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Potentialities and limits of *Jatropha curcas* L. as alternative energy source to traditional energy sources in Northern Ghana

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ABSTRACT

This article aims to analyze not only the limits but also the potentialities of Jatropha curcas as an alternative energy source to the most common energy sources, such as firewood and charcoal, utilized in Northern Ghana. In 2010, a Participatory Rural Appraisal was conducted in seven rural communities in the West Mamprusi District (Northern region, Ghana). In this context, *J. curcas* plantations were promoted at smallholder scale and 480 ha of decentralized *J. curcas* plantations has been established, involving 1,200 farmers (0.4 ha of land per farmer). *J. curcas* was cultivated only on marginal soil, defined as lands unused for at least 2 years. The proposed *J. curcas* system could potentially replace, in terms of energy content, 21% of firewood or 21.8% of charcoal monthly used by households, with comparable costs and time , respect to the traditional energy sources.

Introduction

Jatropha curcas potential for rural development has been recognized by many people (Eckart and Henshaw, 2012). *J. curcas* is a drought-avoidant perennial large shrub or small tree, with a life expectancy of up 50 years (Heller, 1996). It grows in tropical and subtropical regions, with annual precipitation between 600 and 1500 mm (Trabucco et al., 2010). Its high ecological adaptability allows its growth in an ample range of conditions from semiarid to humid (annual rainfall varying from 300 to 3,000 mm) (Maes et al., 2009) and in wide varieties of soil types, including poor quality soils (Ye et al., 2009). *J. curcas* seeds contain about 30–35% of oil per seed dry weight, which can be expelled or extracted (Jongschaap et al., 2007). The production of oil from *J. curcas* seeds requires two steps: i) de-husking process (with a decorticator), to separate seeds from fruit husk, and ii) oil extraction process, to produce oil and seed cake by-product (Fig. 1). *J. curcas* oil can be used as cooking and lighting fuel, adopting special design equipment, replacing the traditional biomass sources, such as firewood, charcoal, kerosene or petrol. In addition, the oil can be utilized for soap making. The extraction of oil from *J. curcas* seed generates also important by-products: fruit husks are the by-products of de-husking process, while about 50–70% of the original seed weight remains as de-oiled seed cake (Fig. 1) (Brittaine and Lutaladio, 2010; Devappa et al., 2010). Fruits husk and seed cake, having high nutrient content and calorific values, have a wide variety of applications as fuel or organic fertilizer (Ye et al., 2009).

However, *J. curcas* is still a (semi-)wild undomesticated plant and its basic agronomic properties are not thoroughly understood, the growing and management practices are poorly documented, and the environmental effects have not been investigated yet (Contran et al., 2013). *J. curcas* yield is still unknown, and a wide yield range is reported in literature: annual dry seed production can range from about 0.4 t to 12 t per ha (Achten et al., 2008; Parawira, 2010). The current knowledge gaps about the impacts and potentials of *J. curcas* plantation makes large-scale *J. curcas* cultivation for oil and biodiesel production an hazardous business, with predictable negative repercussions on local populations and environment, such as the plantation of *J. curcas* on productive agricultural lands rather than on marginal lands (Kant and Wu, 2011; Dyer et al., 2012).

Contrary to these large scale industrial *J. curcas* programs, community-based *J. curcas* initiatives for local use, such as extensive *J. curcas* plantations on poor quality soils, agro-forestry systems in which *J. curcas* is intercropped, and agro-silvo-pastoral practices, can be seen as efficient opportunities to promote rural development in developing countries. The diversification of smallholder plantations and the introduction of new sources of income for local populations could lead to greater economic and ecological resilience and strength sustainability actions (Settle and Garba, 2011). In contexts where the main energy sources are firewood and charcoal, whose environmental

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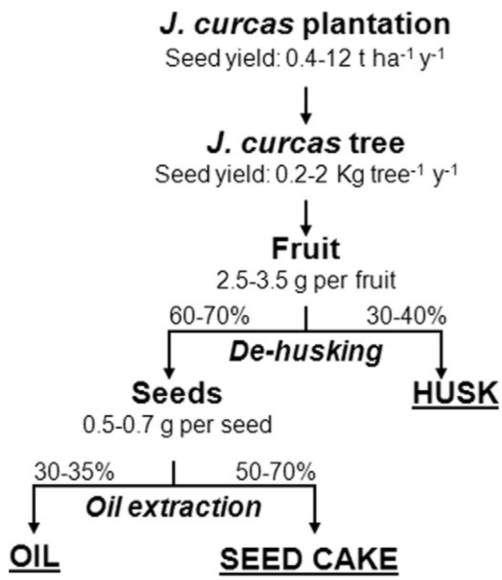

Fig. 1. *J. curcas* system.

sustainability represents a great concern (Menéndez and Curt, 2013), *J. curcas* could be considered a possible alternative energy source.

The aim of this paper is to explore not only the limits but also the potentialities of *J. curcas* as alternative energy source to substitute the traditional energy sources (especially wood and charcoal) normally used in Northern Ghana. This study has been performed in the context of the project "*Use of Jatropha plant to improve sustainable renewable energy development and create income-generating activities*: *an integrated approach to ensure sustainable livelihood conditions and mitigate land degradation effects in rural areas of Ghana* (*Ghaja*)", implemented for five years (2009–2014), within the "Environment and sustainable management of natural resources, including energy" program (EuropeAid). Fourteen rural communities of the West Mamprusi District, in the Northern Region of Ghana, were involved in the project: 7 communities in 2010 (i.e. Bimbini, Loagri, Nasia, Yama, Wungu, Kparigu, Janga) and 7 communities in 2011 (i.e. Bulbia, Zua, Nabulgu, Moatani, Boamasa, Guakudow, Zagsilari). Besides the financial resources for the realization of smallholder *J. curcas* plantations on abandoned farmland and for the provision of the equipment required for *J. curcas* oilseed and by-products production, this project provided: i) scientific input practices combined with appropriate agro-ecological and agronomic management, ii) improvement of farmer knowledge and capacity, iii) development of farmers' capacity to add value through their own business development, and iv) a focus on women's educational and agricultural technology needs. These points are considered the key requirements for sustainable development of African agriculture, as proposed by Pretty et al. (2011).

Materials and methods

Study area

Ghana is one of the most developed countries of the sub-Saharan area. The economic growth of the country has been estimated to 13.5% in 2011 (IMF, 2011) and poverty reduction rates are the best in the Region, as reported by the United Nations (UN, 2011). In 2006, Ghana achieved target A of the first Millennium Development Goal, halving the number of people living below the poverty threshold by 2015, and target B, halving the number of people suffering from hunger (UN, 2011). Despite these successes, Ghana still faces several challenges: Ghana ranks 135 out of 187 countries on the Human Development Index (UNDP, 2011) and 53.6% of its population lives under the poverty threshold, estimated in 2 USD/day (IFAD, 2011). Due to the exponential economic growth during the last decade, the energy demand is high and one of the most difficult challenges which Ghana has to face is the energy supply. About 64% of the total energy supply in Ghana comes from wood-fuel (firewood and charcoal), 9% from electricity, and 27% from petroleum (Duku et al., 2011). The Ghana government is conducting several efforts to modernize the energy supply sector, but assessments indicate that about 50% of the Ghanaian population has no access to grid-electricity and about 90% has not access to liquefied petroleum gas, confirming biomass as the dominant source of energy supply (Kemausuor et al., 2011). Wood-fuel consumption in Ghana is double than other energy sources.

The study area was located in the West Mamprusi District (5,013 km^2), in the Northern Region of Ghana, within longitudes 0°35′ W and 1°45′W and latitudes 9°55′N and 10°35′N and with Walewale as capital (http://westmamprusi.ghanadistricts.gov.gh). The district is classified as a tropical savannah climate zone, characterized by a pronounced dry season (from October to March), in which precipitation is less than 60 mm per month (Peel et al., 2007). In the area of study the average annual precipitation is 1100 mm, and the average annual temperature is 27.8 °C (min 22.3 °C–max 33.4 °C) (www.climatedata.eu).

District total population amounts at 131,650 inhabitants, whose 47.5% is less than 14 years old, 47% is among 15 and 64 years old and 5.5% is over 65 years old. District has 7 markets, the main one is in Walewale. As regards the communities involved in the project, only Bulbia has its own market (District Planning Coordinating Unit-West Mamprusi District Assembly, 2010).

Participatory Rural Appraisal method

A Participatory Rural Appraisal (PRA) was conducted in all the seven communities involved in the Ghaja project in 2010, (Bimbini, Loagri, Nasia, Yama, Wungu, Kparigu, Janga). Within these communities, 402 farmers, hereinafter referred to as interviewees, have been selected (about 55–65 people per community). Each interviewee was representative of a household. The interviewees were 1.8% of the communities' population. Data were collected at the beginning of 2010, before the start of *J. curcas* cultivation. PRA was carried out on small group (max 15 interviewees per group). Groups were selected within the same community. Participatory methods (e.g. individual interviews, focus group discussions, questionnaire, resource mapping, and rankings) were used to elicit data on socio-demographic and socio-economic characteristics, energy services, local land uses and cropping patterns, indigenous knowledge and skills on *J. curcas* cultivation and transformation processes. With reference to energy sources, interviewees have been asked to indicate their main uses, the place of collection, the time spent to access the energy sources, and the main problems in accessing them. Descriptive statistics, percentage data, and weighted averages of categorical data (±S.D.) have been used to present the results. The percentages of missing data or not answered questions are not reported.

Agricultural practices and oil extraction activities

Between 2010 and 2013, 480 ha of extensive *J. curcas* plantations have been established, involving 1200 farmers, who decided to cultivate *J. curcas* plants in 0.4 ha (1 acres) on marginal soils. Each farmer is representative of a household. Marginal soils were considered lands unused for at least 2 years, due to the unproductive food production. Plant density was 3 m × 2 m (1,667 plants per ha). Direct seed propagation method was used, consisting in sowing 2 seeds at 4–6 cm deep at the beginning of August. Plants were not irrigated and their cultivation was under rainy conditions.

In Table 1, the production for 1 ha of *J. curcas* standard plantation is presented.