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PLANTS TO ENERGY: A REVIEW OF SOME POTENTIAL BIO-FUEL PLANTS OF JALANDHAR

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ABSTRACT

In the era of increasing energy insecurity the first confront that we face is to move away from fossil fuels subsequently to build a new energy economy based on renewable source. Fossil fuels are not sustainable so the key issue for attaining sustainability is bio-based economy which can be achieved through biomass. Potential biomass feedstock includes conventional crops, forestry products, agricultural residue, waste material and specially cultivated energy-crops. An effort to identify higher plants from Jalandhar which may be useful as alternative source of fuel as energy-crop belonging to family *Apocynaceae, Asclepideaceae, Asteraceae, Euphorbiaceae, Convolvulaceae, Fabaceae, Papaveraceae* are analysed for their yield of petroleum-based products.

Keywords: Bio-fuels, Biomass, Energy-crop, Feedstock, Fossil-fuels, Renewable-energy.

INTRODUCTION

Crops that meet the biological requirement for use as bio fuel feedstock are which give high yield per hectare. Highly productive bio fuel feed stocks can be grown in tropical developing countries as compared to those in temperate developed countries. A sustainable feedstock for the production of transportation fuels can be obtained from forestry (woody biomass) and agricultural biomass. Biomass is any organic matter typically plant based that get its energy from sun which is further used to move on by consuming it, as heat when burnt and also be changed to gas and liquid fuels. Biomass energy is renewable which include dedicated energy-crops, trees, agricultural food and feed crops. Fuel sourced from renewable biological resource (plant material/animal waste) is bio fuel which is seen as alternative energy source that could replace fossil fuels [Kalita, D. 2008]. Several plant families specially *Euphorbiaceae* and *Asclepideaceae* were screened to consider their suitability as source of petroleum like hydrocarbons [K.G. Ramavat]. Every *Euphorbia spp.* contains latex as C30 triterpenoid which can be cracked like oil to make high-octane gasoline. *Euphorbia* and *Asclepias spp.* were found to contain high amount of biocrude. Biocrude was also extracted from resinous species of family *Asteraceae*.

In the present review an effort has been made to assess potential biofuel plants of Jalandhar belonging to families *Euphorbiaceae, Moraceae, Apocynaceae, Asteraceae, Convolvulaceae, Fabaceae, Papaveraceae.*

Plant *species* of **Asteraceae** family as biofuel-crop is:

- *Lapsana communis* L. (nipplewort): Classes of oil lipids in the plant are oil yield 6.1%, fatty acids, alcohols, sterols, esters (nonglyceride, triglyceride and triterpenol), hydrocarbons in traces, unsaponifiable matter (12.6%), free fatty acids (69.5%) [Carr and Bagby, 1987].

Plant *species* belonging to **Apocynaceae** family as energy-crop are:

- *Alstonia scholaris*(L.) R. Br. (indian devil tree): The plant was screened as potential alternative crop for renewable energy by Augustus *et al.,* in 2003. They revealed the presence of *cis*-

polyisoprene (natural rubber) hydrocarbon fractions in the plant [Augustus, *et al.,* 2003]. Qualitative and quantitative studies of various phytochemicals and physical constant values involving moisture content, ash and extractives were carried out by Khyade and Vaikos in 2009. They recorded the presence of alkaloids, commarins, flavonoids, phylobatannin, reducing sugars, simple phenolics, saponins and tannins [Khyade and Vaikos, 2009].

- *Calotropis procera*(Aiton) W.T. Aiton (giant milkweed): Its leaves, flower and root contain high amount of protein with 11.7%, ash 10.9% with varying quantity of alkaloid and contain calotropin and calotropaginin in leaves [Khairnar, A.K., 2011]. Peoples and Lee (1982) evaluated the plant as source of high quality of hydrocarbon i.e. biocrude [Peoples and Lee, 1982].
- *Calotropis gigantia* (L.) R. Br. ex Schult (giant rubber bush): Rama murti and Seshadri (1943) reported that its latex contains resinols as esters and two new alcohols α-calotropeol and β-calotropeol (smaller amount of β-amyrin), cardiac poisons similar to usharin and calcium oxalate [Rama murti and Seshadri, 1943]. Sharma and Swarup selected it as one of the most energy rich crop and its biocrude was hydrocracked to hydrocarbon fuels by Bhatia, V.K., *et al.,* (1989) [Sharma and Swarup, 2003; Bhatia, V.K., *et al.,* 1989]
- *Caseabela thevetia* (L.) Lippold (yellow oleander): Botanical Survey of India (2004) revealed that kernels of plant yield upto 67% of a non-drying oil. Schmelzer, H.G. 2008 revealed its seeds contain 57-63% oil and after purification consist mainly of 6% oleic acid, 16% palmitic acid, 11% stearic acid, & 7% linolenic acid and 5% linoleic acid [Schmelzer, H.G. 2008].
- *Catharanthus pusillus(Murray)G.Don* (tiny Periwinkle): In total 88 volatile and semi-volatile components were identified in flowers, leaves and stems which include diterpene compounds, sesquiterpene, some pyridine, pyrazine, indol, carotenoid derivatives. Flowers are richer in terpenic molecules; leaves can be characterised by methyl and propyl esters of fatty acids, mono- and di- saturated, trans-phytol, carotenoid derivative compounds, hydrofarnosyl acetone, methyl anthranilate, manool and epi-manool oxide while stems have high volatile aldehydes such as hexanal, octanal, cis-2-nonenal, cis-2-decenal, trans-2,6-nonadienal, trans, trans-2,4-decadienal [Pinho, P.G.D., *et al.,* 2009].
- *Nerium indicum* Mill. (sweet-scented oleander): Its root contain bitter glycosides, fenolinic acid, neriodorin, neriodorein, karabin, potassium salts in excess whereas bark contains scopoletin and scopolin besides this it also contains tannins, red colouring matter, aromatic oil, wax, flobefin, yellow coloured stable oil, and oleandrin [www.ayushveda.com/herbs/nerium indicum.htm].
- *Plumeria acutifolia* Poir. (frangipani tree): Hassan, E.M., *et al.,* (2008) phytochemically investigated its leaves, spectroscopically identified and isolated new monoterpene alkaloid named as plumerianine and three known triterpenes i.e. lupeol, uvaol and ursolic acid [Hassan, E.M., *et al*., 2008]. Ye, G., *et al.,* (2009) isolated and identified spectroscopically a new iridoid alkaloid plumercidine from its flower [Ye, G., *et al*., 2009].
- *Plumeria alba* L. (dwarf plumeria): The phytochemical analysis by Zaheer, Z., *et al.,* (2010) of the flower extract using chloroform showed the presence of steroid; petroleum ether revealed gum, steroid and alkaloid whereas flavonoid was reported using petroleum ether and methanol [Zaheer, Z., *et al*., 2010].
- *Tabermontana divaricata* (chameli): Singh, A., *et al.,* (2011) reported 0.2-0.3% of alkaloids having phenanthroindalizidine and furoquinoline framework [Singh, A., *et al*., 2011].
- *Vinca rosea* L. (periwinkle): Pinho, P.G.D., *et al.,* reported in total 88 volatile and semi-volatile components in flower, leaves and stems using solid-phase microextraction and gas chromatography/mass spectrometry which include diterpene compounds, sesquiterpene, some pyridine, pyrazine, indol, carotenoid derivatives [Pinho, P.G.D., *et al.,* 2009]. Its flowers

were richer in terpenic molecules; leaves can be characterised by methyl and propyl esters of fatty acids, mono- and di- saturated, trans-phytol, carotenoid derivative compounds, hydrofarnosyl acetone, methyl anthranilate, manool and epi-manool oxide while stems have high volatile aldehydes such as hexanal, octanal, cis-2-nonenal, cis-2-decenal, trans-2,6-nonadienal, trans, trans-2,4-decadienal [Pinho, P.G.D., *et al.,* 2009]. Tafur, S. *et al.,* 1975 isolated three dimeric alkaloids in the plant [Tafur, S. *et al.,* 1975].

Plant *species* of **Convolvulaceae** family as potential petrocrops are:

- *Argyreia nervosa (Burm. F.) Bojer* (elephant creeper): Modi, A.J., *et al.,* (2010) reported the presence of various alkaloids, glycosides, flaconoid glycoside and steroids in its phytochemical analysis [Modi, A.J., *et al.,* 2010]. Sharma, D.K., 2006 identified the plant as potential petrocrop [Sharma, D.K. 2006].
- *Convolvulus arvensis* L. (bind weed): The microchemical screening tests by Sher, Z., *et al.,* (2011) in different parts of the plant reported that its root contain alkaloid, mucilage, anthraquinone derivatives, saponins, tannins, starch, fat, protein and cellulose; stem part contains mucilage, anthraquinone derivatives, calcium oxalate, saponins, starch, fat, protein, cutins and cellulose; leaf consists of mucilage, calcium oxalate, tannins, starch, fat, protein, cutins and cellulose and flower contains alkaloid, mucilage, anthraquinone derivatives, calcium oxalate, tannins, starch, fat, protein and cellulose [Sher, Z., *et al*., 2011].
- *Ipomoea aquatic Forssk.* (water morning glory): The phytochemical screening by Sivaraman, D., *et al.,* (2010) from fresh leaf extracts showed the presence of alkaloids, carbohydrates, proteins, sterols, phenols, flavonoids, gums and mucilage, glycosides, terpenes and tannins [Sivaraman, D., *et al.,* 2010]. It was reported by Kameoka, H., *et al.,* (1992) that its oil contains 58 volatile components of which 49.14% were terpenoids [Kameoka, H., *et al.,* 1992].

Some of the plant *species* belonging to **Euphorbiaceae** family found in Jalandhar as biofuel-crops are:

- *Croton bonplandianus* Baill. (ban tulsi): Sharma and Mbise (1988) yielded good quantity of biocrude which can be hydrocracked to petroleum oil and also reported that the plant is rich in nitrogen, phosphorus and potassium [Sharma and Mbise 1988].
- *Euphorbia antiquorum* L. (fleshy spurge): Zhia-da, M., *et al.,* (1990) isolated three triterpenes (euphol 3-O-cinnamate, antiquol A, antiquol B) together with known triterpenes, euphol, 24-methylenecycloartanol, cycloeucalenol also sitosterol, (Z)-9-Nonaacosene and p-acetoxyphenol from the latex [Zhia-da, M., *et al.,* 1990].
- *Euphorbia dentate* Michx. (toothed spurge): Buchanan, R.A., *et al.,* (1978) evaluated the plant rich in protein and oil contents but donot produce natural rubber.
- *Euphorbia heterophylla* L. (wild –poinsettia): James and Friday (2010) reported the presence of alkaloids, saponins, flavonoid and tannins on the basis of phytochemical analysis [James and Friday, 2010]
- *Euphorbia hirta* L. (dudhi): Augustus, G.D.P.S., *et al.,* (2003) identified the plant with potentially useful compounds like the presence of *cis*-polyisoprene (natural rubber) through NMR spectra of hydrocarbon fractions [Augustus, G.D.P.S., *et al.,* 2003]. Kumar, S., *et al.,* (2010) reported the presence of alkanes, triterpenes, phytosterols, tannins, polyphenols and flavonoids in the plant [Kumar, S., *et al.,* 2010].
- *Euphorbia milli Des. Moul.* (crown of thorns): The plant contains toxic alkaloid miliiamine ($C_{43}H_{47}$ N_3 O_9), and the proteinaceous fractions and non-proteinaceous fractions (0.01%) in the latex [Yadav and Jagannadham, 2008; Nellis, D.W. 1997].

- *Euphorbia neriifolia* L. (Indian spurge tree): Two tetracyclic atisine diterpenes antiquorin and neriifolene were isolated by A.S. Ng (2001) from the plant. Kalita and Saikia (2004) evaluated the plant with potential renewable sources of energy [Kalita and Saikia, 2004].
- *Euphorbia pulcherrima Willd. Ex Klotzsch* (poinsettia): Whole plant especially young leaves contain high laticifer (triterpenol, cycloartenol) and starch content in the latex which also constitutes sterol, triterpenol and contains sitosterol, beta-amyrin, germanicol, cycloartenol, beta-amyrin acetate, germanicol-acetate [Augustus, G.D.P.S., *et al*., 2003; Biesboer, D. D., *et al*., 1982].
- *Euphorbia royleana Boiss.* (danda thor): The aerial parts of the plant constitutes ten new ingol lathyrane-type diterpenes (1-10) and two known ingenol esters (11 and 12) [Li, Xiao-Li, *et al*., 2009]. The plant comes under one of the most energy rich crops [Sharma, M. and Swarup, R. 2003].
- *Euphorbia tirucalli* L. (fire-stick plants): Latex of the plant contains di-ester, di- and tri-terpenes, serine proteases, steroids, trimethylellagic acid; stem bark contains pentacyclic triterpene and taraxerane triterpenes; plant has high resin content due to which it could yield high quality rubber [Mwine, J. and Damme, V.P. 2011].
- *Jatropha curcas* L. (purging nut): Its bark contains β-Amyrin, β-sitosterol and taraxerol; aerial parts contain o and p-coumaric acid, p-OH-benzoic acid, protocatechuic acid, resorsilic acid, saponins and tannins, β-Amyrin, β-sitosterol and taraxerol; leaves contain flavonoids such as apigenin, vitexin, isovitexin, atriterpene alcohol and flavonoidal glycosides. Its seeds contain Curcin, lectin, phorbolesters, esterases and lipase. Its roots contain β-sitosterol and β-D-glucoside, marmesin, propacin, curculathyranes A and B and curcusons A-D, diterpenoids jatrophol and jatropholone A and B, coumarin-tomentin, coumarino-lignan-jatrophin and taraxerol. Its seed kernel is rich in phytates, saponins and trypsine inhibitor which also is major component of seed cake [Misra and Misra 2010]. Its seed oil contains oleic acid, linoleic acid, palmitic acid and steric acid as major fatty acids [Akbar, E., *et al.,* 2009].
- *Jatropha glandulifera* (adalai): Parthasarathy and Saradhi (1984) investigated and revealed the presence of coumarino-lignan, jatropholone-A and fraxetin from its roots [Parthasarathy and Saradhi 1984].
- *Padilanthus tithymaloides* (devil's backbone): Its phytochemical studies on the leaves showed the presence of reducer's compounds, quinine, phenols/tannins, triterpene or steroids, cycloartanol triterpene [Suarez, C. H., *et al*., 2011].
- *Ricinus communis* L. (arind): Kensa and Yasmin (2011) showed the presence of alkaloids, flavonoids, tannins, saponins, steroids, phenols, resins, and carbohydrates through the phytochemical analysis [Kensa and Yasmin 2011].

Potential Plant *species* of family **Fabaceae** found in Jalandhar are:

- *Dalbergia sisso Roxb.ex DC.* (shisam): Vasudeva, N. *et al.,* 2009 identified flavonoids, isoflavonoids, glycosides, steroids, quinines, terpenoids and sterols, furans and other miscellaneous compounds in the plant [Vasudeva, N. *et al.,* 2009].
- *Pongamia pinnata* L. (karanj) Brigesh, S. *et al.,* (2006) determined the presence of carbohydrates, glycosides, proteins, aminoacids, phytosterols, saponins, flavonoids, alkaloids and tannins through phytochemical analysis. Its leaves, flowers, seeds and stem bark are known to have karanjin, a furanoflavoid (toxic) [Brigesh, S. *et al.,* 2006].
- *Trigonella foenum-graeum* L. (fenugreek): Hemavathy and Prabhakar in 1989 reported total lipid extraction from the seeds with 7.5% which consisted of neutral lipids (84.1%), glycolipids (5.4%), phospholipids (10.5%), neutal lipids consisted mostly of triacylglycerols

(86%), diacylglycerols (6.3%), small quantity of monoacylglycerol, five glycolipids, seven phospholipids, free fattyacids and sterols [Hemavathy and Prabhakar, 1989].

Plant *species* belonging to **Moraceae** family are:

- *Artocarpus heterophyllus* Lam. (jackfruit): Jagadeesh, S.L., *et al.,* (2007) investigated the sugars, starch, carotenoid contents in the study of its chemical composition [Jagadeesh, S.L., *et al.,* 2007].
- *Artocarpus integrifolia* L.*f.* (Indian jackfruit-tree): Augustus, G.D.P.S., *et al.,* (2003) revealed through NMR spectra of hydrocarbon fractions the presence of *cis*-polyisoprene (natural rubber).
- *Ficus benghalensis* L. (bengal fig): Sirisha, N., *et al.,* (2010) revealed an antioxidant property of the plant due to rich source of polyphenolic compounds and flavonoids in the plant. Bark, roots, leaves, fruit and latex of the plant has great medicinal value as it has versatile phytochemical constituents [Sirisha, N., *et al.,* 2010]. These constituents were investigated by Ahmad, S., *et al.,* (2011) and revealed that the plant contains Bengalenosides that is, glycosides or flavonoids, ketones, flavonols, pentacyclic triterpenes and triterpenoids, coumarins, sterols, tiglic acid esters, α- D-glucose and mesoinositol which was responsible for their pharmacological activity [Ahmad, S., *et al.,* 2011]. Its alcoholic and aqueous extraction by Murti and kumar (2011) confirmed the presence of Tannins, Alkaloids, Flavonoids and Saponins in the roots of the plant [Murti and kumar, 2011].
- *Ficus carica* L. (anjeer): Its phytochemical properties were revealed by Joseph, B. and Raj, S.J. (2011). It has numerous bioactive compounds such as mucilages, flavonoids, vitamins, enzymes, nicotinic acid and tyrosin. Its leaf contains ficusin, bergaptene, stigmasterol, psoralen, taraxasterol, beta-sitosterol, rutin, sapogenin, calotropenyl acetate, lepeolacetate and oleanolic acid and sitosterol. It also contains arabinose, β-amyrins, β-carotines, glycosides, β-setosterols and xanthotoxol, umbelliferone, campesterol, fucosterol, fatty acids, 6-(2-methoxy-Z-vinyl)-7-methyl-pyranocoumarin and 9,19-cycloarlane triterpenoid as anticancer and 6-O-acyl-β-Dglucosyl-β-sitosterol, calotropenyl acetate and lupeol acetate as antiproliferative agent [Joseph and Raj, 2011].
- *Ficus elastic Roxb. ex Hornem* (rubber fig): Ogunwande, I.A., *et al.,* 2011 revealed that oil of the plant constitutes 6, 10, 14 – trimethyl – 2 -pentadecanone and phytol [Ogunwande, I.A., *et al.,* 2011].
- *Ficus religiosa* L. (peepal): Augustus, G.D.P.S., *et al.,* (2003) through NMR spectra of hydrocarbon fractions revealed the presence of *cis*-polyisoprene [Augustus, G.D.P.S., *et al.,* 2003]. Makhija, K.I. *et al.,* (2010) revealed through phytochemical screening of bark presence of tannins, saponins, flavonoids, steroids, terpenoids and cardiac glycosides also wax, beta-sitosterol, leucopelargonidin-3-0-β-D-glucopyranoside, leucopelargonidin-3-0-α-L-rhamnopyranoside, lupeol, ceryl behenate,lupeol acetate, α-amyrin acetate, leucoanthocyanidin and leucoanthocyani. Leaves yield campestrol, stigmasterol, isofucosterol, α-amyrin, lupeol, tannic acid, arginine, serine, asparticacid, glycine, threonine, alanine, proline, tryptophan, tryosine, methionine, valine, isoleucine, leucine, n-nonacosane, n-hentricontanen, hexa-cosanol and n-octacosan. Fruit of F.religiosa contains asgaragine, tyrosine, undecane, tridecane, tetradecane, (e) βocimene, α-thujene, α-pinene, β-pinene, α-terpinene, limonene, dendrolasine, dendrolasine α-ylangene, α-copaene, β-bourbonene, β-caryophyllene, α-trans bergamotene, aromadendrene, α-humulene, alloaromadendrene, germacrene, bicyclogermacrene, γ-cadinene and δ-cadinene. Alanine, threonine, tyrosine have been reported in seeds of *F. religiosa*. The crude latex showed the presence of a serine protease, named religiosin [Makhija, K.I., *et al.,* 2010].

Plant *species* of family **Papaveraceae** as bio-fuel crop are:

- *Argemone maxicana* L. (shialkanta): The alkaloids identified from its aerial part were two benzophenanthridine–type alkaloids, *N* demethyloxysanguinarine and pancorine; three benzylisoquinoline-type alkaloids, (+)-1, 2, 3, 4-tetrahydro-1-(2-hydroxymethyl 3, 4 dimethoxyphenylmethyl) - 6, 7-methylenedioxyisoquinoline, (+)-higenamine and (+)-reticuline and six known non-alkaloid compounds [Changa, Y.C., *et al.,* 2003].

- *Papaver somniferum* L. (opium poppy): It contains about 25 alkaloids among which morphine (10-16%) is most important, other alkaloids are like codeine, narcotine, thebaine, noscapine, narceine, papaverine [www.bitterrootrestoration.com/health-care/poisonous-plant-poppy.html].

CONCLUSION

There is a diversity of food and non-food crops that have potential for bio fuel feedstock in tropical developing countries like India where the biodiversity is vast. In order, to overcome harmful environmental impacts, turbulence in energy markets we need to look for alternate source of energy keeping in view both economic and environmental reasons. To achieve this plant world is the only area of sustainable energy.

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