Evaluation and Bioinduction of Energy Components in *Jatropha curcas* L.

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Jatropha curcas L. is a multipurpose species with many attributes and considerable potential. The oil from the seeds is potentially the most valuable end product. Nearly 40% of the land area in India is wasteland. However, a large number of latex bearing and oil yielding plants can grow under such unfavourable agro-climatic conditions. *J. curcas*, a Euphorbiaceae, grows well under such adverse climatic conditions because of its low moisture demands, fertility requirements, and tolerance to high temperatures. The seed contains 19.0 oil, 4.7 polyphenol, and 3.9% hydrocarbon. This semi-drying oil could be an efficient substitute for diesel fuel. The gross calorific value for the seed (0% moisture content) was 4980.3 cal/g (20.85 MJ/kg), oil was 9036.1 cal/g (37.83 MJ/kg), and hydrocarbon was 9704.4 cal/g (40.63 MJ/kg). The oil fraction consists of saturated fatty acids: palmitic acid (14.1%), stearic acid (6.7%) and unsaturated fatty acids: oleic acid (47.0%), linoleic acid (31.6%). Treatment of plants with growth regulators significantly influences the production of hydrocarbons. Among the treatments, ethephon and morphactin induced the maximum production of hydrocarbon with 5.0 and 5.4%, respectively.

Key Words: *Jatropha curcas* L., Oil, Fuel, Gross calorific value.

INTRODUCTION

Vast areas of land (around 42%) in India are represented by arid and semi-arid conditions. *Jatropha curcas* L., a member of the Euphorbiaceae, is native to tropical America and naturalized throughout tropical and subtropical parts of Asia and Africa. In India, it is found in semi-wild conditions and grows in fields. It is a large shrub with thick branchlets and numerous large leaves attaining a height of 3–4 m in 3 yrs.

Goat or cattle do not browse the plants. The *Jatropha* plant has few insect or fungal pests and is not a host to many diseases that attack agricultural plants[1]. It can be successfully cultivated both in irrigated and rain-fed conditions. The plants grow quickly forming a thick bushy fence in a short period of time of 6–9 months,

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and growing to heights of 4 m with thick branches in 2–3 yrs. Seeds resemble castor seeds in shape, but are smaller and brown. The plant is valued for its rich oil, high in fats known in the trade as curcas oil obtained from the seeds. Its oil can be used in place of kerosene and diesel and as a substitute for fuel wood. It has been promoted to make rural areas self-sufficient in fuels for cooking, lighting and motive power[1]. *J. curcas* can tolerate high temperatures and grows very well under low fertility and moisture conditions.

J. curcas is a hard woody plant suitable for annual pollarding. The bark is rich in tannin and also yields a dark blue dye. The tender green leaves are fed to tasar silk worms, sustaining a small-scale silk industry in rural India. The leaves also yield a dye and latex, which has many medicinal uses that could support potential pharmaceutical industries. The roots contain yellow oil with strong anthelmintic properties[2].

Considering its wide spectrum of utility and the prospects of its growing in wastelands without competing with other crops, *J. curcas* was selected for investigation of its gross calorific value (GCV), fatty acid composition, and the influence of growth regulators on the yield of extractable chemicals in seeds.

EXPERIMENTAL

Experimental design: Stem cuttings of the experimental crop (*J. curcas*) were randomly collected from foot hills of Alagar Koil, Madurai, Tamil Nadu, India, from a minimum of 25–35 populations with 20–30 plants per population belonging to same agroclimatic zones and cultivated in $3 \times 3\ m^2$ plots with a plant to plant spacing of 1 m at the experimental plots in the botanical garden of V.H.N.S.N College, Virudhunagar. Control plots were also maintained in the same area. In order to have three replications for each chemical treatment and for control, three separate plots were maintained.

Extraction of oil, polyphenol and hydrocarbon: The matured seed samples were randomly removed from the three separate/ individual plots, and maintained for each chemical treatment in order to have three replications, consisting of a total fresh weight of 2000–2500 g composited into one sample for chemical analysis. Each sample was sub-sampled twice. The mature seeds collected were allowed to air-dry and ground in a Wiley mill equipped with a sieve having a pore size of 1 mm diameter. Extractables were removed from the ground seed with acetone and then with hexane in a Soxhlet apparatus for a minimum of 24 h per solvent[3, 4]. Care was taken to completely remove the acetone from the residue before hexane extraction. Acetone extracts were allowed to air-dry, then partitioned between hexane and aqueous ethanol (water : ethanol, 1 : 7), to obtain fractions referred as 'oil' and 'polyphenol'. After solvent removal, the fractions were dried and weighed for yield. The residue was re-extracted for 24 h with hexane to obtain the 'hydrocarbon' fraction. The extract after hexane removal was dried and weighed for yield.

Gross calorific value (GCV): Gross calorific value of the seed sample, oil fraction and hydrocarbon fraction was determined by bomb calorimeter (Toshniwal, model CC.0.1). The values are expressed in cal/g and MJ/kg[5].

Fatty acid composition: The methyl esters of the fatty acids in the oil fraction were analyzed for its composition by using a GLC equipped with a SE 30 column[6].

Bioinduction: Six plant growth hormones of different concentrations were applied as foliar sprays to determine their effect on yield of chemical constituents in the seed (Table-1). Each treatment was replicated three times. A foliar spray was applied every 14 days for a period of two months beginning at the onset of flowering. A 1% Triton-X solution was added to prevent the growth hormones from evaporation and help in bonding the chemical to the leaf surfaces. Plants in the control plots were sprayed with only a 1% Triton-X solution. After the 2 months treatment period, mature seeds were collected to quantify the extractable botonochemicals.

Statistical analysis: Three replications for each chemical treatment were maintained for extraction of chemical constituents and gross calorific value. Values in Tables 1 and 2 are the means of three replications ± SD.

TABLE-1
EFFECT OF GROWTH REGULATORS ON THE CONSTITUENTS OF EXTRACTABLE IN SEEDS*

Name of the growth regulator	(%) Yield		
	Oil	Polyphenol	Hydrocarbon
Control	19.0 ± 0.31	4.7 ± 0.23	3.9 ± 0.09
Gibberllic acid (GA_3) (20 ppm)	17.0 ± 0.24	3.3 ± 0.10	4.1 ± 0.11
Indole acetic acid (IAA) (15 ppm)	17.9 ± 0.04	3.9 ± 0.02	4.2 ± 0.06
Indole butyric acid (IBA)(12 ppm)	16.8 ± 0.21	3.2 ± 0.03	4.0 ± 0.04
α-napthalene acetic acid (NAA) (6 ppm)	17.5 ± 0.07	3.5 ± 0.04	4.5 ± 0.06
Ethephon (10 ppm)	17.8 ± 0.08	3.1 ± 0.08	5.0 ± 0.03
Morphactin (10 ppm)	19.6 ± 0.05	3.0 ± 0.06	5.4 ± 0.11

* Values are means of 3 replications ± SD

TABLE-2
CALORIFIC VALUE OF SEED SAMPLE AND EXTRACTABLES*

Parameter	Gross Calorific value	
	(cal/g) (dry)	(MJ/kg)
Seed sample	4980.3 ± 19.1	20.852 ± 0.080
Oil fraction	9036.1 ± 20.1	37.832 ± 0.084
Hydrocarbon fraction	9704.4 ± 24.4	40.630 ± 0.102
Biomass and fossil fuels		
Fuel oil (Mexico)‡	10308.0	43.158
Crude oil	10531.0	44.091
Gasoline	11256.0	47.127

*Values are means of 3 replications ± SD. ‡Ref. 7.

An ANOVA test was used to determine the statistical significance of the various chemical treatments and control for the production of oil, polyphenol and hydrocarbon. Post-ANOVA (Scheffe's test) was used where the 'F' value was significant[8]. The results of Scheffe's test for the oil fraction are presented in Table-3.

TABLE-3
SCHEFFE'S TEST FOR THE OIL FRACTION FROM SEEDS OF *JATROPHA CURCAS*

Morphactin	19.6a
Control	19.0a
Indole acetic acid	17.9bc
Ethephon	17.8bc
α-naphthalene acetic acid	17.5bcd
Gibberllic acid	17.0cd
Indole butyric acid	16.8cd

Means followed by the same letter are not significantly different ($p = 0.05$) according to the Scheffe's test.

RESULTS AND DISCUSSION

Jatropha seed contained 19.0% oil, 4.7% polyphenol and 3.9% hydrocarbon (Table-1, control). The seed oil has a low viscosity compared to castor oil. It can be used as a lubricant, illuminant, for soap and the candle industry[9]. The use of the oil for soap-making may be one of its most profitable uses[1]. When mixed with iron oxide, it can be used as a varnish. The oil cake is rich in nitrogen (4.4%) and hence is a good fertilizer[2].

Gross calorific value: The gross calorific values of the seed, oil fraction, and hydrocarbon fraction indicate that it could be used as an intermediate energy source (Table-2). The gross calorific values are comparable to well known natural fossil fuel sources. The gross calorific value of the seed (0% moisture content) was 4980.3 cal/g (20.85 MJ/kg) which is higher than the calorific value of lignite coal, cattle manure and comparable to the calorific value of corn cobs (10% moisture content). The high gross calorific value can be attributed to the presence of a high quantity of oil, polyphenol and hydrocarbon in the seed. The gross calorific value of the oil fraction is 9036.1 cal/g (37.83 MJ/Kg), which is higher than the calorific value of anthracite coal (Table-2). The gross calorific value of the hydrocarbon fraction was 9704.4 cal/g (40.63 MJ/kg) which was higher than the calorific value of anthracite coal and comparable with that of crude oil. These results indicate that *J. curcas* may serve as an intermediate source of energy.

Fatty acid composition: The oil fraction of *J. curcas* contains saturated fatty acids, mainly palmitic acid (16 : 0) with 14.1% and stearic acid (18 : 0) with 6.7%. Unsaturated fatty acids consist of oleic acid (18 : 1) with 47.0% and linoleic acid (18 : 2) with 31.6%. The oil contains a high percentage of monounsaturated oleic and polyunsaturated linoleic acid indicating it has a semi-drying property[10], hence, it may be potentially useful for the surface coating industry. In addition, the oil also contains a higher concentration of unsaturated fatty acids than the saturated ones, and when combined with oxygen and exposed to air, it forms a hard film, characteristic of 'drying oils'[11].

Effect of growth regulators: The influence of growth regulators on oil, polyphenol and hydrocarbon production are presented in Table-1. Chemicals like indole acetic acid, gibberellic acid, α-naphthalene acetic acid when used at certain concentrations have been reported to promote cell enlargement and/or division[12], and regulate biosynthesis of economically important compounds such as latex[13–17].

The 'F' value of all the three fractions (oil 96.7, polyphenol 70.57 and hydrocarbon 108.3) showed that there were statistically significant differences between the various chemical treatments and the control.

The post-Anova (Scheffe test) conducted for the oil fraction (Table-3) reveals that there was not a statistical difference between the control and the morphactin treatment. The slight increase in oil production due to the morphactin treatment seems to be negligible. The post-Anova (Scheffe test) conducted for the polyphenol and hydrocarbon fractions reveals statistically significant difference. All the chemicals significantly decrease the production of polyphenol; however, the same treatments significantly increase the production of hydrocarbons. Among the treatments, ethephon and morphactin induce the highest production of hydrocarbons with 5.0 and 5.4% respectively.

Conclusion

J. curcas is a multipurpose species with many attributes and considerable potential. The present study shows that the oil and hydrocarbons can serve as a potential intermediate energy source based on their calorific values. Oil of *Jatropha* seeds has high unsaturated oleic and lionelic acids which makes it potentially useful in the surface coating industry. It appears that the hydrocarbon yields can be increased using ethephon and morphactin growth hormones. If the full potential of this species is to realized, much more research is required, looking into the growing of this species in large scale plantations and more information is needed on the actual and potential markets for all its products.

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