Jatropha curcas – an undemanding plant for biodiesel production

Nut-oil to biodiesel

Jatropha curcas is an undemanding plant which grows in subtropical and tropical regions around the globe, even in the poorest soils – so its production does not compete with food crops. The highly oleaginous nuts can be used for the production of motor and heating fuel. What are the prospects for rural regions if this oil plant, which has only ever grown in the wild, can be brought into cultivation?

Foto: agenda/Böthling

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In the last two years, the oleaginous plant Jatropha curcas has become a veritable media star around the world. Also known as physic nut, the plant even merited a feature in the Germany's leading daily newspaper Frankfurter Allgemeine Zeitung. Another name is often mentioned in the same breath as jatropha: that of Chorvadla, a small Indian village in Gujarat State – a place that few people in the world would ever have heard of, bar its own inhabitants.

The reason for the sudden popularity of this out-of-the-way location is a trial plantation around ten hectares in size. It is planted with long rows of mainly young jatropha bushes; the green of their foliage is in striking contrast to the parched surroundings. The bushes bear fruit the size of a walnut. The fruit contain three black seeds which have an oil content of around 60 percent. Therein lie the hopes of many small farmers all over the world. For the very oleaginous kernels can be used to make both biodiesel and vegetable oil, to be used as motor and heating fuel. The plant flourishes on the most meagre of soils, and needs little water to survive (see box on page 39).

Indian-German cooperation in the bioenergy sector

The test plantation in Gujarat is part of a public-private partnership (PPP) project between Daimler Chrysler, the University of Hohenheim, the German Investment and Development Company (DEG) and the Central Salt and Marine Chemicals Research Institute (CSMCRI). The project is receiving some EUR 500,000 in funding from DEG, while Daimler Chrysler is supporting the research to the tune of approximately EUR 1.3 million, including supplying some of its C-class models as test vehicles. The models manufactured in its Indian plant in Pune (Maharashtra State) run on jatropha-based biodiesel, and have already completed a highly-publicized 10,000 kilometres road trip across India.

Can the cultivation and economic use of jatropha help to lower CO_2 emissions, save on costly mineral oil imports and develop rural regions?

Hope for farmers with degraded land

The farmers from Chorvadla in the dry state of Gujarat are sorely in need of a drought-tolerant fuel crop. «There is little we can do with this barren land,» says village elder Vallhaba Bhai, pointing to the parched steppe surrounding the plantation. «In future, maybe we will actually be able to use the land.» The village has around 500 hectares of wasteland which would be suitable for jatropha production. Even in the monsoon season, there is little rainfall in this part of Gujarat. To the north of the state lie the deserts of Rajasthan. But even many parts of Gujarat are dominated by acute water scarcity. The river beds run dry for most of the year. Recently the state has gained a new supply of water from the controversial Narmada dams, transported through a complex channel and pipeline system. This allows the farmers of Chorvadla to grow sesame, millet and cotton on their better land – but only with the aid of irrigation.

Ten men from the village work on the trial plantation. This helps to spread the word about jatropha among the villagers. In addition, the CSMCRI runs information events in the village to generate interest in the new crop. For what is the use of the best research findings on the usefulness of physic nut as a biofuel without a supply of the raw material itself?

First step: Study the wild plant

Before thousands of small farmers invest money and labour into jatropha plantations, well-founded research is needed into this plant, which is otherwise only known as a wild plant. «A crop plant like maize, for example, has been selected and improved by breeders over many centuries,» explains Professor Klaus Becker of the University of Hohenheim. «Jatropha has great potential, but so far little or no breeding work has been done.» Professor

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Producing their own supply of biodiesel derived from Jatropha oil gives farmers great cost savings.

Becker has been working on jatropha for fifteen years.

Four years ago the University of Hohenheim in Germany approached Daimler Chrysler about its project in India. The involvement of the Stuttgart-based corporation has not only brought the project financial and logistical support but also, above all, international attention. Even so, Klaus Becker warns against premature euphoria: «As yet, we do not have standardized seed stock, predictable yields, or research-based production methods – but nowhere is all this being studied more intensively than right now in Gujarat.» In partnering with the CSMCRI, the University of Hohenheim has successfully attracted one of the most expert research institutes in India. The recultivation of degraded and salinized soils happens to be one of its research priorities.

In the past year, CSMCRI has collected numerous wild species of the jatropha plant, from which it has selected a number of «elite cultivars». These cultivars produce three or four times the yields of the wild plants used hitherto. Trials with the elite cultivars, which have been planted on the test site near Chorvadla as well as another plantation in Orissa State, aim to find out how much water the plant requires to thrive in the first phase of growth, how much water and fertilizer it needs to produce optimum yields, and how much space it requires for optimum growth. Another question is whether jatropha will remain resistant to pests or whether this characteristic will change in the context of large-scale production.

Propagation is a sticking point

One major problem is that of propagating from the selected elite plants, which are currently being studied on the plantation to establish their agronomic parameters. The offspring need to be genetically identical. So far that can only be achieved by using cuttings and transplants. But because a cutting needs to be at least 30 centimetres in size, only a limited number of cuttings can be obtained from one parent plant.

Propagation from seed may result in alteration of the genetic material. One possible means of propagating genetically identical jatropha plants on a large scale may be tissue culture. So far, however, all attempts at this have failed, to Professor Becker's regret. Although as a scientist he believes that propagation by tissue culture is the right approach, he warns against undue euphoria at this stage: «Currently hundreds of thousands of hectares of jatropha crops are being developed, all using plants which have been propagated from seed; nobody yet knows how these plantations will turn out.»

Jatropha also grows on rocky soils with only a thin layer of humus. The plant can survive in these conditions even without fertilizers or artificial irrigation.

«Our aim is to optimize the yields of jatropha,» reports Junabhai Sambhubhai Patolia of CSMCRI. «In order to keep yields up, we have to irrigate during the four-month dry season at a rate of about 100 litres per plant,» explains the scientist. During the establishment phase, it is also necessary to weed the plantation and the farmers have to prune the plants. Harvesting is done by hand.

All parts of the plant are poisonous and are never grazed upon by goats or cows. The plantations can therefore be left unfenced – a crucial advantage in poor regions. Nevertheless, the scientists calculate an initial investment equivalent to EUR 250 per hectare. That is a substantial sum for a small-scale Indian farmer. The plant only gives economically viable yields after five years – but then remains productive for more than thirty years. After that, it is time to replant.

On the soils around Chorvadla, the scientists aim to achieve yields of around two tonnes of fruits per hectare, once the different cultivars and cultivation methods have been researched. This could be made into about 500 litres of biodiesel. At the filling station, the current price of a litre of diesel is around 35-40 rupees, which converts into about 70 cents in Euro. Any farmer who was self-sufficient in fuel derived from jatropha oil would stand to gain up to 20,000 rupees per hectare, equivalent to EUR 350. This is the amount a farmer could save if he did not have to buy diesel for his vehicles.

In order to manufacture biodiesel, an oil mill if not a proper biodiesel plant is required. These usually expensive facilities are generally operated by cooperatives. The processed fuel could be sold on the local market, but in that case, the additional costs of transportation and middlemen also have to be taken into account. An alternative option is to market the nut unprocessed, which would generate the equivalent of EUR 250 per hectare, according to the scientists' estimates.

Utilizing by-products

«In order to optimize the economic benefits to the farmers, we must find a use for the whole of the plant,» says Pushpito Ghosh, director of CSMCRI in Bhavnaghar. Besides the production of biodiesel, the team of scientists and engineers is conducting research into other uses of the by-products. The oil cake left after pressing the fruits can be made into livestock feed. The one prerequisite is to neutralize the highly toxic phorbol ester which the plant contains.

The transesterification of the plant oil into biodiesel produces a large quantity of glycerine. The institute uses this to make products such as soap, but is also experimenting with the use of bacteria to obtain biopolymers from the gelatinous mass. These could be used in the manufacturing of car seats, for instance.

In the year 2005, the in-house pilot plant produced around 8,000 litres of biodiesel which complied with the European DIN 14214 standard. CO_2 emissions are comparable to those from oilseed rape biodiesel. The pilot plant is capable of producing 250 litres per day and costs around EUR 30,000. A similar plant could equally well be operated by a farmers' cooperative. So far, however, interest in the jatropha research work at the institute in Bhavnagar has come mainly from industry – from corporations such as BP and the Indian conglomerate Reliance.

In Gujarat, there are no concrete plans as yet for the commercial production of biodiesel from Jatropha. Nevertheless, the Indian market for diesel is huge. India has to import the bulk of its petroleum and pay dearly for it. In 2005, diesel consumption ran to 40 million tonnes. Consumption for 2006 is expected to be 52 million tonnes. Even the addition of 5 percent of biodiesel would equate to a demand for 2.5 million tonnes, making it a worthwhile market for the exploration of alternatives. There is an abundance of land on which the undemanding fuel plant can be grown: India has over 170 million hectares of wasteland. Climate change, erosion and degradation are most likely to affect small farms, which are often on low-quality soil, and some of which have already lost up to one-third of their arable land.

India's economy is prospering. In 2005 it grew by 8 percent, and experts expect similar growth for 2006. The country has a productive industrial sector and large numbers of highly skilled workers. Nevertheless, a quarter of India's 1.2 billion inhabitants have to survive on less than one dollar per day. India's population of working age numbers 400 million, of which 36 million are unemployed. Many of the poor live in rural areas. Almost 60 percent of Indians work in agriculture, a sector which does generate as much as a quarter of gross national product. Rural development is therefore a central challenge for the Indian government. Jatropha is expected to play an important role, at least if one believes the government's declarations.

GTZ programme to promote jatropha in India

Another promising fuel project involving jatropha is being supported in India by the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ – German Technical Cooperation). Twenty years ago, the oleaginous physic nut gained considerable attention; back then, the project was not pursued further, probably because the time was not yet ripe for biofuels. Now interest has been reawakened by the explosion in mineral oil prices.

In July 2006, the subcontinent's first commercial plant to produce biodiesel from jatropha went into operation. Partners of this PPP project, initiated by GTZ near Hyderabad in Andhra Pradesh State, are the leading German plant engineering firm, Lurgi AG and the Indian partner Chemical Construction International. An Indian company, Southern Online Bio Technologies Ltd. is operating the plant with a capacity of 10,000 tonnes of biofuel per year. A bus company from Hyderabad will purchase its entire output. Other public bus operators and Indian Railways are also said to be showing great interest. The operator of the biodiesel plant has arranged contracts with farmers from around sixty villages in the surrounding area, to promote the systematic cultivation of jatropha as well as Pongamia pinnata, a native oil tree.

Already there is surplus demand for the nut of the jatropha bush. So far, the majority of projects have been supplied with nuts from wild plants, since commercial plantations do not yet exist. The price of wild fruits has rocketed: originally 3 rupees, it has now risen to over 20 rupees per kilogram.

Furthermore, assistance in the form of microfinancing programmes will encourage the establishment of small, local oil mills. This will create new, sustainable sources of income in the rural areas around Hyderabad.

Jatropha curcas: The undemanding oil supplier

The Jatropha plant is a shrub belonging to the spurge family and originates from Central and South America. Today it grows in subtropical and tropical regions around the globe. The evergreen shrub thrives in a very dry climate with only 250 millimetres of rainfall per year, but also grows in regions where annual rainfall is anything up to 2,500 millimetres. The plant develops best with rainfall of around 900 to 1,200 millimetres. The jatropha bush has thick roots which help it to utilize water very efficiently. In times of persistent drought, it sheds its leaves so as to reduce transpiration.


Photo: agenda/Böthling

Hedges made with jatropha bushes can protect the soil from wind erosion. The roots are dense and close to the surface, which also mitigates water erosion. The jatropha plant grows even on nutrient-poor, stony soils. Therefore its cultivation does not compete with food production. On the contrary, by planting jatropha it is possible to improve degraded soils so that food can be grown again. The shedding of leaves on jatropha plantations begins to rebuild the humus layer.

All parts of the plant are toxic. For generations, farmers have used jatropha hedges to protect fields and gardens from game damage caused by roaming animals. Plantations of physic nut bushes do not therefore need to be fenced in, which saves effort and expense.