Jatropha facts

Jatropha growth and oilseed production in Africa

Policy message

- Jatropha shows highly variable seed yields. To minimize risks for African farmers, it should be grown only as a supplement to current farming systems at least until reliable germplasm and agricultural practices provide consistent yields
- Like all crops, jatropha responds positively to good soil and suitable weather conditions. Growth and yield can be severely limited by poor management and reduced by pests. Sustainable and optimized crop management may alleviate crop growth limitations and reductions, but not necessarily result in improved seed yields
- Sustainability of jatropha should be studied on the system level and not only on the basis of life cycle analyses, since these are product-based and do not respond to land use issues

Harvesting of jatropha fruit from a living fence in Mali. (©Kenis)

Attempts to domesticate jatropha and initiate viable oilseed production chains have led to ambitious projects with many failures. Difficulties with taking decisive steps forward are primarily related to the increase in seed productivity in beneficial and sustainable production systems. In Africa, there is tremendous potential for optimizing agronomy measures, but advances in plant breeding and crop management are required to increase oil yield, oil quality and nontoxic press-cake in stable varieties with predictable seed and biomass productivity. Such qualities reduce risk and increase the chances of jatropha playing a role in sustainable livelihoods of African farmers (Muys et al., 2013).

Jatropha genetic resource base

Jatropha accessions (Figure 1) were introduced in Africa long ago (Henning, 2007) and belong to a subset of Central American genetic diversity, which has led to genetic similarities found today among most African materials (red dots) (Jongschaap and Van Loo, 2012; Torres Salvador, 2009; Van Loo and Jongschaap, 2013). Many accessions are now illegally transferred between countries, while the Convention on Biological Diversity and the Bonn Guidelines are generally neglected. These accessions are not systematically tested or integrated into plant breeding schedules, but used more on a trial-and-error basis.

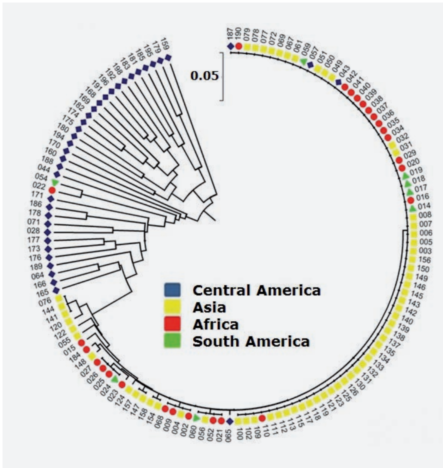

Figure 1: Genetic diversity of Jatropha accessions: Central American accessions (blue) display high diversity; Asian (yellow) and African (red) accessions are a subset of Central American accessions and display high genetic similarity (©Jongschaap).

Jatropha biomass and seed production

Jatropha grows well in Sub-Saharan Africa: jatropha hedges have been planted for many decades and numerous plantation assays have evolved in various regions over the last ten years. The species is found in almost all agro-ecological zones that meet the minimum requirements for crop growth and development for temperature, radiation, precipitation and soil fertility (Tinguely, 2012; Trabucco et al., 2010). The plants die in areas with frost and water logging, while flower initiation, fruit setting and seed production are all negatively affected in areas with intensive rainfall during the flowering phase and in continuously humid areas. Various production systems have been applied: monoculture, intercropping systems and hedges (Albéniz Larrauri, 2011; Obiero et al., 2012), in different densities (1,000-2,500 trees/hectare) and on land areas ranging from just a few metres of hedge for subsistence farmers to hundreds of hectares for large companies.

Featured case studies

Flowering and fruit setting: in the *Bioenergy in Africa* project, different jatropha accessions from Africa, Asia and Central America were systematically tested for flower and fruit setting and seed production in different environments and management options. Under humid and rainy conditions, flower and fruit abortion reduced fruit and seed yield considerably. Wider spacing led to lower biomass and seed productivity per hectare, but an increase on a per plant base.

A new jatropha disease in West Africa: under the *Jatrophability* project, the 'anthracnose' causing fungus *Colletotrichum truncatum* was identified as the causal agent of a new disease in Burkina Faso, causing stem cankers, resulting in branch death and no fruit yield (Figure 3). A preliminary management plan has been developed for farmers whose plants were affected the previous year, based on pruning, hygiene and intercropping with plants not susceptible to the disease.

Integration of biofuels and biogas: the *Probiofuel* (Prospects for Sustainable Biofuel Production in Developing Countries: A Case Study of Kenya, East Africa) project's aim was to evaluate the potential to integrate biofuels and biogas into smallholder farms. Results showed that performance of jatropha was positively linked to humid conditions, well distributed annual rainfall of 500–750 mm, moderately sandy to loam soils, neutral pH and a high level of management.

Figure 3: Burkina Faso: A jatropha plant with stem canker, one of the most serious pathogenic diseases affecting jatropha in West Africa. (©Ellison)

Figure 2: Fieldwork in Belize: Taking measurements to determine biomass growth (stems and leaves) via allometric relations. (©Van Loo and Jongschaap)

Jatropha growth rates differ across locations, but always lead to green bushy trees (Figure 2). Jatropha is like other crops: it grows better at higher radiation levels, appropriate temperatures and with a good supply of water and nutrients. It has been found that seed production is not linearly related to an increase in aboveground biomass, and varies greatly across locations for reasons that are not yet fully understood. A yield gap of 75% or more between potential and actual productivity can be expected, as with many other crops in Africa (Bindraban et al., 2012). In hedgerow production systems, seed yield per plant is reduced due to direct competition for resources with neighbouring plants. In contrast, in intercropping, yield is often higher than in monocultures because it benefits from the management of the associated crop. In the *Bioenergy in Africa*, *Jatrophability* and *Probiofuel* projects, genetic resources, nutrient availability (fertilizer application), pests and diseases were identified as major factors in reduced productivity in monoculture, intercropping and hedgerow production systems.

Marginal lands

It is often advocated that jatropha can and should be cultivated on marginal lands to avoid competition with food crops, but most agronomists claim that jatropha grows much better in favourable soil and climatic conditions. The concept of 'marginal lands' can cover many different conditions, each more or less favourable for jatropha. Very stony grounds with a limited amount of fertile soil will be considered 'marginal' for most crops, while jatropha may grow well on such soils. Clay and waterlogged soils, however, are not favourable for jatropha. Its performance on other types of marginal lands should be studied, but jatropha should not be planted on marginal lands of high conservation value.

Pests and diseases

There has been a long-standing belief that jatropha is largely resistant to pests and diseases because of its toxicity, particularly in regions where it has been introduced, because local pests and diseases have not had the opportunity to co-evolve with the plant. The argument fails to consider the multitude of pests and diseases, either generalists that have evolved to cope with a range of toxic plant compounds, or pests of closely-related species with similar defence mechanisms. There is now increasing evidence that jatropha is highly susceptible to pests and diseases and that these may seriously hamper plant growth and seed production (Anitha and Varaprasad, 2012; Rouamba, 2011).

In the *Jatrophability* project, the importance of pests and diseases in jatropha production systems in West Africa was studied and a list of the most serious ones was compiled. In some cases, damage was so severe that farmers became discouraged about jatropha cultivation. The most serious insect pests are flea beetles from the *Aphthona* genus (Rouamba, 2011). Different species occur in various parts of Africa causing similar types of damage

(Figures 4 and 5). Trees are totally defoliated by adults and possibly weakened by the larvae feeding on their roots. These beetles have a particularly significant impact on the establishment of seedlings, but larger trees become increasingly attacked, preventing growth and fruiting. The effect of cropping systems and other factors on beetle populations and damage has been studied, and recommendations to mitigate their effects on jatropha plantations have been proposed.

With the recent mass planting of jatropha in Africa and elsewhere, there has been an increase in serious pathogen problems, particularly stem cankers (Figure 3) and root and collar rot pathogens (*Phythophthora*, *Rhizoctonia*, *Fusarium* and *Colletotrichum* are all implicated in the disease complexes). These pathogens typically can attack a number of different plant species and are likely to have 'jumped' on to jatropha from closely related species. The genetic diversity of the jatropha plantings is usually restricted, and this partly explains why the 'new' diseases can be so devastating, as once adapted, they can be easily dispersed. Effective management of these diseases requires early detection, and will mainly involve cultural methods. Therefore, there is an urgent need to conduct field trials to test these management approaches.

Challenges

Major obstacles that prevent significant progress in improving jatropha production systems are primarily related to the difficulties in increasing seed yield. Advances in plant breeding for optimizing oil quantity and quality have been made in the EU FP7 JATROPT project (www.jatropt.eu), where genetic marker maps should result in stable varieties, with predictable seed and biomass productivity and low phorbol ester content. Additional research should focus on the response of crop growth and production of different jatropha genotypes to variations in radiation, temperature, water and nutrients. Other research areas might then look at more efficient use of available resources, for example by optimizing production system design adapted to local environmental and socio-economic conditions. Specific research should lead to pest and disease management plans, including tolerance or resistance in plant breeding programmes. Another pending question is to identify what productivity levels are acceptable for the different agro-ecological zones, and what production systems are most efficient and socially acceptable in the local context.

Definitions

Accessions: genetically similar germplasm from a specific region, but not necessarily a variety.

Agro-ecological zones: Sufficiently uniform zone based on combinations of soil, land type and climatic characteristics.

Germplasm: collection of genetic resources of an organism.

Intercropping: practice of growing two or more crops at the same time in proximity in order to increase resource use efficiency.

Life cycle analysis: environmental impact assessment, expressed per unit of product, and associated with all stages of a product's life from-cradle-to-grave.

Marginal land: land that is considered to be unsuitable for crop growth for a variety of reasons.

Sustainability: the capacity to endure preventing ecological, economic, and cultural deterioration.

Yield gap: difference between potential yield, based on radiation, temperature, (effective) precipitation, and observed yields, often limited by soil fertility and reduced by pests and diseases.

Figure 4: Close up of flea beetle infesting jatropha leaf. (©Kenis)

Figure 5: Mali: A three-year-old jatropha plant defoliated by a flea beetle of the *Aphthona* genus, one of the most serious insect pests; different species occur in various parts of Africa. (©Kenis)

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Policy implications

Jatropha currently shows low and highly variable seed yields. Until reliable **germplasm** and agricultural practices provide consistent yields, to minimize risks for farmers, policy frameworks should be sensitive to avoiding large scale monocropping of jatropha. Instead they should promote its use as a supplementary crop in systems that do not compete with food security (including feed), such as hedges, fences, ridges or wide **intercropping** systems. In any case, jatropha should not be planted on lands of high conservation value.

As with all new crops, the improvement of jatropha cultivation and management requires important research investments, particularly on: **germplasm** selection and seed quality; response of crop growth and production of different genotypes to variation in radiation, temperature, water and nutrients; more efficient use of available resources, for example by optimizing production system design adapted to local environmental and socio-economic conditions; sustainable pest and disease management; jatropha performance on various types of **marginal lands**. Public research should focus on the development of management systems targeted to smallholder farmers.

Sustainability of jatropha should be studied on the system level and not only on the basis of **life cycle analyses**, since these are product-based and do not respond to land use issues.

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Jatropha Facts *Jatropha Facts* is a series of five policy briefs providing research insights on important issues of jatropha and bioenergy. Each policy brief addresses a specific, policy-relevant aspect: (1)jatropha growth and oilseed production in Africa; (2) the potential of jatropha for climate change mitigation; (3) the potential of jatropha for rural energy supply in Africa; (4) the economic feasibility of biofuels in Africa; and (5) the food security implications of jatropha and other biofuels.

ERA-ARD
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