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'A review on environmental and agricultural aspects of *Jatropha curcas*'

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Abstract

The present work is a bibliographical synthesis on the agroecological performance of *Jatropha curcas*, a bioenergy plant with multiple uses, many attributes and considerable potential. It is a tropical plant, which can be grown in areas with low to high rainfall. It is very plastic, can withstand drought, can grow on marginal or fallow land, and can also improve soil quality. In this way, *Jatropha* could create jobs and improve the quality of rural life. The main objective of this work is to assess the environmental performance of *Jatropha* in an arid to semi-arid climatic context and to identify the main uses of *Jatropha curcas* that can be exploited to improve the quality of the environment.

Keywords: *Jatropha curcas*, plasticity, performance, agroecological, environment

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1. Introduction

Jatropha curcas L., also called Pourghere, is a monoecious plant belonging to the Euphorbiaceae family. The genus *Jatropha* has 175 species and is widely distributed in tropical countries [1]. *Jatropha curcas* is a perennial shrub, easy to grow, from 2 to more than 5 m in height, but under favourable conditions it can reach a height of 8 or 10m.

Jatropha curcas, native to Mexico, is currently widespread in tropical and subtropical areas of Latin America, Asia, and Africa [2]. It is a very plastic plant that can be cultivated in several regions where the climate may be favourable, it has the reputation of adapting to arid and semi-arid conditions and poor soils, can withstand salinity, and can withstand long periods of drought (up to 3 years) [3]. *Jatropha*

curcas is an oleaginous plant that produces seeds with an oil content of 27 to 40%. This oil is unsaturated, rich in oleic acid (C18: 1, 34.3 to 45.8%), linoleic acid (C18: 2, 29.0 to 44.2%) and palmitic acid (C16: 0, 13.4 to 15.3%) [4].

Jatropha curcas is mainly used as a medicinal plant, but also to fight against desertification or planted as a protective hedge around gardens and fields or intensively to produce biodiesel.

Currently, jatropha is considered the most environmentally friendly source of biofuel. Indeed, the oil extracted from *Jatropha* seeds is very promising as an alternative in the production of biodiesel. Its use as a bioenergetic plant is increasing not only because of the high oil content of its seeds, but also because it is not edible and does not compete with food crops. It contributes to food safety in the production of biodiesel. Some advantages of its use as a biodiesel resource are continuity resources (renewable) and ecological energy [5] with less impacts compared to fossil diesel. *Jatropha* has aroused interest all over the world and was chosen by many investors for its high oil content, hardiness, drought resistance and longevity observed up to 50 years (a decline in yield after 30 years) [3].

Jatropha curcas is a large multi-purpose shrub with several attributes and considerable agroecological potential. This plant deserves special attention because of the positive role it could have on the environment as an ecological plant. The main objective of this work is to assess the environmental performance of *Jatropha curcas* and to constitute a referential of its multiple uses, in order to exploit its different agroecological and environmental properties in an arid to semi-arid climatic context. This referential could arouse new interest in the scientific community to explore the environmental properties of *Jatropha curcas*, and help researchers and decision-makers in the choice of using *Jatropha curcas* as a tool for sustainable development, especially in rural areas and under climatic conditions favourable to its development.

2. Ecological potential of Jatropha curcas

Jatropha curcas is a very tolerant plant with regard to climatic and soil conditions.

2.1. climate, soil and distribution area

Jatropha curcas is found in all tropical regions, such as in mid-altitude regions and in more humid areas. The plant's area of expansion (Figure 1) shows that *Jatropha* likes heat, it tolerates an average annual temperature of 11 to 28 ° C, but its optimum temperature is between 20 and 28 ° C. Resistance to light frost is probably a varietal factor and different ecotypes do not show the same sensitivity. This ability to adapt should be considered when planting in high altitude areas. It is a plant that is very tolerant to climatic conditions and has an extremely high resistance to water stress. *Jatropha* adapts to varying

rainfall regimes. Its production is moderately low with a minimum rainfall regime of 500 to 600 mm/year, and becomes optimal with a level of rainfall of 1200 to 1500 mm/year [7].

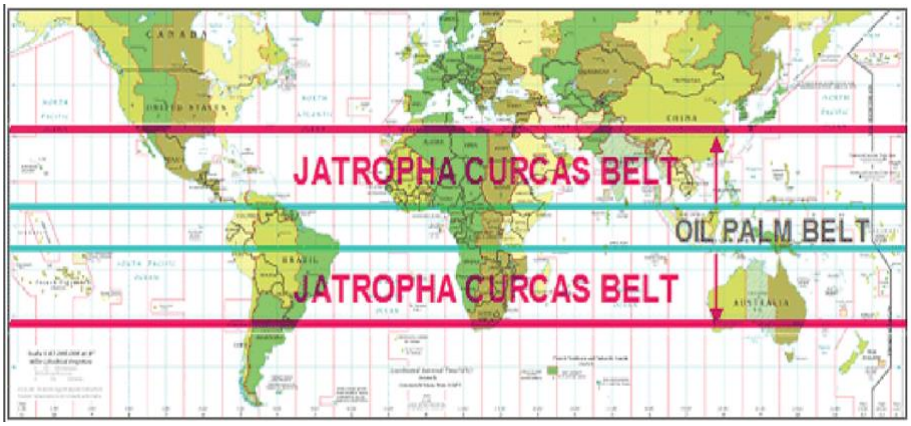

Figure 1. Global indications of the most suitable climatic conditions for *Jatropha* growth (30°N, 35°S)[6]

2.2. *Precipitation :*

Rainfall remains an important factor in the yield, which generates different productions depending on its intensity. The minimum requirements for its survival are 300 mm/year. The plant tolerates drought well and also grows in rainy areas. But in these areas, the oil content of *Jatropha* is lower compared to arid areas. It grows rapidly in warm regions but its growth slow during winter in the highlands. It can withstand periods of drought of 3 successive years [8].

The main adaptive characteristics enabling *Jatropha* to resist drought are root development on the surface and in depth, which provides the plant with a good supply of water; cuticular protection; and the reduction or elimination of foliage in the dry season, which minimizes transpiration losses [9], in addition, *Jatropha* is considered as a succulent plant whose roots and trunk can store and accumulate a lot of water in a short time [10].

3. The soil

Jatropha adapts well to most edaphic conditions and can grow in medium quality soils, sometimes arid, dry and stony [11]. Clay soils are not suitable for *Jatropha*, as its root growth is reduced in heavy or compact soils with a risk of waterlogging, even if only for a short time [12-4]. It prefers deep, well-drained, sandy-textured soils with a lumpy structure, where its root system can develop optimally [8].

4. The plasticity of *Jatropha curcas* and its ability to adaptation

The natural distribution of *Jatropha curcas* (figure 2) shows that its introduction has been most successful in dry tropical regions and in arid areas with annual rainfall between 300 and 1,000 mm [3]. This flexibility of adaptation is an important asset for the development of this oilseed.

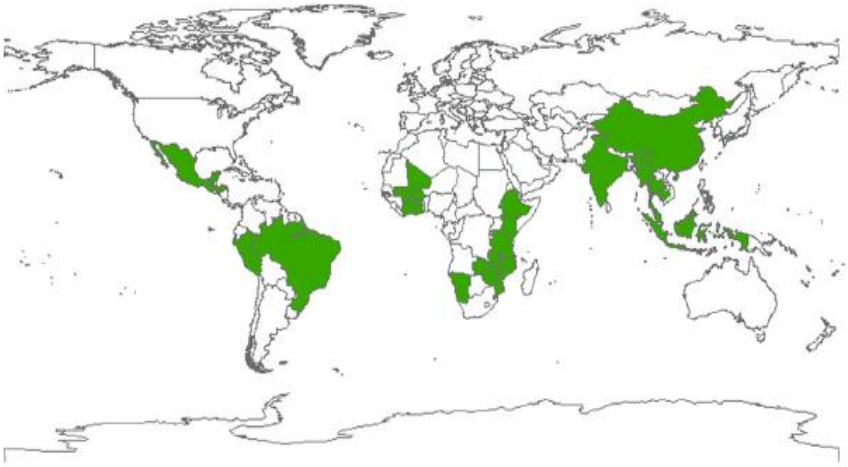

Figure 2. Distribution area of *Jatropha curcas* [15]

Jatropha can grow in many parts of the world, it has a certain plasticity which gives it the possibility of being established in all the least developed countries of Africa, Central America, and Asia [16], from the arid tropical climate to the humid tropical and all the island climates of the world's intertropical belt. Due to its incredible adaptation capacity, high oil content and hardiness, *Jatropha* has become the target of several research and planting projects. Many *Jatropha* projects have been implemented in Asia (India and Indonesia), Africa (East and West) and Latin America (Mexico, Brazil), worldwide over 1,000,000 ha of *Jatropha* have been spread [17]. The main countries currently having *Jatropha* activities are India, Indonesia, Mozambique, Tanzania, Madagascar, Mexico and Brazil. Most hectares planted are in Asia (85%) and Africa (13%) while only 2% are said to have been planted in Latin America [15]. Based on sources cited by [18], It is estimated that in India, *Jatropha* can cover an area of 40 to 64 million hectares of uncultivated land (poor and marginal land). In addition, the *Jatropha* Promotion on Waste-land Project, proposed by the Indian Planning Commission in 2003, plans to expand the area of *Jatropha* plantations to 12 million hectares. Figure 3 represents the countries with completed or ongoing Jatropha projects showing the extension of the area covered by *Jatropha curcas* in the world [18].

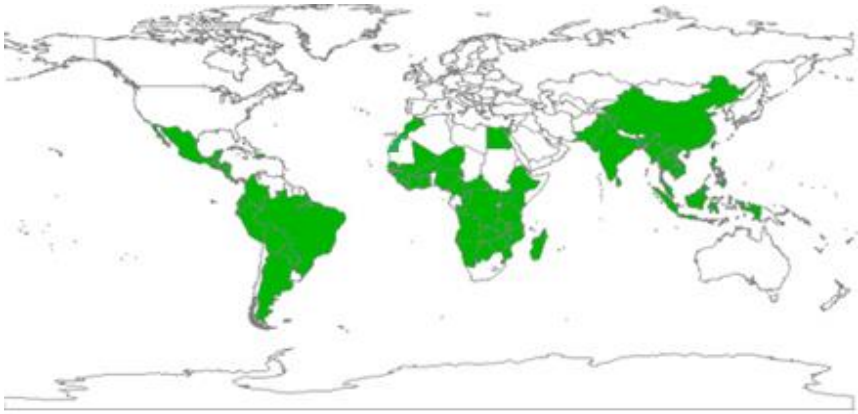

Figure 3. Geographic coverage of countries where *Jatropha curcas* activity has been reported [18]

In Africa we find it in semi-arid regions as well as in equatorial zones [19]. *Jatropha curcas* is a very plastic plant, figure (4) below represents the possible distribution of *Jatropha curcas* in Africa. It gives an overview of the climatic zones most suitable for *Jatropha* cultivation in Africa.

Areas in dark green illustrate regions of Africa where climatic conditions are very favorable for the cultivation of *Jatropha* with an average of 600 millimeters of rainfall per year and temperatures never falling below 2º C, covering an area of 'approximately 10.8 million square kilometers. The lighter areas represent the land where *Jatropha* can still be cultivated, even though rainfall is scarcer (around 300 millimetres) and average minimum temperatures can go below 2º C, and which represent around 5.8 million kilometres [20].

Figure 4. . Map showing the potential distribution of *Jatropha curcas* cultivation in Africa [20].

In Morocco, there are currently a few pilot projects for planting *Jatropha curcas* in certain regions such as: Missour, Erfoud, Souss, Essaouira, Laayoune in southern Morocco. These projects are carried out mainly by NGOs, but also by the Office chérifien of phosphates (O.C.P.). Several *Jatropha curcas* plantation projects have been launched and are increasingly being implemented in several countries around the world [21].

5. Environmental performance and agronomic interest of *Jatropha curcas*

Jatropha curcas is an extremely frugal plant, capable of growing in semi-arid regions, poor and saline lands - as long as it is not exposed to severe frost- [22]. It is characterized by its various agroecological properties according to which the plant can have several uses with environmental aspect:

5.1 The fight against erosion and deforestation

Jatropha curcas could potentially be a tool for reforestation. due to its developed root system, strong

branching, and rapid growth, it is used to fight against erosion and deforestation [14], and thus reclaim land exposed by uncontrolled deforestation and previously lost to agriculture.

5.2 The Valorization of marginal soils and nutrient mobilization

Jatropha curcas is adapted to marginal, low fertility and unsuitable soils with low nutrient content [1]. It can grow without much care on saline, infertile or marginal soils [23]. The root system of *Jatropha curcas* allows it to mobilise nutrients from deep layers of the soil. Spaan *et al*, [24] reported that *Jatropha* has the potential to regenerate marginal soil by exploring it. Concepts for the rehabilitation of marginal soils were established by Münch [10], who noted that on the island of Fogo, *Jatropha curcas* never showed symptoms of nutrient deficiency, yet the soil is particularly poor in phosphorus , he inferred that the plant has a particularly developed absorption system. The experiments carried out in this type of soil show that *Jatropha* can give a reasonable production, on condition of giving it the necessary maintenance during the growth phase, maintaining the production by inputs (nitrogen and phosphorus) [25-29], and select suitable ecotypes [30].

This property of adaptation of the plant to marginal soils is one of the main issues put forward for the intensive development of *Jatropha curcas*, especially in India where fallow or marginal lands occupy about 40 to 64 million hectares which could be partially or grown entirely with *Jatropha*. In this perspective India intends to introduce *Jatropha* only in wasteland, degraded and marginal lands, to avoid conflicts with food production and simultaneously recover these unproductive areas, strengthen rural socio-economic development and produce fuel [18].

5.3 Improving soil properties:

Jatropha curcas can mobilize nutrients from the deepest layers of the soil, its deepest roots would bring mineral elements to the surface that are very easily leached out [31,32]. Ogunwole *et al.* [26] observed the impact of growing *Jatropha* (2 years old) on degraded soil and semi-arid conditions in West India. They noted an improvement in soil structure over the 0-10 cm horizon, including an increase in aggregate stability of 6-30% and a decrease in bulk density of 20%. The improvement of soil properties under *Jatropha* cover has been noted by many authors.

Diédhiou [33] reports a general improvement in the chemical properties of soil under Jatropha cultivation compared to control soils under different pedo-climatic conditions in Senegal. Its falling dead leaves enrich the soil in organic matter and symbiotic bacteria in its root system fix nitrogen [34] (Legendre, 2008). According to Pellet *et al* [22], *Jatropha curcas* can, after a few years, make land that was previously uncultivated suitable for food crops between shrubs.

5.4 The Phytoremediation of contaminated soils

Jatropha curcas has enormous potential for adaptation in various habitats, including contaminated sites due to their plasticity. Studies have been carried out to assess the phytoremediation capacity of *Jatropha curcas* in soils contaminated by various heavy metals. In Spain, in the mining areas of Cobre Las Cruces and Aznalcóllar, considered to be one of the biggest ecological disasters in Europe [33] studied the possibility of eliminating heavy metals (Cr, Fe, Ni, Cu, Zn, Cd, Hg, Pb and As) present in high concentrations in soils, by means of phytoremediation using *Jatropha curcas L.* The results showed that *Jatropha curcas* can grow on soils with high concentrations of heavy metals. Metals with lower initial concentrations such as Cd, Hg and Sn were completely removed from the soil. A reduction of 30-70% of Cr, Ni, Cu, Zn and Pb in the soil was obtained, in addition *Jatropha curcas* absorbed large amounts of Fe (> 3000 mgkg-1plant) which were found in the vegetable biomass [35]. Similar results were established by José Marrugo-Negrete *et al.,* [36] who showed the phytoremediation capacity of *Jatropha curcas* on soils coming from mining areas and contaminated with different levels of mercury. The results showed that this plant species has a good ability to tolerate and accumulate mercury from polluted soils.

5.5 Use as a plant filter and wastewater treatment

Jatropha curcas has the potential to purify domestic wastewater. Several studies have been carried out on the feasibility of domestic wastewater treatment with *Jatropha curcas* used as Plant filters. Studies have shown that the roots of the *Jatroph*a crop are nitrogen and phosphorus fixers ([37,38].

5.6 Use in agriculture

Organic amendment

The press cake of *Jatropha* is an excellent soil fertiliser [3]. It is a valuable organic substrate [39]. Its mineral composition is comparable to that of chicken manure [40,41]. In greenhouses, the cake used as an organic amendment has improved certain soil properties in addition to the agro-morphological parameters of maize [42]. In India, the press cake is combined with cow dung and used to wrap the seed before sowing, but also to make combustible briquettes [43]. According to Henning *et al.* [44], the use of cake as a fertilizer at a rate of 5 t / ha in maize trials, resulted in a 45% increase in yield. Similar results were given by Sanou [45] which show the positive effect of the application of green manure of *Jatropha* (fresh biomass) on the rice yield which caused an improvement of 11% compared to the control. Tapsoba reported that combining *Jatropha* with other crops improves their yield, in the case of maize, with an increase in maize grain yield of 89.23% [46]. In association with sorghum and cowpea in central eastern Burkina Faso, *Jatropha* affects crop growth and yields [33].

6.1 Biocidal properties of Jatropha curcas with no effect on the environment.

onsidering the wide distribution of this plant and the presence of toxins in most of its constituents, the biocidal properties of *Jatropha* have attracted the attention of users and then scientists to control insect predators of crops or stocks, or disease vectors. All parts of the plant have been studied: leaves, bark but especially the oil [3]. Achten *et al* [14] describe the use of its oil extract as an insecticide, molluscicide, fungicide and nematicide:

a. Insecticidal properties

The emulsified oil reveals effective insecticidal properties against pests and weevils. Gubitz [47] tested the efficacy of oily extract of *J. curcas* on cotton boll caterpillars and on sorghum stem borers [48].

b. Larvicidal properties

The fight against mosquito larvae is also a subject of study. Kambou et al., 2008 [49] tested extracts of seeds and bark of *Jatropha* on larvae of the mosquito Ochlerotatus triseratus, while Rahuman et al. (2007) tested extracts of leaves and bark on Anopheles aegypti and Culex quinquefasciatus [50].

c. Molluscicidal properties

Jatropha oil is effective against molluscs that are vectors of Schistosoma, which causes bilharzia. These molluscs are necessary passages for the development of the larvae of Schistosoma mansoni or S. haematobium, before their release in water and passage through the skin in humans [3]. Vassiliades [50] presents the molluscicidal properties of two Euphorbiaceae, including *Jatropha curcas*, on Lymnaea natalensis (intermediate host of Fasciola gigantea or liver fluke) and Bulinus guernei (intermediate host of Schistosomes and Paramphistomes, similar to the fluke). *Jatropha curcas* has the qualities required for possible use in a control program because it caused 100% mortality after laboratory tests.

d. Antifungal properties

The cake obtained after extracting the oil from *Jatropha curcas* appears to contain active ingredients with antifungal activity [51]. Ogbebor *et al.,* [52] demonstrated the antifungal properties of the leaves of 21 plants to fight against Collentotrichum gloeosporioides, a pathogenic agent of the rubber tree. *Jatropha* was relatively effective against the disease at the highest concentration (100 g of leaves per 100 g of water) with a slightly lower leaf infestation index than the control, 3 weeks after the infestation.

6.2 Energy uses of *Jatropha* by-products

The dry fruit husk can be ground into a powder to form combustible briquettes. 1 kg of briquettes burns for about 35 minutes and produces a temperature between 525 and 780°C [22]. On the Cape Verde islands, its wood is also used as an energy source, mainly due to the lack of other suitable species. It has succeeded in obtaining pyrolytic charcoal with a graphite structure from *Jatropha* biomass [35].

6.3 Role in climate stabilization

a. Carbon Sequestration

Jatropha curcas can be used to cover unplanted soil (eroded, marginal, degraded), as a means of improving soil quality and reducing atmospheric carbon. It enables the fixation and storage of a significant amount of atmospheric carbon due to its aerial organs (leaves) and improves the fertilising capacity of the soil, thus contributing to the fight against global warming [53]. Firdaus and Husni [54] show that a *Jatropha* plantation stores about 5 tonnes of carbon per hectare during its growth and thus participates in the climate stabilization process by carbon sequestration.

b. Reduction of greenhouse gases.

Jatropha curcas is considered a source of green fuel. Unlike fossil fuels, the use of its oil as a biofuel can contribute to the reduction of greenhouse gas emissions through a neutral carbon balance and contribute to increasing the income of farmers [55]. This oil is economical in terms of carbon balance compared to fossil fuel [56-58. Indeed, the combustion of fossil fuels (petroleum, coal, natural gas) leads to the release of CO_2 into the atmosphere, carbon that has been trapped in the subsoil for millions of years (hence the term fossil energy). It comes from the decomposition of the fauna and flora that lived on Earth before. The consumption of these hydrocarbons releases CO_2 into the atmosphere that had been out of the carbon cycle for several million years and thus contributes to massive greenhouse gas (GHG) emissions and global warming. On the contrary, CO_2 emitted during the combustion of biofuels (oil or ethanol sector) has previously been fixed by plants during photosynthesis. The carbon balance then appears to be neutral and the use of this energy avoids additional greenhouse gas emissions [59-62]. Several researches carried out in Thailand, Côte d'Ivoire, Malaysia and China on the environmental impacts of *Jatropha curcas* biodiesel have shown a favorable energy balance compared to an alternative system based on fossil fuels with a significant reduction in greenhouse gases [18].

6.4 Synthesis of activated carbon

Activated cardon are usually obtained by carbonization, followed by physical or chemical activation of carbonaceous materials. cakes or fruit husk of *Jatropha curcas* were used as a raw material in various processes for the synthesis of activated coal. Wimonrat T. (2010) [63] have prepared activated carbons with a large specific surface area by simple thermochemical activation of the *Jatropha curcas* fruit husk with NaOH as a chemical activating agent.

6.5 The anticorrosive power of *Jatropha curcas*

In industry, the use of metal corrosion inhibitors is essential, but they can have negative effects on the environment. That is why the use of eco-friendly natural products " Green Inhibitors of Corrosion " is increasing, such as pure organic compounds, essential oils, and plant extracts. Studies have shown the effectiveness of several natural products as green corrosion inhibitors like *Jatropha curcas* as a corrosion inhibitor [64-69]. (Mokhtari *et al.* [70] has shown that the oil possesses the anticorrosive power of steel. The inhibitory efficiency of *Jatropha curcas* oil on steel corrosion in an acidic medium HCl at 1M is remarkably high. A protection efficiency of 99% was recorded (the gravimetric study). The valorization of *Jatropha curcas* oil as a steel corrosion inhibitor (generally used in mechanical machining) constitutes an added value to *Jatropha* which could very well be exploited in the industrial and economic field.

Conclusion

The present work can constitute a referential of environmental performance of *Jatropha curcas*. Based on a bibliographical synthesis, it allowed to draw up the different uses and agroecological potentialities of *Jatropha* which can have a positive impact on the environment. This plant grows easily in Sahelian and semi-desert regions, in infertile marginal soils, and is known for its resistance to drought. It can very well be used as a plant for reforestation of marginal lands, and as a means of fighting against desertification. *Jatropha curcas* is easy to grow because it does not require a lot of work or maintenance. This work has shown that *Jatropha curcas* has real strengths, it can improve the environment through land reclamation, erosion control, better soil fertility, better microclimate and through mitigation of greenhouse gases (GES) emissions.

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