Applied Energy 87 (2010) 732–742

Contents lists available at ScienceDirect

Applied Energy

journal homepage: www.elsevier.com/locate/apenergy

Biology and genetic improvement of *Jatropha curcas* L.: A review

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ARTICLE INFO

Article history:
Received 19 March 2009
Received in revised form 15 July 2009
Accepted 17 July 2009
Available online 20 August 2009

Keywords:
Jatropha curcas
Floral biology
Genetic improvement

ABSTRACT

Bio-diesel is a fast-developing alternative fuel in many developed and developing countries of the world. The bio-diesel production from vegetable oils during 2004–2005 was estimated 2.36 million tonnes globally. Of this, EU countries accounted for about 82% and USA about 6%. Global bio-diesel production is set to reach some 24 billion litres by 2017. Shortage of edible oil for human consumption in developing countries does not favour its use for bio-diesel production. Hence non-edible oil from crops like Jatropha (*Jatropha curcas*) and Pongamia (*Pongamia pinnata*) is favoured for bio-diesel production and the trend is expected to continue. Especially *J. curcas* has gained attention in tropical and sub-tropical countries and has spread beyond its centre of origin, because of its hardiness, easy propagation, drought endurance, high oil content, rapid growth, adaptation to wide agro-climatic conditions, and multiple uses of plant as a whole. The full potential of *J. curcas* has not been realized due to several technological and economic reasons. One of the major reasons is the lack of high yielding varieties with high oil content. In this review, we attempt to discuss the currently available information on *Jatropha* species identity, taxonomy and description, distribution and ecological requirements of the species, possibilities of exploitation of genetic potentiality, exploitation of existing diversity for yield and oil content by direct selection, hybridization and creation of diversity by mutation, and biotechnological interventions.

Contents

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doi:10.1016/j.apenergy.2009.07.013

1. Introduction

1.1. Global status of bio-diesel requirement

Biomass as a source of renewable energy is fundamental for development and sustenance of civilization. In view of growing interest for renewable energy sources, liquid bio-energy production from vegetable oils is one of the possible options to reduce greenhouse gas (GHG) emissions. Bio-diesel production from vegetable oils during 2004–2005 was estimated to be 2.36 million tonnes globally. Of this, EU countries (1.93 million tonnes) with expectation of 30% annual increase and the USA (0.14 million tonnes) together accounted for 88% and rest of the world (0.29 million tonnes) for the remaining 12% [1]. Global bio-diesel production is set to grow at slightly higher rate than bio-ethanol and will reach 24 billion litres by being the largest share by 2017 [2].

1.2. Bio-diesel crops

Bio-diesel is expanding very fast because of demand, necessary policy support and technological availability. India consumes approximately 40 million tonnes of diesel and ranked fifth in the world after the US, China, Russia and Japan in terms of fossil fuel consumption. Recently, Government of India launched "National Mission on Bio-diesel" with a view to find a cheap and renewable liquid fuel based on vegetable oils [3]. However, shortage of raw material to produce bio-diesel is a major constraint [4]. The total number of oil-bearing species range from 100 to 300, and of them 63 belonging to 30 plant families hold promise for bio-diesel production [5]. Many developed countries are using edible oil-seed crops such as soybean, rapeseed, groundnut, sunflower for production of bio-diesel. However, developing countries like India, having dearth of huge quantity of edible oil (6.31 million tonnes) for consumption, cannot afford to use edible oils for bio-diesel production and hence non-edible oil seeds such as Pongamia (*Pongamia pinnata*) and Jatropha (*Jatropha curcas*) are explored along with meeting additional criteria of greening the wastelands without compromising the food, fodder security and improve livelihoods [4,6]. Thus, *J. curcas* which meets the American and European standards, gained importance in tropical and sub-tropical countries [7].

1.3. J. curcas L. as a choice crop

J. curcas is native of tropical America, but is now found abundantly in many tropical and sub-tropical regions throughout Africa and Asia because of likely distribution by Portuguese ships via the Cape Verde islands and Guinea Bissau [8]. *J. curcas* has spread beyond its original distribution because of its hardiness, easy propagation, drought endurance, high oil content, low seed cost, short gestation period, rapid growth, adoption to wide agro-climatic condition, bushy/shrubby nature and multiple uses of different plant parts [9–11]. Added to this, qualitative sustainability assessment, focusing on environmental impacts and strengthened by some socioeconomic issues, is quite favorable as long as jatropha is cultivated on wastelands/degraded lands [12]. In view of these advantages, many investors, policy makers and clean development mechanism (CDM) project developers are interested to tackle the twin challenges of energy supply and GHG emission reduction.

1.4. Reasons for review

For several reasons, both technical and economical, the full potential of *J. curcas* is far from being realized. Apart from agronomic, socioeconomic and institutional constraints, planned crop improvement programs are lacking globally. Earlier research programs involving large-scale plantations launched in Brazil, Nicaragua and India indicated that the crop productivity is far too low to be commercialized. In extreme cases, the plantations failed to produce fruits. There is limited information available on genetics and agronomy of jatropha. There is lack of bench mark descriptors and information on genetic variability, effects of environment and genotype $\times$ environment ($G \times E$) interaction [13]. Furthermore, there is a need for integration of the available scattered knowledge on, and experiences with crop performance of different *J. curcas* provenances in different environments and management interventions. Keeping this in view, an attempt is made to review available literature on genetic improvement of *J. curcas* from various journals, articles, reports and conference proceedings to cover wider range of information.

2. *Jatropha* naming and species

Current name is *J. curcas* Linnaeus (Euphorbiaceae). Linnaeus [14] was the first to name the physic nut *J. curcas* L. The genus name *Jatropha* derives from the Greek word *jatŕos* (doctor) and *trophé* (food), which implies its medicinal uses. According to Dehgan and Webster [15] and Schultze-Motel [16], synonyms of the physic nut are: *Curcas purgans* Medik.; *Ricinus americanus* Miller.; *Castiglionia lobata* Ruiz & Pavon.; *Jatropha edulis* Cerv.; *J. acerifolia* Salisb.; *Ricinus jarak* Thunb.; *Curcas adansoni* Endl.; *Curcas indica* A. Rich.; *Jatropha yucatanensis* Briq.; *Curcas curcas* (L.) Britton & Millsp. Table 1 presents vernacular names.

2.1. Taxonomy and description

2.1.1. Taxonomic status

The genus *Jatropha* belongs to tribe Joannesieae of Crotonoideae in the Euphorbiaceae family, and contains approximately 175