Potential energy of the Jatropha

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Abstract

Jatropha is one of the researched oilseeds with the potential to produce quality oil to meet the needs of the National Program for the Production and use of Biodisel (PNPB), focusing mainly on the Southeast, Midwest, and Northeast regions of Brazil. In this sense, the interest in the agronomic knowledge of this culture has increased, aiming at the selection and improvement of more productive and economically viable varieties, mainly due to the high potential in the production of oil for the production of biodiesel. The present work has the focus of analyzing the overview of the Jatropha culture in Brazil, identifying the regions with productivity potentials, as well as the characteristics of the crop, searching for studies of their uses and applications, and, finally, to verify the potential of Jatropha for biodiesel production. The study showed that Jatropha cultivation is feasible for family farming, especially in semi-arid regions, as a sustainable and extra source of income.

Keywords: *Jatropha curcas* L., oil extraction, sustainability

Resumo

O pinhão manso é uma das oleaginosas pesquisadas com potencial de produção de óleo com qualidade para atender as necessidades do Programa Nacional de Produção e Uso do Biodisel (PNPB), concentrando-se principalmente nas regiões Sudeste, Centro Oeste e Nordeste do Brasil. Nesse sentido, tem-se aumentado o interesse no conhecimento agronômico desta cultura, visando à seleção e o aprimoramento de variedades mais produtivas e economicamente viáveis, principalmente devido ao alto potencial na produção de óleo para a produção do biodiesel. O presente trabalho tem o enfoque de analisar o panorama da cultura do pinhão manso no Brasil, identificando as regiões com potencias de produtividade, como também as características da cultura,

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buscando estudos dos seus usos e aplicações e, por fim verificando como o pinhão manso se enquadra no âmbito das culturas energéticas. O estudo mostrou que a cultura do pinhão manso é viável para a agricultura familiar, principalmente nas regiões semiáridas, se comportando como uma fonte sustentável e extra de renda.

Palavras-chave: *Jatropha curcas* L., extração de óleo, sustentabilidade.

Introduction

Stimulating the use of renewable energy as a substitute for fossil fuels is the key to the use of biofuels. Brazil is a developing country and needs quality oils, where in line with the idea of meeting growing national and global demands, seeks alternatives in conventional and potential raw materials, the opportunity to generate and offer oils with consistent qualities of this product (SATO et al., 2009, ROCHA et al., 2010).

The jatropha stands out as an oleaginous crop of great importance within this context. This is due to the fact that it presents the necessary technical conditions for the production and generation of biodiesel, as well as the fact that it can be grown in small farms. Therefore, the choice of this crop is based on the expectation of high oil productivity, low production cost, being a perennial species and extremely resistant to water stress, which is an advantage mainly in the semi-arid region of the country (ARRUDA et al. 2004; SEVERINO et al., 2007; SATO et al., 2009; NERY et al, 2009).

Jatropha still has other economic potentials, since it can minimize soil degradation, desertification, deforestation, and bioenergy production, replacing part of the petroleum diesel and climate protection. It is for this reason that the culture has deserved specific attention (FERREIRA, 2011).

Historically, jatropha has been used to protect soil from erosion. In addition, it can be used as live fences, as well as in traditional medicine, due to the presence of oil in its leaves, latex, and bark (SATO et al., 2009, SPINELLI et al., 2010; LIMA et al., 2012). According to Sato et al. (2009) all parts of the plant can be used economically for the manufacture of soap, oil lamps, electricity generators, and in the process of burning as fuel for stoves. The seed extract serves as molluscicide, insecticide and nematicide. The presscakes of physic jatropha is considerably rich in nitrogen and can be used as organic fertilizer (LAVIOLA; DIAS, 2008; ROCHA, 2011; LIMA FILHO, 2015). It is worth mentioning that presscakes of physic jatropha cannot be used for animal feed due to its toxicity (SATO et al., 2009).

Among the crops with production potential of oil for the production of biofuel, the jatropha presents one of the best conditions, as well as presenting good productivity, it is not competing with the food industry, such as corn and soybean edible oils, for example. Therefore, it becomes an interesting culture to produce. However, the jatropha is still in the domestication stage, and has few studies about the culture (SATO et al., 2009). However, many researches are being carried out, based on genetic improvement, herbicide creation and pest and disease control.

Thus, this review sought to organize the characteristics pertinent to the culture of the jatropha, searching for studies of their uses and applications, and, finally, as it falls within the scope of energy crops.

Characteristics of the jatropha culture

The jatropha is a plant popularly known as pion, Paraguayan pinion, purgeira, purga pine, among other names (ALVES et al., 2008; VIRGENS et al., 2017). The scientific name of this plant is *Jatropha curcas* L., which belongs to the group of Angiosperms, *Euphorbiaceae* family, the same family of castor bean (*Ricinus communis* L.), manioc (*Manihot esculenta* Crantz) and rubber tree (*Hevea brasiliensis*) (LIMA et al. al., 2012).

The jatropha is a shrub, perennial species that can reach up to 40 years of age and can reach up to five meters in height. Its origin is still not well defined, and is supposedly native to Central America, being found in almost all intertropical regions, occurring on a larger scale in tropical and temperate regions (VIRGENS et al., 2017).

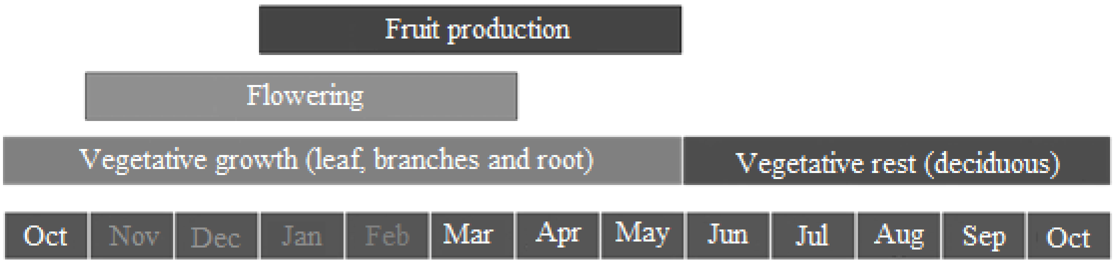
Drumond et al. (2010) points out that the species has developed satisfactorily in both dry tropical and humid equatorial zones, as well as in arid and stony soils, which can withstand long periods of drought, from sea level up to 1,200 m altitude. However, the authors report that in the soils of slope, place of low rainfall and exposed to the wind, the jatropha develops little, not exceeding 2.0 m in height.

In general, the jatropha has a fast growth, is deciduous, with fruits of the ovoid type, with 1 to 3 cm, containing three seeds per loci; the seeds are 2 cm long and 1 cm wide, normally (SATURNINO et al., 2005). It also has other characteristics such as smooth stem and softwood, stem divided from the base in long branches, in which the leaves are green and shiny, wide, and alternating, palm-shaped with three to five lobes, with whitish and protruding nervure on underside (DIAS et al., 2007). In addition, its roots are short and little branched.

In relation to its reproduction, the jatropha is a monoic plant, where the opening of the feminine flowers in the same inflorescence occurs in different days. After opening the first flower, the others will open for about 11 consecutive days. Pollination is by insects and the period of development of the flower to the fruit is about 60 days. Because the opening of the flowers occurs on different days, the fruit presents non-uniform maturation. In general, 53 to 62% of fruit weight is represented by seeds and 38 to 47% by bark, varying their weight from 1.5 to 3.0 grams (DIAS et al., 2007).

The plant can start production from the sixth month of planting, gradually increasing in function of cultural treatments and reaching the adult stage three years after its planting, age in which is considered the first commercial production defined. In relation to the phenomenological cycle of the jatropha, Figure 1 represents the phases of each stage of development of the plant.

Figure 1 - Phenomenological cycle of the jatropha.



Source: Bajay (2009).

According to Figure 1, vegetative growth occurs in the months of October to May, followed by vegetative rest, from June to October. The phase of the flowering of the jatropha occurs from the month of November extending until the month of March, as a result of which the fruit production phase is in the middle of January until the end of May.

The cultivation of the jatropha has some worries. The main ones are related to the lack of information about basic agronomic aspects of the crop, such as drought tolerance mechanisms and since it is a wild species, it needs a degree of genetic improvement. This is evident in the lack of available information regarding the performance of seeds and cultivars.

The culture of the jatropha is not demanding in fertility, being able to be cultivated in other available areas. Rocha (2011) reports that as jatropha is a rustic species, its planting can be carried out in areas where food production is not the preference.

The planting system can be in pits or furrows, depending on soil conditions and topography, using a plow or furrower, at a depth of approximately 30 cm. Jatropha can propagate either vegetatively or by seed. Rocha (2011) and Virgens (2017) point out that in the process of seed reproduction, the plants do not always reproduce the desired characteristics of the mother plants, since the jatropha is an alogama plant, resulting in great variation among plants.

Severino et al. (2007) found that seedlings of seedlings originated from seeds, sown directly on the soil, developed a normal root system with thick, linear primary roots and abundant fine roots. The authors reported that jatropha plants originating from seedlings produced in tubules or bags develop an atypical root system with knot formation, a small number of lateral roots, although the fine roots are abundant. Concomitantly to this, the study showed that seedlings of jatropha propagated by cuttings do not develop a normal root system, possessing only thin and superficial roots, with no capacity to deepen in the soil.

While Souza et al. (2010) identified that jatropha seeds are delayed in the germination process, when submitted to the saline stress condition, during the imbibition phase. In addition, the study showed that there is a reduction in the growth of the jatropha seedlings when submitted to NaCl solution with electrical conductivity of 6 dS m^{-1}.

In order to identify how the growth of jatropha irrigated with saline waters occurs, Nery et al. (2009) verified that at 163 days after sowing, plant height, shoot diameter, number of leaves and leaf area of Jatropha were linearly affected, with decreases of 3.78; 7.35; 9.75 and 17.74%, respectively, per unit increase of CEa, under protected environment. In addition, the authors verified that the leaf area was the most affected variable, and consequently the one that best expressed the effects of the salinity of the water on the jatropha.

Albuquerque et al. (2008) warn that even jatropha having a certain tolerance to water deficit, its production is low in such conditions. The authors also affirm that in these situations the plants become more susceptible, being attacked by insects and mites, as well as pathogens, which cause delay in their development.

For the control of pests and diseases, according to Rocha (2011) there are, to date, no registered products for the culture of the jatropha that can be recommended in the control of the same. However, because it is a non-food crop, there are some alternative controls used and recommended by several research institutions, which include the application of chemical elements such as sulfur and sulfate powder and natural elements such as milk.

Even though it is not a food crop, jatropha needs nutrients, and fertilization is an indispensable process. The functions of nutrients are related, directly or indirectly, to primary or secondary metabolism, exerting the same function in all plants, whether they are cultivated or not (LIMA FILHO, 2015).

For Santos et al. (2017) the period of greatest macronutrient absorption occurred between 7 and 35 days after the beginning of the treatments. This period coincided with the highest relative growth rate (HRGR), absolute growth rate (AGR), foliar mass ratio (FMR) and dry biomass accumulation. In addition, it was possible to verify that the highest content of Ca and Mg occurred in the leaves (48 and 47% of the total absorbed respectively), whereas N, K, S and P were more accumulated in the stem (58, 56, 56 and 53%, respectively).

Another study by Laviola and Dias (2008), similar to Santos et al. (2017), found that Jatropha has a high nutrient content in its tissues, presenting the following order of accumulation in the leaf limb: N> Ca> K> Mg> P> S> Mn> Fe> B> Zn> Cu. The study was also applied to the mature fruits, in which the following order of nutrient accumulation was observed: N> K> Ca> P> Mg> S> Mn> Fe> B> Zn> Cu.

Laviola and Dias (2008) also point out that it is possible to note the existence of some peculiarities in relation to the macro and micronutrients requirements for leaf and fruit formation, mainly in relation to the Ca requirement. Jatropha extracts high amounts of nutrients from the soil. As a consequence, if they are not adequately replenished by fertilization, soil impoverishment may occur over the years of cultivation.

For correction of soil and nutrient deficiencies, as soon as they are detected at the beginning of symptoms, they can be performed by means of cover fertilization (Lima Filho, 2015). In order to correct the micronutrients, foliar applications can be efficient even in the same agricultural year, however the application of the same in the soil is the one that has more effects, being the most appropriate form of correction in the case of delayed diagnosis or for the correction of the deficiency in long term (LIMA FILHO, 2015).

As jatropha is a perennial crop, besides soil correction and nutritional correction, pruning is necessary for the conservation of plants. For Melo et al. (2008) the pruning practice in the jatropha plants promotes the emission of new lateral branches, which increases the production of fruits and seeds. In agreement with this statement, Souza (2005) reports that the pruning has the purpose of regulating the production, increasing, and improving the fruits, maintaining the complete balance between the fruiting and the normal vegetation.

The jatropha flowers are only born at the end of the branches, and the pruning of branches raises the potential of fruit production, besides maintaining the uniformity of the plants. With proper pruning, the plant should have stronger lateral branches to support the weight of the fruits. Pruning should be done during the dry season, especially when the plants lose their leaves. Pruning in the rainy season increases the risk of infection by plant pathogens. Pruning should be conducted in such a way as to keep the plant with a low size, eliminating 20 cm from the tip of the branches (ROCHA, 2011).

Uses and applications of jatropha

With the advent of the federal government's biodiesel program, jatropha was listed as a promising oleaginous for this program. This is because biodiesel can be progressively incorporated into diesel, thereby reducing the import of this petroleum derivative. In addition, this crop has many advantages such as: high oil content (about 30-40% of the weight of the seed); low cost of implementation and integration with other cultures.

The jatropha can be considered a crop that provides food security, since according to Sato et al. (2007), the crop allows its planting in the form of a consortium with annual food crops. It contributes to rural development (with the employment of family labor), and with the consequent fixation of man in the field.

Jatropha oil can also be harnessed as a raw material for the research and development of cosmeceuticals. Pereira (2011) states that the jatropha has antibacterial action, in which its extract was tested against bacteria that cause skin infections, such as *Staphyloccocus aureus*, presenting good antibiotic activity. According to the same author, the jatropha acts directly in the diminution of wrinkles, disappearances of spots and minimization of scars. In addition, still in the medicinal area, *Jatropha curcas* L. is also used as hypoglycemic (DOS SANTOS et al., 2008).

As far as the cultivation is concerned, there are more than 30 thousand hectares planted with the crop, with a production potential of more than 90 thousand tons of grains/year, considering the plantations in the adult stage, which would generate in the extraction of the oil a production of approximately 58.5 thousand tons/year of presscakes of physic (MENDONÇA, 2009).

Mendonça (2009) in agreement with Arruda (2004) still affirms that the presscakes, resulting from the extraction of the oil of the jatropha seeds, constitutes excellent organic fertilizer, rich in nitrogen, phosphorus, and potassium. For Arruda (2004), the residue of the oil extraction can be used for soil recovery, as it is rich in NPK and after detoxification can also be used as animal feed.

This destination could be applied to fruit and seed peels, taking advantage of the protein rich presscake (46-63% depending on the oil extraction method) as a highly nutritive protein supplement in the small and large ruminant ration. However, as already mentioned, there is an impossibility due to the presence of toxic, allergenic and antinutritional limiting factors (MENDONÇA, 2009).

In addition, Arruda (2004) points out that the main advantages of rational jatropha cultivation are the low cost of production and its ability to produce in low fertile and sandy soils, as well as high productivity, ease of cultivation and harvesting of seeds. Another positive aspect is the easy conservation of the seed after harvesting and can be stored for long periods without the inconveniences of the deterioration of the oil as with the seeds of other oilseeds.

Potential as an energy culture

Jatropha is a natural species introduced in Brazil for centuries, which is dispersed in much of the national territory, in the form of isolated or reduced massive plants in small alamedas and fences, backyards and sites, indicating strong antropic action for maintenance and dissemination of the species (DURAES; LAVIOLA, 2009).

Sato et al. (2009) report that in 1980, the first patent on the production of fuels from vegetable oils was registered in Brazil. Currently, such fuels have their production encouraged and supported by the National Program for the Production and use of Biodiesel (PNPB).

In Africa and Asia, Jatropha oil was used as a substitute for diesel during World War II, and, as a consequence of this need, research on the use of this oil in diesel engines began to be developed, however, abandoned in the post-war period (Arruda et al, 2004). However, in the 1970s, with the oil crisis, studies on alternative fuels began to be carried out and this was one of the reasons for the reappearance of the use of vegetable oils as fuels, with jatropha being one of the most promising sources (SATURNINO et al. al., 2005).

Research indicates that pinion oil reduces CO2 emissions, does not emit greenhouse gases, and contains sulfur at expressionless values. Arruda et al. (2004) report that the oil of jatropha presents good performance in diesel engines, when used raw, but its consumption is higher, due to the difference of calorific power with respect to the diesel.

With the same perspective, Albuquerque (2008) verified that the oil can be used as fuel in diesel engines, which performs well, without any special prior treatment and with almost equal power to those achieved with gasoline. In this sense, Matos (2010) verified that jatropha oil has about 83.9% of the calorific value of diesel oil.

Saturnino et al. (2005) compared some attributes between jatropha oil and diesel oil (Table 1).

By means of Table 1, it can be observed that diesel and jatropha have specifications in which the values found are very close, such as specific gravity, cetane index, color, and calorific value. Through this, we have that Jatropha oil is a sustainable alternative, due to several factors, since it is a renewable and non-polluting source, and its final price is also able to have a lower value compared to other fuels.

For Albuquerque et al. (2008), the oil content of the jatropha seeds was between 33 and 36%. One of the major limitations so far is the uniform maturation of the fruits, which causes a significant increase in the cost of harvesting. In order for jatropha to be considered a potential plant for the biodiesel program, further research is still needed to ensure that agronomic, economic, and social responses are consistent.

Table 1 - Comparison of some attributes between jatropha oil and diesel oil.

Specifications	Oil standard	
	Jatropha	Diesel
Specific gravity	0.9186	0.82-0.884
Flash point	240/110 ºC	50 ºC
Carbon waste	0.64	0.15 ou menos
Cetane Index	51.0	Acima de 50.0
Distillation point	295 ºC	350 ºC
Kinematic viscosity	50.73cs	Acima 2.7cs
Sulfur	0.13%	1.2% ou menos
Calorific value	9.470 kcal/kg	10.170 kcal/kg
Pour point	8 ºC	10 ºC
Color	4.0	4 ou menos

Source: Adapted from Saturnino et al. (2005).

Final considerations

Even the jatropha possessing a resourcefulness of a productive plant and with high capacity of adaptation, it still has little expression in the Brazilian market.

This may be due to a lack of knowledge about the crop, cultivation techniques or its consumer market.

Jatropha shows itself as a complementary income possibility for the rural population due to its low cost of cultivation, besides, it does not need pesticides, it does not contaminate the soil, and it does not require preparation of the soil and use of modern equipment.

In addition, it is resistant to drought, has high productivity and is a complementary alternative in the production of biodiesel.

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