Invasive alien weeds as bio-resource: A review

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ABSTRACT

Invasive alien weeds are non-native organisms that cause potential harm to the environment, economics and human health. Its ability to outcompete native species for space, water, nutrients, and other essential resources, adaptability to a variety of environmental conditions, absence of natural predators and parasites and prolific seed producing characteristics, once established it is very difficult to control or eliminate. Eradication through utilization is the present concept of management of invasive alien weeds. Eichhornia crassipes (Mart.) Solms, Salvinia molesta D.S. Mitchell, Parthenium hysterophorus L., Mikania micrantha Kunth, Chromolaena odorata (L.), Mimosa invisa Mart. Ex Colla and Lantana camara L. are the major invasive alien weeds of Kerala. The literature about the bio-utilization of these major invasive alien weeds is reviewed in this paper.

Key words: Chromolaena odorata, Eichhornia crassipes, Lantana camara, Mimosa invisa, Mikania micrantha, Parthenium hysterophouos, Salvinia molesta, Utilization.

India accounts for 8 % of the global biodiversity existing in only 2.4% land area of the world. Reddy (2008) reported that 173 invasive alien species belonging to 117 genera and 44 families are distributed in India representing 1% of the Indian flora. Most of the species were introduced from tropical America (74 %) followed by tropical Africa (11 %). Habit wise analysis shows that herbs with 151 species (87.3%) predominate followed by shrubs (14), climbers (5) and trees (3). Of the 44 families, Asteraceae is the most dominant family with 33 species followed by Papilionaceae (15), Convolvulaceae (10), Caesalpiniaceae (9), Solanaceae (9), Amaranthaceae (8), Poaceae (8), Euphorbiaceae (7), Mimosaceae (6) and Tiliaceae (5). The top ten families contribute 110 species with proportion of 63.6%.

The Invasive alien species are non-native organisms that cause, or have the potential to cause harm to the environment, economics, or human health. Invasive alien species (IAS) are one of the most significant drivers of environmental change worldwide. The major characteristics of invasive alien weeds are ability to outcompete native species for space, water, nutrients and other essential resources, adaptability to a variety of environmental conditions and absence of natural predators and parasites. They are prolific seed producers and highly successful in seed dispersal, germination and colonization. Because of these characteristics, it is very difficult to control or eliminate these weeds. The present concept of management of the invasive alien weeds is eradication through utilization. It is the economic exploitation of invasive species as a means of harnessing their economic potential for meeting basic human needs and at the same time control its spread and possibly eradicate them (Tessema, 2012).

National invasive weed surveillance programme, conducted by AICRP on Weed Control, Vellanikkara, Kerala reported that, the major invasive alien weeds found in aquatic and low land ecosystems of Kerala are Eichhornia crassipes and Salvinia molesta. Lantana camara, Parthenium hysterophouos and Mikania micrantha are the major invasive alien weeds in the high ranges. In the rubber plantations, Mimosa invisa, Lantana camara and Mikania micrantha are the major ones and in coconut plantations, Chromolaena odorata, Mimosa invisa and Lantana camara are the major invasive alien weeds (KAU, 2012).

Utilization of water hyacinth (Eichhornia crassipes)

As biogas: Water hyacinth is low in lignin content (10 %) and contains high amounts of cellulose (25 %) and hemicellulose (35%) (Gunnarsson and Petersen, 2007). So it can be utilized as a potential source of biofuel. The hydrocarbon content is more in water hyacinth than in farm yard manure. Water hyacinth is harvested, dried and placed in a biogas plant. The kiln of the plant acts as an anaerobic reactor. The metal covering of the plant has a small hole through which powdered nickel is added initially, before the whole plant is locked. When entry of air is blocked, it starts fermenting and produces gas in less than 24 hours. Biogas in its raw form contains methane, carbon dioxide, sulphur and dust. It is extracted and purified, till pure methane is obtained. This methane can be stored in cylinders and be

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used for lighting and as cooking gas. One kg of plant waste can produce 10 kg of methane (Ramkumar, 2013).

**Bioethanol and biomethanol production:** First biomass is ground into smaller particles or chips. These chips are then pre-treated often with sulfuric acid to break down the hemicellulose into simple 5- and 6- carbon sugars to unlock the cellulose. Then this treated biomass is separated into glucose and the various pentoses from the hemicellulose. Glucoses are fermented by yeasts and/or bacteria to yield bioethanol. One kilogram of dried water hyacinth produces 22.4 ml of bioethanol.

Bio methanol is produced by the mechanical breakdown and gasification of biomass, which upon subsequent release is condensed into liquid form by catalysis under high pressure (Bhattacharya and Kumar, 2010).

**Silage production:** The water hyacinth plants mixed with molasses and pig manure at the ratio of 85:10:5 (% wet weight) was found to be optimum for silage production; the period of silaging was 28 days. The silage contains 16% protein and 18% dry matter, suitable for use as animal feed (Polprasert, 1994) and it is also palatable. Molasses was added to increase the energy required for the growth of lactic bacteria and pig manure is added as adjunct for enhancing the fermentation process.

**As compost:** The weed is a good absorber of nitrogen, phosphorus and potassium from water and can be used as a good source of compost material (Prabhu, 2006). Geetha (2009) reported that tank method of composting is better than heap method. The best additives for composting *Eichhormia* are cow dung and *Trichoderma*. Cow dung has to be applied at 0.5 kg for every 10 kg water hyacinth and *Trichoderma* @ 15 g kg⁻¹ of water hyacinth. By adding additives the compost will be ready by one month time. *Eichhormia* compost contains N 2.05%, P₂O₅ 1.10% and 2.5% K₂O and the C: N ratio is 1:13 (Bates and Hentges, 1976)

**Vermicompost production:** Water hyacinth biomass has to be mixed with cow dung in the ratio 1:3 and left to decompose for about 50 days. The partially decomposed material is then transferred into vermicompost blocks and African earthworm strains (*Eudrilus eugeniae*) are introduced at the rate of 1,500 worms for every tonne of the weed biomass. The compost will be ready in another 50 days’ time. At the end of the composting period, the number of adult worms is found to be 4,590 (more than three times increase over the initial number of worms introduced) in the water hyacinth compost and 2,610 in the agricultural waste compost (less than two times increase over initial population). The application of vermicompost @ 2.5 t ha⁻¹ has increased the yield of horticultural crops by about 10-25 per cent.

**Green charcoal production:** Green charcoal can be produced from water hyacinth after chopping and drying by two process, carbonization and semi decomposition (Rodrigues et al., 2014). Carbonization is the process of burning the dry hyacinth parts in a modified metallic drum under low oxygen. The carbonization process delivers dark charcoal pieces which when mixed with a binding agent (cassava/ gum arabic) can be molded through a manually operated extrusion system to get the briquettes. In semi decomposition process only stalk is used. The stalk dried for 4 days should be kept in the polyethylene decomposing bags and EM solution has to be added for enhancing the activity of microorganisms. The bags are to be kept for 14 days for fermentation. After seven days, the bags must be turned, to allow microbes act from the opposite direction. After 14 days the processes are stopped, the materials are taken out and air dried for three days, then it is ground using grinding machine using a manual grinder and the resulting powder mixed with binding agent (gum arabic/soil) and compressed manually by hand or machines to yield green charcoal/ water hyacinth briquettes. For producing 40 t of green charcoal, 1300 t of fresh hyacinth and 12 ha area is required for sun drying (Permaculture News, 2006).

**Paper making:** Water hyacinth fibre can be used to produce a range of extremely attractive, specialty papers. Collect the stem, cut the stems in to pieces of not more than 12 cm. Then digest the chopped stem by boiling which will give black pulp and washed. This is followed by bleaching of the pulp and again washed before made in to paper. Bleaching is unnecessary if the paper is to be of natural colour. Water hyacinth pulp needs to be washed with waste paper pulp in order to produce paper with sufficient strength. This is followed by dyeing with suitable dyes. The amount of dye to be used must be learnt by experience. Then lifting, drying and peeling have to be done. Lifting is the process of distributing the pulp into a uniform layer on a net. It needs considerable skill. When the paper is dry, use the knife to pries it up at the edges and carefully peel it off the net. The paper-making process is then complete. A good quality product can be judged by a uniform thickness, no obvious blemishes such as tears or stains and a size of 60 cm x 46 cm. The final paper product can be cleaned and then ‘calendered’ to a smooth finish by passing between two heavy smoothing roll.

**Fibre extraction:** Water hyacinth can be transformed into a source of income for communities. After harvesting, separate and select the stems. The stem should be at least 5 cm long and mature, as young stems produce brittle or soft fiber. Then split the stems lengthwise and air dry. Treat the fibres and twist into ropes of different thickness depending on the crafts to be made. Before twisting, sort the strips into various lengths and thickness. Then the ropes are distributed to the artisans for making beautiful hand bags, flower vases, mats, mattings, furniture’s etc.
Bioactive compounds isolated from Eichhornia: Phytochemical tests results of various experiments indicated the presence of alkaloids, flavonoids, phenols, sterols, terpenoids, anthoquinones, quinines, anthocyanin, saponin, and tannins. The presence of wide range of phytochemical constituents indicated that the plant could be used in a multitude of ways which may be beneficial to the population (Thamaraiselvi et al., 2012).

Methanolic extracts showed significant reduction in the growth of Aspergillus niger (Bobbarala et al., 2009). The crude extracts as well as thin layer chromatographic extraction showed antibacterial property against both gram positive bacteria (Bacillus subtilis and Streptococcus faecalis) and gram negative bacteria (Escherichia coli and Staphylococcus aureus). High anti-algal activity is recorded against Chlorella vulgaris (Shanab et al., 2010). Antifungal, antibacterial and anti-algal activities might be due to the presence of alkaloids and four phthalate derivatives.

Medicinal uses of Eichhornia: Methanolic leaf extract of water hyacinth (50%) at different doses (200 mg kg⁻¹ body weight to 500 mg kg⁻¹ body weight) showed good response against in vivo melanoma tumor (Ali et al., 2009). Some fractions of crude extract exhibited selective anticancer activity against a liver cancer cell line and while others shows high anticancer activity against hormone dependent tumor types (cervix and breast cancers) (Aboul-Enien et al., 2011).

Floating vegetable garden from water hyacinth: A floating garden is built using water hyacinth as a base on which vegetables can be grown. It is cheap and sustainable. Firstly, a floating raft is built using water hyacinth to collect the water hyacinth. The rafts vary in size depending on the space available and size of the family. Typically the length will be around 8 m, the width from 1.5 to 2m, and the height will be less than one metre. Floating water hyacinth is overlaid with bamboo poles of appropriate length to the size of the raft being constructed. Then collect and stack the water hyacinth. Once the rafts basic structure has been created the bamboo poles can be pulled out. After 7 to 10 days, more water hyacinth is added on to the water hyacinth base. Compost is added to cover the base of the raft to a depth of around 25 cm. Seeds of vegetables are then planted. In the rainy season, cucumber and different types of gourd vegetables are planted. In the winter season, beans, tomatoes, cauliflower, cabbage, potato, radish, carrot and onions are grown. A fence can be put around the floating garden to protect the vegetables from rats, ducks and other predators. Once the raft is built, it is tied on to a post so that when the flood water comes the raft will float up and vegetables will be safe. The vegetables can be collected two or three times a week. A new raft needs to be built every year, the old one can be used as manure for the next raft.

Advantages of floating vegetable garden cultivation with water hyacinth:
- Help to mitigate natural hazards
- Reduce the pressure on arable lands by turning the flooded and waterlogged areas into productive ones.
- Floating cultivation does not need any additional nutrients, or chemical fertilizers
- The beds can be recycled as organic fertilizer in the newly prepared floating bed and also in the agricultural fields
- Economical as well as environment friendly
- Helps to supplement peoples income, which contributes towards the alleviation of poverty
- Provides greater food security by allowing them to grow vegetables and crops with lower input costs

For phytoremediation: Sasidharan et al. 2013 reported that concentration of heavy metals (Fe, Zn, Cu, Mn, Al and Cr) in the hyacinth plant was found to be more than that present in the sediments and water collected from the Vembanad Lake. Similar type of study conducted by Thampatti et al (2007) reported that concentration of heavy metals such as Fe, Zn, Cu and Mn in the water hyacinth was significantly higher compared to that present in the field water, soil and sediment. These results indicated that this technology can be utilized for purifying heavy metal loaded effluents from factories in constructed lagoons with water hyacinth.

Utilization of Parthenium

As green manure: Biradar et al. (2006) reported that Parthenium can be utilized as a potential source of green manure for rice before they set seed i.e., either in the vegetative stage or in the early stage of flowering. This might be due to the favourable effect on total bacteria and phosphorous solubilizing bacteria. The enhanced microbial activity resulted in increased nutrient uptake, growth and yield in rice. Parthenium contains 2.55% N, 0.44% P₂O₅, and 1.23% K₂O (Biradar et al., 2006).

For Bio ethanol production: Parthenium pre-treated with Trametes hirsuta (white rot fungus) serve as a potential feed stock for bioethanol production (Rana et al., 2013). This study represents a first time report illustrating the suitability of biologically de-lignified Parthenium as a feedstock for ethanol production. Five white rot fungi were evaluated for lignolytic enzyme activity under submerged fermentation with Parthenium sp. as sole carbon source. Trametes hirsuta ITCC136 was found to be the efficient strain. Hemicellulose content of the Parthenium is 52.65%.

As substrate for xylanase enzyme production: Dwivedi et al. (2009) reported that Parthenium hysterophorus is a low cost carbon source for the production of Xylanase enzyme in submerged fermentation with Penicillium oxalicum. Xylanase is a hydrolytic enzyme that cleaves xylan. The end products of xylan degradation have industrial applications for biofuel, artificial sweetener, animal feed...
production, baking and textile industry, clarification of fruit juices and coffee extraction. Besides, there has been an increasing interest in using xylanases for ecofriendly bleaching of pulp in paper industries.

**For pest control:** Dry *Parthenium hysterophorus* leaf powder on water hyacinth, water lettuce and *Salvinia* caused wilting and desiccation of above-water parts (Pandey, 1994). Water extracts from shade dried *Parthenium* leaves have been applied to *Brassica juncea*, for controlling mustard aphid, *Lipaphis erysimi* (Wiesner et al., 2007). Extract of *Parthenium hysterophorus* show toxicity against root knot nematodes *Meloidogyne incognita* (Hasan and Jain, 1984).

**Medicinal uses:** The plant contains a large number of important bioactive compounds mainly apigenin, borneol, canin, charminarone, luteolin, parthenolide, pathenolide, reynosin, santamarin, tetraneurin E, caffeic, vanillic, ansic acid etc. (Roy and Shaik, 2013). Because of the presence of bioactive compounds, the plant has multiple pharmacologic properties. Methanol, ethanol, chloroform and aqueous extracts were significantly cytotoxic to human cancerous cell lines affecting ovary, lung, prostate, breast and central nervous system (Haq et al., 2011). *In vitro*, parthenolide functioned as growth inhibitor of human lymphoma, human lung carcinoma, human medulloblastoma and human colon adenocarcinoma (Parada-Turska et al., 2007). External leaf paste application showed wound healing activity (Kumar et al., 2012). It inhibits granule secretion in blood platelets which is concerned with the etiology of migraine, so it is used in the treatment and prevention of migraine (Heptinstall et al., 1985). Methanolic extract showed significant thrombolytic effect comparable to standard thrombolytic agent Streptokinase (Al-mamun et al., 2010). In West Indies this weed is used as a remedy against ulcerated sores, skin disease, facial neuralgia, fever and anemia (Arny, 1897).

**For phytoremediation:** Sulphuric acid-treated carbonized *Parthenium* could be a low-cost adsorbent for the removal of Ni (II) from aqueous solution (Lata et al., 2008). It is an effective adsorbent for removing Cd (II) from waste water (Ajmal et al., 2006). Activated carbon prepared from *Parthenium hysterophorous* (PAC) is found to be as good as activated carbon for removal of p-cresol up to a concentration of 500 mg/l in aqueous solution (Singh et al., 2008). Activated charcoal is an expensive activated carbon and so regeneration is essential. In contrast to this, PAC is inexpensive, easily available and does not need regeneration and thus promises sustainable utilization in p-cresol removal from industrial waste water, from automobile exhaust, power plants, and oil refineries. Environmental protection agency (EPA) has classified p-cresol as Group C carcinogen. This toxic effluent is known to cause stomach tumours, corrode the eyes, skin and respiratory tracts and affect the central nervous system, cardiovascular system, lungs, kidney and liver, even leading to unconsciousness and death.

**Utilization of Salvinia molesta**

**As manure:** *Salvinia molesta* can be used as manure. It contains 2.05% N, 0.54% P₂O₅ and 2-3.1% K₂O (Prasad et al., 2006). *Salvinia molesta* is rich in K and incorporation of *Salvinia* improved the water soluble K by 2-4 kg/ha and exchangeable K by 10 to 43.5 kg/ha (Krishna, 2013). Leachate collected on 7 and 14 days of decomposition had biological activity, indicating that auxin-like compounds were released from *Salvinia molesta* upon decomposition (Arthur et al., 2007). It was also reported that, on decomposition 17 % reduction in cytokinin concentration was observed compared to plant material. Application of *Salvinia molesta* @ 40 t ha⁻¹ as soil additive enhances the rice tillering by 30% (Soerjani, 1980). On decomposition *Salvinia* releases growth promoting substance, cytokinin which was responsible for enhanced tillering in rice.

**For compost making:** Tank method of composting is better than heap method (Geetha, 2009). The best additives for *Salvinia* composting are farm yard manure and urea. Urea has to be applied @ 10g per kilogram of weed and FYM has to be applied in the ratio of 10:0.5. *Salvinia* compost contains 1.95% N, 0.178% P₂O₅ and 1 % K₂O (Varshney, and Rzóska, 1976)

**As animal feed:** *Salvinia* can be utilized as feed for chickens (Ma’rifah et al., 2013), ducks (Sumiati and Nurhaya, 2003), swine (Leterme et al., 2009) and feed for fish tilapia (King et al., 2004). Inclusion of *Salvinia molesta* in the diet of chicks can be recommended as an alternate source of protein @ 6% (Gena et al., 2014).

**For bio gas production:** Higher biogas yield was obtained in partially decomposed *Salvinia* than fresh one. Salvinia mixed with cow dung in the ratio of 1:2 produced biogas with average methane content of approximately 40% (Mathew et al., 2013). *Salvinia molesta* fermented aerobically at 32°C yielded 8.8l of biogas per kg of fresh weight (Abassi and Nipaney, 1984).

**For phytoremediation:** *Salvinia* is a hyper accumulator of Cr, Zn, Pb and Ni. Harikumar et al. (2013) reported that *Salvinia* is more efficient in removing endosulfan from aqueous solution compared to *Hydrilla verticillata* and *Salvinia minima*. In 21 days 97.94 % endosulfan was removed by *Salvinia molesta*.

**Utilization of Chromolaena odorata (Eupatorium odoratum)**

**As manure:** Chromalaena can be utilized as a potential source of green manure. In aromatic rice, green manuring of eupatorium @ 7.5 t ha⁻¹ along with 50% RDF recorded higher productivity, soil fertility, rice quality and income besides saving of 50% RDF (Paraye, 2002). The application of FYM 2.5 t ha⁻¹ + eupatorium 2.5 t ha⁻¹ with 100 % RDF to maize + 50 % RDF to toria and eupatorium 5 t ha⁻¹ with 150 % RDF to maize + 25 % RDF to toria were found to be beneficial in terms of growth, productivity, nutrient uptake and economics of maize- toria system (Islam and Munda,
Manjappa and Kataraki (2004) reported that eupatorium as green manure @ 10 t ha⁻¹ alone recorded comparable yield with eupatorium as green manure @ 10 t ha⁻¹ along with recommended RDF. This also clearly indicated the utilization of eupatorium as green manure.

**As compost:** Navaz (2002) reported that un-composted eupatorium has C: N ratio of 63: 1; on composting the C: N ratio is reduced to 14: 1. Eupatorium compost has nutrient content of 0.93 % N, 0.62 % P₂O₅, and 0.85 % K₂O. Eupatorium compost was similar to poultry manure in terms of okra performance and had the highest B:C ratio (Navaz and George, 2004). Eupatorium as green manure has recorded lower yield due to the production of allelochemicals on decomposition (Ambika and Jayachandra, 1992).

**Medicinal uses:** Eupatorium has been used as a blood coagulant due to the presence of bioactive compound 4, 5, 6, 7-tetramethoxyflavone. Used as antiseptic for the regular treatment of skin eruptions and other disorders such as diarrhea, gonorrhea, malaria and cough. It has got antimicrobial, antioxidant, anti-tumor, analgesic, anti-inflammatory activity, anticancer, antidiuretic, immunostimulatory and antiidiabetic activity (Chakraborthy et al., 2011). Bioactive compound such as phenols, flavonoids, alcohol derivatives and other unique compounds are responsible for the medicinal properties (Venkataraman et al., 2012).

**Utilization of Mikania micrantha**

**As feed for silk worm:** Devi (2011) reported that mikania leaves can be used as a feed for Eri silk worm. 1st and 2nd instar larvae are fed by *Ricinus communis* followed by *Mikania mickrantha* from 3rd instar larvae to maturity.

**Briquette production:** Different types of briquettes can be made from mikania by different procedures. The dried mikania biomass was ground to powder form in a disc mill and was then run through a screw extruder briquetting machine at 300°C die temperature to obtain log type briquettes. The biomass was charred in a charring drum to obtain charcoal which, after grinding, was mixed with 30 % clay binder and water to obtain a thick paste, which was then molded into a manual beehive briquette mold to obtain circular cylindrical briquettes with 19 holes. Water boiling tests and combustion tests showed that briquettes from *Mikania micrantha* have good combustion as well as fuel properties and can be used as substitute for fuel wood or an alternative fuel in rural areas (Singh and Poudel, 2013).

**Medicinal uses:** Bioactive compound isolated from the *Mikania micrantha* are mikanolid, dihydromikanolid, m-methoxy benzoic acid, dioxymikanolid, scandenolide and dihydroscandenolide (Li et al., 2013). Ethyl acetate extracts of the weed exhibited significant antibacterial and anti-inflammatory properties (Pérez-Amador et al., 2010). The antibacterial and anti-inflammatory properties are mainly due to the presence of bioactive compounds present in the mikania leaves. The leaves after being boiled in salt water, cooled and applied to the skin to relieve itching (Smith, 1991). In Assam, *Kabi* tribes use the leaf juice of mikania as an antidote for insect bite and scorpion sting. It is a popular antiseptic in Mizoram. It heals minor cuts and bleeding.

**Other uses of Mikania:** Mikania is used as green manure crop for rice in Mizoram. Nutrient content of mikania is comparable with *Daincha*, 70 % biomass decompose in 70 days’ time and enhanced the growth of rice (Abraham and Abraham, 2002). In Africa, mikania leaves are used as vegetable for making soups. In northern parts of Kerala, mikania is used as fodder especially during summer months. In Malaysia, it is used as cover crop in rubber plantations and planting on the slopes to prevent soil erosion (Asia-Pacific Forest Invasive Species Network, n.d.).

**Utilization of Mimosa invisa**

**As Manure:** Jayasree and Abraham (2007) reported that, *Mimosa invisa* can be utilized as a potential green manure crop because of high rate of dry matter accumulation, rapid rate of litter decomposition, high nutrient content of the plant combined with N fixing capacity. *Mimosa invisa* was effectively nodulated with *Rhizobia*. Application of *Mimosa invisa* @ 20 kg plant⁻¹ enhanced the enzymatic activity in the rhizosphere (Thomas and Shantaram, 1984). Misra et al. (2011) also reported that it can be potentially utilized as a green manure crop for rainfed crops because of the rapid growth rate and dry matter accumulation. As green manure applied @ 5 t ha⁻¹ suppressed the weed growth by 57 %.

**As compost:** *Mimosa invisa* can be easily composted as it produces huge biomass and rapid rate of decomposition. It can supply more nutrients in comparison with other sources of compost. *Mimosa invisa* compost contains 2.35 % N, 0.13 % P₂O₅ and 0.41 % K₂O (Barman et al., 2007). Mimosa compost has got positive response in enhancing the soil organic matter. Mimosa compost had significant effect on the crop characters and yield of lentil (Barua et al., 2011).

**As animal feed:** *Mimosa invisa* contains an anti -nutritional factor called mimosine, chemically (β N-3 hydroxy 4-pyridine) - α amino propionic acid, which is toxic to animal. On drying the mimosine content was found to be reduced. Jayasree et al., 2007 reported that admixtures of pastures with *Mimosa invisa* up to 50% was safe for feeding after cutting and ensiling for 60 days.

**Utilization of Lantana camara**

**For pest control:** Coumaran isolated from the *Lantana camara* can be used as bio-pesticide. Coumaran inhibit the acetylcholinesterase at the cholinergic synapses of the insects and act as biofumigant against stored grain pests (Rajashekar et al., 2014). Acetone and ethanol extract of *Lantana camara* showed antifungal activity against *Alternaria alternata* (Singh and Srivastava, 2012), ethanolic extract showed antifungal activity against *Aspergillus niger* and *Aspergillus*
**Medicinal uses:** The ethanolic extracts exhibited antimicrobial activity against *Staphylococcus aureus*, *Proteus vulgaris*, *Pseudomonas aeruginosa*, *Vibrio cholerae* and *Escherichia coli* (Ganjewala, 2009). Ethanol and aqueous extracts of lantana leaves showed significant wound healing activity. Topical application of the extract on the wound (100 mg/kg/day) significantly enhanced the rate of wound contraction (98%), synthesis of collagen and decreased wound healing time (Abdulla et al., 2009). Essential oil from the leaves of *Lantana camara* was reported to possess adulcidal activity against *Aedes aegypti*, *Culex quinquefasciatus*, *Anopheles culicifacies* (Dua et al., 2010). Mosquito larvicidal activity of methanol and ethanol extracts of leaves and flowers of *Lantana camara* were also reported against 3rd and 4th instar larvae of *Aedes aegypti* and *Culex quinquefasciatus* mosquito. It has got antiulcerogenic activity. Ethanolic extract of the leaves of lantana has got antiulcerogenic activity against ethylene glycol and ammonium chloride induced calcium oxalate urolithiasis in male albino rats. Extract treatment significantly reduced the deposition of calcium oxalate and also reduced urinary excretion of calcium oxalate and creatinine (Mayee and Thosar, 2011). Antiulcerogenic activity of the methanol extract of leaves of *Lantana camara* was reported on aspirin, ethanol and cold resistant stress induced gastric lesions in rats (Thamotharan et al., 2010). The medicinal properties are mainly due to the presence of bioactive compounds such as essential oils, terpenes, triperpenes, flavones, coumarin, steroids, iridoid glycosides etc. (Reddy et al., 2013).

**As manure:** Application of *Lantana camara* either as green manure or compost @ 5 t/ha had significant effect on the grain yield wheat (Chauhan and Thakur, 2012). Continuous application of *Lantana camara* for 6 years increased the total P content in soil by 13 % and available P by 69 % respectively (Sharma and Verma, 2000). Enrichment of *Lantana camara* compost with 12.5% rock phosphate, fertilizer N 1% and 10 % pyrite produced high quality phosphocompost with high citric acid soluble P and N content and lower C: N ratio. Application of this enriched compost with 75 % recommended N fertilizer gave higher wheat yield and nutrient uptake which was statistically on par with 100% recommended NPK resulting in 25 % saving of N (Banta and Dev, 2009).

**Other uses:** Lantana was the best substrate for the production of oyster mushrooms (Josiah, 2007). Used as fuel for cooking and heating and for making baskets. Major source of nectar for honey Bees, butterflies and moths, since it produce more number of attractive flowers with nectar. Ornamental lantana is an excellent source of income in the nursery sector. Several ornamental varieties are developed by breeding with wild varieties.

**CONCLUSION**

No doubt, invasive alien weeds are a major threat to natural ecosystem and habitat. Commercial exploitation of these weeds may be initiated to reduce the population. All efforts to control invasive alien weeds to date have proved unsatisfactory and these weeds are extending their domain to new areas. Hence utilization could be one of the most effective means of reducing the problem of invasive alien weeds.

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