment.
- Lesser polluted emissions than fossil fuel.
- The fuel Production Technology (Extraction and transesterification process) is Simple and Proven Technology in Indian Conditions.
- It is a non-edible oil source
- It's a perennial crop having 30 years long life span.
- High oil content in seeds comparatively other TBO varieties.
- *Jatropha* curcas plant is disease resistant plant.
- It is not sensitive to climatic change.

- It can be grown in arid area.
- Due to dormancy character, Survives in Various weather conditions.
- Plant leafs and deoiled cake can be used as organic manure.

(ii) Weakness

- Lack of good quality seeds and planting material.
- Wild behavior
- Most of the information's are assumptions.
- Non-availability of Genuine and Authentic Data And Information
- No tried and tested cultivation experiences.
- Variable output
- Variable oil content
- Long gestation period of crop.
- No model available for effective use of by-products
- Having Vegetative Propagation Properties removal from Farm is difficult
- No Commercial output available with out ample Farming Inputs.
- No economic viability for mono crop.

(iii) Opportunity

- Ever increasing Crude oil price.
- Employment generation capacity in Rural areas
- Better utilization of cultivable waste land
- Low gestation period comparative to other non-edible oil sources
- Having carbon credit value (Kyoto protocol)
- Required in large quantity to sustain huge demand.
- With use of Biotechnology encouraging primary results.

(iv) Threat

- Over publicity
- Abundance of misleading information

- Mall practice in input materials
- Costly Input materials.
- Low (NO) support price for seeds.
- No sustainable Procurement Mechanism available in the Market.
- Requirement of seeds in large quantity even to fulfill demand of 5% blending with diesel.

3. Conclusion

CBMD has arrived to following conclusion through experiments with our partners in last more than four years. As a substitute for fast depleting fossil fuel Bio diesel had come to study in future. It should also serve to reduce and maintain the price of fuel. As the constraint described under SWOT Analysis our country has good opportunity to produce Bio diesel and save the foreign exchange. *Jatropha* can help to increase Rural Employment and Income. It will also provides us self-sustainability and help us in alleviation of poverty from rural areas. *Jatropha* is suitable for cultivable wasteland by which can retain soil fertility of fallow lands. Scientific methodology should be developed to achieve economic viability for cultivators (Farmers) by addressing cultivation myths like sustainable yield, water requirement, Input material etc.

- The experiments carried over through out the country are few in numbers and varied. Hence may not be enough to reach any substantial Conclusion. However *Jatropha* plantation is not advisable High yielding cultivable land to Marginal farmers.
- The sustained and commercially viable production of oil seeds and diesel, there after in large volume is yet to be tested.
- Higher level of research is required for sustained and regular out put from *Jatropha* plants.
- Commercial viability of *Jatropha* plantation can be attained through proper mix of intercropping with the *Jatropha* plants.

- The behavior of *Jatropha* plants is varied in different agro climatic Zones as well as regions across the country. Hence it shall be daring to give monotonous verdict in favour of *Jatropha*. At some places its production was very good but some regions its growth and yield were not satisfactory.
- Use of other non-edible oil source shall be experimented for bio diesel production like Pongamia (Karanj), mahua, ber etc,
- With effective use of Biotechnology, problems related to seeds, yield and oil content could be addressed.
- Fulfilling demand of 5% blending may not be possible in immediate future.
- *Jatropha* cultivation and bio diesel production should be looked upon as a tool for fulfilling Energy need for a village.

4. Road Ahead for Policy in *Jatropha* Curcas:

Biodiesel has distinct advantage as an automotive fuel. Initial cost may be higher, but by using of intercropping techniques and other multi-level production technologies will play a critical role in reduction in production cost and making the fuel economically viable. The following points may be considered for its development in India.

- Pilot projects and R&D work on Biodiesel needs to be encouraged and supported to establish techno–economic viability of large-scale production.
- Establishment of production and processing specification, with test methods.
- Govt. should provide energy education on biodiesel program, related information, and database for with authentic information dissemination among the stakeholders.
- Scientific organizations should determine standard relationship between inputs and yield in different climatic, environmental and social situation.

- Bio-technological interventions for development of good quality of planting materials should be encouraged.
- Govt. should establish a dedicated agency for consolidated efforts in promotion and development of bio diesel with adequate authority and funding.
- This agency should develop various services and schemes for technological and financial availability for *Jatropha* plantation and biodiesel projects.
- Need for establishing scientific procurement mechanism.
- Model for fulfilling village energy needs through *Jatropha* plantation and biodiesel production shall be experimented at some places through Panchayatraj institutions.
- Govt. should include collection of non-edible oil seeds in various schemes such as *Grameen Rozgar Yojana*.
- *Jatropha* plantation and seed collection in various forest regions should be encouraged by ministry of Forest.

Biofuel Park at Rashtrapati Bhavan, New Delhi

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Rashtrapati Bhavan Estate at Raisina Hill, New Delhi covers 384 acres of land. The first home of the country, The Rashtrapati Bhavan, formerly Viceroy's House architected by Sir Edwin Lutyens has several gardens and parks such as well known Mughal Garden, Spiritual Garden, Nutrition Garden, Herbal Garden, Tactile Garden, Cactus Garden, Musical Garden, Bio-diversity Park and Biofuel Park.

The Biofuel Park started on 4th September 2004 when Dr. A.P.J. Abdul Kalam, The President of India planted first *Jatropha* sapling (Pant Nagar Selection) in 2200 Sq.m. Subsequently TNNC-20, 19, 4, 5 and 7 strains from Tamil Nadu Agriculture University (TMAU), Coimbatore were planted. In addition to *Jatropha* other oil yielding tree species such as neem, karanj, castor, mahua have been planted to observe the yield potentials of these tree species under Delhi condition. The main purpose of having Biofuel Park at Rashtrapati Bhavan is to create awareness among the farmers and others about the non-edible oil yielding tree species and motivate them to undertake plantation of these biofuel plant species. Besides, visiting dignitaries from the country and abroad also see Indian efforts towards achieving Energy Independence. His Excellency, The President of Sri Lanka evinced keen interest in *Jatropha* cultivation and spent time in this Biofuel Park last year.

The *Jatropha* planted on 4th September 2004 under irrigated condition on a reasonably good soil has exhibited very good vegetative growth leading to flowering within a year and subsequent fruiting. The flowering was continuous from July 2005 to November 2005. Plants flowered in July and August could only develop fruit/seed, in rest there was no fruit set. The observation recorded are given in Table 1

Table 1 : Observation on Physic Nut *(Jatropha curcas)* Plantation at Rashtrapati Bhavan

Item	**Observation**
Area	2200 Sq.m
Plant Spacing	2x2 m
Variety	Pantnagar Selection
Propagation	Though Two Months Old Rooted Cuttings (2-2½ ft Height)
Number of Plants	550
Date of Transplanting	04 September 2004
Inter Crops	(a) Isabgol (Psyllum ovata (b) Ashwagandha (Withania somenifera)
Irrigation	In Furrows Flooding (Twice in a month in Summer and Once in a month in Winter)
1st Pruning	14 October 2004
2nd Pruning	10 March 2005
Flowering	August 2005 onwards
Fruiting	September 2005
Harvesting	November – December 2005
No. of Seeds/Capsule	1-3 (Average 2)
1000 Seeds Weight	555 gm
Yield per plant (Selected 10 plants, All Plants did not yield but most of them flowered during Nov-Dec 05)	Range 375 to 430 gm (Average 398 gm)
Total Yield	40 Kg (182 Kg/ha)
Oil Content	27% (NBRI)

Fruiting Plant

Seed

Jatropha at Rashtrapati Bhavan

The observations recorded above have number of queries. But the most prominent disturbing observation was that *Jatropha* strains at Rashtrapati Bhavan could not tolerate low temperature (0.2°C on 8th January 2006). The stems/branches dried up in most of the plants. Heavy pruning was necessitated (otherwise not recommended). This indicates that the plant cannot tolerate very low temperature even the short exposure, which are common under Delhi conditions. This may be due to tender stage of the plants (one year old).

The effect of this damage on yield would be visible this year. However this experiment so far has indicated that under irrigated condition if rooted cuttings are used as propagating material, *Jatropha* can start yielding same year under Delhi condition. In the first year inter cropping with pulses, medicinal plants etc in *Jatropha* field is possible. At Rashtrapati Bhavan Psyllum (Isabgol) Aswagandha were taken as inter crops. Both the crops performed well. The oil yield through ordinary crushing was 27%.

The improved cultures/varieties developed in TNAU have exhibited good vegetative growth. We hope these cultures to flower in the second year of planting (seed sowing)

It seems *Jatropha* under irrigated conditions, with standard package of practices using elite planting material (clones of high yielding hybrids) under Delhi condition can be a commercial crop keeping in view the rising petroleum prices.

STATUS OF *JATROPHA*

Prospects and Potential of *Jatropha Curcas* for Biodiesel Production

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1. Introduction

India's energy challenge is particularly daunting today. Oil prices have remained above US $60 per barrel for some time now. Oil and gas imports cost the country is more than Rs 150,000 crore (Rs 1,500 billion) annually. India imports about 73 % of total consumption of 124 million tonnes (MT) of crude and petroleum products. Given that our consumption of energy will only increase and that India has only about 700 million tonnes of economic reserves of crude left (enough oil for 22 years of production at the current level and six years of current consumption!). Oil provides energy for 95% of transport and the demand of transport fuel continues to rise.

As per Planning Commission estimates, the requirement of petrol is expected to grow from approximately 7 million tonnes in 2001-2012 to more 10 million tonnes in 2006-07 and 12.5 million tonnes in 2011-2012. Similarly, the demand for diesel is likely to touch the level of about 52 million tonnes in 2006-07 and 66 million tonnes in 2011-2012. Contrary to the demand situation, the domestic supply is in position to cater to only about 22% of the total demand. Therefore, attempt needs to be made to reduce dependence on imports and seek better alternatives. Biofuels are the best alternatives and the country has a ray of hope for the same. Biofuels are renewable and coming from biological raw material. Biofuels –ethanol and Biodiesel both are gaining worldwide acceptance as a solution to energy crises.

High Speed Diesel (HSD) is the main transport fuel in India, hence introduction of biodiesel both as a diesel substitute and for blending with petroleum diesel is an imperative need. Mainly, biodiesel is being produced by the crops like sunflower. Soybean and mustard oil etc. in many parts of the world. As the nation is facing a shortage of edible oils, it would not be feasible to produce Biodiesel by edible oils. However, the country has enormous potential to produce tree borne oilseeds for Biodiesel production to cope with the demand of about 40% diesel requirement from total crude oil. *Jatropha* among the potential tree borne oilseeds is one of the alternatives. The country has a vast area of wasteland spread over

Approximately 40.00 million hectares of land spread out in 23 states and Union Territories, which have been identified as potential areas for *Jatropha curcas* plantation. According to climatic conditions and potentiality for plantations, 23 states have been selected covering about 40 million hectares for *Jatropha* plantation.

2. Kinds of Wasteland

The *Jatropha* crops have been recommended for cultivation in the wasteland so that the cultivated lands may not be diverted for *Jatropha* crop. *Jatropha* being the drought tolerant and hardy crop, it can be grown under various kinds of wasteland, however, being the oil yielding plant, it also needs the fertile soil for its cultivation and regular bearing of fruits with desired oil content. Though, the plant can survive in the stress condition, however, it will not give economical yield. The initial findings reveals that the soil should have atleast 1.5 to 2 ft. depth and the minimum annual rainfall should be 600 mm. Though, the various kind of wasteland are available in the country, however, some wastelands such as gullied and ravenous, up-land with or without scrub, degraded land under plantation, pastures, grazing, mining industrial wasteland, hill slopes, fallow land, railway tracks, canal, field boundary and community land etc. are found suitable for *Jatropha* cultivation. On the basis of above criteria, following land have been identified for *Jatropha* cultivation in different states as hereunder:-

State-wise distribution of Wasteland suitable for *Jatropha* cultivation

Sr. No.	States	Potential Area for *Jatropha* cultivation (Lakh ha.)
1.	Andhra Pradesh	43.96
2.	Arunachal Pradesh	9.97
3.	Assam	14.56
4.	Bihar/Jharkhand	18.60
5.	Goa	0.40
6.	Gujarat	28.71
7.	Haryana	2.62
8.	Karnataka	17.89
9.	Kerala	1.00
10.	Madhya Pradesh/Chhattisgarh	66.20
11.	Maharashtra	48.55
12.	Manipur	12.62
13.	Meghalaya	9.37
14.	Mizoram	4.07
15.	Nagaland	8.40
16.	Orissa	18.88
17.	Punjab	1.06
18.	Rajasthan	56.88
19.	Sikkim	2.13

20.	Tamil Nadu	17.95
21.	Tripura	1.28
22.	Uttar Pradesh/Uttranchal	12.14
23.	West Bengal	2.58
	Grand Total	**400.37**

3. Merits of *Jatropha* for Biodiesel Production

The Tree Borne Oilseeds namely Jatropha *(Jatropha curcas)*, *Karanja (Pongamia pinnata)*, *Jojoba (Simmondsia chinensis)*, Neem *(Azadirachta indica)* etc. have potential to grow in categorized wasteland. These TBOs posses 20-60% oil content in seeds, which are non-edible and can be utilized as source of Biodiesel production. *Jatropha* is one of the best alternative of energy plantation due to its following characteristics:

- It can be grown in areas of low rainfall (600 mm per year) and in problematic soils. In high rainfall and irrigated areas too it can be grown with much higher yields.
- *Jatropha* is easy to establish, grows relatively quickly and is hardy.
- *Jatropha* lends itself to plantation with advantage on lands developed on watershed basis and on low fertility marginal, degraded, fallow, waste and other lands such as along the canals, roads, railway tracks, on borders of farmers' fields as a boundary fence or live hedge in the arid/semi-arid areas and even on alkaline soils. As such it can be used to reclaim waste lands in the forests and outside.
- *Jatropha* is not browsed by animals.
- Being rich in nitrogen, the seed cake is an excellent source of organic manure.
- One hectare of *Jatropha* plantation will produce 3 to 4 MT seed.

- Gestation period is two years
- Various parts of the plant have medicinal value, its bark contains tannin, the flowers attract bees and thus the plant has honey production potential.
- Like all trees, *Jatropha* removes carbon from the atmosphere, stores it in the woody tissues and assists in the build up of soil carbon. It is thus environment friendly.
- *Jatropha* can be established from seed, seedlings and vegetatively from cuttings. Use of branch cutting for propagation is easy and results in rapid growth;
- The bush can be expected to start bearing fruit within two years and in some cases after one year of planting.
- The plant is undemanding in soil type and does not require tillage.
- It can meet a number of objectives such as meeting domestic needs of energy services including cooking and lighting; as an additional source of household income and employment through markets for fuel, fertilizer, animal feed, medicine, and industrial raw material for soap, cosmetics, etc. in creating environmental benefits – protection of crops or pasture lands, or as a hedge for erosion control, or as a windbreak and a source of organic manure.

Although ability to control land degradation and oil production are the most important environmental uses of *Jatropha*, its products provide numerous other benefits that would additionally improve the living conditions of the rural people and offer greater income opportunities through enhanced rural employment. For instance, the *Jatropha* oil can be used for soap production and cosmetics production in rural areas and all parts of the plant have traditional medicinal uses (both human and veterinary purposes) that are being scientifically investigated.

The oil is a strong purgative, widely used as an antiseptic for cough, skin diseases, and as a pain reliever from rheumatism. *Jatropha* latex can heal wounds and also has anti-microbial properties. *Jatropha* oil has been used commercially as a raw material for soap manufacture for decades, both by large and small industrial producers.

The oil cake cannot be directly used as animal feed because of the presence of toxic compounds, but it is valuable as organic manure having nitrogen content comparable to chicken manure and castor seed cake. *Jatropha* oil cake is rich in nitrogen (3.2%), phosphorous (1.4%) and potassium (1.2%).

4. *Jatropha* Oil as an Alternative to Diesel

In the present scenario, the appropriate answer to the current oil crisis is to explore the possibility of substitution of diesel with an alternative fuel, which can be produced on a massive scale for commercial utilization. The non-edible oil of *Jatropha* has requisite potential of providing a promising and commercially viable alternative to diesel as it has the desired physio-chemical and performance characteristic comparable to petro-diesel. *Jatropha* oil has higher cetone number (51) compared to other oils, which is comparable to diesel (46 to 50) and makes it an ideal alternative fuel and requires no modification in the engine.

The initial flash point of *Jatropha* oil is 100^0C as compared to 50^0C in case of diesel. In view of higher flashpoint, it has advantage over petro-diesel such as more safety during storage, handling and transport. However, higher flash point may create initial starting problem in the engine. Similarly, higher viscosity of *Jatropha* oil could pose the problem of smooth flow of oil in fuel supply pipe and nozzle. These problems/ difficulties can easily be overcome by esterification of *Jatropha* oil, which is a very effective way of overcoming high viscosity and smoke emissions of vegetable oil by forming their ethyl/methyl esters.

5. Status of *Jatropha* cultivation

The country has enormous potential of oilseeds of tree origin like oil palm, mahua, neem, simarouba, karanja, ratanjyot, jojoba, cheura, kokum, wild apricot, bhikal, wild walnut, kusum, tung etc. which can be grown and established in the wasteland and varied agro-climatic conditions. These have domestic and industrial utility like agriculture, cosmetic, pharmaceutical, diesel and substitute, cocoa-butter substitute etc. Most of these TBOs are scattered in forest and non-forest areas and hardly 20% of the existing potential is being crushed and utilized that too of poor quality due to lack of awareness of their uses, collection and marketing etc.

Among the various Tree Borne Oilseeds, *Jatropha curcas* has been found more suitable for biodiesel production on the basis of various characters. The cultivation of *Jatropha* is possible under stress condition and the oil of these species having various characters is more suitable for biodiesel production. To explore the potential of Tree Borne Oilseeds species including *Jatropha curcas*. Board has initiated a Central Sector Scheme with following objectives:

5.1 Objectives

The Board has been entrusted with the nodal responsibility for integrated development of tree borne oilseeds with focus on generation of rural employment through exploitation of existing potential and augmenting the future potential. The brief objectives of the scheme for the implementation during 10th plan are given below :

- Improve the quality of seeds of TBO collected by unemployed women and tribal by augmenting handling through creation of appropriate infrastructure.

- Promote the plantation of potential TBOs in wasteland through augmentation of superior planting material, production technologies and handling system.
- Develop and refine the technologies for improved productivity, quality, value addition etc by assisting capable institutions to take such programmes.
- Create awareness through training, seminar, workshop, publication and publicity etc. among farmers and primary processing industries for improved agronomic practices and new technologies.
- Generateincome and employment opportunities for small and marginal farmers and other weaker sections of society, particularly those living below poverty line and women folk etc.

To achieve the above objectives, the Central Sector Scheme 'Integrated Development of Tree Borne Oilseeds" includes following programmes:-

6. Programmes

- Research and development programmes
- Establishment of TBOs gardens
- Back-ended credit linked subsidy programme
- Back-ended direct subsidy programme
- Model plantation with superior planting material
- Creation of pre-processing and processing facilities
- Establishment of seed procurement and oil expelling centre
- Development of pilot trans-esterification unit
- Transfer of technology

6.1 R&D Programmes

It has been observed that the productivity of *Jatropha* curcas is not much economically beneficial to the farmers due to lesser productivity and non-availability of package of practices. It becomes necessary to make countrywide efforts to enhance the productivity and development of location specific package of practices. To address the various researchable issues, a National network on *Jatropha* has been initiated by the Board during 2003-04 with following major objectives:-

- Selection of superior planting material
- Standardization of propagation techniques – Micro and Macro propagation
- Standardizing agro-techniques
- Establishment of model plantations
- Tree improvement
- Detoxification of seed meal
- Development of pre-processing and processing equipments
- Imparting training to the farmers

The above researchable issues were identified by a team of Scientists from various institutions like ICAR, CSIR, ICFRE, State Agricultural Universities, Ministry of Agriculture, NOVOD Board, IIT etc. The project was launched during 2004-05 in 35 institutions covering 23 states of the country. The consolidated summary of research findings are as hereunder:-

6.1.1 *Survey and collection of superior planting material (seeds/ cutting) from different agro-climatic zones*

This research component was assigned to all participating institutes for collection of superior planting material on the basis of physical traits from potential areas.The identified promising CPTs will serve as parent material for further multiplication. During 2005-06 approximately 726

Candidate Plus Trees (CPT) of *Jatropha* curcas in 18 instututes have been identified as detailed hereunder :-

Sl. No.	**Name of Research Institute**	**No. of CPTs/Seed source identified (2004-05)**	**No. of CPTs/Seed source identified (2005-06)**
1.	CSFER, Allahabad	7	22
2.	MPKV, Rahuri	23	53
3.	UAS, Dharwad*	-	64
4.	ICAR,R.C.NEH, Nagaland	-	11
5.	ICAR,R.C.NEH, Tripura	-	8
6.	SFRI, Jabalpur	382	50
7.	TFRI, Jabalpur	150	25
8.	PDKV, Akola	22	29
9.	SDAU, S.K. Nagar, Gujarat	21	50
10.	NRCAF, Jhansi	77	88
11.	PAU, Ludhiana	40	40
12.	MPUAandT, Udaipur	-	50
13.	CSAUAandT, Kanpur	9	9
14.	CCS,HAU, Bawal	24	50
15.	CSK, H.P.K.V, Palampur (2005)	-	54
16.	BCKV, Nadia, W.B.(2005)	-	25
17.	GBPUAandT, Pantnagar	24	64
18.	SKUAandT, Jammu	23	34
19.	CRIDA, Hyderabad	57	55
20.	IGKV, Raipur	31	40
21.	FCRI, TNAU,Mettupalayam	22	-
	Total	912	821

6.1.2 Progeny Trial

The progeny trial of identified CPTs are required to be conducted to evaluate the adaptability of accessions in particular locations for better growth and development. Each institution was assigned to raise 10000 seedlings and plants in 4 ha. areas. The progeny trials have been organized in 19 institutions summarized as hereunder :

Sl. No.	**Name of Research Institute**	**Raising of seedlings**	**Establishment of progeny trial**
1	CSFER, Allahabad	Raised in nursery	August-2005 2 X 2 meter
2	MPKV, Rahuri	Raised 10000 seedlings in nursery	Trial with 37 entries during August-2005 3 X 3 meter
3	RAU, Sikar	–	Established during August-2005
4	ICAR,R.C.NEH, Nagaland	Seedlings raised in nursery.	Trial with 20 progenies
5	ICAR, R.C.NEH, Tripura	Seedlings raised in polybags.	Established the trial with 2 X 2 meter
6	ICAR,R.C.NEH, Meghalaya	-	Established the trial
7	SFRI, Jabalpur	Raised in nursery and mist chamber	July-2005
8	TFRI, Jabalpur	Raised 8000 seedlings in nursery	Trial with 20 progenies during August-2005, 1200 plants with 3 X 3 meter
9	PDKV, Akola	Seedlings will be raised during March-April, 2006.	The proposed plan for 2006-07 is yet to be finalized.

10	SDAU,S.K.Nagar, Gujarat	Seedlings raised during 2004	Established during July 2005 with 20 genotypes with 3 X 3 meter
11	NRCF, Jhansi	10000 seedlings (4 ha.)	-
12	MPUAandT, Udaipur	10000 seedlings (4 ha.)	Established during 2004 with 20 genotypes
13	CCS,HAU, Bawal	-	Trial with 20 entries during 27 July-2005 3 X 3 meter
14	CSK, H.P.K.V. Palampur.(2005)	20000 seedlings	Trial with 20 entries during 50 genotypes 3 X 3 meter
15	BCKV, Nadia, W.B.(2005)	5000 seedlings	Establishment of progeny trails will be done during July, 2006.
16	NAU,Navsari, Gujarat .(2005)	-	Progeny trial established with 22 accessions.
17	RAU, Bikaner, Rajasthan.(2005)	Trial started on July, 2005.	Growth data recorded upto November, 2005. The plants were completely damaged due to frost during January, 2006.
18	GBPUAandT, Pantnagar	Seedlings raised.	Established with 20 entries during July, 2005 with spacing 3x3 meter.
19	SKUAandT, Jammu	Not reported.	Trial established during July-August, 2005 with 23 genotypes.

The observations are being recorded by the participating institutes

6.1.3 Multi-locational Trial

The purpose of this trial is to evaluate and screening of best CPTs having outstanding performance under different agro-climatic conditions of the country. The seed material having unique trait have been cryo-preserved in NBPGR and analyzed the oil content in TERI. During 2005-06 513 seeds sample have been analyzed for oil content and 305 samples have been cryo-preserved in NBPGR as detailed hereunder :-

Sl. No.	**Name of Research Institute**	**National Networking Trial**	**Zonal Trial**	**No. of samples sent to TERI**	**No. of samples sent to NBPGR**
1	CSFER, Allahabad	Trial established with spacing 2x2 meter at Allahabad under rainfed conditions with 16 entries.	Trial established with spacing 2x2 meter at Allahabad under rainfed conditions with 6 entries.	22	22
2	MPKV,Rahuri	Trial established during July, 2005 with 19 entries and spacing 3x3 meter.	Trial conducted during July, 2005 with 12 entries and spacing 3x3 meter.	119	1
3	ICAR,R.C.NEH, Nagaland	Not reported	Not reported	Not reported	Not reported
4	ICAR,R.C.NEH, Tripura	Trial conducted with 2x2 meter spacing from the seeds collected from different places.	Not reported.	13	Not reported.
5	SFRI, Jabalpur	Established	Established	50	-
6	TFRI, Jabalpur	Established at Institute with 19	Trial conducted with 14	25	10

		accessions with spacing 3x3 meter.	accessions with spacing 3x3 meter		
7	PDKV, Akola	Trial established with 10 accessions at distance of 3x3 meter during July, 2005.	Trial established with 14 accessions with the spacing 3x3 meter during July,2005.	31	29
8	SDAU,S.K. Nagar, Gujarat	Trial established with 20 accessions	Trial established with 14 accessions	-	-
9	NRCAF, Jhansi	Established	Established	88	88
10	MPUAandT, Udaipur	Trial established with 19 accessions	Trial established with 14 accessions	55	55
11	CSK,H.P.K.V., Palampur. (2005)	Trial with 8 genotypes	Nursery in poly tubes 9 genotypes	10	15
12	BCKV,Nadia, W.B.(2005)	Successfully conducted. Only one year old plantation. Growth is very good. No variation was found in molecular level.	Not reported.	-	-
13	NAU,Navsari, Gujarat .(2005)	Seeds from 15 sources collected and nursery raised. Seedlings from 22 different sources were planted in the field.	-	-	-
14	RAU, Bikaner, Rajasthan. (2005)	Not reported.	Not reported.	Not reported.	Not reported.

15	GBPUAandT, Pantnagar	Trial conducted in all seed material of 20 accessions with spacing 3x3 meter.	Trial conducted in all seed material of 6 accessions with spacing 3x3 meter.	66	66
16	SKUAandT, Jammu	Trial conducted in all seed material of 13 accessions	Established nursery progeny trials with seed material of 3 accessions.	34	34
	Total			513	305

6.1.4 *Agri-silvicultural Trials*

These trials are required to be conducted to evaluate the economic feasibility of *Jatropha* cultivation with intercrops. The different permutation combination are being experimented in location specific area. Some of the trials conducted at 10 different institute are summarized as hereunder :

Sl. No.	Name of Research Institute	Progress
1	MPKV, Rahuri	Trial conducted with chickpea variety vijay under rainfed condition during August, 2005. Intercrop yield 3.5 q/ha. obtained.
2	ICAR,R.C.NEH, Tripura	An area of 1000 m^2 is initially selected for Agri silvicultural trials in which *Jatropha* seedlings at a spacing 4m x 3m will be transplanted and rice, green gram, blackgram, seasamum, ginger and turmeric will be grown as intercrops. The area earmarked in sloppy land is about an acre in which *Jatropha* seedlings will be grown in half moon terrace in order to find out the

		performance of *Jatropha* in land of class V or VI category.
3	SFRI, Jabalpur	The trial has been conducted in 1 ha area with Cajanus cajan (Arhar) with spacing 4X4m.
4	TFRI, Jabalpur	*Jatropha* seedlings have been planted at 4x3 meter spacing by taking Masoor (lentil) as intercrop. The agricultural crop is yet to be harvested.
5	PDKV, Akola	Trial conducted at spacing 4x3 meter during July, 2005 with Sunhemp as Leguminus intercrop. The condition of crop was found very good.
6	NRCAF, Jhansi	At the spacing of 4x3 meter Agri-silvicultural trial was established with leguminous crop (Dhaincha) and this was incorporated in the soil.
7	MPUAandT, Udaipur	At the spacing of 4x3 meter Agri-silvicultural trial was established with leguminous crop (Moong) and this was incorporated in the soil.
8	RAU, Bikaner, Rajasthan.(2005)	Trial conducted with leguminous crops i.e. Guar, Moong, Cowpea and Mothbean for green manuring with spacing 4x3 meter.
9	GBPUAandT, Pantnagar	Trial conducted during July, 2005 with spacing 4x3 meter. by taking Urdbean followed by mustard as intercrops under rainfed condition with high moisture zone. Pruning experiments of 75%, 50% and 25% done in row manner/ each row with 100 plants pruned in Feb. 2006.
10	SKUAandT, Jammu	Established plantation. Incorporating with a legume crop for green manuring shall be taken up during this Kharrif season.

6.1.5 Hybridization programmes

The advance line of *Jatropha* curcas having high oil content, high yield, more drought tolerance character resistance to insect-pest and diseases etc. have been identified in various states. These unique traits are being transferred by crossing with specific character. The purpose is to develop high yielding varieties/hybrids through hybridization. The work is in progress in following institution working under the Network of the Board.

- FCRI, TNAU, Mettupalayam
- JNKV, Jabalpur (2005)
- MPUA & T, Udaipur (Dr.Shah)
- CSK, H.P.K.V., Palampur (2005)
- NAU, Navsari, Gujarat (2005)
- CCS, HAU, Hissar

The advance lines have been identified and cross breeding is in progress.

6.1.6 Standardisation of propagation techniques

To develop quality planting material for mass-propagation, the standardization of efficient propagation techniques are required to be developed. The participating institutions have been assigned to develop technique for mass multiplication of superior quality planting material. Various methodologies are being applied for mass multiplication as detailed hereunder :

(i) *Tissue culture : Development of an efficient protocol for in vitro multiplication*

Sl. No.	Name of Research Institute	Progress
1.	SFRI, Jabalpur*	I. Direct morphogenesis : a. Type of explant : Nodal explant (collected from adult tree's cuttings rooted in mist chamber) b. Media composition : MS+BAP5.0mg/lt/ +1AA$_3$.Omg/lt c. Multiplication rate : 5 to 8 fold d. No. of days for morphogenesis : Four to five weeks e. Ex vitro rooting : In vitro grown shoots+sand (non sterilized) in poly huts. f. Plant establishment rate : 62% II. Indirect morphogenesis (through callus culture) : a. Media composition : MS+BAP 4.0 mg/lt.+2, 4-D 1.0 mg/lt. (Green massive callus) III. Differentiation of Shoot from callus : a. MS+BAP 5.0 mg/lt.+1AA$_3$.0mg./lt b. Shoot differentiation 7to8 shoots. c. Shoot length 4 cm.
2.	GBPUAandT, Pantnagar*	▪ Ex-plant tried – leaf petiole and Apical bud. ▪ Max callus inductions obtained with NAA+ BAP ▪ Shoot formation possible from bud and petiole not from leaf.
3.	RRL, Bhubaneshwar (Dr.Thiruvarakkasu)	The experiment conducted for standardization of vegetative propagation through cuttings treated with IBA 50 pm showed 100 percent rooting followed by Control treatment (70%). NAA

		treated cuttings showed comparatively poor response. Number of roots per rooted cutting and root length was superior in IBA treatment. The findings of experiments on auxillary bud and shoot tip culture revealed that explants obtained from juvenile shoots i.e. shoots regenerated from stem cuttings showed positive response when cultured on to MS+BA 1.5 mg/I + Kn 0.5 mg/I + IAA 0.125 mg/I, where about 4-5 shootlets could be obtained from a single explant. Further shoot elongation was achieved in ½ MS+BA 0.25 mg/I + IAA 0.1 mg/I. Rooting was quicker and better in the media supplemented with IBA (2 mg/I). Axillary bud cultures showed poor response. It was observed from organogenesis from leaf callus that profuse callusing was achieved on MS basal medium supplemented with 2,4-D 2.0 mg/I + Kn 0.25 mg/I. Calli in these cultures were more friable and yellowish. Shoot buds started appearing from the calli after sub-culturinig on to the MS media supplemented with BA 0.5 mg/I + Kn 0.25 mg/I + IAA 0.25 mg/I. About 5-6 shoot buds were emerged after 3-4 weeks of sub-culture. Further shoot elongation was achieved in half-strength MS + BA 0.25 mg/I + IAA 0.1 mg/I. Root induction was achieved on the media containing half strength MS + IBA 2.5 mg/I within ten days of culture. The experiment on organogenesis from cotyledon and coteledonary node resulted that direct shoot formation was obtained in cotyledon segments cultured on to MS + 1.5 mg/I BA +

		0.2 mg/I IAA. About 5-6 shoots buds were emerged from each segments without any intervening callus. They were transferred to shoot elongation media containing half-strength MS + IAA 0.25 mg/I + GA_3 0.5 mg/I + NAA 2.0 mg/I + 20 g/L Sucrose + 7 g/l Agar. Rooting was better in the media supplemented with 2.5 mg/I of IBA. About 4-6 roots emerged from the base of the shootlets. Cotyledonary nodes cultured on to MS + BA 1.5 mg/I + Kn 0.5 mg/I + IAA 0.2 mg/I and MS + BA 1.5 mg/I + IAA 0.2 mg/I showed positive response in terms of shootlet formation. However response was quicker in the Kn supplemented media.
4.	CCS, HAU, Karnal	Results from the experiments conducted at Karnal, Bhubaneshwar and Jammu centres are reported that treatment of cuttings with 100 mg./l IBA enhances the rooting of *Jatropha* cuttings. This treatment is especially useful in winter months when *Jatropha* cuttings do not give good rooting otherwise. Treatment of 100 mg/l NAA is also equally effective in this regard. Partial success has been reported in tissue culture of *Jatropha*. Multiple shoots from apex explants and organogenesis from callus have been achieved. However, a commercially viable tissue culture protocol is not yet available.
5.	GBPUA&T, Pantnagar*	▪ Ex-plant tried – leaf petiole and Apical bud. ▪ Max callus inductions obtained with NAA+ BAP ▪ Shoot formation possible from bud and petiole not from leaf.

6.	CSK HPKV, Palampur	The experiment for propagation through cuttings were conducted to study the effect of thickness of stem cuttings on the regeneration of plants. It was observed that the medium thick stem cuttings (1-1.5 cms) recorded maximum sprouting. An experiment to study the effect of various concentrations of rooting hormones on sprouting in interaction with the thickness of stem and month of treatment was conducted during the mid of January, 2006. Also efforts are being made to study the effect of artificially created humidity on sprouting behaviour of *Jatropha* cuttings in interaction with various rooting hormones and thickness of cuttings. For this purpose an indigenous humidifying chamber called as HYDRO PIT has been developed, where in green house effect of solar radiations by using LDPE sheets will be created and humidity level inside the chamber will be increased by soaking sand bottomed chamber with water upto the saturation point.

The work was not assigned to SFRI, Jabalpur, however, the experiments have been conducted at their own.

(ii) Propagation through cuttings

Sl. No.	**Name of Research Institute**	**Progress**
1	SKUA&T, Jammu	Propagation studies from cuttings of different size would be taken up only once in the mid of April, 2005 due to unsuitable weather conditions during January to March, 2005. This experiment is being repeated this year also.

2	RAU,Bikaner, Rajasthan. (2005)	All the old and new plants material were completely damaged due to frost during Dec. and Jan., hence cuttings are not available.
3	ICAR,R.C.NEH, Nagaland*	Studies on propagation through cuttings revealed that 2-2.5 cm. diameter cuttings were found to be most suitable comparison to < 2 cm diameter cuttings. Rainy season cuttings were sprouted better than spring and winter season cuttings.
4	GBPUA&T, Pantnagar*	Cuttings of 30 cm. are sufficient. Apical cuttings from portion is poor in success.
5	ICAR,R.C.NEH, Tripura*	Stem cuttings has been soaked in 10 ppm and 20 ppm GA3 solution to see the sprouting of the *Jatropha*. Cuttings from *Jatropha* shrub of different places having 20-25 cm long and 8 cm girth were planted in raised bed on 5^{th}, 16^{th}, 21^{st} January, 2006, thus indicating nearly more than one month. Sprouting was noticed on 23^{rd} February.
6	TFRI, Jabalpur	Optimum length of cutting for better rooting and sprouting – 6” – 9” (15 cm x 23 cm) long. Best season for planting cuttings – February to March. Cuttings with merestimatic tip give better sprouting and rooting. Large-scale mortality has been observed in cuttings planted during rainy season. There is no appreciable response of rooting hormones.

(iii) Propagation through seeds

Sl. No.	**Name of Research Institute**	**Progress**
1	SKUA&T, Jammu	Only over night presoaking of seeds in water given for uniform germination.

2	GBPUA&T, Pantnagar*	Polythene bag method gave inferior plants as compared to direct bed. It is useless as base rooted plants in shade survived for more than 40 days. Base rooted plants are transport friendly as one truck could accommodate 1 lakh plants as compared to hardly 20,000 polybags.
3	ICAR,R.C.NEH, Tripura*	Germination of seed is recorded in GA_3 solution and water. After soaking in water, 10 ppm GA_3, solution and 20 ppm GA_3 solution for 24 hrs., germination is found to be 12 days, 8 days and 5 days, respectively.
4	TFRI, Jabalpur	6” x 9” size poly bags were found suitable to raise seedlings in nursery. Seeds can be germinated in any size of poly bags filled with suitable potting mixture. Considering the transportation cost, 6” x 9” polybags have been considered to be the most suitable. However, the bags need replacement to bigger size of polybags if seedlings are not used for plantation after 4-6 months. Naked seedlings raised in beds were found suitable for plantation programmes as it requires less transportation cost.

(iv) Studies on seed viability and time of sowing

Sl. No.	Name of Research Institute	Progress
1.	ICAR,R.C.NEH, Nagaland*	Collection and sowing of seeds during raining season found average germination percentage. (75%) in all the populations, however, in winter months, zero germination was observed at foothills of Nagaland.
2.	TFRI, Jabalpur	Studies on seed viability and time of sowing were carried out. Best time of sowing the seed was February to March.

6.1.7 Package of practices

A standard package of practice for *Jatropha* cultivation is required to be developed which is location specific, method of multiplication, nutrient management, moisture requirement, plant protection measures and post harvest management for getting optimum yield. The State Agricultural Universities and other institutions of ICAR, CSIR, ICFRE working in National Network of NOVOD Board have prepared package of practices of *Jatropha* cultivation based on zonal and national trials. These package of practices are to be tried another two to three years.

(i) Cultivation under rainfed condition

Sl. No.	Name of Research Institute	Progress
1	PDKV, Akola	Nursery was raised during the month of June, 2005 and the seeds were sown in water for 24 hours before sowing. The seedlings of 1-1.5 months are suitable for transplanting. The best time for transplanting is immediately after onset of rainy season. The spacing was adopted as 3x2 meter. Irrigation at monthly interval showed the maximum seed yield. The growth was observed to be vigorous if drip irrigation is provided at the rate of 5 ltr. per day. The application of 40 kg. Nitrogen per ha. has been found most suitable for better growth performance. The pruning of apical bud of main stem at one year age is suitable to increase number of main and secondary branches as well as number of branches per plant.
2	NRCAF, Jhansi	The plantation have been done under rainfed condition and only life saving irrigation provided during harsh summer. Only FYM has been added in pits during plantation.

3	MPUA&T, Udaipur	The plantation have been done under rainfed condition during July,2005 and in progress
4	CSFER, Allahabad	Insects infestation was observed in *Jatropha* which was present in leaf of plant and lived in a white web like structure. Monocrotophos was spread in plantation as control measure.
5	TFRI, Jabalpur	Study has been initiated to standardize cultivation practices of *Jatropha* for central India at the TFRI, Jabalpur campus to optimize fertilizer/manure doses, time of plantation, method of plantation/sowing, age of seedlings etc. The details of the experiment carried out are as under. The experiments were laid out in factorial randomized block design comprising 48 treatments replicated three times. Accordingly the experimental field was divided into 144 equal size blocks. Sixteen plants were planted in each block at the distance of 2 x 2 m. The pits were digged before one month of plantation and organic manure viz, FYM and vermicompost were applied and mixed two weeks earlier to plantation as per design of the experiment. Nitrogen, phosphorus and potassium were applied in the form of urea, single super phosphate and muriate of potash as a basal dose at plantation time. However, urea was applied in two equal splits doses, half at plantation time and remaining dose will be applied after three months. The same experiment was also carried out at the spacing of 3x2 m with each block containing nine plants. Except spacing and number of plants per block all other treatments were same.

6	SKUA&T, Jammu	Development of package of practices is in progress under rainfed conditions.
7.	ICAR,R.C.NEH, Nagaland*	Rainfed and hill slopes. Red, rocky and eroded soils.

(ii) Cultivation under irrigated condition

Sl. No.	Name of Research Institute	Progress
1	MPKV, Rahuri	Trial conducted during August, 2005. 4 spacing 2x2, 2x3, 3x3 and 3x4 meter. Pruning and without pruning. The NPK dose was given as 60:40:20. The trial has been started during 2005-06, therefore, the findings will be made available during 2007-08.

6.1.8 Development of elite planting material and model plantation

The *Jatropha curcas* are available in almost all the states but in scattered manner that too with traditional plantation with low productivity and less oil content in the seed. The countrywide efforts have been made and Superior trees having more yield and high oil content have been identified in the country. The seed material of such plants have been collected and are being provided to various Agricultural Universities and institutions for developing model plantation. Such plantation has been undertaken in more than 10,000 ha in 21 states.

The efforts for creating model plantation is being made to meet the requirement of quality planting material for undertaking large scale *Jatropha* plantation in the country. These model plantations have been undertaken by using elite planting material during 2004-05 and 2005-06 in the Central and State Agricultural Universities, ICAR, CSIR, ICFRE institutions and State Govt Seeds Farms. These model plantation in

10,000 ha. in 21 states will be sufficient to provide quality planting material for plantation in 25 lakh ha. area. The planting material will be made available from 2006-07. The state-wise summary of model plantation undertaken by NOVOD Board may be perused as hereunder:-

Sl.No.	**Name of State**	***Jatropha* plantation (ha.)**
1.	A.P.	260
2.	Bihar	110
3.	Chhattisgarh	650
4.	Delhi	665
5.	Gujarat	1140
6.	Goa	10
7.	Haryana	520
8.	Jharkhand	200
9.	Karnataka	120
10.	Kerala	50
11.	Manipur	200
12.	Mizoram	300
13.	Meghalaya	200
14.	Maharashtra	1310
15.	M.P.	845
16.	Nagaland	240
17.	Rajasthan	715
18.	Tamilnadu	960
19.	U.P.	633
20.	Uttranchal	650
21.	West Bengal	100
	Total	9878

Keeping in view the massive requirement of Biodiesel in the country, the similar efforts are also being made to harness the existing potential and augment the future potential of other TBOs such as *pongamia pinnata*, neem, mahua, oil palm etc.

6.2 Establishment of TBOs gardens

The programme has been initiated to create the awareness about Tree Borne Oilseeds, its potential and uses in the urban, sub-urban and metropolitan cities. Minimum three Tree Borne Oilseeds like Neem, *Jatropha*, Karanja, Mahua, Jojoba, Wild apricot, Cheura, Kokum etc. depending upon the climatic condition are to be planted in 2 ha to 40 ha. block. TBOs garden have been established in 11 states covering 126 ha. area as detailed hereunder:-

Sr. No.	Name of State	Implementing Agencies	Target (in ha.)
1	Chhattisgarh	Chhattisgarh Council of Sci. and Tech., Raipur	3
		Department of Agriculture, Raipur	4
2	Haryana	CCS Haryana Agri.Univ., Hisar	10
3	Jharkhand	Chief Conservator of Forest, Ranchi	2
4.	JandK	SK Univ. of Agri. Sci. and Tech. Srinagar	5
5.	Karnataka	Univ. of Agril. Sciences, Bangalore	10
		State Department of Horticulture, Bangalore	13
		UAS, Dhardwad	12
		UAS, Raichur	2

6.	M.P.	M.P. Council of Science and Technology, Bhopal	3
		Jawahar Lal Nehru Krishi Vishwavidhalaya, Jabalpur	9
		Department of Horticulture, Bhopal	20
7.	Mizoram	Department of Horticulture, Aizawl	4
8.	Meghalaya	SDA, Meghalaya, Shillong	9
9.	Maharashtra	Social Forestry, Solapur	5
		State Deptt. of Agriculture	8
10.	Nagaland	Department of Agriculture, Kohima	2
11.	Uttranchal	G.B.Pant University, Pantnagar	5
	Total		126

6.3 Back-ended subsidy programme

6.3.1 *Credit-linked subsidy programme*

The programme is being implemented in partnership mode with entrepreneur and farmers by providing 30% back ended credit linked subsidy which would be linked with credit 50% from financial institutions and 20% beneficiary share to be monitized in the form of land, labour, irrigation facilities etc.

6.3.2 *Back-ended direct subsidy programme*

Under this programme, 30% subsidy will also be provided directly to the beneficiary, who are willing to use 50% funds from their own resources.

6.4 Transfer of technology

To generate mass awareness about the utility of Tree Borne Oilseeds in various industries as well as for Biodiesel production in the country, the programmes like farmers training, trainers training, seminar/workshop etc. are being organized under Transfer of Technology programme.

6.5 Establishment of seed procurement and oil explling cntre

In order to increase the procurement of quality seeds of various TBOs, it is important to create infrastructure facilities for handling and storage of TBOs, which will be equipped with pre-processing facilities like seed driers, depulper, decorticator, cleaner, grader, digital moisture meter, digital weighing machine, seed storage, drying floor godown, expellers etc. Besides, it will maintain the quality of collected seeds by avoiding deterioration of seeds due to prolonged storage at unequipped centres and to provide remunerative prices to seed collectors. The procurement centre are being established with five sub-centres in surrounding areas.

7. Procurement/Purchase Policy

The Minimum Support Price(MSP) for *Jatropha* seed is under process with the Ministry of Agriculture. However, the Minimum Procurement Price of biodiesel has been declared by Ministry of Petroleum and Natural Gas. The price of biodiesel Rs. 25/- per litre w.e.f. 1.1.2006 is in operation. To procure the biodiesel, Ministry of Petroleum has identified 20 centres in 12 states as hereunder:-

Sr.No.	States	Location
1.	A.P.	Ghatkesar (HPC)
2.	Chhattisgarh	Mandirhasaud (HPC)
3.	Delhi	Bijwasan (IOC)

4.	Gujarat	Kandla (BPC)
5.	Haryana	Rewari (IOC)
6.	Karnataka	Devanagunthi (Bangalore) Mangalore (IOC)
7.	M.P.	Indore
8.	Maharashtra	Manmad (BPC), Nagpur (BPC), Loni (HPC), Vashi (HPC)
9.	Punjab	Bhatinda (IOC)
10.	Rajasthan	Jaipur (BPC), Salawas (HPC)
11.	T.N.	Chennari (IOC), Narimanam (IBP), Karur (BPC)
12.	U.P.	Panki (IOC), Lucknow (IBP)

7.1 Estimated plantation of *Jatropha*

The efforts being made by Central Govt/Ministries and various State Governments for undertaking plantation of *Jatropha* in the country. It is expected that 31.17 lakh hectare plantation would be completed by the end of 2008-09. The state-wise estimated plantation during three years may be as hereunder:

Sr. No.	Name of State	Plantation upto 2005-06 (in ha.)	Plantation upto 2006-07 (in ha.)	Plantation upto 2008-09 (in ha.)
1.	A.P.	17500	35000	200000
2.	Chhattisgarh	47000	80000	500000
3.	Gujarat	8000	50000	400000
4.	Karnataka	2000	10000	50000
5.	M.P.	1700	50000	100000

6.	Maharashtra	5000	25000	500000
7.	Mizoram	2000	25000	100000
8.	T.N.	5000	25000	500000
9.	Uttranchal	9220	50000	200000
10.	M.O.E. & Forest	-	40000	160000
11.	Railways	3000	25000	47000
12.	Other ministries	10000	50000	200000
	Total	127420	560000	3117000

8. Conclusion

- 5.60 lakh ha. area will produce 6.00 lakh tonnes of Biodiesel, which will be sufficient to replace more than 1% of diesel requirement of entire country or it can replace 5% of selected states during initial stage from next year onwards.

- 31.17 lakh ha. area will be covered by 2008-09, which will replace 5% diesel requirement for entire country or 10% of selected states.

Biodiesel Situation in Tamil Nadu

Paramathma. M. K.T. Parthiban and P. Raghuram Singh
Forest College and Research Institute, TNAU, Mettupalayam, Coimbatore

Government of Tamil Nadu announced alternative crops for the State of Tamil Nadu in the view of successive years of droughts and to reduce use of water for cultivation. The State Government has promoted less water intensive crops such as *Jatropha*, sweet sorghum and sugar beet for their use for production of ethanol and biodiesel.

The Chief Minister announced various measures to promote bio fuel production in Tamil Nadu for example *Jatropha* for bio diesel and sweet sorghum and sugarcane for ethanol production. Towards this end, the Tamil Nadu Government has also called for expression of interest from stakeholders in the State. Two hundred and seventy one (271) companies, corporate sectors and NGOs expressed their interest.

In the first instance, four companies were given permission for production and processing of bio fuels viz., Mohan Breweries Limited, Chennai; Bannariamman Sugars and Shiva Distilleries, Coimbatore; Riverway Agro Products (P) Ltd., Tirunelveli; and Dharani Sugars, Ambasamudram. Subsequently, 18 more companies were given permission to cultivate *Jatropha* crop and Government will give assistance for their production through contract farming. Currently Government is in the process of working out the modalities for out reach of the farmers.

Renulakshmi Agro-industries Limited established 600 acres of *Jatropha* under contract farming and opened a crushing unit with a capacity of 3 tonnes per day. It is procuring *Jatropha* seeds from

Coimbatore, Erode and Theni districts of Tamil Nadu from the wild collections and supplied oil to Southern Railways at Chennai.

Bannariamman Sugars and Shiva Distilleries Industries Limited has established 1546 acres of *Jatropha* plantations in Windmill areas and the seeds/seedlings were supplied by Forest College and Research Institute, Mettupalayam. This firm conducted few field days to popularize the *Jatropha* among farmers. Three State Ministers, Vice-Chancellor, TNAU and the scientists from the university, corporate bodies, and farming communities, attended the function. The field day was well received by overwhelming response from the farmers. This company currently procures seeds of *Jatropha*, and *Karanj* from their regional centres, and commencing 3000 kg per day biodiesel production from July 2006 onwards. The quantity of their procurement is not known. But this company announced to procure the above seeds from self-help groups.

Mohan Breweries Limited, Chennai has signed a MoU with D1 Oils Limited, UK for the establishment of bio diesel production plant. They are yet to start seed procurement from *Jatropha*. However, they announced to start from the ensuing year.

Riverway Agro Products (P) Ltd., Tirunelveli has planted 600 acres of *Jatropha* plantation in Tuticorin Dt.

Recently, Southern PURA Biofuels in Madurai announced procurement of neem and karanj/pungam seeds from Madurai through Self help groups and DRDA.

The Southern Railway Regional Workshop at Chennai has established transesterification plant to meet their requirements with a capacity of 1000 litres per day. A biodiesel rail engine is running between Chennai and Arakkonam for test run. Southern Railways is purchasing oil and transesterified oil for the last two years.

The State Forest Department, Government of Tamil Nadu has established three *Karanja* based bio diesel esterification plant based on the TNAU model at Hosur and Tuticorin Forest division.

Government of Tamil Nadu has sanctioned a model demonstration plot with a budget of one crore to state forest department to operate 150 villages under JFM model at the rate of 1 acre per individual at an espacement of 2 x 2 m. The cost of establishment and maintenance will be met by the Forest Department without any initial commitment to the farmers.

To kick start appraise the project with a quality planting material, a team comprising of the Principal Chief Conservator of Forests Shri J.C. Kala, accompanied by Dr. M. Paramathma, Professor and Head, Department of Tree Breeding, Forest College and Research Institute, TNAU, Mettupalayam and Shri S. Kalyanasundaram, Divisional Forest Officer, Chengalpattu visited Zimbabwe, Tanzania and South Africa for assessment and procurement of quality *Jatropha* seeds. The team identified superior sources and procured 275 kg of *Jatropha* seeds from Zimbabwe for establishment in the JFM villages of Tamil Nadu.

The State Agricultural Department, Government of Tamil Nadu also received financial assistance from NOVOD Board to establish model *Jatropha* plantations to the tune of 300 hectares in State Seed Farms and another 300 hectares under the comprehensive wasteland development project.

Currently there were more than 25 bio fuels companies and dozen bio fuel promotion societies and expeller and trans-esterification plants manufacturing industries are effectively functioning in Tamil Nadu (Annexure-I). Approximately 44000 acres under *Jatropha* cultivation in Tamil Nadu and most of the area under protective irrigation. Most of the companies proposed to take up 1,62,000 acres of *Jatropha* plantation in the coming years.

Annexure-I

JATROPHA AND BIODIESEL PRODUCTION IN TAMIL NADU

A. Biofuel Industries

S. No.	Name	Address	Phone No./ e-mail ID	Area (Acres Planted)	Pro-posed
1	Mr.V. Bakthavatchalam	Vice President. (Pro), Bannari amman Sugars, 1212 Trichy Road, Coimbatore -18, Tamil Nadu	0422-2302277.	1546	40000
2		Mohan D1 Biofuels Chennai		500	50000
3	R. Nagendran	Managing Director Southern PURA Biofuels APR Complex 1-B By-pass road Arrapalayam, Madurai 16	0452 5582148 Mob: 09344110975 rn@. southernpura com	10	600
4	K.K. Francis	Managing Director KTK Germany Bio Energies (India) Pvt. Ltd No. 81, Marcha-naickenpalayam Village (PO)	Mob: 9447156869 9442561869	Out sourcing of rubber seed	

		Ganapathypalayam, Coimbatore dt.			
5	P. Subramani	Director Indian Operations United Biofuels, Asia Holdings Ltd. 824 Poonamallee highroad Chennai - 600010	044 16427577 Fax: 044 2541178 p.subramani@unitedbiofuels.com	Contract farming	
6	T.R. Ramesh Babu	Director Adhinath's Biodiesel Limited No. 126/58, Anna Salai Chengalpattu – 603 002	Telefax: 044 27422555 adhinaths@gmail.com	500	
7	Vivek N Pai	President Century Agrotech Ltd. 148, Greenways road, R.A. Puram Chennai – 600028	00 91 44 – 52185881/82 centuryagrotech@rediffmail.com	600	35000
9	Jain	Jain irrigation Pollachi		60	1000
10	A.D. Jeyem Pandian	Chairman and Managing Director Pandiyan Estates (p) Ltd 14, K.K. Nagar main road Madurai - 625 020	0452 2580066 Fax: 0452 2580284 adj@pronet.net.in	25	1000
11	V.N. Selva Raj	Managing Director RenuLakshmi Agro Industries (India)	0422 5581373 Fax: 0422 2534884	600	25000

		Ltd. Jeyasanthi Towers 1373 – A, Sathy Main road, Ganapathy (PO), Coimbatore-641006	Mob: 9345707958 renulakshmiagro@gmail.com		
12	C.T. Meiyappan	No. 2, Swamy colony Nanthamapakkam Chennai – 89	Mob: 9444285287	100	-
13	Dr. S. Paulraj	District Forest Officer Hosur Forest Division Hosur Cattle Farm Complex, Mathigiri, Hosur – 635 110 Krishnagiri Dt.	Fax: 04344 262869 Mob: 9443264604 dfohosur@yahoo.com	Karanja-forest	
14	M. Balakrishnan	Project Manager Tropical Sugarbeet Syngenta India Ltd, Seeds division 187, Balyingam Road, R.S. Puram, Coimbatore 2.	0422 2555203 9443131068 balakrishnan.munusuuamy@syngenta.com	20	
15	V. Eswaramoorthy	Sribhuvaneswari Oil mills 235/A. Chittoor road Gudiyatham – 632 601, Vellore		5	25
16	Chief Workshop Manager	Biodiesel division, Chief Workshop Manager		Out sourcing	

		Southern Railways Loco works, Perambur, Chennai			
17	D. Ramesh	Director, Saravanan Bio-ventures Sri Vinayagha Plastor Pvt. Ltd P.O. No. 42, 1-1, 102 Srivilliputhur road Kabhankulam Rajayapalayam – 626 117		50	
18	V.A. Sureshkumar	Texmo Industries N.G. Mills post Mettupalayam road Coimbatore.		100	
19	J.C. Krishnakumar	Sri Krishna Biotech B-6, Shaan complex, 1362, Thadagam road, R.S. Puram Coimbatore – 2		200	Tissue Culture
20	N. Soundra Rajan	Nalla Agro Industries Aurovile (PO), Pondicherry		100	5000
21	S. Suresh Babu	Riverway Agro Products (P) Ltd. V.V. Mineral, Keeraikaranthattu Mahadevankulam (PO) Tirunelveli dt.		600	3000

22	S.V. Natarajan	Vairam Groups Agro fuels Mannanvayal village Kandadevi (PO) Sivagangai dt.	9840048707	100	1000
23	Dr. S. Sithanantham	Director (RandD) Sun Agro Biosystem Pvt. Ltd. 3/340, Main road, Madanandapuram Porur, Chennai – 600116	044 24827652/ 24826984 9884104036 sithanandham @yahoo.com	–	–
24	S. Avudaiappan	General Manager Bhavani Distilleries and Chemicals Ltd. No. 14, VI Cross street, CIT Colony Mylapore, Chennai – 600004	9444273834	–	–
25	Dr. R.C. Pattle,	Karunya Institute of Technology, Karunya Nagar, Coimbatore 114	261430. 2665635.	20	600
26	Michael Raj	Annai Bio crop Pvt Chennai		10	
27		Chetti Nadu Cement Coimbatore		300	
28		Chennai Petroleum Corp. Ltd Nagapattinam		50	50

B. NGOs / Societies

S. No.	Name	Address	Phone No./ e-mail ID		
1	R. Kanakharaj	Managing Director AHIMSA 2/38, Mugappair East Chennai – 600050	044 43550159/ 43550253 ; Mob: 9444402253	35000	–
2	Dr. K. Rajukkannu	United Biofuels Asia Ltd. 76, Sellathamizh Nagar Bikshandarkoil (po) Trichy – 621 216	0431 2591225 Mob: 9894025912		
3	Dr. N.M. Ramaswamy,	Chairman NMR Foundation, Saravanampatty, Coimbatore – 35.	2535753/ 9843336777.	–	–
4	D. Ramanandham	Ponrambalam Enterprises (P) Ltd. 1044-A, Cross cut road, 5th street corner, Gandhipuram, Coimbatore – 12		–	
5	S. Francis	Anbagani, 3342 South street, Venkatakulam (PO) Pudhuklottai – 622 303		50	
6	S. Alagarsamy	MGR. Bio diesel Project promoter Y-24, Flat No. 2,	044 26214429 9884016142 alagar22@	20	

		Leela Apartments, 5th Avenue, Anna Nagar, Chennai – 600040	yahoo.com		
7	K. Arumugham	C/o. Natesan Agency Railway station road Kallidaikurichi, Tirunelveli-627416		50	
8	Valarmathi	HICARD, Ponveedu Thillai Nagar S. Vellakapatti (PO) Karur – 639 004		50	
9	R. Kumarasamy	Park Agrotech Corporation 23, Karuppayam-mal Thottam Vellipamayam road Mettupalayam – 641 301		50	
10	E. Palaniammal	Uraga Ladies and Child Develoment Association Nadupatti Vagampatti (Via), Trichy		25	
11	Dr. Peter GB Vedamuthu	Managing Director Pan Horti Consultants (P) Ltd. 172-A Arumugha nagar, Ramanathapuram Coimbatore – 45	0422 2312854 9842231285 panhorti@ rediffmail.com	10	

12	R.Sivakumar	Kumar Fertilizer Work, 43-43, SITC Institute Estate, Five corner road, Salem – 636 006.	9443248443, 0427 2448443.	15	
13		TN Govt promotion			
	DRDA, Coimbatore	TN Govt. promotion		200	
	Other DRDA	TN Govt. promotion		540	
	Forest Dept	TN Govt. promotion		1000	
	Horticulture Dept.	TN Govt. promotion		500	
	Dept. Agriculture	TN Govt. promotion		1000	500
		Farmers - fragmented		700	
	Total			43980	162275

C. Machinery Manufacturing Industries

S. No.	Name	Address	Phone No./e-mail ID
1	Mr. D. Nataraj	ABC Agro and Food m/c (India) Pvt. Ltd, 284, Dr. Ambethkar Road.	Natraj @ abcmachiners.com 0422 2442380, 2444429, 9842244429
2	Mr. R. Siva Kumar	Kumar Industrial Works 43. Sidco Industrial Estate, Five Roads, Salem	0427 2448443, Fax: 2441806, Mob.94432 48443; Email: kiwkumar@yahoo.com
3	Mr. E. Panner Selvam	No.9, 7th street, Jai Nagar, Arumbakkam Chennai 600 106	Ph; 044 24753501, Mob.9382782175, 9444498141

Biofuel Development Programme in Chhattisgarh

Shri R.K. Chaturvedi
Project Officer, CBDA, Chhattisgarh

1. Introduction

In the scenario of ever increasing petroleum prices in international market, Planning Commission, Govt. of India launched "National Mission on Biodiesel" with a view to find cheap and renewable liquid fuel based on vegetable oils. The report of "National Mission on Biodiesel" was submitted in the year 2003 identifying *Jatropha* (Ratanjot) as the proper oil-seed for extracting required vegetable oil for converting it into the biodiesel as a replacement to petrodiesel. It may be mentioned here that *Jatropha* oil till then found very few takers being non-edible in nature and coming from forests spread over large area.

As per "National Mission on Biodiesel" report, following objective were to be achieved on continuous basis :-

- Utilizing barren Govt. land besides farmers' fallow land.
- Generate additional employment for the rural masses
- Increase green cover for overall environmental improvement
- Augmenting farmers' income from their fallow land through sale of seed.
- Producing biodiesel to achieve energy security goals
- Using biodiesel for running DG Sets in far-flung rural areas for power generation

2. Potential for Biofuel in Chhattisgarh

In line with "National Mission on Biodiesel", Chhattisgarh State Govt. has taken-up an exhaustive programme for planting *Jatropha* on 10 lac hectares fallow and degraded forest land available in the State by the year 2012. This includes land belonging to farmers also, which is lying unutilized for want of proper soil strata. Govt. of Chhattisgarh has setup a specific agency named "Chhattisgarh Biofuel Development Authority (CBDA)" on 26.01.2005 for promotion of biofuel programme in the State. The aims and objectives of CBDA are -

i) Promote RandD facility for undertaking need based research, develop appropriate technology and extension packages to attain the targeted out put.

ii) Increase rural income and ensure women empowerment

iii) Generate rural employment

iv) Promote Renewable Energy through harnessing of biofuel energy.

v) Growing TBOs and extracting Biofuel through identification of areas conducive for TBOs.

vi) Reduce the import bill of oil for the country/State

vii) Promote availability of organic manure.

viii) Reduce toxic emission during combustion of Biofuel, which is practically free of sulphurous compound.

ix) Reduce green house gas emissions through substitution of fossil fuels with plant oils based fuels.

Chhattisgarh has 44% of its geographical area under forest cover, which produces numerous types of tree borne oil seeds (TBOs) such as *Jatropha*, Karanj, Mahua, Kusum in abundant quantities and thus provides ample opportunities for promotion of biofuel programme in Chhattisgarh State. Substantial fallow land is also available for undertaking fresh plantation of TBOs such as *Jatropha*, Karanj etc. It is estimated that by undertaking plantation of *Jatropha*/Karanj on 10 lac hectares of fallow land in the State of Chhattisgarh, following production will accrue -

Jatropha seed	=	100 lac ton
Biodiesel	=	30 lac ton
Deoiled cake (Bio manure)	=	70 lac ton
Glycerol	=	5 lac ton
Biogas	=	35000 lac cu.m.
Electricity	=	700 MW

Thus there is huge potential in Chhattisgarh for biofuel projects through private investment.

3. Policy initiatives of Chhattisgarh Government

The Govt. of Chhattisgarh is targeting degraded forest land, Govt. fallow land and barren/unused land belonging to farmers for plantation of TBOs, so that the set objectives are met within the time frame. Various policy initiatives taken by the State Govt. are summarized as under -

3.1 Supply of *Jatropha* sapling to farmers

Raising *Jatropha* saplings on nurseries/farms belonging to Forest Department, Agriculture Department, Forest Development Corporation, Chhattisgarh State Renewable Energy Development Agency (CREDA), Agriculture University etc. and distributing these *Jatropha* saplings for plantation on unused/barren land belonging to farmers of the State. Upto 500 *Jatropha* saplings are distributed free and thereafter Rs.0.50 per plant is charged from the farmers. One farmer can take upto maximum of 5000 *Jatropha* saplings for planting on his barren land.

3.2 Land and allotment policy for investors

To accelerate TBO plantation as well as biodiesel production, Govt. of Chhattisgarh has come out with an innovative policy for allotting land to private investors who propose to undertake a composite projects involving TBO plantation as well as setting up of a biodiesel plant of appropriate capacity. To this effect Govt. Notification No. F-4-59/Seven/2005 dtd. 03.09.2005 has since been promulgated. Salient points of this notification are -

a) Wasteland in different districts shall be identified by the district committee constituted under the Chairmanship of District Collector.
b) An Indian Company or Partnership Firm or Registered Society would be eligible to get Govt. wasteland on lease for *Jatropha*/ Karanj plantation and installation and running of biodiesel processing unit.
c) Wasteland not exceeding 200 hectares may be allotted to the lessee by the State Govt. on recommendation of District Collector. However, State Govt. may allot more than 200 hectares of the wasteland also.
d) Wasteland shall be allotted for 10 years initially subject to its renewal for further period of 20 years.
e) Lessee shall invest 50% of total project cost within first 2 years and invest total project cost within 3 years of allotment.
f) Security deposit of Rs.10 lacs has to be deposited for land allotment upto 200 hectares which is refundable without interest to the lessee in case entire project cost is invested within 3 years of allotment and project is also completed.
g) The annual lease rent is -

1st year	=	Rs.100/- per hectare
2nd to 5th year	=	Rs.225/- per hectare
6th and 7th year	=	Rs.500/- per hectare
8th year and onward	=	Rs.1000/- per hectare

h) If during the course of lease period, the lessee contravenes any provision/condition of the lease, State Govt. may, after giving an opportunity of being heard to the lessee, cancel the lease.

3.3 Support price for purchase of TBOs

To ensure that farmers going in for planting *Jatropha* on their fallow land get proper price for their TBOs produce, Govt. of Chhattisgarh has declared support price for procurement of the same. The support prices fixed for various seeds/oil are as under :-

Jatropha seed	=	Rs.550 per quintal
Karanj seed	=	Rs.500 per quintal
Jatropha/Karanj oil	=	Rs.18 per litre

Chhattisgarh State Minor Forest Produce Federation, Raipur has been made State Procurement Agency, which is procuring the *Jatropha*/Karanj seeds through its 913 primary forest cooperative societies spread all over the State.

4. Progress Achieved So Far

CBDA has promoted *Jatropha* plantation on unutilized land of the farmers by providing *Jatropha* saplings free of cost or on nominal supply price and simultaneously inviting private investment for *Jatropha* plantation on Government land besides setting up biodiesel processing units, in a big way. Various achievements made so far are summed up as under -

i) Identified Govt. waste/fallow land for *Jatropha* plantation.

ii) Formation of task force in each district under Chairmanship of District Collector.

iii) Raised 6 crores *Jatropha* saplings in nurseries of different departments and got them planted on about 24000 hectares of barren/fallow land belonging to farmers and also on Govt. fallow lands during the year 2005.

iv) During the year 2005-06 arranged 95 farmer's trainings for *Jatropha* cultivation.

v) Got more than 200 stage shows arranged in rural areas for sensitizing farmers about the benefits of biofuel programme.

vi) Biodiesel plant of 3 KL/day capacity set up at Raipur.

vii) Govt. support price for Karanj/*Jatropha* Seeds and their oil declared.

viii) Chief Minister's official vehicle running on pure biodiesel.

5. Action Plan For The Current Year (2006-07)

During the current year, action plan for Biofuel Development is as under :-

i) *Jatropha* plantation

a) 16 crores *Jatropha* saplings will be planted/distributed during the year 2006 as per last year's procedure.

b) Pilot demonstration plantation on 300 acres fallow land in each district

c) Encouraging private investors for contract farming

d) Allotting Govt. waste land on lease to private investors for *Jatropha* plantation to ensure uninterrupted raw material supply for their Biodiesel Plant.

ii) Exemplary farmer's/departmental plantation to be suitably awarded.

iii) Scheme finalized for setting up biodiesel based power generators for rural electrification in a cluster of 50 remote villages.

iv) Govt. Notification issued for allotting Govt. Revenue fallow land on lease to private investors (Company, Partnership Firm or Registered Society) to undertake *Jatropha*/Karanj plantation and also to setup Biodiesel plant. So far 152 proposals have been received from the investors out of which in 92 cases process of allotting land on lease at the level of District Collectors is going on.

v) "State of the Art" Laboratory for exercising quality control on *Jatropha*/ Karanj oils and biodiesel, being setup with a total outlay of Rs.1.5 crore in association with a local NGO.

6. Projected Socio Economic Benefits To Chhattisgarh State

Once targeted area of 1 million hectare is brought under *Jatropha* plantation by the year 2012, various socio economic benefits accruing out of biofuel programme to the State will be as under-

i) As on an average 1 hectare of *Jatropha* plantation yields 2 KL biodiesel, approximately 20 lac tons of biodiesel will be produced, valued at Rs. 5000 crores every year (at current rate of Rs.25/- per litre). The present annual consumption of diesel in Chhattisgarh State is around 8.0 lac KL.

ii) For undertaking *Jatropha* plantation on 10 lac hectares of fallow land, manual labour to the tune of almost 3000 lac mandays would be required for digging the pits, planting the saplings, intercultural operations and other agricultural operations for first 2 years. This alone will translate into almost Rs.1800 crore as the labour wages for rural masses (as per current labour rate). Manual labour involved in post harvest operations besides processing oil for making biodiesel, would be over and above this.

iii) The proposed large scale *Jatropha* plantation will substantially reduce green house gases in the atmosphere by absorbing CO_2 from atmosphere. This will also provide opportunity to the State for trading CO_2 internationally, to the countries having much higher pollution level, in the light of Kyoto protocol.

   On an average 1 hectare of *Jatropha* plantation absorbs 10 tons of CO_2 from the atmosphere and as such 1 million hectares shall result in absorption of 10 million tons of CO_2 from atmosphere. Even on the basis of prevailing trading rate of \$ 7.00 per ton of CO_2, State will be in a position to trade CO_2 to the extent of more than Rs.300 crore, internationally every year.

iv) By processing *Jatropha* crop of 1 million hectare, apart from getting 20 lac tons of biodiesel, 40 lac tons of premium quality of bio-manure would be received for use in agriculture sector.

This bio-manure (possessing 6% N) besides providing much needed major and micro nutrients to the soils will also help in preserving soil humus, so much necessary to preserve soil quality which is getting imbalanced due to persistent use of chemical fertilizers. Even by taking a nominal cost of Rs. 2/- per kg for this bio manure, the value of bio manure so produced will be in the region of Rs. 800 crore annually.

v) Other benefits accruing out of the biofuel programme shall be overall environmental improvement, improved soil fertility of barren land, achieving energy security goals locally, saving appreciable cost being incurred on transportation of fossil fuel at present, besides generating additional employment at village level through large scale plantation and also installation of oil expeller/ transesterification units expected to come up in large numbers.

QUALITY PLANTING MATERIAL

Seed Standards for Quality Seedling-Production

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1. Introduction

Seed is a biological living entity. Botanically it is a matured fertilized ovule and functionally it is a propagative material consists of dormant plant or a generative part that develop into a new plant. Seed, the basic input of plant regeneration, is used both for multiplication and maintenance of generation. Seed, when multiplies through further generation and to maintain its originality it ought to have some basic characters which are collectively termed as seed quality.

2. What is Seed Quality

Seed quality is the possession of seed with required genetic and physical purity that is accompanied with physiological soundness and health status. The major seed quality characters are as follows:

3. Physical Quality

It is the cleanliness of seed from other seeds, debris, inert matter, diseased seed and insect damaged seed. The seed with physical quality should have uniform size, weight, and colour and should be free from stones, debris, and dust, leaves, twigs, stems, flowers, fruit walls, other crop seeds and any other inert material. It also should be devoid of shriveled, diseased, mottled, moulded, discolored, damaged and empty seeds. The seed should be easily identifiable as a species of specific category of silvicultural species. Lack of this quality character will indirectly influence the field establishment and planting value of seed. This quality character could be obtained with seed lots by proper cleaning and grading of seed (processing) after collection and before sowing/storage.

4. Genetic Purity

It is the true to type nature of the seed. i.e., the seedling/plant/tree from the seed should resemble its mother on all aspects. In forestry for maintenance of this purity character, plus tree selection, provenance selection, seed source identification and maintenance of seed source/provenance seed without bulking is important. This quality character is important for achieving the desired goal of raising the plantation either for timber or fruit or tannin or yield of any economic produce.

5. Physiological Quality

It is the actual expression of seed in further generation/multiplication. Physiological quality characters of seed comprises of seed germination and seed vigour. The liveliness of a seed in known as viability. The extent of liveliness for production of good seedling or the ability of seed for production of seedling with normal root and shoot under favorable condition is known as germinability. Seed vigour is the energy or stamina of the seed in producing elite seedling. It is the sum total of all seed attributes that enables its regeneration under any given conditions. Seed vigour determines the level of performance of seed or seed lot during germination and seedling emergence.

Seeds, which perform well at sowing, are termed as quality seed and based on the degree of performance in production of seedling it is classified as high, medium and low vigour seed. The difference in seed vigour is due to the manifestation of the deteriorative process occurring in the seed before the ultimate loss of ability to germinate. Difference in seed vigour will be expressed as variation in rate of emergence, uniformity of emergence and loss of seed germination. Hence it is understood that all viable seeds need not be germinable but all germinable seed will be viable. Similarly all vigourous seeds will be germinable but all germinable seed need not be vigourous. Physiological quality of seed could be achieved through proper selection of seed (matured seed) used for sowing and by caring for quality characters during extraction, drying and storage. Seed with good vigour is preferable for raising a good plantation as the fruits, the economic outcome are to be realized after several years. Hence selection of seed based on seed vigour is important in silvicultural species for raising future plantation.

6. Seed Health

Health status of seed is nothing but the absence of insect infestation and fungal infection, in or on the seed. Seed should not be infected with fungi or infested with insect pests, as these will reduce the physiological quality of the seed and also the physical quality of the seed in long-term storage. The health status of seed also includes the deterioration status of seed, which also expressed through low vigour status of seed. The health status of seed influences the seed quality characters directly and warrants their soundness in seed for the production of elite seedlings at nursery/plantation.

7. What is Seed Standards

Seed is the consumer material for the farmers, the end users who insist on their quality before the purchase of the same. In agricultural and horticultural crops, the quality of seeds that are delivered to farmers are to possess the above said seed quality characters with minimum/ maximum limit in line with their importance and involvement in productivity. *This upper and lower limit of seed quality characters that the seed ought to possess is termed as seed standards.* The seeds that are produced under the supervision, as per the norms of Indian seed act (1966) are distributed in the market as certified class of seed. Even the seed that is not certified at field level are to be sold only as labeled seed, which also should have the minimum level of seed quality characters. In agricultural crops researches have conducted studies on comparing the performance of farmers saved seed and certified seed without specific standards for seed quality characters and proved that the seed produced by farmers and that are distributed with out any norms on seed quality, perform poorer with more of off types.

8. Basis for Seed Standards/the Seed Quality Control System in India

Seed Act (1966) of India for distribution of quality seed to farmers, envisaged its jurisdiction through various interlinked components viz., variety release and notification, seed production, seed certification, seed testing and seed quality control system or seed law enforcement .The procedures for implementing this quality control system are described under Seed Rules (1969) (Figure 1)

In brief, Seed Act (1966) expresses that once the variety is released and notified it comes under the purview of certification, where the seeds are supervised at their production point for adoption of advanced production technique and for the assurance of genetic purity which could be maintained only at field level by proper and honest supervision, as genetic purity is highly controlled by the source seed used for multiplication and to some extent by the environment. The produced seed are again evaluated for its genetic purity through grow out test based on standards that are fixed by Indian minimum seed certification standard as below for the different classes (generation system/stages of multiplication) of seed.

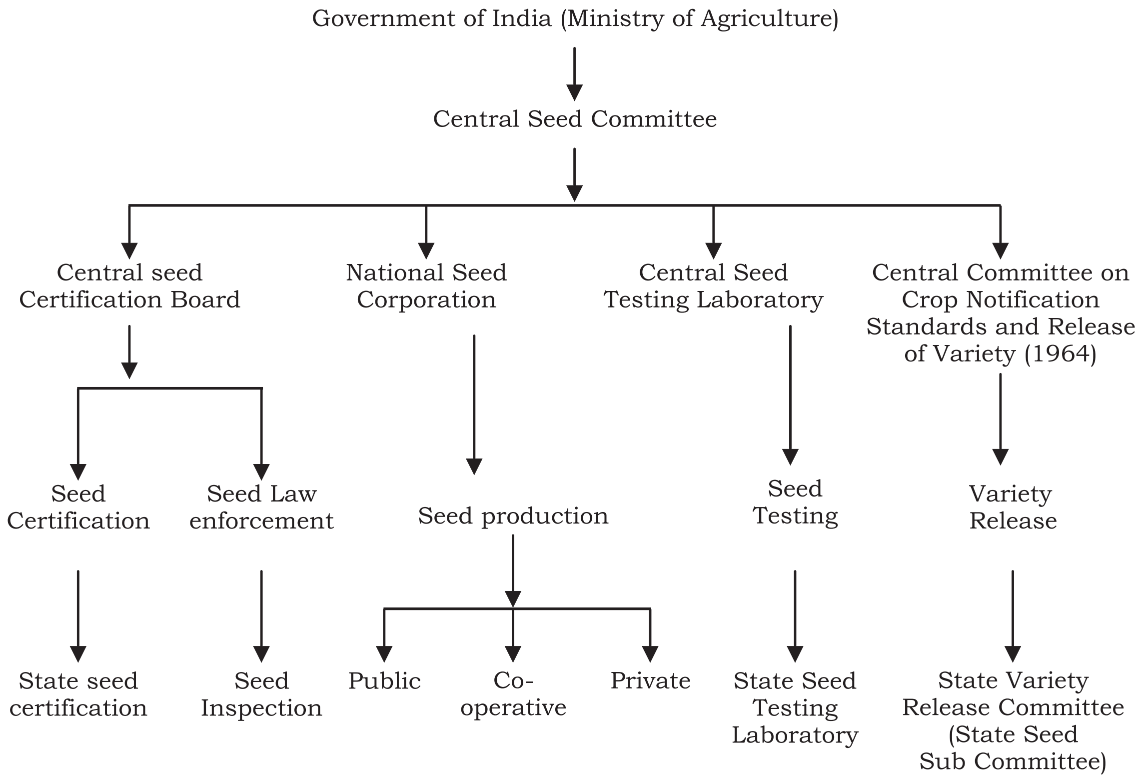

Fig. 1. Structure of Seed Industry

Classes of Seed	**Genetic Purity Requirement (%)**
Breeder seed	99.9
Foundation seed	99.5
Certified	99.0
Hybrids (depending on crop)	80 – 90

The seed thus produced are also evaluated for its physiological, physical quality characters and their health status at authenticated and accredited seed testing laboratories. In addition they also checked for their moisture content depending upon the storage containers as moisture content influences both the physical, physiological quality characters and health status of seed. All these quality evaluations are compared with specific seed certification standards described for each and every crop under the Indian Minimum Seed Certification Standard (Tunwar and Singh, 1988). It emphasis the fulfillment of two types of standards as below to name the seed as certified seed or quality seed.

Field Standard: These standards are to be checked or controlled at field level during the production and maintenance of genetic purity. In verification, field standards are looked for Isolation distance.

- Off type percentage
- Designated diseases
- No. of inspections to check the above characters

Seed Standard: After harvest, seeds are handled for post harvest seed management techniques viz., grading, seed treatment and before storage the seeds are checked for the following characters at authenticated laboratory.

- Seed germination (with maximum requirement)
- Seed purity (with minimum requirement)
- Other crop seed (with minimum requirement)
- Inert matter (with minimum requirement)
- Seed moisture content (with minimum requirement)
- Designated diseases and noxious weeds

GOI (Tanwar and Singh, 1988) has proposed standards for more than 133 crops including vegetatively propagated crops as Seed Act defines seed as below.

Seed means only of the following classes of seed used for sowing or planting.

- Seeds of food crops including edible oil seeds and seeds of fruits and vegetables.
- Cotton seed
- Seeds of cattle fodder
- Jute seed
- includes seedling and tubers rhizomes, bulbs, roots, cuttings, all types of grafts and other vegetatively propagated material of food crop or cattle fodder.

Proposals are also in pipeline for inclusion of seeds of perennials like moringa and fruit crops like citrus, mango as seed Act is amended often with time frame based on applicability. For example, Tanwar and Singh (1988) on publishing the minimum seed certification standards for India revealed that the requirement of seed quality characters for sale and distribution of major oilseed crops are as follows for certified class of seed (Table 2).

Table 2: Seed Certification Standards for a few as seeds as per Indian MSCS (Minimum Seed Certification Standards)

(a) Field Standard

Isolation (m)	150	50	200	200
Off types	0.20	0.20	0.20	0.10

B) Seed Standard

Seed Standard	Castor	Sesamum	Sunflower	Safflower
Pure Seed (minimum)	98.0 %	97.0 %	98.0%	98.0%
Inert matter (maximum)	2.0 %	3.0 %	2.0%	2.0%
Other crop seeds (maximum)	None	20/Kg	None	-
Weed Seeds (maximum)	None	20/Kg	10/Kg	10/Kg
Other distingue shamble varieties (maximum)	10/Kg	20/Kg	-	-
Germination (minimum)	70 %	80 %	70%	80%
Moisture (maximum)	8.0 %	9.0%	9.0%	9.0%
For vapour – proof containers (maximum)	5.0 %	5.0%	7.0%	7.0%

9. Applicability of Seed Quality Control System in Forestry

The requirements of seed standards for quality seed production has also been classified as general and specific standards, where general standards like class of seed, applicability of quality requirement are common to all crops and the specific standards like isolation (field standard), germination (seed standard) etc., are specific to crops irrespective of variety. In addition as per seed Act (1966), the varieties are notified for certification but, while for checking the quality characters, the standards are provided only for the variety but also for the kind of crop. So indirectly, all released varieties with crops are comes under the purview of Seed Act.

Seed Act also deals with seed law enforcement system which insists on verification of quality of seed sold in market (that are billed) that are expressed on the seed container as mark or label or tag through special officers called seed inspectors appointed for the purpose of verification of quality of seed sold in market for any kind of seed. Hitherto specific seed standards are available (implementation of seed law enforcement) for crops irrespective of variety to which the seed in marketing chain are to be fulfilled.

So all seed sold in the market, irrespective of kind or varieties are indirectly comes under the purview of seed Act and its terms and conditions, necessitating the need for quality testing in each and every crop based on specific standards that are developed by Government of India based on the researchers conducted by researchers of public sector at various places with many a variety and kind in which forestry seeds also not an exemption as the seeds are used as base material for multiplication.

10. Seed Quality Evaluation Technique

Once the minimum requirements are fixed there is a need for standardization of seed quality evaluation technique, as reproducibility is needed on evaluation of seed quality at any point. Knowing the importance of seed quality evaluations, the International Seed Testing Association (ISTA, 1999) has formulated procedures for seed quality evaluations as reproducible seed quality characters are warranted on international movement of seed irrespective of testing laboratories. In ISTA more than 150 countries including India have enrolled as members and are evaluating the seed quality characters of all kinds (agricultural, horticultural shrub, trees, flowers, fruits, medicinal plants) of seeds in movement expect individual transaction between the farmers. As per the terms of ISTA once in 10 years it renews the procedure and methodologies of seed quality evaluations as per the need and lacuna identified on usage. It also has provisions for inclusion of procedures for new species and modification of evaluation techniques already available.

10.1 Methods of Seed Quality Evaluation

ISTA has defined various methods and procedures for analyzing the seed quality evaluations. In seed quality evaluation the basic unit of operation is the seed lot where the size of lot is fixed based on the size of wheat and maize. If the size of seed is more than maize then the size of the lot is 40,000 kg, but if it is up to the size of wheat then the maximum size of seed lot is 20,000 kg. From each lot adopting sampling intensity, primary samples are taken either using hand or using triers. From the primary sample composites samples are obtained and from this using dividers submitted sample is obtained as per the recommendations of ISTA and Indian seed testing procedures. The submitted sample is dispatched to the seed-testing laboratory and again by proper mixing and dividing working sample is obtained. The size of the working sample varies with species and on this sample only all the seed quality evaluations are carried out.

10.1.1 *Purity Analysis*

This is used or evaluating the physical purity of the sample. The working sample is separated into 3 different fractions viz., pure seed, other crop seed including weed seed and inert matter using purity work board. Based on weight, the seed analyst will report the results of physical purity as pure seed percentage. Samples, which have lesser percentage than the recommended standard is not accepted as seed. But could be improved further by reprocessing and the quality can be improved on further resubmission of sample for analysis.

10.1.2 *Germination Test*

Germination test is used for the analysis of physiological purity the seed. Germination is expressed in percentage to the total number of seeds placed for germination, where ISTA specifies that 400 pure seeds are to be evaluated for seed germination. In this test, seeds are germinated in sand or paper media adopting different methodologies (top of the paper, roll towel, inclined plate) and are germinated in a germinator maintained at 25^0C and 90 – 95% RH. On the completion of the germination period, the period specified for evaluation by ISTA for each of the crop, the germination test is terminated adopting the seedling evaluation procedure of ISTA, as normal seedling, abnormal seedling, dead seeds, fresh ungerminated seed and hard seed. Based on normal seedling, the germination is reported in percentage and is compared with required standard germination for seed to categorize as standard or substandard sample/lot.

10.1.3 *Moisture Estimation*

Moisture content of seed is an important factor that decides the quality of seed both in orthodox and recalcitrant seed. This also helps in maintenance of seed quality in higher order. As per ISTA up to 17 % the seeds are shade dried and then are kept at oven adopting low temperature constant method (103^0C ± 1^0C for 17 h.) or high temperature constant method (130^0C ± 1^0C for 1- 4 h.). The moisture content required for storage is specified for each crop above, which hastens the deterioration of seed in storage, which is needed for the maintenance of seed quality up to the validity period.

10.2 Seed Weight Determination

It is the determination standard 100 seed weight of the seed lot, which is based on the counting of eight replicates of 100 seeds from the pure seed fraction of working sample. Knowledge on this determination favors to judge the homogenous status of seed lot for seed quality characteristics.

10.2.1 *Quick Viability Test*

It is also known as topography test or tetrazolium test, where seeds are preconditioned in water and are prepared (longitudinal cut and removal of seed coat) for exposure of embryo to 2,3,5 tetrazolium chloride, which on soaking will stain the viable portion of seed into pink. The nonviable portions will be colorless. This methodology would be highly useful in knowing the physiological status of seed in case of possession of seed dormancy.

10.2.2 *Seed Health Test*

This test helps in understanding the health status of seed. Seeds are infected by storage and field fungi and also by primary and secondary insects. Indian seed certification standards expresses that the insect activity in seed should not exceed 1% on any account, otherwise the seed would be discarded. Identification of pathogen infection is done using blotter technique, where the seeds are placed in blotter paper and are incubated at NUV light for the growth of fungi. Either field or storage fungi, standards for acceptance of seed for sowing purpose is warranted under seed quality evaluations. In agricultural crops in most cases it ranges from 0.1 to 0.5%.

10.2.3 *Genetic Purity*

In agricultural crops the genetic purity is evaluated through grow out test while ISTA also recommended adoption of electrophoresis (SDS page) technique based on banding pattern of protein or enzyme for identification of purity of gene in the evaluated species, which could be widely adoptable for perennial tree species.

10.2.4 *Vigour test*

Vigour is the stamina of the seed and various techniques are adopted to evaluate this qualitative factor. Some of the promising tests are brick gravel test, electrical conductivity test, GADA test, dehydrogenase enzyme activity, amino acid, free sugars and free fatty acid content. But even in agricultural crops none of the test is a regular standard test in seed testing. Hence the vigour test along with germination test will express the quality of seed in terms of physiological soundness of the seed.

10.2.5 *Other tests*

In addition to this for evaluating the quality of seed, other tests such as H_2O_2 test, exercised embryo test, X-Ray test are also recommended by ISTA for the clear understanding of seed quality evaluation.

10.3 Development of seed standards for *Jatropha*

10.3.1 *The Need*

Jatropha is an emerging crop of common interest as it serves as a source of biodiesel and varieties will be released and this would indirectly express the introduction of seed in seed market and the applicability of seed act and law on the sale of these seed.

10.3.2 *Seed certification in forestry*

In many tree species including *Jatropha* the emerging economic crop, the certification system for production of quality seed and standards for assurance of seed quality are lacking in India though under OECD programme (Organisation Of Economic and Cooperation Development) on tree seeds has categorised seeds into four different classes under certification as below :

- Source identified reproductive material (seed collected from seed production area)
- Selected reproductive material (seed collected from Seed stands)
- Seed orchard material (seed collected from untested seed orchard)
- Tested reproductive material (seed collected from seed orchard selected of genetic superiority)

In all these classes of seed, the minimum requirement for the certification is the availability of particulars on origin, isolation, uniformity, volume production, weed quality, form or growth habit, health and resistance, effective size of the population, age and development in production of source identified reproductive material and selected reproductive material. But on certification of seed collected for seed orchard, in addition to the above, design of plantation; components, isolation and location are required from the approved and registered class of seed with designated authority.

Anon (1979) on proposing the seed certification system in India, insist on field inspections are to be conducted by field inspectors with time boundaries and on the quality assessment of the stands or seed orchard, the occurrence of inferior trees and effectiveness of isolation distance must be checked as per the minimum requirements. It also expresses that after the first inspection, subsequent reinspections may be made at intervals decided by the designated authority.

For certified and selected seed at least one inspection shall be made prior to pollination. For all classes of seed one inspection will be made prior to seed maturity and the size of the crop will be estimated. It also insists that forest reproductive material to be certified under the scheme, must be collected (including extraction, cleaning, packaging and storage) under supervision of officials duly authorised by the designated authority. Tagging of seed of different classes of seed is also stressed and OECD recommended various colour tags to differentiate the class of seed and all these should also be accompanied with certificate of provenance or clonal identity.

The tree seed certification scheme (Anon, 1979) also provide rules for relabelling resealing for the divisions of the reproductive material for distribution in line with OECD. But due to handing problem, long term investment and the non availability of seed production area and seed orchard, the implication of seed certification in India has failed but still necessitating the need as all propagative material including seed comes under the preview of Indian seed act.

11. Minimum Plan that could be Adopted

In the absence of seed certification system in India, for tree crops at least in line with OECD rules as a first step, some plantations that are adequately isolated from other tree could be identified and could be uniquely promoted for seed collection because of which seed could be supplied with known seed source which is one of the basic requirement of tree seed certification. Gurunathan (2006) also insist that selection of seed source is important for collection of good quality seed. (Table 3)

With the collected seed material care could be taken to adopt advanced seed management practices that could improve the physical and physiological quality characters of a seed that are to be marketed as seed.

11.1 Influence of Quality Enhancement Techniques on Seed Quality Attributes of *Jatropha*

On requirement and fixation of standards for seed, production of quality seed is important. Gurunathan (2006) revealed that adequate

Table 3 Influence of Seed Sources on Seed Quality Characters

Sources Characters	100 Seed Weight (g)	Germination (%)	Root Length (cm)	Shoot Length (cm)
Puliyakulum (Tirunelveli)	65.6	51 (45.02)	5.3	29.9
Kurunthamalai (Mettupalayam)	54.4	43 (40.54)	10.9	27.3
Sirumugai (Mettupalayam)	67.3	44 (41.04)	8.0	29.5
Thodamuthur (Coimbatore)	66.2	80 (63.51)	5.9	30.0
Vedarcolony (Mettuapalayam)	61.3	65 (53.04)	8.7	30.3
Uppupallam (Mettupalayam)	50.1	30 (33.02)	6.8	29.3
Belur (Salem)	50.0	55 (47.04)	8.2	28.6
Chittur (Kerala)	67.7	75 (60.04)	8.1	22.3
Thathapuram (Villupuram)	63.2	60 (50.08)	7.8	28.3
Palapatty (Mettupalayam)	67.7	73 (58.01)	8.0	30.4
Valapadi (Salem)	57.8	45 (41.52)	7.0	29.8
Rewari (Haryana)	57.8	62 (51.52)	7.3	29.3
Pthikuttai (Mettupalayam)	62.1	68 (55.01)	5.5	27.4
Siruvani (Coimbatore)	67.5	61 (50.54)	7.8	28.0
Odukkampalayam (Coimbatore)	61.2	82 (66.54)	11.6	32.0
Kalakarai (Coimbatore)	65.5	78 (59.32)	8.1	30.0
SEd	4.021	(5.445)	0.462	0.530
CD (P=0.05)	6.602	(11.53)	0.979	1.124

care on collection of seed based on fruit colour, size and seed sources improve the quality characters of seed, where he insist on collection of yellowish brown fruits based on fresh colour, collection of bigger size and black coloured fruits of dried bulk fruits (Table 4)

Table 4: Influence of Collection Techniques on Seed Quality Characters

Based on Fresh Fruit Colour

Colour Grades	**Initial Germination (%)**	**Vigour Index**	**Germination after 6 Months (%)**
Green	0	0	0
Greenish yellow	64	1694	61
Yellow	76	3108	72
Yellowish brown	88	4264	75
Brown	84	3804	64
Black	74	3044	60
CDP: 0.05	(1.605)	108.4	(1.886)

(a) Based on dry Fruit Colour

Light brown	20	650	15
Brown	68	3052	40
Black	74	3540	58
Bulk	66	2845	39
CD (P:0.05)	(1.836)	84.42	(1.602)

(b) Based on Fruit Size

Big	82	3905	75
Medium	74	3250	63
Small	50	1786	18
Bulk	70	3069	56
CD (P:0.05)	(1.433)	(100.2)	(1.039)

Selection proper extraction technique is also stressed as an important factor for obtaining seeds of good quality by Gurunathan (2006) (Table 5).

Table 5: Influence of Extraction Techniques on Seed Quality Characters.

Extraction Techniques	Initial Germination %	Vigour Index	Germination after 6 Months
Manual	74	33.84	66
Beating with Stick	73	3090	65
Hand operated Thresher	76	2508	45
Power operated thresher	57	3534	70
Rubbing with Stone	67	2078	35
CDP: 0.05	(2.391)	(86.06)	(1.320)

On post harvest handling techniques also he insist on, selection of seed based on size, colour and specific gravity for obtaining quality seed and also for the maintenance of seed quality characters at storage (Table 6). He recommended selection of bigger sized, black coloured and heavy seed for obtaining good quality seed that would perform its best both at sowing and at storage.

Table 6: Influence of Grading Techniques Seed Quality Characters.

(a) Based on Seed Size

Seed Grades	Initial Germination (%)	Vigour Index	Germination after 6 Months (%)
Big	77	3577	72
Medium	63	2902	62
Small	52	2253	45
Bulk	71	3252	57
CD (P: 0.05)	(1.902)	(161.1)	(1.106)

(b) Based on Seed Colour

Light brown	40	1398	24
Brown	60	2627	57
Black	83	3966	74
Bulk	70	2987	62
CD (P:0.05)	(1.009)	98.23	(1.201)

(c) Based on Seed Weight (specific gravity grading)

Colour Grades	**Initial Germination (%)**	**Vigour Index**	**Germination after 6 Months (%)**
Harvest	86	4192	76
Heavy	82	3581	72
Medium	75	2972	65
Light	61	2229	50
Lightest	54	1485	40
CD (P: 0.05)	(0.859)	(77.49)	(0.820)

In line with him, Geethanjali *et al.* (2003) also insisted on grading of seeds and selection of bigger size seed for maintaining the quality of seed in storage, while Kathiravan (2004) recommended 12 mm round perforations as sieve size for grading as that of agricultural crops which on confirmation could serve as a standard size for grading *Jatropha*.

On storage also with his 6-month storage study Gurunathan (2006) insist on selection of seed treatment and container for maintaining the quality of the seed during storage (Table 7).

Table 7: Influence of Storage Techniques on Seed Quality Characters

(a) Seed Treatment

Seed Treatment	Initial Germination (%)	Vigour Index	Germination after 6-Months (%)
Control	72	3456	56
Neem	72	3520	56
Pungam	74	3816	59
Notchi	72	3528	54
Prosopis	76	3673	61
Halogen mix (dry)	73	3292	58
Halogen mix (Slurry)	72	3264	60
Halogen + bavistin (dry)	72	3312	56
Bavistin Dry (mix)	72	3344	60
Bavistin slurry	76	3662	67
CD (P=0.05)	(0.590)	191.7	(1.022)

(b) Storage Containers

Cloth bag	78	2979	55
HDPE	78	3028	61
Gunny bag	78	3002	68
700 gauge polybags	78	3022	75
CD (P:0.05)	(1.893)	(110.9)	(3.277)

However Kathiravan, 2004 recommended seed treatment with halogen + bavistin for extending the storage life of seed to 12 months

12. Seed standards and the need for its development in *Jatropha*

On up gradation of seed quality characters through seed handling techniques, and on commercialization of seed it ought to be compared with some basic limits that are termed as seed standards to prove itself the best among the others. Hence, in *Jatropha*, also development of seed standard is warranted which would be based on the researches conducted by researchers at various places, by collection of data and evaluation of their probability for distribution of each and every character. For instance with regard to germination, in *Jatropha*, Gurunathan (2006), Anon (2005) and Kumar (2003a and 2003b) conducted studies on seed source variation and the compilation of their study to various seed germination levels revealed that more than 50 % of the seed sources recorded more than 70% while 21 % between 60 – 70% and 29 % below 60% (Table 8). Hence based on the recorded observation as more than 50% of the evaluated seed sources recorded more than 70% germination, the minimum germination requirement could be placed as high as 70% as that of castor and sunflower as only quality seeds could produce quality seedling of nursery and could emerge as energy plants at plantations. Varieties or seed sources which possess more than 70% seed germination is ideal for direct sowing of *Jatropha* for large scale plantation in waste lands and reduces seed cost (Paramathma *et.al.*, 2003; 2004a, b; 2005).

Anon (2006) on test verification of seed sources from various seed sources found that the physical purity of this bigger seed could be 99% while the inert matter could be 1%. Kathiravan (2004) and Guru Nathan (2006) expressed that seeds dried to 9% and treated with halogen + baiting mixture and baiting alone respectively could maintain germination up to one and six month respectively with higher germination Hence, the seed moisture could be 9% for storage as in other castor which belongs to the same family. Based on the available work with Atrophy the seed

Table 8. Influence of seed source variation on seed germination

Place of Evaluation	No. of Sources Evaluated	Range of Germination (%)	Sources Maintaining >70%	Between 60-70%	Lesser than 60%	References
RRS, Bawal	24	40-77	7	8	9	Anon (2005)
TFRI, Jabalpur	20	41-81	-	-	-	Anon (2005)
NRCAF,Jhansi	40	37-100	38	1	1	Anon (2005)
Punjab	40	9-47	-	1	16	Anon (2005)
Mettupalayam	19	3-79	2	5	5	Anon (2005)
Mettupalayam	16	30-82	5	5	1	Anon (2006)
IFGTB,CBE	10	57 -83	4	3	0	Kumar *et al* (2003 a)
IFGTB,CBE	8	37-82	5	5	6	Kumar *et al* (2003 b)
Tamil Nadu	16	30-83	5	3	-	Gurunathan (2006)
Mean/Total	193	3-100	66	28	39	
Contribution to total seed sources (133) evaluated	(193-60 =133)		50	21	29	

labeling standards could be as follows and could be sold as labeled seed even without field certification of seed.

Field Standard

Name of the seed source : ——————

Date of collection : ——————

Seed Standard

Germination (%) (Maximum)	-	70%
Pure seed (%) (Minimum)	-	99.0%
Inert matter (Maximum)	-	1.0%
Other crop seed (Maximum)	-	NIL
Seed moisture content (Maximum		
Cloth bag	-	9%
700 gauge poly bag	-	< 7%

But before the practicing the reproducibility of these results for effective applicability has to be test verified with more number of samples in different places of experimentation.

12.1 Seed quality evaluation procedure for *Jatropha*

Once standards are fixed for seed it ought to be test verified by standard test procedures for uniformity and reproducibility. As explained earlier ISTA has broadly outlined the procedure for seed testing from which specific procedure are to be streamlined for *Jatropha*. Studies carried out with NOVOD project of FC and RI, Mettupalayam on evaluation of seed testing procedure with the 16 different seed sources recommended the following as seed testing procedure.

Size of seed lot	:	40,000 kg
Size of submitted sample	:	1000 g
Size of working sample	:	1000 g
Germination Test		
Media for germination	:	Sand

Temperature for germination	:	30°C
Days for counting	:	15 days
Procedure for tetrazolium test		Soaking in water for 16 h. Removal of seed coat and tegman. Longitudinal cut with exposure of embryo for tetrazolium solution. Soaking in 0.5% tetrazolium solution for 4h at 40°C.

On standardisation of seed testing procedures by Kathiravan (2004) also revealed that in germination test the first and final count could be taken at 7th and 14th day after sowing, respectively and between media paper and sand, sand was identified as the suitable medium for germination test for production of normal seedlings with vigour. Anon, (2006) also reported that for the germination test, the days of final count could be fixed at 15th day after sowing of seeds.

13. Role of Seed Standards in Quality Seedling Production

Initial seed quality is important in enhancing the productivity of annual crops and in perennials first for production quality seedling of nursery and for production of superior trees in plantation. On compilation of seedling quality characters based on germination (Tables 9-10) (for which standard is the most important), from the research work of various scientists revealed the reduction of seedling quality characters with reduction with seed germination irrespective of seed handling techniques either as fresh or after storage as follows.

Table 9: Influence of Germination Levels as Fresh Seeds on Seedling of Characters with Seeds Obtained from Various Seed Handling Techniques. (Gurunathan (2006)

(a) Germination above 70%

Seed Obtained from Various Handling Techniques	Germination %	Root Length (cm)	Shoot Length (cm)	Vigour Index	Dry weight of Seedling 10 Seedling (mg)
Seed from yellowish brown fruits	88	13.1	35.3	4264	3.78
Seed from brown fruits	84	12.4	33.1	3804	3.55
Seed from black dry fruits	74	12.5	35.3	3540	4.22
Seed from manual Extraction	74	11.5	34.2	3384	4.02
Bigger sized seeds	77	11.3	35.4	3577	4.26
Black coloured seed	83	12.3	35.5	3966	4.48
Mean	80	12.2	34.8	3756	4.05

(b) Germination between 70 – 60%

Seeds from yellow fruits	64	8.4	18.2	1694	1.35
Seeds from brown dry fruits	68	11.2	33.4	3052	3.42
Seeds after rubbing with stone	67	8.4	29.2	2508	3.66
Medium sized seeds	63	12.6	33.2	2902	3.97
Brown coloured seed	60	11.2	32.6	2627	4.04
Mean	64	10.36	29.32	2556	3.28

(c) Germination below 60 %

Seeds from Light Brown fruits (dry)	20	6.2	26.3	650	2.68
Seeds from Power operated thresher	57	8.3	28.5	2078	3.23
Small sized Seed	52	8.2	28.3	2253	3.48
Light Brown coloured seed	40	7.7	27.3	1398	3.26
Mean	42.25	7.6	27.6	1594	3.16

The comparison of seed germination levels with seedling quality characters from the table 9 revealed that both are positively related and the reduction of seed ling quality characters with seed germination classes are as follows

Table 9(a): Seedling characters and their percentage reduction compared to other germination levels

Germination Levels	Root Length (cm)	Shoot Length (cm)	Vigour Index	Dry weight of Seedling 10 Seedling (mg)
More than 70 %	12.2	34.8	3756	4.05
With in 60-70%	10.36	29.32	2556	3.28
Reduction (%) compared to 70% and above	15.08	15.80	31.9	19.0
Less than 60%	7.6	27.6	1594	3.16
Reduction (%) compared to 70% and above	37.70	20.68	57.56	21.97
Reduction (%) compared to 60-70% and above	26.64	5.86	37.63	3.65

Table 10: Influence of Storage Germination Levels (after six months) on Seedling Quality Characters. (Gurunathan 2006)

Seed Characters	Germi-nation	Root Length	Shoot Length	Dry Production 10 Seedlings	Vigour index
Black Seeds	74	11.1	31.8	4.12	3198
Big Seeds	72	12.4	32.0	4.32	3205
Yellow Brown Fruits	75	11.1	33.1	3.44	3320
Black fruits	75	20.8	32.1	3.29	3967
Mean	74	13.9	32.2	3.79	3422

(a) Germination between 60 - 70 %

Black	62	9.3	29.9	3.40	2441
Medium	62	9.5	29.0	3.62	2503
Green Yellow	61	7.5	16.0	1.12	1425
Mean	62	8.8	24.9	2.71	2123
Reduction over 70% germination	-	36.9	22.6	28.5	37.9

(b) Germination below 60 %

Brown	57	9.5	29.0	3.70	2213
Light Brown	24	6.2	22.2	3.13	684
Black Small	57 45	8.7 7.4	32.4 26.4	3.69 3.44	2345 1520
Mean	46	7.8	27.5	3.49	1691
Reduction over 70% germination	-	43.9	14.5	7.9	50.6

Table 11. Influence of Germination Levels and Seedling Quality Characteristics in Various Categories of Seeds Obtained from Various Seed Sources by Different Researchers.

Seed Source and Category of Seeds evaluated for germination	**Germi-nation (%)**	**Root length (cm)**	**Shoot length (cm)**	**Dry matter Produc-tion (mg)**	**Vigour Index**	**Authority (Reference)**
(a) Germination above 70 %						
Coimbatore Big Seeds.	82	9.5	19.7	1.87	2395	Kumar et al (2003 b)
Mettupalayam. Big Seeds.	73	8.2	17.3	1.54	1862	Kumar et al (2003 b)
Palani Big Seeds.	78	9.4	18.7	1.54	2092	Kumar et al (2003 b)
Mettupalayam Medium	72	21	17.5	3.79	-	Geethanjali et al (2003)
Mettupalayam. Big Seeds.	86	35	35	5.76	-	Geethanjali et al (2003)
Mean	78.2	33.72	21.6	2.90	2416	

(b) Germination between 60- 70 %

Annur- Medium Seed	62	7.9	17.2	1.02	1556	Kumar et al (2003 b)
Madurai. Medium Seeds.	65	9.2	16.9	1.18	1697	Kumar et al (2003 b)
Mettupalayam. From Ripe fruit	68	32	33	0.861	-	Geethanjali et al (2003)
Mettupalayam. From un open Fruits.	56	15	16	0.577	-	Geethanjali et al (2003)

Mettupalayam. Dry opened Fruits.	70	33	35	0.823	-	Geethanjali et al (2003)
Mean	64	19.44	23.62	0.89	1626	
Percentage Decrees Over 70% Germination	-	42.4	8.55	69.3	32.69	

(c) Germination Less than 60 %

Annur Big Seeds	59	8.5	19.3	1.36	1918	Kumar et al (2003 b)
Annur Small Seeds.	41	6.1	12.8	0.68	775	Kumar et al (2003 b)
Coimbatore Small seeds.	49	6.9	14.2	1.04	1064	Kumar et al (2003 b)
Madurai Medium Seeds.	58	7.6	16.3	0.87	1386	Kumar et al (2003 b)
Madurai Small seeds.	37	6.2	12	0.56	703	Kumar et al (2003 b)
Palani Small Seeds.	46	7.2	16.3	0.89	1081	Kumar et al (2003 b)
Mettupalayam. Small Seeds.	57	6.7	13.8	0.87	1169	Kumar et al (2003 b)
Mettupalayam. Small Seeds.	33	10	11.5	1.05	-	Geethanjali et al (2003)
Mean	47.5	7.4	14.5	0.91	1148	
Percentage Decrees Over 70% Germination		78.00	32.9	68.4	52.5	

The compilation of data in various outlooks consistently revealed that seed germination has got a predominant role in production of quality seedling for which standards are needed for seed quality characters.

On the outset, the arguments on need of seed quality standards for *Jatropha* necessitates the standard for the benefit of consumer the nurseryman and the plantation grower. For successful development of seed standard the following are the pre requirements in a systematic way

- Identification of seed production area
- Proper care on pre harvest management techniques for quality seed production
- Development of post harvest seed handling techniques for maintenance and up gradation of quality seed
- Development of field and seed standard for culling out the poor quality seeds
- Development of standard for evaluation of seed quality characters for evaluation of seed quality by any of the consumer
- Making direct policy issues emphasizing the need on quality of forest seed distributed in the market

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Quality Planting Material and Seed Standards In Jatropha

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1. Introduction

India is emerging very fast as a major force in the global economy. During the present phase of accelerated development, it is inevitable that energy consumption increases many folds as compared to the present per capita energy consumption which is very low in comparison to the other developed countries. India probably is the 5th largest energy consumer in the world, however the per capita consumption is very low as compared to the world average. The scenario is bound to change very fast and the gap between demand and supply of crude oil will exert a recurrent pressure on the import bills. On the other hand, non-renewable fossil fuels are getting reduced at a faster rate than ever, pushing the resources at the brink of exhaustion. In the year 2000 India produced 32 million tons of oil and imported 90 million tons, which is 73% of its requirement. The import cost during the year 2002-03 was about Rs. 90, 000 crores, which may go up further due to increase in oil price and demand-pull price. Estimates reveal that by the year 2030, India would be dependant on nearly 95% imported oil. Hence, the oil import bill has serious consequences on the Indian economy. This alarming situation calls for emphasis on the use of non-conventional energy sources in a big way. Petro-crops promise for a better eco-friendly approach in this sector.

2. *Jatropha*: A Source for Biofuel

Biodiesel is an environmental friendly replacement for petroleum-based fuel. There are a number of plant species yielding oil and high molecular weight hydrocarbons, which can provide biodiesel. A lot of work has been done on conversion of vegetable oils, however for sustainable production and utilization it is essential that the rich biodiversity existing in the country is optimally utilized. *Jatropha curcas*, a plant of Latin America origin has shown promising potential to serve as a major raw material for biodiesel production. Although it is available widely across the country there has been no systematic study on the yield and oil content under different climatic conditions. There is a strong GxE interaction and it is therefore essential that agronomic trials are conducted for selection of superior material.

3. Quality Planting Material

The Planning Commission, Govt. of India, has initiated an ambitious program of growing *Jatropha curcas* on wastelands for Biodiesel production, an initial demonstration of the potential of *Jatropha* oil as a biodiesel is being established. The entire cost economics is dependant on the quality and performance of the raw material. Yield and oil content are the two primary factors responsible and special emphasis is being laid on improved production and productivity of the planting material. Both of these characters can be further factored in to relatively simpler traits such as number of mature fruits per cyme/raceme, 100-seed weight, seed-kernel ratio and kernel oil content (%). Other desirable traits are superior fatty acid composition, plant hardiness, short and compact canopy (for easy harvesting and high-density plantation) and synchronised maturity. All these characters need to be pyramided together through stepwise screening and selection

There are as number of issues which need to be resolved to ensure cost-effective large-scale commercial potential of this species as a petro-crop in this region.

(i) Systematic germplasm collection and evaluation programme to identify superior material from the existing natural variations.
(ii) Establish clonal seed orchards and develop mass multiplication techniques to ensure easy supply of elite planting material to growers.

(iii) A series of multi-locational trials under different agro-climatic conditions to establish authentic data on yield estimates and economic of production.

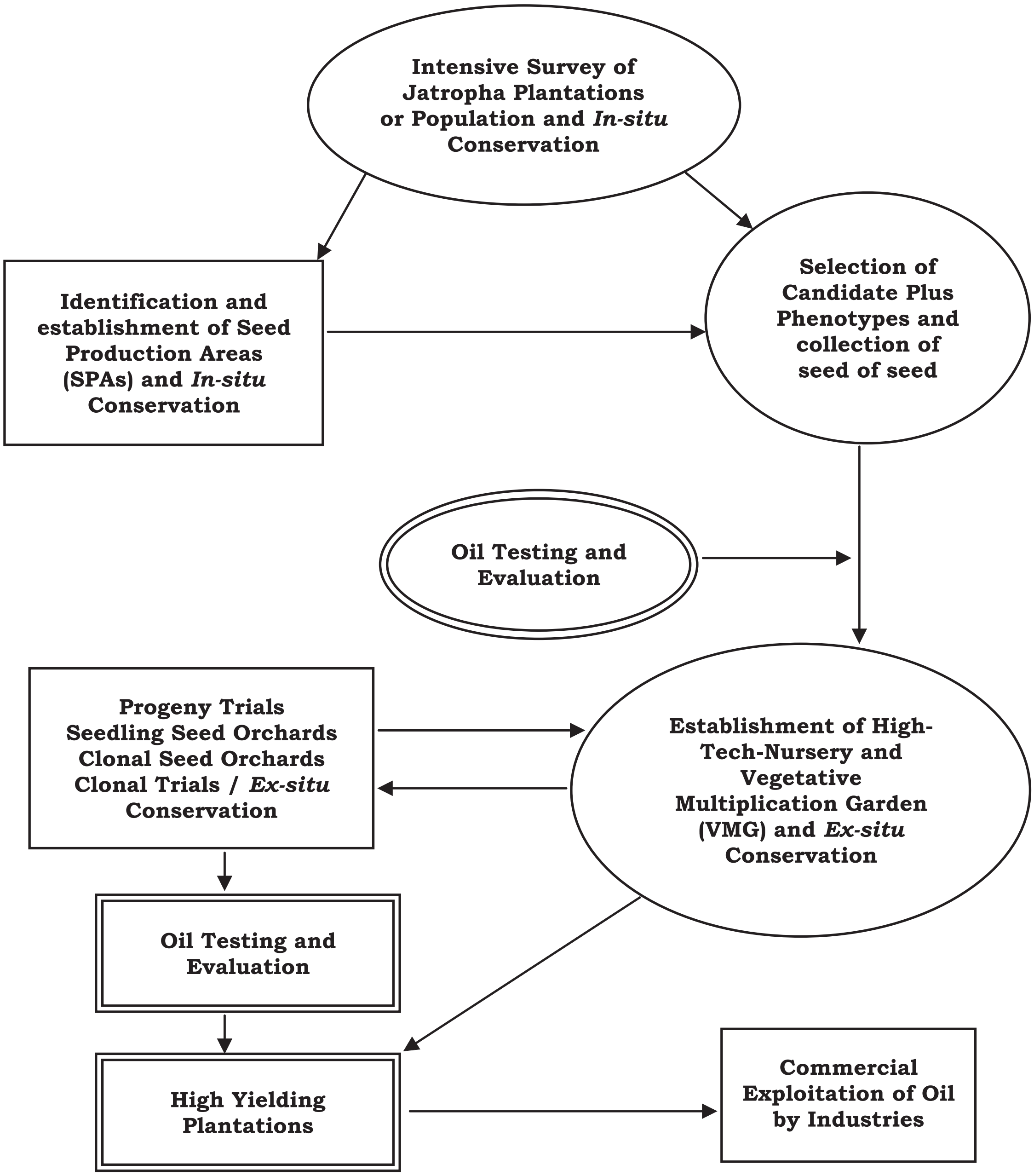

Figure 1. Approach for *Jatropha* Improvement

4. Seed Collection and Testing

Seed collection is the primary and most important step of initiation of any plantation research programme. Seed is a vital input and quality seeds alone may be instrumental in increasing output up to 20 percent. As seed quality deteriorates faster, quality control, though costly, is most crucial both in multiplication and distribution of seeds. The effective planning and implementation of research programme depends on the availability of all types of sufficient seeds with right physiological and genetic characteristics. In the first place, the seed must be collected from a genetically proven superior source. Secondly, there must be continuous checking by testing the physical and physiological status of the seed. Finally it is important that seed is stored until required without losing its germinative capacity and quality.

The behaviour of a seed depends on many parameters like species, year of collection, time and the method of collection, transportation, method of cleaning and de-pulping, storage length and condition, handling of seed during storage and harvesting. Seed testing procedures have, therefore, been developed for maintaining quality control and to provide the prospective seed user the information that has a bearing on the planting value of the seed. Seed testing and characterization procedures have been standardized.

5. DBT Micromission on Quality Planting Material

The Department of Biotechnology, Government of India has launched a micromission on production and demonstration of quality planting material. The main objectives of this micromission are:

- Selection of superior material based on established criteria-Oil content 30-40%; yield 3-5/ha.

- Production of superior quality material- Micro and macropropagation
- Standardizing agrotechnology packages
- Nursery establishment and Demonstrations in identified areas at 10-12 agroclamatic locations.

Under this mission, material/germplasm from different parts of the country is being screened, complete characterization of oil/yield is also being done and based on these characteristics an effort is being made to identify the superior plant. This identified superior material is being mass multiplied at different locations across the country through clonal propagation. Nurseries have been developed at 14locations in 12 states. Demonstration plots of the superior high material are being established and these would serve as a mother stock/source material for further large-scale multiplication plantation of superior material.

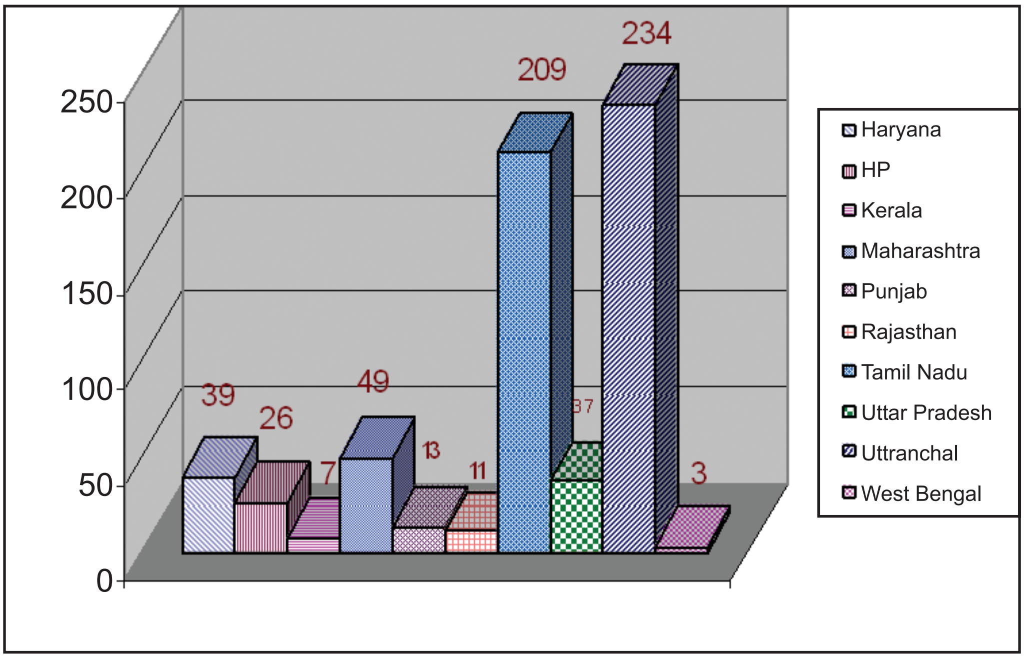

Figure 2. Statewise *Jatropha* collections under DBT Micro-mission project

Nearly 1000 accessions have been collected from different locations covering the 12 states. Complete oil analysis has been done, which includes estimation of oil content, fatty acid content, TAN No. etc. seed samples are categorized into less than 30% between 30-35% and more than 35%. These seed samples are being bulked and nurseries developed accordingly. Complete passport data of all these accessions is being maintained. Plants showing higher yield in terms of seed quality and oil are marked for further collection. Nearly 80 lakhs plants have been produced and planted over an area of approximately 300ha.

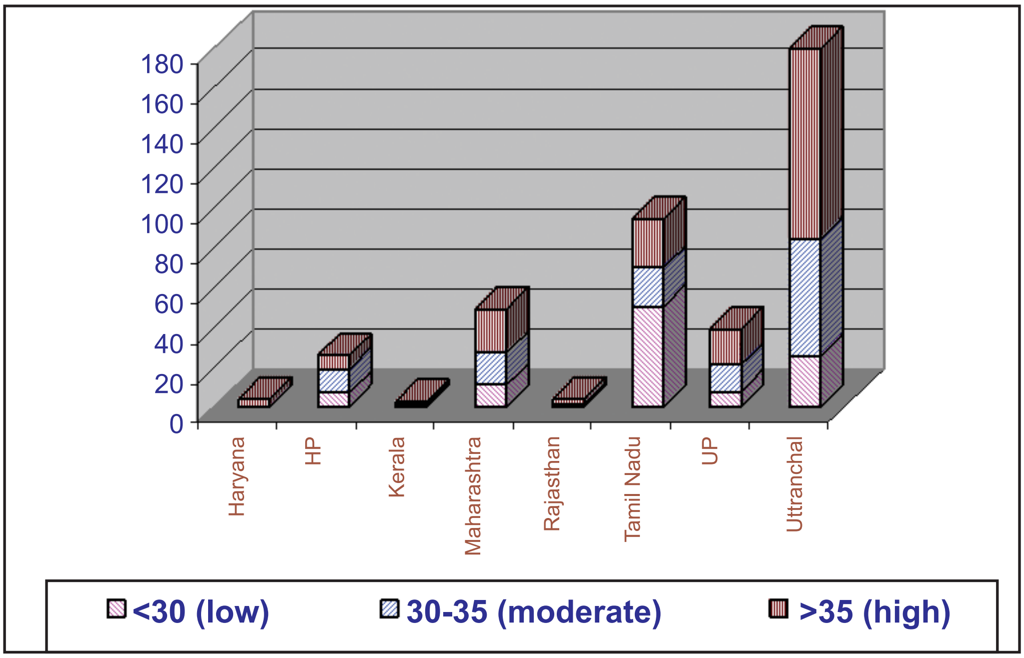

Figure 3. Statewise *Jatropha* accessions characterized under DBT Micro-mission project

Operational Guidelines have been brought out by DBT, which provide complete information on the entire chain starting from selection of mother plants to selection and collection of seed. Characterization of oil quality and yield. Nursery development, clonal multiplication and field trials.

6. Biotechnological Interventions for Improvement

Biotechnological interventions would also play a major role for improvement of *Jatropha*. Concerted RandD efforts in this directon are essential, seed yield and oil content are the two most desirable traits in a biofuel species like *Jatropha*. Other desirable traits are dwarf stem, fatty acid composition, early flowering and synchronous maturity. All of these characters vary with the geographical origin of the plant material. Therefore, an effort towards pyramiding the economically important traits is needed. Fuel property and storage quality of vegetable oil is associated with its fatty acid composition. Therefore, it is necessary to have the desirable fatty acid profile to successfully utilize it as a diesel substitute. It is essential to screen *Jatropha* genotypes with high oil content and to associate oil characters with molecular markers and estimation of genetic diversity of the available germplasm. In addition, screening for desirable fatty acid profile for fuel purpose is also essential.

7. Conclusion

The ultimate success of this programme depends on close interaction of all concerned agencies, proper linkages are required to ensure an end-to-end approach. The large wasteland available across the country should be utilized for this purpose and organized *Jatropha* plantations, only with identified characterized superior material need to be established. Self-help groups, cooperatives, farmers network need to be involved and all stake holders including the oil companies should be major players in this venture.

To conclude, in words of Dr. M.S Swaminathan " in building a paradigm of sustainable development, it is necessary to link concepts and procedures at the macro level with field-level practices to arrive at a way of translating a conceptual response into a reality".

Development of Inter-Specific Hybrids in *Jatropha*

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1. Introduction

Energy is the major and significant component in economic development of any nation. The demand for oil as an energy source is increasing but the production is very low resulting in mismatch between demand and supply of both edible and non-edible oil. In the recent times, efforts are being made to explore plant based fuel resources as a substitute for fossil fuels, which are renewable and environmentally safe. The source for bio fuels is the "forests" which is the storehouse of more than 100 tree borne oilseeds. Among them, *Jatropha curcas,* an excellent shrub having natural spread across the globe, is one of the promising bio fuel crops ideally suitable for growing in the wastelands of the country. Greater potential exists in India for bringing millions of hectares of wasteland under extensive plantation of *Jatropha*, virtually converting unproductive lands into green oil fields. *Jatropha* has long productive life of around 40 years and yields the biodiesel source, the seed from third year onwards. If managed intensively with proper fertilizer and irrigation, it would be a commercial crop for the stakeholders. It is a morphologically diverse genus comprising of 170 species, is a native of Mexico and central America and it is generally grown as live fence in almost all parts of India. In India 14 species have been recorded so far and they showed wide variation for vegetative, floral characters and oil content. The species *Jatropha curcas* is a deciduous large shrub with soft bark exudating whitish coloured watery latex. But the soft stem character makes the crop highly susceptible to heavy winds. We have also observed root rot diseases wherever copies moisture is available. With the objective to develop improved high yielding varieties with more oil content and sturdiness of stem, photo insensitive and resistance to root rot; interspecific hybridization has been attempted between *Jatropha curcas* and its related species.

2. Materials and Methods

A hybridization block comprising of different accessions of *Jatropha curcas* and 9 related species of *Jatropha viz., J. integerrima, J. gossypifolia, J. glandulifera, J. tanjorensis, J. multifida, J. podagrica, J. villosa, J.villosa ssp. ramnadensis and J. maheswarii* has been established at Forest College and Research Institute, Mettupalayam. Inorder to transfer the desirable genes from the related species of interspecific hybridization was carried out utilizing *Jatropha curcas* as the female parent and *Jatropha integerrima* as the male parent, having sturdy stem. The inflorescence of *Jatropha curcas* is complex, called cyathium. In the middle of the cyathium very few female flowers occurs and it is surrounded by a number of male flowers. In the same inflorescence, the male or staminate flowers open later and the female flowers or pistillate flowers opens earlier promoting cross-pollination. Crossing was effected in the morning between 7 and10.30 am. At the time of anthesis, pollengrains from the male parent *J. integerrima* was collected and dusted on the stigma of the female flower in the female parent *Jatropha curcas* and covered with butter paper cover along with proper tag with details of crossing. After 25 days the crossed seeds were collected from the female parent *Jatropha* curcas. A total of 31 F_1s were raised in 10x 20 cm polybags and after 90 days, the F_1 seedlings are planted in the main field in pits of size 30x30x30 cm by adopting a spacing of 2 x 2m. Observations were recorded for morphological and floral traits along with fruiting percentage and seed yield.

3. Results and Discussion

The F_1 hybrids showed a wide range of variation for vegetative, flowering and fruiting characters. They were found to be vigorous at all stage of growth and resembled the maternal parent *Jatropha curcas*, in branching pattern, leaf shape, leaf size and increased number and proportion of male and female flower and resembled the male parent *Jatropha integerrima* with intermediate flower colour. The flower colour among the hybrids varied from greenish white to pure white and pink. Variation for hairiness in corolla was also observed. The flower size also ranged from small to medium. Fruit size was normally smaller in F_1 as in *J. integerrima* whereas it was similar to *J. curcas* in BC F_1 progenies. In few hybrids, the F_1 seeds showed slight mottling as in *J. integerrima* and were smooth.

Out of 163 F_1 hybrids, a total of 20 F_1 hybrid clones *viz.*, 3-4, 3-7, 3-50, 3-53, 3-56, 3-60, 3-66, 3-75, 3-88, 3-91, 3-92, 3-93, 3-94, 3-96, 3-97, 3-107, 3-108, 3-110, 3-111 and 3-112 had white flowers and the rest of the hybrids had pink (Table 1) flowers except the clone 3-90 which had greenish white flowers.

The maturation of the androecium and gynoecium also varied among the hybrids. The hybrids viz., 3-75 and 3-93 were found to be of protandrous type whereas in other hybrids the maturation of female was earlier *ie.*, protogynous type. Thirteen hybrids *viz.*, 3-7, 3-13, 3-19, 3-21, 3-53, 3-56, 3-75, 3-82, 3-90, 3-92, 3-93, 3-107 and 3-111 showed photo insensitivity with continuous bloom throughout the year (Table 1). These hybrids require further confirmation studies for their photo insensitiveness.

The fruiting percentage also varied among the hybrids. Four hybrids *viz.*, 3-66, 3-75, 3-82 and 3-93 showed high fruiting percentage of 95 % followed by the hybrid 3-111 (90 %), 3-108 (85 %) and hybrids 3-50 and 3-88, 3-94 (80 %). With respect to seed yield, highest seed yield was recorded by the hybrid 3-95 (0.55g) followed by 3-94 (0.52g) and the hybrids 3-75 and 3-88 (0.50g) (Table 1). The best hybrids identified are subjected to further evaluation and selection in the subsequent generations.

The hybrids 3-75 with protandrous nature, photo insensitiveness, high fruiting percentage and high seed yield, the hybrid 3-93 with protandrous type, photo insensitiveness and high fruiting percentage, and the hybrid 3-88 with high fruiting percentage and seed yield were identified as the best hybrids and can be further exploited for developing improved varieties of *Jatropha* with high yield and oil content. Few hybrids such as 3-97-5 and 3-66-28 were yielded 380 and 219 gram in one season indicate better potential for exploitation of interspecific hybrid vigour by clonal propagation (Table 2). These hybrids are being under vegetative multiplication. Few hybrids such as 3-1-C-4-4R and 3-97-1-C-12-3R had hard stem and shows resistance to root rot disease and will be subjected further testing in the ensuing season.

Table 1. Morphological and floral traits of *Jatropha* hybrids

S. No.	F_1 hybrids	Flower colour	Leaf shape	Flower opening	Flowering period	Fruiting (%)	Seed weight (g)
1	3 - 4	White	Oval	Protogynous	Throughout the year	1.3	0.35
2	3- 7	White	Oval	Protogynous	Throughout the year	0	-
3	3- 13	Pink	Oval	Protogynous	Throughout the year	0	-
4	3- 19	Pink	Oval	Protogynous	Throughout the year	0	-
5	3- 21	Pink	Oval	Protogynous	Absent in rains/winter	0	-
6	3- 41	Pink	Oval	Protogynous	Absent in winter	80	-
7	3- 50	White	Oval	Protogynous	Absent in rains and winter	0	-

8	3- 52	Pink	Oval	Protogynous	Throughout the year	3.0	0.25
9	3- 53	White	Oval	Protogynous	Absent in rains	0	-
10	3- 54	Pink	Oval	Protogynous	Throughout the year	70	0.38
11	3- 56	White	Oval	Protogynous	Absent in rains and winter	0	-
12	3- 58	Pink	Oval	Protogynous	Absent in rains and winter	0	-
13	3- 59	Pink	Oval	Protogynous	Throughout the year	70	0.45
14	3- 60	White	Rounded	Protogynous	Throughout the year	95	0.40
15	3- 66	White	Oval	Protogynous	Throughout the year	95	0.50
16	3- 75	White	Rounded	**Protandrous**	Throughout the year	95	0.40
17	3- 82	Pink	Oval	Protogynous	Absent in winter	80	0.50
18	3- 88	White	Oval	Protogynous	Throughout the year	65	0.40
19	3- 90	Greenish White	Oval	Protogynous	Absent in winter	50	-
20	3- 91	White	Elon-gated	Protogynous	Throughout the year	-	0.47
21	3- 92	White	Oval	Protogynous	Throughout the year	95	0.80
22	3- 93	White	Oval	**Protandrous**	Absent in winter	80	0.52
23	3- 94	White	Elon-gated	Protogynous	Absent in winter	50	0.55
24	3- 95	White	Oval	Protogynous	-	-	-

25	3- 96	White	Oval	Protogynous	Absent in winter	70	0.40
26	3- 97	White	Elong ated	Protogynous	Throughout the year	85	0.45
27	3- 107	White	Oval	Protogynous	-	-	0.45
28	3- 108	White	Oval	Protogynous	-	-	-
29	3- 110	White	Oval	Protogynous	Throughout the year	90	0.45
30	3- 111	Pink	Oval	Protogynous	-	-	-
31	3- 112	White	Oval	Protogynous	-		-
32	*J. Curcas*	Light green	Rounded	Mixed	Throughout the year	95	0.50
33	*J. Inte-gerima*	Red	Elong-ated	Protogynous	Throughout the year	0	-

Table 2. Seed yield of *Jatropha* hybrids

	September	**October**	**November**	**Total Yield (g)**	**Total Yield (g)**
	Seed (g)	Seed (g)	Seed (g)	pod	Seed
3-66-12	17.43	-	15.876	61.785	33.308
3-66-17	10.77	22.15	7.943	65.028	40.877
3-66-21	30.08	-	5.948	29.133	36.034
3-66-23	-	-	1.930	3.405	1.930
3-66-24	-	-	16.788	30.684	16.788
3-66-25	-	4.620	11.783	29.232	16.403
3-66-26	-	8.537	55.062	114.251	63.599
3-66-27	-	3.595	64.314	26.120	67.909
3-66-28	-		432.654	**432**.654	**219**.219
3-66-29	1.170	-	48.224	89.589	49.394
3-66-33	21.36	21.36	14.242	87.348	56.968

3-66-36	7.314	1.045	17.892	48.067	26.863
3-66-42	-	28.20	3.332	53.395	31.534
3-1/C-4 (4R)	3.098	-	-	23.512	23.098
3-91-1-	5.105	19.85	17.444	60.096	42.041
3-91-2	-	6.751	59.830	126.505	68.318
3-97-5	4.662	580	260	**843**.397	**380**.802
3-97-6	-	-	64.392	122.628	64.392
3-97-7	-	13.18	45.563	118.187	58.801
3-97-1/C-12 (3R)	-	-	30.658	65.138	30.658

Strategies for Development of Quality Planting Stock of *Jatropha* Curcas for Biofuel Plantations

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1. Introduction

Environmental degradation and energy crises have prompted to search alternative fuels in the world. Biodiesel is emerging as an alternative to fossil fuel. It is a renewable source of energy, which can help in decreasing the dependence on fossil fuels and minimizing the green house gases and other pollutants. Widely fluctuating global oil prices and depleting resources of fossil fuels have further becoming burden on the country's economy. As the country produces only 30% of its annual crude oil requirement of 111 MT, it imports crude oil to the tune of Rs.1,02,500 crore for meeting the remaining requirement (Bhattacharya and Joshi, 2006). In this scenario, biofuel is a ray of hope for meeting our energy challenges. Both edible and non-edible oils of plant origin and animal fats are useful for biodiesel production. In India edible oils are not sufficient and it is mainly used for human consumption and hence focus is drawn on production of biodiesel from non-edible oil seeds. According to an estimate even 5% replacement of fossil fuel by biodiesel would help to save over Rs. 4000 crore annually in foreign exchange (Bhattacharya and Joshi, 2006).

Many non-edible tree borne oil seed species such as *Ratanjot, Karanja,* Pilu, Mahua, Sal and Cheru are widely found in our country suitable for biodiesel production. Among several Tree Born Oil Seeds (TBOs), *Jatropha curcas* is recognized as most potential species for biodiesel production since the seeds contains high level of oil (35-40 %) and could be grown under different land use situations (Datta and Pandey, 2005). It can be easily propagated by seeds or cuttings and start bearing within 2 years and can be commercially exploited in 4 -5 years and lasts for 50 years. More over it is not grazed by cattle and withstands extreme drought conditions. The biodiesel produced from *Jatropha* possesses excellent fuel properties and can be readily blended with petro-diesel safely even up to 20%. Plantation of *Jatropha* will help in greening the wastelands of our country, which are distributed in almost 80 million ha. Since the *Jatropha* is a fast growing and hence it will add substantial quantities of organic matter to the soil through litter fall and fine root turnover. The increased organic matter will improve the physico-chemical properties of degraded lands. Besides biofuel plantations create additional employment in rural areas. Environmental degradation could be arrested through biodiesel production, which helps in achieving Bharat Stage II emission norms from April 2005 and Euro-III norms from April 2010 in the entire country as targeted in national auto fuel policy (Katwal and Soni, 2003).

2. *Jatropha*-based Biofuel Development in Chhattisgarh

Chhattisgarh, a newly borne state of India is a treasure house of tree born oil seeds. The state is covered with almost 45% of forest cover. Many TBOs like *Karanja, Jatropha,* Mahua, Kusum, Pilu, Sal etc are widely found in the forests. Since times immemorial, the people of the state are exploiting TBOs for various household purposes. However, in recent years, the process of domestication and commercialization of *Jatropha* has started in the state for commercial production of biodiesel. Looking to the immense scope and potentials, the state has launched *Jatropha*-based biodiesel programme for mitigating energy crises and environmental problems. Chhattisgarh has 13.7 m ha geographical area, out of which forest area is 45 % and net sown area is 35.3%. Eighty percent of the cultivated area is monocropped with rice. Approximately 1/10th of rice area is covered with bunds, which are mostly unutilized.

A good proportion of rice bunds can be utilized for *Jatropha* cultivation. Besides the sizable area of forest is degraded, which can be partially utilized for cultivation of *Jatropha*. Cultivable and fallow wastelands occupy 1.7 m ha, which has strong potential for *Jatropha* cultivation. The extent of wastelands in different districts of Chhattisgarh is given in Table 1 (Dholakia, 2005).

Chhattisgarh is one among the nine potential states identified by GOI to integrated development of biofuels program. The state govt. launched its ambitious biofuel program in 2005 to meet its energy requirement, provide employment opportunities, alleviate poverty and reclaim the wastelands. It has been targeted to cover 20 lakh ha, which cover degraded govt. revenue lands, private and forest lands. During 2005-06, 6 crore of *Jatropha* was planted and in 2006-07, it is targeted to plant 16 crore of *Jatropha* on waste lands. (Dholakia, 2005). The state govt. started promoting large-scale cultivation of *Jatropha* through different rural development and watershed programmes. To encourage small and marginal farmers, 500 plants are provided at free of cost and only Rs. 0.5 per seedling up to 5000 plants from state Govt. nurseries. The state govt. has also declared support price of Rs. 550 per qt for procuring of *Jatropha* seeds. The state minor forest products federation cooperatives (CGMFP) and TRIFED had started the collection process. To encourage entrepreneurs, the state govt. has also declared land allotment policy to a company/registered society on lease basis. More than 90 cases were scrutinized for land allotment. The state govt. is also providing incentives and relaxations for setting up biodiesel processing plants. Support price of *Jatropha* oil has fixed at Rs. 18 per liter. To promote the biofuel program, Chhattisgarh biofuel development authority (CBDA) has been declared to centrally monitoring the all activities related plantations and processing units. It is encouraging Govt. and private nurseries to develop large scale planting material of *Jatropha*.

3. Improved Planting Stock – A Growing Need of *Jatropha* Plantations

In order to meet the huge annual targets, there is a need to raise large amount of seedlings in the nurseries. Use of inferior and unhealthy planting material may result partial or complete failure of *Jatropha* plantation. Therefore, quality of planting material is most important for establishment of successful plantations. With the growing demand to increase area under *Jatropha* plantation, quality sometimes is compromised. Besides, the lack of knowledge among the growers on the importance of using quality planting stock will also hamper the exploitation of total yield potential of *Jatropha*. The quality of stock has to be maintained through initial seed collection to final transplanting operations. Many private as well as govt. nurseries are raising *Jatropha* seedlings on large scale, but some are unaware about the development of improved quality planting stock. The lack of adequate knowledge, facilities and cost of production are main reasons for not keeping quality in commercial nurseries.

The change of focus from quantity to quality needs to be viewed seriously as recent nursery manuals tend to focus on morphological characteristics for assessing vitality in seedlings (Lindquist and Ong, 2005). Morphological characters are easy and rapid to measure and provide reliable information on seedling/steckling quality. Root-shoot ratio is important as it shows the relationship between the transpiration area and water absorption area in a seedling. But it is not a completely reliable method as seedling with same ratio may have a large taproot and few laterals, or a mass of fibrous roots. Another important measure sturdiness quotient, which is the quotient between seedling height in cm and the stem diameter in mm, is a reliable method of field survival of a seedling (Lindquist and Ong, 2005). Root growth potential (RGP) is a method to measure the ability of plants to develop new roots in optimal environment. RGP is considered to be an important, as the ability to grow new roots is regarded as key attribute of seedling quality (Ritche, 1984). However, morphological assessment is not adequate and physiological quality (Photosynthesis, transpiration, stomatal conductance and leaf temperature) is equally important for assessing overall quality of planting stock of *J. curcas*.

4. Development of Quality Planting Stock of *Jatropha* from Seed

Jatropha curcas is usually grown from seeds but it can also be propagated by branch cuttings. The planting stock raised from seed are not generally uniform, because *Jatropha* is a cross-pollinated species, seeds collected from the wild will not be genetically uniform. The seeds collected from natural habitats in the bulk are sometimes unhealthy due to seeds borne pathogens, which transmit diseases from seeds to seedlings and into plants to seeds. The quality of *Jatropha* seedlings depends on two factors. i.e. (i) genetic makeup of the parent stock and (ii) physical growth of seedling. The genetic traits depend on the parental population. Lot of variability exists in natural population of *Jatropha* with respect to seed yield (0.2 – 2 kg/tree) and oil content (30-48%) since it is widely distributed in different edapho-climatic conditions in the country. Therefore, selection of seed sources is important and primary need of developing high quality planting material of *J. curcas*. The Department of Forestry, Indira Gandhi Agricultural University had made rigorous survey in different localities of Chhattisgarh and studied the variability of seed and oil yield. Seed yield varied from 0.2 to 1.5 kg seed, while oil content from 35-48% (Puri *et al.* 2005). The variations in oil content are presented in Table 2. The seeds of Pendra region of Bilaspur district of Chhattisgarh are quite promising which contain 48% of oil content and hence it is suggested for using the seed material to develop nursery stock. After seed source identification, proper seed collection and processing is also equally important for maintaining quality of seedlings. The quality of planting stock of *Jatropha* will be affected due to improper collection and handling of seed. In general, the premature and over mature seeds will affect seed germination and seedling vigour. The seeds should be collected from 8-15 year old trees and it should be avoided to collect seeds from young and too old trees. The ideal time for seed collection in C.G. state is September month, when the fruits are fully ripened. Collection should be made when fruit turn pale green to light yellow colour. After collection of fruits, drying must be done in shade for a week. Later the shelling is done to recover seeds. Grading of seeds has to be done and only healthy and sound seeds should be used for nursery raising. The seeds can be stored in storage bins and can be used before six months for ensuring better germination, as delay in sowing will cause reduction in germination.

Three kinds of nursery could be successfully raised for *Jatropha*, which include 1) Containerized nursery 2) Bare root seedling nursery and 3) Root trainer nursery. Each of these methods has its advantages and disadvantages. Various kinds of containers used in traditional forest nurseries such as bricks, donas, baskets, earthen pots, tubes and poly bags can be used for raising seedlings of *Jatropha*. Among all these, poly bag containers are commonly used since these are cheaper, light in weight, easy in handling, durable and are available in plenty in the markets. Besides, it offers other advantage like minimum disturbance to the root system, less damage during transportation and can be kept in the field for longer period without any loss in growth while naked root plants require immediate planting. The poly bags should not be too large and too small in size. The large poly bags needs a lot of potting mixture, consumes time for its filling and also transportation becomes costly affair. On the other hand small poly bags are not suitable as *Jatropha* is fast growing and do not have sufficient space for growth of roots. The optimum size of poly bag should be 10’ x 15’cm or 10’ x 20’ cm. The vigour of the seedling depends on health of the root. In order to provide an optimal physical environment for root development, nursery-potting mixtures is well maintained. Best root development is obtained when an organic potting medium is used. The nutrients are more easily distributed throughout the organic medium, which enhances the fibrous root system. The best potting mixture is sand: compost: soil in the ratio of (2:2:1). Poly bags of suitable size to be filled with potting mixture containing amendments 1) single super phosphate @ 1.2 kg per cubic meter soil mix 2) Nitrogen de-oiled neem cake @ 10 kg per cubic along with phorate and Indofill M- 45 @ 200 g and 250 g, respectively per cubic meter of soil mix. The potting mixture is thoroughly mixed using rotatory drum. The potting mixture should be sieved through 2 mm mesh to remove clods and stones. One or two fresh seeds will be sown in each poly bag. The simple pre sowing treatments considerably improve germination. The seeds should be soaked in cold water for 24 hr or given boiling water treatment for 2-3 minutes and kept in cold water for 24 hrs will ensure better germination. It will be possible to get 80-90% of germination within a week. Shifting of poly bags is an important aspect, which gives slight shock to the roots of *Jatropha* and is necessary for healthy development of root system. This will prevent the penetration of taproot into the ground. The shifting of bags along with grading will be done at least once in two months. The grading should be done keeping the quality aspects such as root: shoot ratio, sturdiness and vigour of seedlings. The weeding and irrigation is provided as and when required. The pest and diseases should be managed to obtain quality-planting stock of *Jatropha*. The scientific studies revealed that poly bags has disadvantage as these does not allow proper root development in *Jatropha* plants. The lateral and tap roots gets coiled and restrict the shoot growth. The poly pot plants have limited aeration and problem of root spiraling, both these factors responsible for mortality of seedlings after they planted in the filed. Poly bags are not environmental friendly and cannot be used safely for longer period. Besides, the shifting of poly pot at regular interval increases the cost of seedlings.

Bare root nursery is another method also suitable for raising of *Jatropha*. It offers the advantage of raising more number of seedlings in unit area, better utilization of resources, save transportation charges at the time of planting and also cost effective in raising seedlings. For raising bare root nursery, the raised beds of 12.5 x 1.2 m or 10 x 10 m will be first prepared. The surface dressing will be done with soil mix containing FYM/Compost and it should be drenched with @ 0.2% of endosulfan and bavisitin. The pretreated seeds are sown in the nursery beds at 5-10 cm apart within the lines and a spacing of 25 cm is maintained between the rows. Sowing should be preferably done during January-February. Weeding, hoeing and irrigation are done at frequent intervals to produce healthy seedlings. The seedlings are taken out either with ball of earth or naked roots for planting. The grading is done to select healthy quality seedlings to ensure better survival under field conditions. The major disadvantage in bare root stock is that seedlings have to be immediately planted in the field after lifting from the nurseries and moreover roots are naked, chance of damage to root system likely during transportation which will not only affect the seedling quality but also their survival and growth.

In order to overcome these practical problems, root trainer nursery is most promising and appropriate for production of high quality planting material of *Jatropha*. The root trainers are semi-rigid or rigid containers with internal vertical ribs or corrugated walls, which direct root growth straight down rather than allowing spiral growth. It requires lesser input and ensures better root formation. Root trainer nursery is undoubtedly superior to polybag nursery and help in producing quality planting stock. Root trainer grown seedlings will be more vigorous, straight and have rapid growth ensure better survival in field planting. They can be repeatedly used and become economical for raising large scale planting stock over a period of time. Weeding, shifting, watering, transportation and handling etc. become easy since the root trainers are small in size and light in weight. The root trainer will develop more fibrous root system, which will improve the uptake of nutrients in water. The root pruning and wrenching practices have to be adopted for development of fibrous root system.

5. Artificial Shade on Nursery Beds

The shading over nursery beds is required to protect *Jatropha* seedlings against sun, frost, hailstorm, rain and fast winds. Shading is provided to the plants in hot and dry summer months during March-June. This protects tender seedlings from intense solar radiation and high temperature. It also reduces evaporation and transpiration losses resulting in lessening of irrigation. The seedling turns to pale green to yellow during summer months if they are not provided by any shade. The shading is done by agro plastic shade nets (black or green), opaque polythene or low cost bamboo mats, grasses and tal leaf matting. The shade nets/other shading material may be erected on iron frame or wooden frame above 1 m over the bed. The shades will be removed at least 15 days before seedlings are taken out for field planting. This will help in hardening the seedlings before transplanting in the field.

6. Propagation by Stem Cuttings

Jatropha curcas can also be successfully propagated by means of stem cuttings. It is the cheapest and economical methods of propagation. It will help in rapid multiplication of superior phenotypes/genotypes that contains highest seed and oil yield. The uniform and identical true to type planting stock can be developed through vegetative techniques. Clonal propagation techniques will be useful in capturing maximum genetic gains in quickest time (Swamy *et al.* 2002). The rooting potential of *Jatropha* mainly depends on season, age and size of the cuttings. The studies conducted on rooting of stem cuttings revealed that season is the most important parameter that strongly influences the rooting (Table 3). Preference will be given to take cuttings in spring (January-February) or rainy seasons. Cuttings taken from juvenile (2-3 year old) plants are better for rooting than those derived from mature trees. The rooting potential decreases with age of the plants. However, the cuttings taken from 7-8 year old trees gave about 70-80% rooting. The size of the cuttings should be 20±5 cm with diameter 2.0±0.5 cm is most ideal for rooting. Auxin treatment (IBA, NAA) is not essential, cuttings should be taken from middle of the crown and plant in good rooting medium and irrigate as and when required (Table 3). The rooting media like vermiculite, mixture of FYM, sand and clay soil in 2: 1: 1 or compost, sand and soil in 1:1: 1 ratio should be used. The cuttings should be preferably grown in root trainers.

7. Propagating Structures

In order to improve the rooting and quality of stecklings, the proper environmental conditions should be maintained. The various types of propagation structures are quite useful for maintaining the temperature, relative humidity and light conditions, since rapid propagation of *Jatropha* cuttings could be possible by maintaining high temperature with high relative humidity. The different propagation structures viz. shade roof, shade house, propagating frame, green house, mist chamber and growth chambers are useful in propagating cuttings of *Jatropha*. Shade roof is the low cost and simplest structure. It can be made by using one sidewall of any building in such way that solar radiation does not affect the plants directly. This is useful for small nurseries of *Jatropha*. On the other hand, shade house is used for raising and hardening *Jatropha* cuttings/ seedlings. It is open or partly closed from all four sides, only overhead shade is provided by plastic nets or polythene sheets. About 50-75% of solar radiation enters through shading material. The shade house should be provided with overhead sprinklers to irrigate seedlings at varying intervals. This is most useful propagating structure for regenerating cuttings of *Jatropha* especially during summer.

Propagating frames are made of aluminum or angle iron and tightly covered with glass, polythene, plastic or fibreglass. They are also called as misting tunnels. They provide warm and humid conditions, which can be quite useful for propagating cuttings in winter months. Besides, *Jatropha* can be successfully propagated in greenhouse or poly house conditions. The green house is made up of metal frame covered with fibreglass or polycarbide sheets. Ventilation can be provided with exhaust fans. For controlling temperature in summer, "fan and pad " cooling system device in which wet pad or some materials eg. Wood chips or rubber pad etc. is installed. The water loss is prevented by controlling humidity. The sprinklers can be used in the green house for irrigation. The artificial lights can be used for early induction of rooting in cuttings of *J. curcas*. Mist chamber or misting unit is more sophisticated phyto-environmental facility that facilitates to maintain all environmental condition like temperature and humidity through automatic misting. The misting is usually maintained for 5-10 minutes interval in summer season and 15-20 minutes in winter and rainy seasons. The proper environmental conditions increase the physiological activities and help in achieving hundred percent rooting in cuttings of *Jatropha* under mist chamber. Besides, it is quite useful structure to develop quality-planting stock of *Jatropha* throughout the year. The growth chambers and phytorons are useful for propagating *Jatropha* but are quite expensive and still not operational for large-scale production of quality planting stock of *J. curcas*.

8. Conclusion

Jatropha curcas has been increasingly promoted as biodiesel crop in Chhattisgarh. It is targeted to plant 16 crore plants during 2006-07. The success of plantations greatly relies on use of quality planting stock, which is sometimes under weighed. Morphological indicators such as sturdiness, root shoot ratio and root growth potential (RGP) along with physiological quality parameters like photosynthetic rates, stomatal conductance and transpiration should be included for assessing the overall quality of planting stock of *Jatropha*. The traditional methods of polybag and bare root nursery techniques should be discouraged and preference will be given to grow seedlings in root trainers under optimum environmental conditions to maintain the quality standards. Propagation by stem cuttings is suggested for rapid and mass multiplication of superior phenotypes/genotypes of *J. curcas*. Preferably cuttings should be taken from young plants during spring (February) and rainy (August) season. The rooting potential as well as quality of stecklings can be improved by regenerating cuttings under phyto-environmental facilities *viz.* shade house, polyhouse and mist chambers. However, the cost of production of planting stock needs to be carefully assessed before adopting such improved technologies. It is strongly suggested to use only quality planting stock to ensure sustainable yields of *Jatropha* for improving biofuel production.

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Table 1: Extent of wasteland in different districts of Chhattisgarh

District	Area (ha)
Koriya	46,994
Surguja	2,68,230
Jashpur	1,91, 351
Raigarh	1,17,326
Korba	80, 775
Janjgir-Champa	63, 948
Bilaspur	1,14,462
Kabirdham	54,045
Rajnandgoan	1,35,723

Durg	1,31,264
Raipur	1,79,621
Mahasamund	52,178
Dhamtari	24,854
Kanker	1,23,905
Bastar	1,76, 469
Dantewada	2,35, 583

(Source: Dholakia, 2005)

Table 2: Variation in oil content in different seed sources of Chhattisgarh

Seed source	**Oil (%)**
Raipur	46
Bilaspur (Pendra Road)	48
Kanker	40
Sarguja	39
Korba	36
Bastar (Jagdalpur)	38
Jashpur	40
Dhamtari	37
Korea	43
Mahasamund	43

(Source: Puri *et al*. 2005)

Table 3: Effect of IBA, cutting position and age on sprouting and rooting of *Jatropha curcas* in mist chamber and field conditions during spring

Characters	2 year old plants						6 years old plants					
	Mist Chamber			Field			Mist Chamber			Field		
	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3
(L) Sprout ing (%)	83.3	70	53.3	56.6	50	40	94	66	38	56	24	16
Rooting (%)	70	66.6	40	53.3	46.6	33.3	68	52	30	34	22	14
Max. no. of roots	15	8	8	12	10	9	13	5	5	12	8	5
Max. root length (cm)	9.5	6.9	5.5	8.1	7.5	6.2	10.5	3.2	2.6	8.7	6.4	5.2
Sprouting (%)	73.3	60	46.6	50	40	33.3	86	44.7	38	54	22	16
Rooting (%)	66.6	50	33.3	33.3	40	33.3	52	36	20	32	18	10
Max. no. of roots	11	11	8	8	5	5	12	6	4	11	8	8
Max. root length (cm)	6.4	4.9	3.8	6.3	6.1	5.5	9.9	2.6	2.6	8.7	6.2	5.1
(U) Sprout-ing (%)	70	53.3	40	26.6	23.3	13.3	72	38	24	46	30	12
Rooting (%)	43.3	50	33.3	23.3	16.6	6.6	22	18	10	30	16	6
Max. no. of roots	10	9	8	7	5	3	9	6	5	8	7	3
Max. root length (cm)	5.4	3.3	2.1	5.1	4.4	3.2	8.7	2.6	2.4	7.3	5.7	4.9

Note: L = Lower, M = Middle, U = Upper, T_1 = Control, T_2 = IBA 500 mg/l, T_3 = IBA 100 mg/l.

(Source - NOVOD Board Report, 2005)

Influence of Seed Management Techniques for Production of Quality Seedlings in *Jatropha*

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1. Introduction

Seed is the basic input of regeneration and often undergoes deterioration with time, as any of the biological organism. Hence the reproducibility of same results with time in seed quality aspects viz., physical purity, physiological soundness, genetic purity and sound health in any seed is questionable. Moreover quality of fresh seed is even influenced by pre-harvest and post- harvest conditions prevailing at any production point. But with all these lacuna seeds need to be, not only germinable but also vigorous for production of quality seedlings at nursery, which are the basis for future plantation. Hence researchers recommend several seed management techniques for production of quality seedlings that are to be used for raising plantation.

2. Seed Management Techniques

The prior most important seed management technique is the homogenizing the seed lot for uniformity based on physical seed characters viz. size, weight, volume and shape. Gurunathan (2006) reported that bigger, heavier and dark black colored seeds of *Jatropha* recorded the maximum seed and seedling quality characters respectively on grading the seeds based on size, weight and colour. The other researchers working with *Jatropha* (Kathiravan, 2004 and Geethanjali et al., 2002) also revealed that bigger sized seeds produced elite seedling at nursery.

On homogenizing the seed, seeds are recommended for treatment with bioactive foreign material for obtaining the effect of protection, production and invigoration. Seed treatments can be broadly classified as Pre-sowing, Pre-storage and Mid-storage treatment depending upon the time of application of seed treatment. Hence for boosting the ability of the seed at any instance, seed could be selectively treated and could be made productive. Normally for enhancing the performance of the seed at nursery seeds are being imposed with presowing seed management techniques.

3. Presowing Seed Treatments

Presowing seed treatments are given to the seed before sowing to achieve the needy objective of enhancing the production and invigouration using the bioactive chemicals, which are effective in improving the performance of seed under field conditions. These bioactive chemicals are applied to the seed by different methods such as fortification, priming, pelleting and infusion.

Bio-active chemicals that are commonly used in presowing seed management technique are

- Seed protectants, fungicide, and bacteriocide.
- Herbicide antidotes: To prevent the ill effects of herbicide, herbicides antidotes are infused.
- Growth regulators: GA3, IAA, kinetin are incorporated to nullifying the endogenous deficit of the growth substances.
- Nutrients: Micro and macro elements.
- Substances to resist adverse stress conditions: Substances like fusicoccin alleviate the adverse effect in soil.
- Botanics (fresh leaf extract)

4. Seed fortification technique

Seed fortification is the incorporation of required substances into the seed for invigourating the seed. In this physiological seed management technique, the seeds are soaked in water or dilute solutions of bioactive chemicals such as micronutrients, growth regulators, botanics, vitamins and seed protectants in equal volume of seed to solution ratio for a duration of 6-24 hours depending on the crop to raise the moisture content of the seed to 20-25 per cent, just enough for endogenous impregnation of the chemicals by exogenous application. The choice of chemicals, its concentrations and duration of soaking vary with species, but these factors decide the success of the seed depending upon the initial seed quality characters of the seed which are highly variable due the various factors influencing the seed quality characters at field and storage. Seeds are commonly fortified with micronutrients, growth regulators and botanics (eco-friendly) as the response of seed to these bioactive agents are highly invigourative and the materials are easily available.

Nutrients are the alternatives to growth regulators as they are cost effective and the lethality rate will be lesser at supra optimal conditions. In *Jatropha*, Gurunathan (2006) formulated a study to fortify the seeds with micro and macro nutrients in the form of different compounds *viz*., Na_2HPO_4, K_2HPO_4, KCl, KNO_3, $CuSO_4$, KSO_4 and $ZnSO_4$ in two different concentrations of 1 and 2 per cent in 1:1 seed to solution ratio with the soaking durations of 3 and 6 h. and found that seed soaking in Na_2HPO_4 at 2 per cent for 6 h enhanced the nursery emergence by 25 per cent and also seedling quality characters at raised bed nursery (Table 1).

Table 1. Inorganic nutrients on seed and seedling quality characters at nursery

Treatment (C) Characters		Seedling percent (%)			Vigour index (1)		
Soaking duration hours (D)		3	6	Mean	3	6	Mean
Na_2HPO_4	1%	64(53.53)	60(50.57)	62(52.05)	1810	1663	1736
	2%	60(50.57)	88(69.44)	71(60.06)	1734	3379	2491
K_2HPO_4	1%	52(46.53)	56(48.44)	54(47.49)	1582	1355	1474
	2%	49(44.42)	69(56.37)	59(50.40)	1412	2028	1717
KCl	1%	75(60.02)	58(49.60)	66(54.81)	1997	1855	1950
	2%	48(44.04)	61(51.16)	55(47.60)	1350	1794	1567
KNO_3	1%	77(61.36)	52(45.95)	64(53.66)	2378	1636	2013
	2%	39(38.83)	73(58.48)	56(48.66)	1270	2381	1823
$CuSO_4$	1%	68(55.76)	49(44.42)	59(50.09)	2141	1181	1626
	2%	53(46.91)	48 (44.04)	39(38.83)	1511	1373	1115
K_2SO_4	1%	73(58.69)	61(51.35)	67(55.02)	2364	1854	2103
	2%	77(61.13)	50(44.81)	53(52.97)	2388	1245	1775
$ZnSO_4$	1%	58(49.60)	67(54.73)	62(52.17)	1613	1717	1670
	2%	51(45.38)	79(62.72)	65(54.05)	1422	2360	1879
Water soaking		65(52.73)	69(56.37)	67(54.55)	1892	2139	2013
Control		63(51.16)	63(53.53)	63(52.35)	1770	1928	1849
Mean		61(51.29)	65(53.82)	63(52.56)	1745	1778	1760
Factors		C	H	CH	C	H	CH
SEd		(0.490)	(0.173)	(0.693)	31.39	11.46	44.39
CD (P=0.05)		0.978	0.346	1.384	62.79	22.92	88.8

** Figures in parentheses are arc sine transformed values*

Gurunathan (2006) also made an attempt to improve the germination of seeds through fortification treatments with growth regulators viz., IBA, BA, kinetin, GA_3, NAA and Riboflavin at different concentrations (100, 200 and 300 ppm) and durations (6, 8, and 12 h) in the seed to solution ratio of 1:1. The results revealed that the nursery performance at raised bed nursery was the highest with the seeds fortified with Riboflavin 100 ppm for 8 h, which was 20 % higher than control seed. But all the treatments at 8h including water found to have an influencive effect not only on the seedling percent (germination) but also on the seedling vigour parameters (root length) as in Table 2.

Table 2. Growth regulators seed and seedling quality characters at nursery

Growth hormones in ppm (G)		Seedling percent (%)				Root length (cm)			
		Soaking duration in hours (H)							
		6	8	12	Mean	6	8	12	Mean
IBA	100	65(54.33)	79(62.73)	78(62.05)	74(59.70)	16.0	15.0	14.0	15.0
	200	86(68.02)	80(63.43)	79(62.73)	82(64.73)	17.5	14.5	12.0	14.7
	300	70(56.79)	66(54.33)	56(48.45)	64(53.19)	15.0	12.0	10.5	12.5
BA	100	81(64.90)	80(63.43)	79(62.73)	80(63.57)	15.5	13.5	14.5	14.5
	200	85(67.62)	77(61.00)	78(62.05)	80(63.56)	18.0	17.0	13.5	16.2
	300	62(51.65)	71(57.10)	73(53.69)	68(55.81)	15.0	13.5	13.0	13.8
Kinetin	100	75(59.67)	81(63.79)	85(66.84)	80(63.43)	16.5	17.0	15.0	16.2
	200	77(61.34)	80(63.43)	76(60.67)	78(61.81)	17.0	14.5	13.5	15.0
	300	79(63.08)	74(59.34)	83(65.27)	78(62.56)	18.0	19.0	16.0	17.7
GA_3	100	65(53.13)	67(54.94)	71(57.10)	68(55.06)	19.0	14.5	14.5	16.0
	200	81(63.79)	71(57.41)	73(58.69)	75(59.96)	21.0	17.0	14.5	17.5
	300	68(55.55)	69(56.17)	70(57.10)	69(56.17)	19.5	14.0	12.5	15.3
Riboflavin	100	86(68.02)	90(71.56)	85(66.81)	87(68.80)	20.5	19.0	11.0	16.8
	200	65(54.33)	86(68.02)	74(59.67)	75(60.67)	18.0	19.0	18.0	18.3
	300	62(51.65)	84(66.03)	62(51.95)	69(56.54)	14.0	15.5	13.5	14.3
Water soaked		70(56.79)	69(56.17)	65(54.33)	68(55.81)	13.4	12.8	10.2	12.1
Control		64(53.19)	64(53.19)	64(53.19)	64(53.19)	12.6	12.6	12.6	12.6
Mean		73(58.69)	75(59.67)	74(59.34)	74(59.34)	16.9	15.3	13.5	15.2
Factor		G	H	GH		G	H	GH	
SEd		(0.471)	(0.211)	0.816		0.758	0.339	1.312	
CD (P=0.05)		(0.948)	(0.424)	1.643		1.526	0.682	2.643	

He also fortified the seed with botanical leaf extracts *viz., Sandalum album* (Sandal), *Cynodon dactylon* (Arrugampul), *Prosopis julifera* (Mesquite), *Calotrophis gigantica,* (Calotrophis), *Coleus forskoli* (Karpuravalli), *Vitex negundo* (Notchi), *Eucalyptus tereticornis* (Eucalypts), *Cassia ariculata,* (Aavaram), *Ocimum sanctum* (Tulsi), *Azadiracta indica,* (Neem), *Jatropha curcus* (Physic nut), *Simaruba glauca* (Paradise tree), *Cleodendron inerma, Adathoda* vasica (Adathoda) and *Rauwolfia serpentine* for 6 h with different concentration (1%, 2%, 3% and 4%) as a means of ecofriendly seed treatment and found that seed soaking in for 2 per cent notchi leaf extract for 6 h enhanced the seed and seedling quality characters. (Table 3).

Table 3: Influence of seed fortification treatment with leaf extracts on seed and seedling quality characteristics of nursery

Botanicals		Seedling percent (%)	Root length (cm)	Shoot length (cm)	Hypo-cotyl length (cm)	Dry matter production 10 seedling^{-1}(g)
Control		58(49.41)	8.1	27.2	14.4	7.27
Water soaking		62(52.14)	8.5	29.5	15.8	7.95
Santalum album	1%	46(42.52)	6.2	31.0	16.3	6.63
	2%	69(56.17)	8.2	30.4	14.0	8.23
	3%	56(48.64)	8.3	30.7	14.7	5.93
	4%	52(45.96)	7.4	29.9	12.5	5.93
Cynodon dactylon	1%	57(48.83)	9.8	30.9	15.0	7.93
	2%	34(35.67)	10.0	30.9	15.7	6.60
	3%	33(35.06)	7.9	28.5	16.7	6.33
	4%	22(28.20)	7.2	25.2	14.2	5.33
Prosopis julifera	1%	53(46.53)	6.1	31.2	16.0	8.40
	2%	63(52.34)	6.4	32.2	15.3	8.57
	3%	34(35.46)	5.4	30.4	13.7	4.63
	4%	46(42.52)	4.2	31.6	15.0	8.37

Calotrophis	1%	62(52.14)	7.9	34.1	15.0	8.30
gigantica	2%	75(59.78)	12.2	31.4	17.0	5.47
	3%	52(45.96)	6.4	29.3	14.8	5.13
	4%	44(41.75)	5.1	29.6	15.8	9.43
Coleus	1%	40(39.03)	9.2	31.2	15.8	8.57
aromaticus	2%	57(49.02)	10.1	30.2	18.0	8.03
	3%	57(48.830	9.8	30.1	17.7	11.20
	4%	63(52.34)	11.0	30.3	15.7	8.33
Vitex	1%	61(51.16)	8.5	27.3	12.2	7.50
negundo	2%	87(69.19)	10.2	30.4	15.1	10.93
	3%	63(52.34)	7.2	29.1	14.7	4.90
	4%	46(42.51)	6.2	29.3	12.7	3.17
Eucalyptus	1%	72(58.05)	9.2	30.6	15.0	5.63
tereticornis	2%	45(42.13)	6.8	22.5	14.7	8.83
	3%	46(42.51)	7.0	33.1	14.6	10.67
	4%	44(41.74)	7.1	30.4	15.3	7.33
Cassia	1%	56(48.45)	7.1	28.5	15.7	8.40
Ariculata	2%	52(46.33)	7.2	33.2	15.0	10.50
	3%	44(41.74)	6.9	27.5	12.3	13.30
	4%	27(31.08)	6.2	30.6	13.0	7.37
Ocimum	1%	58(49.41)	6.0	28.9	15.5	9.00
sanctum	2%	80(63.20)	9.1	30.3	13.8	15.20
	3%	62(52.14)	8.5	28.7	13.2	10.53
	4%	46(42.51)	5.7	28.7	13.2	7.00
Azadiracta	1%	23(28.43)	5.2	30.5	13.0	6.67
indica	2%	56(48.64)	6.2	27.5	13.2	4.77
	3%	67(55.15)	6.4	30.4	14.2	4.70
	4%	34(35.86)	5.7	28.5	15.3	14.47
Jatropha	1%	45(42.32)	7.2	27.3	14.0	8.23
curcus	2%	51(45.57)	7.3	32.0	15.7	10.27
	3%	66(54.55)	8.2	30.1	13.5	9.33
	4%	40(39.03)	6.8	29.7	13.7	7.33

Simarouba glauca	1%	69(56.17)	9.8	31.9	13.5	6.63
	2%	63(52.73)	7.4	27.9	12.8	7.00
	3%	53(46.53)	6.1	29.9	13.5	7.83
	4%	40(39.03)	5.5	34.9	15.2	6.40
Cleodendron inerma	1%	57(49.02)	8.1	32.3	14.8	6.73
	2%	57(48.83)	7.5	32.4	15.3	7.20
	3%	57(49.21)	7.2	33.3	15.7	4.70
	4%	63(52.53)	8.3	34.4	20.3	11.50
Adathoda vasica	1%	80(63.67)	8.1	31.5	17.3	8.80
	2%	58(49.41)	7.4	30.3	15.0	5.20
	3%	44(41.74)	7.1	30.1	13.8	8.53
	4%	45(41.93)	7.2	28.5	14.2	5.23
Rauwolfia serpentina	1%	45(41.93)	6.8	31.6	16.2	8.27
	2%	58(49.60)	7.3	28.4	16.3	8.50
	3%	52(45.95)	7.0	28.3	13.5	9.97
	4%	40(39.03)	7.1	30.1	16.2	10.90
SEd		(0.365)	0.137	1.408	0.530	0.028
CD (0.05)		(0.724)	0.272	2.788	1.052	0.056

* Figures in parentheses are arc sine transformed values

5. Seed Infusion

It is another method of impregnation of seed with bioactive chemicals through organic solvents instead of water. This technique of infusion helps to avoid the damage caused to the seed due to water soaking, hence highly suitable to seeds that suffer with soaking / seed coat injury. Simultaneously it also provides protective, regulatory and selective functions of the chemicals to improve the performance of seed with the help of organic solvents.

In seed infusion technique desired solutes are dissolved in the organic solvent at desired concentration. Seeds are immersed in solvent with desired solute for 5 to 24 hrs depending on species. After the desired period the solvent is evaporated by air and by vacuum desiccator for 30 minutes to 1 hour or under ambient condition for 24 hours for complete expiry of solvent from the seed. Then the seeds are taken for sowing. Organic solvents used for infusion are acetone, petroleum ether, dichloromethane, ethanol and dichloroethane.

The depth and amount of chemical penetrated into the seed vary with duration of treatment (amount of chemical reached the embryo increases with increase in time) concentration of solutes (higher the concentration more will be the penetration) and type of chemical. For example compared to IAA, GA reaches the embryo lesser in quantity in a given time due the higher molecular weight of GA_3. In *Jatropha*, Anon (2006) conducted preliminary studies on seed infusion technique and found acetone as good solvent that could be used for infusing the chemicals into the seed, in addition it was also found soaking of seed in IBA5ppm for 5 minutes improved the germination of seed by 10 per cent, but the study insist on the need of confirmation with fresh samples for finalization.

6. Seed Priming

Seed priming is the treatment in which the seeds are physiologically conditioned to face the given environment in the field when it is sown specially the water deficit condition by making the seed hardier for further growth at various stress condition. The initiation of radical emergence through the endosperm is the most sensitive in reduced water potential of the soil. Priming involves the hydration of seeds in an osmotic and other bioactive solution that permits the preliminary process of germination, but final phase of radical emergence will not be altered. Osmotic conditioning begins when a seed is hydrated in low water potential osmotic solution. After the moisture equilibrium is achieved, further uptake of water by the seed is prevented. Osmo conditioning can be effectively achieved by adjusting the concentration of osmoticum in the conditioning solution to a level just preventing germination.

Chemicals used for priming are. PEG 6000, Mannitol, NaCl, KH2 SO4, Glycerol, KNO3 and Mg SO4. The factors influencing the efficacy of priming treatment are concentration of osmoticants, duration of treatment, temperature and light intensity, manner and extent of drying and type of seed and its response to priming /osmo conditioning.

7. Method of Osmopriming

Large seeded legume seeds soaked in 20-30% of PEG 6000 solution with or without other chemicals or with the chemicals alone and the seeds are incubated at 10-30°C for 12-96h. Then seeds are washed with distilled water and air dried at 25°C. Then primed seeds can be used for sowing. The amount of water entering the seed during conditioning may vary depending upon whether the concentration of the salt (or) a non-penetrating organic molecule used as a matrix. The osmotic potential of conditioning solutions in generally kept at -0.8 to 01.6 Mpa and seed conditioning is best achieved in the light for seeds in which germination is under phytochrome control. Mechanisms involved in priming for improving germination are enhanced metabolic activity and respiration rates, activation of enzymes involved in metabolism of seed reserves, improved capacity for synthesis of RNA and protein and increased accumulation of ATP, restoration of membrane integrity and membrane repair or synthesis and reduction of growth inhibitory substances such as ABA.

In short, priming is the physiological preconditioning of seed with controlled seed imbibition. Gurunathan (2006) initiated a study in *Jatropha*, to standardize the priming treatment using various bioactive chemicals viz., IBA, BA, (100, 200, 300 ppm) NAA (100, 200 ppm) and inorganic chemicals viz., KNO_3 (1% and 2%), and KCl (1% and 2%) for a duration of 12 h and 24 h at 15^0C (dark) and at ambient condition in the seed to solution ratio of 3:2 at raised bed nursery. Based on the seed and seedling quality characters, the results revealed that seed priming with IBA 200 ppm at ambient temperature for 12 or 24 h enhanced the nursery performance of the seed, while priming at low temperature was injurious to seed quality improvement. (Table3).

Table 3. Influence of seed priming at different temperatures on seed and seedling quality characteristics of nursery

Treatments(C)		Seedling percent(%)						
		Priming Temperature(T)						
		Ambient			15 ºC			
		Priming duration in hours(H)						
		12h	24h	Mean	12h	24h	Mean	Grand Mean
IBA	100 ppm	74 (59.35)	74 (59.18)	74 (59.27)	65 (53.85)	59 (50.37)	62 (54.25)	68 (56.76)
	200 ppm	87 (69.04)	87 (69.19)	87 (69.11)	34 (35.73)	45 (42.25)	40 (35.73)	63 (52.42)
	300 ppm	70 (56.99)	80 (63.42)	75 (60.20)	20 (26.80)	43 (40.98)	32 (33.89)	53 (47.05)
BA	100 ppm	73 (58.97)	70 (56.99)	72 (57.98)	53 (46.97)	77 (61.35)	65 (54.16)	69(56.07)
	200 ppm	83 (65.72)	78 (62.03)	81 (63.88)	42 (40.59)	75 (60.20)	64 (54.40)	67 (55.14)
	300 ppm	73 (58.75)	70 (56.57)	71 (57.66)	36 (36.80)	54 (47.35)	45 (42.08)	58 (49.87)
NAA	100 ppm	73 (58.97)	79 (62.73)	76 (60.81)	20 (26.80)	50 (45.19)	35 (36.00)	56 (48.40)
	200 ppm	80 (63.18)	83 (65.48)	81 (63.88)	46 (42.83)	54 (47.16)	50 (45.00)	66 (54.44)
KNO_3	1%	77 (61.25)	70 (56.58)	73 (57.66)	46 (42.63)	53 (46.97)	50 (44.80)	61 (51.23)
	2%	66 (54.25)	36 (36.99)	51 (45.62)	59 (50.37)	40 (39.22)	50 (44.80)	50 (45.21)
KCl	1%	76 (60.80)	72 (58.11)	74 (59.46)	53 (46.58)	67 (54.66)	60 (60.62)	67 (55.04)

	2%	46 (42.63)	37(37.66)	42(40.15)	40(39.03)	34(35.73)	37(37.38)	39(38.77)
Water soaked		75 (59.78)	69 (55.98)	72 (57.88)	54 (47.10)	50 (45.00)	52 (46.05)	62 (51.97)
Control		70 (56.99)	66 (54.25)	68 (55.67)	36 (36.80)	34 (35.73)	35 (36.00)	52 (46.05)
Mean		73 (58.97)	69 (55.98)	71 (57.34)	43 (41.08)	53 (46.58)	48 (44.08)	60 (50.13)
Duration Mean		58 (49.87)	61 (51.23)					

Factors	C	T	H	CT	TH	CH	CTH
SEd	(0.382)	(0.150)	(0.150)	(0.541)	(0.212)	(0.541)	(0.765)
CD (P=0.05)	(0.759)	(0.297)	(0.297)	(1.074)	(0.421)	(1.074)	(1.519)

Chemicals(C)		Root length(cm)						
		Priming Temperature(T)						
		Ambient			15^0 C			
		Priming duration in hours(H)						
		12h	24h	Mean	12h	24h	Mean	Grand Mean
IBA	100 ppm	18.7	17.7	18.2	14.7	12.0	13.3	15.8
	200 ppm	20.5	23.1	21.8	8.7	10.0	9.3	15.6
	300 ppm	16.8	18.7	17.8	9.0	9.8	9.4	13.6
BA	100 ppm	17.3	16.2	16.8	13.3	18.2	15.8	16.3
	200 ppm	18.7	16.7	17.7	10.2	19.0	14.6	16.2
	300 ppm	16.2	15.0	15.6	8.2	14.3	11.3	13.4
NAA	100 ppm	16.5	16.7	16.6	5.8	14.9	10.4	13.5
	200 ppm	18.2	21.0	19.6	8.7	13.0	10.8	15.2

KNO3	1% 2%	18.3 16.5	16.7 14.0	17.5 15.2	8.4 10.4	14.0 7.7	11.2 9.0	14.4 12.1
KCl	1% 2%	17.8 10.4	15.7 9.6	16.8 10.0	9.7 11.1	13.3 8.1	11.5 9.6	14.1 9.8
Water soaked		12.5	12.2	12.3	10.8	9.8	9.0	11.1
Control		10.5	11.7	11.1	8.3	7.8	8.1	9.6
Mean		16.4	16.1	16.2	9.8	12.3	11.0	13.6
Duration Mean		13.1	14.2					

Factors	C	T	H	CT	TH	CH	CTH
SEd	0.346	0.136	0.136	0.49	0.192	0.49	0.693
CD (P=0.05)	0.688	0.269	0.269	0.973	0.381	0.973	1.376

Shoot length (cm)								
IBA	100 ppm 200 ppm 300 ppm	26.7 27.7 26.3	28.7 29.2 33.7	27.7 28.4 30.0	24.2 20.7 19.8	23.2 21.0 20.4	23.2 21.0 20.4	25.4 24.7 25.2
BA	100 ppm 200 ppm 300 ppm	27.2 27.7 25.5	27.8 30.3 29.2	27.5 29.0 27.3	21.2 21.2 19.9	23.1 24.6 20.8	23.1 24.6 20.8	25.3 26.8 24.1
NAA	100 ppm 200 ppm	24.2 26.2	28.2 27.7	26.2 26.9	18.5 17.9	20.2 20.2	20.2 20.2	23.2 23.6
KNO3	1% 2%	28.5 27.3	30.5 25.5	29.5 26.4	21.0 17.7	21.9 16.3	21.9 16.3	25.7 21.4
KCl	1% 2%	27.5 25.0	28.5 27.7	28.0 26.3	17.9 20.0	19.5 18.0	19.5 18.0	23.7 22.2

Water soaked	27.7	25.3	26.5	21.3	20.1	20.1	23.3
Control	25.4	23.5	24.5	16.5	14.6	15.6	20.1
Mean	26.6	28.3	27.4	19.8	20.3	20.4	23.9
Duration Mean	23.2	24.3					

Factors	C	T	H	CT	TH	CH	CTH
SED	0.397	0.155	0.155	0.561	0.220	0.561	0.794

8. Seed Pelleting

Seed pelleting is another physical seed treatment in the seed is enclosed with foreign material to obtain a standard size and it has its own influence on the micro environment of the seed and influences on seedling grown at seed soil interface.

Pelleting process can be broadly classified into three as Stamping, Coating, and Rolling. Seeds are first mixed with adhesives and then coated with filler materials on rolling for uniformity. Materials used in pelleting are (a) Adhesives (b) Coating materials and (c) Bioactive chemicals.

Adhesives are nothing but glues or binders or stickers that are used as media to fix the coating material on the seed coat so as to increases its size and weight or to improve the *Ballistic* property of seed. Use of water alone without adhesives may lead to fragile coats that are extremely prone to dusting and cracking and subsequently to the loss of active ingredient. The physical integrity of the coated seed is given by this adhesive, which is important in any handling, transport and planting operations. The Common adhesives are gum Arabic, methylcellulose, gelatin, casein and caseinae salts. Carboxyl Methyl Cellulose (CMC) is widely used due to the ease of availability, low cost and low rate. CMC 3% (w/v), Methyl ethyl cellulose 5% (w/v) and Gum arabic up to 45% are commonly used.

Properties of adhesives for selection are: -

- Must have affinity (combinability) for both seed coat and selected filter material.
- Should have the required degree of water solubility or insolubility for easy emergence.
- Should have the required strength and plasticity to prevent dusting and breakage.
- Should have the most appropriate viscosity for easy application.

Coating materials or the filter materials commonly used are Lime, gypsum, dolomite or rock phosphate and charcoal are the filler materials commonly used for pelleting. The selection criteria for coating materials or the filler materials are:

- Must be porous to allow movement of air to the seed.
- The coating must weaken or break down easily when it comes in contact with soil moisture to prevent any physical impedance.
- Should be non-toxic to seeds.
- Able to apply on commercial basis
- Size of the particle should be pass through 300-mesh sieve.

Organic materials are also used for ecofriendly pelleting as below since these protect the rhizobia, on the seed and are called as nutrient pellets. The size of the organic materials should pass through 150-mesh sieve

- Dried blood: 15 parts in 85 parts of dolomite
- Milk power: 3 parts of 97 parts dolomite
- Yeast extract: 1 part of 99 parts of dolomite

. In addition such as leaf powders of neem, arappu, notchi and pungam trees are used for pelleting.

As revealed elsewhere seed pelleting is a physical treatment given to seed to invigourate the seedling vigour by enriching the rhizosphere with needy substance.

Gurunathan (2006) pelleted the *Jatropha* seeds with various filler materials viz., pungam (*Pongamia pinnata*), arappu (*Albizia amara*), mesquite (*Prosopis juliflora),* neem (*Azadirachta indica*), notchi (*Vitex negundo*) (@ 300 g kg^1 of seed) leaf powders, biocontrol agents viz., *Pseudomonas, Trichoderma,* (@50g kg^1 of seed) *Psedudomonas* + *Trichoderma* (@25+25g kg^1 of seed respectively), coffee fruit pulp powder, activated charcoal powder (@100g kg^1 of seed), biofertilizers viz., VAM (Vesicular Arbisicular Mycorhiza), *Phosopho-bacterium, Azospirllium,* and azophos, (@100g kg^1 of seed using ten per cent maida as common adhesive (200 ml/kg) and were dried in shade to 9 per cent moisture content and sowed the seeds in raised bed nursery. The seeds were also stored at ambient conditions and evaluated for their storability after 6 months in storage. The results of the nursery study revealed that seed pelleting with *Azospirllium* @ 100g kg^1 of seed followed by pungam leaf powder @ 300g kg^{-1} seed maximized the nursery emergence and seedling vigour both immediately after treatment and after storage. (Table 4 and 5).

Table 4. seed pelleting on seed and seedling quality characters at nursery

Treatment Characters	Seedling per cent (%)	Root length (cm)	Shoot length (cm)	Hypocotyl length (cm)	Dry matter production 10 seedling^{-1} (g)
Control	63 (52.70)	6.7	19.4	11.2	6.17
Pungam	84 (66.58)	15.2	28.3	21.2	19.13
Arappu	63 (52.70)	10.3	20.6	11.8	19.60
Prosopis	73 (58.25)	8.4	24.5	11.5	18.10
Neem	73 (57.58)	4.4	25.1	12.3	14.17

Notchi	75 (59.72)	8.7	27.5	12.1	13.00
Pseudomonas	72 (58.70)	6.0	24.5	12.5	13.27
Trichoderma	75 (59.05)	9.2	25.0	12.5	18.47
Pseudomonas + *Trichoderma*	66 (56.32)	8.6	20.1	10.2	13.23
Coffee fruit pulp powder	82 (61.01)	9.1	21.3	18.1	11.73
Activated charcoal	77 (62.97)	11.4	24.1	12.4	11.63
VAM	77 (60.65)	9.4	24.5	19.7	8.50
Phosophobacterium	73 (60.02)	11.5	24.7	13.0	12.57
Azosprillium	84 (64.29)	8.1	27.1	13.4	12.70
Azophos	66 (56.49)	9.6	22.9	11.0	20.33

SEd	(2.272)	0.285	0.381	0.340	0.035
CD (P=0.05)	(4.642)	0.574	0.776	0.700	0.072

Figures in parentheses are arc sine transformed values

Table 5. Performance of pelleted seed after six months of storage

Treatment Characters	Seedling percent (%)	Root length (cm)	Shoot length (cm)	Hypocotyl length (cm)	Dry matter production 10 seed-ling^{-1} (g)
Control	**13 (20.81)**	5.8	19.2	10.9	6.43
Pungam	69 (56.33)	12.4	26.2	21.1	17.30
Arappu	28 (31.70)	12.1	16	10.3	17.50
Prosopis	41 (40.20)	7.4	21.7	9.7	16.37
Neem	49 (44.16)	6.2	24.2	11.5	14.67
Notchi	42 (40.56)	7.6	22.5	12.3	12.43
Pseudomonas	42 (47.86)	5.1	20.6	12.4	11.90

Trichoderma	55 (47.51)	5.2	21.3	11.4	16.53
Pseudomonas + Trichoderma	55 (46.97)	6.3	10.4	9.4	11.97
Coffee fruit pulp waste	56 (50.99)	7.3	19.4	17.6	10.80
Activated charcoal	63 (52.45)	8.8	23	17.5	12.50
VAM	63 (52.45)	9.1	24.2	16.3	10.83
Phosophobac-terium	42 (40.20)	9.3	23.4	12.4	11.53
Azosprillium	56 (48.62)	6.5	27.5	13.0	11.13
Azophos	48 (31.90)	6.5	23.6	11.5	18.50

SEd	0.742	0.182	0.525	0.354	0.041
CD (P=0.05)	1.511	0.364	1.055	0.716	0.092

* *Figures in parentheses are arc sine transformed values*

Likewise various seed treatment could be imposed on the seed for invigourating the seed for productivity in terms of economic output of *Jatropha* the seed yield. The advantages of these seed treatment are: -

- Is simple technique, easy to operate on large quantities of seed.
- Performance would be better and proved in many agricultural crops.
- Can be used for incorporating all chemicals into seed since it dissolves all chemicals easily.
- The treatment durations are short and drying back is an easy process. Normally hazards of drying did not occur.
- Rate of seed deterioration is also controlled by these treatments.
- Bioactive chemicals are made available to the embryo directly
- Increased germination

- Resistance against adverse environment such as sub optimal and supra optimal temperature stresses.
- Better and uniform field establishment.
- Helpful in precision planting in mechanized farming.
- Seeds with free wing enable aerial seeding.
- Small seed and irregular shaped seeds are made easy to handle.
- Accurate dosing of seed with chemical is possible.
- Wastage of chemical is prevented.
- Pelleting acts as inoculant, protective, nutrient and hydrophilic.
- Lime pelleting of seed; protect the multiplication of rhizobia in the rhizosphere of acid soils.
- Stress conditions can be overcome by pelleting even in low water holding capacity.

Method of sowing

In addition to equipping the seed with streamlined focus with various seed management techniques, sowing the seed in appropriate method too is equally important for successful regeneration of seed with expected output. The main factors influencing the method of sowing are the depth of sowing and orientation of seed at sowing based on the position of radical. Gurunathan (2006) conducted studies on orientation of seeds based on caruncle position as caruncle upwards, caruncle downwards and flat (caruncle sidewards) in different depths viz., 2 cm, 4 cm, 6 cm at polypot nursery revealed that sowing the seeds as caruncle downwards enhanced germination to 80 per cent at 2 cm depth with better vigour characteristics. But at 4 cm higher germination was obtained with seeds positioned as flat (71 %) and at 6 cm the seeds kept as caruncle upwards recorded the highest germination of 69 per cent (Table 6).

Table 5. Influence of seed orientation and depth of sowing on nursery performance

Depth (D)	Position of caruncle (P)	Seedling percent (%)		Stem collar diameter (cm)		No of leaves seedling^{-1}		No. of roots seedling^{-1}	
		Nursery period (months)							
		1	3	1	3	1	3	1	3
2 cm	Down	80 (63.51)	77 (61.12)	1.16	1.72	8.0	11.7	6	6
	Up	43 (40.97)	36 (37.12)	0.94	1.28	5.0	7.7	5	5
	Flat	55 (48.06)	47 (43.39)	1.01	1.31	5.0	8.0	5	5
	Mean	59 (33.65)	53 (47.21)	1.15	1.42	6.5	10.0	5	5
4 cm	Down	68 (55.79)	62 (51.94)	1.17	1.53	7.0	10.0	6	6
	Up	73 (58.48)	66 (54.33)	1.17	1.67	7.2	10.2	6	6
	Flat	77 (61.11)	72 (58.26)	1.00	1.26	6.0	10.0	5	5
	Mean	73 (58.48)	67 (54.87)	1.25	1.62	6.4	9.0	6	6
6 cm	Down	55 (48.06)	48 (43.66)	1.02	1.34	6.0	9.6	6	6
	Up	71 (57.42)	69 (55.96)	1.16	1.72	8.0	11.7	6	6
	Flat	69 (55.96)	62 (51.94)	0.94	1.28	5.0	7.7	5	5
	Mean	65 (53.81)	60 (50.53)	1.01	1.31	5.0	8.0	5	5
(P) Mean	Down	68 (55.79)	62 (52.27)	1.1	1.5	7.0	10.4	6	6
	Up	64 (53.17)	59 (50.45)	1.1	1.6	6.7	9.9	6	6
	Flat	66 (54.17)	58 (49.87)	1.0	1.3	5.3	8.6	5	5
SEd	D	(0.535)	(0.334)	0.032	0.035	0.058	0.133	0.157	0.157
	P	(0.535)	(0.334)	0.032	0.035	0.058	0.133	0.157	0.157
	DP	(0.927)	(0.578)	0.056	0.061	0.100	0.230	0.272	0.272
CD (P=0.05)	D	(1.125)	(0.702)	0.067	0.074	0.122	0.280	0.330	0.330
	P	(1.125)	(0.702)	NS	NS	0.122	0.280	NS	NS
	DP	(1.948)	(1.216)	0.117	0.128	0.211	0.485	0.571	0.571

10. Conclusions

Seed management is an inevitable practice for successful crop/tree production. To achieve uniformity and synchrony of growth of plant, presowing seed management system must be followed sequentially depending on the requirement. Seed fortification with fortifying nutrients and growth regulator are the primary steps of presowing seed treatment. To get an active and efficient uniform growth of seedlings and plants, seed pelleting technique may give wonderful effect. Stress management in the field upon drought can be managed by seed hardening and seed infusion techniques. Hence adoption of presowing seed management techniques before tree planting even in *Jatropha* should be adopted properly for effective results but requires repeated studies for reproducible confirmed results.

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Quality Planting Material and Seed Standards in *Jatropha curcas*

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1. Introduction

Increasing population density and the additional decline in availability of productive land due to degradation would further fuel the large-scale migration of people into the already overpopulated metropolis in Asia and Africa in future, unless urgent corrective measures are adopted to increase rural incomes and generate new perspectives in the weaker regions. Economic development in many developing countries has led to huge increases in the energy demand. As most of the countries now enjoying rapid development (China and India e.g. –both countries already rank among the top 5 net CO_2 emitters in the world) are also large petroleum importers, their dependence on external energy sources from highly unstable regions would increase to uncomfortable levels. Energy security has thus become a key issue for many countries.

India produces about 25% and imports 75% of its oil requirement. India is the least explored region for oil. India's import bill is about 100,000 crore per annum and consumption is about 2% of world's oil. Moreover, due to uncertain supplies and fluctuations in prices for fossil fuel in international market, the need to search renewable, safe and non-polluting sources of energy assumes top priority. Non-edible oil bearing trees like *Jatropha* and karanja can be utilized either as biofuel or with processing. The use of these trees on wastelands is of vital importance for the human population in developing countries. Biodiesel has drawn attention because it is environmentally safe can be made from renewable sources and prepared locally. Since India is deficient in edible oils, the non-edible oil like karanja, *Jatropha*, etc could be the desirable source for India for production of bio diesel. These plants could be grown on wasteland, about 80 million hectare of which is available in India. These crops grow in arid and semi-arid region and require almost no post plantation management and care. Since, almost all the wasteland is available in rural and economically underdeveloped region, the large-scale bio diesel production has an enormous potential for employment and development of these areas.

Jatropha is a perennial tree living for 40 to 50 years or more depending upon local conditions. The *Jatropha* takes about 2 to 3 years to commence fruiting and another 2 years or more to come to the stage of full bearing. Thus, only after 4 or 5 years will the grower be in a position to reap the reward for his labours. If the original planting material used happens to be poor in quality, it will result in the establishment of a plantation giving poor yields and turn out to be a source of loss to the grower as long as the plantation lasts. He has no other option but to uproot the unproductive and uneconomic trees. These facts will underline the need to plant quality planting material that will ultimately give good yields. The *Jatropha* is capable of being propagated by seed and cuttings. As tree is cross-pollinated in nature, the progeny is likely to be variable, but certain precautions, if observed, are found to help in the production of quality planting material.

2. Quality Planting Material

- *Genetic uniformity: Jatropha* is propagated through seeds and cuttings. Since the crop is highly cross pollinated, seeds collected from the wild will not be genetically uniform.
- *Region-specific selection:* When supplying the planting material, the adaptability of the selection should be taken in to consideration.

- *Seed viability and germ inability:* The seed vigour and the seed viability should be tested before sowing.

- *Diseases:* The material should be free from insets and pests.

- *Seed certification methodology:* There is a need to evolve a clear protocol so that seed certification agencies are entrusted with the purity and quality certification of *Jatropha* seeds.

- *Seed yield potential and oil content*: The high yielding genotypes with more oil content should be used. There is need to develop strategies and facilities to check the seed yielding potential and oil content of the seeds by taking proper samples of the seed lots. The following are the steps to be taken in this connection
  (a) Selection of mother trees/plus trees
  (b) Selection of Provenances
  (c) Collection of fruits/capsules

3. Selection of Mother Trees/Plus Trees

The plus tree should be selected based on morphometric characters such as fruit size, number of fruits per cluster, crown spread of the tree, free from pest and diseases, yield and oil content. Collection of seed and cuttings should be done from these superior genotypes.

3.1 Selection of Provenances

- Only those with a record of consistently high yields and containing a high proportion of heavy bearers and situated under average conditions without heavy manuring or irrigation and free from the incidence of pests and diseases are to be chosen.

- *Jatropha* being a cross-pollinated crop, the precaution is necessary to ensure that there is a greater chance of the female flowers of such plants being pollinated by pollen from heavy yielders.
- The fruits developing as a result of such pollination have a somewhat greater chance of producing superior progeny than others.

3.2 Collection of fruits

Time of Harvest of Fruits

- The proper time for the harvest of fruit is likely to vary according to the seasonal conditions of the locality.
- The considerations that weigh in this connection are the general development of fruits, their capacity for germination, the period of storage required and the facilities for planting in the nursery.
- The fruits to be utilised for seed purpose are generally harvested only when they are fully mature, i.e., yellow or black in colour. The green fruits should be discarded.
- There was no difference in the performance of seedlings derived from the two groups.

Method of Harvest

- For seed purpose the fruits should be harvested from the tree. The fruits fallen on the ground should be avoided.

Selection of Fruits

- In addition to taking all precautions in the selection of mother trees and observing other factors mentioned previously, some sort of selection has to be done among the fruits also.
- This is necessary because some bunches the development of fruits, particularly of those situated towards the top and bottom extremities of the bunch, is not always uniform.
- Undersized and light seed should be rejected.
- Such seeds do not germinate properly and have to be rejected.

Storage of Seeds

- The seeds after harvest are not immediately planted in the nursery, but are generally stored in shade for about 3-4 months.
- *Jatropha* seeds can be stored easily in shade for 6 months.
- Storage had no bad effect on the viability of seeds or the quality of seedlings.

The best quality germplasm (oil content more than 35%) available with different states are presented in Table 1 to Table 11.

Table 1: Oil content of *Jatropha* samples received from SFRI, Jabalpur

Sr. No	*Sample Name*	*Seed Oil %*
1	SGR-27	35.02
2	DWS6	35.15
3	DWS8	35.19
4	Raj- Kaliya khedi-4	35.19
5	DWS16	35.23
6	RAT 4	35.23
7	RAT 6	35.27
8	RAT 17	35.36
9	DWS3	35.40
10	Raj-Borkhedi-3	35.41
11	Raj-Barkhedi-Saranpur	35.45
12	SGR-14	35.50
13	RAT 15	35.51
14	CHP-21	35.57
15	CHP-16	35.60
16	SGR-12	35.62

17	SGR-29	35.66
18	DWS5	35.69
19	SGR-3	35.78
20	Raj-Goda-Kheda-4	35.86
21	Raj-KaliyaKhedi-5	35.87
22	BWN-3	35.90
23	Raj-Kariya-Khera-P-III	35.93
24	Bhopal Sinora I	35.94
25	CHP-7	35.94
26	DWS24	35.99
27	SGR-8	36.20
28	Bhopal Sinora-6	36.22
29	DHR11	36.29
30	RAT 13	36.39
31	SHR IV	36.40
32	DHR14	36.50
33	SHR ICR 3	36.56
34	DMH4	36.67
35	DHR13	36.68
36	DWS7	36.72
37	DWS12	36.73
38	DMH3	36.80
39	Rajghar, Barkheda-2	36.83
40	SHR ICR 2	36.96
41	DHR17	37.06
42	DHR18	37.11
43	Raj-KhariyaKhedaP-I-II	37.24
44	DWS4	37.25
45	DHR7	37.28

46	DWS17	37.28
47	Raj Ghoda PTII	37.34
48	RajGodaKheda5	37.45
49	CHP-15	37.49
50	DHR9	37.53
51	DWS13	37.53
52	DHR5	37.54
53	SGR-11	37.55
54	Bhopal, Ramgarh-I	37.64
55	RajKhajuriIIB	37.73
56	Raj-Khajura-5	38.11
57	SGR-22	37.97
58	SGR-2	37.98
59	Bhopal Barmara-2	38.01
60	DHR4	38.05
61	Bhopal Sinora-5	38.06
62	BhopalBarmora -IV	38.29
63	DWS9	38.40
64	Raj KaliyaKhedaSarampura	38.46
65	Bhopal -2	38.57
66	Raj GhodaKheda I	38.80
67	Bhopal Sinora-4	38.84
68	Raj Khajuri IIA	38.87
69	DMH11	38.92
70	DWS14	39.02
71	DWS10	39.08
72	Bhopal-Sinora II	39.25
73	Raj-Borkheda-5	39.30
74	DHR12	39.49

75	Raj Goda Kheda 3	39.61
76	Raj-Borkhedi-4	39.65
77	BWN 7	40.22
78	DWS21	42.55
79	Raj-Khajura-3	37.20
80	Bhopal Barmara-3	39.80
81	SGR-7	36.53

Table 2. Oil content of *Jatropha* samples received from TFRI, Jabalpur

Sr. No	*Sample Name*	*Seed Oil %*
1	TFRI 27	35.10
2	TFRI 46	35.52
3	TFRI 39	35.78
4	TFRI 20	35.86
5	TFRI 45	35.87
6	TFRI 38	35.99
7	TFRI 11	36.35
8	TFRI 34	36.60
9	TFRI 26	36.63
10	TFRI 3	36.97
11	TFRI 10	36.97
12	TFRI 50	37.49
13	TFRI 24	37.74
14	TFRI 31	37.92
15	TFRI 49	38.04
16	TFRI 4	38.15
17	TFRI 29	38.64

18	TFRI 41	38.68
19	TFRI 9	38.69
20	TFRI 30	38.82
21	TFRI 12	39.73
22	TFRI 22	40.40
23	TFRI 36	41.48

Table 3: Oil content of *Jatropha* samples received from PDKV

Sr. No	*Sample Name*	*Seed Oil %*
1	PDKV20	35.42
2	PDKV14	35.47
3	PDKV21	35.85
4	PDKV23	35.97
5	PDKV30	36.33
6	PDKV 2	36.66
7	PDKV 22	36.83
8	PDKV 3	37.06
9	PDKV24	37.61
10	PDKV28	37.88
11	PDKV 4	38.07
12	PDKV27	38.47
13	PDKV17	38.58
14	PDKV 5	38.67
15	PDKV13	38.84
16	PDKV16	39.99
17	PDKV15	40.53
18	PDKV31	41.16
19	PDKV 6	42.36

Table 4: Oil content of *Jatropha* samples received from MPKV, Rahuri

Sr. No	*Sample Name*	*Seed Oil %*
1	MPKV- J 122	35.71
2	MPKV-J119	36.43
3	MPKV-J110	38.10
4	MPKV-J127	42.96
5	MPKV-J109	35.71
6	MPKV-J124	36.15
7	MPKV-J123	36.00
8	MPKV-J125	36.55
9	MPKV-J103	37.04
10	MPKV-J17	37.83
11	MPKV-J4	35.94
12	MPKV-J3	37.80
13	MPKV-J7	35.34
14	MPKV-J8	37.89
15	MPKV-J11	40.16
16	MPKV-J12	37.50
17	MPKV-J10	41.21
18	MPKV-J8	38.74
19	MPKV-J16	36.20
20	MPKV-J42	40.86
21	MPKV-J66	37.71
22	MPKV-J65	39.13
23	MPKV-J50	37.97
24	MPKV-J29	37.11
25	MPKV-J94	35.88

26	MPKV-J91	39.18
27	MPKV-J93	38.60
28	MPKV-J90	36.91
29	MPKV-J92	38.50
30	MPKV-J88	36.36
31	MPKV-J89	35.21
32	MPKV-J64	35.16
33	MPKV-J55	36.90
34	MPKV-J57	35.76
35	MPKV-J74	38.79
36	MPKV-J58	40.91
37	MPKV-J75	42.70
38	MPKV-J77	40.08
39	MPKV-J60	39.01
40	MPKV-J54	35.85
41	MPKV-J14	38.06

Table 5: Oil content of *Jatropha* samples received from CCSHAU, Bawal

Sr. No	*Sample Name*	*Seed Oil %*
1	BNK 13	37.96
2	BNK 21	38.18
3	BNK 14	38.31
4	BNK 16	38.80

Table 6: Oil content of *Jatropha* samples received from SKAUST, Jammu

Sr. No	*Sample Name*	*Seed Oil %*
1	JIP22	36.47
2	JIP 19	37.59
3	JIP23	38.89
4	JIP 12	39.05

Table 7: Oil content of *Jatropha* samples received from MPUAT, Udaipur

Sr. No	*Sample Name*	*Seed Oil %*
1	MPC-UD-8	35.01
2	MPC-UD-35	35.13
3	BANSI SITE	35.33
4	MPC-UD-30	35.38
5	MPC-UD-16	35.53
6	MPC-UD-22	35.63
7	MPC-UD-03	35.73
8	MPC-UD-36	35.79
9	KUMBHOLGARH	36.03
10	MPC-UD-38	36.05
11	MPC-UD-57	36.19
12	MPC-UD-52	36.26
13	GOGUNDA (HYOLA)	36.35
14	MPC-UD-34	36.64
15	MPC-UD-2	36.73
16	MPC-UD-13	36.77
17	MPC-UD-55	37.52

18	MPC-UD-51	37.95
19	MPC-UD-6	38.06
20	MPC-UD-53	39.40

Table 8: Oil content of *Jatropha* samples received from NRC, Jhansi

Sr. No	*Sample Name*	*Seed Oil %*
1	NRC-J -63	35.15
2	NRC-J -43	35.17
3	NRC-J -48	35.18
4	NRC-J -62	35.34
5	NRC-J -67	35.41
6	NRC-J -52	35.72
7	NRC-J -66	35.86
8	NRC-J -56	36.27
9	NRC-J -55	36.35
10	NRC-J -36	36.61
11	NRC-J -31	36.77
12	NRC-J -35	37.45
13	NRC-J -32	40.31

Table 9: Oil content of *Jatropha* samples received from CSAUT, Kanpur

Sr. No	*Sample Name*	*Seed Oil %*
1	SIT3	36.08
2	SIT1	36.10
3	SIT4	37.27

Table 10: Oil content of *Jatropha* samples received from NDUAT, Faizabad

Sr. No	*Sample Name*	*Seed Oil %*
1	NDUAT-1	42.15

Table 11: Oil content of *Jatropha* samples received from IGAU, Raipur

Sr. No	*Sample Name*	*Seed Oil %*
1	Raipur-Chattis- 3	35.24

4. Seed Standards

Characteristics of a Good Seed

The seed should be sufficiently mature, gathered from a group of individuals, plump and firm, and should sinks in water, fresh or it should have been properly stored, free of insect and disease. Healthy and vigorous seedlings are necessary for good establishment and growth of trees. Selection of seeds and provision of optimum conditions are essential for producing high quality seedlings. Kaushik et al (2003) observed that selection of large seeds ensure production of quality seedlings in nursery (Table 12). Yellow capsules registered superiority over brown and green capsules, means fruits can be harvested at yellow stage. Harvesting the crop earlier than this resulted in poor quality owing to immaturity, and harvesting beyond that did not show further improvement (Table13).

Seed Testing

The success or failure of artificial propagation depends on the quality of seed. So it is necessary that the seed should be tested before use. Seed testing offers two advantages.

Table 12: Effect of seed size on *Jatropha* seedlings

Seed size	*Height (cm)*	*Root length (cm)*	*Collar Diameter (mm)*	*Number of leaves*
Large	46.77	17.60	11.05	20.00
Medium	42.74	14.80	10.80	17.00
Small	35.80	12.80	9.60	16.00

Table 13: Effect of capsule maturity on germination and seedling vigour

Stage of maturity	*Germination (%)*	*Seedling vigour*
47 DAA (Green)	73.00	2365
57 DAA (Yellow)	89.00	4005
67 DAA (Black/brown)	89.00	4038

- It prevents loss of money and effort resulting in failure due to bad seed.
- It helps in finding out the real cause of failure. Seed testing is done with the following objectives:

  a) Determination of genuineness.
  b) Determination of purity.
  c) Determination of seed viability.

  The following tests are generally carried out in *Jatropha*:

- Physical test: As light and hollow seeds are infertile, they can be separated by physical test such as winnowing or submersion in water.

- Chemical test (TTC test)
- Germination test (Standard germination test)

The quality seed available with different institutes with respect to seed weight and germination percentage is listed in Table nos. 14 and 15.

Table 14: List of institutes with good seed in terms of maximum 100-seed weight

Institutes	*100-seed weight (gm)*
IGKV Raipur	77.12
SDAU, SK Nagar	70.5
RRS Bawal	73.2
SKUA and T Jammu	71.88
MPKV Rahuri	91.33
Kanpur	63.00
NRC Jhansi	79.88
PAU Ludhiana	71.00
MPUA and T Udiapur	73.20

Table 15: Accessions having good seed germination (%)

Accessions	*Germination (%)*
BNK 21	73.3
BNK 2	77.3
BNK 6	77.0
BNK 7	74.0
NRCJ 57	100.
NRCJ 32	94.0

NRCJ 66	79.0
NRCJ 40	77.0
PAU 3	47.2
PKVJ-MKV 1	79.0
UTNOOR	74.0
TNMC 22	63.3
TNMC 23	58.0
TFRI II	61.0
MPCDUJ	72.0
MPCUDG	71.0
MPCCHB	79.0
SKNJ 11	55.0

Once the quality material identified/selected then the *Jatropha* multiplication can be done by the following means

- By seed
- Through cuttings
- Clonal propagation/tissue culture

In the absence of quality planting material at the stages of seed or seedling, we will be creating millions of hectares of *Jatropha* plantation with uncertainties largely looming over the future of farmers. We will end up in un-yielding or low seed-yielding plantations, disease susceptible plants in the field, low oil containing seeds from such plantations and so on. Sincere efforts should be made in production of quality planting materials so that the farmer grows *Jatropha curcas* without any hesitation. If the farmers' interests are taken care of, the entire supply chain of seed to bio diesel will be stronger and longer.

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Importance of Raising Elite Planting Material of *Jatropha Curcas* L. for Energy Independence of India

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1. Introduction

The energy challenges of India can be met by tree-borne oilseeds; focused primarily on *Jatropha curcas* L.(Ratanjot) for usage as renewable alternate fuel to petro-diesel. Many agencies including Government and private sector have been making efforts for the promotion and development of biodiesel in the country.

Jatropha is adapted to a wide range of soils and climates. It can grow almost on any type of soil whether sandy, gravelly or saline and thrives even on the poorest stony soils and rock crevices. It is a drought resistant perennial, living up to 50 years. In India *Jatropha curcus* L is found in almost all States and is generally grown as live fence for protection of agricultural fields against damage by livestock as unpalatable to cattle and goats. The tree grows up to a height of 5-6 meters. The seeds are crushed to extract raw oil, a process that also provides organic fertilizer from the husks. *Jatropha* seeds contain about 30-37 % of non-edible oil. *Jatropha* oil is used for making soap, candles, and varnish and as lubricant, hydraulic oil etc. *Jatropha* oil is an environmentally safe, cost-effective, renewable source of non-conventional energy and a substitute for diesel, kerosene and other fuel oils. The oil can be mixed up to 50% and used for tractors and oil engines.

Methods and Material

Four different qualities of seed (*Jateropha curcas*L.) have been collected from different places to carry out the present investigation. All the results have been taken after two years of plantation. This investigations revealed that morphological parameters of *Jatropha* viz. plant height, stem diameter, number of branches, number of fruits per bunch per plant, seed yield (t/ha), seed test weight (g), dry matter (%) seed moisture (%), crude protein (%)and seed oil. The experiment was carried out during 2004 – 2005 at the research plot of Department of Agroforestry, Allahabad Agricultural Institute – Deemed University, Allahabad (U.P.)

2.1 Treatments

Sl. No	Particulars	Treatment
1.	Riva, Madhya Pradesh	T_1
2.	Allahabad, Uttar Pradesh	T_2
3.	Pratapgarh, Uttar Pradesh	T_3
4.	Mirzapur, Uttar Pradesh	T_4

3. Result and Discussion:

3.1. Growth and Development of Plants

It was observed from the experimental findings that the plant height of *Jatropha* was found to be significant. The maximum plant height was recorded in treatment T_1 (1.60m) and minimum plant height was recorded in treatment T_4 (1.10m). It has been observed that if sufficient moisture is provided the vegetative growth will be more.

It has been observed from the Table 1, that the stem diameter of

Jatropha was found to be significant and maximum stem diameter was observed in treatment T_1 (6.60) and minimum was observed in T_4.

Similar trend was again notice in number of branches per plant. The maximum number of branches was observed in treatment T_1 (10.20). There was no significant effect was observed in number of fruits per bunch under different treatment.

Table 1: Performance of seed quality of *Jatropha* curcas L.

Treatments	Plant height (m)	Stem diameters (cm)	No. of Branches per plant	No. Fruits per bunch	Seed yield (t/ha.)	Test weight (g)
T_1	1.60	6.60	10.20	10.70	4.63	670.60
T_2	1.40	5.50	8.05	10.20	3.2	626.40
T_3	1.25	4.65	7.95	10.05	2.34	621.20
T_4	1.10	4.21	5.35	10.35	1.7	584.80
Average	1.34	5.24	9.65	9.93	2.96	625.60
F – test	S	S	S	NS	S	S

S = Significant, N = Non significant

It is evident from that Table 1, that maximum seed yield of *Jatropha* (4.63 t/ha) was recorded in the treatment T_1 which was followed by treatment T_2 while the minimum seed yield of *Jatropha* (1.7 t/ha) was recorded in treatment T_4. It also revels that there was significant difference in test weight due to the seed quality, maximum test weight was recorded in the treatment T_1 (670.6) which was followed by treatment T_2 while the minimum test weight was recorded in treatment T_4.

2.2 Dry matter (%), Seed moisture(%), Crude protein(%), Seed oil(%) of *Jatropha* curcas L.

This investigation revealed that seed characteristics of *Jatropha* viz. dry matter and seed moisture was found to be significant for different quality planting material. The maximum dry matter and seed oil (%) was observed in treatment T_1. There was no significant effect difference on crude protein (%). The maximum oil (%) was recorded in treatment T_1 (35.17) while the minimum oil (%) was recorded in treatment T_4.

Table No. 2 Dry matter, seed moisture (%), crude protein (%) and seed oil (%) of *Jatropha*.

Treatments	Dry matter (%)	Seed moisture (%)	Crude protein (%)	Seed oil (%)
T_1	96.3	3.7	15.27	35.17
T_2	96.0	4.0	16.27	33.2
T_3	95.2	4.8	16.43	33.15
T_4	95.40	4.6	15.45	31.32
Average	95.72	4.28	15.85	33.21
F – test	S	S	NS	S

4. Conclusions

It may be concluded from the experiment based on height, Dry matter, oil (%) and Seed yield that the treatment T_1(Riva, Madhya Pradesh) shown better performance than other seeds collected from different places. Thus there is an urgent need to raise elite planning material before going to the farmers field as it is a perennial plant and plantation will be in the field for 40-50 years.

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Status of Research Activity on *Jatropha Curcas* in Orissa University of Agriculture and Technology

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1. Introduction

Investigations have been taken up at Bhubaneswar since May 2005 with the following objectives :

- Survey and collection of superior plant types (seeds and cuttings)
- Ex situ conservation and evaluation on performance of the collected provenances.
- Standardization of propagation techniques.
- Development of package of practices.
- Agri silvicultural trials with *Jatropha*.
- Creation of superior seed bank for growers and conduct awareness programmes.
- Plant improvement and Hybridization.

1.1 Survey and Collection of Superior Planting Material :

Seeds and stem cuttings have been collected from different sources as detailed below :

Accessions from Orissa	Accessions collected from Network Centres
JSK 1 - 1	Chhatrapati
JSK 2 - 1	Urlikanchan
JSK 2 - 4	Phuleja
JSK 2 – 5	Hansraj
JSK 2 – 6	SKN – 1

JSS 3 – 1	SKN – B
JSA 4 – 1	JH – 4
JSG 5 – 1	IST - 1
Jodhapur Local	
TN – 1	
TN – 2	
TN - 3	

1.2 Ex situ conservation and evaluation

The seeds collected from different provenances were sown in the 4th week of May 2005 in the nursery and seedlings were planted in the Central Research Station of OUAT at Bhubaneswar. Stem cuttings were also planted in the main field during June 2005. Growth observations on the one year old plants are in progress.

1.3 Standardization of propagation techniques

Experiments on seed treatment and stem cutting treatment have been initiated during May 2006 with the objective to standardize the propagation technique.

1.4 Development of package of practices

The following experiments have been designed to develop a package of practice for commercial cultivation of *Jatropha curcas* in Orissa.

- Studies on standardizing the date of planting and age of seedling for successful performance in Orissa.

- Studies on maximizing fruit production through crown management in *Jatropha curcas*.

- Studies on the response of *Jatropha curcas* provenances to graded levels of nutrient application.

1.5 Agri-silvicultural trials with *Jatropha*

A trial on *Jatropha curcas* provenances under agri-silvicultural system has been started from June 2006 and will continue till profitable growing of intercrop under *Jatropha curcas* is feasible.

1.6 Creation of superior seed bank for growers and conduct awareness programmes

The provenances have been raised under SSO and CSO for production of superior quality seeds to the growers. Awareness programme has been launched during the current year through publication of popular article on TBOS with special reference to *Jatropha curcas* All India Radio and Door Darshan have been approached to broadcast/telecast programmes on TBOS and biodiesel plants for the benefit of cultivators. Training Associates (Forestry) in KVKs of the University have been advised to conduct training programmes on cultivation of TBOS.

1.7 Plant improvement and hybridization

Progeny study on the collected materials is in progress. Plant improvement through mass selection and hybridization will be taken up in future.

LAND AVAILABILITY

Land Availability for Biofuel Plantation

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1. Introduction

As per land statistics, the total geographical area of India is 329 million hectares. Excluding inaccessible and other inestimable areas (geographical area under illegal occupation by China and Pakistan), the reporting geographical area is 306 m ha (based on data of Office of the Director, Map Publication, Survey of India). Out of this, area under cultivation is about 173 million hectares. It is, generally, estimated that nearly 50 per cent of the geographical area of the country is either waste or degraded.

Keeping in view the growing population and its fuel-fodder-foodgrain requirements, it is generally agreed that the existing cultivated areas should not be diverted to alternative uses like Jatropha cultivation. Considering that the country is bestowed with a large extent of wastelands, the focus is on utilizing these wastelands for Jatropha cultivation so that the following two issues of national importance could be immediately addressed.

- Development of large chunks of wastelands in the country and put them to productive use.
- Create significant level of employment opportunities to the rural population that is suffering from unemployment.

2. Wastelands

3. Wasteland is described as "degraded land which can be brought under vegetative cover with reasonable effort and which is currently underutilized and/or land which is deteriorating for lack of appropriate water and soil management or on account of natural causes." Wastelands can result from inherent or imposed disabilities such as location, environment, chemical and physical properties of the soil or financial or management constraints.

Land degradation status in the country is estimated by various agencies and areas of wastelands differ widely from 38.4 m ha to 187.7 m ha due to varying definitions and parameters used and the intensity of surveys, ground truthing and scale of mapping. The estimates of degraded land made by different organizations in the country are given below.

Sl. No.	**SOURCE**	**AREA (m ha)***	**% to reporting geographical area (306 m ha)**
1	Nat. Comm. on Agr. (1976)	175.0	57.18
2	Min of Agriculture (1982)	173.6	56.73
3	Directorate of Economics and Statics, DoAC	38.4	12.55
4	NWDB, MoEF (1985)	123.0	40.20
5	SPWD (1984)	129.6	42.35
6	NBSS and LUP (1994)	187.7	61.33
7	NRSA and DoLR (2000)	63.8	20.85
8	NRSA and DoLR (2005)	55.3	18.07

* *While the figures at Sl.Nos. 1 to 6 are statistical estimates of wastelands area, those at Sl.Nos. 7 and 8 are scientific derivatives by using remote sensing and GIS technologies and hence are more reliable.*

The 55.3 m ha degraded wastelands estimated by NRSA and DoLR (2005) include 30.51 m ha culturable wastelands and 12.66 m ha extremely degraded notified forest areas. Thus, wastelands to the extent of 43.17 m ha can be brought under some productive use, Jatropha cultivation being one of the potential alternatives.

2.1 Wastelands suitable for Jatropha cultivation

Of the several categories of culturable wastelands, only 5 categories have been considered as suitable for Jatropha cultivation covering an area of 21.45 m ha. Similarly, the degraded notified forest area excluding arable land inside the notified forests and covering 10.84 m ha is considered suitable for Jatropha cultivation. The total wastelands area that is suitable for Jatropha cultivation, therefore, works out to 32.29 m ha. The category-wise details are given below.

Category of wasteland suitable for Jatropha cultivation	Area (in million ha)
A) Non-forest Culturable Wastelands :	
i) Gullied/Ravinous-Shallow (mainly Community, Govt.)	1.03
ii) Land With Scrub (Government/Panchayats)	15.05
iii) Land without Scrub (mainly Community, Govt.)	3.74
iv) Saline/Alkaline-Slight (mainly private)	0.41
v) Shifting Cultivation – abandoned (community)	1.22
B) Degraded Forest Land :	
Degraded Forest –Scrub	10.84
Total	**32.29**

As can be seen above, most of the degraded lands in the country are the Common Property Resources (CPRs). These resources include community pastures, community forests, panchayat lands and common dumping and threshing areas. A significant proportion of these lands are encroached upon.

The area of wastelands in the States in each of the above categories varies from negligible to large. For ease of management of plantation in a State, there should be a minimum area under a wasteland category where plantation can be undertaken. Based on this criterion, details of States where the above categories of wastelands are predominant are given below.

Category of Wasteland	**Total Area (m ha)**	**Minimum area available in a State**	**States with minimum area under each category**
Gullied/ Ravinous - JandK, Shallow	1.03	> 10,000 ha	(11 States) AP, Bihar, Gujarat, Jharkhand, MP, Maharashtra, Orissa, Rajasthan, Tamil Nadu, Uttar Pradesh
Land With Scrub	15.05	> 1 lakh ha	(18 States) AP, Arunachal Pradesh, Assam, Chattisgarh, Gujarat, Haryana, HP, Jharkhand, Karnataka, MP, Maharashtra, Manipur, Meghalaya, Nagaland, Orissa, Rajasthan, Tamil Nadu, Uttar Pradesh
Land without Scrub	3.74	> 1 lakh ha	(9 States) AP, Arunachal Pradesh, Chhattisgarh, Gujarat, MP, Maharashtra, Meghalaya, Rajasthan, Tamil Nadu
Saline/ Alkaline-Slight	0.41	> 5000 ha	(5 States) Bihar, Maharashtra, Raja, Tamil Nadu, Uttar Pradesh
Shifting Cultivation (abandoned)	1.22	> 0.1 mill ha	(3 States) Assam, Manipur, Mizoram
Degraded Forest – Scrub	10.84	0.2 mill ha	(12 States) AP, Assam, Bihar, Chhattisgarh, JandK, Jharkhand, Karnataka, MP, Maharashtra, Orissa, Rajasthan, Tamil Nadu
Total	32.29		

2.2 Demand for Bio-Diesel vis-‡-vis area requirements for Jatropha cultivation

9. Projections of the year-wise demand for petroleum diesel in the country, requirement of biodiesel for 5% blending and the area that needs to be planted with Jatropha to meet this biodiesel requirement are given below.

Year	**Diesel Demand (Mmt)**	**Bio-diesel Requirement (Mmt)**	**Jatropha Area (M.ha.)**	**Additional Area (M. Ha)**
2005-06	-	-	2.42	-
2006-07	52.33	2.62	2.54	0.12
2007-08	54.95	2.75	2.66	0.12
2008-09	57.69	2.89	2.79	0.13
2009-10	60.58	3.03	-	-
2010-11	63.61	3.18	-	-
2011-12	66.90	3.35	-	-

- Growth in Fuel demand is taken at the rate of 5% annually.
- The Jatropha plantation of 2005-06 will produce enough seed to yield the required biodiesel in 2008-09 and the estimates for subsequent years are also made accordingly.
- Bio-diesel requirements during 2006-07 and 2007-08 need to be met through imports or any such other means.

From the above, it may be said that, for meeting the 20% blending requirements, roughly about 12 m ha area needs to be put under Jatropha plantations in the country. As against the estimated availability of 32.29 m ha for the purpose, this requirement appears to be very much plausible.

3. Preparedness of States

Detailed discussions with State Governments indicate that the States are gearing up to take up Jatropha on wastelands. To begin with, States have pledged a total area of 1.72 m ha for Jatropha cultivation as per details given below.

(in hectares)

Sl. No.	State Area	Forest Area	Panchayat	Total
1	Andhra Pradesh	15000	160000	175000
2	Assam	25000	-	25000
3	Bihar	50000	-	50000
4	Chattisgarh	50000	51400	101400
5	Gujarat	49800	-	49800
6	Haryana	50000	-	50000
7	Jharkhand	6600	65400	72000
8	Karnataka	-	500000	500000
9	Madhya Pradesh	-	53000	53000
10	Mizoram	14000	12000	26000
11	Rajasthan	60000	-	60000
12	Sikkim	5000	-	5000
13	Tamil Nadu	50000	-	50000
14	Uttaranchal	500000	-	500000
	Total	**875400**	**841800**	**1717200**

Critical Issues

Availability of land for Jatropha cultivation requires the following ground-level issues to be addressed for lending credibility to the gross estimates presented above.

(a) One of the most critical aspects of non-forest wastelands pertains to ownership, usufruct and management, which could each be in private, community or Government hands. With land reform, in the ryotwari areas, uncultivated lands which were not part of the farmers holdings were vested with the State, while in other areas, where such lands were settled with landlords their ownership and management was vested either with village communities and the duly constituted village bodies, or with the State. There is little *de facto* distinction between the two categories, as both are used for grazing, and are generally quite degraded. These are also referred as common or village lands, constituting, in effect, common property resources (CPRs) and are demarcated in land records as lands for grazing or other community purposes. However, village commons were subject to very substantial encroachment (de facto privatisation), which is largely undocumented. In addition, many poor families have been allotted lands under various programmes in the last 20 years. Up to 1998, nearly 5.8 m ha of culturable wasteland had been distributed to poor families all over India, led by the States of Andhra (1.7 m ha), U.P. (1 m ha), Karnataka and Gujarat (0.55 m. ha. each). Gradually, with the extension of the State control and/or privatisation, and the resultant decay of community management system, the amount of CPRs available to the villagers as well as their quality and productivity, has declined substantially over the years. But CPRs still play an important role in the life and economy of the rural population, especially in the arid, semi-arid and hill regions of the country, and their proper management and improved productivity will have substantial impacts on the production system, on the environment and on livelihoods.

(b) Forest Wastelands fall within the purview of the State Forest Department. There are special plans, known as the Working Plans, for treatment of forest areas. Obviously, treatment of forest wastelands would have to conform to the Working Plans. Introduction of new treatment practices with focus on production of non-edible oilseeds would need suitable changes in the respective Working Plans, which sometimes is a long drawn process.

(c) The commons are under uncontrolled usage and maintenance of assets on such lands is a serious problem. Under Social Forestry programmes, block plantations established on community lands are handed over to the respective Gram Panchayats after initial 3-5 years. However, the cases of successful protection and maintenance of assets by Panchayats are less than 30%, notwithstanding the fact that the Panchyats were promised 90% of the produce by the State Government. The phenomenon is almost universal. The main reason for this is that the plantation areas are reverting back to pre-plantation usage despite the fact that such areas are made available for planting by concerned Village Panchayats. The logical conclusion is that the areas are not really available for all practical purposes.

(d) The 3rd category of Wastelands belongs to private owners. In Maharashtra State horticulture has been practiced on a large scale (of the order of 1.5 million hectares) since 1990. The scheme provides attractive subsidy. Hence the farmers are more inclined to put their non-agricultural land under horticulture. There are species that can come on relatively poorer sites with a little bit of protective watering in the initial stage. As against horticulture scheme the off-take of a similar Social Forestry scheme of planting on private land did not find many takers and the net planting per year was scarcely 3000 hectares on an average.

(e) It would be worthwhile to assess the availability of field bunds and similar sites for linear planting. It is a common practice to plant even forestry species of tree origin on farm bunds, homesteads etc. The Forest Survey of India has assessed that such linear plantation and singularly growing trees are equivalent to about 3% of the total geographical area of the State.

(f) Non-forest wastelands close to the villages are often used by the community for grazing, but lands distant from villages are lying barren, and are available in large chunks. Some State governments have in the past offered barren lands, such as desert lands of Rajasthan and saline lands of U.P. and Gujarat, on lease to industry, but the response has been lukewarm. The scheme by the Rajasthan government was advertised in the newspapers in 1990-91 and a minimum of 2000 acres was being offered on a long-term lease, whereas the scheme in UP was initiated in 1979, but given up after a few years for want of proposals. The Gujarat government, since 1994, is offering land up to 2000 acres for reclamation, but again there has been no positive response from forest-based industry. Therefore, the complaint of industry that it is being denied the opportunity to rehabilitate wastelands, or that land ceiling laws are a barrier to raising plantations seems to have no empirical basis. The fact is that States like Rajasthan, Gujarat and Madhya Pradesh, where most wastelands are located, have adequate provisions in their laws to grant exemptions from ceiling in deserving cases.

(g) It could be inferred that macro-level aggregations cannot become a firm basis for considered investment decisions. Such estimates do not provide full picture of ownership, current usage and its opportunity cost, net treatable area and other information essential for establishing and managing plantation assets. Hence it is necessary to undertake micro-level exercises, which indeed would involve field survey as well.

Availability of Land for Jatropha Plantation in Chhattisgarh

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Chhattisgarh government has an ambitious target to bring one million hectare of wasteland under Jatropha cultivation at the end of next plan period(2012).The aim is to cover farmers fallow land/bunds, Revenue (government) Wasteland, degraded Forest Land.

According to Wasteland Atlas Published by NRSA Chhattisgarh has following categories of wasteland.

Category	Type	Area in Sq.km
1	Gullied and/or ravenous land shallow	49.11
2	Gullied and/or ravenous land radium	1.68
4	Land with scrub	2812.41
5	Land without scrub	1192.48
11	Shifting cultivation area (Abandoned Jhum)	69.39
12	Shifting cultivation area (Current Jhum)	56.38
13	Under utilized/degraded notified forest land	2820.18
14	Under utilized/degraded notified forest land (Agri).	129.36
16	Degraded land under plantation crop	4.59

17	Sands (Food Plain) 3.79	
24	Mining Wastelands32.50	
25	Industrial Wastelands	4.91
26	Barren Rocky Stone Waste/ Sheet Roc area	394.98
27	Steep sloping area	12.39
	Total Area of State = 135194	**7584.15**

The percentage of wasteland is 5.61 % .This seems to be anunderestimation. As per the statistics published by the state revenue department which is based on Ground level data the classification of different types of lands are as follows:-

Forest

		Area in Hact.
Reserved Forest	=	2489766
Protected Forest	=	1437198
Others	=	547767
Revenue Forest	=	1825072
Total	=	6299803

Non Agricultural Land

Used for other purposes	=	697718
Barren Land	=	347019
Total	=	1044737

Agricultural Land (Not in use)

Immediately can be used for Agriculture	=	165690
Can be used after some treatment	=	171380
Total	=	337070

Non Agricultural Land (Other than Fallow)

Pasture Land	=	849874
Horticultural/Plantation	=	709
Total	=	850583

Fallow Land

Current Fallow	=	249570
Old Fallow	=	237777
Total	=	487347

Net Sown Area	=	4770296
Grand Total Area	=	13789836

From the above table the following categories can be considered under wasteland, barren land (347019), and fallow land. Apart from this arable land which is not under use (337070) can be planted with Jatropha/ Karang.

The forest department statistics shows that roughly 8795 Sq.Km. of forest land is degraded. Jatropha can be planted as one of the species in these forest lands.

It is expected that around 2 lac hectares of revenue wasteland will be given on short term lease for Jatropha/Karang plantation. State government has already announced policy of State Government allowing allotment of Government Revenue Land to Companies/Partnership Firms/ Registered Societies on lease for Jatropha cultivation. So far 120 proposals have come from private investors for allotment of about 4 lac hectares of Govt. fallow land on lease. Out of these proposals, 50 proposals along with their DPR's have been forwarded to Collectors of the concerned districts for allotment of about 70,000 hectares land on lease to these investors involving investment of approx. Rs.350 cores.

Production Practices

Production Practices Including Post Harvest Management of *Jatropha Curcas*

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1. Introduction

The scientific efforts have transformed Indian agriculture in second half of the preceding millennium. It is evident from the efforts made in achieving self sufficiency in food grain, higher productivity and trained human resource to meet the challenges of globalization. The promotion of agro-processing and value addition is likely to benefit farmers with strong hold on food security and now venturing bio-energy sector to meet the ever increasing needs of liquid fuel. The agriculture sector may contribute its share by developing a strong, ever sustainable source, for generating bio-fuel. A precursor to achieve self reliance in biodiesel production in the country is possible by developing elite planting material, its production practices, plantation in different type of wastelands and post harvest management to develop a multifaceted approach, establish a well knit strong biodiesel production and distribution system to achieve Energy Security by 2020 leading to Energy Independence by 2030 and beyond.

Realizing the inherent potential of the *Jatropha curcas* L. with its superiority over other tree oil species, it has been accepted to undertake plantations by turning the wasteland green and supplement or substitute petro-diesel with biodiesel and clean the environment. It would provide employment opportunities and a long term livelihood option from the beginning of plantations, through its maintenance and collection of fruits every season to the rural poor, inhabiting the economically underdeveloped regions, mainly representing the wastelands.

The efforts would ensure eco^2 sustenance (economic and ecological) to upturn the environmental scenario and make the climate more congenial for us and generations to come. Keeping constant vigil on environmental impacts of large-scale plantations, it would lead its impact instantly on bio-fuel scenario and sustain-ably improve quality of living as non-owners of the plantations. The Jatropha system is ought to emerge as Jatropha based system.

The introduction of *Jatropha curcas* in large scale plantation is likely to affect existing cropping system. The popularization of available (adoptable) production technology using quality planting material and plantation on prioritized land in the regions inhabited by the communities, truly struggling for livelihood would get a viable option. This workshop would lead its impact in framing short, medium and long term strategies through past experiences, scientific, technological interventions and policy frame work, to execute the ambitious programme, solve energy crisis and attain energy independence.

The most essential step before executing a large-scale plantation is to convince all the stakeholders not to undertake plantation on cultivable land to cause threats to food security, which demands "No diversion of cultivable land for Jatropha plantation". However, attempt to achieve energy security demands "Identification of land, estimation, availability and marking of such lands across states, improved early variety/Elite planting material with higher yield per crop and Agro-technique (plantation and management) for irrigated and rain-fed conditions.

2. Ecological requirements

It is hardy to dry weather conditions and can be grown over a wide range of arid or semi-arid climatic conditions. Whilst Jatropha grows well in low rainfall conditions (500 to 750 mm), it can also tolerate to high rainfall (up to 1200 mm) conditions. It can stand long periods of drought by shedding most of its leaves to reduce the transpiration loss. It tolerates annual temperature range of 18-28 °C even higher ranges but it can't tolerate very harsh winter or fog. For the emergence of seeds, hot and humid climate is preferred. The flowering is induced in rainy season and bears fruits in winter. The foliage drops with dip in temperature during winter and with rise it starts blooming.

Jatropha has very strong adaptive mechanism to sustain variable climates. It can tolerate extremes of temperature but not the frost. The frost damages plants whereas, high temperatures adversely affect yield. Therefore, it is suggested that the areas with low temperature experiencing frost should not be promoted for Jatropha plantation due to its adverse affect on growth and damages to plantation, until resistant/tolerant lines are identified. The germplasm should be screened to isolate lines which can withstand high temperature does not show sensitivity to sex switching (irrigation as adaptation measure overcome) and drying of staminate flowers during summer (high temperature coupled with low humidity).

3. New Plantations and Some Facts

The fact revealed at the conference in Delhi by a participant and stakeholder of Bikaner, Rajasthan that out of the Jatropha plantation of about 1000 ha more than 250 ha is affected due to frost. The non-flowering/fruiting of germplasm at JNKVV, Jabalpur with a precipitation of 75" rainfall during kharif 2005 (exceptionally high) alarm to learn lesson before actually planning large scale plantations. It proves that plantations in such situations either due non-suitability of agro-climatic condition or the inappropriate planting material are at the root cause. Similarly, the high temperature (40±2 C°) during summers recorded sex switching from protandry to protogyny (signal transduction) and capsules with few unfilled seed maturing in late June-July harvest during 2005 at this center also reveal it's specific climatic requirement.

4. Kind of Land Required

4.1 Types of Land and Potential of Plantations

In a scenario of decreasing availability of good land for agriculture, degradation of soil and water resources, increasing pollution, and threats to the environment and ecosystem, new approaches in farming systems are needed to meet increasing food, fodder, and fuel requirements to feed increasing population and protect vulnerable system due to anthropogenic factors including climate change. Jatropha can grow on lands unsuitable for economically viable agriculture.

The suitability of Jatropha to low fertility wasteland situation besides other cogent reasons may be raised on manageable wasteland on priority to establish plantations. The inclusion of Jatropha in the existing farming/ cropping system (growing on bunds) and adoption of agro-forestry approach on manageable wastelands, Jatropha plantations are likely to emerge as a Jatropha Based system to achieve self reliance in fuel sector, serve rural poor by extending social justice and draw other associated benefits.

4.2 Wasteland Scenario of the country

Incidence of poverty and land degradation is seen to co-exist in several agro-ecological zones in India. The policies and interventions related to poverty alleviation, aimed at breaking this nexus, drive labour and capital flows by creating the alternate livelihood systems beyond the exploitative dependence of stakeholders on marginal natural resources. The large-scale plantation of Jatropha for **ìBiofuelî** is likely to bring in multifaceted implications. Jatropha plantation religiously done in degraded rural pockets of India would transform agriculture; minimize dependence of inhabitating rural communities on other forest resources as, a long-term option and help conserve biodiversity for generations to come.

The first five types of wasteland can be used for plantation under Jatropha with some management and yield sacrifice. The land with scrub (15.1 mill. ha) out side forest and degraded forest with scrub (10.9 mill. ha) should begin simultaneously. The land without scrub, shifting cultivation ravinous saline and alkaline land has to be taken at last (Table 1). In all the situations a watershed or water harvest need to be established for initial irrigation of plantation. The developing of trenches on contours against slope and alternate trench formation would help conserve more of moisture and use of local mulch to minimize; evaporation losses should be the priority.

Table 1. Wasteland may be considered for Jatropha plantation (Area in million ha)

Land Type	**Area**
Shallow /medium ravinous	1.5
Land with scrub	15.1
Land without scrub	3.7
Saline/alkaline slight	0.4
Shifting cultivation	3.5
Degraded forest-scrub	10.9
Total waste land for Jatropha	**31.1**

The land holding with farmers constitute 170 million ha of land under cultivation (Table 2). The cultivable land is being slowly brought under urbanization and development of other projects hence; the land under cultivation is reducing. It is a serious concern and threat to food security, therefore no land under crop cultivation be brought under Jatropha plantation. The last three categories offer land close to culturable land, which totals to 42 mills. ha may be put to plantation.

Table 2. Land held by Farmers may be available for Jatropha plantation (Area in million ha)

Land Type	**Area**
Land under cultivation	170
Land suitable for mixed cropping	25
Land under field boundaries	25
Pvt. Cult. Land likely to be under Jatropha	5
Deg. and cult. Land likely to be under Jatropha	12

4.3 Types of Lands Fit for Plantation

- Inside Forest
  - Degraded Forests
  - Revenue villages close to Forests
- Outside Forests
  - Community lands managed by Panchayats
  - Community lands managed by Government
  - Fallow lands held by Farmers
  - Wastelands held by Farmers
  - Low productivity lands where income is low
  - Lands occupied by field boundaries

4.4 Pre-plantation Activities:

Though plantation can be done without any cleaning activities, but it is advisable to partly clean up the area. Tall trees can be left as it is.

All shrubs and bushes on the soil should be cut above the roots. If the land is suitable for growing intercrop, it should be tilled in the month of April and May and all dry vegetation should be burnt and destroyed before plantation.

4.4.1 Quality Planting Material

The constant emphasis to identify and generate required quantity of planting material is the need and priority, but this itself is a constraint due to non-availability of such promising type in bulk quantity right now. The testing and identification itself is a time taking process. The commitment to bring area under quality planting material is to eliminate the problems of low yield. There is a remote possibility of the substitution of low yielding plantations by elite or improved varieties at later stage due to involvement of time, labour and money.

Therefore, it is imminent to move with strong footing with modest area under quality plantation under the direct control of network partners to ensure further supply of quality planting material as per demand to stakeholders. The seed/clonal orchards are developed only for the purpose of developing quality material for large scale plantations to meet the ultimate projections of the country. The quality material as identified to constitute the multilocation National and Zonal trails may fulfill the needs of wider as well as regional climatic requirement and progeny trials to fulfill local needs. Different centers have identified plants yielding more than 2–4 kg., and oil above 30% may be revisited for collection of seeds to meet the requirements. It is necessary to use superior genotypes so that seed yield and oil production can be maximized. In the absence of recognized sources, it is necessary to identify ideal plant types in natural stands and collect seeds Yield above 2.0 kg per plant and Oil content more than 30%.

The current movement of plantations under contract farming (excluding concerns with strong R & D) by private growers and enthusiast are great strength in terms of agencies coming forward for plantations are also likely to bring the ill effects of low yield at the cost of occupying large areas under plantation without proper evaluations (due to lack of quality planting material and ignorance of optimal norms for selecting material). Some organizations have started marketing seeds with the names with no testing and evaluations are big threats.

The norms decided for selection of plants under project work may be recommended for farmers also. The requirement of material as per the projections may be met hopefully through In vitro mass propagation Protocol of Jatropha to solve the problem of quality planting material.

4.4.2 Production technology:

Realizing the importance of this species, the projects have been supported by various organizations to conduct systematic research and results obtained would continue to fill in desired gaps to plan the plantation programme in phased manner to achieve the expected outcome.

5. Soil & Soil preparation

Jatropha curcas is a hardy plant well adapted to arid land semi arid conditions. It is a plant that can grow almost anywhere, even on soft, rocky, gravelly, sandy, calcareous, saline and sloping soils. It has low fertility and moisture demand. To combat phosphate deficiency it avails of the symbiosis with root fungi (Mycorrhiza). The crop is undemanding in soil type and even does not require tillage. It can grow even in crevices of rocks. It does not thrive in wetland conditions. It has been experienced that the land where the soil depth is less than 45 cm plantation of Jatropha should not be taken up as a commercial crop as the expected returns shall not be available from such sites.

The leaves shed in winter months to form mulch around the base of the plant. The organic matter from shed leaves has been observed to enhance earthworm activity in the soil around the root-zone of the plants, which is a fair indicator of improvement in microfauna and fertility and texture of soil.

6. Mycorrhiza and Jatropha

Mycorrhiza ("M") is a symbiotic, non-pathogenic, permanent association between the roots of land plants and a group of fungi. Mycorrhizae are essential soil organisms that are more than 400 million years old and played a key role in allowing plants to colonize land plants. The most common among these are AM (arbuscular mycorrhiza) fungi benefiting 90% of the land plants. They provide extended arms to the plant root helping explore more soil nutrients and thus providing a selective advantage to the plant in terms of general health and better survivability. Some of the benefits and uniqueness of this group of fungi include:

- It offers up to 50% reduction in the phosphorus fertilizer application
- It allows better uptake of nutrients like phosphorus and immobile trace elements like zinc, cobalt, magnesium, iron, copper, molybdenum, etc.
- It offers tolerance against range of soil stresses like heavy metal toxicity, salinity, drought and high soil temperatures.
- Higher resistance to various soil-borne and root-borne pathogens thus it becomes a potential bio-control agent.
- It helps in soil conservation and soil structure stabilization, thus restoring land productivity.

As Jatropha ("J") is itself a very hardy plant and with its known naturally existing association with "M" fungi, this combination of "M" & "J" will not only give higher yields with respect to seed production but will also give higher vegetative biomass. A technology been developed by TERI, now ensures means of availability of this biofertiliser on a mass scale, commercially.

"M" associations have been observed with "J" and are known to add the plants growth under conditions where particularly phosphate is limited, since most of the "J" plantation is expected to come on wastelands the "M" would be an essential component for plant production.

6.1 Varieties

Sardar Krishinagar Agricultural University claim to have evolved four genotypes viz., Chhatrapati, Urlikanchan, Liansraj and Sardar Krashinagar big. The relative performance of such varieties is not known. Only one variety has been identified by the AICRP on underutilized crops in workshop held in May 2006. The variety named SDAU-1 (Chhatrapati) has been developed by Sardar Krishinagar Dantiwada Agriculture University. This variety has been found suitable for cultivation in the region of Rajasthan and Gujarat. It is reported to yield 1000kg. in rainfed conditions. The Tamil Nadu Agricultural University has collected and evolved high yielding lines from indigenous as well as exotic material which are in the advanced stage of testing.

The NOVOD Board has initiated Network project on Integrated Development of Jatrapha covering various aspects including assessment of provenances in multilocational (national and zonal) and progeny trails to evaluate performance for water adaptability, and suitability for regional as well as local needs. The result of such provenances shall be known in 2-3 years.

Two types' viz., (i) Nicaragua types and (ii) Mexican types are reported in the Western world. Mexican types are free of toxic substances and the Nicaragua types are poisonous types. The centers of diversity of land races and ecotypes are central and south America. In Madagascar *J. mahafalensis* (2n=22) is commonly cultivated. In India variety the local types are widely cultivated.

There is an urgent need to evolve varieties capable to maintain higher seed yield per unit area with high quantity and good quality oil suiting to varied agro-climatic conditions. The non-availability of improved variety itself is major constraint to begin with the plantation.

6.2 Propagation

Seeds or cuttings rapidly and easily propagate it. The propagation through seeds does not give population true to the parental stocks due to cross pollination. The stem cuttings maintain the purity of parental stocks due to clonal propagation. Therefore, there is constant emphasis to develop *in vitro* mass propagation protocol to produce large number of quality material to fulfill the ultimate need.

6.2.1 Nursery

It is evident from other crops that the grading of seeds help in screening of quality seeds to separate filled seeds against the unfilled ones to have higher germination (%) from the seed lots. Nursery provides necessary control of moisture, light, soil and allows healthy development of saplings. The nursery soil should have good structure, porosity, rich in organic matter and good water holding capacity. The nursery should be raised in three months prior to onset of monsoon.

6.2.2 Sowing in Poly-bags

The polythene bags of 10 x 20 cm and 15 x 25 sizes have been found suitable for three and six months nursery. The saplings in this size can be maintained for the period of three months. The nursery need to be kept for six months could be planted in poly-bag size of 15x25cm. The size of poly-bags may be decided as per need, conditions and type of land

(land without scrub and with scrub would need rich mixture for an assured establishment with rapid growth). The mixture of soil, sand and compost/vermi-compost in a proportion of 1:1:2 is ideal. The seeds are sown 4-6cm deep in each poly bags and watering is done regularly.

The pre soaked seeds germinate in 7-8 days in hot humid weather, whereas the process continues for 10-15 days. It takes more time in low temperature conditions. Saplings from seeds develop a typical taproot and four lateral roots. The nursery should be irrigated as and when need be. The areas where high temperature prevail (40±1) for longer duration locally available materials like grass straw etc. can be used to create shed till rainy season. The saplings are normally ready for transfer 45 days after seeding. The saplings should be transferred timely to allow tap roots to develop straight in the field or else it tends to grow side ways which limits its strong hold in the soil and disable to draw moisture from deeper zone. The weeding in nursery should be done as and when required. Eliminate weak and abnormal sapling for nursery to establish good uniform plantation.

6.2.3. Sowing in beds

The large scale plantation can be done using rich mixture in seed beds (1:1:2) to raise and carry bare root saplings to long distances for transplanting. The transportation should be done on rainy days or packing in water soaked media. The saplings establishes with high success. The same saplings as per need may be transferred in polybags.

The seedlings can be raised in minimal media using only sand to make up time loss. The six inch deep sand bed is prepared by horizontally keeping bricks (9”x3”x4”) in two layers. The square or rectangle blocks are made and filled with four inch deep layer of filtered sand. A layer of seed is spread over the sand and is covered with two inch layer of sand and irrigated with shower to wet the seed bed. The seed bed is then covered with wet gunny beds to keep it moist. The seed bed is irrigated every day during dry days. The seeds start emerging within 7-8 days. The seed germinated within 10-12 days are then transferred in mixture pre-filled poly-bags (¾) and irrigated. The poly bags are arranged in a block of 10x10 with gaps between blocks for working. The sand bed may be made with a manageable interval to raise required quantity of seedling.

The plantations from nursery raised saplings have shown high rate of survival better establishment. The saplings grow very fast. The saplings at 3-4 leaf stage are ideal for transplanting.

6.2.4 Direct Seeding

The Jatropha plantation can be done by sowing seeds of existing trees with seed yield above two Kg. and oil content more than 30% due to non availability of genetically improved varieties. Two seeds are sown at each intersection according to the planting geometry. Good quality seeds of attractive colour should be selected for germination. For this purpose, good quality fruits should be collected in the month of Sept. and October and seed should be graded. Freshly harvested seeds should be kept over a month time at ambient temperature to overcome dormancy, and achieve good germination. Jatropha indicates innate (primary) dormancy. Dry seed will normally germinate readily without pre-treatment. Only one normal seedling should be retained per hill, the extra seedling may be transplanted wherever necessary.

It has been observed that direct seed sowing done at the beginning of the rainy season helps in development of healthy tap root system which grows deep and later spreads out to support the balance of the plant and to enable it to utilize moisture conserved deep in the soil.

6.2.5 Cuttings

The rooted semi-hard and hard woodcuttings also may be used for planting. Cuttings are ready for planting in 2-3 months time. Normally the cuttings of 25-30 cm length from one-year-old branch are good source and planted in semi-shed conditions with intermittent irrigation. The cuttings are placed with its cut end in poly-bags or directly in the ideally developed nursery bed. The experience with laying of long manageable size of stump planted horizontally in soil, starts sprouting shoots from nodes with regenerating roots, which can be cut at middle of internodes and planted in poly-bags for further establishment. This practice is very good for generating plants from hybrid or precious plants to maintain genetic purity of plus trees. It grows rapidly and starts bearing in the same year of planting.

The multiplication through cuttings helps a great deal to maintain genotype of parental stocks but some of the experiences in drier areas reveal that due to absence of tap root the plantation suffers mortality during dry spell especially at the initial stage of establishment.

6.2.6. Lifting of plants from Nursery

Before lifting, plants should be thoroughly watered to avoid desiccation during transport until planting. Plants after lifting from nursery and before planting in the field be kept under shade and water should be sprinkled. Such lots should be transported to the destination as quickly as possible.

6.3 **Mass Multiplication of Planting Material:**

6.3.1 Macro and Micropropagation

The tender shoots from precious plants may be cut and planted in sterilized sand in mist chamber have given good results. The cuttings from multiple shoots generated *in vitro* can also be rooted and raised in poly-houses. The developing of protocol for mass propagation *in vitro* is in progress. The repeatable protocol would enhance the availability of quality planting material for large-scale plantation.

6.4 Seed rate and spacing

6.4.1 Plantation

The seed rate for planting one hectare is 5-6 kg (seeds with good viability minimizes seed requirement per ha). The 2 x 2 m spacing accommodates 2500 plants per hectare under irrigated or partially irrigated conditions. In south Indian conditions 2 x 1.5 m spacing (3250 plants) is found to be ideal. On rain-fed wasteland, high density planting with a spacing of 2 x 1 m or 1.5 x 1.5 m accommodating 5000 or 4444 plants per hectare respectively shall be desirable. Satisfactory planting densities are 2 x 2 m, 2 x 2.5 m, 2.5 x 2.5 m and 3 x 3 m. This is equivalent to the crop densities of 2500, 2000, 1600 and 1111 plants/ha respectively. The plantation after first rain during monsoon is ideal period for Jatropha plantation. The areas with the history of less rainfall should be managed with care.

The plantation in wasteland may be supplemented with sludge in trenches to promote accumulation of soil particles and conserve moisture in and around saplings to support growth.

6.4.2 Planting Density and Geometry

The major criteria for planting density and geometry (square, rectangle and alternate) are based on the soil type and availability of facilities for irrigation. The alternate planting geometry guarantees the availability of sunlight to every plant for a longer period of time with less of shadow. The ideal spacing could be 2x2m under rain-fed conditions and 2.5 x 2.5m, 3 x 3m, 4 x 2m for irrigated conditions, which may accommodate intercrop till Jatropha enters reproductive phase and during phase of leaf defoliation. The alternate planting allows movement of tractor only in one direction. The large-scale plantation in long stretches of land should be done with a planting geometry of 2.5 x 1.5m. The ideal geometry is one which accommodates maximum plants per ha. and harness maximum light to enhance yield, provide more space for mechanized operations such as sowing of intercrop, weeding and soil pulverization with rotavator.

6.4.3 Hedge rows or soil conservation

The spacing for hedgerows is 15 -25 cm x 15-25 cm in one or two rows. Thus there will be between 4,000 to 6,700 plants per km for a single hedgerow and double that when two rows are planted.

Field Preparation and Planting:

6.4.4. Digging of pits

The site preparation cleaning and leveling of land for plantation can be used to dig the pits without tillage. Pits of standard sizes are dug initially, based on the slope of land, availability of water and quality of soil. The planting density in fertile soils should be lower than in soils with low fertility. The pits should be dug in with proper layout to mechanically manage plantations. The pits size of 30 cm^3 (30x30x30 cm) is ideal for plantation in soils fairly rich in nutrients. The pits should be dug prior to rainy season when sufficient moisture is available in the soil. Refilling of pits is done by mixing with mixture of soil, sand, compost/ organic mixture and 40-50 g methyl parathion (2%) dust per pit to protect the plants against termite wherever necessary. However, the sandy or gravelly land should be dug in the size 45 cm^3 to provide more of rich soil with compost for initial establishment of the saplings. The mixing of neem cake deters termite development and also supplements nutrients.

The land could be ploughed once or twice depending on the nature of soil and history of cultivation. In case of heavy soil deep ploughing is given whereas in light soils, shallow ploughing is enough. Under clay soil the trenches may be taken with 30 cm depth, 30 cm width and 2 m distance between them. Pits are filled with soil and compost or organic manure @ 400g/pit. In the initial phase of growth, roots grow very rapidly and try to penetrate in soil to suck nutrients from the soil. Initial growth is very important hence, nutrients should be applied in the initial year of plantation.

6.4.5. Direct Planting

The seeds or cuttings are directly planted in the main field with the onset of monsoon during June-August months. For direct sowing two seeds are dibbed at each spot at the desired spacing. When the seedlings are 4 weeks old, weaker seedlings should be removed to retain one healthy seedling on each spot and the seedlings so removed could be used for gap filling. This method has a limitation that during dry spell in water scarce region transplanting should be followed by manual life saving irrigation followed by mulching using locally available material as mulch. The large semi hard wood or hard woodcuttings can be directly planted in the field.

6.4.6 Transplanting

For better establishment of saplings, monsoon season should be preferred for planting (Jun-Sept.). For transplanting seedlings are grown in poly-bags ½ kg. capacity filled with soil and organic mixture @ 100g per poly-bags plus 400 g soil. Two seeds should be sown around 6 cm deep in poly-bag and watering should be done regularly. When the seedlings are around 4 weeks, weaker of the two seedlings should be removed and used for gap filling. The grown up seedlings or cuttings are transplanted in the main field. The pits are filled with 500 g farmyard manure and 100g neem cakes to ensure profuse rooting in nutrient deficient soils. The transplanting in the field should be done preferably in the evening. The cloudy days during rainy season causes no shock to the plants. The saplings removed from nursery should be kept in shady place to avoid wilting.

7. Manure and Fertilizers

Although Jatropha is adapted to low fertility site and alkaline soils, better yield is obtained on poor quality soils if fertilizers with small amounts of calcium, magnesium and sulphur are used. Mycorrhizal associations have been observed with Jatropha. In general application of super phosphate @ 150 kg/ha and alternated with one dose of 40:100:40 kg/ha NPK at 6 monthly intervals is reported to improve the yield. The application should coincide with rainy season or followed by proper irrigation immediately after application of fertilizers. From fourth year onwards 10% extra super phosphate should be added to the above dose.

The fertilizer doses for national, zonal and progeny trials for irrigated and rain-fed conditions are being tried across 31 locations in the country in proportion of 60:40:20; have N.P.K. for irrigated condition and 30:40 of N.P. for rain-fed conditions. The recommendations emerging out of these trials shall be used to optimize the fertilizer application. The application of 1% FeSO4, ZnSO4 and MnSO4 has shown good results in Tamil Nadu conditions.

8. Irrigation

The seedlings require irrigation especially during the first 2-3 months of planting. The requirement of water is contingent upon local soil and climatic conditions. The stage of fertigation should be matched with the time of irrigation. High oil yielding crop needs fertilizer supplementation, the optimal dose and its frequency are being worked out. During the dry period, the life saving irrigation may be given with time interval depending on the requirement. Drip irrigation is not ideal as it induces too much of vegetative growth. The identification of critical stages and planning as per schedule may help this system to work effectively.

The critical stages of irrigation (viz. transplanting, dry spell during summer in first year of plantation for survival in rain-fed areas, flowering to control sex switching and promote anther dehiscence) and frequency need to be worked out to economize water application. The appropriate mulching method should be worked out. Soon after plantation, irrigation followed by laying of newspaper around plant has been found very effective for the initial establishment of saplings. Any material locally used as mulch will help to conserve moisture for establishment of saplings.

9. Pruning and Canopy Management

Crop architecture plays an important role in a plant like Jatropha where in proper pruning will help in producing more branches, healthy inflorescence to enhance good fruit set and ultimately the yield. The pinching of terminals is essential at six months age to induce laterals. The experiments reveal that the pruning at 30cm height is ideal to manage. Likewise the secondary and tertiary branches are to be pinched or pruned at the end of first year to induce minimum of 25 branches and 35-40 branches at the end of second year. During the second year each side branch should be pruned up to 2/3rd top portion and retaining 1/3rd of branch on the plant. Periodical pruning can be carried out depending upon the vegetative growth of the plants.

The slow growing provenances with more number of nodes per unit length may be pruned at 45 cm height to induce branching. The pruning should be done when the tree sheds leaves and enters into a period of dormancy preferably during winter season. The trees are kept in short height to manage during flowering and fruiting; it also provides ease during picking of mature capsules. The canopy management is advisable in trees with terminal bearing. The plant types with branch in every leaf axil should not be pruned vigorously.

The entire plant has to be cut to ground level leaving 45 cm stump once in 10 years. The re-growth is quick and starts yielding in about a year. It induces new growth and helps stabilize yield.

9.1 Inter culture operations

The standard cultural practices involve timely weeding, proper fertilization, surface ploughing and pruning. The field should be kept free from weeds at all times. Around 3-4 weeding in the initial period is enough to keep the field free from weeds until the crop crosses the stage of grand growth period. Light harrowing is beneficial during the early growth stage. The spacing of 2 x 2m initially allows tractor mounted implements for various operations but the later stages of plant growth suggests to opt for 2 x 2.5 m in partially irrigated conditions.

9.1.1 Weeding

The mechanical weeding with optimal space for movement of tractors can be done using rotavator. It clears weed in wider area away from plants. The chemical weeding can be done in small manageable plants with weedicides by covering plants with plastic buckets of polythene bags using paraquat @ 2ml/lit of water. Basin should be kept free from weeds. The hand weeding or hoeing should be practiced to remove the weeds growing close to plants.

10. Flowering and Fruiting

The flowering depends on the location and agro-climatic conditions. Normally Jatropha flower only once a year in northern India however in Tamil Nadu fruiting occurs almost throughout the year. Few lines are bimodal, which flowers two times in a year. The flowering is mostly continuous in such types in presence of optimum moisture. The inflorescence emerges on tip of the stem. The branches show asynchronous development within a plant. One co-florescence within inflorescence also bears fruits of different age.

11. Harvesting

This is a critical element of cultivation. The capsules are harvested as needed for medicinal purpose. For oil purpose the seeds are harvested at maturity. Majority of capsules that turns yellow are harvested along with brown matured capsules. The picking of green fruits should be avoided. The pods are collected manually and seeds are separated mechanically or manually. The seeds for planting purposes are dried in shed while for the oil purpose it should be dried in sun for four days (6-10% moisture level) before packing. The mature capsule (yellow/brown) should be accepted at the collection centers, to have collections with high oil content. Due to lack of post harvest management the quality of the crop will deteriorate. The quality of seed determines the refining process.

12. Seed Removal

The harvested fruits should be spread in a single layer on the cemented threshing floor for drying. The fruits should not be dried under the sun. After they have properly dried, the seeds can be removed manually or a seed decorticator can be used

13. Yield

The seed yield is an expression of the combined effect of variety, intercultural operations, application of inputs etc. and beyond human control are edaphic, climatic and rhizospheric (especially in plantation crops) variations. The yield predicted from Jatropha ranges from one to five tons; whereas, 2.5 ton is achievable and yield target of 5 ton can be realized on uncultivable wastelands with optimal input including field bunds. The yields increase till the sixth year and stabilize thereafter. It is mainly influenced by the planting material and management practices.

The ICAR has identified first ever variety of Jatropha SDAU J1 (Chatrapati) for commercial cultivation for the semi-arid and arid regions of Gujrat and Rajsthan. The variety SDAUJ I (Chatrapati) give higher yield compare to other local and popular varieties. Farmer can get an average yield of 1000-1100 kg per ha under rainfed conditions. It is drought resistance and can be raised successfully in areas where annual rainfall is 300-500mm.

14. Intercropping

Jatropha plantation being perennial can be intercropped with seasonal crops and other fruit plantations till the main plantation comes to fruiting. The need based field crops suiting to the agro-climatic conditions preferably pulse crops should be grown to harvest substantial as intercrop. In pure Jatropha plantations herbals or pulses can be grown as intercrop during initial growth period and at later stage, shade-loving crops can be grown underneath.

The agronomists are finding appropriate field crop, medicinal and aromatic plants as intercrop to add to farmers' income till the plantation attains reproductive phase.

14.1 Sowing of intercrops

The field preparations (soil pulverization) provide nutrient availability to field crops. The weeding and soil pulverization with rotavator should be done to clean the fields. The seasonal crops popular, remunerative and soil enriching should be grown as intercrop. It would supplement soil with nitrogen, which shall be available to the plantation.

15. Cropping System

The cultivation of any crop or cropping system in given region is based on decades of cultural practice. The introduction of new species and its adoption occur based on economic return and suitability to prevailing climatic conditions. However, the other factors viz. socioeconomic condition, local facility, technological development, policies of the government etc. also affect to some extant in spread. The popular cropping system normally prevail in irrigated ecosystem however, the rainfed cropping system see frequent changes.

The expected change in the cropping system is very much likely to occur due to Jatropha plantation to achieve the increasing need of bio-fuel, its continuing demand, and fulfillment through agriculture sector and interest of farmers in energy plantation. It has created impact earlier, in the age-old system with changing needs and available natural resources. However, we must ensure that it does not affect yield of main crops ensuring food security in present context, not at the cost of energy security.

The ambitious plan of the government for plantation of Jatropha in vast degraded land is likely to cause changes in the cropping system besides bringing self-reliance in liquid bio-fuel. Jatropha should be planted into the assigned class of land with poor value crops such as millets and Niger as intercrop in cropping system such as Kodo/Kutki – Fellow.

The poor value crop based ecosystems should be paid special attention to benefit the most deprived class, where these people have been living since, evolution of the humans and the various life forms. The growing of intercrop with the training and pruning of Jatropha especially in low input crop might help change the fertility status of soil due to litter-fall and its decomposition.

16. Jatropha Based Agroforestry ñ A Multi Pronged Approach

All agroforestry (AF) systems consists of at least two of the three major groups of AF components i.e. trees and shrubs (perennial), agricultural crops (annual or biennial) and pasture/livestock, trees and shrubs being present in all the AF systems. There may be other components also, such as fish, honeybees, silk worms etc. Depending on the nature and type of components involved, Agro-Forestry systems can be classified as:

- Live Fence : A Traditional System
- Home gardens : Intimate, Multistory combination of Jatropha and other TBO's
- Alley Cropping/Hedge Row Intercropping
    - o Jatropha + Lentil/Linseed : Rabi
    - o Jatropha + Mungbean/Cowpea : Kharif
- Plantation – Crop Combination - A shaded perennial crop system
    - o Jatropha + Turmeric/Ginger
- Agri-Horti-Silviculture
    - o Jatropha + Ber + Brinjal + Mothbean
    - o Jatropha + Karonda + Okra + Clusterbean
    - o Jatropha + Guava + Cucurbits
- Silviculture - Olericulture

- Jatropha + Tagets + Zaenia
- Silvi - Medicinal
  - Jatropha + Brahmi + Adusa
  - Jatropha + Kalmegh + Ashwagandha
  - Jatropha + Isabgol + Mentha
- Silvi-Pasture
  - Jatropha + Napier Grass/Ginni grass
  - Jatropha + Gliricitia + Napier grass
- Entomoforestry
  - Jatropha + Sericulture
- Cut and Carry Protein Bank
  - Jatropha + Poultry
  - Jatropha + Rearing of Tusser/Eri silk worm
- Biodiverse Farming System – Small Scale Industries
  - Jatropha + Agave (Rope making)
  - Jatropha + Aloe vera (Cosmetic)
  - Jatropha + Lowsonia (Cosmetic)
  - Jatropha + Bolivia/Butea (Lac cultivation)

Jatropha system would provide alternative options in degraded and viable ecosystem through intensification/diversification, involving high as well as poor value crops encompassing all agro-ecosystem of the country. The inclusion of leguminous crops/trees on poor soils can result in marked improvement in soil fertility by:

- Increasing soil organic matter through addition of leaf litter and plant debris
- Efficient nutrient cycling
- Efficient biological nitrogen fixation
- Little loss of nutrients from the system
- Little erosion run off
- Additional nutrient economy(uptake from deeper layers and deposition on surface layer via litter)

- Nutrient released by root decay
- Increased activity of favourable microorganism
- Adding shoot/root biomass
- Nitrogen supplement from leguminous crops
- Improvement in soil physical conditions
    - o Water holding capacity,
    - o Aggregate stability, Soil temperature,
    - o Permeability,
    - o Drainage etc.

16.1 Plant Protection

The occurrence of diseases and pests are highly region specific. Jatropha has no serious pest or disease problem at present. This may change when it is grown in commercial plantations with regular irrigation and fertilization.

16.2 Diseases

The Collar rot may be the problem in beginning and can be controlled with 0.2% Copper Oxy Chloride (COC) or 1% Bordeaux drenching. It may become a serious problem in some areas during monoculture under irrigated conditions. It is caused by *Macrophomina phaseolina* or *Rhizoctonia bataticola.* The rotting at adult stage has been observed in the soils saturated with moisture for a long period of time. The *Cercospora jatrophae-curcas* leaf spots are reported to be associated with this species. The rot can be controlled by application of 1 % Baurdoux drenching. Minor disease such as root rot (*Fusarium moniliforme*), Damping off (*Phytopthora* spp.) and leaf spots are reported to be caused by *Helminthosporium tetramera* and *Pestalotiopsis* sp.

16.3 Insect Pests

Insects such as beetles, hoppers and leaf minor larvae feeding (*Spodoptera litura*) lepidopteron larvae, die-back of branches/cushion scale (*Pinnaspis strachani*) blue bug sucking on fruits (*Calidea dregei*) locust feeding on leaves of seedlings (*Oedaleus senegalensis*), green stink bug sucking on fruits (*Nezara viridula*) are reported to be associated with this species. Bark eater (*Indrabela* sp.) and capsule borer are the major pests affecting the plant. They can be controlled by the Various Herbal pesticides e.g. Mixtures of vitex, neem, aloe, *Calatropis* or Rogor @ 2 ml/lit. of water. These may be controlled by spraying Endosulfan 3 ml per litre of water. The attack of mites on leaves reduces the leaf size causes crinkling on surface of leaves. Opmite (@ 2 ml/lit) and Wettable sulphur are being tested against mite.

16.4 Post harvest management:

16.4.1 Storage

The seed stored in ambient conditions maintains viability for 7-8 months. The long storage affects seed viability beyond eight months. Therefore, the seed being used for plantation purposes is kept at low temperature without loosing viability and effective emergence.

The oil industry requires continuous supply of raw material for oil extraction and esterification. The seeds/kernel containing the oil must be properly stored and prepared for extraction, to maintain high quality in the final product. The long storage of grain is reported to affect oil quality and quantity hence long storage should be avoided. The drying of seeds up to 4% moisture enhances storability. It should be maintained to enhance storability.

There is few operation to be performed to keep plantation free from disease and insect pests.

16.5 Management of plantation

16.5.1 During Growth Phase

- Use local mulch to avoid evaporation losses immediate after plantation
- Weeding during the initial phase of growth – Keep basin clean
- Fertilizer application during irrigation or state of sufficient soil moisture
- Conduct periodic pruning to maintain the canopy structure

16.5.2 Post Harvest

- Cut branches growing improper, leaning down
- Remove damaged or dead wood
- Grading of seeds before oil extraction to achieve high oil recovery

16.6 Plantation maintenance schedule at later age of plantation

The shrubs can be cut or lopped at any desired height and is well adapted for hedges. The entire plant has to be cut to ground level leaving 45 cm stump once in 10 years. The re-growth is quick and starts yielding in about a year. It induces new growth and helps stabilize yield.

17. Summary and Recommendations

The beginning of plantation should be made in phased manner (rather fulfilling the target just in one go) considering the availability of variety or equivalent quality material for plantation with adoptable production technology rather than blocking the wastelands with low yielding land race with no or remote possibility of its substitution at later stage. The beginning of plantations with demonstration phase with identification land in each potential state with the target to multiply quality planting material and plantation in subsequent years using high yielding variety plus quality planting material derived conventionally and being evaluated by different research organizations in multilocation testing and/or through *in vitro* mass propagation of elite types; and continue to supplement know how at different stage of the development of technology supporting good package to enhance productivity of existing plantations. The R and D shall continue to improve develop and identify high and quality oil yielding genetically improved varieties to meet the indigenous target and ready to transfer technology to seekers across country.

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Production Practices and Post - Harvest Management in *Jatropha*

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1. Introduction

Jatropha is widely utilized as a live hedge plant and can be planted out and established on a wide variety of sites with ease. It has potential to grow in adversity and probably owes its successful cultivation world wide to having no known major diseases or insect pests and its non-palatability to livestock. Furthermore, as a perennial plant, with relatively minimal moisture and nutrient requirements for growth, environmental impacts and capital investments are reduced. Most part of this plant is locally utilized for their versatile medicinal properties. Jatropha's seed yields up to 50% by weight, a slow drying oil, and known as "curcas oil" which is utilized as an industrial raw material. Earlier this oil was used mainly for candles and soap production. During the Second World War it was used as bio-fuel, substituting for diesel. Poisonous and toxic properties offer tremendous scope of Jatropha to use as fumigant and insecticide. Due to matching physical and chemical properties of curcas oil to diesel, the plant offers its potential to be used as substitute of petroleum fuel.

Bio-diesel is an eco-friendly, alternative diesel fuel prepared from domestic renewable resources i.e. vegetable oils (edible or non- edible oil) and animal fats. These natural oils and fats are made up mainly of triglycerides. These triglycerides when transesterified have striking similarity to petroleum derived diesel and are called "Bio-diesel". As India is deficient in edible oils, non-edible oil may be material of choice for producing biodiesel. For this purpose *Jatropha curcas* is considered as most potential source for it. Biodiesel is produced by transesterification of oil obtained from the plant.

Jatropha curcas has been identified for India as the most suitable Tree Borne Oilseed (TBO) for production of biodiesel both in view of the non-edible oil available from it and its presence throughout the country. The capacity of *Jatropha curcas* to rehabilitate degraded or dry lands, from which the poor mostly derive their sustenance, by improving land's water retention capacity, make it additionally suitable for up-gradation of land resources. Presently, in some Indian villages, farmers are extracting oil from Jatropha and after settling and decanting it they are mixing the filtered oil with diesel fuel. Although, so far the farmers have not observed any damage to their machinery, yet this remains to be tested and Petroleum Conservation Research Association is working on it. The fact remains that this oil needs to be converted to biodiesel through a chemical reaction - trans-esterification. This reaction is relatively simple and does not require any exotic material. IOC (R&D) has been using a laboratory scale plant of 100 kg/day capacity for trans-esterification; designing of larger capacity plants is in the offing. These large plants are useful for centralized production of biodiesel. Production of biodiesel in smaller plants of capacity e.g. 5 to 20 kg/day may also be started at decentralized level in villages. In this paper attempt has been made to describe the Production Practices and Post Harvest Management in Jatropha

2. Properties and Ecological Requirement

Jatropha curcas L. (*Euphorbiaceae*) or *Jatropha* commonly known as Physic nut, Ratanjot, Jamalghota, Jangaliarandi or Kala-aranda in India, is a large shrub or tree native to the American tropics. However, it is commonly found and utilised throughout the tropical and subtropical regions of the world. The plant is reported to have been introduced into Asia and Africa by Portuguese as oil – yielding plant. Now it is occurring almost throughout India and Andman Islands in semi-wild condition. Properties like hardiness, fast growth; easy and quick propagation (either by seeds or cuttings) and wide ranging utility have resulted in the spread of Jatropha far beyond its place of origin. The distribution shows that introduction has been most successful in the drier regions of the tropics with annual rainfall of 300-1000 mm. Jatropha exhibits a wide environmental tolerance; it is found in seasonally dry tropics as well as equatorial regions and is well adapted for cultivation within the vast 0areas of marginal and degraded lands in semiarid and arid tropics. It occurs mainly at lower altitudes (0-500 m) in areas with average annual temperatures well above 20°C but can grow at higher altitudes and tolerates slight frost, however very cold areas do not suit to this plant. It grows almost anywhere-even on gravelly, sandy and saline soils and in the crevices of rocks. *Jatropha* shows quick growth as implied by its ability to form a thick live hedge within nine months after planting. Its water requirement is extremely low and can withstand long dry periods of droughts by shedding most of its leaves to reduce transpiration loss. This plant can not tolerate waterloging for long time.

The leaves shed during the winter months and form mulch around the base of the plant. The organic matter from shed leaves enhance the earthworm activity in the soil around the root zone of the plants, which improves the fertility of the soil. The wood and fruit of *J. curcas* can be used for numerous purposes including fuel. The seeds of jatropha contain viscous oil, which can be used for manufacture of candles and soap, in the cosmetic industry, for cooking and lightening by itself or as diesel. Use of *Jatropha* oil as diesel has important implications for meeting the demands of rural energy services and also exploring practical substitutes for fossil fuels to counter greenhouse gas accumulation in the atmosphere.

These characteristics along with its versatility make it of vital importance to developing countries subjected to decreasing tree cover and soil fertility because of increasing populations and development pressures. Nearly half of the world's poorest people live on marginal lands with the number expected to increase from 500 million to 800 million by 2020. Plant species like *Jatropha* that can grow on lands not usually attractive for agriculture and supply raw material for industry, fuel for basic energy services and improve environment are therefore an obvious choice that needs to be assessed carefully and comprehensively.

3. Botanical Features

Jatropha curcas is a deciduous soft-wooded small multipurpose small tree or shrub, with smooth gray bark which exudes whitish coloured watery latex when cut. It usually attain the height of 3-5 m, however it can grow even up to 8-10 m in favourable conditions. It is monoceious and protandrous. Young shoots are glandular, tomentose, base is grey and green. Trunk is straight, branched from the ground, bark is thin and yellowish in colour (Fig. 1).

Figure 1: A whole plant of *Jatropha curcas*

Leaf is smooth, heart shaped, 4-6 lobed and 10-15 cm in length and width, initially light violet later on yellowish green and at maturity it becomes dark green (Fig.2a). Leaf fall occurs in the winter season. Plant flowers during the wet (rainy) season and two flowering peaks are often seen. In humid regions flowering occurs throughout the year. Concentrated flowering occurs during July to August. The plant produces yellowish green flowers in racemose inflorescences with dichasial cyme pattern (Fig.2b). Numerically, 1-5 female flowers and 25 to 93 male flowers are produced per inflorescences. The average ratio of male to female flower is 29:1. Female flowers are quite similar to male flower in shape but are relatively larger. Fruits are grey-brown capsule, 4 cm long and generally tri-halved, each comprised of one seed. Seeds are black, about two cm long and one cm thick. Generally fruits are matured by September-October. The seeds mature in three months after flowering (Fig 2c and 2d).

The flowers are pollinated by insects especially by honey bees. When the fruits begin to open, the seeds inside are mature. Seeds cannot be stored for long time as these loose viability within six months.Generally it has nearly 422 fruits/kg and about 1587 seeds/kg. The 100 seed weight is about 63 g and each fruits contain three seeds.

Figure 2a: Leaf of *J. curcas*

Figure 2b: Flower of *J. curcas*

Figure 2c: Fruit of *J. curcas*

Figure 2d :Seed of *J. curcas*

4. Production Practices in Jatropha

4.1 Propagation through seeds

Jatropha can be propagated by seeds as well as by cuttings. Germination is fast and under favourable conditions it is completed in 10 days. In the nursery, seeds can be sown in germination beds or in containers. Seeds are sown in the nursery beds in line at an interval of 15 cm with the seed depth of 4 cm. Seed to seed distance in line are kept at 5 cm. The overnight soaking of seeds in water improves the germination percentage. Germination starts after 5-6 days and continues to 10-15 days. Dry seeds can also be sown but the germination processes are delayed. In dry season regular irrigation is needed to enhance the germination. Generally seeds are pricked out from transplanting beds (20 x 20 cm spacing) when they are about one month old. The beds are watered sparingly and soils are kept loose to prevent cracking. For transplanting the plants are carefully pricked out from nursery and then placed into wet gunny bags for carrying into the fields.Transplanting should be done within 24 hours of pricking from the nursery bed. Seedlings can be raised in polybags also. Poly bags should be filled with 1:1:1 sand, soil and farm yard manure. Two seeds should be sown in each bag and watered regularly. When the seedlings are around 15-20 days old, weaker of the two seedlings should be removed and can be use for gap filling. *Jatropha* can be planted by sowing seeds directly in planting area. This is a cheap and easy method. But this method has certain limitations; if there is dry spell after the first rains or heavy continuous rains both the situations can badly damage the germination of seeds. If climatic conditions remain favourable, the healthy and vigorous plants can come out. Although the seedlings grow fast and they should be allowed to stay in the nursery for three months until they are 30-40 cm tall. By that time the plant are able to develop their repellant smell and will not be browsed by animals. *Jatropha curcas* grows on a wide range of climates and soils and can be established on degraded, gravelly, sandy or loamy soil with adequate nutrient content. It can be grown in areas of low rainfall and problematic sites. It is not sensitive to day length (ICRAF, 2003).

4.2 Propagation through cuttings

One year old shoots are selected for preparing the cuttings. The thick strong shoots of 20-25 cm long with 4-5 buds preferably taken from the middle of the branch are the best suited material for propagation as they give nearly 80-90% rooting. The cuttings are planted in raised beds of 3-5 m long and 1.5 m width. The soil is mixed with powdered and well rotten farm yard manure. The cuttings are planted closely with the spacing of 15-20cm.The cut ends of the stem cuttings are dipped in 0.3% benlate or wet cerason. The beds are watered regularly. For the quick establishment of hedges and plantation for erosion control, directly planted cuttings are recommended whereas for long lived plantations and vegetable oil production plants propagated by seeds are better. The seeds germinate within a week and become ready for transplanting in 45 days. Plants from seed develop a typical tap root and four lateral roots.

5. Jatropha Plantation

5.1 Methods of transplanting in the fields

In general, transplanting should be done with the onset of monsoon. The field should be prepared by digging small pits of 45 x 45 x 45 cm at the required spacing in the month of April-May and are filled with 5 kg FYM or compost. For the protection of termites 50 g malathion dust (10%) should be mixed with soil in each pit. This plant shows quick growth as implied by its ability to form a thick live hedge within nine months after planting. Jatropha probably owes its successful cultivation world wide to having no known major diseases or insect pests and its non-palatability to livestock so that it will not be grazed or browsed out even during the time of fodder crises also.

5.2 Block plantation

It can be very well planted in the field at the spacing of 2 x 2 m thus about 2500 plants can be planted out in one ha land (Fig.3a-c).

Figure 3a: View of Block Plantation

Figure 3b: View of Jatropha plantation

Figure 3c: Jatropha Plantation in Degraded land

5.3 Bunds/Boundary plantation

It can be planted on the bunds of the field as well as on farm boundaries at the spacing of 1 m. The boundary plantation acts as live fence and should be planted in two rows having row to row distance of 1 m. Thus in addition to seed yield it serves the purpose of bio fence or live fence without extra cost (Fig. 4).

Figure 4: View in Boundary plantation

5.4 As an Agroforestry Systems

If *Jatropha* is to be planted in such a way that agricultural crops can be grown as intercrop, in such situation these plants should be planted at the spacings of 2 x 3, 2 x 4, 3 x 4 or 4 x 4 m, thus giving proper space to intercrops to flourish properly as well as easy in agricultural operations with agricultural implements (Fig. 5and6).The commercial crops like ginger, turmeric patcholi, elephant foot, tomato, cabbage etc can be profitably cultivated under agro forestry systems.

Figure 5: Intercropping of Turmeric with *Jatropha*

Figure 6: Intercropping of Tomato with *Jatropha*

Management Practices

From second year onwards fertilizers are required. For one acre 20:120:60 kg of NPK applied during September-October, respectively. From 4th year onwards, 150g super phosphate is recommended over and above the regular dose.

Irrigation is a must and immediately given after planting. Life irrigation should be given on third day after planting. The irrigation at fortnight interval is compulsory to ensure year round production of flowers and harvest of seeds.

Weeding may be attended as and when needed. For early flowering, GA @100 ppm may be sprayed. It also helps better pod development and yield.

The terminal growing twig is to be pinched to induce secondary branches. Likewise the secondary and tertiary branches are to be pinched or pruned at the end of first year to induce a minimum of twenty five branches at the end of second year. Pruning should be done at 50-75 height. It should be done at least once in a year for 2-3 years. One in ten years, the plant may be cut leaving one meter height from ground level for rejuvenation. The growth is quick and the plant will start yielding in about a year period. This will be useful to induce new growth and yield stabilization there on.

6. Plant Protection

Bark eater (*Indarbella* sp) and capsule borer are the two major pests affecting the plant. They may be controlled by spraying endosulphan @ 3ml/litre of water.

Collar rot may become a problem in the beginning and be controlled by spot drenching of 1% Bordeaux to the affected and neighboring plants.

7. Post Harvest Management

Jatropha seeds are easy to collect as they are ready to be plucked after rainy season and as the plants are not very tall. Seedlings produce flowers 9 months after sowing. However, plants established through cuttings, produce flowers from 6th month onwards. Wherever *Jatropha* is cultivated under irrigated condition, the flowering occurs throughout the year. Economic yield starts from 3rd year end. Fruits are mature during September-October and harvested. Fruits are generally picked manually. Management practices particularly pruning practices helps to maintain the plant within the reach of the seed collector. After harvesting the fruits, shell of the fruits are decorticated and seeds are cleaned. Generally cleaning of seeds should be done manually to remove the unwanted material like husk, dust, litter, dead and decayed organic matter, soil etc and fresh seeds are dried in shade properly. After drying, seeds are graded in order to obtain quality seeds. This can be achieved by sorting out the undersize, deformed and diseased seeds. The seeds are separated either manually or mechanically. Seeds are dried under sunlight for four days until the moisture is brought to 6-10% before oil extraction. Quality seeds should be properly stored after grading in cool dry place. Packaging should be in gunny bags and if possible bags should be kept on wooden surface, away from wall with proper stacking, should be used within six months for raising nursery and plantation programme.

8. Yield

The *Jatropha* plants start yielding fruits and seeds with in the year but in limited quantity. It stands giving seed production @ 2-4 kg per plant from 5th year onwards and seed yield can be obtained up to 40-50 years from the day of plantation. Reports from the North East Hill region (Shankaran et al, 2003) showed the yield in different conditions were as follows:

- Under dry land conditions - 1000 kg/ha
- Under per meter hedge - 1 kg
- Under irrigated conditions - 1500 kg/ha.

9. Uses of *Jatropha curcas*

Jatropha seeds yield high quantity of oil, up to 50% by weight, a slow-drying oil (known as "curcas oil"), utilized as an industrial raw material for manufacturing on a smaller scale. Curcas oil is used in the manufacture of candles and soap. Good quality as well as fine quality soap can also be produced. In China curacs oil is used to produce furniture varnish after boiling curcas oil with iron oxide.

Curcas oil is also used in sciatica, dropsy, paralysis and externally for skin troubles and rheumatism; also considered to be an abortifacient. Latex when dry becomes bright reddish-brown, brittle substance, resembling shellac, and used as marking ink. Bark dye is obtained and used for dyeing cloth. Dye is also extracted from the leaves. Juice of the plant is useful in scabies, eczema, and ringworm.

Young leaves of Jatropha may be safely eaten, steamed or stewed (Ochse,1931). They are favoured for cooking with goat meat, said to counteract the peculiar smell. Though purgative, the nuts are some times roasted and dangerously eaten. In India, pounded leaves are applied near horse's eyes to repel flies. The oil is used for illumination, soap, candles, adulteration of olive oil and making Turkey red oil. Mexicans grow the shrub as a host for the lac insect. Ashes of the burnt root are used as a salt substitute (Morton 1981). Agaceta et al (1981) listed it as homicide, pisicide and raticide as well. The latex has been found strongly inhibitory to watermelon mosaic virus (Tewari and Shukla, 1982). Bark used as a fish poison (Watt and Breyer-Brandwijk, 1962). Little *et al.*, (1974) list the species as a honey plant.

The latex of Jatropha contains the alkaloids such as jatrophine, jatrophan, jatrophone, and curcain, which are believed to have anticancerous properties. Reported to be used as a folk remedy for alopecia, anasorca, burns, dropsy, eczema, fever, inflamation, paralysis and yellow fever.

Seed cake, a by product of extraction of curcas oil can be of value as an organic fertilizer or as a raw material in manufacturing. Being rich in nitrogen, the seed cake is an excellent source of plant nutrients. This residual de-oiled cake contains 38 % protein, 3.2-44% N, 1.4-2.09% P and 1.2-1.6% K. Like all trees, Jatropha removes carbon from the atmosphere, stores it in the woody tissues and assists in the build up of the soil carbon. With the combination of oil production and erosion control and the ability to grow in marginal areas with poor soil and low rainfall, this species has great potential in rural development as a source of house hold income and at the same time creating environmental benefits.

10. Conclusion

There is clear indication that Jatropha cultivation can make a significant contribution to the bio-fuel production and in sustainable development of the country, as the rapidly increasing consumption and consequent depletion of reserves clearly show that the end of fossil fuel is not much far away. It can also promote the development of several sister industries (candles, soap, cosmetics, pharmaceuticals, dye, fumigant and insecticide), promotes employment and checks the migration of wealth from the country. By-products obtained upon oil extraction have tremendous scope for the use by local communities as well as have a good market value. Economic gain can be experienced through the sale or direct use of these by-products. For example oil cake from oil extraction and glycerine from transesterification. Sale of seed cake can be a source of additional income and as fertilizer can be beneficial for unfertile and nutrient poor soil and makes it suitable for crop cultivation. The decomposition of leaves and twigs is very fast thus, released the nutrients to the soil in short time and further improve the soil. Glycerin as raw material is required in the manufacturing of soap and cosmetics. In some circumstances cultivating jatropha may prove its worth than diesel oil as it can generate significant amounts of revenue and profits from the sale of by-products which will provide the job opportunities to the rural and tribal masses. Cultivation of jatropha can be beneficial to both cultivators as well as industrialists and environmentally sound as it helps in storing carbon from the atmosphere.

Jatropha is thus unique among renewable energy sources in terms of the potential benefits that can be expected to result from its widespread use. Its cultivation is technologically simple and requires comparatively low capital investment. The large scale cultivation of *Jatropha* should strongly target the total degraded land (which is about 296 m. ha.) that requires treatment before food production is possible on them again.

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Jatropha (Physic Nut) in Research Frame at Pantnagar

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1. Site of Experiment

The Pantnagar is situated in North Western plain zone (NWPZ) agriculturally at 29^0 N la 79^0 E Lo 243.84 m al. in the tarai areas of Shivalik hills. The area falls under humid, subtropical zone having dry hot summer and cold winters. The soils are heavy loam rich in organic matter. The water table is high with presence of artisan wells. The area has characteristic three crop season i.e. Rabi or winter- (October–February), Zaid or Summer- (March–June) and Kharif or Rainy (July–September).

Table 1: Climatic condition at Pantnagar

Average Temperature ^{0} C		Rain fall (mm)	R.H. (%)	
Max.	**Min.**		**Highest**	**Lowest**
40-16	18-1	1881.0	97	15

The site Pantnagar is characteristic with good fertile soil, high moisture area with hot and humid climate in rainy season and severe cold and moist in winter season.

Jatropha crop traditionally earmarked for hot and dry areas fits in the summer and rainy season at this site. The time of nursery raising starts from April when average temperatures are 25^0C or more. The plants become suitable for plantation in July attaining a height of 3ft. The plantation is done at the onset of rains in July and extends up to end of August. In September the season becomes dry and cool which is considered unsuitable for plantation activities. Once planted it survives up to 50 years.

The Pantnagar has 260 ha = 650 acres of Jatropha plantation in the university farm and experimental plantation at high attitude Zonal Agriculture Research Centres, Majhera (Distt. Nainital) and Lohaghat (Distt. Pithoragarh).

The strength of Jatropha so for recorded is the habit of desiccation tolerance. The bare rooted saplings once kept upright under shade survive even up to 90 days without loss of viability. The weakness of plant as a crop is the low yielding nature and susceptibility towards frost. It could not survive above 4000 ft attitude where winter was severe and dry.

1.1 Parameters crucial for production system

1.1.1 Waste Vs. good land

Although the plant can survive under dry and poor soils but it is responsive to high inputs like fertilizer and irrigation. Production wise its poor in the wasteland and good under good agricultural practices. The preliminary observations have been given in table -2.

Table 2 : Preliminary Mean Observations on various characters under different Agriculture practices

S.No.	Characters	*Rainfed/Poor Input	** Irrigated/ high input
1.	Plant height (m)	1.60	2.12
2.	Branches (no.)	7.75	9.35
3.	Collor diameter (cm)	7.01	11.48
4.	Yield per plant (g)	124	257

Plantation year * **

2003-2004	Soil-Sandy/gravel	Soil-loam/heavy
Observation year	SSP-100g/plant	SSP-100g,
Compost 5kg/plant		
2004-2005	Irrigation-Nil	Irrigation-Two

The selected plants under irrigated/high input area gave first yields up to 1.5kg per plant and further increase in the yield is expected over number of years, as the branches will increase. The preliminary observations suggest a high input responsive trend in this crop thus the optimum dose of fertilizers and irrigation scheduling based on the zonal level is a requirement for crop.

1.2 Male: female flower ratio

The inflorescence in **Jatropha curcas** is terminal having unisexual flowers with male: female ratio up to 25:1. The female flowers are bigger than male and conspicuously lesser in number. Female flowers open 2-3 days after males within a plant thus ensuring a self-incompatible system. The lesser number of female flowers and inadequate pollination can be a major cause of low yields.

A population with male: female flower ratio of 50:50 will be preferred than the present day genotypes. The physiological and genetic aspects need an in depth studies including the breeding behaviour for hybrid seed production.

2. Initial Nursery Growth and Transportation

The hot and humid weather during rainy season induces flowering and fruiting, which extends up to November. The fruits are picked and seed is obtained in the month of December. The low temperatures start the process of defoliation in plant and induction of dormancy in both vegetative tissue and seed. This dormancy breaks down as soon as the temperatures rise. Nursery is raised by stem cuttings as well as seeds. The raised bed method was found better over polybag method. The polybag method is inferior as the transportation of plants is 10 times costlier than bundles of bare rooted plants, which can be accommodated up to 1-lakh plants per truck. Moreover plastic is a pollutant.

The initial growth is a faster in cutting raised plants which can attain an height of 6 ft within 3 months as well as primary branching also starts in the nursery itself. The seed raised plants attain primary branching generally after plantation. The fresh season harvested seed gives a good germination as compared to old seed. The high initial growth gives a competitive edge towards weeds during rainy season. The following nursery treatments were given per acre area.

Soil Treatment

- Vermi Compost @ 10 ton/acre
- Culture-Trichoderma @ 1kg/acre
- Culture – PSB @ 1kg/acre
- Culture – Azatobactor @ ½ Kg/acre

Seed Treatment

- Wash-Running water ½ hr.
- Carbandazime @ 2g/kg

The seedling stage up to one month was found very susceptible to root and collor rot diseases and additional sprays of fungicides became necessary. The seedling stage is also sensitive to urea, which should be avoided up to one-month stage.

3.9 Plantation Distance and Intercropping

The standard plantation distance reported is 2×2 meter totaling to 1000 number of plants in one acre. This parameter is very crucial and requires studies at microclimate level, based on the soil moisture, weed density and type of agricultural implements and practices.

The crop as such remains low yielding up to five years and thinking is to be given whether to treat Jatropha as main crop or intercrop. The intercropping is highly recommended for this to sustain this system up to 5 years. The following agricultural situations can be hypothesized to rationalize the plantation distance.

S. N.	**Use**	**Cropping system**	**Spacing**
1.	Farm fencing	If/PTr Rf	30-50cm 15-25cm
2.	Plantation	Rf/Tr Rf/Ma	3×3m 2×2cm 1.5×2m

Ir- Irrigated, PIr = Partially Irrigated, Tr = Tractor, Rf = Rainfed and Ma = Manual

The irrigated areas have predominantly tractor drawn implements for intercultural operations. It will require a minimum of 3×3m spacing. Similar is the situation with bullock drawn implements. The wider spacing only gives a choice for intercrop.

The low productivity of this crop during first five years makes the intercropping essential rather intercrop can be the main crop and Jatropha can be considered as bonus crop. The crop remains defoliated during winter season providing scope for various types of winter legumes while in summer season the choice of crops will be limited due to high canopy growth. The paddy cultivation is not possible presently as it involves water logging. Various intercrop possible may be as under.

June → **November** → **March**

Moongbean   Gram   Urdbean

Urdbean	Lentil	Moongbean
Soybean	Pea	Lobia
	Mustard	Holy Basil
	Garlic	
	Onion	M and AP Crops
	Coriander	
		Turmeric
		Ginger
		Shatavar

The only criterion is that height of plant should not be crossed by intercrop and there should be no water logging. The intercropping provides the necessary residual fertilizer and irrigation to Jatropha crop without any additional expenditure.

4. Fertilizer, Irrigation and Cutting-Pruning

The preliminary experimentation indicates the input responsive nature of crop. The experimentation for fertilizer and irrigation schedules is under progress. After initial growth in the nursery stage the plantation is done by pit preparation of 1×1×1ft filled with a mixture of 5kg compost and 100g DAP per pit. The compost treated with Phosphate Solublising and Azetobactor Cultures @ 10g/pit gave good initial growth. This does not require watering if soil is saturated in the month of July-August although late August plantations require watering after transplant. The primary branches develop up to November and give minor fruiting during first year after which the defoliation and dormant season starts which remains up to end of February. This is the appropriate time for pruning, which is a 50%. The secondary branching will restart in the month of March when new sprouting will start. This is the stage when plant requires another dose of fertilizers and water. The second pruning is again done in second year after harvest of the crop, which is considered the first yield for practical purpose. The second pruning initiates tertiary branching after which the requirement of pruning is a matter of study but two prunings are necessary for branching and consequent fruiting.

4.1 Seed production

The experiments so for have indicated a high self-incompatibility. The flowers are unisexual, protogynous with monoecious condition. The amount of selfing was found less than 2% and varied among genotypes. Thus every individual plant is different genetically. The improved population will act as a gene pool, and isolation will be necessary. The pollen studies for isolation distance have been initiated but for working requirements it can be safely taken as 300-500m. as in the lines of maize. Looking at the habit of plants and long life cycle the seed production areas will be large even to maintain few varieties. The regular seed production programme from nucleus, breeder to certified is necessary zone wise or the variability will be encountered every year.

Although the vegetative propagation is easy but it will take many years to produce true to type plants of required quantity, thus the tissue culture is a viable option but need to be developed on commercial lines, looking into the huge future demands of quality planting material.

5. Requirements for Genetic Improvements:

5.1 High yielding varieties

The biggest requirement at present is the high yielding varieties to make this system viable for farmers. The existing system with 2kg/plant or 20qtls/acre is too low for farmers. The immediate target can be up to 4kg/plant or 40qtls/acre first-second yields.

The search for noval genes like male sterility, O-toxin etc is immediate in the world germplasm. In conventional breeding approach the crossing programmes with hand emasculation have been initiated but hybrids at a commercial level is far off possibility without a functional male sterility line. The improved composite populations can give an immediate working technology.

5.2 Synchronous Maturity

The crop at present shows asynchronous maturity allowing fruit picking in the duration of around two months. Although shattering is not conspicuous but the picking operation adds labour costs. The lines with synchronous maturity need to be identified for breeding purpose.

5.3 Oil content and quality

Since Jatropha is an industrial crop the adequate oil content in the varieties is must. The standard of 30% oil on mechanical expeller basis has been accepted, the 9-10% oil remains in the deoiled cake under field conditions. A poor quality oil with high saturation has also been found in some germplasm. Since the oil is the basic product, the breeding needs to be focused on this aspect. The variability for oil content has been given in some genotypes in **Table-3**.

Table-3: Oil content and physical properties of Jatropha oil in various genotypes

Genotype	*Oil	Reactive index	Acid value	Relative density	Iodine value
Shu04004	40.0	1.4732	1.7952	0.9226	135.14
Shu04005	38.9	1.4741	1.2342	0.9299	119.48
Pant Sel-4	41.0	1.4714	1.3464	0.9179	129.69
Pant Sel-31	40.5	1.4715	1.2342	0.9113	131.34
Pant Sel-97	40.0	1.4700	1.2342	0.9074	133.24
RJ-3 41.5	1.4691	2.3562	0.9134	167.41	

* Solvent basis (Hexane)

6. Post Harvest Requirements

6.1 Fruit picking tools

The Jatropha being a tree borne oilseed crop attains on height of 5 meters or more during its life cycle. The crude method of sticking and picking fruit damages unripe fruits also. The smaller picking tools need to be developed.

6.2 Decorticator

The mechanical decorticators have been developed. A small capacity (373 kg/hr.) decorticator has been developed at Pantnagar (Singh, M.P. 2005) for village level use. The engineering properties of Jatropha fruits and seed are given in **Table 4**.

Table 4: Engineering properties of Jatropha fruit and seed

S. No.	Properties	Fruit	Seed
1.	Length (mm)	26.45	16.86
2.	Width (mm)	20.81	11.14
3.	Thickness (mm)	26.31	8.67
4.	Weight (100 seed) (g)	249.31	48.76
5.	Angle of internal friction (degree)	31.55	28.39
6.	Bulk density (g/cm^3)	0.2269	0.3812
7.	True density (g/cc)	0.432	0.720
8.	Angle of repose (degree)	46.544	38.69

The portioning of dry Jatropha fruit into fruit husk, seed, seed kernel and seed coat came as follows: -

Total fruit	Seed kernel	Seed coat	Fruit husk
100	36.6%	23.4%	40%

6.3 Dehuller

The seed coat present on the kernel of Jatropha seed constitutes around 40% of the seed weight. The mechanical expelling of oil as done from the whole seed and the deoiled cake retains 9-10% oil. If the seed coat is removed even by 50% the oil recovery even with mechanical expellers will increase by 4-5%. The appropriate dehullers need to be developed.

6.4 Oil Expellers

The mechanical oil expellers used for groundnut, castor and mustard are being used. These expellers up to 70% of total oil present in the seed. The solvent process recovers almost 98% of the total oil present in the seed, but the initial cost to set up it is high. At village level the mechanical expellers are common. The traditional methods of oil extraction may also be helpful and economical and need studies.

6.5 Direct use of Jatropha oil-blends

The use of vegetable oils as fuel for diesel engine has long history. The use of Jatropha oil as fuel in CI engines is becoming frequent in the areas where this oil is available as total oil or oil blended with diesel. Although the use of direct oil still requires debate. Some studies have been done at Pantnagar on fuel properties of Jatropha oil-diesel blends and engine performance by Bhattacharya, T.K. (2005) and it was found that blending of Jatropha oil with diesel was feasible up to 30:70 oil-diesel blend. The performance of the engine in respect of brake power, hourly fuel consumption; emission of CO, UBHC and NOx under the rating test was found to be satisfactory.

7. Cost of production and value addition

The calculation for crop economy at present stage may be more of speculative nature as the full experimentation is yet to be done. Moreover the benefit is linked with the cost of diesel, which is increasing every year in India. Although the authentic data will be available once the Jatropha expands horizontally and vertically with farming community just like sugarcane. The developments like high yield and oil varieties and their value added products need to be considered in totality for detection of crop economy. A cost of production and return analysis has been presented in Table-5.

Table 5: Cost benefit analysis in Jatropha cultivation (1000 plants/acre)*

(1st to 5th years)

S. No.	Operation	Expenditure (Rs.)	Income (Rs.)
1.	Nursery @ Rs. 4/plant	4000	-
2.	Pit preparation @ Rs. 2/plants	2000	-
3.	Transplantation @ Rs. 1/plant	1000	-
4.	Cutting and pruning @ Rs. 0.50/ plant (2 years)	1000	-
5.	Fertilizer and Pesticides @ Rs. 2/plant	2000	-
6.	Seed collection @ 1.50/plant	1500	-
7.	Yield (3rd yr) 500kg × Rs. 10	-	5,000
8.	Yield (4th yr) 1000 kg × Rs. 10	-	10,000
9.	Yield (5th yr) 2000 kg × Rs. 10	-	20,000

10.	Maintenance expenses (4-5 yr) @ Rs. 1/plant/years	2000	-
	Total	**13,500**	**35,000**
	Returns (1-5 years)	**21,500**	
	Return/acre/years	**4,300**	
	(6th to 10th years)		
1.	Yield (6th yr) 2000 kg × Rs. 10	-	20,000
2.	Yield (7th yr) 2000 kg × Rs. 10	-	20,000
3.	Yield (8th yr) 2000 kg × Rs. 10	-	20,000
4.	Yield (9th yr) 2000 kg × Rs. 10	-	20,000
5.	Yield (10th yr) 2000 kg × Rs. 10	-	20,000
6.	Maintenance expenses @ Rs. 1/ plant/yr.	5000	-
	Total	**5000**	**1,00,000**
	Returns	**-**	**95,000**
	Return/acre/year	**-**	**19,000**

* The data will change according to cultivation zone

The price of biodiesel fixed at the rate of Rs. 25/- may be less for obtaining returns by farmers. Why cost of biodiesel should not be comparable to diesel is a debatable issue.

7.1 Efforts for value additions:

7.1.1 Leaf and cake manure

The Jatropha gives substantial foliage and cellulosic waste material as well as various medicinal uses have been reported. An effort has been made to utilize unused biomaterial for developing a value added product. The crop attains maximum foliage during months of July to October and fruiting ends in December after which the defoliation occurs. The green leaves of Jatropha were picked and a quick method of composting was developed. A high grade Jatropha leaf manure was prepared on experimental basis. The analysis report has been given at **table 6.** The formulation of cake manure is under study.

Table 6: Manure Test Report ñ Jatropha leaf manure

Organic carbon (%)	N (%)	P_2O_5 (%)	K_2O (%)	Ca (%)	Mg (%)	S (%)	Zn (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)
11.49	2.00	0.97	1.0	2.13	0.68	0.92	322	82	607	615

7.2 Fuel bricket from deoiled cake

Traditionally cow dung bricket or uplas are made in the country. The deoiled cake of Jatropha having 8-10% residual oil can be combined with cellulosic waste like seed husk from other threshed crops along with cow dung to make village level Jatropha uplas. The other combinations with coal powder are also under study.

8. CONCLUSIONS

Jatropha being a tree borne oilseed has all potential as an industrial crop. The production system can not be stabilized only by targeting waste land, road and railway corridors rather it will require established farming system to ensure adequate feed stock/raw material for industry.

The working technology is available for production aspects and R&D interventions are required to make this crop economical. Intensive research is required on the crop breeding aspects to give a high yielding stable production system.

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EXTRACTION AND TRANSESTERIFICATION

Biodiesel Production Through Transesterification

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In recent years, biodiesel has been in focus as a part replacement component of petroleum diesel. The reasons for this focus are obvious as most countries of the world are exploring alternate energy sources, which are environment friendly and are from renewable sources. Bio-diesel scores very well as an alternate fuel of choice as it helps in decreasing dependence on fossil – fuels and also as it has almost no sulphur. Higher cetane of biodiesel as compared to petro diesel implies its much improved combustion profile in an internal combustion engine. Because of the well-established advantages of biodiesel, its production capacities world over has witnessed a double-digit annual growth rate for the last few years.

Out of the total value chain for biodiesel production probably easiest and the most understood part is the production of biodiesel from vegetable oils or fats. Chemically all vegetable oils, whether edible or non-edible, and fats are made up of fatty acid triglycerides. This means that even though there is a change in the sources of edible oils, chemically they remain almost same. These triglycerides when reacted with an alcohol (usually methanol or ethanol) in the presence of an acid or a base catalyst very readily give quantitative amounts of fatty acid esters. This reaction is called transesterification and the product obtained i.e. fatty acid esters is called biodiesel. Let's be clear about one thing that the vegetable oils as such are different then biodiesel. Though in some application **Straight Vegetable Oils (SVO)** can also be used in small percentage in a mixture of petroleum diesel, but this has long-term implications. The very fact that SVO's have much higher boiling range and very high viscosity as compared to petroleum diesel implies that these will not be able to burn completely in an internal combustion engine. This incomplete combustion leads to formulation of coke, especially around fuel injection nozzle and the subsequent restriction in fuel atomization leads to more smoke and unburned particles. However, after transformation of SVO into biodiesel by the process of transestrificaion most of the problems associated with SVO are sorted out. This implies that transesterified SVO i.e. biodiesel is component which can partly or fully replace petro diesel as a fuel for internal combustion engines.

Transesterification reaction was developed almost a century ago and has been used in chemical industry very frequently. The chemical kinetics and the reaction variables have been thoroughly examined. Depending upon the catalyst used for transesterification / esterification, commercial biodiesel technologies can be divided in to three categories:-

- Base catalyzed transesterification with refined oils
- Base catalyzed transesterification with low fatty acid oils and fats
- Acid esterification followed by transesterification of low or high FFA (free fatty acid) fats and oils

It may be mentioned that fuel grade biodiesel must meet standard specifications before it can be blended in petro diesel. Initially, the ASTM specifications were almost universally adopted for quality control of biodiesel. However, with the progress of biodiesel industry outside U.S especially, in Europe, several other country-adopted specifications for biodiesel were also adopted. Concerns of automobile manufacturers were also taken into account while drafting the specifications and more and more criteria were added into the standards. Bureau of Indian Standards (BIS) also adopted specifications for biodiesel for use in India **IS 15607**.

Though the basic transesterification reaction to produce biodiesel remains very approachable and easy, some complications arise in order to meet all the laid down specifications for biodiesel. The basic goal for all technologies remains to produce biodiesel in the most cost effective manner while meeting all the specifications. This calls for a near complete removal of glycerin, soaps, water, alcohol and any remaining acid or triglyceride. A successful and commercial transesterification technology should be flexible to undertake some variations in the feed stock quality and should be in a modular form. In general, most of the biodiesel today is produced by either base catalyzed reactions or by acid treatment followed by base catalyzed reaction. Though there have been some reports of laboratory scale experiments for transesterification using bio-catalyzed or heterogeneous catalysts, but these are yet to achieve commercial maturity. In the base catalyzed transesterification, sodium hydroxide followed by potassium hydroxide is the most commonly used catalyst. The alcohol used is generally methanol, however, ethanol has also been used. The quality of feed oil, especially the amount of free fatty acid present, has bearing on the type of technology to be employed for transesterification. Feed stocks having large amount of free fatty acids consumes the base catalyst and any water present interferes with the reaction by formation of emulsions. However, technological advances have made it possible to utilize both low and high FFA oils for conversion to biodiesel.

There has been a lot of debate about the proper economic size of the biodiesel plants. Small-sized plants are favored because of low initial cost and that they avoid sophisticated control technologies. These multi location small size plants reduce distribution and transportation costs and also empower local communities to produce biodiesel in the area where the feedstock is available. On the other hand, the advantage of glycerin production is lost in small-scale plants, as the glycerin refining units need minimum economic size. The operating cost of small-scale plants and very large plants may not differ substantially if; all the variables are taken into account.

The biodiesel program of U.S is basically driven by availability of excess of soybean oil while in Europe; it is sunflower and rapeseed, which is commonly employed. Malaysian biodiesel program is obviously centered on palm oil. Since India is a net importer of edible oils and also for increased production of edible oils a regular irrigated farm of land is required, in all wisdom, the Indian biodiesel program is based upon non-edible oil seed like *Jatropha* and Karanjia, which can grow on marginal lands. Since all the transesterification standardization has been on edible oils, extension to non-edible oils required additional work. This job has been very well undertaken by several of Indian research institutes, both in public and private domain. The main process variables for the transesterification reaction, which need to be optimized, are the following:-

- Reaction temperature
- Ratio of alcohol to oil
- Type of catalyst
- Concentration of catalyst
- Reaction duration

All the above factors have bearing on the quality of biodiesel as well as on the percentage conversion of oil to biodiesel. It may be mentioned that any successful technology must be able to convert more than 97% of oil into esters.

In my presentation, various technologies available for producing quality biodiesel shall be compared. The list of Indian Institutes / organizations currently producing biodiesel shall be discussed with special reference to their technological innovations. In spite of all the good efforts of various organisations, there are still some gap areas in the total biodiesel value chain starting from plantation to marketing. These include availability of elite material for plantation, toxic nature of *Jatropha*, value addition through seed meal and the special need for emission testing. I propose to discuss briefly some of these gap arise.

Biodiesel an Environmentally Friendly Alternate Fuel Experience of Indian Railways

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Today the world is facing two critical crunches (viz):

- **Energy and freshwater**

Similarly the world also is experiencing two severe destructive developments (viz):

- **Environmental degradation and natural disasters**

Energy and environmental degradation are closely related with each other and the other two entitles are also indirectly connected with the former two.

Biodiesel, which is a substitute to diesel oil, is an excellent energy source, which can greatly address the above entities.

Indian Railways being the single largest consumer of HSD Oil in the country is taking considerable efforts to substitute Biodiesel as an alternate fuel to run both the diesel locomotives and road vehicles. Its efforts are integrated one (i.e.) right from plantation of Jatropha and Pongmmia piñnata trees to preparation of Biodiesel and use in its fleet of vehicles and locomotives.

In Southern Railways considerable Pioneering works have been carried out in all these fields. Nearly 3 lakhs of Jatropha seedlings have been planted in Railway vacant lands and track sidings. Also plantation of pongammia trees are also encouraged wherever shade is required, like platforms, roadsides, building, courtyards etc. In the transesterfication field some pioneering works were carried out in a Raiway Work shop at Chennai. Many of the popular vegitable oils both of edible and non-edible varieties like jatropha, pongammia pinnata, rubber oil, soya oil, palm oil etc were esterified and standards established.First a 5 ltrs capacity glass model of transesterifaction plant was made as an experimental measure. After establishing the standards a pilot plant of 25 ltrs capacity was installed. Then a 150 ltrs capacity production plant was made and now another 300 ltrs capacity plant is installed along with oil expeller, decordicator etc. Now the work shop can produce about 1.5 to 2.0 tonnes/ day of Bio-diesel

On the usage front ONE TATA SUMO road vehicle is running with 100%Bio-diesel for the past two and half years. Another twenty road vehicles both heavy and light categories along with one DG Set are also run with various proportions of blend from 20% to 100% for the past 02 years. After gaining sufficient experience in running the road vehicles now one broad gauge and two metre gauge locomotives along with 5 diesel DEMU shuttle services are also put on 5% blend of Bio-diesel for the past One and half years. Our experience with Bio-diesel is that it is an excellent environmental friendly Bio-fuel.

Southern Railway is also participating in various exhibitions to showcase the production and the use of Bio-diesel with the 5 ltrs capacity glass-working model to spread the knowledge and awareness of Bio-diesel. In one such exhibition organized by FICCI in November, 2005 at New Delhi The President of India had shown keen interest on the exhibits and appreciated the efforts.

The Vision ìBiodieselî ñ Hurdles in the Way for Achieving

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Bio-diesel at the very outset is not a concept, which got invented very recently. More than 100 years ago "diesel" was invented by Mr. Rudolf Diesel and this diesel was made by the process trans-esterification from the vegetable oil and finding the price disparity the diesel so produced from the vegetable oil slowly got replaced with mineral diesel.

I won't know the use of vegetable oil or the process of vegetable oil as to when it got started in our country for being used in the engines as ''diesel-substitute'', but, yes, about 6-7 years back I read that near Murshidabad or Malda area in West Bengal farmers have used expeller grade rapeseed oil or expeller mustard oil as popularly known in India as a mix for operating the engine for driving the pump. this probably match saying that what Bengal thinks today others make thinking about afterwards .

In last 5 years for my attending on regular basis price outlook seminar during month of February / March organised at Kuala Lumpur and / or International Association of seed crushers during 1998 in Japan, 2000 in London; 2001 in Sydney; 2003 in Brazil; 2005 at Bombay and

/ or Glob oil organised annually at Bombay besides conventions / seminar organised by the central organisation (national apex body for oil industry and trade) of which I am Sr. Vice President, we have heard regularly and more during past 3 yrs that Germany is making use of rapeseed oil for making biodiesel and during the current year Europe will be making near 30 lac tons of biodiesel. Now this making is whether for combating with the rising mineral oil prices or for big farm subsidy or otherwise, is a big question?

To me it is an equilibrium theory based on price cum parity, ofcourse with push from environmentalist and government bodies on basis of concern about the ecological requirement and also concern for emission from the vehicle pollution i.e. carbon mono oxide.

The process basically for biodiesel involves trans-esterification and / or esterification and/or now re-esterification and in respect of the process none of these process can be termed as having been invented in very immediate recent past.

Transesterification – to the extent i have seen the operation and my background not being from chemistry, but know that this process with aid of methanol at 10% of the volume of the vegetable oil when mixed with sodium methoxide or pottasium hydroxide at temperature below 75°c creates a reaction whereby glycerin portion from the fats gets detached and after this reaction the oil mass having some water and methanol is subjected to process of evaporation of water and further process of distillation for recovery of methanol and filtering of the biodiesel.

The so made biodiesel in the last requires additive for maintaining cpff i.e. cold point freezing factor so as to enable the biodiesel not to create clogging during the extreme cold i.e. temperatures below –5°C thus Europeans have various requirements about the cpff factor in ranges i.e. at '0' deg/or at –5 to –10°C / or at -11 to –20°C etc.

Esterification/re-esterification - when vegetable oil is processed and fatty acids are removed by the process of alkali refining i.e. chemical refining or by the process of physical refining i.e. deacidification at high temp under vacuum and with aid of super heated steam at temp between 260°c to 280°c and vacuum of near 1 torr the bad odour evaporates and the free fatty acids being volatile are separated thru the process of distillation and this volatile fatty acid when condensed and stored is termed as "fatty acid distillate" which chemically is marketed on the basis of ffa near 86/88 % and having neutral oil around 10% - 12% (contains 11% glycerin therein) .

This fatty acid distillate also is used for making of biodiesel by way of esterification and re-esterification with aid of acids and sometimes even with aid of enzymes and some glycerine and the reaction for this process with some methanol called menthylester (.)

This so produced or re-esterified oil after some pre-treatment-cum-deacidification is again subjected to process of transesterification and then 'biodiesel'.

In India for sometimes wrongful use of esterification / re-esterification has started i.e. the process being popular in Europe, it carries a ban too i.e. esterification or re-esterification is not permitted for making edible oils and is allowed only for making biodiesel, but solely on account of social economy factor in India particularly in Western U.P. / + Uttaranchal / + Haryana and Punjab this esterification / re-esterification with aid of glycerin for making a recycled grade of "so termed edible rice bran" activity is regular practice .

Definitely this process of esterification or re-esterification for making "so termed edible grade oil" needs to be banned in India too and further requirement is for a stricter law and it's strong enforcement for asking the process to be used for making biodiesel i.e. asking factories to convert this available fatty acid distillate/or sell it to 'biodiesel" makers.

Problems in implementation of the biodiesel plant – basically baring few big company's promoters from vegetable oil industry will come forward for this.

♣ The promoters from this industry looks for support from institutions for considering a somewhat little lower margin stipulations so that the ailing industry of vegetable oil segment may come up and join this project for making of green fuel i.e. biodiesel.

♣ Besides higher margin stipulation the concept i.e. marketing policy also has it's own role towards slow growth in implementation of biodiesel since to start with an oil to be processed by vegetable oil industry is given in the controls of petroleum department (.)

♣ To start with it's not wrong nor the system needs any criticism, but points needs to be appreciated is that petroleum department needs to discuss closely with vegetable oil producers may be thru association's connected with the vegetable oil industry or the national apex *bodyíí*<u>*the central organisation for oil industry and trade, new delhi.íí*</u>

The above point is made in view that capacity of vegetable oil producers while is not only small, but it's so widely spread or fragmented that a viable biodiesel capacity plant is not within ability reach of all the industrial entrepreneurs in the line.

If the marketing policy is gone thru it names 20 depots., but without West Bengal and today one has to agree that vegetable oil industry is located in almost all the districts, thus collection system of the depots needs to be reconsidered by the petroleum ministry and in their planning board they need members connected with vegetable oil industry in particular having knowledge or connection with biodiesel which until now is not in existence .

The MSP so announced under the purchase policy i.e. rs.25 per litre (rs.28.40 per kilo) looks probably a "pass-by" ., to me it looks that policy makers are under confusion since couple of years back edible oil prices were above rs.40 per kilo and for couple of years it has touched low of rs.25 per kilo, thus practical steps are required .

The fear about the inflation of the priceline should not be the sole criteria. Policy makers need to make a governing committee consisting experts from petroleum dept and vegetable oil segment so that the fear of priceline does not deter or create problem for the policy makers for rightful steps .

It may be said that inflation is also handled with the tool of politics i.e. the step or the manner by which raw material inputs of vegetable oil industry while got subjected to excise + import duties + special import duties (said to be modvatible thru excise) + service tax (again said to be modvatible thru excise) was very smartly got imposed and implemented, but they also exempted the edible oil from excise.

The end result government collects special import duties, government collects service tax(both said to be modvatable in budgeti06-07), but at the same time have chopped of the hands of the edible oil producers by making edible oil excise free. thus in respect of biodiesel it is required that policies are made keeping all the factors in mind.

Excise or vat should and must start if to be imposed right from the core raw material until the finished product, but not in the manner it is on edible oil industry.

In order to get faster implementation of biodiesel hurdles mentioned above needs to be removed. Policy should announce free marketing, free handling and promoters' needs to be taken into confidence that they will be allowed economical and fiscal freedom in respect of biodiesel production and it's marketing. Another hurdle is the land reform and concept of corporate-cum-contract agriculture (i.e. concerning plantation).

The freedom of marketing :– to start with this concept of depot delivery needs to be dealt with on the ground of logistics and quantities which could be perceived as being or well being getting produced over next 10 years.

Stress on quantity is being made from the angle of logistics and promotional capabilities from the industry, the entire comprehensive process for making biodiesel includes such as :-

Pre-treatment of vegetable oil ➔➔➔ followed by deacidification for bringing down the fatty acids ➔➔➔ followed by trans-esterification ➔➔➔ followed by separation of biodiesel ➔➔➔ recovery of methanol (recycled) ➔➔➔ followed by marketing of biodiesel.

If not all the above activities in mind nor about the developments, it is the vegetable oil segment promoter having easier options to put in step forward for biodiesel, but definitely it's much different for the entrepreneur or corporates having indulgence in petroleum to take a step forward towards vegetable oil segment. thus answer is requirement of a synergy between the two segments since vegetable oil segment is not small have turn over and contribution for taxes / excise and local mandi tax etc etc ., beside import duty near / over rs. 5-6000 crores . total turn overs as under :-

a) Farmers to oil millers 225,00,000 ton

	oil seeds approx	Rs. 22,500 crores
b)	Oil milling upto the crude level 60 lac tons (average price rs.35)	Rs. 21,000 crores
c)	marketing of the agricultural mass 165 lac tons(avg rs 4/- a kilo)	Rs. 6,600 crores
d)	marketing of refined edible oil form 50 lac tons(avg rs.38/-)	Rs.17,500 crores.
e)	handling of imported oil 60 lac tons (average price rs.38/-)	Rs.22,800 crores

total of this segment is Rs.90,000 crores + per year

Thus this segment alone has its own national apex body and synergy is required between petroleum ministry and the vegetable oil segment.

Marketing is definitely possible only need is change in-the concept and to start with ***straight away embark on current system of European marketing*** i.e. whenever biodiesel is produced plan marketing keeping the location of plant in the mind and putting in efforts for marketing the biodiesel so to be produced within a geographical periphery of 100 – 125 kms radius of the plant i.e 100 km in case of big metropolis (i.e. Calcutta, Mumbai, Delhi, Chennai) and 125 kms if near other metros or state capitals.

The marketing options to start with could be by ***designating about 100 ñ 150 pumps belonging to all the Four Oil PSUís*** in and around the metros and let biodiesel be marketed from it.

If not above ***marketing can also be done*** by the desirous biodiesel producer who can invest anything from rs. 2–3 lacs on infrastructure over each of the petrol station for installing 1000 – 1500 litre tanks and a system of dispensing as stand alone and as well thru the mixing pipe system on the line petrol stations have in respect of scooters and motorbikes.

If not above two, then ***the network of the lube dealers*** and the big motor garages plus strategically located tyre / valcanising repair centres also can become network associates since flash point of biodiesel is more than 125, not being a fire hazard.

Additionally one can and definitely i am planning create a secured website for obtaining orders thru debit card / credit cards for ***making direct to home delivery in 15 or 20 litres returnable-cum-reuseable pet jars.***

Above marketing options definitely needs support from oil psu's and i am of the view that when oil psu's have opened vending outlets for daily use groceries, thus then accommodating biodiesel may not be and cannot be a detrimental criteria.

To make biodiesel more successful planning commission and ministry finance needs to formulate and make government announce or come out **with a 10 year path plan** giving initial 7 years period as being tax free i.e. machinery's and raw materials free of tax + excise duty + import duty and let taxation in this regard start from end of 7 years., ***for achieving the vision .***

In order to make biodiesel producers avail benefit of service tax paid and some vat paid on the inputs, i would prefer that government may come out and introduce a very concessional rate of excise and vat at not more than 1% to max 2%.

With all above in the last i am of the opinion that all this effort will be seen as being on a fast track if Oil PSU's consider vide respective negotiation a sort of joint venture or a project specific partnership or financial assistance package since *the product biodiesel is future and needs to be looked at and planned as vision.*

LINKAGES

Biodiesel: Technology and Business Opportunities ñ An Insight

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1. Introduction

The concept of bio fuel dates back to 1885 when Dr. Rudolf Diesel built the first diesel engine with the full intention of running it on vegetative source. In 1912 he observed, " … *the use of vegetable oils for engine fuels may seem insignificant today. But such oils may in the course of time become as important as petroleum and the coal tar products of present time.î*

In 1970, scientists discovered that the viscosity of vegetable oils could be reduced by a simple chemical process and that it could perform as diesel fuel in modern engine. Since then the technical developments have come a long way and the plant oil today has been highly established as bio fuel, equivalent to diesel.

Recent environmental *(e.g. Kyoto Protocol)* and economic concerns have prompted resurgence in the use of biodiesel throughout the world. In 1991, the European Community proposed a 90% tax reduction for the use of bio fuels, including biodiesel. Today 21 countries worldwide produce biodiesel.

India is one of the largest petroleum consuming and importing countries. India imports about 70 % of its petroleum demands. The current yearly consumption of diesel oil in India is approximately 40 million tones constituting about 40% of the total petro-product consumption.

2. Why Biodiesel?

Biodiesel, derived from the oils and fats of plants like *sunflower, rape seeds, Canola or Jatropha Curcas*, can be used as a substitute or an additive to diesel. As an alternative fuel biodiesel can provide power similar to conventional diesel fuel and thus can be used in diesel engines. Biodiesel is a renewable liquid fuel that can be produced locally thus helping reduce the country's dependence on imported crude.

2.1 The advantages of biodiesel are enumerated hereunder

- Biodiesel is non toxic and environmental friendly as it produces substantially less carbon monoxide and 100% less sulfur dioxide emissions with no unburnt hydrocarbons and thus it is ideal fuel for heavily polluted cities. Biodiesel reduces serious air pollutants such as particulates and air toxicity.
- Due to its less polluting combustion, biodiesel provides a 90% reduction in cancer risks and neonatal defects.
- Biodiesel is biodegradable and renewable by nature.
- Biodiesel can be used alone or mixed in any ratio with conventional diesel. The preferred ratio of mixture ranges between 5 and 20%
- Biodiesel extends the life of diesel engines.
- Biodiesel could be cheaper than conventional diesel.
- Biodiesel has good potential for rural employment generation.

3. Biodiesel : Common Plant Sources

Under Indian conditions such plants varieties, which are non-edible and which can be grown abundantly in large-scale on wastelands, can be considered for biodiesel production. Some of the prominent non-edible oil seed producing plants include *jatropha curcas or ratanjyot, pongamia pinnata or karanj, calophyllum inophyllum or nagchampa, hevea brasiliensis of rubber seeds, calotropis gigantia or ark, euphorbia tirucalli or sher, boswellia ovalifololata, neem* etc.

3.1 Selection of species : *Jatropha curcas*

Considering all the options available among non-edible Tree Bearing Oil (TBO) seeds, *Jatropha Curcas* has been identified as the most suitable seed. Jatropha is a genus of approximately 175 succulents, shrubs and trees from the family Euphorbiaceae. Plants from the genus are natives of Africa, North America and the Caribbean. Originating in the Caribbean, the Jatropha had spread as a valuable hedge plant to Africa, Asia and to India by Portuguese traders. Jatropha Curcas is a widely occurring variety of TBO. It grows practically all over India under a variety of agro-climatic conditions. Thus it ensures a reasonable production of seeds with very little inputs.

3.1.1 Jatropha : The Preferred Option

The advantages of the specie are as follows :

- Jatropha can be grown in arid zones (20 cm rainfall) as well as in higher rainfall zones and even on land with thin soil cover.
- It is a quick yielding specie even in adverse land situations viz. degraded and barren lands under forest and non-forest use, dry and drought prone areas, marginal lands, even on alkaline soils and also as agro-forestry crops. Jatropha can be a good plantation material for eco-restoration in all types of wasteland.
- Jatropha grows readily from plant cuttings or seeds up to the height of 3 - 5 m.
- Jatropha is not considered good forage material.

- The plant is highly pest and disease resistant.
- Various parts of the plant are of medicinal value, its bark contains tannin, the flowers attract bees and thus the plant is honey production potential.
- Jatropha removes carbon from the atmosphere, stores it in the woody tissues and assists in the build up of soil carbon.

3.1.2 *Jatropha :* The Limitations

The jatropha also suffers from certain limiting factors, which need to be kept in mind while dealing with the specie. These are as follows:

- Jatropha cannot be grown on waterlogged lands and slopes exceeding 30°.
- The ideal climatic conditions for jatropha can be summarized as annual rainfall not exceeding 600 mm in moderate climatic conditions, 1200 mm in hot climatic zones and soil pH less than 9. The atmospheric temp. should not fall below 0° C as the plants are sensitive to ground frost that may occur in winters.
- Jatropha seeds are hard and possess toxicity
- The golden flea beetle *(Podagrica spp.)* can harm particularly on young plants.
- Jatropha is also host to the fungus *ìfrogeyeî (Cercospera spp.),* common in tobacco

3.1.3 *Jatropha Cultivation : Yield and Productivity*

Apart from planting the seeds, jatropha can also be propagated vegetatively from cuttings. Use of branch cutting for propagation results in rapid growth and the bush can be expected to bear fruit within one year.

Seeds are best sown during mid-February to mid-March and the seedlings 60-75 cms. tall can be transplanted to the field. The ideal planting pitch has been found to be 2m x 2m thus resulting in 2500 plants per hectare. Wider spacing would give larger yields of fruit @794 Kgs/ha. Like all perennial plants, jatropha displays vigorous growth in youth that tails off gradually towards maturity.

In equatorial regions where moisture is not a limiting factor (i.e. continuously wet tropics or under irrigation), jatropha can bloom and produce fruit throughout the year. To withstand extreme drought conditions, jatropha plant sheds leaves to conserve moisture, which results in reduced growth. Although jatropha is adapted to soils with low fertility and alkalinity, better yields can be obtained on poor quality soils if fertilizers containing small amounts of nutrients viz. *calcium, magnesium* and *sulfur* are used for the first two years.

Jatropha plant bears fruits from 2nd year of its plantation and the economic yield stabilizes from 4th or 5th year onwards. The plant has an average life with effective yield up to 50 years. Jatropha gives about 2 Kgs. of seed per plant. In relatively poor soils such as in Kutch (Gujarat), the yields have been reported to be 1 Kg per plant while in lateritic soils of Nashik (Maharashtra), the seed yields have been reported as 0.75 - 1.00 Kg per plant. Thus the economic yield can be considered as 0.75-2.00 Kgs./plant and 4.00-6.00 MT per hectare per year depending on agro-climactic zone and agricultural practices. One hectare of plantation on average soil will give 1.6 MT oil. Plantation on poorer soils will give 0.9 MT of oil per hectare.

The cost of plantation has been estimated as Rs.20,000/- per hectare, inclusive of plant material, maintenance for one year, training, overheads etc. It includes elements such as site preparation, digging of pits, fertilizers, irrigation, deweeding, and plant protection for one year i.e., the stage when it will start bearing fruits.

4. Jatropha to Biodiesel : Process Steps

4.1 Preparation of Seeds

The ripe fruits are plucked from the trees and the seeds are sun dried. They are decorticated manually or by decorticator. To prepare the seeds for oil extraction, they should be solar heated for several hours or roasted for 10 minutes. The seeds should not be overheated. The process breaks down the cells containing the oil and eases the oil flow. The heat also liquefies the oil, which improves the extraction process.

Oil can be extracted from the seeds by heat, solvents or by pressure. Extraction by heat is not used commercially for vegetable oils. The oil from Jatropha seeds can be extracted by three different methods. These are *mechanical extraction* using a screw press, *solvent extraction* and an intermittent extraction technique viz. *soxhlet extraction.*

4.2 Purification of oil

The oil extracted as above can be purified by the following means:

Sedimentation This is the easiest way to get clear oil, but it takes about a week until the sediment is reduced to 20 - 25 % of the raw oil volume.

Boiling with water The purification process can be accelerated tremendously by boiling the oil with about 20 % of water. The boiling should continue until the water has completely evaporated (no bubbles of water vapour anymore). After a few hours the oil then becomes clear.

Filtration Filtration of raw oil is a very slow process and has no advantage in respect of sedimentation. It is not recommended.

4.3 Processing of Oil

The quality of feed vegetable oil particularly FFA content plays an important role in identifying the suitable technology. The important factors to be considered for a biodiesel production plant include:

- Processability of variety of vegetable oils without or minimum modifications
- Processability of high free fatty acid (FFA) containing oils/feed-stocks
- Must be able to process raw both expelled and refined oil
- Process should be environment friendly with almost zero effluent

Certain difficulties are experienced in IC engines while using straight vegetable oil (SVO) or chemically unmodified vegetable oils. One major problem is the higher viscosity of vegetable oils. The triglycerals as present in vegetable oil are mostly associated with their high viscosities, low volatilities and polyunsaturated character. Thus property modifications by trans-esterification are required to impart properties similar to petroleum diesel to the vegetable oil.

The selection of appropriate technology for production of biodiesel calls for careful selection of processing steps, catalyst and downstream process integration.

Various methods for processing of oil are as follows:

- Pyrolysis
- Micro-emulsification
- Trans-esterification

4.3.1 Pyrolysis

Pyrolysis refers to a chemical change caused by application of thermal energy in absence of air or nitrogen. The liquid fractions of the thermally decomposed vegetable oil are likely to approach diesel fuels. The pyrolyzate has lower viscosity, flash and pour points than diesel fuel but equivalent calorific values. The cetane number of the pyrolyzate is lower. The pyrolysed vegetable oils contain acceptable amounts of sulphur, water and sediment with acceptable copper corrosion values but unacceptable ash, carbon residue and pour point.

4.3.2 Micro-emulsification

The formation of micro-emulsions (co-solvency) is a potential solution for reducing the viscosity of vegetable oil. Micro-emulsions are defined as transparent, thermodynamically stable colloidal dispersions. The droplet dia. in micro-emulsions ranges from 100 to 1000 Å. A micro-emulsion can be made of vegetable oils with an ester and dispersant (co-solvent), or of vegetable oils, an alcohol and a surfactant and a cetane improver, with or without diesel fuels. Water (from aqueous ethanol) may also be present in order to use lower-proof ethanol, thus increasing water tolerance of the micro-emulsions.

4.3.3 Transesterification

The process of converting the raw vegetable oil into biodiesel, which is fatty acid alkyl ester, is termed as transesterification. There are three basic routes to biodiesel production from biolipids (biological oils and fats) :

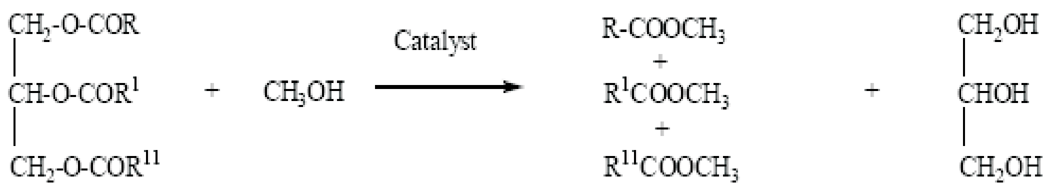
- Base catalyzed transesterification of the biolipid carried out under atmospheric pressure and at temperature ~60-70° C
- Direct acid catalyzed transesterification of the biolipid

- Conversion of the biolipid to its fatty acids and then to biodiesel

The processing steps for the most commonly used method viz. base catalyzed transesterification of the biolipid would be as follows :

1. Exact quantity of potassium hydroxide required as determined by titration is thoroughly mixed in methanol till it dissolves completely to result in potassium methoxide.
2. Jatropha oil is heated, if required (during winter), and mixed in the potassium methoxide while with agitator running.
3. It is then allowed to settle and glycerine is removed from bottom.
4. Biodiesel fraction is then washed and dried.
5. It is then checked for quality.

Transesterification, also called alcoholysis, is the displacement of alcohol from an ester by another alcohol in a process similar to hydrolysis. Methanol is most commonly used for the purpose since it is the cheapest alcohol available. Ethanol and higher alcohols such as isopropanol, butanol etc. can also be used for the esterification. Using higher molecular weight alcohols improves the cold flow properties of biodiesel but reduces the efficiency of transesterification process. The reaction is as follows :



Methods commonly used for producing biodiesel are batch and continuous processes. In general, smaller capacity plants and variable feedstock quality warrant use of batch systems. Continuous systems generally lead the operation on a 24x7 basis, requiring larger capacities to justify larger staffing needs and also requiring uniform feedstock quality.

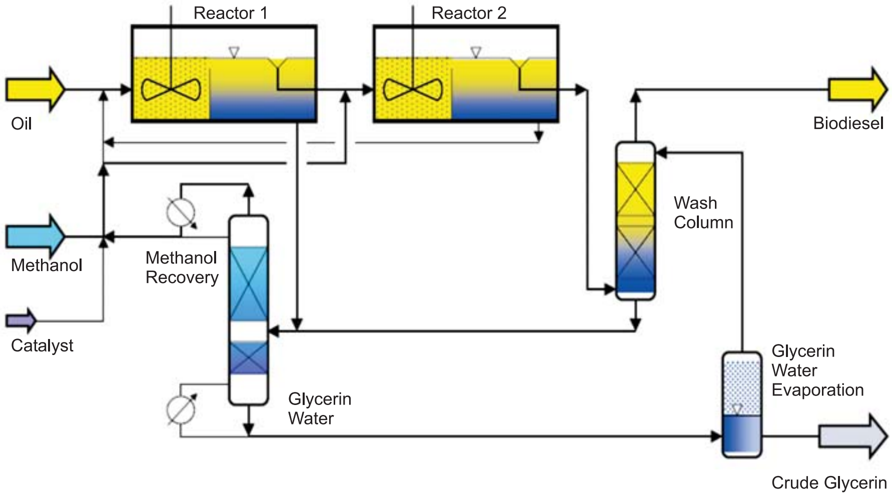
The transesterification works well when the input oil is of high quality. However, quite often low quality oils are used as raw materials for biodiesel preparation. In cases where FFA content of the oil is above 1%, difficulties arise due to the formation of soap, which promotes emulsification during the water washing stage. If the FFA content is above 2%, the process becomes unworkable. The factors affecting the transesterification process are i) oil temp. (ii) reaction temp. (iii) ratio of alcohol to oil (iv) catalyst type and conc. (v) intensity of mixing (vi) purity of reactants.

The approx. process constituents are listed hereunder :

Vegetable oil	**Alcohol**	**Catalyst (Sodium or Potassium Hydroxide)**	**Glycerine**	**Bio-diesel**
100 gm	12 gm	1 gm	11 gm	95 gm

Transesterification *: industrial practice - lurgi process* Lurgi's process of transesterification is used most widely in the world. The process involves intensive mixing of methanol with the oil in presence of a catalyst, and then separation of lighter methyl ester phase by gravity from the heavier glycerol. The process flow chart for production of biodiesel is illustrated in Figure 1

Lurgi's Biodiesel Process



Oil, methanol and sodium methylate catalyst are mixed in the reactor (R-I) and allowed to separate into two phases. The lighter methyl ester/oil phase is mixed with additional methanol and catalyst in the reactor (R-II) followed by gravity separation. This second reactor stage maximizes the biodiesel yield and quality. The lighter phase is washed with water to remove residual glycerol or methanol dissolved in the ester phase, followed by vacuum drying to yield biodiesel.

The denser glycerol phase from R-II containing excess methanol and catalyst is recycled to the front end of R-I. The denser glycerol phase leaving R-I still containing excess methanol is distilled for its recovery in the Methanol Recovery Column and sent back to R-I. The wash water from the Water Wash Column is used in the Methanol Recovery Column. Thus the entire methanol is consumed in the production of methyl ester. The heavier fraction from the Methanol Recovery Column is processed in the Glycerin Water Evaporation Column to recover crude glycerin (conc. 80-85%) as a byproduct. This can be further upgraded to pharmaceutical glycerin by distillation, bleaching, if required, and vacuum drying.

The key features of Lurgi's biodiesel process are:

- Technology applicable to multiple feedstocks
- Continuous process at atmospheric pressure and at 60°C
- Dual Reactor System operating with a patented Glycerin Cross Flow configuration for maximized conversion
- Recovery and recycling of methanol
- Closed loop water wash recycle to minimize waste water
- Phase separation by gravity process (no centrifuges necessary)

Almost all the biodiesel is produced using the base catalyzed transesterification process as it is the most economical one requiring only low temperatures and pressures with 98% yield. Other processes under development include *biocatalyzed trans-esterification, pyrolysis of vegetable oil/seeds and transesterification in supercritical methanol.*

Transesterification : Critical Issues

- Interference of FFA with transesterification deactivates the basic catalyst resulting in loss of catalyst and biodiesel yield.
- As water content of the oil deactivates catalysts, drying of oil may be required.
- Soaps formed with basic catalyst is difficult to remove.

4.4 Biodiesel: physical characteristics

Properties	**Values**
Specific gravity	0.87 to 0.89
Kinematic viscosity@ 40°C	3.7 to 5.8
Cetane number	46 to 70
Higher heating value (Btu/lb)	16,928 - 17,996
Lower heating value (Btu/lb)	15,700 - 16,735
Sulphur wt %	0.00 - 0.0024

Cloud point °C	-11 to 16
Pour point °C	-15 to 13
Iodine number	60 - 135

4.5 Storage of biodiesel : problems encountered

The efficient storage of biodiesel resources can provide energy security to the country. Adequate data are not available for long-term storage of biodiesel and blends. Based on the experience, biodiesel can be stored up to a max. 6 months.

As a mild solvent, biodiesel tends to dissolve sediments normally encountered in old diesel storage tanks. Brass, teflon, lead, tin, copper, zinc etc. oxidize biodiesel and create sediments. The existing storage facilities and infrastructure for petrol and diesel can be used for the biodiesel with minor alterations. For biodiesel storage, shelf life and how it might break down under extreme conditions assume importance. The following merit attention for storage of biodiesel :

- Biodiesel has poor oxidation stability. Use of oxidation stability additives is necessary to address this problem.
- Low temperature can cause biodiesel to gel, but on warming it liquefies quickly. Hence, insulation/jacketing of storage tanks and pipelines would need to be done at the low temperature zones.
- To avoid oxidation and sedimentation of tanks with biodiesel, storage tanks made of aluminium, steel etc. are recommended for usage.

5.0 Indian Scenario

There has been greater awareness on biodiesel in India in the recent times and significant activities have picked up for its production especially with a view to boost the rural economy. The activities launched in the field of biodiesel in India and the agencies involved therein include:

- Development of high quality jatropha through tissue culture by DBT, Aditya, Sheel Biotech etc.
- Plantation by National Oilseed and Vegetable Oil Development Board (NOVOD), NAEB, NGOs and private companies
- Pilot plants for biodiesel production by IITs, IIP-Dehradun, R&D Centre/IOCL, PAU-Ludhiana, IISc, Indian Railways, IICT, CSMCRI.
- Trans-esterification plants with capacities : 300 MT/day and 30 MT/day in AP, 5.00 MT/day in Sivakasi, Oil India planning 24 MT/day capacity plants in various states.
- Trial runs by Indian Railways, Mahindra and Mahindra (Tractors), Haryana Roadways/IOCL, BEST Buses/HPCL, Daimler Chrysler cars etc.
- Supply of biodiesel by Lubrizol India Pvt. Ltd. and Gujarat Oleochem

A National Mission on biodiesel has been proposed by the Govt. of India comprising six micro-missions covering the essential aspects of plantation, seed procurement, oil extraction, transesterification, blending and trade and R&D.

Indian Oil has worked on establishing the production parameters of transesterified jatropha oil and use of biodiesel in its R&D Centre at Faridabad. They have been using a laboratory scale plant of 100 Kgs./day capacity for transesterification; designing of larger capacity plants is underway. Production of biodiesel in smaller plants of capacity e.g. 5-20 Kgs./day may also be started in villages.

Substantial developmental activities have been carried out in regard to the production of biodiesel through transesterified non-edible oil and its use by *IISc-Bangalore* and *Tamilnadu Agriculture University-Coimbatore.*

Kumaraguru College of Technology in association with *Pan Horti Consultants-Coimbatore* has worked on marginally altering the engine parameters to suit the Indian jatropha seeds and to minimize the cost of transesterification process.

5.1 Jatropha plantation : Current status

450 species of oil yielding plants have been identified in various parts of India. *Jatropha* has been selected for focused development in the country due to its less gestation period compared to 7-8 yrs. of *Karanj*. While the jatropha seeds are used for oil extraction, other parts of the plant i.e. leaves, bark etc. can be used for developing organic dyes, medicines, biogas etc.

India has vast stretches of degraded land, mostly in areas with adverse agro-climatic conditions, where species of jatropha can be grown easily. Even 30 million hectares of jatropha cultivation for biodiesel can completely replace the current usage of fuels in India. Use of 11 million hectares of wasteland for jatropha cultivation can lead to generation of minimum 12 million jobs.

Central Salt and Marine Chemical Research Institute (CSMCRI), Bhavnagar has successfully cultivated good varieties of *Jatropha curcus* on marginal land to assess practically realizable seed yields. *GB Pant University* has planted jatropha in 140 ha. at its farm. University scientists have selected new high yielding species of jatropha, which have yield potential of up to 10 tons/ha. Efforts of *National Oilseed and Vegetable Oil Development Board (NOVOD)* include development of quality planting material, improved jatropha seeds having oil contents up to 1.5 times of ordinary seeds etc. NOVOD has planned jatropha plantation at 1719 hectares in various states.

Biodiesel Technologies, Kolkata is a consortium of tea planters, agricultural scientists and chemical engineers engaged in the study, research and experience in the cultivation of *jatropha/safed musli/stevia/patchouli/vanila* and developed efficient biodiesel processing reactors indigenously. For the last 3 years, they are working on jatropha cultivation, oil extraction and design of processing machinery. They have a team of experienced professionals to guide and help the sector.

Nandan Bioagro and Labland Biotech have tied up with British Oil Company, D1 Oils, to cultivate jatropha. The company will encourage farmers to cultivate the crop under an arrangement with the company. ***Godrej Agrovet Ltd.*** is planning to invest over Rs.5 billion, for jatropha and palm oil cultivation in the states of Gujarat and Mizoram. Emami Ltd, one of the leading toiletries outfit in the country, is planning to enter into the farming of jatropha. The company plans a joint venture with a leading European company. For technical collaboration for extraction of jatropha oil, Emami plans to approach the companies in US, UK and Austria. The company will start farming of jatropha in Suri in West Bengal and Balasore in Orissa.

Jatropha plantation has been planned in a total of 4,00,000 hectares of land in the country with the following objectives :

- Increasing the yield of Jatropha plants by using good planting material.
- Selection of varieties/strains, which have more seed content.
- Development of processing techniques, which results in maximum oil recovery from seeds.

5.2 Oil Seed Crushing and Oil Extraction : Current Status

Presently the edible oil is extracted through traditional *ghani*. The recovery of oil in the *ghani* is lesser and of inferior quality. The capacity is also much less as compared to the improved expellers. Oil extraction can be more effectively carried out by the following methods:

Method 1: Prepressing of seeds lightly can precede oil milling. This results in higher capacity; lower power consumption, lower wear and tear and maintenance. The oil recovery is lower in this case.

Method 2: Here either in the same screw press – two-stage pressing is carried out or prepressed cake from first stage screw press in sent for second pressing to other screw press. Any kind of oil-bearing seed can be processed in oil mill, preparatory equipments are recommended prior to expelling. Pressed cake can be sold after recovering the max. oil. Hence, double pressing system is recommended.

Depending on process sophistication, the cost of oil extraction will be 19-90 paise per litre.

GB Pant University has developed a decorticator for jatropha seeds. Under an MNES sponsored project, *IIT-Delhi* has developed a power-operated decorticator for jatropha seeds with a capacity of 150 Kg. seeds/ hr. It is operated by 2.5 HP single-phase motor. Such machines are highly useful at rural level. IIT-Delhi has also extracted Karanja oil from the kernels by mechanical process at lab scale. NOVOD has established a technology for individual farmers for decorticating jatropha seeds with a capacity of 20 Kg/hr. It is available at Rs.6,500/- per unit.

Under the *National Mission on Liquid Biofuels*, NOVOD has taken initiative to support development of improved oil expellers. To facilitate extraction of oil from seeds, as an initial step, one oil expeller machine established at NSIC in Rajkot has been tested and found working satisfactorily.

At the Biotech Park-Lucknow, a 1.0-ton/day oil expeller has been installed for extraction of oil from jatropha seeds. Around 20 jatropha extraction units were opened at in the Erode district of Tamil Nadu.

Some of the agencies manufacturing oil extraction equipment are, M/s MA Deliverance Agro-Industries, Mazabuka and M/s. Sardar Engineering Company, Kanpur (45 Kgs./hr. seed crushing capacity). Using Sundhara Press mechanical oil expellers, up to 75 - 80% of the oil can be extracted. With the Yenga hand press, 60 - 65% of oil can be extracted (5 kg of seeds give about 1 litre of oil). Gagan International, Ludhiana is one of the leading manufacturers and exporters of biodiesel plants and is the first to indigenously fabricate the biodiesel plants. They have been manufacturing biodiesel producing plants ranging from 400 lts./day to 15000 lts./day. The cost of equipment would be around Rs.6.50 lakhs for 1000 lts./day plant and Rs.50 lakhs for 15000 lts./day.

The disadvantages of expellers are listed as follows :

- The press must operate continuously for at least eight hours; intermittent operation is unsatisfactory.
- Oil from an expeller contains more impurities than oil from a batch press and must be filtered to obtain clean oil.
- Maintenance costs are high and it requires skilled mechanics.

5.3 Transesterification process : current status

A bench scale process was developed for catalyst free transesterification of jatropha seed oil, other vegetable oils, acid oil etc. at IICT, Hyderabad. The crude product is further processed to obtain biodiesel meeting ASTM specifications. IICT is working on the development of a green process for biodiesel using solid catalysts and enzymes.

The Department of Bio-energy, Tamil Nadu Agricultural University (TNAU) has studied different variations of methanol, sodium hydroxide, reaction time and reaction temperature to optimize the process conditions for maximum biodiesel yield for alkali-catalyzed transesterification of jatropha oil. An average biodiesel yield of 96% was obtained in an up-scaled biodiesel plant of TNAU. Their pilot plant of 250-litres/day capacity consists of a biodiesel reactor with heating and agitating devices, catalyst mixing tank, glycerol settling tanks and biodiesel washing tank. The properties of the biodiesel (free fatty acid, acid value) were found to be within specified limits.

Transesterification process has been optimized and patented by R&D Centre of IOCL. Technology know-how has been transferred to *M/s. Venus Ethoxyethers, Goa* for commercialization.

CSMCRI has developed a simplified process for biodiesel production from the oil complying with Euro-3 specifications for free fatty acid methyl ester. An important objective has been to identify outlets for by-products to enhance the overall value of the seed and thereby make jatropha cultivation more remunerative. While biodiesel conforming to Euro-3 specs. is produced in Europe from rapeseed oil, this is the first time that such biodiesel has been made from jatropha oil. The biodiesel developed by CSMCRI has been evaluated at Daimler Chrysler AG and found to be matching all specifications. The cetane number has been established to be 58.5.

Delhi College of Engineering has established small capacities of 5, 10, 50 and 100 liters batch reactors. Studies on biodiesel from waste cooking oils and greases being carried under a project sponsored by PCRA.

5.4 Biodiesel usage : Field trials

Diesel forms nearly 40% of the energy consumed in the form of fossil fuels and its demand is estimated at 40 million tons. Therefore blending becomes an important national issue, which apart from giving the economic dividends, lowers the country's oil bill. Private sector companies have been focusing their R&D work on performance of engine with biodiesel and its pollution characteristics. Some of the major companies taking lead in field trials of biodiesel include Tata Motors Ltd., Mahindra and Mahindra Ltd., Wartsila India ltd. etc. At Kumaraguru College of Technology, auto rickshaw was successfully run on pure biodiesel prepared from jatropha oil.

Trains have successfully been run on 5-10% blends of biodiesel in association with IOCL. HPCL is carrying out field trials in association with BEST, Mumbai. Daimler Chrysler India completed first phase of the field trials on two C-Class Mercedes-Benz cars powered by pure biodiesel and clocked over 5900 Km under hot and humid conditions. CSIR plans to test vehicles on biodiesel developed from jatropha in association with Tata Motors and IOCL. NOVOD has initiated test run by blending 10% of biodiesel in collaboration with IIT-Delhi in Tata Sumo and Swaraj Mazda vehicles. Haryana State Transport buses have been run by using biodiesel.

5.5 Commercial Production of Biodiesel : Indian Efforts

In India, approximate 85% of the operating cost of biodiesel plant is the cost to acquire feedstock. Securing own feedstock to insure supply at a fair price and sourcing it locally to avoid long haulage for delivery of seeds to biodiesel plant are critical factors in controlling profitability. The capital cost both in India and internationally are ~Rs.15,000 - 20,000/- per MT of biodiesel produced. At 10000 MTPA, the capital cost of oil extraction and transesterification plant would be Rs.20,000/MT capacity. A plant size of 10,000 MTPA can be considered optimal assuming cost of oil extraction at Rs.2360/MT and cost of transesterification at Rs.6670/MT with by-products produced @ 2.23 MT seed cake/MT of biodiesel and 95Kgs. of glycerol per MT of biodiesel. Fixed costs towards manpower, overheads and maintenance is 6% of capital cost, depreciation is 6.67% of capital cost. The return on investment (ROI) is 15% pretax on capital cost.

The following small units are already in commercial production :

1. *Aatmiya Biofuels Pvt. Ltd., Por-Vadodara,* Gujarat had set-up biodiesel plant with a commercial production capacity of 1000 liters/day from jatropha.

2. *Gujarat Oelo Chem Ltd., Panoli* based firm started producing biodiesel from vegetable based feedstock in March 2005.

BP, formerly British Petroleum, would be funding a project estimated at US $9.4 million to TERI in AP to demonstrate feasibility of production of biodiesel from *jatropha*. The project is expected to take 10 years and involve cultivation of jatropha in around 8000 ha. of wasteland. The agricultural land for the project has been identified. TERI would also install the necessary equipment for seed crushing, oil extraction and processing to produce 9 million litres of biodiesel per annum. A full environmental and social assessment of all elements of the supply chain and life cycle analysis of green house gas emissions would also be completed as part of the project.

The commercial pilot plant established by Biodiesel Technologies, Kolkata produces 450 lts/day of biodiesel. Diamond Energy Resources Pvt. Ltd. has been working on jatropha plantation and further development since last fifteen years. The company targets to set up three transesterification plants, each of 100 TPD capacity. They are in touch with *Lurgi, Germany* and two other companies from USA for technology support for setting up the plant in West Bengal. The company has taken up large-scale cultivation of jatropha in four districts of South Bengal –

West Midnapore, Bankura, Birbhum and Purulia covering over 10,000 ha of arid lands. The Southern Online Biotechnologies Ltd., is setting up 30 TPD or 90,000 TPA biodiesel plant estimated at Rs.150 million at Choutuppal in AP with technology support from *Lurgi*. It would require seeds of 100 TPD or 32,000 TPA. As the current availability of seeds in the state is around 4,000 tons, it plans to use other raw materials like acid oils, distilled fatty acids, animal fatty acids and non-edible vegetable oils like neem, rice bran etc.

Kochi Refineries Ltd. is setting up a pilot plant of 100 liters/day with a US based Company, Team Sustain Ltd., to extract biodiesel from rubber seed oil. Shirke Biohealthcare Pvt. Ltd., Pune is setting up a refinery with a capacity to process 5,000 liters biodiesel per day from jatropha oil. The refinery will also produce 1 MW power with the oil cake, apart from natural gas, which will be used to run the power plant. Jain Irrigation System Ltd. plans to set up a large-scale commercial biodiesel plant in Chattisgarh by 2008 with a capacity of 150,000 TPD estimated at Rs.480 million. R&D work given satisfactory results on 3 TPD biodiesel plant at Jalgaon, which was built at a cost of Rs.5 million.

Nova Bio Fuels Pvt. Ltd. plans to set up 30 TPD biodiesel plant in Panipat by 2006 with an investment of Rs.200 million. The plant would also market its byproduct, glycerine, to pharma companies. Naturol Bioenergy Ltd. is setting up 300 TPD integrated 100% EOU biodiesel plant in Kakinada, AP at an estimated cost of Rs.1.4 billion. KTK German Bio Energies India is setting up a commercial plant at Ganapathipalayam village with an investment of Rs.9 million to commence production by early 2006. Mint Biofuels, Pune scaled up their plant capacity from 100 L/day to 400 L/day to produce biodiesel from Karanj seeds in early 2006. They also plans to set-up biodiesel plants ranging from 5000-100000 TPD at Chiplun, Pune at an investment of Rs.300 million within 4 years. Sagar Jatropha Oil Extractions Pvt. Ltd, Vijayawada is setting up a biodiesel plant at an investment of Rs.100 million. The company has also experienced success with contract farming of the jatropha plant in the state.

6. Biodiesel : International Experiences

Several countries in the world have active biodiesel programmes. They also have provided legislative support and have drawn up national polices on biodiesel development. France is the world's largest producer of biodiesel; its conventional diesel contains between 2-5% biodiesel and that will soon apply to the whole of Europe. Soya based biodiesel is being produced in USA. Rape seed based biodiesel is in Germany. Germany has more than 1,500 biodiesel filling stations. Sunflower based biodiesel has made good success in France and UK.

The full potential of jatropha is far from being realized. The Agricultural Research Trust, Zimbabwe (ART) has developed non-toxic varieties of jatropha curcas, which would make the seed cake following oil extraction suitable as animal feed without its detoxification. The cultivation and management of jatropha is poorly documented in South Africa and there is little field experience available. Currently, growers are unable to achieve the optimum economic benefits from the plant. The markets for the different products have not been properly explored or quantified, nor have the costs or returns (both tangible and intangible) to supply raw materials or products to these markets. Consequently, the actual or potential growers including those in the subsistence sector do not have an adequate information base about the potential and economics of this plant to make decisions relating to their livelihood, not to mention its commercial exploitation.

The severe emission regulations in the world have placed design limitations on heavy-duty diesel engines. The trend towards cleaner burning fuel is growing worldwide and this is possible through jatropha based biodiesel.

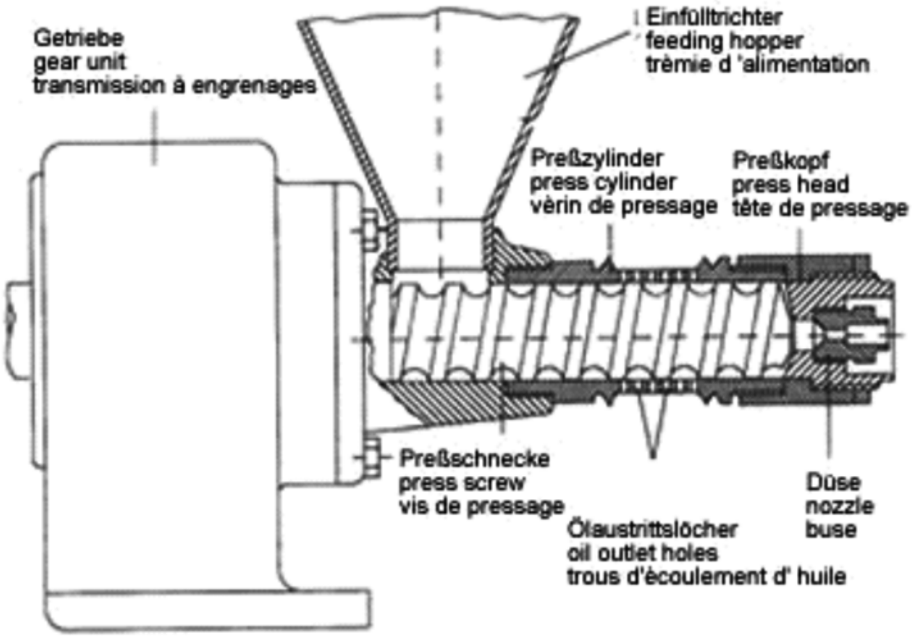
6.1 Biodiesel production

Expellers or continuous screw presses are used throughout the world for the extraction of oil from copra, palm kernels, peanuts, cotton seeds, flaxseed and almost every other variety of seed, wherever there is a large enough seed supply to justify a continuous operation. An expeller can exert much greater pressure on the seed cake than a hydraulic press can. This increased pressure permits the recovery of a larger proportion of the oil, about 3-4% of the oil is left in the cake with an expeller, compared to 4-6% with a hydraulic press. The expeller is an essential part of almost all modern oil seed extraction plants. It is used both by itself and as a pre-press before solvent extraction. Expellers vary in size from machines that process 100 pounds of seed per hour, to machines that process 10 or more tons of seed per hour. Different types of oil expellers for jatropha seeds are built in many countries.

Biodiesel technology providers worldwide are *Lurgi PSI, Superior Process Technologies, Biodiesel Industries, Cimbria Sket ñ Bratney, Crown Iron Works, Renewable Energy Group etc.* The following types of small-scale extractors are being used worldwide:

Screw-cage type Sayari expeller was developed by FAKT Consulting Engineers, Dietz, Metzler, Zarrate for use in Nepal. It was fabricated using the iron sheets instead of cast iron to limit the weight of the parts to 40 kgs. The processing capacity is 70 kg of jatropha seeds/hour, the residual oil content in the press cake is 10-12%. The price is around US$4000 including the motor and base frame. Oil extractor was provided with hard screws and cones in a modular assembled form in one shaft. The advantage of this expeller is preheating of seed is not required.

Komet oil expellers manufactured in Germany, feature a special cold pressing system with a single conveying screw to squeeze the oils from various seeds. Virtually all oil bearing seeds, nuts and kernels can be pressed with the standard equipment without adjusting the screws or oil outlet holes. The vegetable oil produced needs no refining, bleaching or deodorizing. Generally, any sediment in the oil will settle to the bottom of the collecting vessel after approximately 24 hours and form a hard cake.



6.2 Sectional view of KOMET oil expeller

ENERGEA-Austria developed continuous transesterification reactor technology, which offers biodiesel production with up to 50% lower investment cost and ~ 100% yield. Installation can be done in container sized modules with considerably less space requirement. The reactor operates on multi-feed-stock technology capable for processing vegetable oils/fats. *ENERGEA* has signed a contract with *Australian Renewable Fuels Pty. Ltd.* for supply of biodiesel units with a capacity of 40,000 MT/

yr. Construction of the 2,50,000 MT/yr. biodiesel plant and 25,000 MT/yr. glycerine plant for *Biofuels Corporation Plc., Teesside-UK* has been completed.

7. Byproducts

The marketing of byproducts is necessary for economic viability. The common byproducts produced while processing the biodiesel are as follows :

- Glycerol
- Oil seed cake

While producing 1 MT of clean jatropha oil, 1.9 MT oil seed cake excluding shell and 0.095 MT glycerol could be obtained as byproducts. The uses of byproducts derived from biodiesel processing and some developmental efforts are described hereunder :

7.1 Insecticides/molluscicides

Jatropha seed press cake and jatropha oil have insecticidal and molluscicidal properties. The active component is a phorbol ester, which gives the toxic property. A research project of the European Community is investigating the biological mechanisms involved. The overall aim is to develop a technology for the economic exploitation of jatropha.

A specialized developed process yields potassium sulphate as a by-product, which can then be used as an inorganic fertilizer to supplement potash in tea and other crops. The standard refining process yields about 10% glycerine as a by-product, the market value of which at present is ~Rs.50,000/- per MT.

7.2 Soap production

Jatropha seed extracts give a very good foaming white soap with positive effects on the skin, partly due to the glycerine content of the soap. The soap produced out of jatropha seed extracts is useful for both human and veterinary purposes. Jatropha oil can substitute tallow in commercial soap making.

7.3 Engine lubrication

A test at the TMW engine factory in Germany showed the suitability of pure raw Jatropha oil as a lubrication oil for low revolution engines.

7.4 Jatropha : Medicinal and other uses

The latex of *jatropha* contains an alkaloid known as *jatrophine*, which has anti-cancerous properties. It can heal wounds and also has anti-microbial properties. It is also used as an external application for skin diseases and rheumatism and for sores on domestic livestock. The tender twigs of the plant are used for cleaning teeth and juice of the leaf is used as an external application for piles. The roots are used as an antidote for snakebites. The *jatropha* oil is a strong purgative and widely used as an antiseptic for cough.

The bark of *jatropha* plant yields a dark blue dye, which is used for colouring cloth, fishing nets and lines.

Jatropha oil cake containing 6% of N_2, 2.75% of P and 0.94% of K can be used as organic manure. The detoxified seed cake can be used as a nutritious fodder for the animals. Jatropha leaves are used as food for the tusser silkworm.

8. Conclusion

Production of bio-fuel from plant materials is a major step toward harnessing one of the world's most-prevalent, yet least-utilized renewable energy resources. A breakthrough process for converting biomass into biodiesel fuel promises a cheaper way to go green. Eco-dreamers have long been hoping for a way to mitigating the global warming, but the slow pace of progress in alternative fuel technologies has prevented that vision from materializing. Ethanol, the most popular and commercial biofuel, has long been refined out of plant matter, but it requires the costly, energy-intensive step of distilling every molecule of water out of the solution. In contrast, the biodiesel process is based on aqueous phase reactions, which does not to go through the expensive distillation phase. As the process is exothermic, there is no need for distillation which need a lot of energy. The resulting biodiesel has almost the same chemical structure as traditional diesel and burns the same way in diesel engines.

The leading oil companies in the world are currently looking forward to tap the excellent business opportunity offered by biodiesel. If the developed process is scaled up to commercial levels by more and more oil companies, it could be a major step towards the creation of an eco-friendly transportation fuel that is relatively clean on combustion and provides farmers with substantial income.

The technologies available for biological conversion of cellulosic biomass to biodiesel enjoy a high potential to succeed in the commercial marketplace. India, with its huge waste/non-fertile lands, has taken a well noted lead in the area and commercial production is where the industries have to focus on for self sustainable development. India's biodiesel programme has been based on jatropha seeds only but for reduced operating cost a multiple feedstock-based strategy is needed.

Linkages for Promotion of Biodiesel Sector in India

Praveen Mithra
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In July' 2003, the report of Committee on Development of Bio-fuels constituted in Planning Commission was made public. This report highlighted the increased acceptance and usage of biodiesel worldwide as a solution to environmental problems, energy security, reducing imports, rural employment and demands of agricultural economy. Since then a lot of initiatives have been taken up by many stake-holders organizations, NGOs and individuals in India for promotion of Biodiesel but in absence of any National Policy on Biodiesel these efforts lack direction and are not yielding much of tangible results.

This presentation makes an attempt to list the various technical, administrative and policy issues, which need to be seriously considered by the decision makers to expedite the commercial exploitation of Bio-diesel in India. It also suggests the role and responsibilities which can be assigned to the different stakeholders in the Bio-diesel Programme i.e. Ministries, State Governments, R&D institutes, manufacturers, users etc.. A Public Private Panchayats Partnership (P4) model establishing linkages among various stakeholders is also proposed in the presentation.

It is imperative that a comprehensive National Policy on Bio-diesel be formulated which addresses these issues in wholesome manner:

BIOFUEL POLICY

National Policy On Biofuels

Dr. D.K. Khare,
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1. Vision

The National Biofuel Policy is proposed to contribute to energy security of the country through sustainable production, conversion and applications of biofuels. The policy would be for the duration of ten-year time horizon subject to periodic review. This vision statement on biofuels – biodiesel, bioethanol and other biofuels for at least 20% of renewable biofuels in the petroleum sector especially in the area of middle distillates and to reduce imports of oil by means of displacing imported crude oil or refined oil products by domestically produced biofuels thereby saving foreign exchange and promoting energy security.

The policy provides the direction for development of marketing and industrial infrastructure; pricing, fiscal and financial support environmental, legal and administrative issues and for creating the environment for extensive Research Design and Development required to align the characteristics and cost of biofuels with those obtained from crude oil.

2. Aim:

The Policy aims at promoting the use of biofuels to replace petrol and diesel for transport and other applications with the objective of contributing to energy security and in meeting the objective of environmental protection and climate change. The National Policy on Biofuels provides the basis for accelerated development of biofuels in the country. Biofuels are derived from renewable energy sources. Priority would be given to those biofuels which provide competitiveness and security of supply and also show cost-effective environmental balance.

3. Directives

This Policy aims at promoting the use of biofuels or other renewable fuels to replace diesel or petrol for transport and other applications with a view to contributing to objectives such as meeting climate change commitments, environmentally friendly security of supply and promoting renewable energy sources. The policy considers the overall climate and environmental balance of various types of biofuels and other renewable fuels.

3.1 Definition of Biofuel

The following definitions shall apply for the purpose of this Policy:

i. 'biofuels' means liquid or gaseous fuel for transport produced from biomass;
ii. 'biomass' means the biodegradable fraction of products, waste and residues from agriculture, forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste;
iii. 'other renewable fuels' means renewable fuels, other than biofuels, which originate from renewable energy sources

Products as listed below shall be considered biofuels:

i. **ëbioethanolí:** ethanol produced from biomass and/or the biodegradable fraction of waste, to be used as biofuel;
ii. **ëbiodieselí:** a methyl-ester produced from vegetable or animal oil,of diesel quality, to be used as biofuel;
iii. **Others** such as biogas, biomethanol, biodimethylether, bio-ETBE

(ethyl-tertio-butyl-ether), bio-MTBE (methyl-tertio-butyl-ether), biosynthetic fuels, biohydrogen, pure vegetable oil, etc.

iv. This policy focuses on bio-ethanol and biodiesel

4. Approach

The policy is based on the following approach involving different stakeholders:

i. Farmers are to be encouraged to undertake farming of crops that provide the feedstock for ethanol and other biofuels.
ii. Providing support to such cultivation by assuring a minimum support price to be offered by the Government and industries.
iii. Education and training of farmers on such biofuel yielding crops, cultivation techniques and economic benefit to them.
iv. Use of waste land to be encouraged to raise plantation of neem, karanja, jatropha and other such species to grow oilseeds for biodiesel production.
v. Extensive support to R&D institutions is to be provided for developing suitable process for biofuels from various feed-stocks, developing agricultural processes for growing crops for biofuels in wasteland.
vi. Panchayati Raj institutions have a major role in creating awareness among people about Jatropha and other species suitable for cultivation in residual areas, common land and farm hedges. They would identify panchayats / clusters of Panchayats for this programme, collaborate with various agencies including State and Central Govt. organizations - National Oilseed and Vegetable Oil Development Board, National Dairy Development Board etc. and provide support through district level forest and agriculture officers.
vii. Industrial sector to be encouraged to increase ethanol production from all available feedstock such as cereals, agro-residues, and

starch-based crops besides optimizing the present level of production from sugarcane molasses route. For this purpose, necessary incentives such as soft loans for establishing new industries/ updating existing industry, tax holiday and classification of ethanol as a chemical to allow its free and unhindered movement need to be provided.

viii. While large volumes of production of biofuels for blending in transport applications for fossil fuels would take some time, parallel use of biofuels in the short term to be used for diesel powered gensets, water pumps sets for irrigation, agricultural machines using diesel, liquid fuel stoves for cooking, distributed power generation etc .

ix. In order to accomplish these tasks a 'National Biofuel Development Board' is proposed to be created. The Board would develop the roadmap for use of biofuels in petrol and diesel engines in a time bound manner besides taking necessary steps to introduce the policy measures some of which have been listed above

x. A Biofuel Development Fund would be created to meet financial requirement for implementing the policy measures given above. The Fund would initially be created from budgetary support by the Government but would generate its resources from other sources like cess on fossil fuels, market borrowings, tapping funds from national and international agencies, private participation etc. The National Biofuel Development Board would administer this fund.

5. Strategy

Biofuels would be able to grow rapidly in the future only if continuous policy support and direction is provided. Various strategies have to be followed for accelerating the pace of biofuel market development in the country. Major strategies as proposed in this policy are as follows:

i. Stimulating demand for biofuel by issuing biofuels directive, setting national targets, ensuring sustainable production, conversion and applications.

ii. Promoting R&D extensively for advanced technologies including second generation biofuels and establishing bio refineries.

iii. Provision of Tax incentives:

a. Partial or full exemption of central excise duties on all biofuels.

b. Energy Taxation Directives and

c. Incentives for biofuel production, conversion and applications in stationary, portable and transport applications.

iv. Capturing environmental benefits

a. Setting minimum environmental standards for feedstock production.

b. Providing fuel quality directives

v. Targeting applications of biofuels for stationary and portable applications for generation of distributed power, energisation of pump sets, liquid fuel stoves etc., especially for rural areas.

vi. Active involvement of central and states governments and their agencies in the production, extraction, processing and distribution of biofuels for commercialization.

vii. Expanding feedstock supplies that combine centralized with decentralized production and applications

viii. Promoting of public and private partnership.

ix. Special focus on decentralized market driven approach which takes into account local and regional variations, biodiversities and requirements.

x. Setting up of large scale HRD programmes in the central and states including education, awareness, training and capacity building.

6. Targets

The Policy would ensure that a minimum proportion of biofuels is placed in their markets, and, to that effect, shall set national indicative targets. The aim of the policy is to project short term -5% by 2012, medium term-10% by 2017 and long term-20% beyond 2017, demands and plan for the substitution through various forms of biofuels. The National Biofuel Development Board (NBDB) would bring out directives on the following issues:

i. Year wise targets for total biofuels quantity required and possible supply
ii. Year wise target for Tree Borne Oilseeds (TBO) plantations for the next 15 years.
iii. Year wise target for Biofuels (biodiesel) use as a liquid fuel for next 15 years.
iv. Fiscal incentives – including the various tax incentives and rebates at the Central and State level.

7. Development of Specifications and quality standards for Bio-fuels

The Bureau of Indian Standards (BIS) has already come out with the specification for pure biodiesel, which is an Indian adaptation of the American standard ASTM D 675. Standards and specifications for biofuels for various applications in the country at par with the international standards would be notified by BIS in consultation with the concerned stakeholders.

8. Proposed Fiscal and Financial Incentives

8.1 Fiscal incentives including taxes

The competitiveness of biodiesel depends on the level of duty and taxes imposed by Central and State Governments on such fuels. If the duty imposed on biodiesel were the same as petrol or diesel, biodiesel would be far too expensive for biodiesel to be competitive. The following detailed directives would be issued in consultations with all stake holders including concerned Ministries / Departments, from time to time:

i. Excise duty, VAT and sale tax exemption or reduction would be provided to all biofuels in pure form as well as blended for upto a certain percentage with a view to lowering the price of the biofuel at the fuel stations.
ii. Vehicles wholly or partially using certain biofuels or other environment friendly fuels would qualify for certain tax reduction benefits in relation to benefits attributed to the most closely comparable conventional vehicles.
iii. Liberalized custom / excise duty on technology procurement would be allowed on technologies required for production of biofuels, most efficient biofuel engines for portable and stationary applications for power generation and transport applications.
iv. Suitable production based tax benefits would be provided.
v. Biofuel technology and projects to be allowed 100% foreign equity through automatic approval route to attract Foreign Direct Investment (FDI) to the sector.
vi. State Government would be advised to announce appropriate tax incentives for setting up of biofuel plants.
vii. State Governments would be advised to announce appropriate policies on government controlled waste / degraded land transfer / lease procedures to potential entrepreneurs, public and private companies, cooperatives, NGOs, farmers, etc. for raising oil bearing trees etc.

8.2 Financial incentives for biofuels processing and its applications:

i. Financial incentives including subsidies, grants, and loans on concessional rates of interest would be provided for processing of biofuels, product development; production, commercialization and applications; blending of biofuels with fossil fuels; modification / development engines required for power generation, agriculture machineries and transport applications.

ii. Prototype development to be supported through government financial assistance and form of subsidies and grants for biofuel applications.

iii. Demonstration Projects to be set up with the financial support of the government for production, conversion and applications of various types of biofuels with state of art technologies at strategic locations with a view to replicating them for further expansion.

iv. Financial support for setting up of bioethanol and biodiesel production plants based on new feed stock such as lignocellulosic materials, advanced technologies should be set up for second generation biofuel production, standardizing biorefining plants etc.

8.3 Financial incentives for research design and development

Financial support would be provided for research and development programmes/projects jointly taken up by the leading research institutions, public and private companies to evolve methods to lower the cost of biofuel; quality enhancement; product development; production, commercialization and applications on second generation biofuels; blending of biofuels with fossil fuels; modification/development of engines required for power generation, agriculture machineries and transport applications, etc. with a view to use biofuels upto 100%.

8.4 Financial incentives for plantation

Several government departments or their agencies provide financial incentives including subsidies, grants, loans on concessional rates of interest for plantation programmes that also include oil bearing trees and other species. Detailed guidelines would be prepared based on the existing funding pattern and the most liberal model of incentives to be adopted for plantation of oil bearing trees.

Plantation of oil bearing trees would be declared as a priority sector for the purposes of lending by Financial Institutions and banks including NABARD. Similarly, the creation of infrastructure such as storage godowns, setting up units of oil expelling / extraction and trans-esterification should come under priority sector for the purposes of lending by Financial Institutions and banks including NABARD.

Minimum support price is to be fixed and to be reviewed on a periodic basis for different types of oil bearing seeds and other feed stocks.

9. Identification of land and land transfer policy

The policy for identification and promotion of plantation of oil bearing plants in various categories of lands would be announced in consultation with the state governments and other central and state agencies. The policy would include the following:

i. Community / Government wastelands inside and outside forests (which research may show as good for plantation of oil bearing trees - This would be for all types of land).
ii. Wastelands/degraded/fallow lands.
iii. Agricultural field boundaries.
iv. Intercropping both on irrigated agricultural land and rain fed farms.
v. Lands being used for Agro forestry

Tenancy laws for agriculturally inferior or degraded lands held by landholders to provide for long term lease to entrepreneurs including cooperatives and corporate sector for plantation for vegetable oil production.

Provision would be made in the land laws of States to enable State Government, with the approval of the Gram Panchayat, to give community land on long-term lease to the BPL families, NGOs etc. for growing oil bearing trees.

Government Departments holding land not presently in use to be permitted to provide on long term lease for plantation of oil bearing trees to entrepreneurs including cooperatives and corporate sector for plantation for vegetable oil production.

10. Biofuel Purchase Policies:

There is need for the long term support price with annual price escalation to be announced. The price of biodiesel would be matched with diesel price, after excise duty, at the oil depots of the petroleum companies. In view of the uncertainty in feedstock and market pricing and also the initial high cost of technology; excise duty and State VAT exemption to blended part of biodiesel in diesel should be extended for 7 years and reviewed thereafter.

The Government (State and Central) would announce a Minimum Support Price and make arrangements to buy seeds, if the market price falls below the Minimum Support Price.

11. Refinancing Agencies:

Development Banks led by NABARD would provide finance to the financial institutions for plantation. For other activities in the biodiesel programme, NABARD, IREDA, Banks and SIDBI as well as other financing agencies would to be actively involved in providing finance for Biofuel programme at small and medium levels. For large projects IDBI, Commercial Banks and other financial institutions would be involved.

12. Research, Design and Development (RD&D)

The essential focus of RD&D would be on the following areas of major technological challenge:

- Converting cellulosic biomass into a more usable source of energy through technologies such as pretreatment, biological processing, and gasification.
- Enabling biofuels plants to diversify range of products they produce along with biofuels, such as additional fuels, animal feed protein, and chemicals, improves economics and efficiency.
- Increase crop yields and making other advances in feedstock production to reduce the cost and the environmental input of biofuels.
- Increase yield of oilseeds and to increase oil content of the oilseeds

Other RD&D areas for bioethanol and biofuels include developing conversion technologies for waste cellulosic materials and dedicated cellulosic crops such as grasses and trees; biomass gasification and conversion to various fuels, including synthetic diesel and gasoline, etc.

Comparative evaluation of technologies commercially available in the world would be carried out and the results of evaluation should be widely shared with the concerned stakeholders.

Indian biofuel industry to be provided suitable import duty and other tax concessions for importing advanced technologies with the condition that these will be manufactures in the country which would be decided on a case by case basis by National Biofuel Development Board.

13. Use of By-Products

To encourage, use of by products of non-edible oil, bioethanol and biodiesel in established as well as emerging new applications such as seed cake, bio-glycerin, bio-pesticides, biogas, biomass gasification and bio-fertilizers, so as to maximise returns to entrepreneurs and farmers.

14. Legislation for Enabling Use of biofuels:

The Policy promulgation will be followed by an appropriate legislation in the next five years. Legislation to use of Straight Vegetable Oil (SVO), bioethanol, biodiesel and other forms of biofuels would be issued. The legislation will include the following:

i. Mandatory obligation of the oil companies to purchase biofuels – bioethanol, biodiesel and other biofuels conforming to the prescribed specifications offered to them and blends it with diesel initially to the extent of 5% and progressively up to 20%, depending on the availability at the depot. The mandatory obligation provision would be in-force only after ensuring sustainable production of biofuels, which is expected to take place in the next five years.

ii. Engine / equipment manufacturers are required to provide warranties on usage of SVOs / Bioethanol / Bio-diesel / other biofuels and modify the engines / equipments if so required.

iii. Freedom of the citizen and entities to use Straight Vegetable Oil (SVO), bioethanol or biodiesel in any blend with diesel as fuel in engines that run small industry, agricultural machinery and for power generation in stationary and portable purposes apart from using in transport in rural areas once successfully demonstrated after suitable modifications in the technology.

iv. Freedom to process vegetable oils, fats etc into biodiesel and use it locally.

15. Demonstration Projects

Demonstration Projects to be set up immediately for production, conversion and applications of various types of biofuels with state of art technologies at strategic locations with a view to replicate them for further expansion with the central financial assistance so as to gain operational experience and provide larger scale awareness about use of biofuels and thus ensure sustained involvement of all stakeholders in the development and expansion of the National Biofuel Programme in the country.

Government will extend financial assistance for setting up pilot demonstration of bioethanol and biodiesel production plants based on new feed stock such as lignocellulosic materials, advanced technologies for second generation biofuel production etc., and its proper use in stationary and portable applications.

16. Capacity Building

A detailed programme of HRD and training for capacity building among growers, processors, Panchayats, and other stakeholders and above all training institutions would be drawn up and implemented.

17. Evaluation and progress reporting/Monitoring

The government shall take up evaluation on a periodic basis on the following:

(a) Cost-effectiveness of the measures taken in order to promote the use of biofuels and other renewable fuels;
(b) Economic aspects and the environmental impact of further increasing the share of biofuels and other renewable fuels;
(c) Life-cycle perspective of biofuels and other renewable fuels, with a view to indicating possible measures for the future promotion of those fuels that are climate and environmentally friendly, and that

have the potential of becoming competitive and cost-efficient;

(d) Sustainability of crops used for the production of biofuels, particularly land use, degree of intensity of cultivation, crop rotation and other use;

(e) Assessment of the use of biofuels and other renewable fuels with respect to their differentiating effects on climate change and their impact on CO2 emissions reduction;

(f) Review of long-term options concerning energy efficiency measures in transport sector.

18. National Biofuel Development Board

In order to integrate its different activities as part of the National Biofuel Policy and Programme Framework, a suitable institutional mechanism is required. A National Biofuel Development Board would be set up as the Apex Body to develop policies and oversee implementation and monitoring of the programmes on a regular and continuing basis. The Board would be an Autonomous institution. Biofuels are renewable energy sources. It would be appropriate that the service to the Board is done by a suitable Ministry. The composition, terms of reference and functioning of the Board would be prepared.

19. National Biofuel Fund

The financing arrangements of the Board would be made through a National Biofuel Fund with administrative and financial autonomy. This fund would be utilized for the activities of the Board which include preparing policies and plans, research, development and demonstration and taking up selected field projects, HRD, education and awareness and other related activities. Private financial participation in this Fund would be invited subsequently.

PROGRAMAME DETAILS

PROGRAMME

Bio-diesel Conference towards Energy Independence

Focus : Jatropha

Date	:	9th and 10th June 2006
Venue	:	Rashtrapati Nilayam, Hyderabad

09th June 2006

Time			Programme
0900			Inaugural Function
0900 to 0910			Purpose of the Conference
0910 to 0925			Energy Independence Address by The President
0925	**Session : 1**		**Jatropha Experiences**
	Chairman	:	**Dr D.N. Tiwari,** Vice Chairman, State Planning Board, Chhattisgarh
	Speakers	:	**Shri Vinayak Patil**, Nasik, (Maharashtra)
			Shri G M Pillai, DG, WISE, Pune
	Discussion Participants	:	**Farmers from different States** Haryana, Madhya Pradesh, Uttranchal, Uttar Pradesh, Tamil Nadu and Others.

1025 to 1045			**TEA BREAK**
<u>1045</u>	**<u>Session: 2</u>**		**<u>Status of Jatropha</u>**
	Chairman	:	**Dr. B K Kikani,** VC, JAU Gujarat
	Co-Chairperson	:	**Smt Leena Mahendale (IAS)** Principal Secretary and Special Officer (I), Mumbai
	Speaker	:	**Dr. R.S. Kureel**, Director, NOVOD Board
	Discussion Participants	:	**Shri Shakeel Ahmed**, DRM, South-Eastern Railway, Kharagpur
			Shri M. Jayasingh, Chief Mechanical Eng. (Retd.) Southern Railway, Chennai
			Dr. V Ranga Rao, Etv Annadata, Ramoji Film City, Hyd.
			Shri A.K. Lohia, Secretary, UBFDB
<u>1145</u>	**<u>Session: 3</u>**		**<u>Quality Planting Material and Seed Standards</u>**
	Chairman	:	**Dr. N.B. Singh,** Agri. Commissioner DAC

Co-Chairman	:	**Dr. Brahma Singh,** OSD (Hort), Rashtrapati Bhavan
Speaker	:	**Dr. M. Paramathma**, TNAU
Discussion Participants	:	**Dr. Renu Swarup**, Director, DBT
		Dr. S.B. Lal, Dean, CF AAI
		Shri R.K. Patnaik, Prof. and Head Deptt. of Forestry, OUAandT,
Orissa		
		Dr. Naresh Kaushik, CCS, HAU, Bawal

1245 **Session : 4** **Land Availability**

Chairman	:	**Dr. Renuka Viswanathan**, Secy, M/o RD
Co-Chairman	:	**Shri V.S. Sampath,** DG, NIRD, Hyderabad
Speaker	:	**Dr. D. Ramakrishnaiah**, Dir., M/o RD
Discussion Participants	:	**Shri V. Venkatesan,** Consultant, M/o RD
		Shri K Raju, PS, RD, AP Sectt. Hyderabad
		Shri Rajgopal, Secy Planning, Govt of TN

			Shri C.S. Joshi, Dir, SF, Pune
			Shri R. P. Agarwalla, CCF, Guwahati
			Shri P C Mishra, Spl. Secy, RD, Govt of Chhattishgarh
			Smt. Veena Sekhri, Chairperson, BFDB, Uttaranchal
1345 to 1430			**LUNCH BREAK**
1430	**Session: 5**		**Production practices including Post- harvest management**
	Chairman	:	**Dr.C.R. Hazra,** VC, IGAU, Raipur
	Speaker	:	**Dr. V.K. Gour,** JNKVV, Jabalpur
	Discussion Participants	:	**Dr. S.N. Naik,** IIT, Delhi
			Shri Shirish, Dhopeshwarkar, Hyd.
			Dr. Arvind Shukla, GBPUAI, Pant Nagar
			Dr Lalji Singh, IGAU, Raipur
1530	**Session : 6**	**Extraction and Trans-Esterification**	

	Chairman	:	**Dr.V. Prakash,** Director, CFTRI, Mysore
	Speaker	:	**Dr. D.K. Tuli**, Indian Oil Technologies Ltd., Faridabad
	Discussion Participants	:	**Shri C.S. Bhaskar**, Naturol Bio Energy Ltd, Hyderabad
			Shri O.P. Goenka, Spl. Adviser, COOIT, Hyderabad
			Shri Raju Mansinghka, Sr. Vice President and Member of NOBOD Board, Kolkata
			Dr. R. Mandal, Executive Director, SREI
1630 to 1650			**TEA BREAK**
1650	**Session : 7**		**Linkages**
	Chairman	:	**Smt Radha Singh,** Secy, M/o. Agriculture
	Co-Chairman	:	**Shri TL Sankar,** Adviser Energy, ASCI, Hyderabad
	Speaker	:	**Shri Parveen Mithra**, Vice President Advisory Services, SREI

Discussion Participants	:	**Dr. S.D. Singh,** Vice-Chairman, BFDB, UA
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		Dr. Pradeep Ghosh, Secretary M/o EandF
		Dr. Soumitra Biswas, Advisor, TIFAC
		Shri A.K. Goel, Director, PCRA, Delhi

1800 **Drafting Policy Frame Work**

Chairman	:	**Dr. Panjab Singh**, VC, BHU, Varanasi
Members	:	Sessions Chairmen / Co-Chairmen Lead Speakers

10.06.06

0900 Session: 8 Plenary

Presentation by Dr. Panjab Singh
Discussion
Recommendation

LIST OF PARTICIPANTS

<u>List of Participants</u>

Biodiesel Conference Towards Energy Independence ñ Focus : Jatropha

DATE : 9 ó 10 JUNE 2006

VENUE : <u>RASHTRAPATI NILAYAM, HYDERABAD</u>

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