



Review Article

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## Evaluation of *Jatropha curcas* as Potential Biocide and Biopesticide

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### Abstract

*Jatropha curcas* (Linnaeus) belongs to the family of Euphorbiaceae and has been widely known as biofuel crop. Apart from being considered as biofuel crop, *Jatropha* is also known to possess insecticidal/antifeedant activity. This biopesticide property of *Jatropha* can be attributed to its specific chemical constituents that can target pest during different stages of life cycle. Chemical constituents such as phorbol esters and terpenoid compounds are responsible for high bioactivity of *Jatropha*. This paper attempts to evaluate potential of *Jatropha* as biocide and biopesticide. This study highlights importance of *Jatropha* as an ideal potential option for incorporation into pest management program.

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### Introduction

*Jatropha curcas* (Linnaeus) belongs to the family of Euphorbiaceae and has been widely known as biofuel crop (Openshaw, 2000). *Jatropha* is originally native of tropical America, but now is widely common in many parts of the tropics and sub-tropics in Africa/Asia. Another important advantage with this crop is that it is easy to establish, grows relatively quickly and is hardy and also drought tolerant. It can grow well even in marginal/poor soil. It is easy to establish, grows relatively quickly and lives, producing seeds for 50 years. Oil content in seeds of *Jatropha* is 37%. The oil derived from seeds can be used as fuel without being refined. This oil has potential to undergo combustion with clear smoke-free flame. It has been tested successfully as fuel for simple diesel engine. *Jatropha curcas* is becoming the future source of biodiesel for India. It is found to be growing in many parts of the

country, and can grow with minimum inputs (Mittelbach, 1983). Among the various oil seeds, *Jatropha curcas* has been found more suitable for biodiesel production. It is possible to grow this plant under stress condition and the oil of these species have various characteristics which makes it suitable for biodiesel production. *Jatropha* oil has higher cetane no. (51) as compared to other oils which make it an ideal alternative fuel for engine (Jain and Sharma, 2010).

There are many advantages associated with *Jatropha*. One advantage of *Jatropha* is that it can be grown in arid zones (20 cm rainfall) as well as in higher rainfall zones. This plant is a quick yielding species even in adverse land situations, such as degraded and barren lands under forest and non-forest use, dry and drought prone area and marginal lands with alkaline soils. It is also considered as good plant material for eco-restoration in all types of wasteland. *Jatropha* is not

considered to be good forage material. Moreover this plant is highly pest and disease resistant. *Jatropha* is also important from ecological point of view as it removes carbon from the atmosphere, stores it in the woody tissues and assists in the build-up of soil carbon. The plant also holds application to prevent and/or control erosion, to reclaim land, to act as a live fence, especially to contain or exclude farm animals and to be planted as a commercial crop. It is not browsed by animals as its leaves and stems are distasteful to animals. However, after treatment, the seeds or seed cake could be used as an animal feed. All parts of the plant are of medicinal value. Bark of *Jatropha* contains tannin which attracts bees and thus the plant has a honey production potential. Wood and fruit of this plant can be used for numerous purposes including fuel production. Its fruit contain viscous oil that can be used for soap making, in the cosmetics industry and as a diesel/kerosene substitute or extender. Its use as biodiesel is important because it can be considered as practical substitutes for fossil fuels to counter greenhouse gas accumulation. However, the full potential of *Jatropha* has not been fully realized due to several reasons. Firstly, the growing and management of *Jatropha* is poorly documented. Secondly, there are fewer efforts put forward towards marketing its products. Therefore, actual or potential growers are generally reluctant to invest time and money in a crop that only has promise rather than concrete rewards.

Primarily, *Jatropha* has been well studied for its properties to serve as biodiesel in future (Kumar and Sharma, 2008). It is well known that *Jatropha* oil can be used as fuel in diesel engines directly and by blending it with methanol (Gubitz et al., 1999). Experimental testing of engines with *Jatropha* oil in Thailand has revealed satisfactory engine performance (Takeda, 1982). A technique to produce biodiesel with high free fatty acids contents (15% FFA) from *Jatropha* has been developed by Berchmans and Hirata (2008) and Tiwari et al. (2007). This technique involved two-stage transesterification process to improve methyl ester yield. The first stage involved the acid pretreatment process to reduce the FFA level of crude *Jatropha* seed oil to less than 1% and second was the alkali base catalyzed transesterification process which gave 90% methyl ester yield. Efforts have also been put forward by researchers to reduce cost of biofuel production from *Jatropha*. In this regard, the lipase producing whole cells of *Rhizopus oryzae* immobilized onto biomass support particles was used and found to be a promising biocatalyst for

producing biodiesel (Tamalampudi et al., 2007). Higher oil extraction can result in more profit since oil sells for more than the residual seed cake. In order to increase such profits, efforts have also been done by researchers to innovate new techniques to increase oil percentage. Higher % of oil from the *Jatropha* seeds can be extracted using more efficient expeller system. The simple technology specially developed for this chemical process can also be performed in less industrialized countries (Mittelbach et al., 1983; Connemann, 1994). Application of methyl ester of *Jatropha* oil and dual fuel operation with methanol induction can give better performance and reduced smoke emissions than the blend. Sarin et al. (2007) have examined the blends of *Jatropha* and Palm biodiesel for their physico-chemical properties to get optimum mix of them to enhance oxidation stability needed for South Asian and South East-Asian countries.

Apart from potential of *Jatropha* as biofuel, *Jatropha* has insecticidal/antifeedant activity therefore making it ideal potential option for incorporation into pest management program.

### ***Jatropha* as biocide and biopesticide**

A substance that kills or retards the growth of microorganisms and is considered to cause minimal or no harm to the environment is a green, or eco-friendly, biocide (Ashraf et al., 2013). According to the European Commission's Biocidal Product Directive 98/8/EC (2013), biocides can be divided into four main types—disinfectant, preservative, pest control and other biocidal products – and further classified into 23 product types, including approximately 955 substances and 372 notified substances. Biocide which is effective against microorganisms, economical and compatible with the environment, is preferred for industrial requirement. There is need to explore broad-spectrum green microbiocides with very low toxicity, environmental acceptability, and that are safe and easy to handle and store (Ashraf et al., 2013). The green biocide is determined according to the principles of green chemistry; a biocide must fulfill all of the requirements before it can be declared safe for living beings and the environment and be considered green (Ashraf et al., 2013). Biocidal potential of *Jatropha curcas* is an emerging new aspect of the plant. The main biocidal action among *Jatropha curcas* extracts, has been ascribed to the phorbol ester (tetracyclic diterpenoid) fraction from the seed oil (Ratnasdass and Wink, 2012).

Phorbol ester present in this plant is a member of the tiglane family of diterpenes (Makkar et al., 2007). Phorbol ester in *Jatropha* show biocidal as well as insecticidal activity due to the stimulation of the cellular target protein Kinase C (PKC). This fraction has also

application as a plant-derived protectant of a variety of crops, from a range of pre-harvest and post-harvest insect pests (Ratnasdass and Wink, 2012). *Jatropha* extract inhibit growth of various bacteria as summarized in Table 1.

**Table 1.** Effect of *Jatropha* extract on growth of bacteria.

Bacteria	Result	Reference
<i>Citrobacter freundii</i>	Decrease	Dada et al. (2014)
<i>Enterobacter aerogenes</i>	Decrease	Setha et al. (2014) Dada et al. (2014)
<i>Enterococcus faecalis</i>	Decrease	Suhaili et al. (2011)
<i>Escherichia coli</i>	Decrease	Rampadarath et al. (2016); Abubakar et al. (2016); Kuta et al. (2015); Dada et al. (2014); Suhaili et al. (2011); Kalimuthu et al. (2010)
<i>Klebsiella pneumonia</i>	Decrease	Abubakar et al. (2016); Dada et al. (2014); Suhaili et al. (2011)
<i>Listeria monocytogenes</i>	Decrease	Suhaili et al. (2011)
<i>Morganella morgeni</i>	Decrease	Suhaili et al. (2011)
<i>Pseudomonas aeruginosa</i>	Decrease	Abubakar et al. (2016); Kuta et al. (2015)
<i>Salmonella enterica</i>	Decrease	Suhaili et al. (2011)
<i>Salmonella typhi</i>	Decrease	Abubakar et al. (2016); Kuta et al. (2015)
<i>Serratia marcescens</i>	Decrease	Suhaili et al. (2011)
<i>Serratia marcescens</i>	Decrease	Dada et al. (2014)
<i>Staphylococcus aureus</i>	Decrease	Abubakar et al. (2016); Kuta et al. (2015); Suhaili et al. (2011)
<i>Streptococcus agalactiae</i>	Decrease	Suhaili et al. (2011)
<i>Shigella dysenteriae</i>	Decrease	Igbinosa et al. (2009)

*Jatropha curcas* has significant properties to be considered as biopesticide. Its seed oil has also been used to reduce infestation of insect pests [*Aphids crassivora* Koch (Hemiptera: Aphididae), *Marucates tulalis* F. (Lepidoptera: Crambidae) and *Megalurothrips sjostedti* Trybom (Thysanoptera: Thripidae)] in cowpea (Ahuchaogu et al., 2014). In another study the acetonic, ethanolic and water extracts of the root and seeds of *Jatropha curcas* exhibited satisfactory insecticidal bioactivity which can successfully substitute chlorpyrifos (synthetic insecticide) in the control of insect *Oecophylla longinoda* (Ojiako et al., 2015).

Insecticidal activities of *Jatropha curcas* plant parts have also been reported against mosquitoes, *Anopheles arabiensis* Patton (Diptera: Culicidae) (Zewdneh et al., 2011), *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae) (Ojiako et al., 2014), mites, *Rhipicephalus (Boophilus) annulatus* (Ixodida: Ixodidae) (Juliet et al., 2012), cockroaches, *Periplaneta americana* Linnaeus (Blattodea: Blattidae) (Lateef et al., 2014), Desert locusts, *Schistocerca gregaria* Forskal (Orthoptera: Acrididae) (Bashir and Shafie, 2013), *Busseola fusca* Fuller (Lepidoptera: Noctuidae) and *Sesamia calamistis* Hampson (Lepidoptera: Noctuidae) (Makkar et al., 2007), *Helicoverpa zea* Boddie (Lepidoptera: Noctuidae) (Olapaju et al., 2008),

termites; *Coptotermes* (Blattodea: Rhinotermitidae) and *Odontotermes obesus* Rambur (Blattodea: Termitidae) (Acda, 2009a, 2009b; Verma et al., 2011). Table 2 summarizes effect of *Jatropha* extract on growth of different insects.

Biopesticide property of seed oil of *Jatropha* can be attributed to its specific chemical constituent which can target pest during different stages of life cycle. Seed oil derived from *Jatropha* have been reported to effect oviposition deterrence and inhibited egg hatching in potato tuber moth, *Phthorimaea operculella* Zeller (Lepidoptera: Gelechiidae) (Shelke et al., 1987). It also inhibited growth of tobacco hornworm, *Manduca sexta* Linnaeus (Lepidoptera: Sphingidae) larvae (Sauerwein et al., 1993). Application of *Jatropha* seed oil had resulted in anti-ovipositional activity and longterm protective ability of treated cowpeas against the seed beetle *Callosobruchus maculatus* F. (Coleoptera: Chrysomelidae: Bruchinae) (Adebowale and Adedire, 2006). Moreover its application has reduced the number of tested insect pests (*Aphids crassivora*, *Maruca testulalis* and *Megalurothrips sjostedti*) in a field trial to control field pests of cowpea (Ahuchaogu et al., 2014). Recently, *Jatropha curcas* has been reported to increase mortality of black moth (Ingle et al., 2017).

**Table 2.** Effect of *Jatropha* extract on growth and number of different insects.

Insect	Result	Reference
Black moth	Decrease	Ingle et al. (2017)
<i>Helicoverpa armigera</i>	Decrease	Ingle et al. (2017)
<i>Bactrocera cucurbitae</i>	Decrease	Rampadarath et al. (2016)
<i>Oecophylla longinoda</i>	Decrease	Ojiako et al. (2015)
<i>Callosobruchus maculatus</i>	Decrease	Ahuchaogu and Ojiako (2015)
<i>Sitophilus zeamais</i>	Decrease	Ojiako et al. (2014)
<i>Aphids crassivora</i>	Decrease	Ahuchaogu et al. (2014)
<i>Maruca testulalis</i>	Decrease	Ahuchaogu et al. (2014)
<i>Megalurothrips sjostedti</i>	Decrease	Ahuchaogu et al. (2014)
<i>Periplanata americana</i>	Decrease	Lateef et al. (2014)
<i>Schistocerca gregaria</i>	Decrease	Bashir and Shafie (2013)
<i>Rhipicephalus annulatus</i>	Decrease	Juliet et al. (2012)
<i>Anopheles arabiensis</i>	Decrease	Zewdneh et al. (2011)
<i>Odontotermes obesus</i>	Decrease	Verma et al. (2011)
<i>Coptotermes vastator</i>	Decrease	Acda (2009a); Acda (2009b)
<i>Helicoverpa zea</i>	Decrease	Olafeju et al. (2008)
<i>Culex quinquefasciatus</i>	Decrease	Kovendan et al. (2011)

This high bioactivity of *Jatropha* oil can be attributed to the presence of phorbol esters in the kernels, stem, flowers, buds, roots, bark (outer brown and inner green) skins and wood (Makkar et al., 1998). *Jatropha* species also contain terpenoid compounds, among which are diterpenoid compounds with about 68 diterpenes (Devappa et al., 2010a).

Majority of these diterpenes are cytotoxic, antitumor and antimicrobial activities while the phorbol ester, lignans, cyclic peptides, terpenes and Jatropherol display insect deterrent and a broad range of biological activities (Devappa et al., 2010b). Further phytochemical analysis of the root, stem and petiole of the plant showed the presence of alkaloids, saponins, tannins, terpenoids, steroids, glycosides, phenols and flavonoids (Sharma et al., 2012) which are known to have bactericidal, fungicidal and antimicrobial properties (Rachana et al., 2012; Narayani et al., 2012; Egharevba and Kunle, 2013). The seed is known to possess a generous amount of curcintoxalbumin (Stirpe et al., 1976) which is known to inhibit protein synthesis in-vitro. The modification of amino acids (arginine, lysine, and tryptophan) in the active site results in loss of the inhibitor activity (Weike et al., 2006) which may be fatal to insects.

## Conclusion

The present paper indicates that *Jatropha* has an immense potential for biocide and biopesticide. Since this crop is drought tolerant and can survive harsh climatic conditions, therefore it can play an important role for developing green biocide in future. This plant has

biocide as well as biopesticide property which can be utilized further by including it into pest management program.

## Conflict of interest statement

Author declares that there is no conflict of interest.

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