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Experiences with *Jatropha* cultivation in sub-Saharan Africa: Implications for biofuels policies

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ABSTRACT
Jatropha curcas L. has emerged in recent times as a leading energy crop in sub-Saharan Africa with over 32 countries in the region involved in its cultivation. By 2008, five countries in the region (Senegal, Nigeria, Mali, Ethiopia, and Zimbabwe) had policies promoting Jatropha cultivation. These policies were not informed by empirical evidence arising from the performance of Jatropha in the region. This paper analyses performance data of Jatropha in the region with a view to synthesizing information that is useful for evidence-based policy formulation. Production data in terms of agronomic issues and seed yields are analyzed. The results show that most of the attributes generically associated with Jatropha have not been achieved in the region and there has been inadequate research to support Jatropha cultivation. Policies supporting cultivation of Jatropha need to be informed by these observations in order to promote viable cultivation of the crop.

KEYWORDS
Agronomic performance; biofuels policy; cultivation; *Jatropha*; sub-Saharan Africa

Introduction

Commercial cultivation of *Jatropha curcas* L. in sub-Saharan Africa (SSA) is a relatively new farm enterprise driven by the regional biofuels agenda. There are several countries in the region that are involved in the cultivation of *Jatropha*. According to the GEXSI report (2008) there were 119,000 ha under *Jatropha* in SSA and the acreage was expected to reach two million ha by 2015. *Jatropha* has been marketed extensively in SSA as an appropriate energy crop that has other multiple uses.

Jatropha has a long history in Africa as a traditional hedge crop. It is its transformation into a commercial energy crop that has brought about new dimensions in the cultivation of the plant. There is the strong political support for *Jatropha* cultivation in many countries in SSA. This is a catalyst for both public and private investment in the *Jatropha* industry. By 2008, five countries in the region (Senegal, Nigeria, Mali, Ethiopia, and Zimbabwe) had policies promoting *Jatropha* production (GEXSI, 2008) and other countries were expected to follow suit. These policies were mainly influenced by the acclaimed potential of *Jatropha* as a crop that can ensure sustainable energy supply and enhance rural development. Worth noting is the growing consensus among policymakers that energy is central to reducing poverty and hunger, improving health, increasing literacy and education, and improving the lives of women and children (Brittaine and Lutaladio, 2010). This has escalated the push for production of biofuels from local resources.

It is without doubt that pro-*Jatropha* policies in SSA have mainly been influenced by acclaimed attributes of the plant. These include that it is a high-yielding oil crop, which is drought tolerant and has low nutrient, water, and management requirements and is well adapted to grow on marginal lands (Achten et al., 2010). Most of the data used to substantiate these claims have been extrapolated from outside SSA and have not been adequately corroborated by local systematic research. However,

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substantial data are now available in the region in terms of performance of *Jatropha* as an energy crop. This emerging information is essential for directing policy formulation based on empirical evidence derived in situ under local conditions.

The need for informed policies to support the burgeoning *Jatropha* enterprise is axiomatic. For policymakers to plan for cultivation of *Jatropha*, there is need for information on issues such as suitability of potential areas for plantations and agronomic performance characteristics amongst others (Zhengguo et al., 2010). This information is now emerging in SSA. However, the establishment of *Jatropha* has not been without challenges and has been put to test in the last decade. The objective of this paper is to provide ex-post analysis of the performance of *Jatropha* as an energy crop using information from existing plantations. This is an attempt to provide empirical information that can be used for evidenced-based policy formulation to support the cultivation of *Jatropha* in SSA.

Claims on *Jatropha*

There are several claims that have been proffered for *Jatropha* as a suitable plant for production under harsh environments. These include: reclaims marginal soils and wastelands; is drought tolerant and may have low water use; has low nutrient requirements; is tolerant or resistant to pests and diseases; requires low labor inputs; and does not compete with food production (Jongschaap et al., 2007). In addition, *Jatropha* is reported to produce seed yields of up to 12 t ha^{-1} (Openshaw, 2000). It is not the objective of this paper to validate these claims but to assess how the plant has performed in terms of these attributes.

Reclamation of marginal lands and wastelands

Land degradation and fragile soils are amongst the most serious environmental problems afflicting SSA. One of the major concerns in SSA is the escalation of desertification due to the fragility of soils in the region. Much emphasis has been placed on the cultivation of *Jatropha* on soils that have been described generally as being low in fertility, poor, marginal, degraded, and wasteland (Ramakrishnaiah, 2006). The hope is that *Jatropha* would rehabilitate such lands. The characterization of lands as marginal or wasteland needs to be discussed further in order to clearly define such land types.

The definition of the term wasteland is rather ambiguous and should not be confused with the term marginal land (Jongschaap et al., 2007). The term wasteland is usually used to indicate unoccupied areas or lands where ownership is not clear. On the other hand, marginal lands have unsuitable conditions for crop production due to soil and climate conditions (Jongschaap, 2007). The term wasteland is not normally used in SSA. The term used is marginal land (Von Maltitz and Brent, 2008). The typologies of marginal lands are shown in Table 1. It will be a good attribute if *Jatropha* has the ability to assist in the reclamation of such lands shown in Table 1, except for wetlands.

There is empirical evidence that *Jatropha* has the potential to contribute to erosion control and improvement of soil quality. The improvement of soil quality is critical to any reclamation program of marginal lands (Ogunwole et al., 2008). Work done by Ogunwole et al. (2008) in India on a degraded entisol showed an 11% average increase in mean weight diameter of the soil, 2% increase in soil macro-aggregate turnover, and 6–30% improvement in macro-aggregate stability. This represents significant improvement in soil physical properties.

The mechanism of land reclamation is through the taproot, which extracts nutrients from deep soil, and the return of nutrients to the soil through leaf fall, debris, and other organic remains (Brittaine and Lutaladio, 2010). What is worth noting is that the rooting system is influenced by the propagation method. Vegetatively propagated plants do not develop a taproot. Thus, propagation method is a fundamental issue in both land reclamation and ability to withstand droughts. The little evidence available on the reclamation of marginal lands through the cultivation of *Jatropha* is promising. Much more work still needs to be done.

Table 1. Typology of marginal lands.

Category	Type of lands
Non-forest marginal lands	• Gullies and ravines • Lands with scrub • Saline/alkaline land • Rocky and steep sloping areas • Sands • Abandoned agricultural land • Shallow soils
Forest marginal lands	• Degraded forests • Abandoned plantations
Mining marginal lands	• Landfills • Lagoons
Wetlands	• Dambos • Flood plains • Swamps

Source: Jingura et al., 2011.

Competition with food production

The attraction on the use of marginal lands and wastelands for cultivation of *Jatropha* has been based on the premise that such soils have low potential for economically viable agriculture. The cultivation of *Jatropha* on such lands would not be in conflict with food production. There is much sensitivity and controversy on the use of prime soils for the cultivation of *Jatropha* (Del Greco and Rademaker, 1998). The fear has always been that biofuels will lead to the transfer of arable land toward the production of energy crops.

Conflicting information is available in the literature on the effect of cultivation of *Jatropha* on food security in SSA. The GEXSI report (2008) showed that *Jatropha* cultivation has not led to reduction in food production. The information listed in Table 2 would suggest that *Jatropha* is mainly grown on land not used for food production. The GEXSI report (2008) stated that 70% of *Jatropha* projects practiced intercropping with both food and nonfood crops. The conclusion drawn was that *Jatropha* production can support food production through intercropping and use of unused lands to establish *Jatropha* plantations. Furthermore, when grown as a live fence around fields, *Jatropha* can also contribute to food security by protecting food crops from animals (Wahl et al., 2009).

On the contrary, evidence emanating in SSA from countries such as Mozambique and Tanzania indicates that farmers are not growing *Jatropha* on marginal lands but on fertile soils replacing food crops (Justica Ambient (JA) and União Nacional de Campeneses (UNAC), 2009; Wahl et al., 2009). Food security is a major issue in SSA and use of croplands for cultivation of *Jatropha* would exacerbate rather than ameliorate the situation. What appears to be the issue is that there is lack of identification of lands suitable for cultivation of *Jatropha* in

Table 2. Former use of land under *Jatropha* plantations in Africa and at global level.

	Proportion of land under *Jatropha* plantations (%)	
Former land-use	Africa	Global
None or wasteland	30	49
Agriculture for non-food crops	58	45
Secondary forests	7	5
Agriculture food crops	5	1.2
Primary forests	0	0.3

Source: GEXSI (2008).

many countries in SSA. This leads to encroachment onto croplands, with the potential to affect food production.

Mapping of suitable areas for planting *Jatropha* is required and in doing so other land-use practices should also be considered (Muok and Källbäck, 2008). From a policy perspective, it is desirable to set criteria that can be used to identify land that can be used for *Jatropha* cultivation. For example, the Kenyan criteria, which stipulate that *Jatropha* cultivation should not compete with food crops (Muok and Källbäck, 2008), are plausible. As a general rule, high-yielding agricultural lands such as croplands and grasslands should be avoided in order to ensure food security (Zhengguo et al., 2010). This is an important issue for consideration if *Jatropha* is to fit into sustainable food-fiber-fuel production systems.

Drought tolerance and low nutrient requirements

Ability to withstand drought conditions and survive on marginal soils is a major attraction in crop production in SSA given the arid and semi-arid conditions prevalent in the region. *Jatropha* has been acclaimed to be a plant with these attributes. As such, farmers in SSA ventured into *Jatropha* cultivation expecting a crop that would thrive on marginal soils and would have low water requirements (JA and UNAC, 2009).

Seed yields that have been obtained are a good measure of how *Jatropha* has fared as a crop. Seed yields that have been reported include 1.65 t ha^{-1} in Tanzania (Brittaine and Lutaladio, 2010), less than one kilogram per tree in Mozambique (JA and UNAC, 2009), 0.63 t ha^{-1} in Mali (FACT, 2006), and 0.86 kg per tree in Kenya (Gesellschaft für Technische Zusammenarbeit (GTZ), 2009). Generally seed yield of *Jatropha* on poor-quality land has been as low as 0.2 t ha^{-1}. This performance needs to be compared with optimum production figures available for *Jatropha*. The optimum seed yield of *Jatropha* was calculated to be 7.8 t ha^{-1} for mature plantations after three to four years of growth (Jongschaap et al., 2007).

It can be argued that production figures of *Jatropha* in SSA are mainly not from mature plantations. However, the indications thus far show that marginal soils cannot support seed yields around the optimum of 7.8 t ha^{-1}. As a consequence of low seed yields, most plantations established in the late 1980s to the 1990s were abandoned (Jongschaap et al., 2007).

The reality check has shown that *Jatropha* is not a wasteland or marginal land crop. Just like other crops, *Jatropha* requires good soils, supply of additional nutrients, and reliable rainfall. Annual precipitation range suitable for *Jatropha* cultivation is 250–1 500 mm, with an optimum range of 900–1 500 mm (Benge, 2006; Trabucco et al., 2010). Seed yield of *Jatropha* in the optimum rainfall range can be double (5 t^{-1} ha) that in areas with lower rainfall (Maes et al., 2009). However, there is little quantitative data available on water needs, water productivity, and water-use efficiency of *Jatropha* (Brittaine and Lutaladio, 2010). What is clear is that irrigation is quite common in *Jatropha* cultivation. In order to achieve good stand establishments, farmers in Mozambique applied 5–7 liters of water per day per plant to supplement rainfall in the early phases of growth of *Jatropha* (JA and UNAC, 2009). Data from Kenya also showed that at least 40% of *Jatropha* farmers practiced irrigation (GTZ, 2009). This indicates that *Jatropha* is a plant that needs care and cannot be relegated to wasteland status.

Given the experiences in SSA on *Jatropha* cultivation, there is need for policy support in building irrigation infrastructure to support water requirements of the plant, especially in areas with low annual precipitation. On a global scale the GEXSI report (2008) noted that 49% of *Jatropha* projects practiced irrigation and this was less developed in Africa. It is important to state that irrigation cannot be ignored in *Jatropha* cultivation.

One of the characteristics of marginal lands is low soil fertility. It is known that limitations of soil fertility hamper crop development (Jongschaap et al., 2007). The low seed yields of *Jatropha* reported earlier have also been ascribed to poor soil fertility on lands used for *Jatropha* cultivation. This would mean that use of fertilizers, both organic and inorganic, is required to augment nutrient supply.

Jatropha cannot be expected to perform to its true biological potential on poor soils without appropriate technical interventions. Currently there is insufficient data on the response of *Jatropha* to fertilizers under different growing conditions to make specific recommendations for optimum crop nutrition (FACT, 2006).

Both inorganic and organic fertilizers have been used in *Jatropha* production and have been observed to increase seed yield. Application rates have been based on judicious extrapolation from other related crops such as castor beans. The implication is that the knowledge gap in terms of growth and yield response to fertilizer inputs of *Jatropha* needs to be bridged by systematic research, which generates site-specific data. It therefore means that research has to generate information that can be used to develop fertilizer regimes for *Jatropha*.

Seed yield

Seed yield is one of the most important traits in commercial production of *Jatropha*. As shown earlier, optimum seed yields (above 5 t ha^{-1}) have not been obtained in SSA. Barring many reasons given for low seed yields, it is important to state that the unavailability of genetically improved or selected planting materials is a major contributing factor (Wahl et al., 2009). The quality of planting materials is very important in determining the performance characteristics of crops (Francis et al., 2005). Unlike with other commercial agricultural crops that have planting materials certified according to performance characteristics, there is currently little or no certified planting material for *Jatropha* in SSA (Jingura et al., 2011).

It is an imperative that biofuels policies must support the development of elite planting germplasm to support *Jatropha* plantations. This is not without precedence in agriculture. Farmers need to have access to certified planting materials in order to establish plantations based on good-quality germplasm. Coupled to seed yield is harvesting of the fruits, which is a labor-intensive practice due to the heterogeneous or asynchronous fruiting of the plants. It is not a truism that *Jatropha* has low labor inputs. In fact, the whole value chain from establishment to post-harvest handling requires substantial labor inputs. This provides opportunities for marginalized rural people to monetize their labor and derive a livelihood from *Jatropha* plantations. But this can present a limitation in areas where labor is in short supply.

Resistance to diseases and pests

It is known in crop production that pests and diseases are deleterious to crop production. Crop protection is well developed in food and fiber crops and is well supported by enabling policies in many countries. One of the claimed attributes of *Jatropha* is its reported tolerance or resistance to pests and diseases (Jongschaap et al., 2007). However, information originating from SSA seems to suggest that *Jatropha* is vulnerable to several diseases and pests. Information originating from several countries in SSA shows the occurrence of several pests and diseases. Table 3 provides an insight into some of the pests and diseases that have been reported.

Although information presented in Table 3 does not provide evidence on the severity of the identified pests and diseases, it does indicate the susceptibility of *Jatropha* to pests and diseases. As such, *Jatropha* cannot be precluded from the integrated management of pests and diseases. With

Table 3. Pests and diseases of *Jatropha* reported in the sub-Saharan Africa region.

Country	Pest/Disease	Reference
Mozambique	– Leaf spot, collar rot, root rot	– JA & UNAC, 2009
Kenya	– Golden beetle, leaf spotting, mildew	– GTZ, 2009
Zimbabwe	– Stem borer, golden flea beetle, fungus of *Cercospera* species (frogeye)	– FACT, 2006
Tanzania	– Scutellarid bug, golden flea beetle, stem borer, powdery mildew	– Wahl *et al.*, 2009

monoculture it is very likely that the load of pests and diseases will increase with time. Pests and diseases can cause economic damage and can be transferred from crop to crop. For example, it has been observed that *Jatropha* is host to the *Cercospera* species fungus, which is common in tobacco. Thus, regulatory mechanisms need to be properly informed in order to guide proper planning for *Jatropha* cultivation. What is missing in most countries are appropriate integrated pest and disease management regimes for *Jatropha*. In addition, as breeding programs for *Jatropha* unfold, resistance to pests and diseases is a trait that needs attention.

Conclusion

The need for appropriate policies to support biofuels in SSA is without doubt. It is also clear that production of feedstock, such as *Jatropha* seeds, is a critical success factor for the biofuels industry. Evidence herein presented shows that *Jatropha* is a crop that needs to be properly supported and most of its acclaimed attributes can only be achieved with best practices. Thus, it is a fundamental issue that as the new generation of policies supporting *Jatropha* in SSA emerges, it is premised on evidence in vogue in the region. This paper provides some insights that can inform some of these policies. However, research has to be strongly supported in order to generate local data that can be used for planning purposes.

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