

# **Position Paper on *Jatropha curcas***

## **State of the Art, Small and Large Scale Project Development**

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### **Summary**

Much information has been collected during the Seminar on *Jatropha* held, in March 2007, in Wageningen, the Netherlands. Some of them are summarized in this paper. Much research is still necessary to improve yield, to allow use of bioproducts such as oil cake as animal fodder etc. Good documented yield data are still scarce. Cooperation with research institutions is therefore recommended.

At this stage it is still particularly important to distinguish between “reality”, “promises” and “dangerous extrapolations”. To avoid, spectacular and regretful failures and waste of money for investors as well as great disappointments of local populations, promoters of large scale plantation are invited to adopt stepwise approaches: large scale plantations should only be considered after some 4 to 5 years obtaining experimental data (annual seed yield and oil yield, economical viability etc.) from a sufficient number of small scale experimental plots (about 1 ha) corresponding to the whole range of soil and climatic conditions of such projects.

### **Introduction**

Over the last 2 to 3 years the plant species *Jatropha curcas* has again generated the interest of many actors in the field of bio-energy. Many excellent characteristics, including high yield ability, high oil content, resistance to drought, and good quality of the plant oil, have been attributed to this plant. However, the exact expression of these characteristics is still not well understood nor validated or researched. Preliminary findings show some of these to be true, others are exaggerated, while most will be valid only under specific conditions (which are often not indicated clearly). FACT (Fuels from Agriculture in Communal Technology), an international knowledge and expertise centre based in the Netherlands, organized an international seminar<sup>1</sup> with over 80 participating researchers and practitioners from all over the world to share their insights and knowledge on *Jatropha curcas* as a species to supply oil for the energy. The Seminar was held from 26 to 28 March 2007 in Wageningen, the Netherlands. It aimed to gain insight in the most elementary aspects of this species before moving either into large scale exploitation or

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<sup>1</sup> We thank GW Foundation for financially supporting this seminar

into small scale application for sustainable rural development. Most elementary aspects include yield, an area where reliable and well documented information is still scarce, genetics, plant breeding and agronomy.

The seminar provided most recent and useful insights on the intentions and developments of international and national investors to set-out large scale operations in Jatropha, covering 10 to 100 thousands of hectares. In this position paper the Seminar Program Committee elaborates on the deliberations of the seminar to provide the most recent and factual information to researchers and to investors and organisations who intend to set-up large plantations of Jatropha in Developing Countries.

### State of the Art in Jatropha

Much information has been collected during the seminar about Jatropha, learning to distinguish between “reality” and “promise”. For a number of characteristics “state of the art”, “reality” and “promise” can be easily distinguished. Data have been presented on yield, plant architecture, soil and fertility conditions, water requirement, impact of pests and diseases, propagation and genetics. A reflection is given about long term sustainability.

### Yields (table 1)

The reported yields range from extremely low to high. Some of the variation may also be explained by difference in the following growth and production related factors:

- a. Age; yields increase with age. It is therefore important to indicate at which age yields have been measured . This is not always the case.
- b. Soil conditions; waterlogged soils are not suitable for Jatropha which seems to be very sensitive to limited oxygen supply to roots.
- c. Water availability; differences in rainfall, length of the dry season and irrigation practices.
- d. Nutrient availability due to different soil fertility levels.
- e. Pests and diseases in different degrees of incidence and length, according to the ecological conditions.

Another part of the variation is explained by genetic factors. This is a common feature; a strict selection of seeds or cuttings leads to more uniformity in offspring and higher yields per plant.

Table 1. Yield of *Jatropha curcas*. (in ds dry seed : ds )

A high variability between plants in the same field is observed with plants from seeds in a number of experiments
Under some soil conditions Jatropha may completely fail (waterlogged areas, frost susceptible areas etc..)
First year Yields reported in Guatemala first year were 1.25 tonne dry seeds ha-1 y-1 with fertilizer and 800 mm irrigation in the 6 dry months etc. but only half of that without irrigation (precipitation 4000 mm/in 6 month), at a planting distance of 2,5m x 2,5m.(Barillas, Octagon SA)
First year (E. Brazil: first year 250 kg dry seeds ha-1 y-1 (due to late planting), while prognosed 800 kg dry seeds ha-1 y-1, optimal climate, good soil fertility, etc (Moller), planting density unknown
First year

In Indonesia yields of 4 to 5 tonne ds (ds=dry seed) ha-1 y-1 after one year are recorded, with plants grown at a density of 2 x 2 meters (2500 plants ha-1), with total precipitation of 2000 mm y-1 and good soil with high organic matter content (ref: R.Manurung)
Second year India with 4 x 3 spacing (833 plants ha-1) and high nutrient level 1.27 tonne dry seeds ha-1 y-1 after 2 years, at an average precipitation of 800 mm y-1 (Patolia)
After 4 years In Nicaragua best field delivered after 4 years, 4.5 tonne dry seeds ha-1 y-1 (N. Foidl)

### Plant architecture (table 2)

This is a very important issue as it:

- a) determines to a large extent, although not completely, seed yields in each site.
- b) Can facilitate manual and mechanical harvesting of seeds, which determines by enlarge the costs of seed production.

Much has still to be learned from plant manipulation; from more or less intensive pruning, curving of branches, at different moments, etc..

Specialists in plant morphogenesis are required to make progress in this area

Table 2 Plant architecture

Branching pattern determines yields of seeds per plant
Branches without light, do not flower and finally die off.
Canopy size determines the maximum number of flowering branches. Large trees on a low planting density or smaller (dwarfed) plants on high densities (up to 10000/ha) can apparently both result in sufficient flowering branches.

### Soils and soil fertility (table 3)

It is clear that Jatropha responds highly on soil conditions:

- Well aerated soils are a must
- The plant seems to respond well to organic matter (OM) and fertilizer

The relation between plant nutrients, OM content of the soil and micro nutrients and yields is not fully understood. However rough recommendations can be given.

Table 3 Soils and soil fertility

<b>Soils</b>
Clay soils are unsuitable for Jatropha if water logging or saturation occurs due to climatic conditions. In general heavy clay soil that swell and shrink (Montmorolleniet) (“working soils”) are not suitable because root system development is impaired.
Acid (PH < 6) or Alkaline (> 8.0 8.5) soil are not suitable for Jatropha.
Sandy to Loamy soils seem to be a best fit.
<b>Fertility and yield response</b>
Jatropha responds good to fertilization application in poor soil conditions
Both to chemical fertilizer as to Organic Matter gifts
Eg. Some tests: without compost: Indonesia 2 tonne/ha ds v with compost 5 tonne/ha ds (Manurung, pers com).
India: poor soil linear response to J cake (Patolia); in India fertilizer trials show a good

response as well (Patolia).  
 Brazil: response to fertilizer (Moller, Embrapa).  
 Belize: More branching and 50% yield increase were observed when 'bagasse', organic wastes from sugar cane, were used as fertilizer (Baumgart).

**Rainfall and humidity** (table 4)

Although Jatropha can survive precipitation as low as 300 mm, by shedding its leaves, it does not produce well under such conditions. It seems that there is an optimal rainfall per annum, that is also influenced by the rainfall pattern. Rainfall induces flowering as well as drought. The cycle of flowering can thus be influenced using irrigation. High humidity or high rainfall can result in more fungus attacks for which the plant is sensitive.

Table 4 Rainfall and humidity

<b>Rainfall and humidity (bold figures)</b>
Minimal rainfall requirements to survive 300 mm ha-1 y-1.
Minimum rainfall to produce fruits: 600 mm ha-1 y-1.
Optimal rainfall 1000 to 1500 mm ha y-1.
Short periods of drought ( one month) will induce blossoming.
<b>Rainfall periodicity/irrigation</b>
Too much rain and humidity will provoke fungus; high rainfall might require other spacing.
Costs of irrigation installation 500 to 1000 USD/ha; operational costs depend on depth of water, etc. In Latin America normally ranging from 0.35 to 0.5 USD/ha and mm applied (N.Foidl).

**Pest and diseases** (table 5)

Unlike the common believe that the plant is highly resistant to pest and diseases, it is vulnerable to most common pests and diseases found in food crops. The positive news is that most of these pests and diseases can be treated fairly easily and if required biologically

Table 5 Pest and diseases

<b>Pests and diseases</b>
Resistance to pests and diseases as is mentioned in <i>Jatropha curcas</i> L. only applies to freestanding older trees.
All normal pests and diseases were encountered in Jatropha in Guatemala in young monocultures.
All pests and disease can be controlled by both chemical or biological methods as is applicable to other crops.
Seed treatment with fungicide and Tricoderma will help protect seed; wounds caused by pruning create an entrance for infection by fungi and bacteria
Costs per year for pest/disease treatment can be 80 USD/a/ha (example in Nicaragua, N.Floidl)

**Propagation** (table 6)

Propagation methods range from seed (grown in a nursery) to direct seeding, or planting cuttings. New is the use of micro propagation that can have good results with induction of better roots.

Table 6 Propagation

<b>Propagation</b>
Stakes or Cuttings as source material for propagation are not recommended as 1) root system is only developed laterally which does not provide strength to the plant 2) the cutting surface is an entry point for fungi and insects
Seeds in nursery or direct seeding with seed treatment is recommended.
New technology: Robert Manurung in Indonesia succeeded in micro propagation with good developed root system, he claims high yields with these plants expecting 10 tonne dry seeds ha <sup>-1</sup> y <sup>-1</sup> In few years. Similar field trials with cloned plants are ongoing in India and China.

### Long term sustainable yields (table 7)

There is not much evidence on how Jatropha will produce over the years. The notion that the plant can live for 50 years seems based on individual trees, but not on a production plantation. There is already some evidence that the duration of a plantation might optimally last less than the 20 years quoted in many guides.

Table 7 Long term sustainable yields

<b>Long term sustainable yields</b>
In Nicaragua yields slowly decreased after the fifth year, due to increasing pests and disease levels. Severe pruning is necessary to keep production on a good level, but this also increases the plants susceptibility to plant diseases.

### Genetics

The genetics of the Jatropha plant define the potential production and give us tools to breed more productive, healthier plants. In order to start breeding the genetic variation needs to be assessed. Several parties have done genetic studies amongst others the University of Newcastle. The first results are that the variation within the plants from India and Thailand is low and the same holds for the African gene pool. The Indian sources differ slightly from the African sources. More genetic variation is expected in the centre of origin (Meso America). Wageningen University has set up a worldwide screening programme (JEP) where genetic variation is mapped.

### The promise

The promise of *Jatropha curcas* as a species to produce high quantity and quality feedstock for bio energy is considerable. First, yields are expected to increase over the years as seed improvement takes effect. Yields are expected to reach 6 to 7 ton ds ha<sup>-1</sup> y<sup>-1</sup> within few years<sup>2</sup>, but only under optimal climate conditions, using high yielding strains, and optimal soil fertility conditions. But normally most conditions are far less than optimal resulting in yields as low as 300 kg ds/ha/a or even no yield.

Looking at such promise, it might be concluded that Jatropha might be an alternative for other oil producing plants such as oil palm, especially for less humid areas. Oil palm has different optima as Jatropha in terms of climate and soil conditions. For the long term Jatropha might be grown on a similar acreage as oil palm and could even become an export crop. Clearly before this would happen, serious consideration should be given to the following aspects like the national policy on biofuels in a country, social and organisational aspects of setting up large scale plantations, environment and biodiversity issues, etc..

<sup>2</sup> Foidl questions yields of more than 5000 kg dry seed/a/ha based on reasons of energy efficiency of the plant.

The near-by promise is that Jatropha<sup>3</sup> will allow local communities to generate their own conveniently used fuels for electricity, transport or cooking, thereby avoiding expenses to obtain fossil fuels externally.

### **Implications for large investments on Jatropha**

Many international and national investors have rushed in to establish large acreages to be cultivated with Jatropha curcas. Evidence of this trend can be found in many African countries (Ethiopia, Mozambique, Senegal, Gambia, etc..) and in Latin America (eg. Brazil, Honduras, Belize etc.). In Asia also mega investment plans are proposed, e.g. in India, Philippines, Indonesia and China. The list of countries in which incredible large areas are planned to be grown with Jatropha is drastically increasing. In selecting these areas the appropriate growth conditions could simply not have been taken into consideration because of the lack of reliable information (on crop requirements and climate/soil characteristics). There is a fair chance of disappointment when the desired performance of the crops is not attained. As it takes several years to observe this reality, the adverse effects will not only mean a financial loss to the investor. It will also negatively affect the local community that have been promised improved living conditions. A rebound effect might be a reluctant attitude to embrace new investments and development opportunities in poor areas. The scientific community and practitioners in Jatropha curcas therefore recommend:

- Firstly, investors and country governments should base their plans on realistic and conservative data (replace with conservative estimations) in all respects: in plant production, external inputs (fertilizer/ irrigation), labour input, in oil extraction and in the cost-benefit analyses of end-product and by-product
- Secondly, investor and country governments should ensure their projects to be sustainable for the middle and long term.

On the first recommendation some input has been provided in the aforementioned table, while for the second recommendation the PPP ( People, Planet, Profit) concept can be adhered to. For Jatropha plantations some criteria have been formulated below. These criteria serve as a generally guidance only.

#### **People:**

No destruction of village or social structures

No infringement of common lands or traditional user rights

No displacement of people

Enhancement of local employment or income generation of local people

Decent wages to be paid

Preferably no dependency of a sole income source of people (risk avoidance)

#### **Planet:**

Take care on what is real waste or idle land;

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<sup>3</sup> This seminar was on Jatropha, however there are also other oil producing species that can be considered, like e.g. Pongamia

Minimal and no lasting environmental pollution in production by agro chemicals and fertilizers;

Careful consideration of the sustainability of monocultures and preferably intercropping;

No selection of lands with high biodiversity importance

Intercropping preferable, especially in the earlier years

**Profit:**

Prepare clear business plans, based on conservative/proven data

Company profits preferably reinvested in the country

Jatropha should in first instance be used to supply internal markets. Local use is more energy efficient and there is always enough internal demand.

Company profits sharing with farmers, and farmers decent payment

No excessive company profits

Finally, it is recommended that such PPP concept or lessons learned from small and larger projects will step by step lead to a type of certification system just like FSC one for wood products, or the RTSP for oil palm.

**Conclusions and recommendations**

The preliminary data as presented in this paper needs to be interpreted with care. Much of this information has not been verified, but does provide an overview of the current knowledge base.

Some general technical findings are that :

- Yields can not yet be predicted at any degree of accuracy. Promising seed sources that perform successfully in one location may under-perform in another.
- Variation between plants is still considerable, thereby making harvesting costs labour intensive.
- The economics do not allow high labour rewards to be paid, thereby limiting countries with more costs than 3 to 5 USD ha<sup>-1</sup> d<sup>-1</sup>.
- On the exact effects of environmental conditions on flowering and fruit setting not much is known. This also has consequences for mechanical harvesting that is being developed.

These technical aspects have bearing on the socio-economic effects of large scale plantations, in terms of peoples labour costs and dependency.

The seminar program committee therefore recommends not to engage in large scale plantations now. It encourages investors and developers to start on a small scale (e.g. 100 ha) based on verified or scientifically proven data, and learn by doing to extend the size of such plantations. In such plans and projects, the criteria of Sustainable Development ( like the aforementioned PPP) are recommended to be applied.

Therefore substantial efforts should be made to streamline observations in current Jatropha planting sites, to implement specific experiments for unravelling the impact of different production factors on crop performance and to exchange knowledge and information, in order to prevent unjustified investments.

The program committee