

Growing Jatropha

Including propagation methods for Jatropha curcas
and production and use of Jatropha products



Ab van Peer MSc

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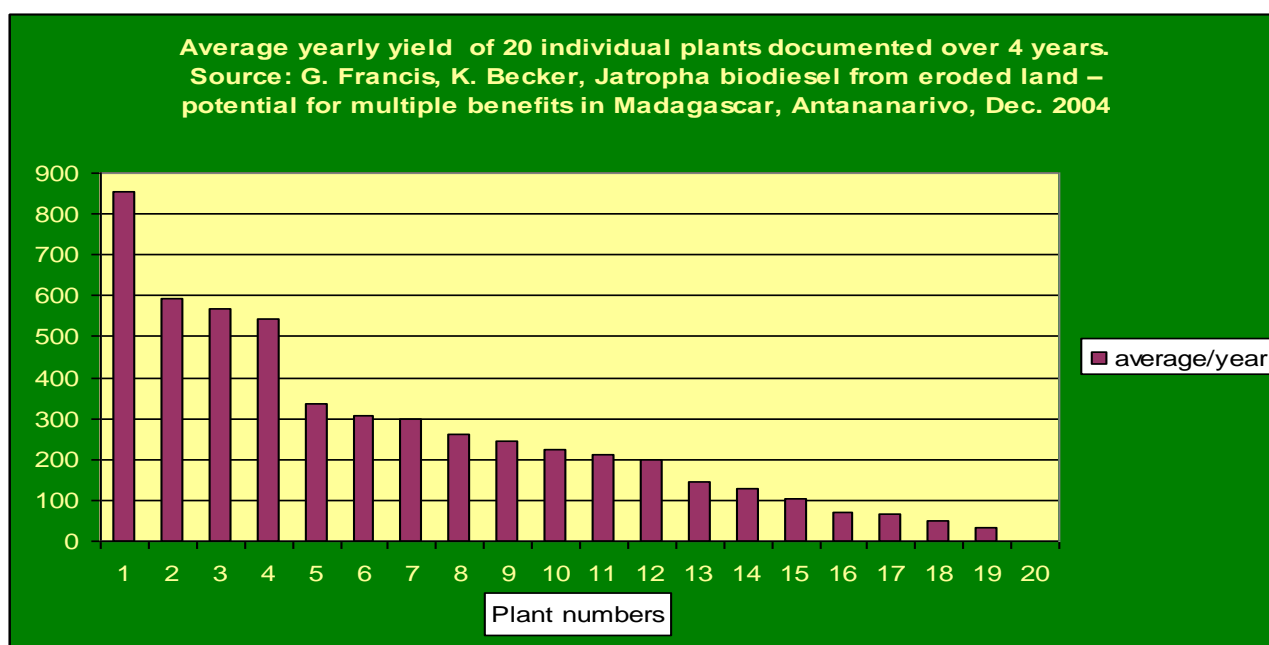
Growing *Jatropha curcas* L.

1. Preface

Growing plants in general and *Jatropha curcas* L. in particular requires knowledge and understanding of the environmental conditions these plants require to grow and thrive. Regarding the factors influencing plant growth, an understanding of soils probably is the most important one.

In subtropical and tropical areas (this is where *Jatropha* belongs); variation in soil type, pH and nutrient content is huge. In the case of growing *Jatropha* it is even more crucial to understand (at least) the soil conditions since there is very little information about *Jatropha* itself. Therefore the first module in this booklet is about soils

Until recent, seed and plant selection of *Jatropha curcas* L. never took place, so the whole *Jatropha* industry is working with a wild plant without known characteristics. Early trials showed a lot of variation between individual plants, which simply means that yield, will be unpredictable and far from optimal. Therefore proper plant selection is crucial for the development of a well yielding *Jatropha* crop.



Propagating large quantities of *Jatropha curcas* is not a complicated task as such, provided that proper techniques are being used. There is a relation between the scale of an operation and the most suitable way to propagate *Jatropha*.

Therefore the second module in this booklet is about seed selection, nursery and propagation techniques.

In principle growing *Jatropha* should not be easier or more difficult than any other agriculture crop. By using proper agricultural methods under the climatically right conditions, *Jatropha* should become a useful additional cash crop for small farmers, in combination with the crops they already grow. It can also become a useful raw material for industrial and energy production. But since there is lack of basic knowledge, growers or growers groups should start right from the beginning with growing experiments and the implementation of proper agricultural practices. Plant selection and production should go hand in hand, in order to achieve a high yielding *Jatropha* crop.

Therefore the third module is about field activities.

Lately some articles have been published about the need to domesticate *Jatropha curcas*. L In view of the fact that *Jatropha* has been around for hundreds of years and has been planted as a hedge along thousands and thousands of kilometres, this is a remarkable statement. It can only be understood in the context of the usage of *Jatropha* for the production of fuel. However, it is a fact that, in spite of domesticated *Jatropha* around all over the world, there hardly is information available (other than anecdotal) regarding the use of *Jatropha* as a medicine, soap, insecticide etc. One might hope that the actual interest for *Jatropha* fuel will result in scientific research in all these other fields as well.

The contents of this manual are based on decades of agronomical field experience in Asia and Africa and on information freely available through the internet from sources I personally know or trust. This information represents findings and beliefs at the present time. These will no doubt change in the future. Likewise, growing *Jatropha* in Indonesia is not the same as growing *Jatropha* in Tanzania. Soils, light conditions, precipitation and temperature might be different and so will be plant response.

Statement from Dr. Carl. E. Whitcomb Ph.D, plant propagation specialist:

Established growing systems should not be changed without proper experiments. Try any new technique on a small scale before committing more plants and capital than you can afford to lose. It may take several tries to maximize the benefits from a particular treatment or technique under your local conditions.

Unless otherwise stated, all pictures are from the author.

Disclaimer: Any recommendations, opinions or findings in this report are based on circumstances and facts as they existed at the time the author prepared this manual. Implementation of recommendations may adversely be affected due to locally differing circumstances, beyond control of the author.

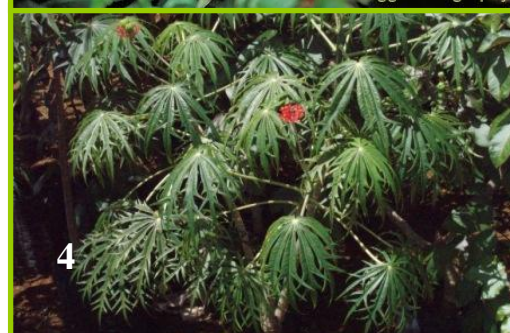
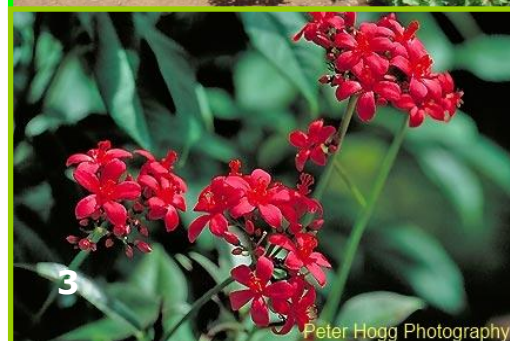
Jatropha Curcas L.

2. Introduction

Jatropha is a genus of approximately 175 succulent plants, shrubs and trees (some are deciduous, like *Jatropha curcas* L.), from the family Euphorbiaceae. The name is derived from (Greek **iatros** = physician and **trophe** = nutrition), hence the common name **physic nut**. *Jatropha* is native to Central America and has become naturalized in many tropical and subtropical areas, including India, Africa, and North America. Originating in the Caribbean, *Jatropha curcas* L. was spread as a valuable hedge plant via Africa to Asia by Portuguese traders (1). The mature small trees bear separate male and female flowers in bunches, and do not grow very tall. As with many members of the family Euphorbiaceae, *Jatropha* contains compounds that are highly toxic. The *Jatropha* genus has many ornamental species as well.

Species of *Jatropha* include among others:

- ***Jatropha curcas* L.(1)** also known as physic nut, piñoncillo and Habb-El-Melúk, is used to produce the non-edible *Jatropha* oil, for making candles and soap, and as a feedstock for producing biodiesel. (Fully grown *Jatropha* in Tanzania ,called Mbono Kaburi)
- ***Jatropha gossypifolia* L. (2)** also called bellyache bush: its fruits and foliage are toxic to humans and animals. It is a declared weed in Australia and that is the reason that even *Jatropha curcas* is a forbidden plant in Australia.
- ***Jatropha integerrima* Jacq.(3)**, or spicy *Jatropha*: ornamental in the tropics, continuously crimson, flowers almost all year. This plant is widely used in the streets of Jakarta in Indonesia. It is not a vigorous grower and therefore sometimes grafted on *Jatropha curcas*.
- ***Jatropha multifida* L.(4)**, or coral plant: bright red flowers, like red coral, characterized by strongly incised leaves.
- ***Jatropha podagrica* Hook. (5)** Buddha belly plant or bottle plant shrub. Used for tanning leather and produce a red dye in Mexico and the South-western United States. It is also used as a house plant.



3. Botanical description

(adapted from Heller-Physic nut. (1)

The physic nut is a drought-resistant species which is widely cultivated in the tropics as a living fence. Many parts of the plants are used in traditional medicine. The seeds, however, are toxic to humans and many animals. Considerable amounts of physic nut seeds were produced on Cape Verde during the first half of this century, and this constituted an important contribution to the country's economy. Seeds were exported to Lisbon and Marseille for oil extraction and soap production.(Savon de Marseille) Today's global production is almost negligible. (Heller J.-Physic nut.(1)

The physic nut, by definition, is a small tree or large shrub which can reach a height of up to 5-7 m. The plant shows articulated growth, with a morphological discontinuity at each increment. Dormancy is induced by fluctuations in rainfall and temperature.

The branches contain latex. Normally, five roots are formed from seedlings, one central and four peripheral. A tap root is not usually formed by vegetatively propagated plants (Kobilke 1989(2). The physic nut has 5 to 7 shallow lobed leaves with a length and width of 6 to 15 cm, which are arranged alternately. Inflorescences are formed terminally on branches. The flowers are unisexual; occasionally hermaphrodite flowers occur (Dehgan and Webster 1979 (3).

Pollination of the physic nut is by insects. Dehgan and Webster (1979) believe that it is also pollinated by moths because of "its sweet, heavy perfume at night, greenish white flowers, versatile anthers and protruding sexual organs, copious nectar, and absence of visible nectar guides". When insects are excluded from the greenhouse, seed set does not occur without hand-pollination. The rare hermaphrodite flowers can be self-pollinating. During field trials, Heller (1992 910) observed a number of different insects that visited flowers and could pollinate. (Flies, Bees, Ants) In Senegal, he observed that female flowers open later than male flowers in the same inflorescence. To a certain extent, this mechanism promotes cross-pollination. Münch (1986 (4)) did not observe this chronological order in Cape Verde. The exocarp (skin of the fruit) remains fleshy until the seeds are mature. The seeds are black, 2 cm long and 1 cm thick.



male and female flowers



male flowers only

Module 1 - Soils

Regarding the factors influencing plant growth, an understanding of soils probably is the most important one.

In subtropical and tropical area's (this is where *Jatropha* belongs), variation in soil type, pH and nutrient content is huge. In the case of growing *Jatropha* it is even more crucial to understand (at least) the soil conditions since there is very little information about *Jatropha* itself.

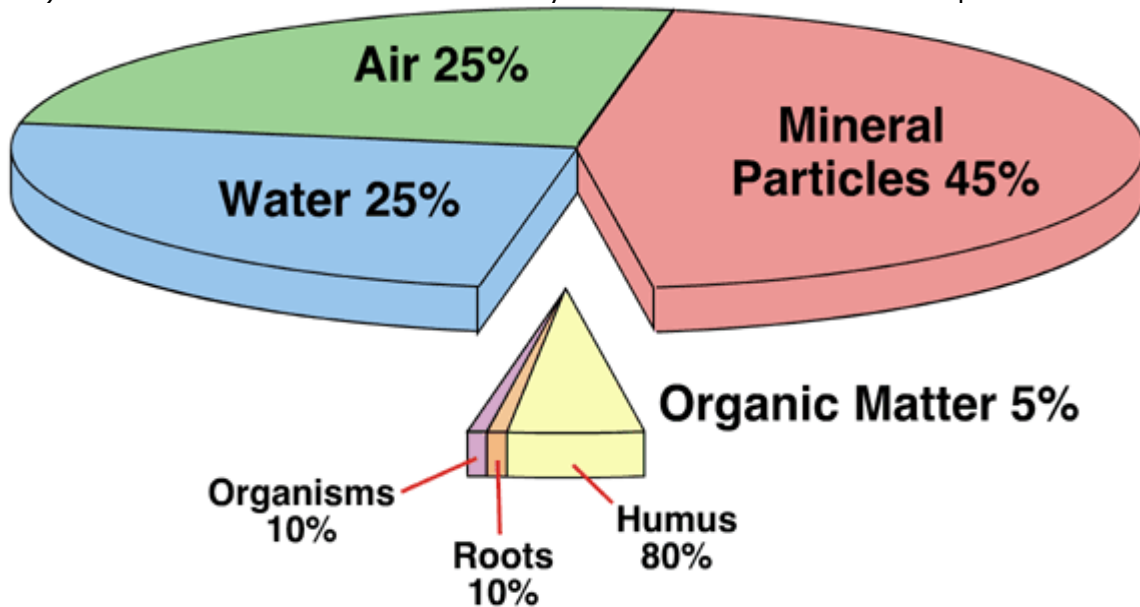


Table 1. Most soils contain four basic components: mineral particles, water, air, and organic matter. Organic matter can be further sub-divided into humus, roots, and living organisms. The values given above are for an average soil in a subtropical climate. (table from PhysicalGeography.net. (5))

Soil fertility.

Definition: Soil fertility is a combination of the following elements:

Soil structure and texture, soil pH, content of nutrients, nutrient storage capacity, soil depth, soil organic matter content, soil organisms.

The next pages are covering the main aspects.

Soil texture

The first and very rough characterisation of soils is based on visual aspects.

Most soils are characterised by the presence of clay, silt and sand.

Depending on the mixture of these particles we characterise soils "heavy" or "light".

| Particle size ranges for sand, silt, and clay. | |
|--|-----------------------------|
| Type of Mineral Particle | Size Range |
| Sand | 2.0 - 0.06 millimetres |
| Silt | 0.06 - 0.002 millimetres |
| Clay | less than 0.002 millimetres |

Table 2. The texture of a soil refers to the size distribution of the mineral particles found in a representative sample of soil. Particles are normally grouped into three main classes: sand, silt, and clay.

Soil Structure

Soil structure has a major influence on water and air movement, biological activity, root growth and seedling emergence.

Heavy soils (clay, silt) do have a structure determined by very small particles. When this type of soil becomes wet, it takes a long time to dry up, even when proper drainage is applied. These soils are difficult to work with, and growth is difficult to control. On the other hand, most clay soils (like black cotton) are relatively rich in nutrients. Their structure is determined by how the individual soil granules clump or bind together and aggregate, and therefore, the arrangement of soil pores between them. Soil structure, especially in heavy soils is degraded by over-fertilization, compaction through heavy machinery and frequent traffic, and over irrigation. **Never work a soil when it is too wet!** In temperate areas frost repairs a lot of soil degradation. In tropical areas it is much more difficult to maintain a good soil structure. Organic material, which is among others important for the exchange of nutrients from the soil to the plant, is decomposed very fast by high temperatures, high humidity and intensive labour.



Jatropha on heavy black cotton soil in Kilwa, Tanzania.



Jatropha on light sandy soil in Senegal

Light soils like sand are based on a very coarse particles size. This means that water drains very fast which is a good thing if you have enough water. On the other hand, a lot of water and good drainage leaches the available nutrients very fast, so light soils mostly are poor soils.

Jatropha curcas L. and soil structure.

Most of the literature regarding agronomy practices for *Jatropha curcas* states that the plant grows best on well drained sandy soils. This however is nothing special, since at least 50% of all the plants all over the world prefer the same growing conditions. On top of that, cultivation in light sandy soils makes it more convenient for men. Water and nutrient levels can be maintained quite easily. In spite of the above, *Jatropha* grows well on clay soils, as long as there is proper drainage and/or run off.

Soil pH

Soils support a number of inorganic and organic chemical reactions. Many of these reactions are dependent on particular soil chemical properties. One of the most important chemical properties influencing reactions in a soil is pH. Soil pH is primarily controlled by the concentration of free hydrogen ions in the soil matrix. Soils with a relatively large concentration of hydrogen ions tend to be acidic. Alkaline soils have a relatively low concentration of hydrogen ions. Hydrogen ions are made available to the soil matrix by the dissociation of water, by the activity of plant roots, and by many chemical weathering reactions.

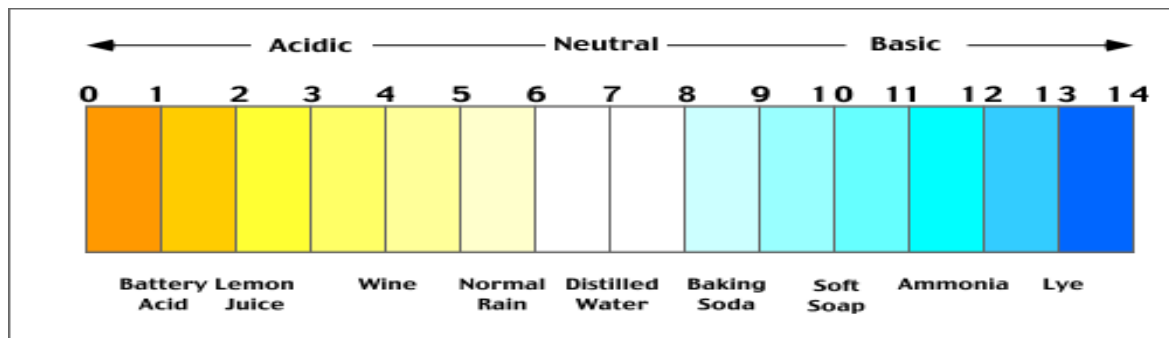
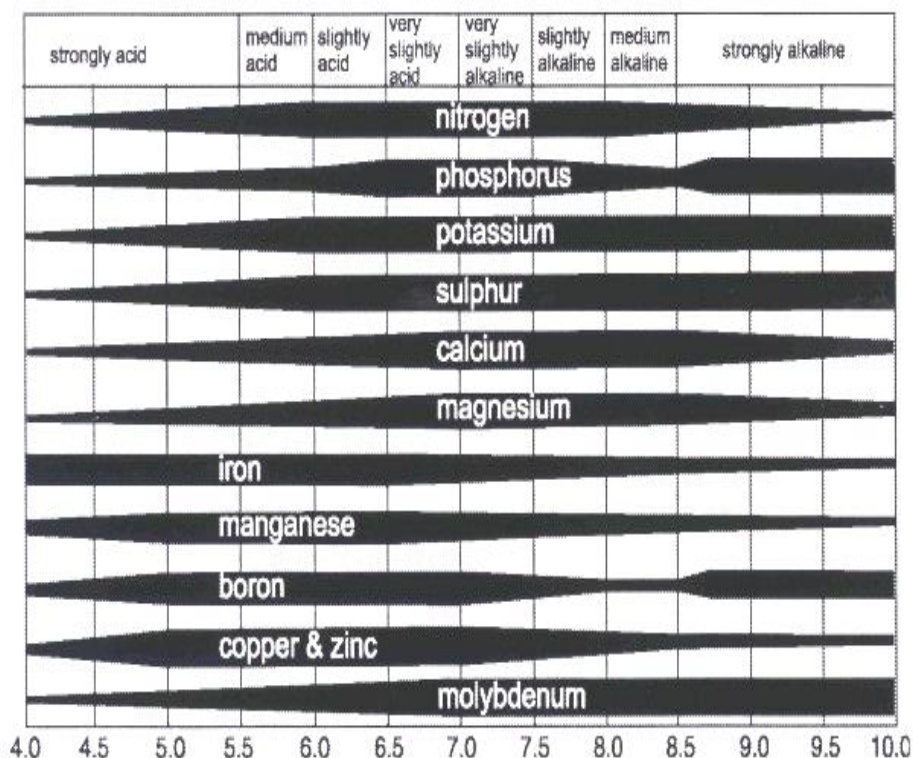


Table 3. The pH scale. A value of 6.5-7.0 is considered neutral. Values higher than 7.0 are increasingly alkaline or basic. Values lower than 6.0 are increasingly acidic. The illustration above also describes the pH of some common substances. (Source: PhysicalGeography.net (5))



Soil fertility is directly influenced by pH through the solubility of many nutrients. At a pH lower than 5.5, many nutrients become very soluble and are readily leached from the soil profile. At high pH, nutrients become insoluble and plants cannot readily extract them. Maximum soil fertility occurs in the range 6.0 to 7.0.

Table 4. Influence of pH on nutrient availability. Table adapted from R.E.Lucas and J.F.Davis (Soil Science 92:177-182,1961)

Nutrients and their specific role in plant growth.

Table 5. Plants contain practically all (92, periodic table) natural elements but need only a few for good growth.

| Nutrient | Role in plant growth | Characteristics in soil | Deficiency | Excess |
|-----------------|--|---|--|--|
| (N) Nitrogen | Stimulates growth (cell elongation) | Easily leached, uptake blocked by too much K | yellow leaves, stunted growth. | dark green leaves, scorching |
| (P) Phosphorus | Induces new cell formation, flowers and seeds | Leached by low pH, Blocked by high pH Too much P blocks trace elements. Deficiencies more pronounced in sandy soils with low organic matter content | Reddish leaves, less branching and rooting Reduced growth. Production of dark green foliage. Reddening or yellowing of leaf margins and necrosis of older leaves | Causes lack of Cu and Fe, resulting in chlorosis |
| (K) Potassium | Improves cell structure, drought tolerance | Uptake blocked by too much N | Curling leaf margins, leaf dying | Lack of N, Ca, Mg, resulting in yellow leaves |
| (Ca) Calcium | Needed for transport of other nutrients. Cell division and elongation. Proper working and permeability of cell membranes | Less mobile at low temperatures | Blossom end rot of fruits, | Lack of Boron and Mg |
| (Mg) Magnesium | Needed for proper photosynthesis and P transport | Low pH decreases availability | Discolored spots on leaves, interveinal chlorosis | Lack of Ca and K |
| (Fe) Iron | Needed for proper photosynthesis Necessary for the formation of proteins | High P inhibits uptake of Fe, becomes immobile at low temperatures and wet soils | Interveinal chlorosis and necrosis. | Lack of Mn |
| (Mn) Manganese | Green parts of leaf, chloroplasts | Low pH causes deficiency. Becomes more mobile at low temperatures and wet soils | Veins form Christmas tree model | Lack of Fe and Mo |
| (Zn) Zinc | DNA | Becomes less soluble at lower temperatures | Stunted leaf growth | Lack of Mn and Fe, looks like nitrogen deficiency |
| (Cu) Copper | Lignin formation (cell walls) and seed | Uptake of Cu can be blocked due to soil characteristics | Critical in conifers (yellow tips) | Lack of Mn, Fe, Mo |
| (Mo) Molybdenum | Needed for proper enzymatic functions | | Yellow spot on citrus, clamp hart of Cauliflower | Lack of Cu |
| (B) Boron | Sugar transport, cell division, Meristem growth... Pollen germination | Very little difference between deficiency and excess | Necrosis and stunting, heart-rot. Leaf distortion and leaf texture changes. Death of growing points. Cracking and rotting. Poor fertilization and fruit set | Boron toxicity, Increased by high pH soils. Sandy soils. High levels of nitrogen or calcium. Cold wet weather and periods of drought |

Adapted from nutrient deficiencies in crop plants. W.F.Bennet 1998

ON TERMINAL BUDS : - Ca & B
 ON YOUNG LEAVES : - Cu, S, Fe & Mn
 ON OLD LEAVES : - N, P, K, Mg, Zn & Mo

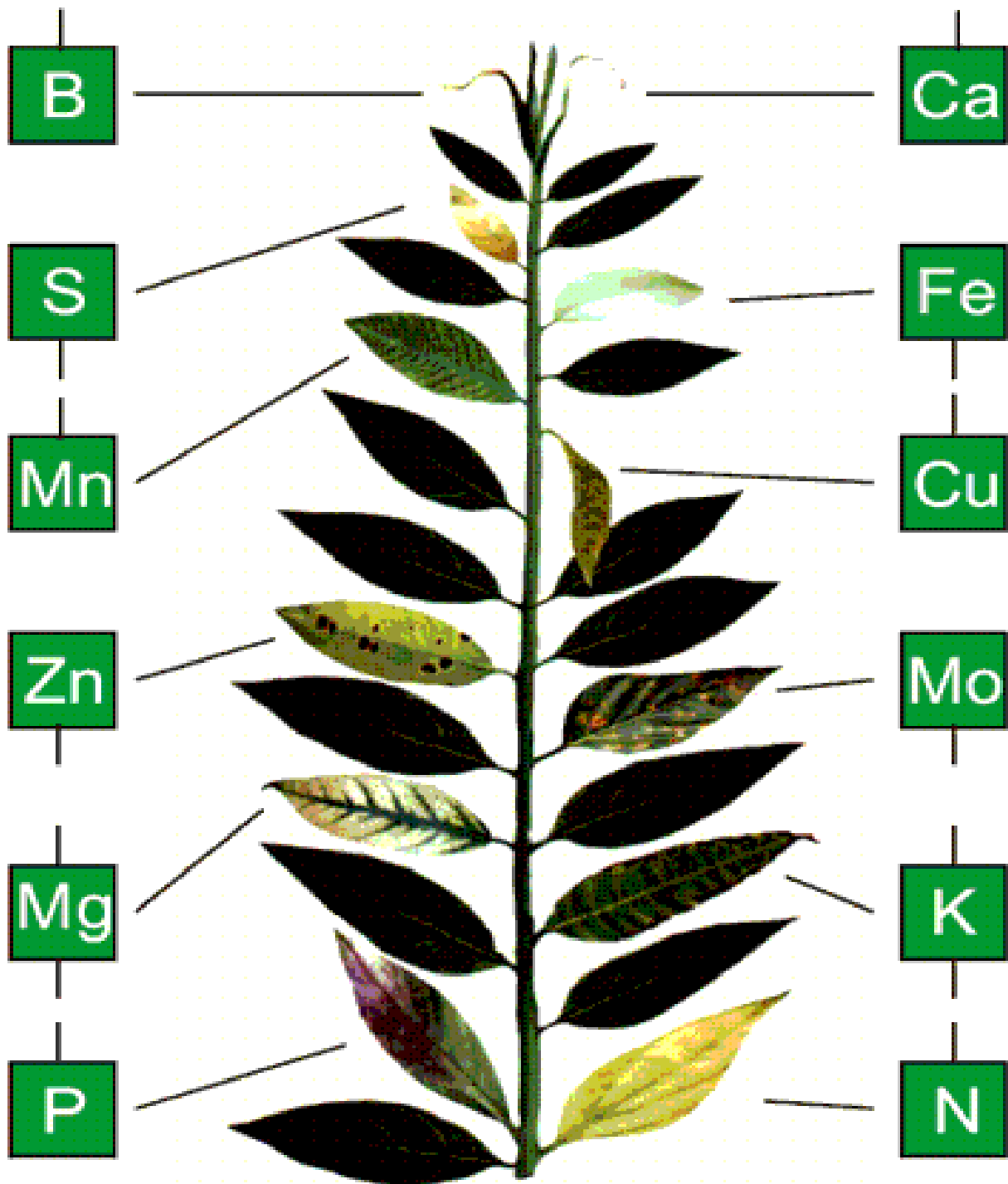


Chart from Micelf USA Inc.

Location of nutrient related deficiencies in the plant.

(N) Nitrogen, (P) Phosphorus and (K) Potassium are the most important nutritional (macro)elements for plant growth.

N. Nitrogen can be applied both as an organic or inorganic fertilizer.

Organic fertilizers come as compost, manure or green manure and as seedcake from oil crops like *Jatropha* and Neem. It can be applied as a planting hole filler (see planting *Jatropha*, page 24) or as a mulch in existing plantation.

Nitrogen as an inorganic fertilizer comes in various forms. Urea usually is the most effective and cheapest N fertilizer. However, under certain conditions (water and high temperature) some of the nutrients might evaporate. Ammonium nitrate and ammonium sulphate are also popular fertilizers. Their secondary benefit is that they will acidify (lower the pH) gradually.

Most of the composed fertilizers (N+P+K) also contain Nitrogen. Usually these fertilizers are more expensive and less specific.

| Sample nr. | Laboratory | Date | Org. matter | Total N | Phosphate | Potassium |
|------------|------------------|--------------|-------------|---------|-----------|-----------|
| 232548 | Sucofindo (Indo) | 01 May 2007 | | 3.7 | 1.1 | 1.6 |
| | | 01 June 2007 | | | | |
| 501065 | BLGG (NL) | 01 June 2007 | 85.6 | 4.1 | 1.9 | 1.9 |
| 501066 | BLGG (NL) | 01 June 2007 | 81.3 | 4.2 | 0.2 | 2.3 |
| Internet | SRCVO Mali | 01 June 1990 | | 4.1 | 0.5 | 1.2 |
| 19201 | South Africa | 01 June 2007 | | 3.5 | 0.3 | 1.2 |
| | Henning | 01 June 1990 | | 5.7 | 2.6 | 0.9 |
| average | seedcake | | 83.4 | 4.2 | 1.1 | 1.5 |
| | Cattle dung | | 25.5 | 1.2 | 0.2 | 1.1 |
| | EFB Palm | | 43.11 | 0.8 | 0.2 | 2.6 |
| | Chicken | | 35 | 3.0 | 2.7 | 1.5 |

Table 7. Various organic fertilizers compared with *Jatropha* seedcake from several sources

P. The negative effects of a lack of Phosphorus in the soil is highly underestimated. The element P is very important for the development of young plants, roots, flowers and seeds and therefore at most important when *Jatropha* is being planted.

There is very efficient P inorganic fertilizer available, like superphosphate and triplesuperphosphate. However, some tropical countries have abundant reserves of rock phosphate, which is an excellent long lasting fertilizer.

The availability of sufficient nutrients and P in particular is very important for the development of a new plantation. *Jatropha* plants need to have many branches in order to have many flowers. Branching after pruning or even natural branching is stimulated by the availability of sufficient nutrients. Foliar application of P will also stimulate flowering.



Pictures showing the influence of nutrients availability on natural ramification (Cambodia) in the same location with different soil conditions. Left: lack of nutrients, Right: sufficient nutrients

K. Potassium plays a key role in water relationships in plants. Potassium affects water transport in the plant, maintains cell pressure and regulates the opening and closing of stomata and is responsible for cooling and absorption of carbon dioxide for photosynthesis. It also acts as a catalyst, regulating enzymatic processes in the plant that are necessary for plant growth. Potassium is important for a plant's ability to withstand extreme cold and hot temperatures, drought and pests. It makes a plant tough!

The other nutritional elements are needed in very small amounts. (micro nutrients or trace elements)

However, specific deficiencies of these elements can become growth limiting factors



Table 8.
Buckwheat plants growing on water.

- I. All nutrients except potash (K)
- II. All nutrients available
- III. All nutrients except iron (Fe)

Soils and water

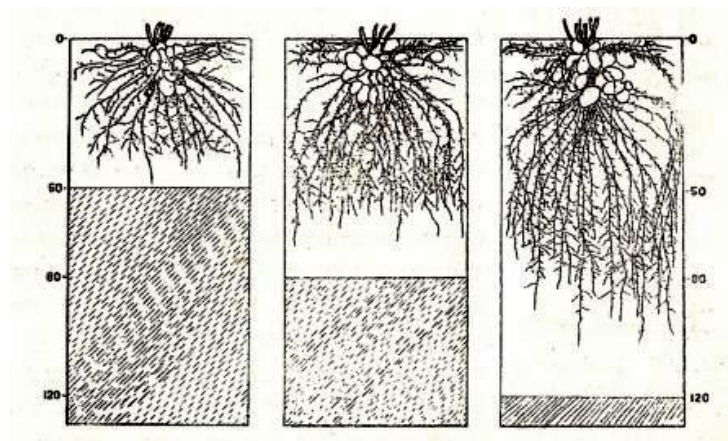
Without water plants do not grow. With too much water they do not grow either, except for e.g. aquatic plants.

Water is the carrier for nutrients, sugars and any other element that have to be transported from roots to leaves or v.v. Besides that, water is also one of the building elements, responsible for growth. Plant cells contain a lot of water.

In the soil, water is responsible for transport of nutrients and air to and from the plants root system. Without water the plant suffers lack of everything it needs. With too much water the plant suffers lack of oxygen.

In spite of its reputation, *Jatropha* loves water, with one exception; *Jatropha* does not survive flooding. Flooding means lack of oxygen and *Jatropha* will show the effects of flooding within a couple of days. (Yellow leaves, no growth, start of root decay.)

Soils with high water tables are not necessarily unsuitable for *Jatropha*. It depends on the height (min. 80-100 cm) and the stability of the water table. Continuous variation in water table height is a disaster for every plant and in *Jatropha* it causes the same problems as flooding.



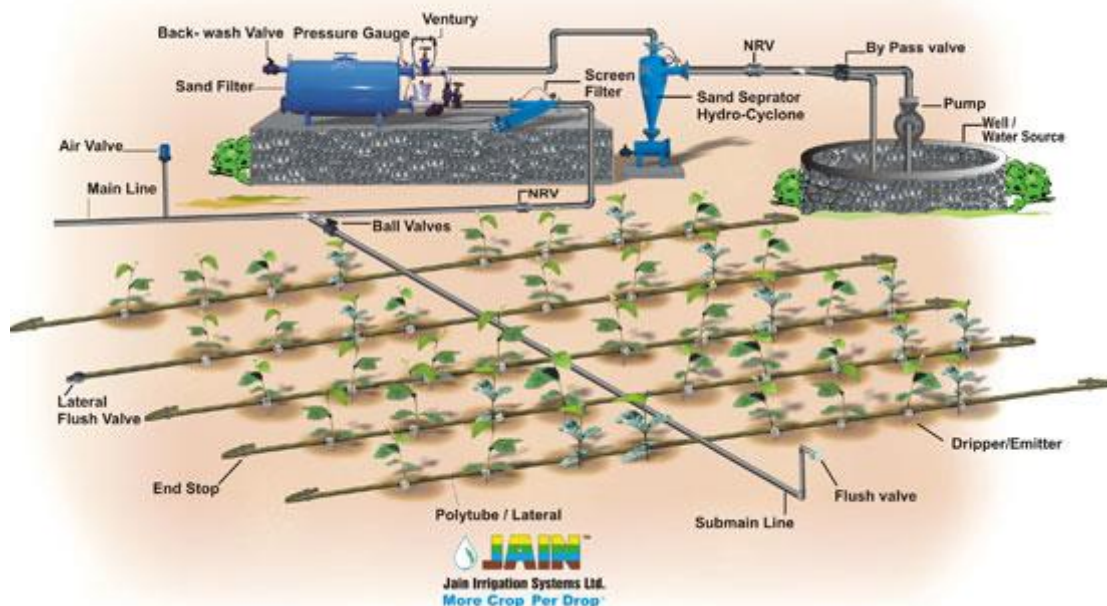
Root system of potato at different water tables.
(drawing TNO Groningen)

Heavy soils have a tendency to stay wet for a long time after flooding. Growing *Jatropha* in these soils is however not a problem, as long as they are planted on ridges or on a slope. Since heavy soils are usually fertile soils, *Jatropha* will grow and produce very well on these soils. Light soils usually are poor soils, due to heavy leaching. (Nutrients drained away by water). For the same reasons these soils have a tendency to become very dry. Growing *Jatropha* on these soils means that one has to except the influence of a dry climate or to organize irrigation. Irrigation on dry soils is the ideal way to control growth of a *Jatropha* stand, but it all comes at a cost. (According to the irrigation Cie. Netafim drip irrigation will roughly cost minimum \$500/ha)

Comparing water use efficiency between surface, sprinkler and drip systems in the Middle East

| Irrigation System | Wetting area | Amount water used | Water Losses (evaporation and conveyance) | Water saving relative to surface |
|-------------------|--------------|--------------------|---|----------------------------------|
| | % | m ³ /ha | % | |
| Surface | 100 | 500 | 40-45 | - |
| Sprinkler | 100 | 320 | 15-20 | 30% |
| Drip | < 50 | 122 | Very low (1-2%) | 75% |

Source: Khalifeh, 2002.



Typical drip irrigation system as designed by Jain

Practical solutions for yield improvement.

Soil fertility.

Definition: Soil fertility is a combination of the following elements:
soil depth, soil structure, soil pH, nutrient content, nutrient storage capacity,
organic matter content, soil organisms.

The most practical way to improve yield is to improve the (yield-limiting) minimum factors.

Correcting pH

Knowing the pH of your soil makes it easier to understand growing problems in the field. Adjusting pH large scale by surface applications of lime (pH goes up) or sulphur and organic material (pH goes down) can be very expensive. It also has to be repeated after a couple of years. Fortunately *Jatropha curcas* is rather tolerant regarding pH. The pH however can be influenced in the case fertilization is being applied. (see correcting nutrient levels). In heavy soils a low pH can also be increased by frequent harrowing.

***Jatropha curcas* L. and pH.**

Most of the literature regarding agronomy practices for *Jatropha curcas* states that the plant grows best on soils with a pH between 6 and 8.5 (N.Foidl). This again is nothing special, since at least 50% of all the plants all over the world prefer a similar pH. There is hardly scientific evidence and no experience that *Jatropha* does not grow or not produce on soils with a pH lower than 6. On top of that, pH is not a constant.

So pH is not really a concern, but one should be aware of the pH when planting *Jatropha* and designing a maintenance and fertilizer program, because maintenance and fertilization can both increase or decrease pH.

Correcting nutrient levels

Adjusting nutrient levels large scale can become quite expensive. Therefore one should take soils samples and leaf samples on a regular base, to find out the real growth limiting factor.

| Country | Remarks | pH | remark | N= kg N/ha | remark | P=P-Al, mg P2O5/100gr | remark | K= mg K/kg | remark |
|-----------|--|-----|----------|------------|------------|-----------------------|----------|------------|--------|
| Thailand | unused land | 4.4 | very low | 30 | low | <3 | very low | 32 | low |
| Indonesia | agriculture land | 5.7 | low | 115 | good | 14 | very low | 122 | good |
| Indonesia | neglected construction site | 4 | very low | 45 | low | <3 | very low | 27 | low |
| Tanzania | cleared bush, suitable for agriculture | 7.6 | high | 251 | high | <3 | very low | 139 | good |
| Cambodia | neglected agriculture land | 3.8 | very low | 18 | very low | 6 | very low | 20 | low |
| Thailand | former agriculture area | 4.4 | very low | 24 | low | <3 | very low | 58 | low |
| Cambodia | cleared bush | 6.8 | good | 91 | rather low | <3 | very low | 154 | good |

Table 6. Soil samples showing some of the most important nutritional characteristics of soils, namely: pH and the nutrients N,P,K. In this particular case they have one characteristic in common: There is a structural lack of Phosphorus. The role of Phosphorus in perennial crops is highly underestimated. In the ornamental horticulture it is very well known that a sufficient supply of Phosphorus guarantees a better root system, more branching and more flowering. In annual oil seeds like sunflower, sufficient P increases both yield and oil content.

Apart from fertilization to stimulate growth, nutrients taken by yielding the seeds have to be replenished as well. To ensure continuous productivity of *Jatropha*, the amount of nutrients absorbed by the seed production has to be substituted on a regular base, otherwise long term production will decline.

Nutrient removal of 1Mt. of *Jatropha* seed in kg. (Fact April 2010(12)

| N | P | K |
|--------------|-----------------|------------------|
| 15-35 | 0.7-7.0. | 14.3-31.6 |

Different ways of fertilization.

Fertilization at planting or replenishing lost nutrients can be done via different means;

- Use of organic fertilizers or seedcake from *Jatropha*, Neem, etc. Apart from the nutrient content in the various organic fertilizers, also the organic matter content in these fertilizers is an important contribution to soil fertility. The latest is especially the case with *Jatropha* seed cake. (see page 12)
- Mineral fertilizers like Rock Phosphate and Potassium are releasing their nutrients over a longer period, avoiding leaching by heavy rain.
- Crops like Beans and other leguminous plants are important soil improvers. Beans are binding Nitrogen from the air, enriching the soil with N after the crop is finished. Groundnuts are known to be very high in Phosphorus, so the remains of the harvest should stay on the land, improving the soil with P. (see intercropping)
- Chemical fertilizers (especially N) do have high concentrations of nutrients. However, the production of these fertilizers goes at the cost of high CO₂ production, so if carbon credits are important for your project, chemical N fertilization is a non starter.
- With the help of Mycorrhiza, a special type of fungus, *Jatropha* plants have a better chance to profit from limited nutrients, especially Phosphorus. Mycorrhiza is specific for both soil and plant type and it needs solid research to find out if a Mycorrhiza treatment can and will be effective or not.
- Foliar feeding. By means of spraying, plants can be fertilized via the leaves, using only minimal quantities of fertilizer. This is a very effective method to bring plants from a generative stage into a vegetative stage or vice versa.

Module 2 - Propagation

Selecting planting material

For any type of crop or individual plant, the selection of propagation material is crucial to achieve the set objectives. In the case of *Jatropha* the main objective is to have healthy plants with a high production of seed containing a high percentage of oil, of which the quality has to meet certain characteristics.

Without going into plant breeding, propagation material can be improved a lot by simple observation and data collection from plants grown out of local seeds.

As already mentioned in the preface, there is a lot of variability between individual *Jatropha curcas* plants. There is variability in yield but also in shape or habitat and in vigour. These three characteristics are easy to evaluate in existing *Jatropha* stands and therefore the first criteria to select on.

High yielding plants usually have many branches and fruit bunches with more than 10 fruits per bunch. These plants are suitable for selecting your seed stock from. In practice this seed should be used to set up a seed orchard. Even in the seed orchard a lot of variation will be noticed, but by gradually removing poor performing plants, the quality of the seed orchard will improve over the years.

The same counts for plants that show natural ramification characteristics. The more branches the plant makes under natural conditions, the less pruning is needed. (Note that there is a correlation between ramification and soil fertility, see page 12)

Vigorous plants are healthy and usually do have less problems with diseases.

Caution: Vigorous plants are not always high yielders!

One more step into plant selection is setting up selection trials with *Jatropha* seeds coming from different sources. The philosophy behind these trials is that local *Jatropha* plants not automatically are the best plants to start with. They probably are the best survivors for a particular area due to natural selection, but that does not mean that they are the high yielding ones you are looking for.

Selection trials are not difficult and do not require a lot of area. They only require time for proper care and data collection.

An example of how to set up a proper selection trial is given in Annex 2



Selection field in Thailand

The nursery.

It is the type of project that dictates the type of nursery needed.

Big plantations usually have a central nursery, mainly for research, and local nurseries as close as possible to the plantation site, in order to avoid long distance transport of plants.

Projects serving small farmers usually only have a central nursery serving both production and research purposes. An example of this type of nursery is added in annex 2

A nursery should at least be equipped as follows:

1. Access to good water. (pipe, pump or river)
2. Access to good soil, sand, manure etc. and a place to mix these
3. A covered area. Either for sun- or rain protection
4. A simple storage for material like poly bags, watering tools etc.
5. Should be located close to a road
6. Proper drainage

Apart from production and research, this type of nursery usually serves as a demonstration area as well. The size should be adapted to the number of plants being produced.

Remark: A full cycle of *Jatropha* seedlings takes about ten weeks, so depending on climate several cycles could be realized within one year.



Various *Jatropha* nurseries in Tanzania, Indonesia and India

Three key roles for a nursery are to be monitored

1. Input versus output of seedlings or cuttings (germination and survival rate)
2. Testing of soil mixtures for poly bags and control of water quality and quantity
3. Control of diseases

Generative propagation of *Jatropha curcas*

When *Jatropha* seeds are being collected and used for propagation purposes, seed quality and selection is crucial. (see previous chapter) *Jatropha* seed maintains a good germination rate during almost 6 months, provided that the seeds are stored properly, which means dry and at a temperature below 25°C.

Before storage, clean the seeds, select the best seeds only (the biggest ones) and disregard seeds with different size, different colour, damaged seeds etc.

Seed for propagation should never be dried in direct sunlight.

Freshly collected seed with a moisture content of 15-20 % gives good germination up to 80-95%. Dry seeds with 7-8% moisture content might give a germination rate of 70-75% even after 6 months, if properly stored. Seeds older than a year should not be used for propagation.

Direct seeding

Direct seeding in the field is the easiest and most cost effective method for setting up a *Jatropha* plantation. It also provides an excellent quality plant for the future, since the *Jatropha* seedling is developing a taproot and therefore can stand dry periods. On top of that direct seeding is a method commonly known by most farmers, since they plant their maize and other crops in the same way.

Drawbacks of direct seeding

More seed is needed, since 2 seeds are needed for each planting hole.

Rain is crucial during the first ten days of germination and should continue regularly for at least two months. Usually with direct seeding there is no planting hole preparation, which will result in poor seedling development, especially on poor soils.

Seeding in poly bags.

Direct seeding in poly bags filled with soil, sand and manure or compost (1:1:1) or other mixtures depending on local availability.

Sown bags are watered daily but once the germination is complete they should be watered as per need.

If field planting is delayed, the polythene bags should be shifted timely to check excessive root growth anchoring in the soil.

In practice, germination of seeds in poly bags can be rather poor due to poor drainage or insufficient irrigation. Seeding in poly bags requires a well aerated soil mixture with good drainage and a moderate nutrient level. Too much nutrients usually generates high salt contents in the bag.



2 bottom pictures D1, Malaysia

Seeding in beds and transplanting into poly-bags.

In the nursery, raised beds of 1 meter large are prepared and a space of 20 cm is left in between two beds for drainage and walking.

Generally sand, soil and compost mixtures are being used, but only river sand also gives good results. Seeds should be sown 2-3 cm deep in soil. The white dot on the seed could be placed downwards, but if fresh seeds are being used, this hardly influences germination. It influences the shape of the taproot though. Moderate and frequent irrigation should be given. Cover the bed during the first weeks to protect against excessive rain. Healthy seeds germinate within 2-10 days after sowing.

After about 20-30 days, the seedlings can be transplanted into poly-bags and hardened during a period of about one to two months, depending on climate. If transplanted bare rooted, seedlings should be kept in the seed bed for at least 6 weeks.

Raised beds usually give the highest germination rate of *Jatropha* seeds.



All pictures on this page taken in Indonesia

Vegetative propagation of *Jatropha curcas*

(producing cuttings is a fast way to multiply plants with the same characteristics(clones))

A.Propagation by hard cuttings in poly bags

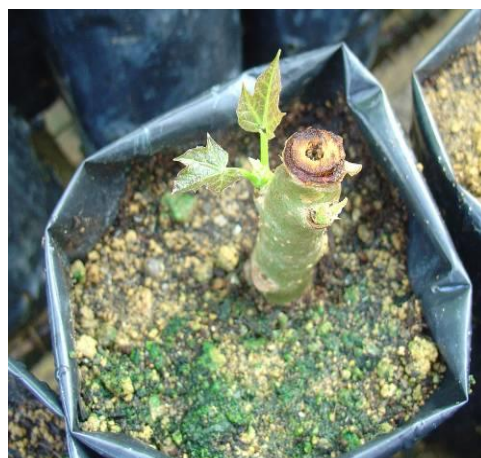
(hard cuttings are parts of fully grown *Jatropha* plants).

How to make as many hard cuttings as possible?

1. Use branches with a diameter of maximum 3-4 cm and a minimum length of 4-6 nodes. The colour of the wood should be greyish. This is usually found in the middle of a *Jatropha* plant. Green wood is too young and can easily be attacked by fungi.
2. Use sharp knives or scissors in order to make a clean cut. Do not use a machete because it will damage the cuttings. Cut the stems slightly slanted.



3. After cutting, wash the cuttings in water with 1-2grams/litre carbendazim or equal to protect the cuttings from an early attack of fungi. (This is much easier and more realistic than disinfecting your knife or scissor after every cut with ethanol as sometimes recommended)
4. Let the cuttings dry in a shady place for some hours.
5. Before sticking the cutting in the pre-filled poly bag, poke a small hole with a stick in the soil mixture.
6. *Special attention has to be paid to the soil mixture. Soil in the bags should be light and good draining. Too many nutrients is not necessary and in fact will negatively influence rooting. Different local mixtures can be used to fill the bags. Coco peat turns out to be an excellent rooting medium, but might be too expensive. Mixtures of soil and sand and compost (1-1-1) are doing quit well. Make sure water and soil do not content too much salts. Farm yard manure can be very salty. Does a small trial with different mixes from local available material before you start a big nursery. The trial takes you only 4 weeks. Materials that can be used: sand, soil, compost, rice husk, peat, coco-peat, charcoal, saw dust.*
7. After placing the cuttings, water the poly bags slightly.
8. Fresh hard cuttings do not need direct sunlight the first days (there are no leaves), so place them in a shaded area for the next 10 days and maintain a high enough humidity*, not by watering but covering them with white plastic or placing them in a greenhouse or plastic tunnel.



B.Planting cuttings directly in the field has the same drawbacks as from direct seeding. If cuttings are directly being planted in the field, they should have a length of 20-40 cm.

*Humidity is a trade off, the higher the humidity, the faster the rooting but also the development of unfavourable fungi. Once planted in a poly- bag or plastic pot, the cuttings are treated like seedlings and will be ready for transplanting after 8-10 weeks.

▪

Propagation by soft cuttings.

Producing soft cuttings is a fast way to multiply plants with known characteristics.

Soft cutting method from IPB-Indonesia

Principles:

1. Mother-plants of *Jatropha curcas* are being planted in uncovered beds with a base of organic fertilizer like goat or chicken manure. Plants will be fertilized and irrigated if needed. Usually NPK 15-15-15 will be used; eventually foliar feed will be used as well.
2. Soft cuttings are placed in small tunnels under shade.



Pictures from the IPB nursery in Pomat (Bogor)

Preparations for planting the mother-plants.

Beds for the mother-plants are in the open air should be raised and loosened at least 40 cm. Organic manure should be mixed with the soil.

The mother-plants should be from selected high yielding species and planted at a spacing of 50 per m².

Preparations for taking the cuttings.

The cutting beds are placed under shade- net with about 50 % shade. Beds are raised and should have parabolic shape in order to avoid accumulation of excessive moisture in the centre. The top of the bed is covered with at least 10 cm saw dust, preferably from soft wood. The saw dust has to be moistened but not wet.

In stead of saw dust, good quality coco peat could be used as well, probably with better results. Coco peat should be tested on salt content.

The beds are being covered with plastic but it should be easy to open them for hardening the cuttings.

Taking the cuttings.

Top shoots from the mother-plants with a length of about 6 cm or 3 leaves should be cut with a sharp knife or razor blade.

Cuttings are being washed in water (either or not with a carbendazim) in order to get rid of the latex.

After washing, cuttings are put in the cutting bed **without rooting hormone**. Beds are closed but have to be opened every day to check moisture content and to clean the cuttings from dropping leaves. After 8 days the cuttings should start to grow and have to be sprayed with water soluble fertilizer from time to time to speed up growth. After 4-6 weeks the cuttings should be ready to be transplanted.



Tissue culture

Tissue culture is a proven method to propagate vast numbers of plants with given characteristics. Although this technique is being tested in *Jatropha curcas* in various countries, so far no proven results have been commercialized.

It will become an important method once new varieties of *Jatropha* have been developed through a lengthy breeding process.

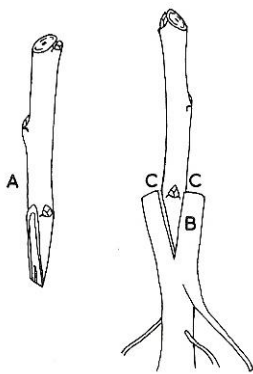
So far no commercial quantities of *Jatropha* have been produced via this method (picture D1)



Grafting

Grafting is the technique of growing a part of a plant (cutting, graft) on the root system of another plant. This is usually done because the graft's own root system has unfavourable characteristics. (diseases, wild growth, etc) *Jatropha curcas* has been used as a root system for *Jatropha integerrima* for its vigorous growth. (Indonesia)

In Tamilnadu (India) grafting is being done to vegetatively multiply hybrids from *Jatropha* on the Faculty of agriculture from The Tamil Nadu University. (see picture below left)



From : The propagation of tropical fruit trees
Page 135 (19)



Module 3. Field

As already mentioned in the chapter about propagation, there are different types of *Jatropha* planting.

1. Planting trough direct seeding
2. Planting trough direct planting of hard cuttings
3. Planting of bare rooted seedlings
4. Planting of seedlings in poly bags
5. Planting of cuttings in poly bags

Apart from the amount of time involved in the different planting systems, there is a big difference in the way the plants get established and make a root system.

Direct seeding produces a plant with a tap root. Theoretically this type of plant will survive better than cuttings in drought conditions. However, there is not much data supporting this claim. On top of that, **there is no data regarding *Jatropha* yield in relation to root system.**

Plants out of poly bags (either cuttings or transplants) make more lateral roots and are supposedly more vulnerable to drought. Again there is no data supporting this and claims are probably based on experiences in other crops.

An important noticeable difference between cuttings and seedlings however is that cuttings are yielding earlier than seedlings, due to the fact that cuttings usually come from adult plants, (with the exception of soft cuttings). However, this difference is only noticeable the first year after planting, until the seedlings had the time to develop a comparable volume.



No taproot from cuttings.



Taproot from seedlings

Pictures by Naresh Kaushik, regional research station Bawal, India

Land preparation

There are distinct differences between land preparation for monoculture *Jatropha* plantations, *Jatropha* alley cropping and *Jatropha* hedges.

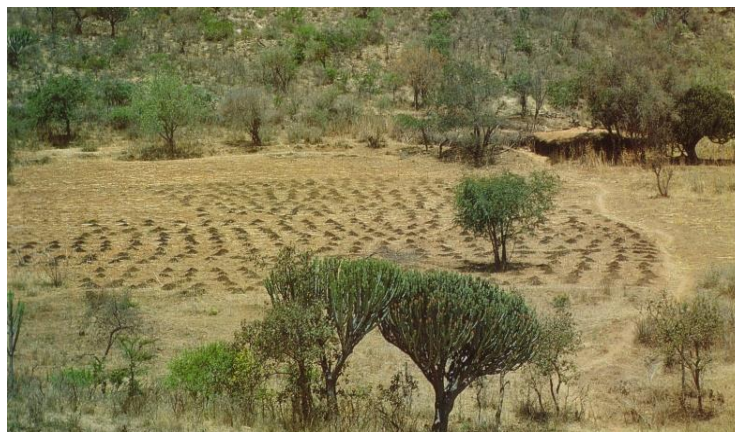
Land preparation for *Jatropha* monoculture.

Since monoculture *Jatropha* plantations usually cover large area's, most of the preparation is done mechanically. In the case mechanical harvesting is foreseen, slopes more than 10-15% should be avoided and distance between rows should not limit harvesters. To level the land, topsoil has to be put aside before levelling and returned after levelling. Planting holes can be drilled with an auger; however in heavy soils this can only be done during the dry season, in order to avoid a "bucket" effect in the planting hole. (Roots will not be able to penetrate the walls of the planting hole) In stead of making holes, the whole planting line can be ripped mechanically, loosening the soil to facilitate planting. If done timely before the rain starts, this is an excellent way of creating a water sink in the soil.

Planting holes should have a volume of about 10-15 litres and filled with a good soil, mixed with at least 1 kg organic manure. Make sure the manure is well weathered and not too salty, which sometimes is the case with cow manure. After planting plants should be watered immediately, if no rain is expected.



Large scale *Jatropha* plantation from Bioshape in Tanzania. (+/- 8 months)



Land preparation with organic fertilizers in Mbulu, Tanzania

Land preparation for proposed alley cropping.

The land should be emptied from previous crops and crop rests in order to execute proper land preparations. Rows of *Jatropha* should be planted before any other crop. Planting holes should be filled with a mixture as mentioned before. Use a rope to plant *Jatropha* in straight lines, this facilitates maintenance and intercropping. In hilly area's the *Jatropha* should be planted along contours. (Please find a model in the chapter alley cropping.) To plant a reasonable amount of plants on a certain area, double rows of *Jatropha* could be planted

Land preparation for planting hedges.



A 10 years old *Jatropha* hedge in Leguruki, Tanzania

Jatropha and hedges.

Boundaries are everywhere. Housing plots, streets, canals, maize fields, soccer fields; they all have boundaries, requiring maintenance. So most of the time these boundaries become a mixture of poles and trees and wire and weeds or in other words, they become a mess and a burden. Why not planting all these boundaries with *Jatropha*, becoming a blessing in stead of a curse.

Hedges can produce a lot of seed. It is estimated from a project in Mali (by Henning) that a hedge could produce 0.8kg per meter/per year. So if an average farmer has a plot of 0.5 ha (100x50 m), he can plant 300 meter (depending on the shape of his plot) of *Jatropha* hedge which will bring him 240 kg of seeds. And so will his neighbour, and his neighbour etc. etc. A km of *Jatropha* hedge can produce 800 kg of seeds.

To plant a proper *Jatropha* hedge, (either from seeds or from cuttings) a ditch of 30 cm wide and 30 cm deep should be created along the boundaries. The soil should be mixed with organic material and than the ditch should be refilled. After this seeds or cuttings or plants from poly bags can be planted when the rains start or when irrigation water is available

Maintenance .Although *Jatropha* is a tough plant, during the first months of establishment weed control is essential. This can be done mechanically, by hand or by using herbicides. *Jatropha* is pretty tolerant when it comes to herbicides.



Pruning

The five main factors to make a Jatropha bush productive are: selection, pruning, light, water and nutrition.

Jatropha flowers appear at the end of a branch. Ergo: A Jatropha bush should have as many branches as possible to get many flowers. Simple but **not** true! Apart from many branches, a Jatropha bush also needs light. With too many branches many of them will not receive enough light and the branches will stay "blind", in other words they do not produce flowers.

Pruning should take place as follows: Start just before the rainy season

1e pruning-plant is knee height. This is usually 3-9 months after planting (depending on climate)

2e pruning-plant is waist height

3e pruning-shoulder height. This is the moment to select the right branches that should form the frame work and disposing of any useless branches.



1e pruning, 2e pruning, 3e pruning, (pictures D1)



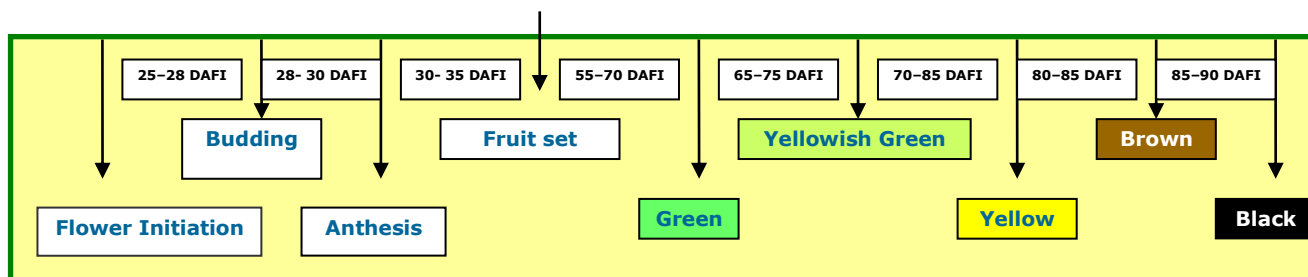
Days after pruning: 9-15-80-145 (Pictures from Jose Ines Bazan-Mota, Tecoman, Mexico)

Jatropha and pruning.

Jatropha flowers at the top of the branch. So the more branches you have, the more flowers you have? Not true. Jatropha needs full sunlight to flower and with too many branches the Jatropha plant becomes too dense and a lot of branches will not flower at all. Pruning therefore is a continuous process of thinning and choosing the right branches. Cutting back a Jatropha tree completely will cost at least the total yield of one season and it will take years to build up a good yielding plant again.

Flowering, fruiting and picking

The flowering of *Jatropha* is strongly depending on rain and/or irrigation. Usually flower initiation takes place shortly after the plant receives its first water.



It takes about 90 days for a *Jatropha* fruit to develop from the moment of flower initiation. Once the fruit has been set (around day 40), the seeds start to develop. From day 85 the fruits are ripe and the seeds contain maximum oil %.

Picking the seeds at the right time gives the maximum oil yield. From various studies it is advised to pick fruits when they are yellow. The oil content might be optimal at this stage, but there still is a substantial amount of moisture in the fruit. (45 %) During the brown stage the fruit is drying rapidly (35%), which means saving a lot of weight when picking. On top of that, the brown and black fruits are easier to dehull than the yellow ones.



In future mechanical harvesting is going to take place on plantations or other large scale operations. However, like in other crops (coffee), mechanical harvesting will always be a trade of between yield and quality. Use of plant growth regulators or defoliation might be a way to force *Jatropha* into equal fruit ripening.

Picture: over the top harvester

Information about harvesters can be found on the following web sites

<http://www.rakennustempo.fi/eng/?ID=1479>

<http://www.oxbocorp.com/news.php>

<http://www.youtube.com/watch?v=68wcBFI7Bv4>

http://www.beiinternational.com/Jatropha_XZIT.html

http://www.gregoire.fr/index_uk.html



Alley cropping (Combination of a permanent crop with one or more intercrops)

Jatropha and alley cropping (intercropping)

Most growing models with Jatropha do promote temporary intercropping with the idea that farmers have some income from the intercrop (food) during the time that the Jatropha is not yet yielding. This means however that once the Jatropha starts to yield there is no more income from the food crop, which simply means that the income per acreage is too low to be interesting for a farmer. Therefore the combination of crops should be developed as a permanent model, giving the farmer a reasonable income and food security and enabling the soil to get gradually improved through the interaction between the Jatropha alleys and the intercrop.

To be successful in intercropping Jatropha with other crops (or other crops with Jatropha), farmers should consider Jatropha as a normal agricultural crop. Forget about the story that Jatropha does not require much water and grows on any soil. The production of Jatropha should be embedded in other crops as within a normal mixed farming system, with all its needs and attention. Even more, growing Jatropha should go hand in hand with improved agricultural practice for food crops, like using better seeds, planting in time and in rows, weeding, using fertilizer or organic manure, etc. etc. In this way, the production of Jatropha will enhance food production as well.

Planting more than one crop in the same field has many advantages.

1. Small farmers are used to intercrop, looking for different food plants to spread the risk of a crop failure and anticipating on erratic rainfall.
2. If more than one crop is cultivated and harvested with different growing cycles, farmers can use their time more economically.
3. With a better coverage of the area, weeds are suppressed.
4. Pest and disease incidence is lower with intercropping.
5. Crops can benefit from each other
6. Control of erosion
7. better use of nutrients

Example

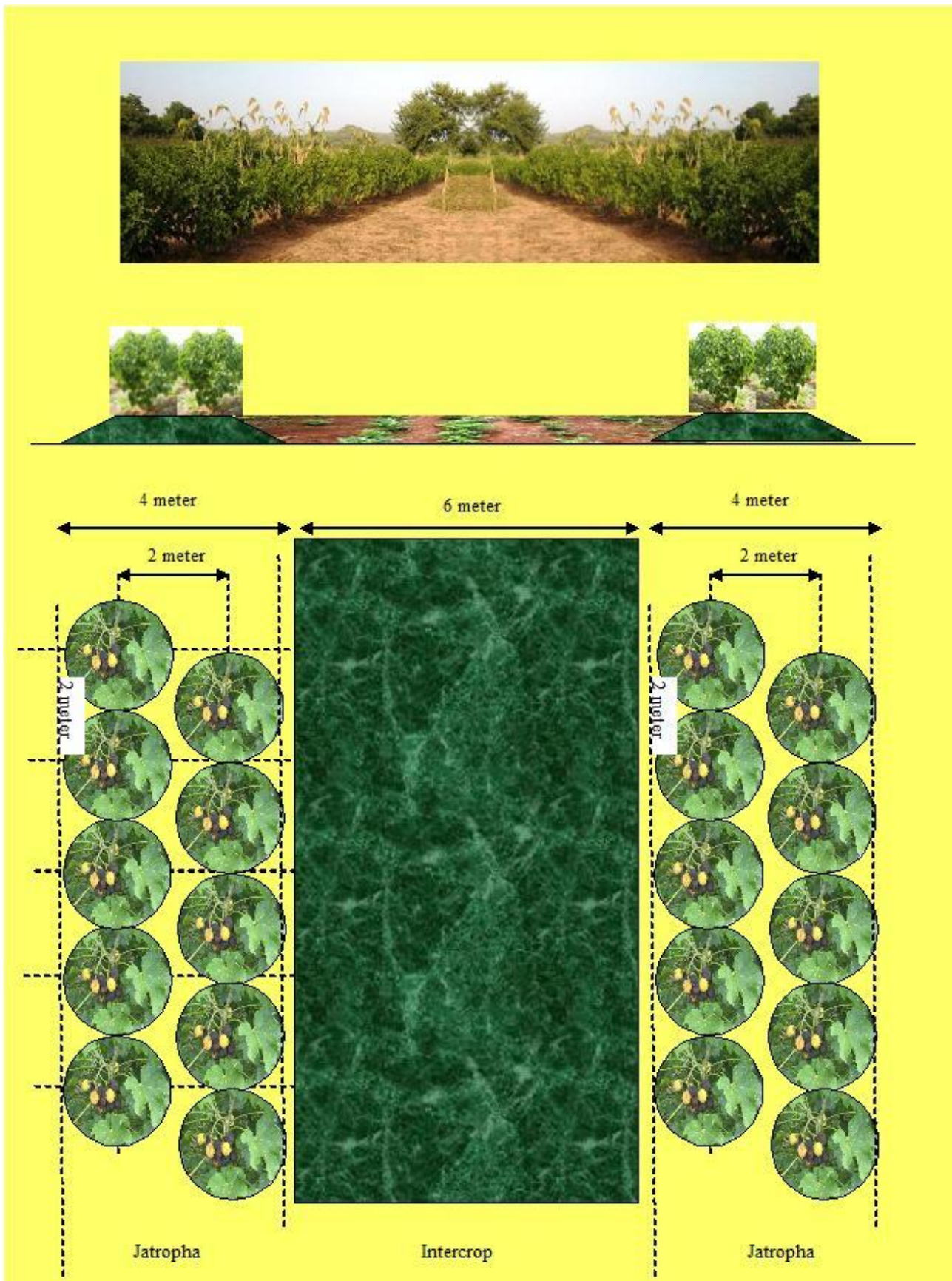
A double row of Jatropha is planted 2x2 (=4 meter) Between the double rows 6 meter is kept for other crops and/or machinery or animal ploughing is. This gives us 1000 Jatropha plants per ha and still 6000m² for another crop to grow in between the Jatropha. (See drawing.)

The space in between the double Jatropha rows could be a variable. Actually, it is depending on the type of intercrop and/or the equipment which is going to be used.

The effect of Jatropha on poor soils

Initially poor soils will result in poor harvests. You get nothing for nothing. However, in due time a couple of systems are going to work. Jatropha will gradually develop into a large shrub, providing shade and/or shelter to other crops (depending on planting distance). Furthermore the roots of Jatropha grow pretty deep and will touch layers where the normal annual crops or weeds do not reach. The nutrients picked up from these layers are reaching the surface via the Jatropha plants. Through pruning and shedding of the leaves, the nutrients will return to the surface, enriching the upper layer where other crops are intended to grow. As the seeds from Jatropha are pressed, the remaining seed cake should be returned to the surface as well, because it is rich in N, P and K, equal or even richer than chicken manure.

Alley cropping model



How can Jatropha benefit from intercropping.

Food in between Jatropha. Example: growing beans in between the Jatropha. With a distance of 6 meter between the Jatropha rows the beans have plenty space to grow, even in combination with maize. The beans or other crops will grow between the Jatropha, protected from strong winds and excessive radiation. After harvest the root systems will deteriorate, providing the soil with nitrogen. On top of that the flowering beans or other crops will attract insects, badly needed for the pollination of the Jatropha. Many crops could be intercropped with Jatropha in a way that the intercrop takes advantage of the Jatropha and vice versa. Farmers should concentrate on the local market. Whenever they can make a good price for melon, they should grow melon in between the Jatropha. The melon crop will make sure that the Jatropha plants get pollinated by insects. Same counts for ground nuts, cow peas, pigeon peas, sweet potatoes, peppers, corn, sunflower, maize etc.

Further on, growing an intercrop means maintenance and weeding, from which the Jatropha will benefit as well.



Alley cropping in Mali (2009)

Trees in between Jatropha. In principle you should not grow Jatropha in a forest, because the forest creates shade and Jatropha needs sun! However, Jatropha plants could take advantage of existing trees (Acacia) or introduced trees (Prosopis*) because those trees attract insects badly needed for pollination of Jatropha flowers. So why not interplanting Jatropha rows temporarily with this kind of pollinator trees. The moment they become too big you cut them or prune them and use them for charcoal production or even firewood. You create a sustainable source of firewood and charcoal.

Honey Bees and other insects. These trees also have the potential to become important for the production of honey, provided there is water available for the honey bees!!



Prosopis juliflora



Acacia sp.



Beehives in Same, Tanzania

Life stock in between Jatropha

It is known that cattle (goats, sheep, and cow) do not eat *Jatropha* leaves. This means that you can grow *Jatropha* in grazing area's. As with food intercropping, ample attention should be given to grow the right type of pasture.



Life stock grazing in Kenya (Picture Bedford) Cattle grazing in Brazil. (Picture Green Power))

Diseases

Jatropha toxicity and diseases.

Many internet sites will tell you that due to the toxic constituents of *Jatropha curcas*, the crop does not have many diseases. This is wishful thinking, not true and not backed by practical experience.

Indeed, as long as *Jatropha* is growing in the wild, single plants or small patches, you hardly see any fungus or insect attack.

How big is the difference when you start to plant *Jatropha* large scale on nurseries and as an intercrop.

Not much research has been done, but already there is a whole list of pest and diseases that are observed in actual *Jatropha* plantations.

The list in Annex 1 is not complete and still growing. On top of that, there are no recommended treatments for *Jatropha* since the crop only recently caught the attention of the pesticides manufacturers. So there are no labelled pesticides for *Jatropha* which means that you are using the pesticides at your own risk. In some countries this is an offence.

Module 4- *Jatropha* products

Jatropha PPO (pure plant oil) can be used for transport



This car drove Londen-Barcelona-Londen on Jatropha oil in 2007. Picture by Elsbett, a company that converts and adapts engines to PPO

PPO can be used in Multi Functional Platforms. In several African countries (Tanzania, Madagascar) but also in India, Jatropha oil is being used for the production of electricity via multi functional platforms. An MFP consists of a diesel engine running on Jatropha oil, powering a generator, a crusher to produce Jatropha oil via crushing of Jatropha seeds and a grinder to grind local products like maize. The MFP produces electricity to be sold via the establishment of a local grid. Depending on the power of the generator 1 MFP might produce electricity for as much as one hundred households. These engines are equipped with a dual tank system.



MFP in Leguruki, Tanzania

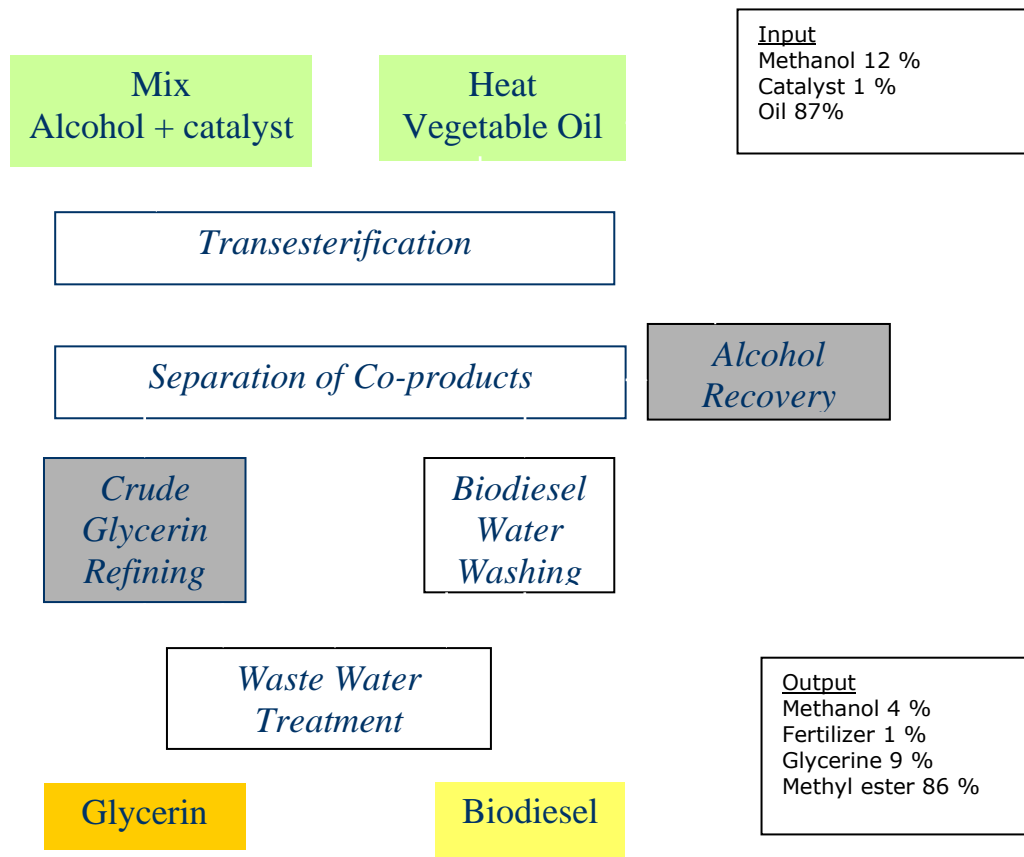


MFP from Malibiocarburant in Mali

Many attempts are being made to use Jatropha oil in lamps and stoves. Until now there are no stoves and lamps commercially available.

Production of Bio diesel via transesterification with methanol or ethanol

Production steps



Most of the biodiesel produced today is done with the base catalyzed reaction. This catalyst splits the oil into glycerine and biodiesel.

The catalyst is typically sodium hydroxide or potassium hydroxide, which is dissolved in methyl alcohol. The reaction mix of oil and catalyst is kept just above the boiling point of the alcohol to speed up the reaction. Recommended reaction time varies between 1 to 8 hours. Excess alcohol is normally used to ensure total conversion of the fat or oil to its esters. After separation of the glycerol and biodiesel phases, the excess alcohol is removed with a evaporation process or by distillation.

Jatropha Soap

Handbook on Jatropha Curcas





(Picture Mali Folk centre)

(Picture Lode Messemaker)

It is fairly easy to produce soap from vegetable oil. Technically spoken the triglycerides of the plant oil are converted to salts of metal ions (natrium, potassium) and fatty acids (stearate, palmitate). The components necessary for soap making, and their ratios, are:

**1 litre of plant oil,
0, 75 litre of water and
150 g of caustic soda
per litre of oil.**

Adding less water gives a harder soap, adding more water requires addition of flour or starch to get a consistence that is solid enough. As the ingredients are relatively cheap and the soap can generally be sold at a good price, soap making can be an attractive option. The outline of the recipe is as follows:

1. Prepare a solution of the caustic soda by dissolving the soda into the water (never mix these components the other way around – risk of burning!) Stir until everything has dissolved. The bowl will get hot, cool it using cold water at the outside, or just let it cool down for a while.
2. Pour the oil into a bowl and put it beside the bowl of caustic soda solution. Pour the caustic soda solution slowly into the oil, stirring all the time. Immediately the mixture will go white and soon it becomes creamy.
3. Continue stirring until the mixture is like mayonnaise. This is the moment to add additives like glycerine, perfume etc. If the mixture is still creamy, pour it into a mould, where it can harden overnight. The moulds can be made from a wooden tray or a cardboard box, lined with a plastic sheet. Alternatively, consider using convenient and attractive shapes like small plastic bowls or pipes
4. The mixture hardens overnight in tropical temperatures or in several days in temperate regions. Then it can be released from the mould and cut if necessary.
5. Even after this first hardening the soap continues to mature for some time. It should be stored for some two weeks on shelf before sale.

This soap is said to have medical characteristics. In Tanzania it is sold to the Masai tribe around Lake Manyara in Tanzania and is said to be very effective against skin fungi. However, due to its high price and poor marketing, it can not compete with industrial soaps.

Jatropha seedcake fertilizer is seedcake directly applied in the field or passed through a biogas installation.



For direct use in the field the seedcake should be fermented. This can be done via a decomposing process in combination with other plant rejects. It can also be put on top of the soil in direct sun and worked through several times. This process might take a couple of weeks but it is absolutely necessary in order to get rid of the oil in the seed cake.

Putting the seedcake in a bio digester to produce gas is another way of fermentation. The sludge from the bio digester again is an excellent seedcake which can be applied directly.

Jatropha fertilizer trial by Professor Thomson Sinkala



Jatropha organic fertilizer tests at Thomro Biofuels Farm, Zambia

It would be interesting to see if Jatropha seed cake fertilizer could act as a fertilizer and insecticide at the same time. It is known that extracts from Jatropha are toxic to certain snails (M.Rug 2000, Zy Wang-2009) and snails are a serious pest in rice fields all over the world.

Also insecticidal characteristics of Jatropha oil solutions have been reported (Adebawale, K.O. and others)

In Tanzania mixtures of Jatropha oil with old engine oil are being used as wood preservative. (verbal com)

In the Jatropha seedcake there still is a substantial amount of oil (5-8%, depending on expelling efficiency). Therefore it makes an excellent fuel, provided that it is pressed in pellets or briquettes.

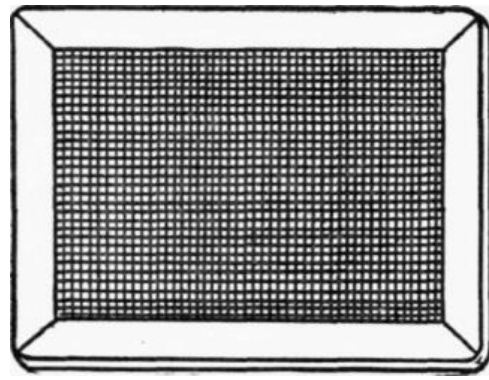
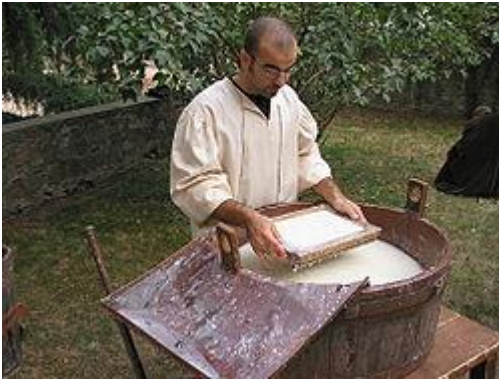
Briquettes can be made with a very simple extruder (see pictures from Diligent, Tanzania) and can be used as fuel in boilers and ovens with a chimney. It is not suitable for open cooking fires because it smokes a lot.



Briquettes and extruder at Diligent (Tanzania)

For use in open fire these briquettes should be turned into charcoal. Although a lot of experiments all over the world are taking place, so far no commercial Jatropha charcoal has been marketed.

Paper from Jatropha pruning material



paper mold

The art of papermaking.

Medieval festival at Monselice.(Italy) (picture from wikipedia)












The fibers are made from the *Jatropha* bark and/or wood. Bark alone gives a greenish color. Wood or bark is left soaking in water for some days and then pounded to obtain the fibers. First the fibers are suspended in water to form a slurry in a large vat. The mold is a wire screen in a wooden frame (somewhat similar to an old window screen), which is used to scoop some of the slurry out of the vat. The slurry in the screen mold is sloshed around the mold until it forms a uniform thin coating. The fibers are allowed to settle and the water to drain. When the fibers have stabilized in place but are still damp, they are turned out onto a felt sheet which was generally made of an animal product such as wool or rabbit fur, and the screen mold immediately reused. Layers of paper and felt build up in a pile (called a 'post') then a weight is placed on top to press out excess water and keep the paper fibers flat and tight. The sheets are then removed from the post and hung or laid out to dry. A step-by-step procedure for making paper with readily available materials can be found online.^[8]

When the paper pages are dry, they are frequently run between rollers (calendered) to produce a harder writing surface. Papers may be sized with gelatin or similar to bind the fibers into the sheet. Papers can be made with different surfaces depending on their intended purpose. Paper intended for printing or writing with ink is fairly hard, while paper to be used for water color, for instance, is heavily sized, and can be fairly soft.

The wooden frame is called a "deckle". The deckle leaves the edges of the paper slightly irregular and wavy, called "deckle edges", one of the indications that the paper was made by hand. Deckle-edged paper is occasionally mechanically imitated today to create the impression of old-fashioned luxury. The impressions in paper caused by the wires in the screen that run sideways are called "laid lines" and the impressions made, usually from top to bottom, by the wires holding the sideways wires together are called "chain lines". Watermarks are created by weaving a design into the wires in the mold. This is essentially true of Oriental molds made of other substances, such as bamboo. Hand-made paper generally folds and tears more evenly along the laid lines.

Annex 1: Diseases

| | Name | Symptoms | treatment |
|---|--|---|---|
|  | Polyphagotarsonemus latus mites | Young plants get very thick and sturdy leaves with veins almost on top of the leaf surface. Growing points will dry and the plant stops growing until a new flush starts, provoked by rain or irrigation. It is a typical disease of nursery plants and recently planted plantations. | If single plants are being attacked, cut the infested part and burn it. Larger area's can be treated with: Dicofol 18.5% EC @ 3ml/lt Vertimec 1.9 EC @ 0.5ml/lt |
|  | Oidium spp Powdery mildew | White powdery fungus mainly on younger leaves and stems. Most Jatropha,s get this disease in area's with low average temperatures and relatively high humidity. | Products based on dithiocarbamate (Zineb, Dithane, Manzate etc.) |
|  | Fusarium Wilt | Young and fully grown plants collapse in a very short time as if they do not get water. Indeed they do not get water, because the vascular system blocked by the fungus. The disease spreads from one plant to another , sometimes through flood and open channel irrigation. | Soil fumigation or drenching |
|  | Macrophomia spp Collar rot | Usually caused by over irrigating or high water table. The plant tries to recover by making new roots in the rotted area. Farmers use to cover these area's with soil, in order to stimulate secondary root growth | Improve growing conditions |

| | | | |
|---|--|---|--|
|  | <p>Scutellera nobilis Fabr.</p> <p>Scutellarid bug</p> <p>(picture D1)</p> | <p>Sucks on fruits , diminishing yield</p> | <p>Cypermethrin.</p> <p>Do not use during flowering, because it is highly toxic to bees.</p> |
|  | <p>Ferrisia virgata</p> <p>Mealy bug</p> | <p>ucks the sap from leaves and stems, sometimes from fruits if heavily infested and causes crinkling leaves, dry stems and reduced reproductive parts.</p> | <p>Chlorpyrifos or Mercaptothion, Dimethoate.</p> <p>Malathion 50%</p> |
|  | <p>Slugs and snails</p> | <p>Feed on leaves and stem, mainly in the nursery</p> | <p>Course sand around the nursery beds keeps them out.</p> |
|  | <p>Leaf Webber</p> | <p>Physical damage, mainly on leaves</p> | <p><i>Bacillus thuringiensis sub sp. Kurstaki</i></p> |
|  | <p>Stomphosistis thraustica</p> <p>Leaf miner</p> | <p>Physical damage, mainly on leaves</p> | <p><i>Bacillus thuringiensis sub sp. Kurstaki</i></p> |

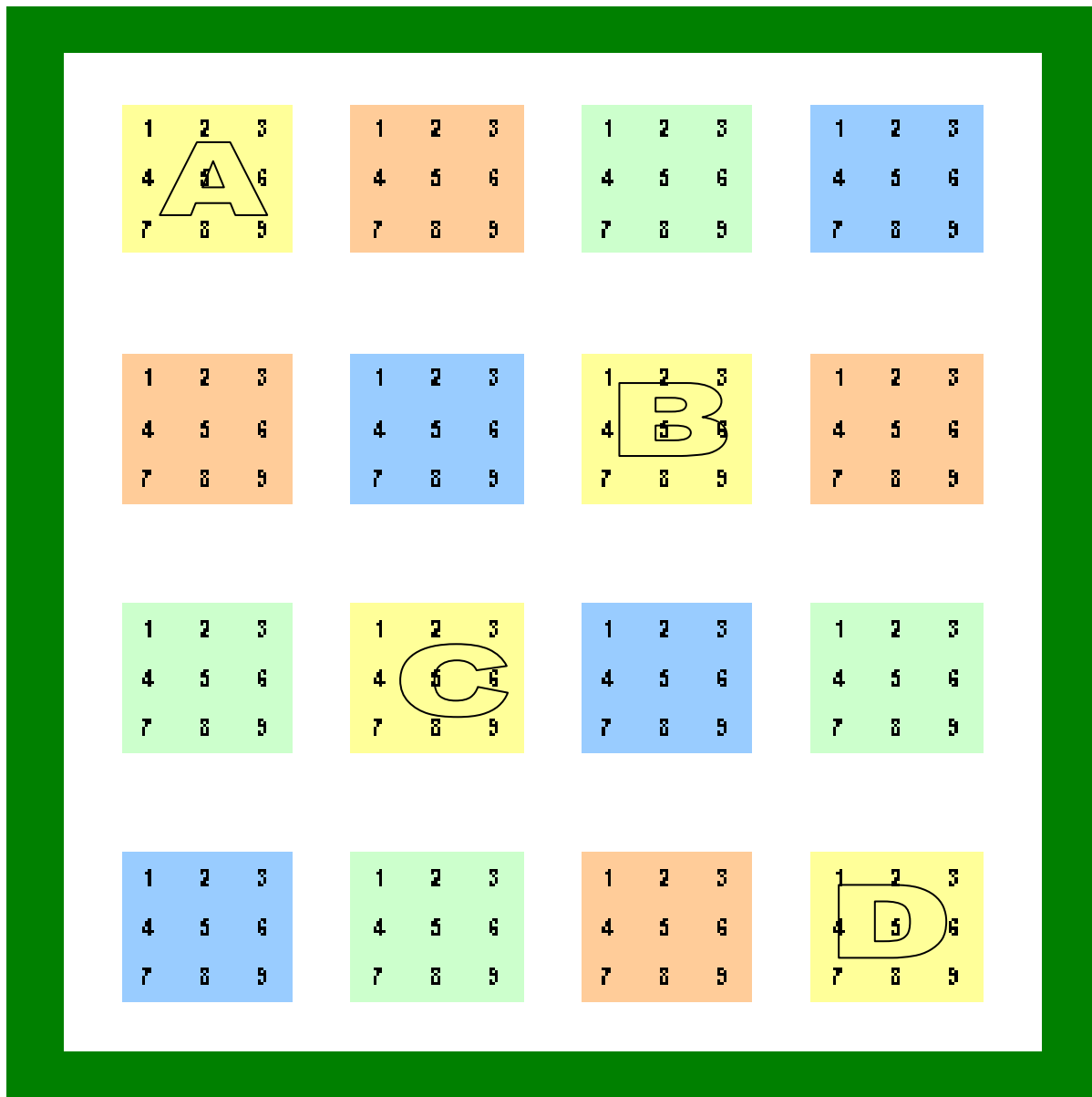
Annex 2: Selection trial layout

Bimonthly observations on 9 marked individual plants from each block

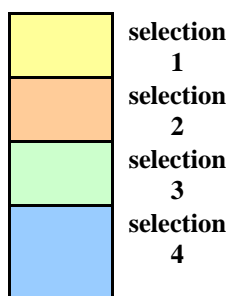
1. Nr. of branches per month
2. Height
3. First flowers (date)
- 4 Canopy. diameter
5. Yield of dry seeds

Duration of the trial: 2-3 year.

Planting distance 2x2 mtr

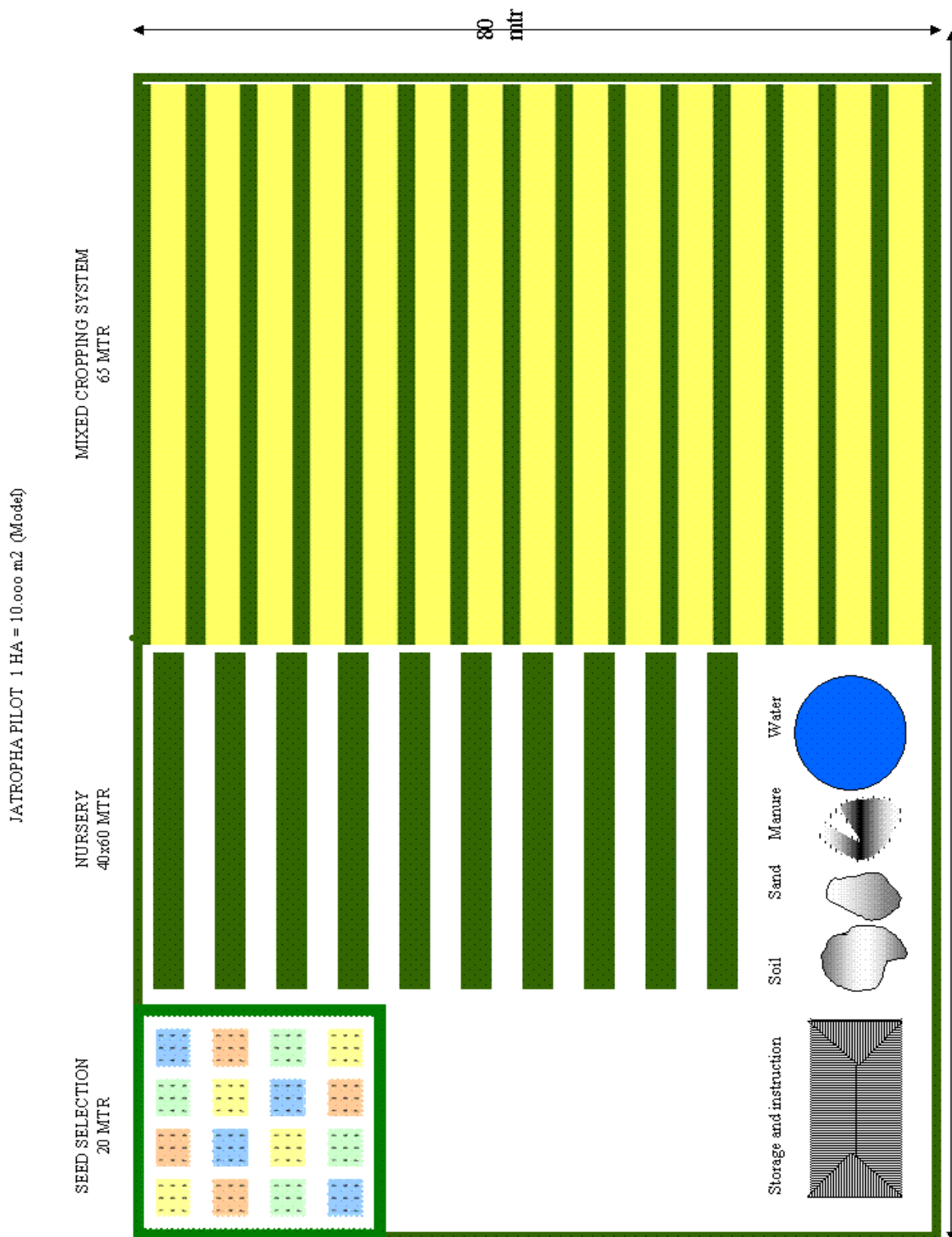


Borderplants



A B C D
repetitions

Annex 3. Pilot project



Annex 5. Crop documentation form

Crop suitability and/or progress form
Total acreage:.....

Country:.....
Location:.....
Date of planting:.....
Date of evaluation:.....
Evaluated by:.....

| | | | | | | |
|---------------|---------------|-----------|---------------|--------------|--------------|-----------|
| Site +/- | Accessibility | Rocks etc | Slopes | Erosion | Shade | Weeds |
| Soil +/- | Fertility | Sandy | Loam/Clay | Peat | Water table | Drainage |
| Soil analyses | N | P | K | ECe | | |
| Ownership • | Estate O | Coop O | Smallholder O | Government O | | |
| Plants • | Seedling O | Cutting O | Branching O | Density | ...M XM | |
| Irrigation • | Non O | Furrow O | Drip O | Sprinkler O | Hand O | |
| Fertilizer • | Non O | Organic O | Inorganic O | Solid O | Liquid O | |
| Farmer level | Excellent | Good | Fair | Average | Poor | |
| Precipitation | <500 | 500-1000 | 1000-1500 | 1500-2000 | 2000-2500 | >2500 |
| Grains/ha • | <1000 kg O | 1000 kg O | 2000 kg O | 3000 kg O | 4000 kg O | 5000 kg O |

Annex 4-Jatropha Fact Sheet



All photographs from Internet

- nr of fruits per bunch 3-30
- nr of seeds per fruit 3(1-4)
- weight per seed
 - Fresh 1-1.2 g
 - Dry 0.6-0.9 g
- nr. of dry seeds per kg - 1200-1400
- kg. seeds per tree after 5 years - 0.5-5.0 *
- In hedges the maximum yield is reported to be 0.8 kg/year/m or 2800 kg per ha
- fruit yield per ha 1500-10.000 kg *
- seed yield per ha 1000-7.000 kg *
- oil yield per ha 350-2500 l *
- biodiesel per ha 300-2200 l

*depending on selection, planting density, rainfall, temperature and cultural practices

- Dry fruits consists of 35% coat and 65% seed kernel.
- Seed contains 28-38% oil
- After mechanical expelling there is +/- 30% oil and 70% seedcake
- Kernel contains +/- 55-60% oil



- After refining there is +/- 90% biodiesel and 10% glycerine