Journal of Agriculture and Rural Development in the Tropics and Subtropics
Volume 110, No. 1, 2009, pages 29–38

Jatropha curcas L.: Visions and Realities

M. Grass [1]

Abstract

Since several years Jatropha is experiencing a renaissance. The main drivers for this development are the biofuel boom in general and the special attributes of Jatropha itself. This paper discusses the current knowledge as well as expectations of Jatropha and the consequential outcomes starting with data availability and quality followed by economic and political needs and constraints. Text

Keywords: Jatropha curcas, biofuel

1 General Data about Jatropha

From the genus Jatropha known to date with about 165-175 species (Heller, 1992) *Jatropha curcas* L. (*J. curcas* L.) is seen as the most primitive species within this group. Heller states that the provenance of *J. curcas* L. can be located in South America. However, a different position is presented by Münch and Kiefer (1986) which argue that *J. curcas* L. could have its origin already in Gondwanaland and, therefore, can be found in America, Africa and probably Asia as well. Another hypothesis shared by most authors is that *J. curcas* L. was spread by Portuguese seafarers to Africa and India. To date, a final scientific clarification of the spread of *J. curcas* L. is pending.

A rough picture of the area theoretically suitable to *J. curcas* L. cultivation, was presented by Jongschaap *et al.* (2007). The authors claim that "the most suitable climate conditions for the growth of Jatropha (*J. curcas* L.)" can be expected between 30°N and 35°S. This theoretical widespread distribution is restricted to zones with no frost, sufficient water availability, and soil conditions supporting Jatropha plant growth.

The promoters of Jatropha production for renewable energy production claim that:

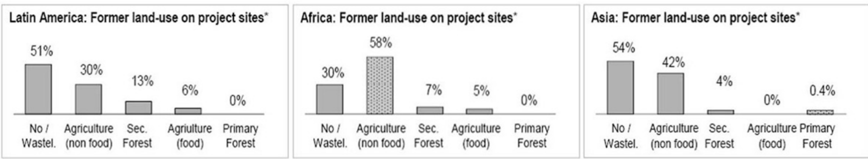
- it can be grown on marginal soils
- it is drought resistant
- it requires no high soil fertility
- it is to a certain point pest resistant
- it provides even under this restrictions high yields

[1] Dipl.-Ing. sc. agr. Martin Grass, Universität Hohenheim, Institute for Agricultural Economics and Social Sciences in the Tropics and Subtropics, Dept. of Rural Development Theory and Policy, 70593 Stuttgart, Germany, email: Martin.Grass@uni-hohenheim.de

This leads to the argument that Jatropha plantations will not compete with food production when compared to Palm oil or Sugar cane production. However the case is not as simple as stated.

Marginal land is classified by the OECD as "land of poor quality with regard to agricultural use and unsuitable for housing and other uses" (OECD, 2001).
However, this definition regarding the possible locations for cropping Jatropha does neither include physical and chemical soil terms nor climatic conditions which can influence the growth response of Jatropha. Although MÜNCH and KIEFER (1986) state that Jatropha is adaptable to most soil conditions, their interdependencies are not explored yet. A first overview of different land types allocated to current Jatropha plantations (Figure 1) is shown by a study of the organisation "Global Exchange for Social Investment" (GEXSI) in 2008.

Figure 1: Land Use for Jatropha.



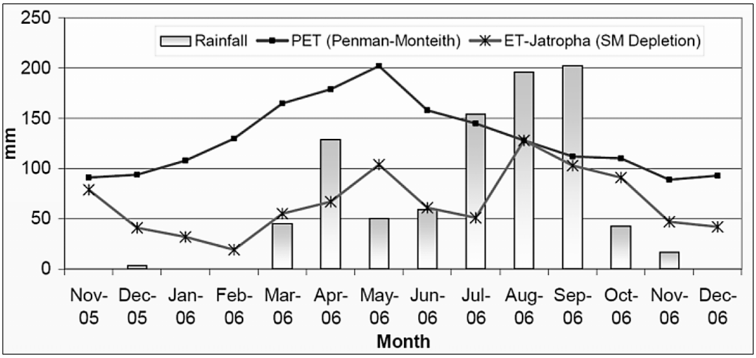
Source: GEXSI (2008), * Sample n = 90 projects with a total planted acreage of 325,000 ha

MÜNCH and KIEFER (1986) pointed out that Jatropha can survive with an annual rainfall of 400 mm. However, FRANCIS *et al.* (2005) state that for production purposes 900 – 1,200 mm rainfall or water supply are needed. Not only the total amount of annual rainfall but also the distribution of water supply within the year (Figure 2) is important for plant growth as was shown by WANI *et al.* (2007).

Nutrient demand of Jatropha is mostly calculated based on the nutrient content of the Jatropha seedcake exported from the site of production, assuming that only the Jatropha seeds leave the production system. This view is supported by MÜNCH and KIEFER (1986) who state that the pressed oil contains theoretical only water and CO_2, and, therefore, no nutrients will be extracted other than those contained in the Jatropha seedcake. Results of seedcake nutrient analyses presented by different authors are shown in Table 1. A broader nutrient analysis of the all Jatropha components was presented by JONGSCHAAP *et al.* (2007). Based on mean values from Table 1, for a harvest of 1000kg of Jatropha seeds, on average[1] 40 kg Nitrogen, 16 kg Phosphorus, and 10 kg Potassium need to be added to the plantation, to at least balance the macro nutrient outtake and to maintain soil fertility.

[1] Assuming 25 % of weight is extracted Jatropha oil and 75 % of weight is seedcake

Figure 2: Water relations for the growth of a 2 years old *J. curcas* plantation at ICRISAT (India) from November 2005 to December 2006. ET = Evapotranspiration; PET = Potential evapotranspiration; SM = soil moisture.



Source: Wani *et al.* (2007), cited in Jongschaap *et al.* (2007)

Table 1: Nutrient composition of Jatropha seed cake as recently presented by different authors.

Nutrient	Wani *et al.* (2007)	Francis *et al.* (2005)	GTZ 1995	Sreedevi (2005)
Nitrogen (%)	4.91	5.7-6.5	5.72-6.48	4.44
Phosphorus (%)	0.90	2.6-3.0	2.61-3.06	2.09
Potassium (%)	1.75	0.9-1.0	0.90-0.97	1.68
Calcium (%)	0.31	0.6-0.7	0.60-0.66	
Magnesium (%)	0.68	1.3-1.4	1.26-1.34	
Zinc (ppm)	55			
Iron (ppm)	772			
Copper (ppm)	22			
Manganese (ppm)	85			
Boron (ppm)	20			
Sulphur (ppm)	2433			

The assumption that Jatropha is relatively resistant to pests and diseases might strongly rely on the fact that current knowledge is generally based on experimental plots or small scale experience. Growing Jatropha in large scale monocultures will increase the risk for pests and diseases to occur. A group of organisms likely to affect Jatropha, such as fungi (e.g. phytophtora, mucoraceae), insects (e.g. stem borer, leaf miner, caterpillars, and scale) and diseases (e.g. mosaic virus) was defined by Grimm (1999); Münch and Kiefer (1986); Narayana *et al.* (2006); Shanker and Dhyani (2006); Tewari *et al.* (2007); Üllenberg (2008). To which extend they will affect individual plants or need to be treated in larger scale plantations is not known to date. Especially the possible interaction between the Jatropha mosaic virus and the cassava mosaic virus needs to be studied in more detail. Evene remote possibilities for the virus to spread from one culture to the other, requires safeguard measurements to be taken as cassava serves as staple food in many developing countries.

Breeding of Jatropha is yet in its early stages as Jatropha still is classified as a wild, non-domesticated species. This is clearly shown by the high variation in seed morphology and oil content. Kaushik *et al.* (2007) found for 24 accessions[2] that the hundred-seed weight ranged from 49.2 g up to 69.2 g and the seed oil content varied from 28% up to 38.8%. However, the authors state that "in general the phenotypic coefficient of variation was higher than the genotypic coefficient of variation indicating the predominant role of the environment". Nevertheless, current results of worldwide Jatropha screening constitute the first step towards promoting breeding success. In the case of India, Kaushik (2007) aims to develop a stable variety of Jatropha with at least 35% seed oil content and seed yield of 2 kg per plant and year within the next 8 years.

This uncertainty raises the question if the assumption of Jatropha providing high yields under sub-optimal and marginal conditions is supported by the current knowledge base (Jongschaap *et al.*, 2007).

2 Agronomic Data of Jatropha

Research on Jatropha has started more than 20 years ago. Unfortunately, this research was characterized more by sporadic action than by continuous work. This explains the current lack of in-depth and long term information on *J. curcas* L. production systems, leading to the fact that current plantation practice is mainly based on data from experimental plots and small scale experience. Therefore, all *J. curcas* L. growers are forced to make decisions according to the local conditions where he wants to establish a *J. curcas* L. plantation.

Suggestions available as to how to establish and manage Jatropha plantations range from spacing of 2.5m × 2.5m to 4m × 4m or even wider spacing, different planting hole depths, different application doses of start up fertilizer, and the choice of using either cuttings, seedlings or direct seeding. A study carried out by GEXSI (2008) provided a first overview on *J. curcas* L. projects on a global scale. Their results[3] show that according to the different planting techniques nurseries were used in 85%, direct seeding in 45%, cuttings in 40% of the projects, and in about 20% of the projects even two or all three methods were used simultaneously. Since planting shortly before a rainy season will provide the needed water supply for enhanced plant growth, the local climatic and soil conditions need to be carefully considered. Pruning of Jatropha in the first years leads to a more bushy structure supporting a higher flowering rate and thus increasing yields. Within the sample of 90 projects 80% used pruning, 67% used fertilizer and 49% irrigated their plantations (GEXSI, 2008).

[2] *Jatropha curcas* collected from different agro climatic zones of Haryana state (India)

[3] GEXSI, 2008 "Sample: n = 95 projects"

Assumptions on attainable yields vary widely e.g. for seeds 0.5 to 12 $t\,ha^{-1}\,a^{-1}$ – depending on soil, nutrient and rainfall conditions Francis *et al.* (2005), and for fruits 7.5 $t\,ha^{-1}\,a^{-1}$ (Openshaw, 2000). Both authors do not clearly explain the scientific basis supporting these estimates. In contrast, Kashyap (2007) states for India, that under rainfed conditions, yield is limited to max. 1.5 $t\,ha^{-1}\,a^{-1}$.

The productive lifespan of a Jatropha plantation is yet another uncertainty. There is a significant difference between a plantation being productive for just 30 years (Francis *et al.*, 2005) or up to 50 years (Henning, 1997).

Variations can be found as well in the figures regarding the efficiency of manual harvesting techniques. van Eijck (2006) estimates that 2 kg of Jatropha seeds can be harvested by one person per hour, Heller (1996) , however, states that 18 kg of Jatropha seeds can be harvested per person per hour. Even figures of up to 50kg per person/hour circulate, but are without scientific evidence. The same situation can be observed for labour data for plantation establishment and maintenance (Table 2).

Table 2: Assumed labour demand to establish and maintain 1 ha Jatropha in man days.

	1st year	*2nd year*	*3rd year onwards*
Francis *et al.* (2005)	200	50	50
Becker (2008)	91	46	40
Kashyap (2007)	75 - 80		
Wani (2008)	165	115	110

The inconsistency of the available data does not support decision making processes and invites miscalculations for Jatropha plantation planning, establishment and maintenance, increasing risk of failure should economic viability calculations turn out to be too optimistic.

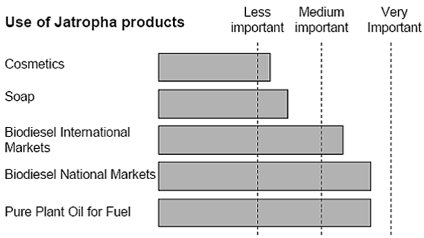
3 Product Range of Jatropha and Possible further Development

Even if the current boom for Jatropha production is based mainly on the incentive of producing biofuel (Figure 3) the possible range of products which can derived from Jatropha is much broader (Figure 4).

The current focus on biofuel as major marketable product from Jatropha has the disadvantage that the economic viability of Jatropha production depends on its strength to compete with fossil diesel and thus relies on the development of crude oil prices. A possible strategy to mitigate the risk of volatile crude oil prices would and should be the development of a broader range of Jatropha based products as stated by Münch and Kiefer (1986). These products could tip the scales of economic viability of Jatropha production even when facing the lack of agronomic data and other uncertainties.

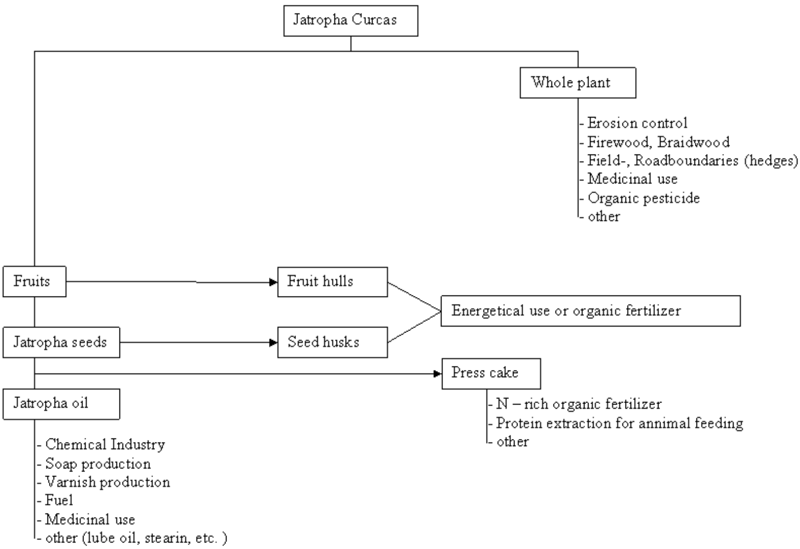
A strategy to develop a more diverse and sustainable market for Jatropha products was proposed by Ranaivoarison (undated) in Madagascar. A step by step approach is considered to make the rural population sensitive to possible income generation via

Figure 3: Use of Jatropha products



Source: GEXSI (2008) based on expert estimates for 39 countries

Figure 4: Range of possible Jatropha based products

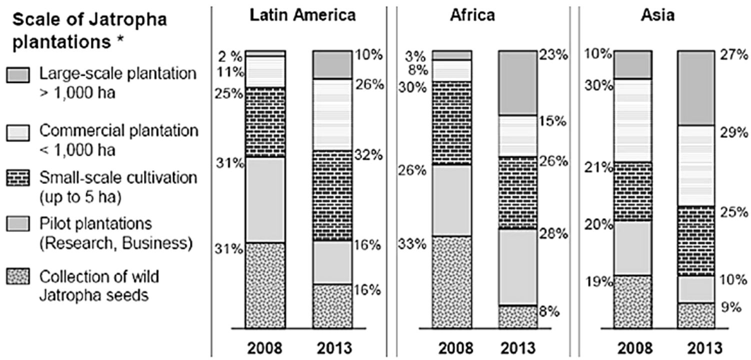


Source: Adapted from Münch and Kiefer (1986)

participation in the Jatropha production. This includes as a first step the establishment of a local market for Jatropha products such as soap or Jatropha oil for lighting purpose, followed by a second step for energy (decentralised electrification) and biofuel production on a larger scale when economic success was proven. An example of Jatropha soap production already entering a local market is that of Kakute Ltd. in Tanzania.

The Jatropha product industry is very young. Few projects are more than two years old and hardly any project can demonstrate significant production of Jatropha oil yet (GEXSI, 2008). However, it is expected that in the near future commercial and large-scale plantations will strongly expand their activities (Figure 5). This increase will lead to an estimated annual global investment of up to 1 billion USD (GEXSI, 2008) per year within the next 5-7 years. Nevertheless, smallholder production seems to play an important role in Jatropha production and is likely to continue to do so.

Figure 5: Possible development of Jatropha expansion



Source: GEXSI (2008), * Information from n = 33 countries with strong or starting Jatropha activities, Expert Country Estimates

4 Political Framework Situation and Future Needs

Many developing countries simply adopt the EU and U.S. measures such as mandatory fuel-blending obligations as well as a broad range of programs to support their national biofuel industries. Beside this, national legislations regulating the growing biofuel sector are still under development or often just starting. Therefore, investors often act in a grey zone that will most probably be subject to rules and regulations in the near future which then could affect their business directly.

One probable outcome is the assimilation of the biofuel sector into the national fossil fuel sector. The main question here will be to which extend policies targeting financial regulations such as taxation or subsidies will be applied to biofuels as they are widely applied to fossil fuels by most developed and developing countries (Bacon and Kojima, 2006; GTZ, 2007).

Another topic for future actions of governments in developing countries are regulations on land ownership and use as currently land property and land title systems are often strongly disputed due to non-existent or unclear legal instruments. Especially land that is classified as common property (often state owned land as well) often provides the basis for the livelihood of the rural poor and thus constitutes an area for future conflicts.

Therefore, investors applying to governments for land to install their production would benefit from a direct communication with the local population and field visits to potential production sites would be a first step to avoid possible conflicts. However, as the number of players in this sector is expanding the competition for land among them and locals is likely to increase.

Mainly biofuel exports targeting EU and U.S. markets will face the sustainable biofuel production standards and certification. Therefore, regulations targeting issues such as environmental protection, energy efficiency, greenhouse gas balance, and social responsibility will play an important role for biofuel production in the near future.

Irrespective of the enthusiasm for biofuel production, possible effects on food production and thus food security need to be carefully observed. Up to now the GEXSI (2008) study revealed that in their sample only 1.2% of areas planted with Jatropha had been used for food production in the 5 years prior to the start of the project. In addition, intercropping is widely used and, therefore, Jatropha production could enhance food production and develop underexploited areas. Nevertheless, the issue needs to be introduced into national policy and regulations to make sure that food security is not compromised.

Among all these uncertainties, the question of social justice has not yet been addressed. Will the local, rural labor force benefit from the Jatropha hype in the sense that a share of potential wealth will reach them or their families, or will they have to stay poor in order to limit production costs and make the system work?

5 Conclusion

There is an urgent need to understand more about Jatropha in general, its possible application and its performance in larger plantations. In addition, breeding programs and selection tools need to be developed to provide appropriate plant material for different agro-ecosystems. This requires an interdisciplinary approach covering Jatropha systems and their determining and limiting factors.

But not only the production system and the plant itself need investigation. Research also needs to focus on the potential range of marketable products based on Jatropha other than biofuel. This includes the development of products, establishment of markets, and definition of framework conditions.

The first steps of coordinated research have been taken and platforms promoting knowledge exchange are already online (e.g. www.jatropha-platform.org, www.jatropha.wur.nl, www.jatropha.uni-hohenheim.de). These actions will provide investors as well as governments and other stakeholders with reliable information to overcome the current challenges. Nevertheless, governments in developing countries will need international cooperation to develop appropriate framework conditions such as national land title systems and should be involved in creating international standards and certifications for biofuels to adapt them to their specific needs.

In conclusion, I strongly believe that the propagation of Jatropha can be seen as a possible option for rural development. Especially if focused on the local value chains with the value generated staying in the region, but as well if income generation from working in a Jatropha plantation provides a positive effect on the livelihood of the rural population.

References

Bacon, R. and Kojima, M.; Coping with Higher Oil Prices?; Energy Sector Management Assistance Program, Report 323/06, c/o Energy and Water Department, The World Bank Group, Washington; 2006.

Becker, K.; Biofuel from *Jatropha curcas* – Challenges and perspectives for small-scale farmers in the Tropics; presented on the international conference of the Society for Tropical Ecology, 18-22 February 2008, Hohenheim; 2008.

van Eijck, J.; *Transition towards Jatropha Biofuels in Tanzania? An analysis with Strategic Niche Management*; 123 pages; Eindhoven University of Technology, Department of Technology Management, Technology and Policy; 2006.

Francis, G., Edinger, R. and Becker, K.; A concept for simultaneous wasteland reclamation, fuel production, and socio-economic development in degraded areas in India: Need, potential and perspectives of Jatropha plantations; *Natural Resources Forum*; 29:12–14; 2005.

GEXSI; Global Market Study on Jatropha, Final Report; Prepared for the World Wide Fund for Nature (WWF), London/Berlin, May 8th; 2008; URL http://www.jatropha-platform.org/downloads.htm.

Grimm, C.; Evaluation of damage to physic nut (*Jatropha curcas*) by true bugs; *Entomologia Experimentalis et Applicata*; 92:127–136; 1999.

GTZ; International Fuel Prices 2007; 5th Edition – More than 170 Countries, Eschborn, Germany; 2007; URL http://www.gtz.de/en/themen/umwelt-infrastruktur/transport/10285.htm.

Heller, J.; *Untersuchung über genotypische Eigenschaften und Vermehrungs- und Anbauverfahren ber der Purgiernuß (Jatropha curcas L.)*; Verlag Dr. Kovač, Hamburg; 1992.

Henning, R.; Fuel Production Improves Food Production: The Jatropha Project in Mali; in: *Biofuels and Industrial Products from Jatropha curcas, Developed from the Symposium "Jatropha 97 ", Managua, Nicaragua, February 23-27, 1997*; chap. 3.2; Dbv-Verlag für die Technische Universität Graz, Austria; 1997.

Jongschaap, R. E. E., Corré, W., Bindraban, P. S. and Brandenburg, W. A.; Claims and Facts on Jatropha curcas L., Global *Jatropha curcas* evaluation, breeding and propagation programme; Report 158, 42 pages, Plant Research International Wageningen UR; 2007.

Kashyap, D.; Biofuels and Food Security: Case of Non-Edible Oils in India Experiences of German Technical Cooperation; presented on the conference: Policies Against Hunger VI -Bioenergy and Food Security, 16-19 December 2007, Berlin Germany; 2007.

KAUSHIK, N.; personal communication; 2007; fellow & Area Convenor Plant Biotechnology Environmental & Industrial Biotechnology Division, The Energy and Resources Institute, New Delhi – 110 003, India.

KAUSHIK, N., KUMAR, K., KUMAR, S., KAUSHIK, N. and ROY, S.; Genetic variability and divergence studies in seed traits and oil content of Jatropha (*Jatropha curcas* L.) accessions; *Biomass & Bioenergy*; 31:497–502; 2007.

MÜNCH, E. and KIEFER, J.; Die Purgiernuss (*Jatropha curcas* L.); Diploma thesis, University of Hohenheim, 277 pages; 1986.

NARAYANA, D. S. A., SHANKARAPPA, K. S., GOVINDAPPA, M. R., PRAMEELA, H. A., GURURAJ RAO, M. R. and RANGASWAMY, K. T.; Natural occurrence of Jatropha mosaic virus disease in India; *Current Science*; 91(5):584–586; 2006.

OECD; Glossary of statistical terms: marginal land; 2001; URL `http://stats.oecd.org/glossary/detail.asp?ID=1591`.

OPENSHAW, K.; A review of *Jatropha curcas*: an oil plant of unfulfilled promise; *Biomass & Bioenergy*; 19:1–15; 2000.

SHANKER, C. and DHYANI, S. K.; Insect pests of *Jatropha curcas* L. and the potential for their management; *Current Science*; 91(2):162–163; 2006.

SREEDEVI, T. K.; Farmers' Participatory Evaluation of Pongamia Seed Cake as a Plant Nutrient Source in Integrated Nutrient Management; Field Research Report, International Crops Research Institute for the Semi-Arid Tropics, Patancheru 502 324, Andhra Pradesh, India; 2005.

TEWARI, J. P., DWIVEDI, H. D., PATHAK, M. and SRIVASTAVA, S. K.; Incidence of a mosaic disease in *Jatropha curcas* L. from eastern Uttar Pradesh; *Current Science*; 93(8):1048–1049; 2007.

ÜLLENBERG, A.; Jatropha in Madagaskar; Sachstandsbericht - Mai 2008, Im Auftrag von Deutsche Gesellschaft für technische Zusammenarbeit (GTZ), Madagaskar; 2008; URL `http://www.jatropha.de/madagascar/GTZ-Bericht_Jatropha_V2.1.pdf`.

WANI, S. P.; personal communication; 2008; principal Scientist on Watersheds and Regional Theme Co-ordinator, ICRISAT-Patancheru – 502 324, India.

WANI, S. P., SREEDEVI, T. K., KESAVA RAO, A. V. R. and DIXIN, Y.; Biofuels: a strategy for enhanced water use efficiency, improved livelihoods and protecting environment in the semi-arid tropics; Linkages between Energy and Water Management for Agriculture in Developing Countries 29-31 January 2007, Patancheru, India, Published by ICRISAT, IWMI, FAO, IWREC; 2007.