JATROPHA CURCAS L.

AN INTERNATIONAL BOTANICAL ANSWER TO BIODIESEL PRODUCTION & RENEWABLE ENERGY

Total Renewable, Sustainable Organic Solutions to the Global Energy, Water & Environment.

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MOTIVATION FOR THIS STUDY

Jatropha Curcas L. has been widely accepted as a favorite agricultural solution for all subtropical and tropical locations for sound logical reasons:

- It is classified as a non – invading plant species, having to be planted in order to be established.
- It is not competing with food grade oils.
- It's toxicity is sensed by animals and therefore not foraged on.
- It is high yielding (1000 liter per hectare).
- It has a very high oil content of approximately 42%.
- The oil seed is collected by hand, after dropping to the ground.
- It requires only moderate rainfall (approx. 600mm only) and can withstand long periods of drought, but will thrive under higher rainfall.
- It is a permanent, uncomplicated crop that, once established, can last for many decades. It therefore eliminates normal annual seedbed preparations and planting.
- Due to its low demand on soil fertility, it is ideal to replant marginal lands to prevent desertfication.

Given the simular geographical, climatic and lack of rural employment opportunities, growing a crop for renewable energy provides the answer for long term prosperity. It is generally accepted that no matter how much oil seed is produced, there will not be an over supply for many decades to come.

DOVE BIOTECH has long appreciated both the economic benefits and ecological benefits of planting *Jatropha Curcas L.* for bioenergy production Combined with **Dove Biotech's** "**State of the Art" technologies for Biodiesel and Biogass, *Jatropha Curcas L.* there are both short and long term benefits for a truly holistic bioenergy projects in developing and developed countries in the tropical and sub tropical belts of the world.**

Assessment of the impact of the dissemination of "the Jatropha System" on the ecology of the rural area and the social and economic situation of the rural population (target group) using as a model selected countries in Africa

0.1 ABBREVATIONS

ARI-	Monduli Alternative resources of income for Monduli women
ATI	Appropriate Technology International, an US American NGO
BftW	Bread for the World
BUN	Biomass Users Network
CNESOLER	Centre National d'Energie Solaire et des Energies Renouvelables, Bamako, Mali
DAEA	Department of Agriculture and Environmental Affairs, South Africa
DED	German Development Service
DMA	Division Machinisme Agricole
ELCT	Evangelical Lutheran Church of Tanzania
GTZ	German Agency for Technological Co-operation
JCL	In English language used abbreviation of *Jatropha curcas L.*
KAKUTE	Private Firm in Arusha, Tanzania, to disseminate Jatropha
KZN	KwaZulu-Natal
MFP	Multi Functional Platform
OSCA	Owen Sithole Agricultural College, Empangeni, KZA, SA
POPA	Plant Oil Producers Association, Zimbabwe
SA	South Africa
SUDERETA	Sustainable Development through Renewable Energies in Tanzania
TZS	Tanzanian Shillings
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organisation
USD	United States Dollar
ZMK	Zambian Kwacha

1. DESCRIPTION OF THE PLANT, DISTRIBUTION, ECOLOGY

Jatropha curcas L. or physic nut, is a bush or small tree (up to 5 m height) and belongs to the euphorbia family. The genus Jatropha contains approximately 170 known species. The genus name Jatropha derives from the Greek *jatrós* (doctor), *trophé* (food), which implies medicinal uses. Curcas is the common name for physic nut in Malabar, India. The plant is planted as a hedge (living fence) by farmers all over the world, because it is not browsed by animals


About 1 1/2 year old plant in test plantation, KwaZulu-Natal, South Africa


35 year old Jatropha trees in Falan, Mali


Jatropha hedge in Mto Wa Mbu, Tanzania

1.1 Botanical description

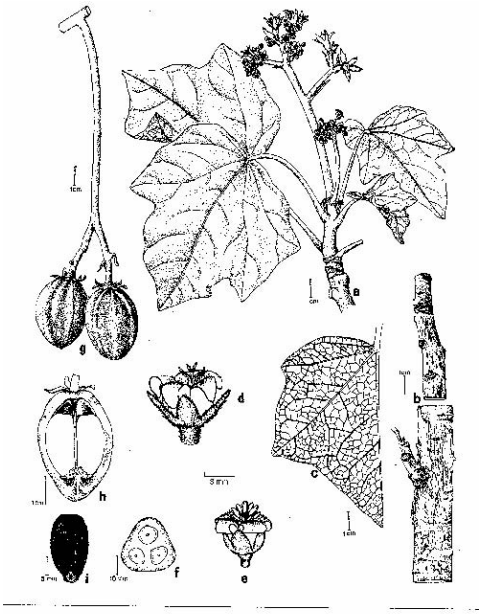


Fig. 2. Important parts of the physic nut: a - flowering branch, b - bark, c - leaf veinature, d - pistillate flower, e - staminate flower, f - cross-cut of immature fruit, g - fruits, h - long tudinal cut of fruits; a - c and f h from Aponte 1978; d and e from Dehgan 1984 (reprinted with permission).


Inflorescence containing male and female flowers

Jatropha curcas L., or physic nut, has thick glorious branchlets. The tree has a straight trunk and grey or reddish bark, masked by large white patches. It has green leaves with a length and width of 6 to 15 cm, with 5 to 7 shallow lobes. The leaves are arranged alternately.

Dormancy is induced by fluctuations in rainfall and temperature/light. But not all trees respond simultaneously. In a hedge you may have branches without leaves and next to them, branches full of green leaves.

The branches contain whitish latex, which causes brown stains, which are very difficult to remove.

Normally, five roots are formed from seeds: one tap root and 4 lateral roots. Plants from cuttings develop only lateral roots.

ripe Jatropha fruits

Inflorescences are formed terminally on branches. The plant is monoecious and flowers are unisexual. Pollination is by insects.

After pollination, a trilocular ellipsoidal fruit is formed. The exocarp remains fleshy until the seeds are mature. The seeds are black and in the average 18 mm long (11 – 30) and 10 mm wide (7 – 11). The seed weight (per 1000) is about 727 g, this are 1375 seeds per kg in the average. The life-span of the Jatropha curcas plant is more than 50 years.

Varieties

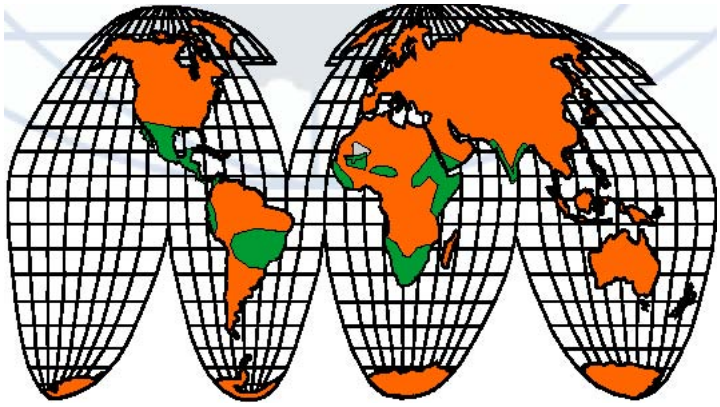
The Jatropha variety in Nicaragua has fewer, but larger fruits. The yield per ha seems to be the same.

Jatropha seeds from Mali (left) and Nicaragua

A non-toxic variety exists in Mexico, which is used for human consumption after roasting. It does not contain Phorbol esters.

("This non-toxic variety of Jatropha could be a potential source of oil for human consumption, and the seed cake can be a good protein source for humans as well as for livestock.", Becker et al, 1999).

1.2 Distribution



Main distribution areas of Jatropha curcas (green)

Jatropha curcas originates from Central America. From the Caribbean, Jatropha curcas was probably distributed by Portuguese seafarers via the Cape Verde Islands and former Portuguese Guinea (now Guinea Bissau) to other countries in Africa and Asia. Today it is cultivated in almost all tropical and subtropical countries as protection hedges around gardens and fields, since it not browsed by cattle.

1.3 Ecology

Jatropha curcas L. is not a weed. It is not self propagating. It has to be planted. It grows well with more than 600 mm of rainfall per year, and it withstands long drought periods. With less than 600 mm it cannot grow except in special conditions like on Cape Verde Islands, where the rainfall is only 250 mm, but the humidity of the air is very high (rain harvesting). It cannot stand frost. It survives a very light frost, but it loses all leaves. The production of seeds will probably go down sharply.

2. DESCRIPTION OF THE JATROPHA SYSTEM

2.1 The Jatropha System

The Jatropha System is an integrated rural development approach. By planting Jatropha hedges to protect gardens and fields against roaming animals, the oil from the seeds can be used for soap production, for lighting and cooking and as fuel in special diesel engines. In this way the Jatropha System covers 4 main aspects of rural development:

• promotion of women (local soap production);

• poverty reduction (protecting crops and selling seeds, oil and soap).

• erosion control (planting hedges);

• energy supply for the household and stationary engines in the rural area;

The obvious advantage of this system is that all the processing procedure, and thus all added value, can be kept within the rural area or even within one village. No centralised processing (like in the cotton industry) is necessary.

2.2 Possible Uses of the Jatropha Plant

- The Jatropha plant is used as a medicinal plant:
  - The seeds against constipation;
  - The sap for wound healing;
  - The leaves as tea against malaria; etc.
- Jatropha is planted in the form of hedges around gardens or fields to protect the crops against roaming animals like cattle or goats;
- Jatropha hedges are planted to reduce erosion caused by water and/or wind;
- Jatropha is planted to demarcate the boundaries of fields and homesteads;
- Jatropha plants are used as a source of shade for coffee plants in Cuba;
- In Comore islands, in Papua New Guinea and in Uganda Jatropha plants are used as a support plant for vanilla plants;

3. JATROPHA PROMOTION IN SELECTED COUNTRIES

3.0 Benin

There is no knowledge about actual activities. But Benin, in former times Dahomey, exported in the years around 1940 large quantities of Jatropha to France (Marseille), where the oil was used for the fabrication of the famous "Savon de Marseille".

In the years around 1990, the director of CADER Attakora in Natitingou, in the north of Beninn, started a campaign of the dissemination of Jatropha hedges in the north of Benin.

3.1 Egypt

Jatropha plantation near Luxor, Egypt

5.000 Ha Jatropha plantation irrigated with waste water

In the desert near Luxor a 5.000 ha Jatropha plantation is installed in 2003 in collaboration with the Egyptian government. Irrigation is done with waste water.

3.2 Ethiopia

In the south of Ethiopia, Jatropha is used in the form of hedges. In Addis Ababa, a Biodiesel company was founded which wants to exploit Jatropha in a large scale for Biodiesel production.

3.3 Ghana

(See Annex 2)
A private firm, Anuanom Industrial Project Ltd, is starting a large scale Jatropha project. The planning is for 250.000 hectares of Jatropha plantation. Up to now there are no real serious figures about the state of development available. A report mentions that 100 ha of Jatropha are already planted to deliver seeds for the extension of the industrial plantations. The Jatropha oil will be used for the production of Biodiesel. UNDP extends it project MFP (multi functional platforms) to Ghana.

3.4 Guinea (Conakry)

Guinea has a high density of Jatropha plants. (mostly hedges, in the Fouta Jallon area), but there are no reports about activities/projects.

UNDP extends it project MFP (multi functional platforms)toGhana.

Jatropha hedge in Madagascar

3.5 Madagascar

In the years around 1940, Madagascar was exporting Jatropha seeds to Marseille, France, as raw material for soap production ("Savon de Marseille"). There are still large quantities of Jatropha hedges, but their seeds are more or less not used.

3.6 Mali

GTZ-Projects (1987 – 1997)

Within the "Special Energy Programme" of GTZ Jatropha activities commenced in 1987 and continued in different organisational forms until 1997. The Malian partner of the GTZ project was DMA and CNESOLER.

During the GTZ projects basic studies were carried out on the density of Jatropha hedges in different regions of the country, on the yield of the hedges, on the oil yield of the expellers and the ram presses, on the economy of soap production and the use of Jatropha oil as diesel substitute. Also studies were undertaken on the value of the Jatropha press cake as an organic fertiliser.

At the end of the GTZ projects, in 1997, the population of Jatropha was estimated at around 10.000 km of Jatropha hedges, which represents a potential of about 2.000 tonnes of Jatropha oil.

UNIDO / UNDP

UNDO/UND started a large scale project to disseminate "Multifunctional Energy Platforms (MFP)" in the rural areas of Mali. 450 units are planned, and 15 %, i. e. almost 70 units, should run with Jatropha oil as fuel. This programme will be extended to Senegal, Guinea, Côte d'Ivoire and Ghana.

DESCRIPTION OF THE PLATFORM EXAMPLE

Essentially, it comprises a 10 H.P diesel engine, capable of driving up to a dozen different ancillary modules. Among are a grain mill, a de-huller, a shea butter press and even an electric alternator. This alternator can drive modules such as a water pump, provide power for up to 250 light bulbs, charge batteries, drive a sawmill or weld metal. The platform employs simple and appropriate technology and is an economic, practical and sustainable solution for many of the problems faced by rural communities. Local artisans are trained to master all aspects of this simple and appropriate technology.

MALI FOLKECENTER

Mali Folkecenter, a NGO in Bamako, took up the Jatropha activities in 2000, which were carried out by GTZ between 1987 and 1997. In the meantime CNESOLER was in charge of the Jatropha activities (CNESOLER was the national partner of the GTZ project). Mali Folkecenter gets financial support from the Siemenpuu Foundation in Finland.

UNIFEM price 2003 (German UNIFEM Section)

In 2003 the Jatropha project in Mali, started by GTZ and continued by Mali Folkecenter, received the 2nd price of the German UNIFEM branch.

3.7 Mozambique

As a former Portuguese colony, in some areas there are large populations of Jatropha hedges. From Mozambique the knowledge of the Jatropha hedges invaded Zimbabwe, Malawi and Zambia.

The South African Oil & Gas Company "Sasol Technology (Pty) Ltd" built a gas pipeline from South Mozambique to Johannesburg, South Africa. Along the pipeline they initiated activities of rural development. The project manager in charge of these community development activities explains the objective of these activities as follows: The objective is to do rural development to let the population participate in the economic benefits of the pipeline. He intends to create small as well as large Jatropha plantations in the neighbourhood of the pipeline.

3.8 Namibia

There are some initiatives to plant Jatropha in Namibia, mostly from white farmers. But the climate (rainfall is not sufficient) does not allow Jatropha plantation in a larger extent.

3.9 Senegal

A project carried out by ATI (now Enterprise Works), an American NGO, in the region of Tiès, planted Jatropha hedges and extracted Jatropha oil with ram presses. The oil was used to run Diesel engines (for flower mills) and to make soap.

Soap from the ATI project

3.10 South Africa

- **Emerald Oil Int. (Pty) Ltd** is initiating a 100.000 tons per year Biodiesel plant in Durban. It tries to organise the production of the feedstock for the plant (Jatropha curcas seeds) in South Africa or to import it from the neighbouring countries (Zimbabwe, Malawi, and Zambia) or from Madagascar.

It supports the Agricultural Extension Service of KwaZulu-Natal to establish large scale plantations of Jatropha hedges.

- **Owen Sithole College of Agriculture (OSCA)** The College has a very small Jatropha test plantation (100 plants) in co-operation with the Agricultural Extension Service, KwaZulu-Natal.


Small Jatropha test plantation at OSCA, KwaZulu-Natal

- **The Agricultural Extension Service, KwaZulu-Natal**

is very active in promoting the plantation of Jatropha in the Makatini flats just south of Swaziland at the coast of the Indian Ocean. For this it formed a Jatropha Task Team, which also organises public field days (see annex 14, page 48).

3.11 Sudan

• Jatropha is found in Sudan in many areas such as Khartoum State in Central Sudan Kassala State in the East and Kordofan State in the West. However, it is dominant in the Southern States especially in Bahr El Jebel and Bahr El Gazal States.

• It is mentioned as an indigenous plant in some books describing the plants of Sudan. The farmers in the south plant them as hedges to protect their gardens and fields.

• Jatropha Research started in Sudan as early as 1972 with studies concerning the molluscicidal effect of the plant.

• A Jatropha Project exists in Kutum, North Darfur, with participation of the German Development Service.

Jatropha plant in Kutum,North Darfur,Sudan

3.12 Tanzania

KAKUTE Ltd, This firm disseminates the know how concerning "The Jatropha System" and produces Jatropha soap in an industrial scale. The dissemination is done within a project called "ARI-Monduli" (Alternative Resources of Income for Monduli women). This project is financed by the American McKnight Foundation and is executed in close co-operation with Heifer International **Foundation.**

Jatropha soap produced by KAKUTE

Test plot of KAKUTE
With Jatropha cuttings

KAKUTE produces around 1.000 kg of soap a year and sells it in form of pieces of 30 and 90 g each. Their revenues from the sale of soap is about 6 million TZS (about 6.000 USD).

KAKUTE created a test plantation on private ground (2, 5 ha) to get experience with Jatropha plantations.

KAKUTE tries to use Jatropha against erosion: Between Arusha and Lake Manyara is a very big plain (Massai steppe). A water line for cattle was installed there and now Massai cattle herds from far away come to get water. This led to an overgrazing around the water basin and consequently to deep erosion grooves.

KAKUTE tries to plant Jatropha against the erosion, but with little success, since the origin of the overgrazing, the water source, still exists. The project ARI-Monduli disseminates the Jatropha know how in different ways:

Erosion in the Massai plains

• **Nurseries** A women group of 12 members about 20 km from Arusha started to integrate Jatropha in their tree nurseries. They sell each seedling for about 50 TSh to individuals and schools, which plant them around their compounds.

• **Plantation in Teachers Training School,** In a teachers training school a 2 ha area was planted with Jatropha seedlings (more than 2.000) in the beginning of 2002. In mid 2003 the first seeds could be collected. This plantation was also used as a site to inform the population about the advantages of "the Jatropha System" by organising a public field day.

• Soap making women's group in Mto Wa Mbu

A women's group in Mto Wa Mbu buys Jatropha oil from Engaruka and makes soap from it. They sell this Jatropha soap for a very good price.

• Seed collecting, oil extracting and soap making

There are 2 women's groups in Engaruka who collect Jatropha seeds and seedlings and extract the oil. Part of the oil is sold to the Jatropha soap women's group in Mto Wa Mbu, the other part they process themselves to soap. KAKUTE started these activities about two years ago within the ARI-Monduli project.

Mto Wa Mbu

A women's group in Mto Wa Mbu, a town just besides the Manyara lake on the way to the Ngorongoro Crater, buys every month 20 litres of Jatropha oil from the first women 's group of Engaruka for 2.000 TZS per litre (2 USD).

From this oil they produce about 40 kg of soap and sell this for about 126.000 TZS (120 USD), a piece of about 100 g for 500 TZS. Since soap making is an easy process and does not require much labour, this is economically a very interesting business.

Simple method to produce soap bars

The Jatropha soap has the image of a medical soap. It is produced by the women's group within a dispensary and is sold by women in other dispensaries. Many different medicinal properties are attributed to the Jatropha soap (it helps against different skin diseases). This is why the soap can be sold for such a good price.

Sale of Jatropha soap in a dispensary

Engaruka

The village of Engaruka, just at the borderline of Ngorongoro Conservation area, has a high density of Jatropha hedges. Almost all gardens within the village are surrounded/protected by Jatropha hedges. The origin of the plants is not known, but they are there since people remember. One saying goes that the Germans introduced it during their colonial time before 1918. The village is divided into two sections. Each has a group of about 30 women, all married and almost all Massai. Since two years they collect Jatropha seeds. First they only collected seeds and sold the seeds to KAKUTE for about 150 TZS per kg. Now they extract oil with a ram press and get 2.000 TZS per litre. This is about 1.250 TZS more and needs about 1 hour of labour (yield of the ram press is about 1 litre per hour).

Sale of Jatropha soap in a shop in Engaruka

The women told us that before they went to collect wood to sell it to have some money. Now they don't have to collect firewood for sale anymore. And soon they intend to stop selling the oil and make soap and sell the soap, what they are already doing to a certain extend. KAKUTE is in charge of this project. To assure that the Jatropha activities stay in the hands of the women, Kakute refuses to buy seeds from men. So if men want to get money by collecting Jatropha seeds, they have to sell them first to the women.

Vyahumu Trust

The VYAUMU TRUST is a project of ELCT (Evangelical Lutheran Church of Tanzania) to improve the income of Tanzanian farmers by enabling them to produce sunflower oil and to sell it directly. This improves their income from sunflower farming by 100 to 200 %

Sayari-expeller for sunflower seed oil extraction in Mlali, Tanzania

The Vyahumu Trust produces the oil expeller, a key element for the production of Jatropha oil, which was developed by order of GTZ to be produced and used in Nepal with the name "Sundhara" expeller. In Tanzania this expeller is named "Sayary" expeller. The VYAHUMU TRUST assures also the pre sale and after sale service.

3.13 Uganda

• Mr. Matthias Goergen, a consultant for GTZ, reported about Jatropha hedges planted by the autochtone population in Uganda (West Nile Province). But they are planted as well by the refugees in the camps, who do subsistence agriculture on small plots (0,3 to 0,5 ha per person). It seems that the population does not use the Jatropha fruits. The hedges are used only for fencing.

• Mr. Alex Baudet founded a Biodiesel company in Uganda (Uganda Biofuels Ltd. in JONAM COUNTY in NEBBI district).

Jatropha hedge planted by the autochtone population

3.14 Zambia

In Zambia, mainly in the areas near the border to Mozambique, large quantities of Jatropha hedges exist. But generally the population neglects the use of the seeds. The hedges serve as a protection device against cattle.

In Lusaka a 2 ha test plantation exists, which was planted by the NCSR (Nations Council of Scientific Research), by contract with a soap production firm. The intention was to replace imported tallow by Jatropha oil. After the soap firm was sold, the management lost interest in the Jatropha approach.

In Southern Province, besides the Lake Kariba, Jatropha plants are well known to the population, because workers, who returned from Zimbabwe, brought seeds back home and planted them.

Jatropha hedge around a homestead near Choma

In 1999 an excursion trip with about 20 farmers from Southern Province to the BUN Jatropha project in Zimbabwe initiated a lot of enthusiasm within the group of farmers. Almost all of them started small Jatropha plantations or hedges. A study from Malawi two years later mentioned 100 farmers who started to plant Jatropha.

3.15 Zimbabwe

Bun Project

The Jatropha project of BUN started 1996. It is funded by the Rockefeller Foundation, the Australian Agency for International Development (AusAid) and the Royal Netherlands Embassy.

The project is located in Makosa, near the Mozambique border. Jatropha plants are in abundance there. Traditionally they are used as a live fence around homesteads and gardens.

The objectives of the project are:

- Use of the plant as a source of oil for use as fuel (domestic and industrial use) and for soap making;
- Use of the press cake as organic fertilizer;
- Use of the oil for lighting purposes;

Binga Trees Project (http://www.jatropha.de/zimbabwe/binga.htm)

The Binga Trees Programme started off August 1996 with the aim to develop local resources that appeared to be untapped in spite of their capacity to improve the living conditions of Binga District's rural population of 105.000.

Important among the perceived under-utilised resources are a number of food and/or oilseed producing trees such as the Moringa oleifera, the Jatropha curcas, the Cashew nut, and the Trichilia emetica, which all have an obvious potential to improve the household food security in a variety of ways

Environment of Africa (http://www.jatropha.de/zimbabwe/ea/ea-jclactivities.htm)

One community group of five members representing both men and women has started up planting Jatropha curcas in the urban areas of Chinotimba, Victoria Falls. The group use both seedlings and cuttings of Jatropha. The seedling are raised in own nurseries and the cuttings are collected from existing fencing material in the neighbourhood. Jatropha is mainly planted on marginalized soil i.e. unused public areas and school areas for fencing. The group involves the children and the teachers from local

JCL-nursey near Victoria Falls

schools in the planting project and use the project as a teaching lesson for the children to raise awareness of the environment and to take ownership of the trees. The management and care of the plants is organized between the user group and administration of the school.

- Planting of hedges in urban areas
- Distribution of seeds to rural areas
- Planting Jatropha in plantation

POPA (Plant Oil Producers Association)

POPA was founded in 1992 by Zimbabwean commercial farmers who wanted to produce Jatropha oil in a large scale. Soon they discovered that the profit margin concerning Jatropha oil as fuel was not so big as they expected, especially because there was no possibility of mechanical harvesting of the Jatropha seeds. The activities of POPA slowed down.

4. IMPACTS OF THE PROMOTION OF THE USE OF JATROPHA

4.1 Social impacts

Gender issues (who does the work, which gets the money, changes of the distribution of the workload, changes of the social status)

- **In Mali** the Jatropha hedges belong to the men, who are the owner of the land. The women can collect the seeds to make soap at a subsistence level. As soon as the women want to make money by selling soap, the men open their hands and ask for money, because they are the owners of the Jatropha hedges.

  Because of this situation, the women didn't want to give their earned money to the men. They only produced the soap in small quantities for the own family, but they did not use the potential of seeds on the hedges of the family.

  It seems that since the years of 1997, the situation improved in favour of the women, because the men (village chief) gave them plots to grow Jatropha.

- **In Tanzania,** the situation is different. As in Mali, the land is owned by the men. But the women have the right to collect the seeds from the family hedges, and to process or sell them. The money is for them. Also the village gave them plots where they can plant Jatropha for their own profit.

• **In Zambia** the author was told, that the situation is like in Tanzania, described above.

• About the situation in **Zimbabwe**, there is no information.

People without own farm land (accessibility of seed, Jatropha in public forests for free collection)

• In the projects and regions visited, there were no "wild" Jatropha trees. All Jatropha trees were planted as protection hedges; i. e. there was always an ownership of a family. And only members of the family were allowed to collect seeds.

Other social issues, like cultural/religious traditions (in some countries women are not allowed to own trees or farm land), or indigenous knowledge

• **In Mali** as well as in **Tanzania**, women are not allowed to own farm land and trees. But in both cases the responsibles for the distribution of the land gave some plots to women groups to grow Jatropha there.

In Mali, in 1997, this donation of a plot to the women's group was renounced twice after the women planted more than 1.000 seedlings. The women lost interest to try it a third time.

Mali Folk Center reported that recently the situation changed and land was given to women's groups to grow Jatropha. This information has to be verified.

• Concerning indigenous knowledge the soap making with oil from different oil fruits is well known in Mali and has an old tradition. They often used Shea butter and ground nut oil for soap making. Caustic soda, the only product which has to come from outside the village, is well available on all the rural markets, even far from the big cities. In this way, soap production with Jatropha oil improves the food situation, since no edible oils have to be used for soap making.

In **Zambia** the soap making technology is not known in the rural areas.

The situation in **Zimbabwe** and **Tanzania** concerning traditional rural soap making is not known.

Working places: The large scale Jatropha plantation in Egypt needs to employ a big number of workers to maintain the irrigation system, to harvest the seeds and to maintain the plantation itself. The 5.000 ha plantation will need about 3,3 million working hours to collect the seeds, which are about 15.000 working months or about 1.500 full time workers, as long as no mechanical device to collect the seeds is invented.

4.2 Ecological impacts

- on **Biodiversity** (is Jatropha competing with other crops?) and on the genetic diversity of the Jatropha species

  - Jatropha is not a weed. It does not propagate by itself, it has to be planted. The author did not see any self propagation of trees even after some 30 years. When the hedges are not maintained, more and more plants die (due to termites?), and the old hedge can only be guessed.

  - There are only three varieties of Jatropha known so far. And no selection process to get high yield varieties has been done so far. These 3 varieties are:

    Cape Verde variety. These are small seeds (weight of 1.000 grains is about 682 g, length of seed is about 16,8 mm). This variety is found almost in all countries of the world, except Central America.

    Nicaragua variety. This variety is different from the Cape Verde variety by larger leafs, which have a more rounded form, and by larger seeds (weight of 1.000 grains is about 878 g, length of seed is about 20,3 mm). The yield of the trees seems to be the same, because there are less fruits on a tree than with the Cape Verde variety.

    Non toxic Mexican variety. (Weight of 1.000 grains is between 524 g and 901 g). Birgit Schmook reports, that the seeds in the zone around Misantla, Veracruz, are very appreciated by the population as food.

- **Erosion and the desertification process**

  - The Massai plain near Arusha is very much endangered by erosion due to overgrazing (see picture at right, the reason is the installation of a permanent water basin, which attracts cattle from a large area). Kakute plants Jatropha trees, which are not browsed by the animals, to protect the soil.

  - The Massai women in Engaruka, Tanzania, report, that they were cutting trees and selling wood along the road to get some income. Due to the revenues

Erosion in the Massai plain near Arusha, Ti

gained by the use of the Jatropha plant, they don't do this anymore, which protects the still existing trees. Their income is higher with Jatropha. They received two plots from the village to install Jatropha plantations.

• Rehabilitation of degraded land

Since Jatropha has a deep reaching taproot, it is able to "pump" minerals from the depth of the soil to the surface. This leads to a rehabilitation of degraded land (see also decision of Tamil Nadu State on waste land rehabilitation in annex 9.

• Other environmental aspects of Jatropha promotion

The NGO Environment Africa uses the plantation of Jatropha to raise awareness with school children and teachers for environmental aspects: "The group involves the children and the teachers from local schools in the planting project and use the project as a teaching lesson for the children to **raise awareness** of the environment and to take ownership of the trees".

Jatropha plantations can play an important role in **carbon sequestration**. The existing large scale project in Egypt and the planned large scale Jatropha projects in South Africa and Ghana are calculated with an initial financing by the Trade of Emission Certificates (see annex 10).

4.3 Economic impacts

Egypt

The 5.000 ha Jatropha plantation near Luxor is initiated by a British Biodiesel firm, D1. An important financial aspect is the money, which the project will receive from the trade of emission certificates of CO_2 sequestration. Since no data have been made available by the project, here is an estimation of the money the project can apply for: 1 ha has about 1.600 plants; each has after 7 years about 200 kg of biomass, including roots. Dry matter content about 25 %. This gives a biomass of 80 tonnes dry matter per ha. About half that weight is carbondioxide, i.e. 40 tonnes. The trade of emission certificates pays between 3 and 4 USD per ton of CO_2 sequestration, which is about 150 USD per ha. The 5.000 ha plantation can consequently calculate with financial aid of 750.000 USD due to carbon sequestration

Mali

• External evaluation of the Jatropha project

In 1995 a GTZ-expert in economy analysed the economic feasibility of the Jatropha approach. He studied 2 versions of oil expelling: a hand operated ram press and a motor driven Sundhara expeller. For the last he calculated 2 different engines: a cheap Indian motor (Lister) with regularly breakdowns and a more solid German Hatz motor. The summary and conclusions are added in **annex 6**.

Ram-press: Mr. Wiemer states: The calculations for the hand operated Bielenberg press indicate that the extraction of Jatropha oil with this equipment is not financially feasible under field conditions in rural Mali.

Motor driven expeller: Mr. Wiemer states: The results of the financial analysis indicate that for the Lister version an internal rate of return on investment (IRR) of 49 % can be projected. For the Hatz version, the profitability of the oil mill is lower (26 % IRR) due to the more expensive equipment, but also carries a much lower risk of mechanical breakdowns.

• Soap production (calculation of the project)

As can be seen in the table further down, the extraction of 12 kg of seeds gives 3 l of oil, which are transformed into soap. The soap making technology is very simple and therefore a real village technology: the only investment is a hand operated hand press for 150 USD. The soap will be made in plastic bowls or buckets, and the pieces are cut with ordinary knifes.

As the table shows, the processing of 12 kg of seeds gives 28 pieces of soap of 170 g each, which is 4,760 kg. This takes 5 hours of work (estimated). The total input is added to 3,04 USD.

The soap can be sold for 4,20 USD, and the 9 kg of press cake are well appreciated as organic fertilizer. It can be sold for 0,27 USD, which gives a total of revenues of 4,47 USD.

Reduced by the input of 3,04 USD, the net profit of processing 12 kg of Jatropha seeds is 1,43 USD, which is about 0,3 USD per hour.

Even if the estimated time for processing is doubled, the net profit is about 0,15 USD per hour. This is more than the average wage for workers.

Some details of the economy of soap production with the means of the Bielenberg hand press are shown in the following table (prices in US$, 500 FCFA = 1 US$):

Description	Quantity	Unity	Price per unity US$	Amount in US$
Inputs				
Seeds (give 3 l of oil with handpres)	12	kg	0,1	1,20
Caustic soda	0,5	kg	1,2	0,60
Labour (4 h for pressing, 1 h soap production)	5	h	0,2	1,00
Depreciation/maintenance (5 years, 80 t/a, 240.-)		US$/kg	0,42	0,24
Total expenses				3,04
Revenues				
Presscake	9	kg	0,03	0,27
White soap	28	pieces (170 g)	0,15	4,20
Total revenues				4,47
Net Profit				1,43
Profit per liter of oil			0,48	
Profit per kg of soap			0,21	
Price per kg of soap			0,39	

• **Poverty reduction**

In the pilot zones in Mali the average length of hedges was found to be 15.000 m. Each meter of hedge produces 0,8 kg of seeds, i. e. that 12 tons of seed can be collected in the average village.

The above table shows which added value can be obtained by processing these seeds. If only seeds are processed and the oil and the by-products press cake and sediment are sold, a total sum of about 1.800 USD will stay in the village.

If the oil is processed by an entrepreneur to soap and the soap is sold, then the total of about 3.600 USD will stay in the village (lower part of the above table).

Sudan

Economic evaluation of the utilization of Jatropha seeds for soap making (from Henning, mission report, Sudan, 2001)

This economic evaluation adds the costs of material and labour input for a soap production of 3 litres of oil, which gives 5 kg of soap, reduced by the value of the sold press cake.

- harvesting of 12 kg of seeds 4 h work
- Caustic soda, 0,5 kg 1,0 US$
- Oil extraction (12 kg seeds, 3 l oil) 4 hours work
- Soap making (5 kg soap) 1 hour work
- Depreciation of oil press 0,24 US$
- Sale of press cake 0,27 US$

- **Result:** 5 kg of soap = 50 pieces of 100 g, one piece is worth 0,43 US$ (100 Sudan Dirham SD) 50 x 0,43 = 21,5 US$ minus caustic soda and depreciation, plus sale of press cake = 0,97 US$ **economic result: 20,53 US$ for 1 production.** The minimum to live in Khartoum is 170 US$ (Information by the German Embassy). To earn this money, 8,3 production cycles have to be made, i. e. 8,3 x 3 = 24,9 l of oil have to be processed, which will take 8,3 x 9 = 74,7 hours of work. This is a workload of less than two weeks. **i.e. with harvest of Jatropha seeds, oil extraction, soap making and sale a worker can earn a monthly salary with about 75 hours work!**

Poverty Reduction

By promoting the integrated utilization of the Jatropha plant, the Jatropha System can provide direct financial benefits to the rural economy. To illustrate this with a rough calculation, assume the average village of the pilot area has 15 km of Jatropha hedges, which represents 12 tons of seeds.

These 12 tons of seeds may generate 1.800 US$ of cash income when the oil is extracted and the products are sold:

• 9.000 kg of presscake for 0.03 =	270.- US$
• 2.400 liters of oil for 0.60 =	1.440.- US$
• 600 kg of sediment for 0.15 =	90.- US$
Total	**1.800.- US$**

If we take the real example of an entrepreneur in a small village near Bamako, who buys the seeds for soap production and hires people for the production process (extraction with Bielenberg ram press, soap production, see table above), the cash income for the village population, including the entrepreneur, amounts to 3.630 US$:

• 12.000 kg of seeds for 0.10	1.200.- US$
• 5.000 hours of labor for 0.20	1.000.- US$
• profit of the entrepreneur	1.430.- US$
Total	**3.630.- US$**

If these figures are extrapolated to Jatropha plantations, a profit in the range of cotton farming is within reach.

Tanzania

The following economic evaluation of activities of the use of the Jatropha plant is based on experience of KAKUTE in its Jatropha project ARI-Monduli (Alternative Resources of Income for Monduli women). The figures are ascertained by Kakute.

The economic calculation is differentiated between seed collection, oil extraction and soap making. It is obvious, that the collection of seeds and its sale gives the least added value. Oil extraction is more profitable than seed collection, but not as good as soap making. This explains very clearly that the Massai women of Engaruka are not very much interested to sell seeds or oil; they want to gain the added value of the whole production chain and sell only soap.

Collection and sale of seeds

Collection of seeds: (figures from KAKUTE, 2003)
Collection of seeds: 2 kg in 1 hour
Sale of seeds: 150 TZS per kg

Value added for 1 hour work	300 TZS	0,29 USD	per hour

Extraction and sale of oil

Oil extraction: (figures from KAKUTE, 2003)
5 kg of seed for 1 litre of oil is 1,7 hours of work
1,0 hours of work to extract 1 litre of oil

			0,71	**per**
Input:	**5 kg of seed**	**750 TZS**	**USD**	**litre**
	1,5 hours of work to extract 1 litre of oil depreciation of ram press 0,02 USD / kg			
			0,10	
	for 5 kg:	105 TZS	USD	per litre
	Sale of 1 litre of		**1,90**	
Output:	**oil**	**2.000 TZS**	**USD**	
Value added for 1 hour of work		**1.145 TZS**	**1,09 USD**	**per hour**

Production and sale of soap

Soap making: (figures from KAKUTE, 2003)

16 hours work for 252 bars of soap
1 bar sold for 500 TZS
Purchase of 20 litres of oil à 2.000 TZS = 40.000
Purchase of 3 kg of Caustic Soda a 2.000 TZS = 6.000 TZS
Plastic for wrapping soap = 3.000 TZS
10 hours for miscellaneous work (organising purchase of oil, wrapping the soap, etc)

Input:	**20 l oil**	**40.000 TZS**	**38,10 USD**	
	Plastic	3.000 TZS	2,86 USD	
	Caustic Soda	6.000 TZS	5,71 USD	
	Total input for 26 hours work	49.000 TZS	46,67 USD	
Output:	**252 bars à 500 TZS**	**126.000 TZS**	**120,00 USD**	
Total of revenues		**77.000 TZS**	**73,33 USD**	
Value added for 1 hour of work		**2.962 TZS**	**2,82 USD**	**per hour**

Zambia

• **Jatropha oil as diesel substitute** (for details see annex 7) In a feasibility study in 1998, the author stated, that Jatropha oil can be produced for less than 3.000 ZMK (1000 ZMK = 0,41 USD). But this is a prohibitive price for the use of the oil as diesel substitute.

• **Jatropha oil for soap making** (for details see annex 7)

The economy of soap making depends very much on the price for Jatropha seeds. If the price is fixed to 500 ZMK (which is 0,21 USD or double the price of seeds in Mali), a piece of soap is calculated to 248 ZMK, about half the price of cheap industrial soap. Women of a women group in Mazabuka confirmed that the Jatropha soap can be sold for about 1.000 ZMK a piece, i. e. 4 times the production price).

If the price for seeds is raised to 1.000 ZMK (4 times the price for seeds in Mali), the price for soap raises only to about 373 ZMK, which is still less than the cheapest industrial soap and about a third of the price, the women's group of Mazabuka suggests.

If only using the working hours for seed collection and oil extraction, plus material does the calculation, the profit for 1 hour of work is calculated to be more than 1.000 ZMK (1.007 ZMK), that is more than double the wage as paid for rural labour (400 ZMK).

Answers to distinct questions of the Terms of Reference:

The best documented data concerning the economy of the use of the Jatropha tree were found in Tanzania, in the ARI-Monduli project of KAKUTE. The further down given answers refer to KAKUTE, if not otherwise indicated.

• **Household income** (sale of seeds, production and sale of oil, production and sale of soap) There is no data available concerning the financial effect of the profit of Jatropha processing to the single households of the members of the women groups.

• **Household food security** (Jatropha is grown in form of hedges to protect food crops) There is no data available concerning the amount of food saved by Jatropha curcas. In Mali it was told by the CMDT (Malian Cotton Producing Society), that about 10 % of the crops are eaten by roaming cattle. This might be an approximate value concerning the protection of food crops by Jatropha hedges. Probably the real value is higher, because food crops are grown in gardens within or near the village, where the density of roaming animals is higher.

• **Farming systems** (integration of Jatropha into the farming calendar, Jatropha as integrated part of the farm design) Before the beginning of the Jatropha project of GTZ in Mali a socio-economic study on the feasibility of the Jatropha approach was done (Keita). This study stated, that no major conflict concerning the collection of Jatropha seeds and the agricultural works is visible (see annex 12).

No documentation concerning farm design has been found in the countries the author has visited. There is a document in Portuguese language from Quental Mendes, 1992, where small farming units are proposed with Jatropha hedges as an integral part of them, mainly for the boundaries between the fields and the farms (see annex 11).

• **The income situation in rural areas**

No general remarks about the income situation in rural areas can be made. But a description of the economy of soap production in different countries (see above) shows, that this production as part of an integrated approach is economically very interesting.

In Tanzania, the profit of 1 hour's work of soap making is more than 2 USD, which is a fantastic profit margin, if the income of a technical person working in a flower mill in the rural area is only 10 USD a month.

• **Availability of renewable energy in the rural areas** (household energy, fuel)

No general statement about the availability of renewable energy in rural areas can be made. Wood as a renewable household energy for cooking is very scarce in the Massai region of Tanzania. The interest to use Jatropha oil instead is very high.

KAKUTE developed a cooker for Jatropha oil, but the development is not yet completed.

In the Massai area between Lake Victoria and Iringa, a high density of Jatropha hedges are reported. In this region the potential of plant oil as a renewable energy source for cooking and lighting might be sufficient to supply the household needs. A detailed study has to verify this statement.

In Mali, in the regions of Jatropha use, the average village has a potential of 12 tons of seed, which is 2.400 litres of oil. This quantity of a renewable fuel is at least far enough to supply the village need for lighting and for flower milling, as well as for the electricity production for lighting of the dispensary and the school. It will be probably not enough for the energetic needs for cooking for the whole village.

But some of the villages have up to 40 km of Jatropha hedges, which represents a quantity of 6.400 litres of oil. This will probably cover all actual energy needs of the village.

Bosch-Siemens, a big German firm for household machines (washing machines, refrigerators, stirrers etc) is developing a plant oil cooker, which will be tested in the second half of 2004 in the Philippines. This cooker works perfectly with plant oil and should be sold for less than 30 USD, the head of the project stated.

• **Creation of small business units** (milling services, oil extraction services, entrepreneurs who buy seed and sell oil or products, soap making, etc.)

In Tanzania the ELCT is running a project, VYAHUMU TRUST, to produce edible oil from sunflower seeds to increase the income of the sunflower farmers (the oil is sold three times the price of the sunflower seeds). The extraction of the oil is organised as a service provided by small entrepreneurs who own a Sayari oil expeller (see photo page 14, Vyahumu Trust).

SUDERETA, a NGO of ELCT, supported by BftW, is going to run a project on solar lamps with a pure commercial approach. A book, Enterprise or Trust, describes this approach (see attachment 13).

The women's group of Engaruka can be regarded as a firm (30 members), which collects seed for sale, but started to process also the other steps of the production chain, oil extraction and soap making. In this way the whole added value stays within the village (see page 12).

The women's group of Mto Wa Mbu, described on page 11, forms such an economic unity, which buys oil and the other inputs, produces soap and sells it. Their organisational form is that of a women's group, not a firm. But it could be regarded easily as a "Enterprise of Trust".

SUDERETA is very much interested to start a pilot project for the utilisation of the Jatropha plant.

• **Local, regional, international markets** (availability of energy in the rural area changes the pattern of production, i. e. more edible oils may be produced, which improve the local diet and replace imported edible oils)

Up to now the Jatropha activities are locally based and have no effect to other regions. With the large plantation in Egypt (which will go into full production in 2007) this will change. Then oil may be traded as it is done now with edible oils.

South Africa tries to import seeds or oil in large quantities as raw material for the start of a Biodiesel production, until the own plantations will be able to produce.

Until now South Africa imported 5 tons of seed from Zimbabwe, and has a contract of 60 tonnes from Zambia.

To start the Jatropha plantation in Egypt, the project had to import about 15 tons of seed. The seeds came from India.

A German firm imported 500 l of Jatropha oil from Tanzania for engine tests.

Besides of the above-mentioned activities the author doesn't have any information about substantial trade of Jatropha seeds, oil or soap outside local markets.

5. CRITICAL ASSESSMENT OF THE JATROPHA SYSTEM, BASED ON FINDINGS

In the various African countries the utilization of this plant is spreading. In all the countries mentioned in this report, the plant is already there and the farmers use it mainly as live fences around homesteads, gardens and fields. Also the seeds are used in some countries in West Africa by women to produce soap in a traditional way.

Only since a few years many GOs and NGOs and private companies show interest in the possibilities, which the use of this plant can offer. 2 main aspects are predominant in the use of the plant:

1) NGOs working in rural areas are interested in the income generating possibilities by the utilization of the Jatropha plant, mainly for oil for soap making.
2) Some government organisations and private companies are interested in the energetic aspect by using Jatropha oil for the large scale production of Biodiesel. The carbon sequestration effect of Jatropha plantations seems to play an important role in the financing of these large projects.

Economic evaluation of these 2 ways of using Jatropha oil:

Soap production:

The economy of soap production is positive in all the cases were data were available.

In the case of Tanzania, were the most and the most recently collected data were available, the economy of soap production shows impressing profit. The profit changes within the different steps of the processing chain.

- The first step, the collection of seeds, shows the lowest income for 1 hour of work, only 0,29 USD per hour.
- The second step, oil extraction by the hand operated ram press, shows an income of 0,73 USD per hour, i. e. almost 3-fold the income of seed collection.
- The third step, the production of soap from the Jatropha oil, shows the highest profit, 2,82 USD per hour.

This third point explains, why the firm KAKUTE in Arusha, Tanzania, can exist by producing and selling Jatropha soap. Due to its Jatropha promotion activities they are able to buy cheap seeds in areas with high Jatropha potential. The women, who sold the seeds, are aware of the situation and decided, not to sell seeds anymore, but to process them, to oil and soap and sell that.

Jatropha oil as fuel:

Jatropha oil in Tanzania (Arusha, Engaruka, Mto Wa Mbu) is traded in small quantities for 2 USD per litre. This is 3-times the price of Diesel fuel at the filling station.

This means, it is economically not interesting to use Jatropha oil as diesel substitute. If somebody has Jatropha oil, he sells it to soap makers or produces soap himself, and buys diesel with the profit.

This is the reason, why KAKUTE offers lamps and cookers for the use of Jatropha oil, but this seems to be an alibi, and there is not much interest by the population. Petrol for lighting and cooking is cheaper, if it is available.

Jatropha plantations:

It is not clear, why governments (Egypt) and private firms (D1) are so much interested in producing Biodiesel with Jatropha oil. The author has not yet seen any economic calculation, which shows, that the Biodiesel from Jatropha oil might be cheaper than the diesel fuel.

It seems that these organisations prepare for a sharp increase of fossil fuel prices, and want to get the technology ready to produce renewable fuel. With higher fuel price, this seems economically viable.

The money received by selling Certified Emission Reductions is just a financial help to start such large. Jatropha plantations.

Gender Aspects:

- **Mali:**

Soap production with Jatropha oil, in Mali as well as in Tanzania, seems to be a very profitable activity. But in Mali there has not been a growth of this activity as expected. The seeds on the trees were not collected. The women used the technology (oil extraction and soap making), but only to a very limited extent. The reason seems to be the following:

The men own the land and therefore also the Jatropha hedges. The women collect the seeds and make soap. Traditionally this soap was just for the use in the family.

With the new technology (oil extraction), the women can produce a really good soap and sell it for a high price. They can "really" earn money. The men asked for part of the money, because the hedges are theirs. The women refused, so the men refused to give the women the right to collect the seeds from the hedges.

Now the women use the new technology only in a very small extend, just to produce the soap for the family. The possible economic impact has to wait until the socio-economic conditions allow the women to use the Jatropha seeds to the full extent and keep the money for themselves.

- **Tanzania:**

In Tanzania, the men are, as in Mali, the owners of the land and of the Jatropha hedges. And the women collect the seeds, extract the oil and make soap. But in Tanzania the women can keep the money for them. The men don't interfere. This is the reason why in Tanzania the utilization of Jatropha had much more impact in a short time (2 years) than in Mali (10 years).

As a conclusion, one can say, that there are no hints, that the following central hypothesis is wrong:

The Jatropha System creates a positive reciprocity between raw material/energy production and environment/food production.

i. e. the more seeds/oil Jatropha hedges produce, the more food crops are protected from animals and erosion. Also additional income is created, mainly for women.

It may still take some time, until the Jatropha System will contribute economically to the rural development in a large scale. But it seems that the activities of many different organisations more and more support the Jatropha approach.

6. NON TOXIC VARIETY RESEARCH

With N. Foidl, G. Oliver, B. Schmook, T. N. Bhandare, J. B. Pandey, M. Sujatha. Feeding studies on rats and fish established that the seed meal prepared from seeds collected from a wild variety of *Jatropha curcas*, which originated from Mexico is non-toxic. The protein, energy, lipid and amino acid contents in the seeds of the non-toxic provenance are similar to those of toxic varieties.

The meals contained significant levels of trypsin inhibitor, lectin and phytate, and their levels did not differ between the non-toxic and toxic varieties. Absence of phorbol esters in the seeds of non-toxic variety from Mexico suggests that one of the toxic principles in meals from toxic varieties is phorbol esters. Phytate constitutes a major single anti-nutritive component of *Jatropha* meals, which is not heat labile and can have adverse effects, whereas other anti-nutritional factors like trypsin inhibitors and lectins can be destroyed by heat treatments.

The non-toxic variety of *Jatropha* from Mexico can be a suitable alternative to the toxic *Jatropha* varieties. This non-toxic variety of *Jatropha* could be a potential source of oil for human consumption, and the seed cake can be a good protein source for humans as well as for livestock. Keeping in view the advantages of the non-toxic variety, the seeds of this variety have been sent to Nicaragua, Zimbabwe, Mexico and India for cultivation through traditional and tissue culture techniques and comparison for yield, resistance to diseases, survival and nutrient requirements with the toxic varieties of the region.

Co-operation:

- Sucher & Holzer, Projekt Biomasse
- Managua University, Managua, Nicaragua
- Plant Oil Producers' Association, Harare, Zimbabwe
- Co-op Agro Forestry Federation, Nashik, India
- CIQRO, Mexico
- Central Salt and Marine Chemicals Research Institute, Bhavnagar, Gujarat, India
- Oil Seeds Research Institute (ICAR), Hyderabad, India

Edible provenances of *Jatropha curcas* from Quintna Roo state of Mexico and effect of roasting on antinutrient and toxic factors in seeds H.P.S. Makkar, K. Becker and B. Schmook[1]

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ABSTRACT

Seven seed samples of *J. curcas*, both in raw and roasted state, sold in some villages in Quintana Roo state, Mexico for human consumption were analysed for physical characteristics, nutrients and antinutrients. The average seed weight varied from 0.53 to 0.74 g and kernel weight as proportion of raw seed weight was from 61 to 66 %. The contents of crude protein, lipid and ash of kernels from raw seeds were 27 - 30 %, 55 - 62 % and 3.7 - 5.2 % respectively.

The levels of antinutrients in meal from the raw seeds were: trypsin inhibitor activity (14.6 - 28.7 mg trypsin inhibited/g), lectin (25.6 - 52.2 unit; one unit is the reverse of minimum amount of mg meal/ml assay which produced haemagglutination), saponins (1.9 - 2.3 % as diosgenin equivalent) and phytate (8.4 - 10 %).

Phorbol esters in kernels from raw seeds were not detected in four samples and in other three samples it ranged from 0.01 to 0.02 mg/g as phorbol-12-myristate 13-acetate equivalent. Roasting of seeds inactivated almost 100 % of trypsin inhibitor activity. Although lectin activity reduced on roasting, it was still present in high amounts. Saponins, phytate and phorbol esters were not affected by roasting.

Key words: ***Jatropha curcas, roasting, lectin, trypsin inhibitor, phorbol esters, non-toxic jatropha***

INTRODUCTION

Species of the genus *Jatropha* are known to be very toxic. *Jatropha curcas*, also known as "physic nut, purging nut, big purging nut, American purging nut, pinoncillo, Habb-El-Meluk, black vomit nut depending on the region is a member of the Euphobiaceae family. In Mexico it is known as pi๐on or pioncillo by the people living or coming from Veracruz state, or as sikil-t̆ by the Mayas in Yucatan Peninsula.

The Mayan families usually have one tree in their gardens whereas some people from Veracruz plant it as living fences around their garden or fields [1]. It is a shrub or small tree which can reach a height of up to 8 m. The plant grows quickly, survives in poor stony soil and is resistant to drought. It is considered to have originated in Central America but presently grows in most of the tropics [2].

The seeds of *J. curcas* are a good source of oil. Although the seed cake (meal) is rich in protein, it is toxic to rats, mice and ruminants and, therefore, can not be used as an animal feed. Several cases of *J. curcas* nut poisoning in humans after accidental consumption of the seeds have been recorded. Symptoms such as giddiness, vomition and diarrhea have been reported [3].

Recently the nutritive potential and toxic characteristics of different provenances of *J. curcas* were investigated. A mixed sample of seed obtained from different trees in the Papantla region of Veracruz state in Mexico were found to be non-toxic. Phorbol esters were present in minute amounts in kernels of this mixed sample of seeds, but trypsin inhibitor, lectin and phytate were present in significant amounts, and their levels were similar or higher to those in toxic varieties. The nutritive value of meal from the non-toxic provenance, derived from the chemical composition, was similar to the toxic varieties and compared well with those in some conventional seed meals [4].

In another part of Mexico (Quintana Roo state; approximately 1200 km southeast from Veracruz state), like in Veracruz state seeds of *J. curcas* after roasting are also consumed by humans. The consumption of raw seeds is considered to produce cramps and uneasy feeling in stomach. The objectives of the present investigation were to evaluate the levels of various antinutritional and toxic factors present in seeds obtained from Quintana Roo state compared to those from Veracruz state, and to study the effects of roasting on antinutrional and toxic factors.

MATERIALS AND METHODS

The raw and roasted seeds of *J. curcas* were purchased from 7 different farmers in the state of Quintana Roo. These farmers either eat or sell the roasted seeds for human consumption. Samples NC 5 and NC 6 were from Sac-xan village, and NC 9, NC 16, NC 45, NC 50 and NC 51 from Sergio Butron, Cocoyol, Francisco Botes, Ramonal and Juan Sarabia villages, respectively. All these villages are in Othon P. Blanco municipal area of Quintana Roo state in Mexico.

The altitude of these places is 0 m from the mean sea level. The mean temperature lies between 24ฐ - 26ฐ C and the annual rain fall between 1200 mm and 1500 mm. There is no standard procedure for roasting the seeds. The seeds are generally roasted on an iron plate (30-40 cm diameter) kept on an open fire; the temperature of the hot plate is difficult to ascertain. The seeds (50 to 80 in number) are roasted at one time for about 15 minutes with several turnings of seeds with the help of a wooden spoon.

The crude protein (CP; N x 6.25), lipid (L) and ash were determined using the AOAC [5] procedure. In the seed meal (kernels de-oiled using petroleum ether of bp 40-60 ฐ C), tannins, trypsin and amylase inhibitors, saponins, and phytate were analysed by methods described by Aderibigbe et al. [6], cyanogens and glucosinolates by Makkar and Becker [7] and lectin by a haemagglutination test in which agglutination of trypsinized cattle erythrocytes is determined by the meal extract diluted sequentially two-fold [8]. The method of Makkar et al. [9] was used for determination of phorbol esters.

All analyses were conducted at least in duplicate by taking a representative sample of each provenance. The values reported are average of two values. The individual value did not deviate from the mean by more than 5 %.

A handful of seeds (8 - 10 in number) was taken from each raw or roasted sample. The weight of each handful of seeds and the number of seeds in it were used to calculate the average weight of seed. Average kernel weight as per cent of seed weight was calculated by removing shells carefully and recording the weights of kernels and shells.

RESULTS AND DISCUSSION

Physical characteristics of seeds are presented in Table 1. The average weight of raw seeds varied substantially (0.53 to 0.74 g), but the kernel weight as proportion of raw seed weight did not vary to the same extent (61 - 66 %). Amongst the samples investigated, the seed weight of only one tree (NC 45) was higher than that of the non-toxic provenances (mixed sample) from Veracruz state (0.74 vs 0.65 g), and the kernel weight as a proportion of the raw seed weight was slightly higher for only one tree (NC 5; 65.5 vs 63.5 %) [4].

The higher average weight of raw seeds compared to the roasted, and the higher kernel weight as a proportion of the total seed weight for the roasted seeds was due to loss of water from the seeds during roasting, more so from the shells (Table 2). The color of seed-shells and kernels after roasting varied from light brown to dark brown, and the taste was similar to roasted peanuts.

The contents of crude protein, lipid and ash in kernels from raw seeds ranged from 27 to 30 %, 55 - 62 % and 3.7 - 5.2 %, respectively (Table 2). These values are higher than or similar to those in kernels of the non-toxic provenances from Veracuz State [4].

Trypsin inhibitor, lectin, saponins, phytate and phorbol ester contents are shown in Table 3. Except for sample NC 45, trypsin inhibitor and lectin activities in meal from raw seeds were lower than those in meal from the non-toxic provenance from Veracruz State. Saponins and phorbol esters levels from raw seeds were also lower in samples of this study. On the other hand, phytate levels were either similar or higher by 1 % unit [4]. Roasting of seeds almost completely inactivated trypsin inhibitor activity and decreased lectin activity.

For all samples except NC 51, roasting decreased lectin activity slightly; for meal-extract from roasted NC 51 seeds agglutination was observed at two dilutions lower compared to raw meal, and for other samples agglutination was observed at a dilution one lower (Table 3). Roasting was not very effective in decreasing lectin activity in the seeds. It is interesting to note that phorbol esters, the main toxic agents for jatropha toxicity [3] were not detected in four seed samples and in the other three samples their levels were lower than in those from the non-toxic provenances from Veracruz.

Roasting did not affect saponin, phytate or phorbol ester levels (Table 3). In addition to lowering of heat-labile antinutritional factors such as trypsin inhibitors and lectins, heat treatment should increase protein digestibility [6].

Conclusions: The edible (non-toxic) varieties of *J. curcas* are restricted not only to Veracruz State in Mexico but are present in Quintana Roo state too. The seeds collected from Quintana Roo state seem to be of better quality as levels of protein, lipid and ash are higher and antinutritional and toxic factors lower in most samples investigated. Roasting of seeds as employed by farmers does not inactivate lectin activity completely and therefore consumption of seeds at higher amounts might produce adverse effects. Wide variation exists in levels of nutrients and antinutrients in seeds of edible provenances, which offers promise in selection of seeds and their large scale multiplication using conventional breeding approaches or tissue culture based techniques. This is likely to improve food security in various tropical countries by providing edible oil, and roasted nuts and seed cake - good sources of protein supplement for both humans and animals.

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Table 1. Physical characteristics of *Jatropha curcas* seeds

Sample	Average seed weight (g)	Kernel wt. (% of seed wt.)
NC 5 raw	0.60	65.6
NC 5 roasted	0.59	66.7
NC 6 raw	0.57	61.2
NC 6 roasted	0.53	64.6
NC 9 raw	0.62	63.1
NC 9 roasted	0.61	65.0
NC 16 raw	0.59	63.5
NC 16 roasted	0.59	64.1
NC 45 raw	0.74	61.9
NC 45 roasted	0.71	62.2
NC 50 raw	0.63	64.1
NC 50 roasted	0.61	65.0
NC 51 raw	0.64	62.1
NC 51 roasted	0.62	62.5
A mixed sample of raw seeds from different trees from Veracruz [a]	0.65	63.5

a, Makkar et al. [4]

Table 2. Chemical composition of kernels

Sample	Dry matter of kernel (%)	Crude protein[a] (%)	Lipid[a] (%)	Ash[a] (%)
NC 5 raw	91.7	27.3	59.2	4.7
NC 5 roasted	94.9	26.8	61.4	5.2
NC 6 raw	92.3	29.0	55.3	5.2
NC 6 roasted	94.9	28.6	55.8	5.2
NC 9 raw	93.7	28.4	60.7	4.0
NC 9 roasted	95.7	26.3	62.2	3.6
NC 16 raw	93	29.5	56.4	5.2
NC 16 roasted	93.3	28.9	59.5	5.1
NC 45 raw	92.4	26.8	61.7	4.3
NC 45 roasted	95.5	26.1	59.7	4.6
NC 50 raw	92.5	28.0	61.4	3.7
NC 50 roasted	94.9	27.9	60.1	4.4
NC 51 raw	91.5	29.7	61.2	4.3
NC 51 roasted	95.1	28.2	61.3	4.3
Raw kernel (edible) from a mixed sample of seeds from different trees from Veracruz [b]	94.2	27.2	58.5	4.3

a, Data are on dry matter basis, b, Makkar et al. [4]

Table 3. The levels of trypsin inhibitor, saponin, lectin and phytate in meal (oil-free) and phorbol esters in kernel

	Sample				
Item	**Trypsin inhibitor activity in meal[a]**	**Lectin activity in meal[b]**	**Saponin in meal[c] (%)**	**Phytate in meal (%)**	**Phorbol esters in kernels (mg/g)[d]**
NC 5 raw	14.6	25.6	2.3	9.3	nd
NC 5 roasted	nd	12.8	1.9	10.7	nd
NC 6 raw	15.1	25.6	2.2	9.2	0.02
NC 6 roasted	nd	12.8	2.3	9.6	0.01
NC 9 raw	22.3	25.6	1.7	8.7	0.01
NC 9 roasted	0.7	12.8	1.8	9.3	0.01
NC 16 raw	15.1	25.6	1.8	9.7	0.01
NC 16 roasted	nd	12.8	2.5	9.8	0.015
NC 45 raw	28.7	52.2	1.9	9.7	nd
NC 45 roasted	0.5	25.6	2.1	10.1	nd
NC 50 raw	21.1	25.6	2.1	8.4	nd
NC 50 roasted	0.6	12.8	2.1	9.1	nd
NC 51 raw	24.8	25.6	1.9	10.0	nd
NC 51 roasted	nd	6.4	1.9	10.5	nd
Raw kernel (edible) from a mixed sample of seeds from different trees from Veracruz [e]	26.5	51	3.4	8.9	0.11

nd, not detected; a, mg trypsin inhibited/g; b, [1/(minimum amount of meal in mg/ml assay which produced haemagglutination)]; c, diosgenin equivalent; d, phorbol-12-myristate 13-acetate equivalent; e, Makkar et al. [4]

Editorial Office: Plant Foods for Human Nutrition, Kluwer Academic Publishers, Achterdom 119, P.O. Box 990, 3300 AZ Dordrecht THE NETHERLANDS

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8. ATTACHMENTS :

Annex 1 - ToR of Jatropha Case Study

Case Study „Jatropha curcas L."

Assessment of the impact of the dissemination of "the Jatropha System" on the ecology of the rural area and the social and economic situation of the rural population (target group) in selected countries in Africa, Asia and Latin America.

Objectives of the case study:

As indicated in the study of Dr. Heller in the IPGRI-publication "Physic nut – Jatropha curcas L. Promoting the conservation and use of underutilized and neglected crops", Jatropha curcas has the potential of an important role in integrated rural development.

7 years after the publication of that study it would be important to see in practice, if the development potential of that crop can be directed into rural development, or if there are serious unforeseen difficulties (side effects), which oppose to the dissemination of this approach for sustainable rural development.

Worldwide there are many NGOs and national and international organizations, which adopted the Jatropha System to integrate it into their activities. The experiences of these organisations should be evaluated to compare the real development impacts with the predicted ones.

This case study should evaluate the impact of the production and use of Jatropha oil on the ecological situation of the rural area and the social and economic situation of the rural population.

Study outline:

1. Description of the plant, distribution, ecology, uses

2. Description of the Jatropha-System

3. Jatropha promotion in selected countries
   Africa: Mali, Sudan, Cape Verde, South Africa, Zambia, Zimbabwe, Tanzania
   Asia: India
   Latin-American: Nicaragua,

4. Impacts of the promotion of the use of Jatropha

4.1 Social impacts e.g. on:

• gender issues (who does the work, who gets the money, changes of the distribution of the workload, changes of the social status?)
• people without own farm land (accessibility of seed, Jatropha in public forests for free collection);
• other social issues, like cultural/religious traditions (in some countries women are not allowed to own trees or farm land), or indigenous knowledge

4.2 Ecological impacts e.g. on:

• biodiversity and on the genetic diversity of the Jatropha species
• erosion and the desertification process
• rehabilitation of degraded land

4.3 Economic impacts e.g. on:

• household income (sale of seeds, production and sale of oil, production and sale of soap);
• household food security (Jatropha is grown in form of hedges to protect food crops)
• farming systems (integration of Jatropha into the farming calendar, Jatropha as integrated part of the farm design)
• the income situation in rural areas
• availability of renewal energy in the rural areas (household energy, fuel)
• creation of small business units (milling services, oil extraction services, entrepreneurs who buy seed and sell oil or products, soap making, etc)
• local, regional, international markets (availability of energy in the rural area changes the pattern of production, i. e. more edible oils may be produced, which improve the local diet and replace imported edible oils)

Annex 2 - Jatropha in Ghana

Jatropha activities in Ghana

Since 2002, **Jatropha Hamburg** is the German cooperation partner of the **Anuanom Biodiesel Project** in Ghana. Though being a private enterprise initiative, the long-term socio-economic benefits of the Anuanom project have been recognised by the Ghanaean government. The production of bio-energy will have various positive effects for Ghana: the country has no petroleum resources. The necessary importation of fossil fuels is a constant socio-economic effort, which has the same well-known effects as in other developing countries without petroleum: fuel shortage, high trade deficit, foreign indebtedness, lack of foreign exchange. At the same time, the lack of income perspectives in rural regions tends to increase the migration from the land to the cities, creating idle farmland on the one hand, growing poverty populations in cities on the other hand. The familiar picture.

The Ghanaean government supports this project, because it will generate income for rural regions and, in the long run, will reduce the dependency on petroleum imports at the same time. The ministries of agriculture and energy, as well as the Presidential Office have documented their interest in the development of the project in written statements. In practice this means that authorization procedures are accelerated, and a purchase commitment is granted to the producers of Biodiesel, which means the nation-wide marketing will be handled by the state.

Current State of Development and Planning Cultivation of Jatropha curcas L. Anuanom operates a pilot plantation of ca. 100 ha which currently serves the production of Jatropha seeds. A highly productive variety bearing nuts with an oil content of 60-67% is raised here. The seeds are delivered to farmers in the country, who want to participate in the production of Jatropha curcas L.. Since 2000, an incentive program promotes the cultivation of Jatropha curcas.

This agricultural program is granted international support by ADRA, an American NGO, as the organization in charge, and by the UNDP co-financing it with 50.000 USD. The Ghanaian Ministry of Agriculture backs up with personnel who promote Jatropha curcas L. in meetings with rural Local Assemblies giving information and training around the cultivation of the plant. Up to the present (May 2002) a total of ca. 2000 ha has been planted in Greater-Accra-Region, Eastern Region and Western Region. The planted area is increasing by the week.

The growth rate of plantations is expected to be boosted during 2003, when the processing production starts as planned, and the first harvest deliveries prove to yield cash income for growers. Up to 2004/2005, an increase of the total cultivating area to 250.000 ha is planned. This would be around a quarter of the total idle farmland in Ghana.

Products and Markets

Oil is won from the Jatropha nuts by cold-pressing. A part of it can flow back into the production process as generator fuel, or can be marketed as fuel. It is planned for the future to generate electricity for the local energy market.

Biodiesel is won by esterfication of the oil with **ethanol**. Ethanol – unlike methanol, which is a petroleum product and would have to be imported – can be won from local agricultural products as sugar cane. The centralized nation-wide marketing of the Biodiesel is done by the Ministry of Energy. This appears to make sense for Ghana, because the petroleum importation is governmental, too. However, the project operators maintain the right to market an unlimited quantity of Biodiesel on their own.

Glycerine, the by-product of the esterfication process, is to be purified and can then be sold on an extensive market. During the first stage, the demand in Ghana will be sufficient to buy the entire production. The market price is 500-600 USD/tonne.

The **press cake** is modified and sold as **biological fertilizer**, also primarily on the local market; but import agents from neighbouring countries in West Africa, such as Nigeria, have already confirmed their interest to be supplied. **Production and Plants** In 2003, the Anuanom project will enter a critical stage. The agricultural program will then deliver its first harvested production. The first production unit must be built up by then, and the money must be ready to be paid to the growers.

As far as possible, manufacturers in Ghana will be taken as contractors to build the plant. For technical reasons, some of the components are to be manufactured in or bought from Europe:

- Oil-presses: stamping presses operating with 70-100 tons of pressure are needed for the cold-pressing of the Jatropha nuts. Minimum capacity: 50 tons of nuts/day, equivalent of the expected harvested quantity of ca. 1000 tons/month during 2003/2004.

- Stainless steel tank with mixer for the production of Biodiesel; capacity: 10.000 l. Currently we are checking the market for used equipment fit for the purpose, e.g. from the dairy industry.

- Distilling plant for ethanol; capacity: 200 tons of distillate/month = ca. 6-8 tonnes/day.

- Purifying plant for glycerine.

Financing Apart from the UN grant for the agricultural incentive program, the pre-production development of the project has been entirely financed with private resources by the project operators. A World Bank loan of 2 million USD has been signed and confirmed, the payment of which will be released by 2005. 2 million USD is the estimated investment needed to put up the first production unit and start operations in 2003. Our initiative group in Hamburg cooperates closely with an Austrian consulting team in order to secure the knock-on financing of the Anuanom project. This involves the application for governmental grants from EU development funds as well as contacting prospective private investors here. For a private engagement, an interest in a long-term investment would be essential.

Provided agricultural production goes on spreading as planned, the project will reach its second stage in 2004/2005. This will make investments of ca. 10 million USD for further production units necessary.

Annex 3 - BUN Zimbabwe

PLANT OIL PRODUCTION AND UTILISATION (extract from BUN Zimbabwe newsletter)

The Plant Oil Project was successfully initiated at Makosa Mutoko, Zimbabwe in 1996 by BUN-Zimbabwe. Funded by the Rockefeller Foundation, Australian Agency for International Development (AusAid) and the Royal Netherlands Embassy, the plant oil project is expected to provide income, provide alternative manure and be an ecologically friendly source of alternative energy to rural farmers. Makosa is fortunate to have the oil plants in abundance. The plants have traditionally been used as a live fence or hedge around homesteads and gardens and are called "*jirimono*" in several parts of Zimbabwe.

The objectives of the project are the utilization of the *Jatropha Curcas Linn* (JCL) plant (*physic nut in English*) as a source of oil for use as fuel for domestic and industrial purposes, and finding other uses of JCL. BUN originally facilitated the acquisition of three oil expellers (two manual, one motorized) from local manufacturers for processing the seed into oil. The oil is intended to be used in soap making and to a lesser extent in lamps for lighting purposes, substituting paraffin which is the usual lighting fuel in rural homes.

The residue from the seed cake, which is a good organic fertilizer, is under investigation, with promising initial results.

The community has received training in the use of the oil expeller and oil extraction is in progress at Makosa. In addition six women from the community underwent training in soap making. After training they formed a soap making group and it has shown early signs of viability. The soap which lathers well, is of good quality and cheaper than most soap.

Since the establishment of the venture, it has provided the community and other surrounding areas with laundry soap. The women's group has opened a savings account with a commercial bank in Mutoko. Improvements in soap quality are still underway, backed up by tests on samples sent to the Standards Association of Zimbabwe.

Lamps to utilize JCL oil as a fuel have been designed which have a lower fuel burning rate than paraffin lamps. The lamps operating on different wick mechanisms are easy to make.

The trial use of JCL cake as an organic fertilizer was successful in 1998, showing the value of the cake as manure. Trials will be conducted to determine the optimum application rate.

It is hoped that as the demand for JCL oil grows, more people will grow the hedges, contributing to income generation through sale of seeds, and improvement of the environment. The project is expected to grow and become a more commercially oriented venture owned by the community. The Project hosted 19 Zambian trainees (farmers, NGOs and civil servants) sponsored by GTZ Zambia, and numerous Zimbabwean and international visitors and trainees.

JCL Oil Press based on Sundhara design JCL Oil Press installed at Makosa in 1999 by BUN (*Photo BUN 99*)

One maize field showing the impact of JCL press cake applied to the portion on the left hand size vs. cow dung on the right side. (*Photo BUN 1999)*

Annex 4 - Environnent Africa

Environment Africa - Victoria Falls Branch Planting of hedges in urban areas

One community group of five members representing both men and women has started up planting Jatropha curcas in the urban areas of Chinotimba, Victoria Falls. The group use both seedlings and cuttings of Jatropha. The seedling are raised in own nurseries and the cuttings are collected from existing fencing material in the neighbourhood. Jatropha is mainly planted on marginalized soil i.e. unused public areas and schools areas for fencing. The group involves the children and the teachers from local schools in the planting project and use the project as a teaching lesson for the children to raise awareness of the environment and to take ownership of the trees. The management and care of the plants is organized between the user group and administration of the School.

Distribution of seeds to rural areas

Another Jatropha project involves the distribution of Jatropha seed to ten primary schools in rural areas in Hwange North. Every school is giving 2000 seeds of Jatropha and also some containers for planting the seeds. The intension is to commit the children and the schools to start making nurseries and afterwards either sell or plant the seedlings in the areas close to the school.

The idea is that Environment Africa in future will buy the seedling from the schools for about 200 $ each and sell them as Tree Tickets. Tree Tickets is a concept where foundations or individuals can donate trees to a local rural area selected by the donor. Environment Africa will facilitate the planting and management of the trees.

The school can also choose to plant the seedlings later, harvest the seed and then sell them to Environment Africa for oil extraction. It's the plan to start oil extraction at Chidobe Information and Research centre for demonstration and commercial production. At the moment Hlanganani Oil Pressing and Peanut Butter Making group has been donated a Bielenberg ram presser by DED.

At the moment 12000 Jatropha seeds have been distributed in Hwange North.

An agreement with hotels etc regards collection of used water bottles. The bottles are used for water dripping system in the nurseries and as planting containers.

Planting Jatropha in plantation

In the rural area 1 hectare planted with Jatropha (*Jatropha curcas*) mixed with other oil species as Moringa (*Moringa oleifera*) and Neem (*Azadirachta indica*) are going to be initiated as research plot for further investigation. The plantation is going to be based on seedlings only.

Jatropha cuttings

Planting of Jatropha seeds

Planting of Jatropha cuttings

Annex 5 - Jatropha KwaZulu-Natal

Emerald Oil International (Pty) Ltd. t/a Biodiesel africa
From the desk of BerndSchmidt

Exploratory Mission

The purpose of the mission to explore the level of Jatropha Curcas cultivation and the assessment of the capacities for and on behalf of the Department of Trade and Industry (dti) in KwaZulu Natal.

On Wednesday 17th. And Thursday 18th.of December, Mr. Andre Kudlinski from DTI and Mr. Bernd Schmidt from Biodieselafrica, visited amongst others Jatropha farms and institutions in KZN. We travelled about 800 Km. by Automobile.

At the first meeting on Wednesday morning in Durban with Dr. Sid Kelly, Chief Executive Officer of the Richards Bay Industrial Development Zone (IDZ) Mr. Kelly has informed us, that the City of Richards bay is promoting the growing of Jatropha Curcas on farmland of 4000 ha. in size, to demonstrate, that the City is standing behind the Bio Diesel project in Richards Bay. Funding made available by IDC.

Our Journey is heading north 200 Km. to Empangeni to visit the Owen Sithole Agricultural College a Institution of the Department of Agriculture and Environmental Affairs (DAEA) under the management of Mr. Joseph Foli. This institute is involved in the growing of Jatropha and has been designated as the training facility for the farmers of the vicinity.

Further North (180Km.) We visited the Agricultural research Centre of the DAEA near Jozini at the Makatini Flats. This visit was quite impressive; the research centre has produced a few thousand Jatropha seedlings that are ready for distribution to the farmers in this area. Their experimental plantation of Jatropha with some trees 18 months old, already producing large amount of seeds. Tree size about 1.50 meter height. The amount of seed approximately 2.5 Kg. per tree. Photo material on hand.

We also met with local (Mtubatuba and Makatini Flats) farmers representatives involved in the Jatropha project. We where informed, that a large amount of small-scale farmers are already producing Jatropha.

Unfortunately, we ran short of time so we couldn't visit the largest (5 hectare) private plantation of Jatropha in the Mtubatuba area. Nor could we visit the plantation of the DAEA at Eshowe.

Mr. Kudlinski has recognised the urgent need for funds to start coordinated training of Jatropha farmers and to finance the production and distribution of seedlings as well as the purchase of additional seed.

The many tonnes of Jatropha seed, available until now in South Africa have been made available to the farming community exclusive by Mr. Bernd Schmidt.

Mr. Kudlinski will incorporate his comments and findings from our visit into the Biodiesel project status report that should be ready by mid- January 2004.

Report by: Bernd Schmidt 19 December 2003

Annex 6 - Wiemer, Summary of Economic Analysis

3. Summary and conclusions

In the context of encouraging the use of plant oil as a biofuel, the *Deutsche Gesellschaft für Technische Zusammenarbeit* (GTZ), in close collaboration with the *Centre National de l'Energie Solaire et des Energies Renouvelables* (CNESOLER), undertakes a pilot project in Mali, West-Africa. The aim of the project („*Projet Pourghère*") is to verify the technical, social, financial and economic feasibility of an integrated approach with Jatropha trees (*Jatropha curcas L.*) and - if successful - disseminate the approach on a larger scale. The integrated approach (the „Jatropha System") implies, inter alia, planting the trees in the form of hedges, organizing on village level the harvest and pre-processing stages of the seeds, gaining the Jatropha oil and all by-products in a small scale hand-operated or motor-driven oil mill, and finally studying and influencing market conditions in a way that the sale and the use of all these products becomes financially viable for all the target groups concerned.

The approach is a rather complex system with various agro-ecological, social, financial, meso- and macro-economic effects. Therefore, one component of the project is a monitoring and evaluation system (M&E) to measure and steer the impact of project activities and, wherever possible, to express the most likely effects of the system in monetary terms. The continuous measurement of the parameters defined in the M&E has provided most of the empirical data used as inputs for the feasibility calculations discussed in the present report.

The calculations for the hand-operated Bielenberg press indicate that the extraction of Jatropha oil with this equipment is not financially feasible under field conditions in rural Mali. The assumptions and the results of the feasibility calculations for the engine-driven Sundhara press are summarized in Table 5 (below). The upper half of the table refers to the press being driven by a Lister type engine, the lower half refers to the project being equipped with a more solid Hatz motor. In the first version, the equipment is a grant of the project, the latter case represents strict commercial conditions. The results of the financial analyses indicate that for the Lister version an internal rate of return on investment (IRR) of 49 % can be projected. For the Hatz version, the profitability of the oil mill is lower (26 % IRR) due to the more expensive equipment, but also carries a much lower risk of mechanical breakdowns.

Depending on the interpretation which of the above mentioned effects may be included as direct effects and which ones have to be considered as indirect effects, the economic profitability of the „Jatropha System" as indicated by its economic rate of return (ERR) varies between negative figures and very high positive ones. The negative results are based on the obviously false assumption that the decentralized availability of the Jatropha oil in remote villages may be entirely ignored, which is to ignore the economic value of the local costs of transport of diesel fuel from the border of Mali to these villages. Taking this fully into account, the economic viability of the „Jatropha System", on meso and macro level, is very satisfactory for both engine types, even if all other indirect effects are ignored. This would mean, in conclusion, that the production of Jatropha oil is very competitive with the import of diesel fuel and that the approach merits further assistance and the dissemination on a larger scale.

Tab. 5: Profitability of the "Jatropha System"

Technology (version)	Inputs/assumptions: direct effects	Inputs/assumptions: indirect effects	Results: financial profitability (% IRR)	Results: macro-economic profitability (% ERR) without indir eff..	Results: macro-economic profitability (% ERR) including indir eff..	Results: meso-economic profitability (% MERR) without indir eff..	Results: meso-economic profitability (% MERR) including indir eff..
Sundhara/Lister (effects1)	economic value Jatropha oil = weighted border price CIF, diesel = 102 F/l	2/3 of Jatropha oil used for soap prod. value added: 450 F/l 1/3 of Jatropha oil used as fuel, value of local transport 60 F/l	49	(- 22)	176		
Sundhara/Lister (effects2)	economic value Jatropha oil = weighted border price CIF, diesel, + 1/3 of internal transport = 122 F/l	2/3 of Jatropha oil used for soap prod. value added: 450 F/l 1/3 of Jatropha oil used as fuel, value of transport = 0	49	3	184		
Sundhara/Lister (effects3)	economic value Jatropha oil = weighted CIF price, diesel, + 100% of internal transport = 162 F/l	100% of Jatropha oil used as fuel, value of transport = 0	49	33	135		
Sundhara/Lister (effects4)	meso-economic value Jatropha oil = see Table 4 >>> 289 F/l	see effects 2	49			129	351
Sundhara/Hatz (effects1)	economic value Jatropha oil = weighted border price CIF, diesel = 102 F/l	2/3 of Jatropha oil used for soap prod. value added: 450 F/l 1/3 of Jatropha oil used as fuel, value of local transport: 60 F/l	26	(- 11)	109		
Sundhara/Hatz (effects2)	economic value Jatropha oil = weighted border price CIF, diesel, + 1/3 of internal transport = 122 F/l	2/3 of Jatropha oil used for soap prod. value added: 450 F/l 1/3 of Jatropha oil used as fuel, value of transport = 0	26	0	112		
Sundhara/Hatz (effects3)	economic value Jatropha oil = weighted CIF price, diesel, + 100% of internal transport = 162 F/l	100% of Jatropha oil used as fuel, value of transport = 0	26	17	80		
Sundhara/Hatz (effects4)	meso-economic value Jatropha oil = see Table 4 >>> 289 F/l	see effects 2	26			62	172

Annex 7 - Economic analysis of JCL utilization in Tanzania

Economy of Jatropha Utilization in Tanzania

Data from KAKUTE, 2003

Collection of seeds: (figures from KAKUTE, 2003)

Collection of seeds: 2 kg in 1 hour
Sale of seeds: 150 TZS per kg

Value added for 1 hour work	**300 TZS**	**0,29 USD**	**per hour**

Oil extraction: (figures from KAKUTE, 2003)

5 kg of seed for 1 litre of oil is 1,7 hours of work
1,0 hours of work to extract 1 litre of oil

Input:	5 kg of seed	750 TZS	0,71 USD	per litre
	1,5 hours of work to extract 1 litre of oil			
	depreciation of ram press 0,02 USD / kg			
	for 5 kg:	105 TZS	0,10 USD	per litre
Output:	Sale of 1 litre of oil	2.000 TZS	1,90 USD	
Value added for 1 hour work		**1.145 TZS**	**1,09 USD**	**per hour**

Soap making: (figures from KAKUTE, 2003)

16 hours work for 252 bars of soap
1 bar sold for 500 TZS
Purchase of 20 litres of oil à 2.000 TZS = 40.000
Purchase of 3 kg of Caustic Soda à 2.000 TZS = 6.000 TZS
Plastic for wrapping soap = 3.000 TZS
10 hours for miscellaneous work (organising purchase of oil, wrapping the soap, etc)

Input:	20 l oil	40.000 TZS	38,10 USD
	Plastic	3.000 TZS	2,86 USD
	Caustic Soda	6.000 TZS	5,71 USD
	Total input for 26 hours work	49.000 TZS	46,67 USD
Output:	252 bars à 500 TZS	126.000 TZS	120,00 USD
Total of revenues		77.000 TZS	73,33 USD
Value added for 1 hour of work		**2.962 TZS**	**2,82 USD**	**per hour**

Annex 8 - Economy of Jatropha utilization in Zambia

6. *Economy of Jatropha exploitation*

At village level, the economy of the exploitation of the Jatropha plant is mainly a question of labour costs, since almost no investments are necessary. Therefore the economic calculation is only an approximative one, since the real time for seed collection or oil extraction in Zambia is not yet known. The following calculations are based on datas from Mali . Labour costs were provided by the Zambian Agrobusiness Technical Assistance Centre (ZATAC).

The following calculations show, that the economic interesting part of the Jatropha system is not the seed production with the sale of seeds, but the processing of Jatropha seeds and the sale of the final product: **soap.** In this case the whole added value is produced at village level. And this is the place where income is needed.

6.1 Economy of oil production

Description	Quantity	Unity	Price per unit	Amount in K
Seeds	15	kg	**500**	7.500
Labour oil expelling	6	hours	400	2.400
Depreciation of Yenga press per kg, 5a, 2t/a, 450.000 K,			75	1.125
Total input for 3 litres of oil				11.025
Price of Oil	**1**	**litre**		**3.675**

In this calculation the price for the seeds is fixed to a relative high value of 500 K, as well as the amount of labour for extracting the Jatropha seeds. After the experiences in Mali, a trained team was able to produce two litres of oil per hour.

The price of the seeds is mainly the price of labour to collect them. In Mali the result of a test was 3 kg of seeds per hour. If only 1,5 kg per hour and a salary of 400 K per hour are calculated, the price for seeds drops to less than 300 K. In this exceptional condition the oil may be produced for less than **3.000 K**.

It is obvious, that at such a price is a prohibitive one for the use of Jatropha oil as a diesel substitute. Only under special conditions, for instance when no diesel fuel is available, Jatropha oil might be used as diesel substitute.

6.2 Economy of soap production

The economy of soap making depends much on the price of seeds. Here are two examples with a price of 500 and 1.000 K per kg of seeds.

Description	Quantity	Unity	Price per unit	Amount in K
Seeds	15	kg	500	7.500
Oil	3	litres		
Caustic soda	0,5	kg	4500	2.250
Labour oil expelling	6	hours	400	2.400
Labour soap making	4	hours	400	1.600
Depreciation of Yenga press per kg, 5a, 2t/a, 450.000 K,			75	1.125
Water	3	litres		
Total input for 60 pieces of soap of 100 g				14.875
Price of Soap	**1**	**piece**		**248**

Description	Quantity	Unity	Price per unit	Amount in K
Seeds	15	kg	1000	15.000
Oil	3	litres		
Caustic soda	0,5	kg	4500	2.250
Labour oil expelling	6	hours	400	2.400
Labour soap making	4	hours	400	1.600
Depreciation of Yenga press per kg, 5a, 2t/a, 450.000 K,	15		75	1.125
Water	3	litres		
total input for 60 pieces of soap of 100 g				22.375
Price of Soap				**373**

The prices for industrial soap in the shops vary in a large extend. The cheapest soap is 400 K for 100 g, the usual one is between 1. 000 K and 3. 000 K per 100 g.

The women of Yamah's Pharmacy in Mazabuka agreed that the Jatropha soap can be sold for 1.000 K per 100 g.

Even with the extraordinary high price of 1.000 K per kg of seeds, this Jatropha soap is largely cheaper as the usual Zambian soap.

Since the whole processing until the soap as the final product should be done by a farmer, a woman or a women's group, it is not realistic to calculate with a price of the seeds, since the persons concerned are collecting the seeds themselves. The following table shows the value of 1 hour of work in the Jatropha System:

Description	Quantity	Unit	Price per unit	Amount in K
Seeds	15	kg		
Oil	3	l		
Caustic soda	0,5	kg	4.500	2.250

Labour seed picking	7,5	hours		
Labour oil expelling	6	hours		
Labour soap making	4	hours		
Total labour	17,5	hours		
Depreciation of Yenga press per kg			75	1.125
Water	3	litres		
Total material costs for soap production, 60 pieces of 100 g				**3.375**
Input for 1 piece of soap (without labour)				56
Possible labour wage per hour at a sales price of 350 per piece (294 * 60 / 17,5)				**1.007**

Annex 9 - Wasteland rehabilitation

Role of Jatropha in waste land rehabilitation

The Tamilnadu State Government (India) order reads as below:

Extract:

Waste land development Programme - setting up of TN wasteland Development Agency to implement comprehensive waste land Project;

…. a project for reclaiming 20lakh ha of cultivable waste lands through a massive Wasteland Development Programme is to be implemented over the next five years ….

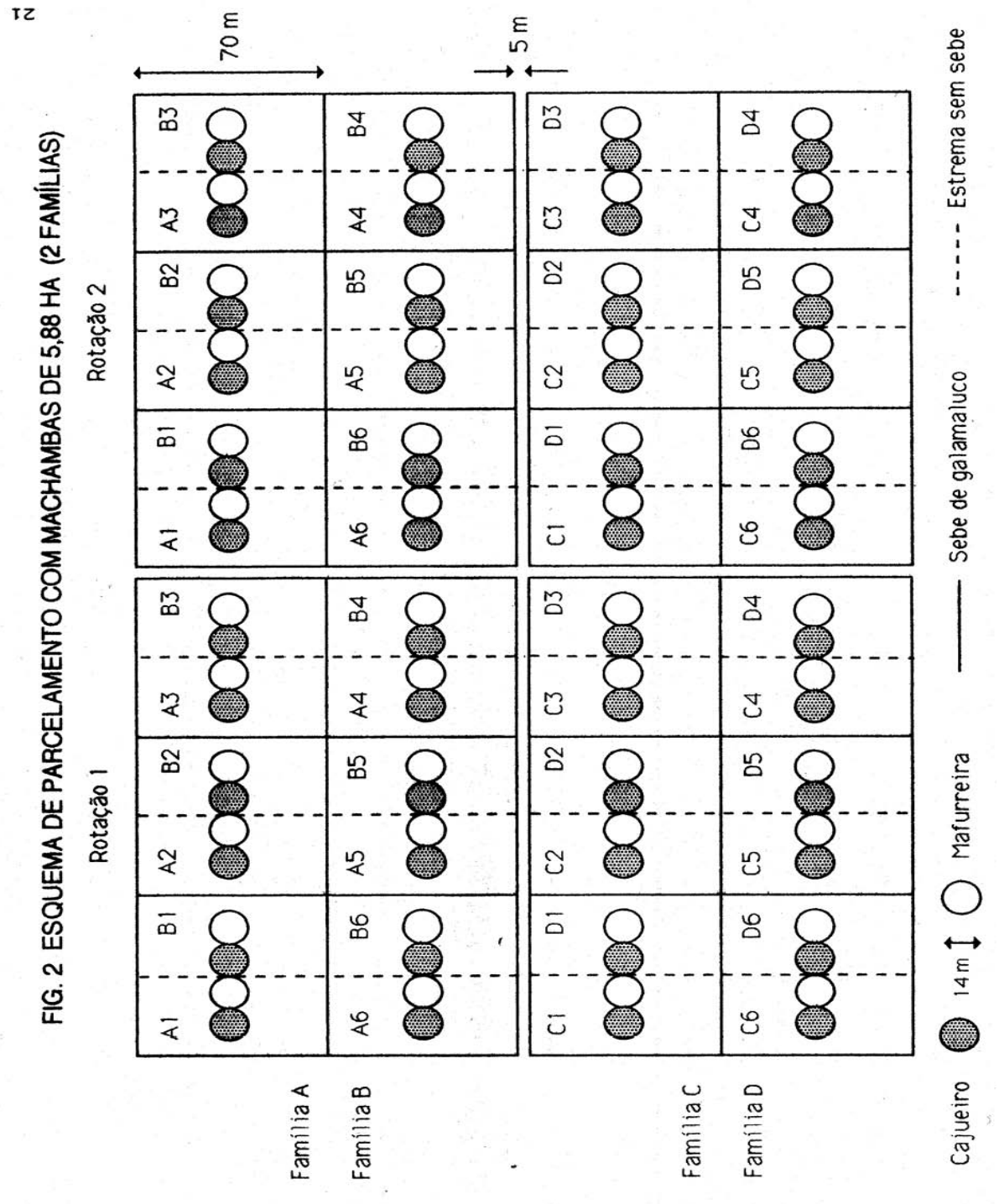
….. The higher grade waste lands with assured rainfall will be used for cultivation of medicinal and horticultural plants…..

…..In medium grade waste lands. Oil seed plants comprising of Paradise tree and Jatropha will be planted for producing edible and fuel oil respectively……

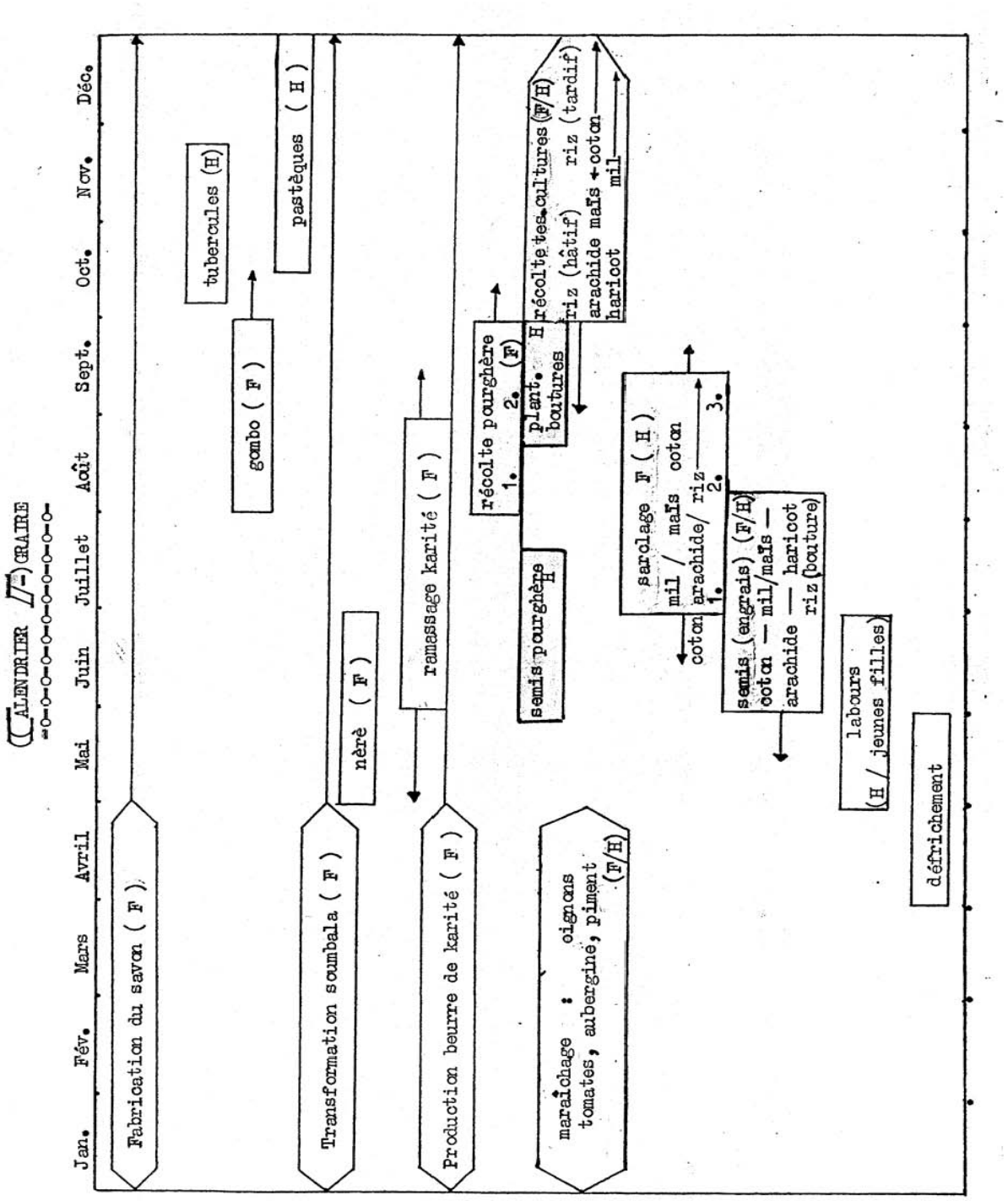
order is dt18th September 2001

Annex 10 - Small scale farms with Jatropha hedges in Mozambique

(Sebe de galamaluca = Jatropha hedges)

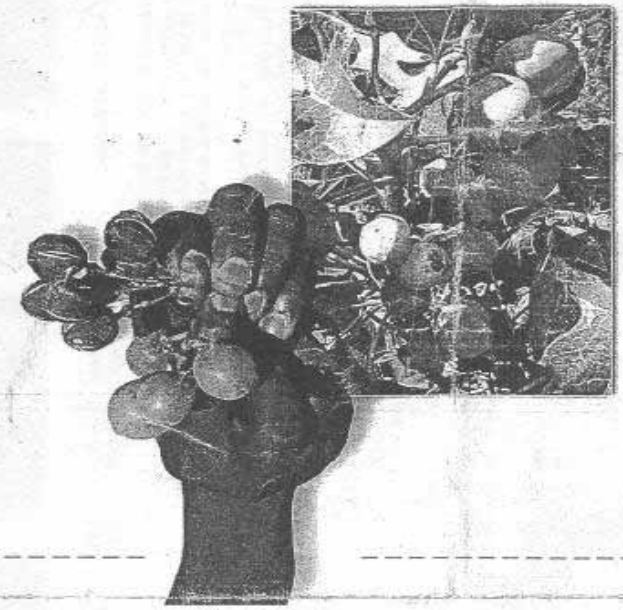


Annex 11 – Agricultural Calendar of Mali



Annex 12 – Paper for Public Field Day in KwaZulu/Natal

Introduction to Jatropha Curcas for the production of biodiesel



Rudolf Diesel, demonstrated his newly invented engine at the Exhibition Fair in Paris in 1898. Fueled by peanut oil, Diesel thought that the use of a biomass fuel represented the real future of his engine. He hoped that it would provide a way for the smaller industries, farmers, and 'common folk" to compete with the monopolizing industries, which controlled all energy production at that time, as well as serve as an alternative to the inefficient fuel consumption of the steam engine.

Will Jatropha become an alien invader?

Research suggests that Jatropha is unlikely to escape on account of the toxicity of the seed that is shunned by animal and bird alike. A living fence planted in the early 1980s in a long-abandoned experiment at the DAEA farm on the Makhatini Flats have not produced any trees despite bearing profusely.

Jatropha plantings however, needs to be undertaken with due regard to the applicable environmental guidelines.

Recommendations

Before planting land to Jatropha curcas, farmers should take note of the following recommendations:

- Virgin land (land previously not cultivated) should not be tilled without the approval of KZN DAEA (Directorate of Environmental Impact Management).
- Farmers should avoid planting Jatropha in *wetland areas or water catchment areas.*
- All stakeholders should educate the general public, and in particular children, on the toxicity of Jatropha seed.
- Farmers in rural areas interested in growing Jatropha, should consider growing the crop as a hedge, particularly in areas where there is limited arable land.
- Farmers are not encouraged to use their best arable lands for growing Jatropha. These lands should be reserved for crops the farmers normally produce i.e. vegetables, maize, dry beans, sugar cane and cotton.
- Farmers intending to grow the crop should plant small areas initially which they can easily manage.
- Jatropha production is not expected to enrich farmers growing small areas but rather to be an additional source of income.

The KwaZulu-Natal Department of Agriculture and Environmental Affairs supports all agricultural development projects that are aimed at improving the livelihoods of the farming community in the province. However, these projects must be undertaken in an environmentally sustainable manner and satisfy environmental and other relevant legislation.

For more information contact the Jatropha Task team members:

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also visit www.biodieselsa.co.za

The biodiesel project

A concerted attempt is underway to grow jatropha curcas for the production of an oil seed that in turn will be processed into biodiesel, an alternative to conventional diesel.
The project is driven by the Jatropha Task Team under the auspices of the KwaZulu-Natal Department of Agriculture and Environmental Affairs.
The cultivation of Jatropha presents untold empowerment opportunities

What is Biodiesel?

Biodiesel is a completely natural, renewable and biodegradable fuel applicable in almost any situation where conventional petroleum diesel is used.

Benefits of Biodiesel

The use of biodiesel reduces the risk of ground-water pollution, the production of greenhouse gases, and the level of most vehicle exhaust emissions, including those associated with the inducement of asthma.
Biodiesel's fuel characteristics exceed that of conventional diesel in most categories.
It operates in most conventional diesel motors with no engine modifications.

Which plants can be used?

Biodiesel is 100% vegetable oil-based and can be extracted from any oilseed crops including soya, groundnuts, canola, sunflower, Moringa oleifera and *Jatropha curcas*.

Why Jatropha curcas?

The Jatropha plant is a drought resistant perennial that is relatively easy to grow.
The oil yield from Jatropha seed is estimated at 1 890 litres oil per hectare (taken at 4000kg of seed), depending on the provenance, year and area of production.
Jatropha can also be used as an additional source of household income and employment through markets for fertiliser, animal feed, medicine, and industrial raw material for soap and cosmetics.
The Jatropha plant can be used to reclaim eroded areas, be grown as a boundary fence or living hedge in arid or semi-arid areas.

COMPARATIVE OIL YIELDS	l per ha
SOYA	446
SUNFLOWER	952
CANOLA	1192
JATROPHA	1-4000

Seed yield per hectare can vary between 2000 and 8000 kg. The oil content of the seed is approximately 40-50%.

Where can it be grown?

Jatropha grows in a number of climatic zones in tropical and sub-tropical regions of the world, in areas of low rainfall and on marginal soils. In KZN, Jatropha is most suited to coastal areas which experience little frost.

Financial benefits?

An unsatiable demand for biodiesel makes the cultivation of Jatropha a viable proposition.
In principle, every kg of seed produced will be bought at the prevailing price (see below). Jatropha growers will have the option to enter into a contract supply agreement with Biodiesel S.A.

What price will it fetch?

The price per kilogram of Jatropha seed will be dictated by the prevailing price of petroleum diesel at the time of transaction. It is envisaged that a kg of seed will fetch 30% of the wholesale price of a litre of conventional diesel. Prices will fluctuate in keeping with the movements of the international crude market and the R/$ exchange rate.
For illustrative purposes, a grower will receive 99 cents a kg for Jatropha seed if mineral diesel wholesales for R3.30 a litre; 114 cents if wholesaling at R3.80/l; 127,5 cents at R4.25/l and so on.

What are the costs?

Plants initially will be sold at R1.25 each. Bulk buyers qualify for a discount.

How can I grow Jatropha?

Register with Biodiesel S.A. to become a contract grower. Early registration is advised in view of an expected under-supply of Jatropha saplings.

Emerging farmers and community growers?

The KZN Agricultural Foundation was established with the express mandate to distribute saplings to emerging and small growers, and to set up extension support networks. Prospective growers must contact the Foundation.

How can it be produced?

Basic production manuals on how to grow Jatropha will soon be available from the KZN Department of Agriculture and Environmental Affairs (Cedara) and certain regional offices.

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