

Jatropha curcas in Zimbabwe

There are different persons and organisations working on Jatropha in Zimbabwe

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A Jatropha workshop has been organized by the Rockefeller Foundation in May 1998 in Harare; Zimbabwe.
[To read the concept paper for the conference, click here.](#)

<p><u>Binga Trees Project</u></p>	<p><u>Environment Africa</u></p>	<p>BUN</p>	<p><u>POPA</u></p>	<p><u>Rockefeller Foundation concept paper</u></p>
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The Potential of *Jatropha curcas* in Rural Development and Environment Protection – An Exploration

A workshop sponsored by the Rockefeller Foundation and Scientific & Industrial Research & Development Centre, Zimbabwe in Harare from 13-15 May 1998

CONCEPT PAPER: FINAL DRAFT

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1. Introduction:

The oil plant *Jatropha curcas* (L) (*Jatropha*) or physic nut is a multipurpose and drought resistant large shrub or small tree. Although a native of tropical America, it now thrives throughout Africa and Asia. It grows in a number of climatic zones in tropical and sub-tropical regions of the world and can be grown in areas of low rainfall and problematical sites. *Jatropha* is easy to establish, grows relatively quickly and is hardy. Being drought tolerant, it can be used to reclaim eroded areas, be grown as a boundary fence or live hedge in the arid/semi-arid areas.

The wood and fruit of *Jatropha* can be used for numerous purposes including fuel. The seeds of *Jatropha* contains (. 50% by weight) viscous oil, which can be used for manufacture of candles and soap, in the cosmetics industry, for cooking and lighting by itself or as a diesel/paraffin substitute or extender. This latter use has important implications for meeting the demand for rural energy services and also exploring practical substitutes for fossil fuels to counter greenhouse gas accumulation in the atmosphere.

These characteristics along with its versatility make it of vital importance to developing countries subjected to decreasing tree cover and soil fertility because of increasing population and development pressures. Nearly half the world's poorest people live on marginal lands with the number expected to increase from 500 million to 800 million by 2020. These areas are by definition isolated and fragile, with soils susceptible to erosion and subjected to environmental stresses of deforestation, prolonged droughts, and decreasing soil and ground water. Although southern Africa is rich in biodiversity and production potential, large areas are under semiarid and arid conditions with a moderate-to-high risk of drought. Plants species like *Jatropha* that can grow on lands not usually attractive for agriculture and supply raw material for industry, fuels for basic energy services and improve environment are therefore an obvious choice that needs to be assessed carefully and comprehensively.

Jatropha is not browsed, for its leaves and stems are toxic to animals, but after treatment, the seeds or seed cake could be used as an animal feed. Being rich in nitrogen, the seed cake is an excellent source of plant nutrients. Various parts of the plant are of medicinal value, its bark contains tannin, the flowers attract bees and thus the plant has honey production potential. Like all trees, *Jatropha* removes carbon from the atmosphere, stores it in the woody tissues and assists in the build up of soil carbon.

Despite these characteristics, the full potential of *Jatropha* is far from being realized. There are several reasons – technical, economic, cultural and institutional -- that need further discussion and examination. The growing and management of *Jatropha*, either on private public or community lands is poorly documented and there is little field experience that is being shared, especially in southern Africa. Currently, growers are unable to achieve the optimum economic benefits from the plant, especially for all its various uses. The markets for the different products have not been properly explored or quantified, nor have the costs or returns (both tangible and intangible) to supply raw materials or products to these markets. Consequently, the actual or potential growers including those

in the subsistence sector do not have an adequate information base about the potential and economics of this plant to make decisions relating to their livelihood, not to mention its commercial exploitation.

It is therefore timely to examine the potential role that *Jatropha* can play in meeting some of the needs for energy services for rural communities and also creating avenues for greater employment. It is important that the discussion on the exploration of potential of *Jatropha* should include the multiple stakeholders involved in research, utilization and exploration of this oil plant including government officials, NGOs, private sector, etc. Most importantly representatives of local communities must be included to examine any existing or latent demand for the plant to determine the framework for any future initiative based on the outcome of the discussions on the potential of *Jatropha curcas*. Hence this workshop.

2. Objectives of the Workshop:

The workshop will explore the potential of *Jatropha curcas* in rural development and influencing livelihoods at the household level in an environmentally friendly manner. Some of the issues to be examined therefore include:

- Use of *Jatropha* in meeting domestic needs of energy services including cooking and lighting;
- Potential of *Jatropha* as an additional source of household income and employment through markets for fuel, fertilizer, animal feed medicine, and industrial raw material for soap, cosmetics, etc.
- Potential of *Jatropha* in creating environmental benefits – protection of crops or pasture lands, or as a hedge for erosion control, or as a windbreak.

3. Production of *Jatropha curcas*

Considerable plantation of *Jatropha* had been undertaken in Zimbabwe by a number of active organizations involved in its promotion including the Agricultural Research Trust (ART), the Biomass Users Network (BUN), the Forestry Commission (FC) and the Plant Oil Producers Association (POPA). An estimated four million *Jatropha* plants have been planted in Zimbabwe by the end of 1997 amounting to nearly 2,000 hectares of plantations.

Although it is known that *Jatropha* can be established from seed, seedlings and vegetatively from cuttings, very little written information is available in Africa about the silviculture and management of *Jatropha*. Plants from seeds develop a typical taproot and four lateral roots, and cuttings do not develop a taproot (Heller J. 1996). *Jatropha* is a fast growing plant and can achieve a height of three meters within three years under a variety of growing conditions. Seed production from plants propagated from seeds can be expected within 3-4 years. Use of branch cutting for propagation is easy and results in rapid growth; the bush can be expected to start bearing fruit within one year of planting. (Jones & Miller, 1992, p. 8)

Whilst *Jatropha* grows well in low rainfall conditions (requiring only about 200 mm of rain to survive) it can also respond to higher rainfall (up to 1200 mm) particularly in hot climatic conditions. In Nicaragua for example, *Jatropha* grows very well in the country's hot climate with rainfall of 1 000mm or more. Experience in Zimbabwe has shown that high rainfall in the relatively cooler parts of the country does not encourage the same vigorous growth. However, in the low-veld areas, such as in the mid-Save region, *Jatropha* grows well, although comparative yields have not been established. *Jatropha* does not thrive in wetland conditions. The plant is undemanding in soil type and does not require tillage. In southern Africa, the best time for planting is in the warm season to avoid the cold season since the plants are sensitive to ground frost that may occur in the cold season. (BUN newsletter 1996).

The recommended spacing for hedgerows or soil conservation is 15cm - 25cm x 15cm-25cm in one or two rows respectively and 2m x 1.5m to 3m x 3m for plantations (Jones N, Miller J.H. 1992, p.7). Thus there will be between 4,000 to 6,700 plants per km. for a single hedgerow and double that when two rows are planted. The number of trees per hectare at planting will range from 1,600 to 2,200. Wider spacing is reported to give larger yields of fruit, 794 kg/ha and 318 g/shrub (Heller J. 1996).

In equatorial regions where moisture is not a limiting factor (i.e. continuously wet tropics or under irrigation), *Jatropha* can bloom and produce fruit all year. A drier climate has been found to improve the oil yields of the seeds, though to withstand times of extreme drought, *Jatropha* plant will shed leaves in an attempt to conserve moisture which results in somewhat decreased growth. (Jones and Miller, 1992, p.7)

Seed production ranges from about 0.4 tons per hectare per year to over 12 t. /ha. /a., after five years of growth (Jones N, Miller J.H. 1992). Although not clearly specified, this range in production may be attributable to low and high rainfall areas. In Mali, where *Jatropha* is planted in hedges, the reported productivity is from 0.8 kg. – 1.0 kg. of seed per meter of live fence (Henning R. 1996). This is equivalent to between 2.5 t. /ha. /a. and 3.5 t. /ha. /a.. The practices being undertaken by the *Jatropha* growers currently need to be scientifically documented along with growth and production figures. The growth and yield of wood may be in proportion to nut yield and could be improved through effective management practices.

Woody biomass growth, unlike seed production, is not recorded in any articles to hand. Although it needs to be tested, it is possible that nearly one-third of net primary production (NPP) in *Jatropha curcas* may be in the form of woody biomass. However, it needs to be tested if there is tradeoff between growing *Jatropha* plants for optimizing woody biomass vs. seed production for oil. Reportedly, *Jatropha* trees/bushes live up to 50 years or more. Like all perennial plants, *Jatropha* displays vigorous growth in youth that tails off gradually towards maturity.

Existing literature indicates that the Agricultural Research Trust of Zimbabwe (ART) has laid down trials of different provenance of *Jatropha curcas*. Such research work is vital in determining the most appropriate provenance and optimum management systems and must be pursued. The current status of this work may give an important insight into the management and yield of *Jatropha* in Zimbabwe. Although non-toxic varieties of *Jatropha curcas* were sent to Zimbabwe for planting, (Gubitz G. M. et al eds. 1997, page 203), their current locations are unclear. It is however possible that ART included these varieties in their provenance trials. Success of such varieties would make the seed cake following oil extraction suitable as animal feed without a need for its detoxification.

Although *Jatropha* is adapted to low fertility sites and alkaline soils, better yields are obtained on poor quality soils if fertilizers containing small amounts of calcium, magnesium, and sulfur are used. Mycorrhizal associations have been observed with *Jatropha* and are known to aid the plant's growth under conditions where phosphate is limiting. (Jones & Miller, 1992, p.7)

A perceived advantage of *Jatropha* is its capability to grow on marginal land and its ability to reclaim problematic lands and restore eroded areas. As it is not a forage crop, it plays an important role in keeping out the cattle and protects other valuable food crops or cash crops. *Jatropha* products from the fruit - the flesh, seed coat and seed cake - are rich in nitrogen, phosphorous and potassium (NPK) and are fertilizers that improve soil. *Jatropha* hedges and shelterbelts by improving the microclimate and providing humus and fertilizers to the soil can further enhance the productivity of other agricultural crops.

However, the above uses can be constrained by the prevalence of pests and diseases that attack *Jatropha*. Existing literature indicates that contrary to popular belief that toxicity and insecticidal properties of *J. curcas* are a sufficient deterrent for insects that cause economic damage in

plantations, several groups of insects have overcome this barrier. Particularly noteworthy is the insect order of Heteroptera that has at least 15 species in Nicaragua that can extract nutrients from physic nut. The stem borer from the coleopterous family of Cerambycidae that is known as a minor pest in cassava can kill mature physic nut trees. The relatively few leaf-eating insects present are not capable of doing much damage once the trees have passed the seedling stage. Biological control can make use of beneficial arthropods – polyphagous predators and specialized parasitoids – either by conservation or augmentative releases; the first alternative being the more cost efficient (Grimm & Maes, 1997). In some areas of Zimbabwe the golden flea beetle (*Podagrica* spp.) can cause harm – eat young leaves and shoots, particularly on young plants. *Jatropha* is also host to the fungus "frog-eye" (*Cercospora* spp.) common in tobacco. The workshop will examine the issue of pests and diseases that afflict *Jatropha* in further detail to ensure that it is safe to be used as a live fence and/or boundary plantation for various agricultural and cash crops.

In summary, the workshop will examine issues relating to silvicultural production systems and nutrient requirements of *Jatropha curcas* can be summarized as below:

- What are the best management techniques (planting practices, spacing, etc.) to promote the optimum growth of *Jatropha* to optimize for instance nut production?
- What types of edaphic factors, climatic conditions provide best for *Jatropha curcas*, both from the perspective of fruit and biomass? What is the ideal rotation age for nuts and the plant? What varieties, including non-toxic varieties perform better in southern Africa?
- How can *Jatropha curcas* plantations by themselves or in agro-forestry combinations (climatic conditions and management practices) alleviate problems of devegetation and soil erosion and improve, the environment.
- Available biological control/IPM techniques to control of pests and diseases of *Jatropha*.

4. *Jatropha curcas* as an Energy Source

4.1 Oil from *Jatropha curcas*

Jatropha oil is an important product from the plant for meeting the cooking and lighting needs of the rural population, boiler fuel for industrial purposes or as a viable substitute for diesel. Substitution of firewood by plant oil for household cooking in rural areas will not only alleviate the problems of deforestation but also improve the health of rural women who are subjected to the indoor smoke pollution from cooking by inefficient fuel and stoves in poorly ventilated space. *Jatropha* oil performs very satisfactorily when burnt using a conventional (paraffin) wick after some simple design changes in the physical configuration of the lamp.

About one-third of the energy in the fruit of *Jatropha* can be extracted as an oil that has a similar energy value to diesel fuel. *Jatropha* oil can be used directly in diesel engines added to diesel fuel as an extender or trans-esterised to a bio-diesel fuel. In theory, a diesel substitute can be produced from locally grown *Jatropha* plants, thus providing these areas with the possibility of becoming self sufficient in fuel for motive power. There are technical problems to using straight *Jatropha* oil in diesel engines that have yet to be completely overcome. Moreover, the cost of producing *Jatropha* oil as a diesel substitute is currently higher than the cost of diesel itself that is either subsidized or not priced at "full cost" because of misconceived and distorted national energy policies. Nevertheless the environmental benefits of substituting plant oils for diesel provides for make highly desirable goals.

In 1995, the Rockefeller Foundation (RF) and the German Government's Technical Assistance Programme (GTZ) joined together to evaluate the use of plant oil as a renewable fuel source for rural development in three of the countries -- Brazil, Nepal and Zimbabwe. Since species whose cultivation would not displace other agricultural crops nor compete for land with greater opportunity for other applications were being considered, *Jatropha curcas* emerged as a prime plant for investigation. This workshop builds on the earlier work of this initiative and examines rural

development and generation of employment in southern Africa to determine the issues, need and prospects for further research and development. The workshop will therefore discuss various issues including:

- Status of ongoing and potential research focusing on the applicability of *Jatropha* oil to meet the cooking and lighting needs of rural households and its competitiveness in substituting diesel in various stationary and mobile applications
- Economic feasibility of *Jatropha* oil in meeting the energy services needs;
- Available technology and products to meet the above mentioned needs and status of technological research;
- Role of the private sector and government policies in commercialization of *Jatropha curcas* products.

5. Other products of *Jatropha curcas*

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

The oil is a strong purgative, widely used as an antiseptic for cough, skin diseases, and as a pain reliever from rheumatism. *Jatropha* latex can heal wounds and also has anti-microbial properties. *Jatropha* oil has been used commercially as a raw material for soap manufacture for decades, both by large and small industrial producers. Soap from *Jatropha* oil is being made by small informal industries in rural areas in both Zimbabwe and Mali. A large manufacturer is interested in using *Jatropha* oil to substitute tallow in commercial soap making. The monthly requirement of this industry alone is 2,000 liters of oil. To supply this demand would require between 18,000-22,000 ha of *Jatropha* plantation or 30,000-40,000 km. Of *Jatropha* hedges or a combination of the two. Currently tallow fetches higher price than diesel in Zimbabwe. What are the possibilities of using commercial interest as above to create a capacity for *Jatropha* oil to address issues of rural energy equity and employment generation?

The oil cake cannot be directly used as animal feed because of its toxicity, but it is valuable as a fertilizer having a nitrogen content comparable to chicken manure and castorbean seed cake. The toxicity of the seeds is because of curcin (a toxic protein) and diterpene esters. Apparently seeds of Mexican origin have less toxic content and with proper processing they can be eaten. Although there are laboratory studies indicating detoxification, its feasibility and profitability on a large scale is yet to be investigated.

The workshop will therefore:

- Examining the potential market for various *Jatropha* products;
- Assessing the value of these products to the rural population;
- Determining the optimum combination for their use; and
- Proposing a strategy to maximize rural development, energy equity and employment.

6. Costs and Returns

6.1 Costs

An estimate of costs and returns from cultivation of *Jatropha* plantations/hedgerows' scenarios is crucial to analyzing its role in rural development. Costs, as well as returns are involved at different

stages of the growing and harvesting of *Jatropha curcas* and the manufacture/use of different plant products and include both tangible and intangible components of each. For instance an estimate of the following cost heads would be required for any economic analysis:

6.1.1. Cultivation of *Jatropha*

- a. Planting costs; c. Tending costs,
- b. Establishment costs; d. Other costs (specify).

6.1.2. Wood

- a. Pruning; f. Pole production;
- b. Thinning; g. Other products, specify;
- c. Felling; h. Storage costs of products;
- d. Firewood production; i. Transport costs;
- e. Charcoal production; j. Other costs, specify.

6.1.3. Fruit.

- a. Collection; e. Charcoal production from shells;
- b. Removal of flesh; f. Storage of products, (oil, cake, shells, flesh, etc.);
- c. Removal of shell; g. Transport costs;
- d. Extraction of oil, (state method); h. Other costs, (specify).

6.1.4. Capital & Labor costs

- a. Buildings
- b. Machinery and equipment
- c. Labor as per respective activity

6.2 Returns

Similarly several types of returns from the growing and use of the products from *Jatropha curcas* need to be carefully estimated. The obvious returns pertain to sale or market prices of the different products. These returns should be recorded and then compared to the cost of the growing plus management of the plants and the manufacture of the products to arrive at profitability of various products.

Some of the costs and returns have been indicated in the literature while others may have to be extrapolated from estimates for similar crops. A discussion document that provides a perspective on various economic costs and benefits is being prepared and will be ready prior to the meeting. The discussion in the afternoon of the last day will focus mainly on the socio-economic analysis gleaned from the workshop and the paper to generate insights for future investigation and research and development

7. EXPECTED OUTPUT

The expected output will be

- A good understanding of the role of *Jatropha curcas* in rural development;
- Based on that understanding a broad commitment from the national participants to pursue *Jatropha curcas* for rural development; and
- A strategy for field implementation.

It is hoped that the deliberations will pave the way for a Plan of Action to galvanize the planting and use of *Jatropha curcas* by rural communities to improve their well being and livelihood in association with the private sector and assisted by appropriate government policies.

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Generative propagation of *Jatropha curcas* L. on Kalahari Sand

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Abstract

In southern Africa, larger areas are under semiarid and arid conditions with a moderate-to-high risk of drought. The drought resistant plant, *Jatropha curcas* L., Euphorbiaceae that can grow on lands not suited for agriculture and both improve the environment and supply raw material for local communities is attractive for resource-poor farmers. Although *Jatropha* is commonly planted in southern Africa, research on cultivation and propagation of *Jatropha* is limited. This study provides documentation of the germination of *Jatropha* seeds planted in nursery in containers composed of Kalahari Sand. Sampling period was undertaken from late raining season to the beginning of dry period (February to June 2003). The study shows high viability of the seeds with a mean germination rate above 93 percent and a completed germination within 9 days. Manure during germination phase appears to have a negative impact on the germination. However, the results indicate that manure has a positive impact on the growth rate after germination has been initiated. Likewise, the intensity of watering and temperature seems to have a fundamental impact on the germination rate. Pre-treatment of the seeds did not effect the germination positively.

Keywords: *Jatropha curcas* L., generative propagation, germination, Kalahari Sand, Zimbabwe.

Introduction

Since the oil crisis of the 1970s and recognition of the limitations of world oil resources, vegetable oils have received special attention (Grimm 1996; Heller 1996; Henning 2000a; Pratt *et al.* 2002).

Special interest has been shown in the cultivation of the tropical physic nut (*Jatropha curcas* L., Euphorbiaceae) for oil extraction, especially since it is drought resistant and can be cultivated on marginal land, without competing with food production (Heller 1996; Grimm 1996; RF 1998).

Jatropha was introduced into Zimbabwe in the 1940s. *Jatropha curcas* L. is a multipurpose large shrub or small tree of Latin American origin. It is local adjusted throughout arid and semiarid tropical regions of the world with an average annual rainfall of between 300 and 1000 mm (Palgrave 1983; Heller 1996; CATIE 2000; Henning 2002). In Zimbabwe, it is now found in many parts of the

country, with known concentrations in the north-eastern districts of Mutoko, Wedza, Chiweshe, Mudzi and Nyanga north. *Jatropha* grows on well-drained soils with good aeration and is well adapted to marginal soils with low nutrient content. It occurs mainly at lower altitudes (0-500 m) in areas with average annual temperatures well above 20° C but can grow at higher altitudes and tolerates slight frost. It is not sensitive to day length (ICRAF 2003). Locally, it is grown as a boundary fence or live hedge and can be used to reclaim eroded areas (Heller 1996; Jøker & Jepsen 2003).

Jatropha is not browsed. Its leaves and stems are toxic to animals, but after treatment, the seeds or seed cake can be used as an animal feed (Makkar *et al.* 2001). Being rich in nitrogen, the seed cake is also an excellent source of plant nutrient (RF 1998; Makkar *et al.* 2001). Traditionally the seeds have been harvested by women and used for medical treatments and local soap production (Duke 1983; Henning 2002). *Jatropha* is fast growing and produce seeds after approximately 1 – 3 years, depending on rainfall conditions and how the plant is propagated (from cuttings or seeds, respectively). *Jatropha* can reach a height up to 8 metre (Heller 1996). *Jatropha* seeds contain about 35 percent of non-edible oil. 6 kg of dry seeds gives about 1.2 litre of oil. Research made by Henning 2002 indicates that commercial exploitation of the plant is comparable with cotton farming. Examples from Mali shows that villagers that plant 15 km of *Jatropha* hedges can harvest about 12 tons of seeds which may generate 1800 US\$ of cash income when the oil is extracted and the products sold (1998 figures). At least 2-3 tons of seeds per hectare can be achieved in semi arid areas (Heller 1996). It is believed that the total land area in Zimbabwe under *Jatropha* is somewhat less than 2,000 hectares (Makkar *et al.* 2002).

Research on cultivation and propagation of *Jatropha curcas* L. is limited, especially in southern Africa (RF 1998). For the quick establishment of hedges and plantations for erosion control, directly planted cuttings are recommended and for long –lived plantations for vegetable oil production, plants propagated by seeds are better (Heller 1996). Research shows that plants propagated by cuttings show a lower longevity and possesses a lower drought and disease resistance than plants propagated by seeds (Heller 1996). Likewise, pre-cultivation of *Jatropha* seedlings in poly-ethylene bags has been shown to accelerate the installation of a plantation by at least 3 months (Henning 2000c).

The main aim of the present study was to document the generative propagation of *Jatropha curcas* L. planted on Kalahari Sand during germination phase and contribute to the knowledge of cultivation of *Jatropha curcas* L. The following three hypotheses have been tested:

Hypothesis 1: Manure has a positive impact on germination of *Jatropha*. Seeds from *Jatropha curcas* L. germinate and grow faster in soil with manure than in soil without manure.

Hypothesis 2: The intensity of watering has a significant impact on the germination and growth of *Jatropha curcas* L.

Hypothesis 3: Temperature has a significant impact on the germination and growth of *Jatropha curcas* L.

Study area

The study was undertaken in Mkhosana, Victoria Falls situated in northern-western Zimbabwe. The area is on Kalahari Sand (deep, well-drained, nutrient-poor sands). The area receives a low and erratic mean rainfall of about 650 mm, falling from November to April. Mean summer and winter temperatures are 30 °C and 10 °C respectively. Ground frost is sometimes experienced between May and August. The altitude is 980 metres above sea level.

Methods

The field methodology involved two stages: (i) a general assessment of the viability of the seeds and the germination rate for generative propagation of *Jatropha curcas* L.; (ii) a more detailed assessment of the germination and growth rate of *Jatropha curcas* L. during the first eight weeks from seed planting. Both assessments were undertaken in nursery with approximately 50 percent density shade. Seeds used in both assessments were locally collected in June 2002. Seeds were stored in Hessian bags and kept under uncontrolled room conditions until required for planting. The seed provenance is unknown. The average temperature for each month is based on own data. Cow manure has been used for trials in the detailed assessment.

General assessment

Pre-cultivation of *Jatropha curcas* L. seeds in containers (milk packets, tin and poly-ethylene bags) composed of Kalahari Sand. The seeds were sown in the soil at a depth of 3 cm in each container (method after Henning 2000b). The assessment was undertaken in the period February to April 2003. Watering in February was made four times per week and two times per week in March and April. Numbers of days to first and last germination for each trial were observed. Moreover, measurements of the percentage of germinated seeds were made.

Assessment of the mean days of germination for seeds planted in May and June 2003 were made afterwards. The total number of germinated seeds during this period was not measured. Watering was

made 2 times per week.

Detailed assessment

Six experimental trials were made. Each trial consisted of ten seeds planted with one seed in each plant container. The seeds were planted in a dept of 3 cm. In two trials (C and D), pre-treatment of the seeds were carried out in order to enhance rapid and uniform germination by removing the testa by cracking each seed in the hand, carefully.

The assessment was undertaken in eight weeks during the period May to June 2003. The heights of the plant were measured once per week. The trails had the following design:

A: Seeds planted in Kalahari Sand without added manure

B: Seeds planted in a mixture (50-50) of Kalahari Sand and manure

C: Pre-treated seeds planted in Kalahari Sand without added manure

D: Pre-treated seeds planted in a mixture (50-50) of Kalahari Sand and manure

E: Seeds planted in Kalahari Sand without added manure

F: Seeds planted in a mixture (50-50) of Kalahari Sand and manure.

Trails A, B, C, and D describe the impact of using manure and pre-treatment of seeds. Trails A to D were watered three times per week.

Design of trails E and F were similar to trail A, B. Trails E and F describes the impact of lower watering intensity on the germination rate in soil with and without manure. Trials E, F were watered once a week.

Results

General assessment

In the period from February to April, out of 4771 planted seeds a total number of 4616 seeds germinated (96.8 percent survival). The mean germination rate for each month varied from 93.2 percent to 97.6 percent. The highest germination rate among the trials was achieved in April (table 1). The mean days of germination of *Jatropha curcas* L. seeds were 6.2 days in February, 7.6 days in March, 7.8 days in April (table 1). The mean day of germination for the seeds during all three months was 7.2 days. Shortest germination period occurred in February after four days and latest germination occurred in April after 10 days.

Germinations trials made in February had a faster germination rate of 1.4-1.6 days compared to the trials established in March and April. However, the mean germination for trials made in February was

2.2 - 4.4 percent lower, compared to the trials made the two following months. The average monthly temperature during the three months varied 1.7 °C from 22.8 °C in February and March to 21.1 °C in April.

Table 1 Analysis of mean days of germination and mean germination rate across month and water intervals.

Month	Mean days of germination (μ)	S.D ^{*)}	Mean germination rate (%)	No. of planted seeds	No. of seeds germinated	Treatment Water interval	Average temperature (°C)
February	6.2	1.8	93.2	441	411	4 times a week	22.8
March	7.6	1.5	95.4	930	887	2 times a week	22.8
April	7.8	1.6	97.6	3400	3318	2 times a week	21.1
Total				4771	4616		

^{*)} S.D Standard Deviation

The mean days of germination for seeds planted in May and June were 7.9 days and 11.8 days, respectively. The mean day of germination for the seeds during all five months was 8.3 days. The average monthly temperature during the whole sampling period varied 7.8 °C from 22.8 °C in February and March to 15 °C in June. Most significant difference in temperature was observed from April to May (3.3 °C) (fig. 1). The most significant difference in mean day of germination was seen from May to June (3.9 days).

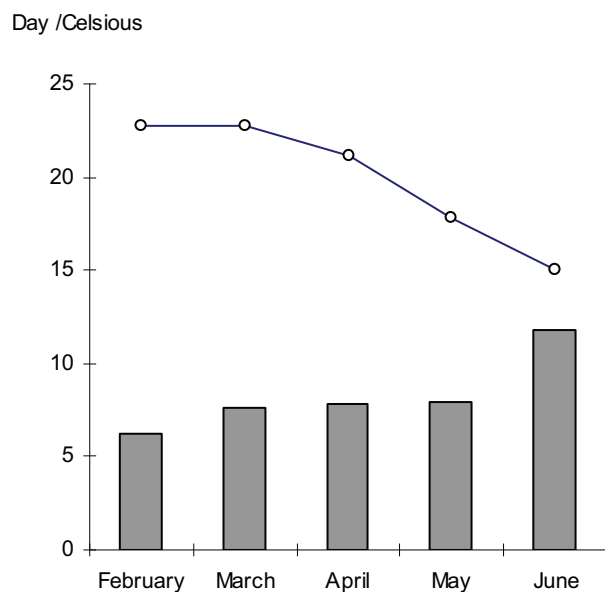


Fig. 1 Mean monthly germination rate for *Jatropha curcas* L.

(̑) and monthly average temperature (o).

Detailed assessment

A significant difference in germination rate was identified (fig. 2). Out of six experimental trails, germination occurred in five trials. Highest percentage germination was obtained in trail A on sand without added manure and watered three times a week (70 percent). Lowest percentage germination was measured in trail D for pre-treated seeds planted in a mixture of sand and manure and watered three times per week (20 percent). No germination was identified in trail E on sand without added manure and watered once a week.

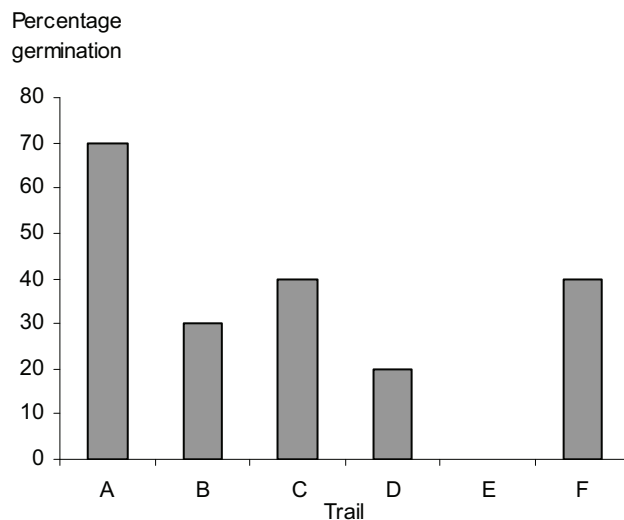


Fig. 2 The germination of *Jatropha curcas* L. in different trails

Figure 3 illustrate the mean shoot length of seedling during the first eight weeks. During the first three weeks seeds in trial B and C had a significant faster mean growth rate compared to the three other trials. Seeds in trial B and C had after three weeks achieved a high of app. 8 cm compared to 1.8 cm for trial A, D and F. Seeds in trail A, D and F had started shooting after two weeks compared to one week for seeds in trial B and C.

Between week three and four, the highest increase in growth was obtained by seeds in trail A, D and F. During one week the seeds grew from 1.8 cm to 7-9.5 cm. The growth rate for seeds in trial B and C were decreasing during this week.

From week four to eight, seeds in all the trials had a decreasing growth rate. During the period from week four to five seeds from trial F changed its position from being the trial with the second lowest length of seedling to be the trial with the longest length of seedling. After eight weeks highest mean length of seedling was above 14 cm (trail F) and lowest length of seedling was about 8 cm (trial D).

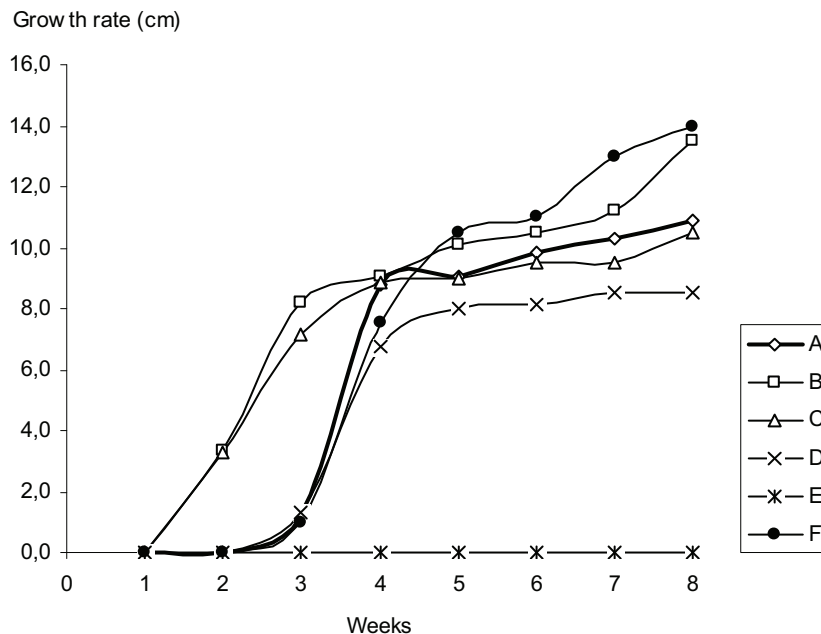


Fig.3. Mean shooting length of seedlings. Seeds in trials A to D have been watered three times per week, while seeds in trials E and F have been watered once per week. A): Seeds planted in Kalahari Sand without added manure B): Seeds planted in a mixture (50-50) of Kalahari Sand and manure C): Pre-treated seeds planted in Kalahari Sand without added manure D): Pre-treated seeds planted in a mixture (50-50) of Kalahari Sand and manure E): Seeds planted in Kalahari Sand without added manure F): Seeds planted in a mixture (50-50) of Kalahari Sand and manure.

Discussion

Comparative research on the influence of different propagation methods on viability and vegetative development was conducted by Kobilke (1989) in Cape Verde and by Heller (1992) in Senegal. The results achieved in Cape Verde and Senegal show that both vegetative cultivation methods and methods of generative precultivation were more successful than direct seeding.

Factors responsible for the survival of direct seeding (seeding time, seeding depth) have been studied by Heller (1992). The result shows low viability for direct seeding (19.8 %) whereas the same provenance seeded in plastic bags showed a higher germination (68 %). The viability depended not only on sowing time and depth of sowing, but also on the trial year.

In our general assessment, Short-term storage under uncontrolled room conditions did not appear to affect the germination of *Jatropha curcas* L. as this showed high viability (> 93 percent).

The seed material used in both assessments was collected from the same area in June 2002. The *Jatropha* seeds are oily and do not store for long. Research on viability of *Jatropha* seeds shows a

decrease due to term of storage. Seeds older than 15 months show viability below 50 % (Kobilke 1989). In our general assessment the viability for seeds planted in May and June was not measured. It can therefore not be excluded that more than ten months storage under uncontrolled room condition could have had a negative affect on the germination of the seeds.

In our assessment no statement can be made on depth of sowing or the occurrence of water stress shortly after seeding, since soil moisture was not determined. However, in the general assessment; it seems that watering intensity and temperature have had an effect on the mean days of germination and germination rate of the seeds planted in February. Compared to the two other months (March and April) we achieved the fastest mean days of germination in February under highest mean temperature and watering intensity. The higher moisture conditions have had a positive effect on the mean days of germination but have also resulted in a lower germination rate due to mouldy seeds.

Assessments made in February to April are comparable with trials made in May and June. The watering intensity was two times per week and the seeds were planted in Kalahari Sand only.

However, the germination period was longer in May and June, especially. It seems that the temperature and the fact that the general assessment was made during the end of the raining season have had an impact on the mean days of germination of the seeds. The watering intensity and humidity have been higher during the raining season than in the dry period (May and June).

In the literature the germination is said to take 10 days under good moisture conditions (Heller 1996; Henning 2000a; ICRAF 2003). In our research we have achieved germination after four days depending on which month the seeds were planted. The best time for planting *Jatropha curcas* L. on Kalahari Sand, in the period late raining season to start of dry season, will be during the raining season. Experience in Zimbabwe has shown that high rainfall in relatively cooler parts of the country does not encourage the same vigorous growth. However, in the low-weld areas, *Jatropha* grows well. *Jatropha* does not thrive in wetland conditions (RF 1998).

In the detailed assessment the general germination rate was low (0 - 70 %), which is likely caused by lower temperature during the period of assessment and dry season. From the trials, manure seems to have an impact on the germination of *Jatropha*. Trials in figure 2 shows highest germination (70 percent) for seeds planted in soil without added manure when watered three times per week and no germination at all when watered once per week. However, germination was identified in all trials which included manure. Even in trial F which was watered once per week 40 percent germination was

achieved. In comparison no germination was achieved in trial E for seeds planted on Kalahari sand and watered once per week. From our research adding of manure seems to keep the soil moist and have a positive impact on the germination rate of the specie. Henning 2000b recommends germination of *Jatropha* in small plastic bags filled with soil with a high concentration of organic material (compost). However, from our research the optimum germination condition for *Jatropha* planted on Kalahari sand was achieved in pure sand under high temperature conditions $> 20^{\circ}\text{C}$ in combination with high watering intensity (three times weekly).

Our observation of the growth rate indicate that *Jatropha curcas* L. is a fast starter and do not need manure to germinate. When germination is initiated the shooting of the seedling is fast and will within two weeks grow app. 10 cm. The impact of adding manure to the soil is not significant. From our observation during the eight week assessment of the growth rate adding of manure seems to have a positive impact on the growth rate. From our data the two trials with the highest growth after eight weeks (app. 14 cm) has both been planted in a mixed soil with manure. Highest growth rate for all trials was achieve in trial F with manure and watered once a week.

From our research adding of manure after germination in order to increase the growth rate seems to be a possibility.

Freshly harvested seeds show dormancy and after-ripening is necessary before the seeds can germinate (Jøker and Jepsen 2003). Kobilke (1989) tried to break induced dormancy. Removal of the testa proved more successful than presoaking alone. However, Pre-treatment of the orthodox seeds did in our research not seem to make an improved impact on the germination and growth rate. The trials with pre-treated seeds appear to have the lowest growth rate.

Conclusion

This study has provided data on the germination of the specie *Jatropha curcas* L. planted on Kalahari Sand. The study shows high viability of the seeds with a mean germination rate above 93 % and a completed germination within 9 days.

Use of manure in generative propagation of *Jatropha curcas* L. on Kalahari Sand seems to reduce the need for watering. Adding of manure has a negative impact on the germination but a positive impact on the growth rate after germination has been initiated.

The intensity of watering and temperature seem to have a fundamental impact on the germination

rate. An increase in the mean days of germination is observed due to temperatures below 15° C.

Moderate watering intensity increases the germination rate.

Pre-treatment of the seeds before planting did not effect the germination positively.

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Jatropha curcas in Zimbabwe

There are different persons and organisations working on Jatropha in Zimbabwe

The table contains names and contact addresses, as well as links to their websites

Africare Zimbabwe		Paulo Chimedza Africare National Agricultural Program Officer
<u>Binga Trees Project</u>		Warndorff, Titia & Jan Binga, Lake Kariba, Zimbabwe e-mail: gwarndorff@healthnet.zw
<u>BUN, Biomass Users Network</u>	Projekt in Makosa supported by Rockefeller Foundation	Maxwell Mapako Private Bag 7768, Causeway Harare, Zimbabwe Tel: ++263 4 79 33 95, Fax: ++263 4 79 33 13 e-mail: bunzwe2k@yahoo.co.uk
Chakras, Donald	Entrepreneur, Promoter of oil seed exploitation, buyer of Jatropha seeds	P.O.Box BW 1140, Borrowdale Harare, Zimbabwe Tel/Fax: ++263 9 42195
Dickson, Geoff	Producer of manual ram presses	Harare, Zimbabwe
<u>Environment Africa</u>	Plantation of Jatropha and use of the oil	Environment Africa Box CT502, Chinotimba Victoria Falls, Zimbabwe 
Oliver, Geoff	Producer of Sundhara expellers (together with Plumb Engineering) Production of Jatropha soap (Flora Joy)	P.O.Box GD 993 Harare, Zimbabwe Tel: +263 29 4144 e-mail: popa@mango.zw see also the POPA newsletter Nr. 10
Plumb Engineering	Producer of Sundhara expellers	James Murray P.O. Box UA 561 Union Avenue Harare, Zimbabwe Tel: +263 4 611690
POPA, Plant Oil Producers Association		Attn. M. Geoff Oliver P.O.Box GD 993 Harare, Zimbabwe Tel: +263 29 4144 e-mail: popa@mango.zw see also the POPA newsletter Nr. 10
SAFIRE Southern Alliance for Indigenous Resources		

<p>Tabudiria Training Centre</p>	<p>Jatropha promotion in Matoko district</p>	<p>Stueckler, Reinhard Box 231, Mutoko, Zimbabwe Tel: ++263-72-2455, Fax: ++263-91334543 e-mail: tabtc@pci.co.zw</p>
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A Jatropha workshop has been organized by the Rockefeller Foundation in May 1998 in Harare; Zimbabwe.
[To read the concept paper for the conference, click here.](#)

<p><u>Binga Trees Project</u></p>	<p><u>Environment Africa</u></p>	<p>BUN</p>	<p><u>POPA</u></p>	<p><u>Rockefeller Foundation concept paper</u></p>
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bagani

last modification 18.02.03

The Potential of *Jatropha curcas* in Rural Development and Environment Protection – An Exploration

A workshop sponsored by the Rockefeller Foundation and Scientific & Industrial Research & Development Centre, Zimbabwe in Harare from 13-15 May 1998

CONCEPT PAPER: FINAL DRAFT

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1. Introduction:

The oil plant *Jatropha curcas* (L) (*Jatropha*) or physic nut is a multipurpose and drought resistant large shrub or small tree. Although a native of tropical America, it now thrives throughout Africa and Asia. It grows in a number of climatic zones in tropical and sub-tropical regions of the world and can be grown in areas of low rainfall and problematical sites. *Jatropha* is easy to establish, grows relatively quickly and is hardy. Being drought tolerant, it can be used to reclaim eroded areas, be grown as a boundary fence or live hedge in the arid/semi-arid areas.

The wood and fruit of *Jatropha* can be used for numerous purposes including fuel. The seeds of *Jatropha* contains (. 50% by weight) viscous oil, which can be used for manufacture of candles and soap, in the cosmetics industry, for cooking and lighting by itself or as a diesel/paraffin substitute or extender. This latter use has important implications for meeting the demand for rural energy services and also exploring practical substitutes for fossil fuels to counter greenhouse gas accumulation in the atmosphere.

These characteristics along with its versatility make it of vital importance to developing countries subjected to decreasing tree cover and soil fertility because of increasing population and development pressures. Nearly half the world's poorest people live on marginal lands with the number expected to increase from 500 million to 800 million by 2020. These areas are by definition isolated and fragile, with soils susceptible to erosion and subjected to environmental stresses of deforestation, prolonged droughts, and decreasing soil and ground water. Although southern Africa is rich in biodiversity and production potential, large areas are under semiarid and arid conditions with a moderate-to-high risk of drought. Plants species like *Jatropha* that can grow on lands not usually attractive for agriculture and supply raw material for industry, fuels for basic energy services and improve environment are therefore an obvious choice that needs to be assessed carefully and comprehensively.

Jatropha is not browsed, for its leaves and stems are toxic to animals, but after treatment, the seeds or seed cake could be used as an animal feed. Being rich in nitrogen, the seed cake is an excellent source of plant nutrients. Various parts of the plant are of medicinal value, its bark contains tannin, the flowers attract bees and thus the plant has honey production potential. Like all trees, *Jatropha* removes carbon from the atmosphere, stores it in the woody tissues and assists in the build up of soil carbon.

Despite these characteristics, the full potential of *Jatropha* is far from being realized. There are several reasons – technical, economic, cultural and institutional -- that need further discussion and examination. The growing and management of *Jatropha*, either on private public or community lands is poorly documented and there is little field experience that is being shared, especially in southern Africa. Currently, growers are unable to achieve the optimum economic benefits from the plant, especially for all its various uses. The markets for the different products have not been properly explored or quantified, nor have the costs or returns (both tangible and intangible) to supply raw materials or products to these markets. Consequently, the actual or potential growers including those

in the subsistence sector do not have an adequate information base about the potential and economics of this plant to make decisions relating to their livelihood, not to mention its commercial exploitation.

It is therefore timely to examine the potential role that *Jatropha* can play in meeting some of the needs for energy services for rural communities and also creating avenues for greater employment. It is important that the discussion on the exploration of potential of *Jatropha* should include the multiple stakeholders involved in research, utilization and exploration of this oil plant including government officials, NGOs, private sector, etc. Most importantly representatives of local communities must be included to examine any existing or latent demand for the plant to determine the framework for any future initiative based on the outcome of the discussions on the potential of *Jatropha curcas*. Hence this workshop.

2. Objectives of the Workshop:

The workshop will explore the potential of *Jatropha curcas* in rural development and influencing livelihoods at the household level in an environmentally friendly manner. Some of the issues to be examined therefore include:

- Use of *Jatropha* in meeting domestic needs of energy services including cooking and lighting;
- Potential of *Jatropha* as an additional source of household income and employment through markets for fuel, fertilizer, animal feed medicine, and industrial raw material for soap, cosmetics, etc.
- Potential of *Jatropha* in creating environmental benefits – protection of crops or pasture lands, or as a hedge for erosion control, or as a windbreak.

3. Production of *Jatropha curcas*

Considerable plantation of *Jatropha* had been undertaken in Zimbabwe by a number of active organizations involved in its promotion including the Agricultural Research Trust (ART), the Biomass Users Network (BUN), the Forestry Commission (FC) and the Plant Oil Producers Association (POPA). An estimated four million *Jatropha* plants have been planted in Zimbabwe by the end of 1997 amounting to nearly 2,000 hectares of plantations.

Although it is known that *Jatropha* can be established from seed, seedlings and vegetatively from cuttings, very little written information is available in Africa about the silviculture and management of *Jatropha*. Plants from seeds develop a typical taproot and four lateral roots, and cuttings do not develop a taproot (Heller J. 1996). *Jatropha* is a fast growing plant and can achieve a height of three meters within three years under a variety of growing conditions. Seed production from plants propagated from seeds can be expected within 3-4 years. Use of branch cutting for propagation is easy and results in rapid growth; the bush can be expected to start bearing fruit within one year of planting. (Jones & Miller, 1992, p. 8)

Whilst *Jatropha* grows well in low rainfall conditions (requiring only about 200 mm of rain to survive) it can also respond to higher rainfall (up to 1200 mm) particularly in hot climatic conditions. In Nicaragua for example, *Jatropha* grows very well in the country's hot climate with rainfall of 1 000mm or more. Experience in Zimbabwe has shown that high rainfall in the relatively cooler parts of the country does not encourage the same vigorous growth. However, in the low-veld areas, such as in the mid-Save region, *Jatropha* grows well, although comparative yields have not been established. *Jatropha* does not thrive in wetland conditions. The plant is undemanding in soil type and does not require tillage. In southern Africa, the best time for planting is in the warm season to avoid the cold season since the plants are sensitive to ground frost that may occur in the cold season. (BUN newsletter 1996).

The recommended spacing for hedgerows or soil conservation is 15cm - 25cm x 15cm-25cm in one or two rows respectively and 2m x 1.5m to 3m x 3m for plantations (Jones N, Miller J.H. 1992, p.7). Thus there will be between 4,000 to 6,700 plants per km. for a single hedgerow and double that when two rows are planted. The number of trees per hectare at planting will range from 1,600 to 2,200. Wider spacing is reported to give larger yields of fruit, 794 kg/ha and 318 g/shrub (Heller J. 1996).

In equatorial regions where moisture is not a limiting factor (i.e. continuously wet tropics or under irrigation), *Jatropha* can bloom and produce fruit all year. A drier climate has been found to improve the oil yields of the seeds, though to withstand times of extreme drought, *Jatropha* plant will shed leaves in an attempt to conserve moisture which results in somewhat decreased growth. (Jones and Miller, 1992, p.7)

Seed production ranges from about 0.4 tons per hectare per year to over 12 t. /ha. /a., after five years of growth (Jones N, Miller J.H. 1992). Although not clearly specified, this range in production may be attributable to low and high rainfall areas. In Mali, where *Jatropha* is planted in hedges, the reported productivity is from 0.8 kg. – 1.0 kg. of seed per meter of live fence (Henning R. 1996). This is equivalent to between 2.5 t. /ha. /a. and 3.5 t. /ha. /a.. The practices being undertaken by the *Jatropha* growers currently need to be scientifically documented along with growth and production figures. The growth and yield of wood may be in proportion to nut yield and could be improved through effective management practices.

Woody biomass growth, unlike seed production, is not recorded in any articles to hand. Although it needs to be tested, it is possible that nearly one-third of net primary production (NPP) in *Jatropha curcas* may be in the form of woody biomass. However, it needs to be tested if there is tradeoff between growing *Jatropha* plants for optimizing woody biomass vs. seed production for oil. Reportedly, *Jatropha* trees/bushes live up to 50 years or more. Like all perennial plants, *Jatropha* displays vigorous growth in youth that tails off gradually towards maturity.

Existing literature indicates that the Agricultural Research Trust of Zimbabwe (ART) has laid down trials of different provenance of *Jatropha curcas*. Such research work is vital in determining the most appropriate provenance and optimum management systems and must be pursued. The current status of this work may give an important insight into the management and yield of *Jatropha* in Zimbabwe. Although non-toxic varieties of *Jatropha curcas* were sent to Zimbabwe for planting, (Gubitz G. M. et al eds. 1997, page 203), their current locations are unclear. It is however possible that ART included these varieties in their provenance trials. Success of such varieties would make the seed cake following oil extraction suitable as animal feed without a need for its detoxification.

Although *Jatropha* is adapted to low fertility sites and alkaline soils, better yields are obtained on poor quality soils if fertilizers containing small amounts of calcium, magnesium, and sulfur are used. Mycorrhizal associations have been observed with *Jatropha* and are known to aid the plant's growth under conditions where phosphate is limiting. (Jones & Miller, 1992, p.7)

A perceived advantage of *Jatropha* is its capability to grow on marginal land and its ability to reclaim problematic lands and restore eroded areas. As it is not a forage crop, it plays an important role in keeping out the cattle and protects other valuable food crops or cash crops. *Jatropha* products from the fruit - the flesh, seed coat and seed cake - are rich in nitrogen, phosphorous and potassium (NPK) and are fertilizers that improve soil. *Jatropha* hedges and shelterbelts by improving the microclimate and providing humus and fertilizers to the soil can further enhance the productivity of other agricultural crops.

However, the above uses can be constrained by the prevalence of pests and diseases that attack *Jatropha*. Existing literature indicates that contrary to popular belief that toxicity and insecticidal properties of *J. curcas* are a sufficient deterrent for insects that cause economic damage in

plantations, several groups of insects have overcome this barrier. Particularly noteworthy is the insect order of Heteroptera that has at least 15 species in Nicaragua that can extract nutrients from physic nut. The stem borer from the coleopterous family of Cerambycidae that is known as a minor pest in cassava can kill mature physic nut trees. The relatively few leaf-eating insects present are not capable of doing much damage once the trees have passed the seedling stage. Biological control can make use of beneficial arthropods – polyphagous predators and specialized parasitoids – either by conservation or augmentative releases; the first alternative being the more cost efficient (Grimm & Maes, 1997). In some areas of Zimbabwe the golden flea beetle (*Podagrica* spp.) can cause harm – eat young leaves and shoots, particularly on young plants. *Jatropha* is also host to the fungus "frog-eye" (*Cercospora* spp.) common in tobacco. The workshop will examine the issue of pests and diseases that afflict *Jatropha* in further detail to ensure that it is safe to be used as a live fence and/or boundary plantation for various agricultural and cash crops.

In summary, the workshop will examine issues relating to silvicultural production systems and nutrient requirements of *Jatropha curcas* can be summarized as below:

- What are the best management techniques (planting practices, spacing, etc.) to promote the optimum growth of *Jatropha* to optimize for instance nut production?
- What types of edaphic factors, climatic conditions provide best for *Jatropha curcas*, both from the perspective of fruit and biomass? What is the ideal rotation age for nuts and the plant? What varieties, including non-toxic varieties perform better in southern Africa?
- How can *Jatropha curcas* plantations by themselves or in agro-forestry combinations (climatic conditions and management practices) alleviate problems of devegetation and soil erosion and improve, the environment.
- Available biological control/IPM techniques to control of pests and diseases of *Jatropha*.

4. *Jatropha curcas* as an Energy Source

4.1 Oil from *Jatropha curcas*

Jatropha oil is an important product from the plant for meeting the cooking and lighting needs of the rural population, boiler fuel for industrial purposes or as a viable substitute for diesel. Substitution of firewood by plant oil for household cooking in rural areas will not only alleviate the problems of deforestation but also improve the health of rural women who are subjected to the indoor smoke pollution from cooking by inefficient fuel and stoves in poorly ventilated space. *Jatropha* oil performs very satisfactorily when burnt using a conventional (paraffin) wick after some simple design changes in the physical configuration of the lamp.

About one-third of the energy in the fruit of *Jatropha* can be extracted as an oil that has a similar energy value to diesel fuel. *Jatropha* oil can be used directly in diesel engines added to diesel fuel as an extender or trans-esterised to a bio-diesel fuel. In theory, a diesel substitute can be produced from locally grown *Jatropha* plants, thus providing these areas with the possibility of becoming self sufficient in fuel for motive power. There are technical problems to using straight *Jatropha* oil in diesel engines that have yet to be completely overcome. Moreover, the cost of producing *Jatropha* oil as a diesel substitute is currently higher than the cost of diesel itself that is either subsidized or not priced at "full cost" because of misconceived and distorted national energy policies. Nevertheless the environmental benefits of substituting plant oils for diesel provides for make highly desirable goals.

In 1995, the Rockefeller Foundation (RF) and the German Government's Technical Assistance Programme (GTZ) joined together to evaluate the use of plant oil as a renewable fuel source for rural development in three of the countries -- Brazil, Nepal and Zimbabwe. Since species whose cultivation would not displace other agricultural crops nor compete for land with greater opportunity for other applications were being considered, *Jatropha curcas* emerged as a prime plant for investigation. This workshop builds on the earlier work of this initiative and examines rural

development and generation of employment in southern Africa to determine the issues, need and prospects for further research and development. The workshop will therefore discuss various issues including:

- Status of ongoing and potential research focusing on the applicability of *Jatropha* oil to meet the cooking and lighting needs of rural households and its competitiveness in substituting diesel in various stationary and mobile applications
- Economic feasibility of *Jatropha* oil in meeting the energy services needs;
- Available technology and products to meet the above mentioned needs and status of technological research;
- Role of the private sector and government policies in commercialization of *Jatropha curcas* products.

5. Other products of *Jatropha curcas*

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

The oil is a strong purgative, widely used as an antiseptic for cough, skin diseases, and as a pain reliever from rheumatism. *Jatropha* latex can heal wounds and also has anti-microbial properties. *Jatropha* oil has been used commercially as a raw material for soap manufacture for decades, both by large and small industrial producers. Soap from *Jatropha* oil is being made by small informal industries in rural areas in both Zimbabwe and Mali. A large manufacturer is interested in using *Jatropha* oil to substitute tallow in commercial soap making. The monthly requirement of this industry alone is 2,000 liters of oil. To supply this demand would require between 18,000-22,000 ha of *Jatropha* plantation or 30,000-40,000 km. Of *Jatropha* hedges or a combination of the two. Currently tallow fetches higher price than diesel in Zimbabwe. What are the possibilities of using commercial interest as above to create a capacity for *Jatropha* oil to address issues of rural energy equity and employment generation?

The oil cake cannot be directly used as animal feed because of its toxicity, but it is valuable as a fertilizer having a nitrogen content comparable to chicken manure and castorbean seed cake. The toxicity of the seeds is because of curcin (a toxic protein) and diterpene esters. Apparently seeds of Mexican origin have less toxic content and with proper processing they can be eaten. Although there are laboratory studies indicating detoxification, its feasibility and profitability on a large scale is yet to be investigated.

The workshop will therefore:

- Examining the potential market for various *Jatropha* products;
- Assessing the value of these products to the rural population;
- Determining the optimum combination for their use; and
- Proposing a strategy to maximize rural development, energy equity and employment.

6. Costs and Returns

6.1 Costs

An estimate of costs and returns from cultivation of *Jatropha* plantations/hedgerows' scenarios is crucial to analyzing its role in rural development. Costs, as well as returns are involved at different

stages of the growing and harvesting of *Jatropha curcas* and the manufacture/use of different plant products and include both tangible and intangible components of each. For instance an estimate of the following cost heads would be required for any economic analysis:

6.1.1. Cultivation of *Jatropha*

- a. Planting costs; c. Tending costs,
- b. Establishment costs; d. Other costs (specify).

6.1.2. Wood

- a. Pruning; f. Pole production;
- b. Thinning; g. Other products, specify;
- c. Felling; h. Storage costs of products;
- d. Firewood production; i. Transport costs;
- e. Charcoal production; j. Other costs, specify.

6.1.3. Fruit.

- a. Collection; e. Charcoal production from shells;
- b. Removal of flesh; f. Storage of products, (oil, cake, shells, flesh, etc.);
- c. Removal of shell; g. Transport costs;
- d. Extraction of oil, (state method); h. Other costs, (specify).

6.1.4. Capital & Labor costs

- a. Buildings
- b. Machinery and equipment
- c. Labor as per respective activity

6.2 Returns

Similarly several types of returns from the growing and use of the products from *Jatropha curcas* need to be carefully estimated. The obvious returns pertain to sale or market prices of the different products. These returns should be recorded and then compared to the cost of the growing plus management of the plants and the manufacture of the products to arrive at profitability of various products.

Some of the costs and returns have been indicated in the literature while others may have to be extrapolated from estimates for similar crops. A discussion document that provides a perspective on various economic costs and benefits is being prepared and will be ready prior to the meeting. The discussion in the afternoon of the last day will focus mainly on the socio-economic analysis gleaned from the workshop and the paper to generate insights for future investigation and research and development

7. EXPECTED OUTPUT

The expected output will be

- A good understanding of the role of *Jatropha curcas* in rural development;
- Based on that understanding a broad commitment from the national participants to pursue *Jatropha curcas* for rural development; and
- A strategy for field implementation.

It is hoped that the deliberations will pave the way for a Plan of Action to galvanize the planting and use of *Jatropha curcas* by rural communities to improve their well being and livelihood in association with the private sector and assisted by appropriate government policies.

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Generative propagation of *Jatropha curcas* L. on Kalahari Sand

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Abstract

In southern Africa, larger areas are under semiarid and arid conditions with a moderate-to-high risk of drought. The drought resistant plant, *Jatropha curcas* L., Euphorbiaceae that can grow on lands not suited for agriculture and both improve the environment and supply raw material for local communities is attractive for resource-poor farmers. Although *Jatropha* is commonly planted in southern Africa, research on cultivation and propagation of *Jatropha* is limited. This study provides documentation of the germination of *Jatropha* seeds planted in nursery in containers composed of Kalahari Sand. Sampling period was undertaken from late raining season to the beginning of dry period (February to June 2003). The study shows high viability of the seeds with a mean germination rate above 93 percent and a completed germination within 9 days. Manure during germination phase appears to have a negative impact on the germination. However, the results indicate that manure has a positive impact on the growth rate after germination has been initiated. Likewise, the intensity of watering and temperature seems to have a fundamental impact on the germination rate. Pre-treatment of the seeds did not effect the germination positively.

Keywords: *Jatropha curcas* L., generative propagation, germination, Kalahari Sand, Zimbabwe.

Introduction

Since the oil crisis of the 1970s and recognition of the limitations of world oil resources, vegetable oils have received special attention (Grimm 1996; Heller 1996; Henning 2000a; Pratt *et al.* 2002).

Special interest has been shown in the cultivation of the tropical physic nut (*Jatropha curcas* L., Euphorbiaceae) for oil extraction, especially since it is drought resistant and can be cultivated on marginal land, without competing with food production (Heller 1996; Grimm 1996; RF 1998).

Jatropha was introduced into Zimbabwe in the 1940s. *Jatropha curcas* L. is a multipurpose large shrub or small tree of Latin American origin. It is local adjusted throughout arid and semiarid tropical regions of the world with an average annual rainfall of between 300 and 1000 mm (Palgrave 1983; Heller 1996; CATIE 2000; Henning 2002). In Zimbabwe, it is now found in many parts of the

country, with known concentrations in the north-eastern districts of Mutoko, Wedza, Chiweshe, Mudzi and Nyanga north. *Jatropha* grows on well-drained soils with good aeration and is well adapted to marginal soils with low nutrient content. It occurs mainly at lower altitudes (0-500 m) in areas with average annual temperatures well above 20° C but can grow at higher altitudes and tolerates slight frost. It is not sensitive to day length (ICRAF 2003). Locally, it is grown as a boundary fence or live hedge and can be used to reclaim eroded areas (Heller 1996; Jøker & Jepsen 2003).

Jatropha is not browsed. Its leaves and stems are toxic to animals, but after treatment, the seeds or seed cake can be used as an animal feed (Makkar *et al.* 2001). Being rich in nitrogen, the seed cake is also an excellent source of plant nutrient (RF 1998; Makkar *et al.* 2001). Traditionally the seeds have been harvested by women and used for medical treatments and local soap production (Duke 1983; Henning 2002). *Jatropha* is fast growing and produce seeds after approximately 1 – 3 years, depending on rainfall conditions and how the plant is propagated (from cuttings or seeds, respectively). *Jatropha* can reach a height up to 8 metre (Heller 1996). *Jatropha* seeds contain about 35 percent of non-edible oil. 6 kg of dry seeds gives about 1.2 litre of oil. Research made by Henning 2002 indicates that commercial exploitation of the plant is comparable with cotton farming. Examples from Mali shows that villagers that plant 15 km of *Jatropha* hedges can harvest about 12 tons of seeds which may generate 1800 US\$ of cash income when the oil is extracted and the products sold (1998 figures). At least 2-3 tons of seeds per hectare can be achieved in semi arid areas (Heller 1996). It is believed that the total land area in Zimbabwe under *Jatropha* is somewhat less than 2,000 hectares (Makkar *et al.* 2002).

Research on cultivation and propagation of *Jatropha curcas* L. is limited, especially in southern Africa (RF 1998). For the quick establishment of hedges and plantations for erosion control, directly planted cuttings are recommended and for long –lived plantations for vegetable oil production, plants propagated by seeds are better (Heller 1996). Research shows that plants propagated by cuttings show a lower longevity and possesses a lower drought and disease resistance than plants propagated by seeds (Heller 1996). Likewise, pre-cultivation of *Jatropha* seedlings in poly-ethylene bags has been shown to accelerate the installation of a plantation by at least 3 months (Henning 2000c).

The main aim of the present study was to document the generative propagation of *Jatropha curcas* L. planted on Kalahari Sand during germination phase and contribute to the knowledge of cultivation of *Jatropha curcas* L. The following three hypotheses have been tested:

Hypothesis 1: Manure has a positive impact on germination of *Jatropha*. Seeds from *Jatropha curcas* L. germinate and grow faster in soil with manure than in soil without manure.

Hypothesis 2: The intensity of watering has a significant impact on the germination and growth of *Jatropha curcas* L.

Hypothesis 3: Temperature has a significant impact on the germination and growth of *Jatropha curcas* L.

Study area

The study was undertaken in Mkhosana, Victoria Falls situated in northern-western Zimbabwe. The area is on Kalahari Sand (deep, well-drained, nutrient-poor sands). The area receives a low and erratic mean rainfall of about 650 mm, falling from November to April. Mean summer and winter temperatures are 30 °C and 10 °C respectively. Ground frost is sometimes experienced between May and August. The altitude is 980 metres above sea level.

Methods

The field methodology involved two stages: (i) a general assessment of the viability of the seeds and the germination rate for generative propagation of *Jatropha curcas* L.; (ii) a more detailed assessment of the germination and growth rate of *Jatropha curcas* L. during the first eight weeks from seed planting. Both assessments were undertaken in nursery with approximately 50 percent density shade. Seeds used in both assessments were locally collected in June 2002. Seeds were stored in Hessian bags and kept under uncontrolled room conditions until required for planting. The seed provenance is unknown. The average temperature for each month is based on own data. Cow manure has been used for trials in the detailed assessment.

General assessment

Pre-cultivation of *Jatropha curcas* L. seeds in containers (milk packets, tin and poly-ethylene bags) composed of Kalahari Sand. The seeds were sown in the soil at a depth of 3 cm in each container (method after Henning 2000b). The assessment was undertaken in the period February to April 2003. Watering in February was made four times per week and two times per week in March and April. Numbers of days to first and last germination for each trial were observed. Moreover, measurements of the percentage of germinated seeds were made.

Assessment of the mean days of germination for seeds planted in May and June 2003 were made afterwards. The total number of germinated seeds during this period was not measured. Watering was

made 2 times per week.

Detailed assessment

Six experimental trials were made. Each trial consisted of ten seeds planted with one seed in each plant container. The seeds were planted in a dept of 3 cm. In two trials (C and D), pre-treatment of the seeds were carried out in order to enhance rapid and uniform germination by removing the testa by cracking each seed in the hand, carefully.

The assessment was undertaken in eight weeks during the period May to June 2003. The heights of the plant were measured once per week. The trails had the following design:

A: Seeds planted in Kalahari Sand without added manure

B: Seeds planted in a mixture (50-50) of Kalahari Sand and manure

C: Pre-treated seeds planted in Kalahari Sand without added manure

D: Pre-treated seeds planted in a mixture (50-50) of Kalahari Sand and manure

E: Seeds planted in Kalahari Sand without added manure

F: Seeds planted in a mixture (50-50) of Kalahari Sand and manure.

Trails A, B, C, and D describe the impact of using manure and pre-treatment of seeds. Trails A to D were watered three times per week.

Design of trails E and F were similar to trail A, B. Trails E and F describes the impact of lower watering intensity on the germination rate in soil with and without manure. Trials E, F were watered once a week.

Results

General assessment

In the period from February to April, out of 4771 planted seeds a total number of 4616 seeds germinated (96.8 percent survival). The mean germination rate for each month varied from 93.2 percent to 97.6 percent. The highest germination rate among the trials was achieved in April (table 1). The mean days of germination of *Jatropha curcas* L. seeds were 6.2 days in February, 7.6 days in March, 7.8 days in April (table 1). The mean day of germination for the seeds during all three months was 7.2 days. Shortest germination period occurred in February after four days and latest germination occurred in April after 10 days.

Germinations trials made in February had a faster germination rate of 1.4-1.6 days compared to the trials established in March and April. However, the mean germination for trials made in February was

2.2 - 4.4 percent lower, compared to the trials made the two following months. The average monthly temperature during the three months varied 1.7 °C from 22.8 °C in February and March to 21.1 °C in April.

Table 1 Analysis of mean days of germination and mean germination rate across month and water intervals.

Month	Mean days of germination (μ)	S.D ^{*)}	Mean germination rate (%)	No. of planted seeds	No. of seeds germinated	Treatment Water interval	Average temperature (°C)
February	6.2	1.8	93.2	441	411	4 times a week	22.8
March	7.6	1.5	95.4	930	887	2 times a week	22.8
April	7.8	1.6	97.6	3400	3318	2 times a week	21.1
Total				4771	4616		

^{*)} S.D Standard Deviation

The mean days of germination for seeds planted in May and June were 7.9 days and 11.8 days, respectively. The mean day of germination for the seeds during all five months was 8.3 days. The average monthly temperature during the whole sampling period varied 7.8 °C from 22.8 °C in February and March to 15 °C in June. Most significant difference in temperature was observed from April to May (3.3 °C) (fig. 1). The most significant difference in mean day of germination was seen from May to June (3.9 days).

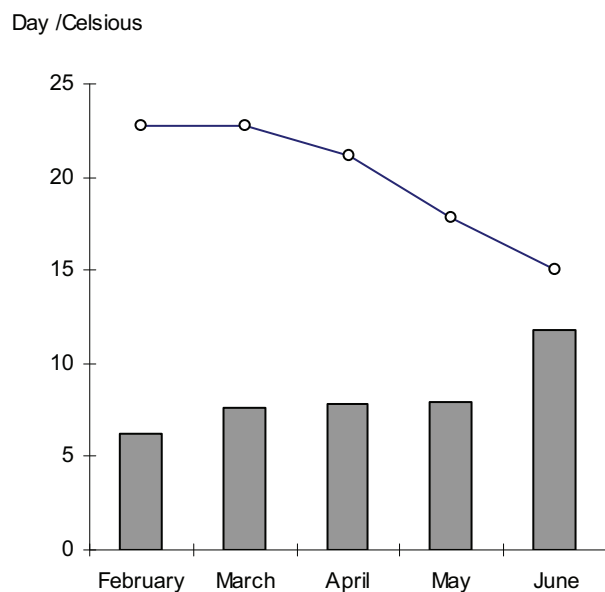


Fig. 1 Mean monthly germination rate for *Jatropha curcas* L.

(\bar{I}) and monthly average temperature (o).

Detailed assessment

A significant difference in germination rate was identified (fig. 2). Out of six experimental trails, germination occurred in five trials. Highest percentage germination was obtained in trail A on sand without added manure and watered three times a week (70 percent). Lowest percentage germination was measured in trail D for pre-treated seeds planted in a mixture of sand and manure and watered three times per week (20 percent). No germination was identified in trail E on sand without added manure and watered once a week.

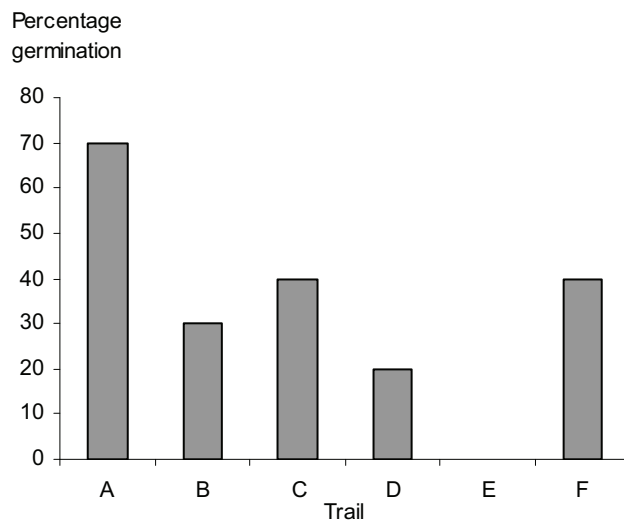


Fig. 2 The germination of *Jatropha curcas* L. in different trails

Figure 3 illustrate the mean shoot length of seedling during the first eight weeks. During the first three weeks seeds in trial B and C had a significant faster mean growth rate compared to the three other trials. Seeds in trial B and C had after three weeks achieved a high of app. 8 cm compared to 1.8 cm for trial A, D and F. Seeds in trail A, D and F had started shooting after two weeks compared to one week for seeds in trial B and C.

Between week three and four, the highest increase in growth was obtained by seeds in trail A, D and F. During one week the seeds grew from 1.8 cm to 7-9.5 cm. The growth rate for seeds in trial B and C were decreasing during this week.

From week four to eight, seeds in all the trials had a decreasing growth rate. During the period from week four to five seeds from trial F changed its position from being the trial with the second lowest length of seedling to be the trial with the longest length of seedling. After eight weeks highest mean length of seedling was above 14 cm (trail F) and lowest length of seedling was about 8 cm (trial D).

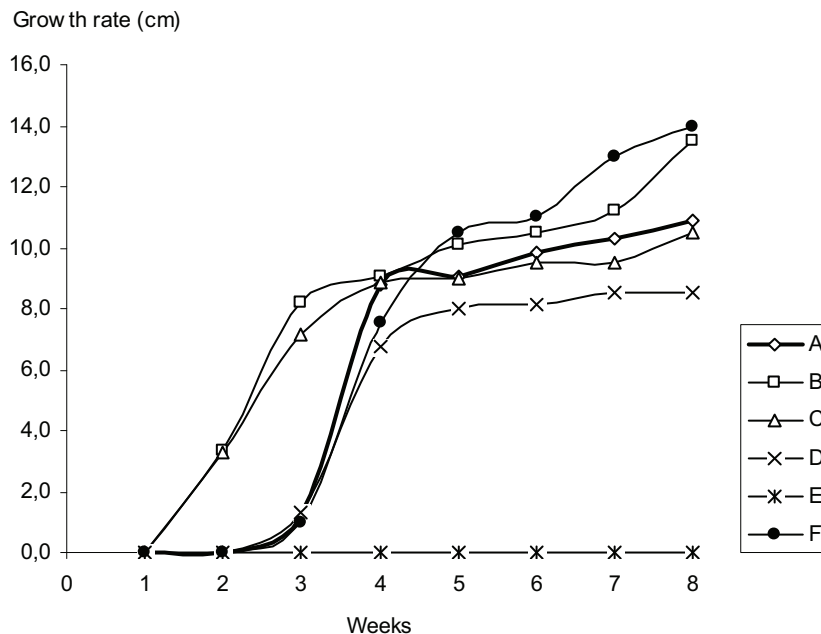


Fig.3. Mean shooting length of seedlings. Seeds in trials A to D have been watered three times per week, while seeds in trials E and F have been watered once per week. A): Seeds planted in Kalahari Sand without added manure B): Seeds planted in a mixture (50-50) of Kalahari Sand and manure C): Pre-treated seeds planted in Kalahari Sand without added manure D): Pre-treated seeds planted in a mixture (50-50) of Kalahari Sand and manure E): Seeds planted in Kalahari Sand without added manure F): Seeds planted in a mixture (50-50) of Kalahari Sand and manure.

Discussion

Comparative research on the influence of different propagation methods on viability and vegetative development was conducted by Kobilke (1989) in Cape Verde and by Heller (1992) in Senegal. The results achieved in Cape Verde and Senegal show that both vegetative cultivation methods and methods of generative precultivation were more successful than direct seeding.

Factors responsible for the survival of direct seeding (seeding time, seeding depth) have been studied by Heller (1992). The result shows low viability for direct seeding (19.8 %) whereas the same provenance seeded in plastic bags showed a higher germination (68 %). The viability depended not only on sowing time and depth of sowing, but also on the trial year.

In our general assessment, Short-term storage under uncontrolled room conditions did not appear to affect the germination of *Jatropha curcas* L. as this showed high viability (> 93 percent).

The seed material used in both assessments was collected from the same area in June 2002. The *Jatropha* seeds are oily and do not store for long. Research on viability of *Jatropha* seeds shows a

decrease due to term of storage. Seeds older than 15 months show viability below 50 % (Kobilke 1989). In our general assessment the viability for seeds planted in May and June was not measured. It can therefore not be excluded that more than ten months storage under uncontrolled room condition could have had a negative affect on the germination of the seeds.

In our assessment no statement can be made on depth of sowing or the occurrence of water stress shortly after seeding, since soil moisture was not determined. However, in the general assessment; it seems that watering intensity and temperature have had an effect on the mean days of germination and germination rate of the seeds planted in February. Compared to the two other months (March and April) we achieved the fastest mean days of germination in February under highest mean temperature and watering intensity. The higher moisture conditions have had a positive effect on the mean days of germination but have also resulted in a lower germination rate due to mouldy seeds.

Assessments made in February to April are comparable with trials made in May and June. The watering intensity was two times per week and the seeds were planted in Kalahari Sand only.

However, the germination period was longer in May and June, especially. It seems that the temperature and the fact that the general assessment was made during the end of the raining season have had an impact on the mean days of germination of the seeds. The watering intensity and humidity have been higher during the raining season than in the dry period (May and June).

In the literature the germination is said to take 10 days under good moisture conditions (Heller 1996; Henning 2000a; ICRAF 2003). In our research we have achieved germination after four days depending on which month the seeds were planted. The best time for planting *Jatropha curcas* L. on Kalahari Sand, in the period late raining season to start of dry season, will be during the raining season. Experience in Zimbabwe has shown that high rainfall in relatively cooler parts of the country does not encourage the same vigorous growth. However, in the low-weld areas, *Jatropha* grows well. *Jatropha* does not thrive in wetland conditions (RF 1998).

In the detailed assessment the general germination rate was low (0 - 70 %), which is likely caused by lower temperature during the period of assessment and dry season. From the trials, manure seems to have an impact on the germination of *Jatropha*. Trials in figure 2 shows highest germination (70 percent) for seeds planted in soil without added manure when watered three times per week and no germination at all when watered once per week. However, germination was identified in all trials which included manure. Even in trial F which was watered once per week 40 percent germination was

achieved. In comparison no germination was achieved in trial E for seeds planted on Kalahari sand and watered once per week. From our research adding of manure seems to keep the soil moist and have a positive impact on the germination rate of the specie. Henning 2000b recommends germination of *Jatropha* in small plastic bags filled with soil with a high concentration of organic material (compost). However, from our research the optimum germination condition for *Jatropha* planted on Kalahari sand was achieved in pure sand under high temperature conditions $> 20^{\circ}\text{C}$ in combination with high watering intensity (three times weekly).

Our observation of the growth rate indicate that *Jatropha curcas* L. is a fast starter and do not need manure to germinate. When germination is initiated the shooting of the seedling is fast and will within two weeks grow app. 10 cm. The impact of adding manure to the soil is not significant. From our observation during the eight week assessment of the growth rate adding of manure seems to have a positive impact on the growth rate. From our data the two trials with the highest growth after eight weeks (app. 14 cm) has both been planted in a mixed soil with manure. Highest growth rate for all trials was achieve in trial F with manure and watered once a week.

From our research adding of manure after germination in order to increase the growth rate seems to be a possibility.

Freshly harvested seeds show dormancy and after-ripening is necessary before the seeds can germinate (Jøker and Jepsen 2003). Kobilke (1989) tried to break induced dormancy. Removal of the testa proved more successful than presoaking alone. However, Pre-treatment of the orthodox seeds did in our research not seem to make an improved impact on the germination and growth rate. The trials with pre-treated seeds appear to have the lowest growth rate.

Conclusion

This study has provided data on the germination of the specie *Jatropha curcas* L. planted on Kalahari Sand. The study shows high viability of the seeds with a mean germination rate above 93 % and a completed germination within 9 days.

Use of manure in generative propagation of *Jatropha curcas* L. on Kalahari Sand seems to reduce the need for watering. Adding of manure has a negative impact on the germination but a positive impact on the growth rate after germination has been initiated.

The intensity of watering and temperature seem to have a fundamental impact on the germination

rate. An increase in the mean days of germination is observed due to temperatures below 15° C.

Moderate watering intensity increases the germination rate.

Pre-treatment of the seeds before planting did not effect the germination positively.

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BUN Zimbabwe
Jatropha Project in Makosa

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 utilisation 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 soaps.

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 2
JCL Oil Press installed at Makosa in 1999 by BUN
(Photo BUN 99)



One maize field showing the impact of JCL presscake
applied to the portion on the left hand side vs. cowdung
on the right side. (Photo BUN 1999)

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