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REVIEW ARTICLE **OPEN ACCESS**

Impact, Management and Uses of *Lantana camara* – A Noxious Weed

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ABSTRACT
Lantana camara belonging to family Verbenaceae is a weed of worldwide significance. It is regarded as one of the noxious weeds because of its invasiveness, potential for spread and environmental impacts. Besides many deleterious effects, the plant has numerous uses and hence must be harnessed and also explored for its revenue generation potential. The current review presents the impact, management and uses of Lantana camara.
Keywords: Lantana camara, weed management

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INTRODUCTION

*Lantana camara*is one of the most invasive plants and top 100 highest impacting invasive species [1]. *Lantana camara*also known as Lantana,Wild sage, Surinam Tea plant,Spanish flag is among hundred most notorious weeds in the world and got entry approximately in 60 countries [2]. It grows under a wide range of climatic conditions and occurs on a variety of soil types reflecting its wide ecological tolerance. The allelopathic effect is the major contributor for hampering the growth of surrounding vegetation and flare up wherever it finds place. The lantadenes are the major toxic components present in this plant which are responsible to cause toxicity in almost all the animals thereby leads to economic losses to the farmers by causing diseases and mortality. Besides many harmful effects, this weed is having many advantages. But the harmful effects often supervenes the utility of this weed. So, it is very important to develop measures to control this weed in a desirable and cost-effective way[3].

BIOLOGY

Lantana camara also known as wild sage is a thorny, multistemmed, deciduous shrub with an average height of 2m (6ft). Stems are square in outline, covered with bristly hairs when green, often armed or with scattered small prickles. It possesses a strong root system. The roots after repeated cuttings give a new flush of shoots. Leaves are opposite, simple with long petioles, oval blades which are rough and hairy and have blunt toothed margins. The leaves of *Lantanacamara* have a strong aroma. Its flowers are small, multicoloured, instalked,dense in flat top clusters with a corolla having narrow tube with four short spreading lobes. Their flowers undergo colour change subsequent to anthesis. These flowers occur in cluster which include white-pink-lavender or yellow-orange-red mix. Berries of *Lantana camara* are round, fleshy, 2-seeded drupe, initially green in colour and turning purple and finally to blue-black colour. Seed germination is easier and faster in *Lantana camara*[4].

Kingdom: Plantae
Subkingdom: Tracheobionta
Superdivision: Spermatophyta
Division: Magnoliophyta
Class: Magnoliopsida
Subclass: Asteridae
Order: Lamiales
Family:Verbenaceae
Genus: *Lantana*species: *camara*

Berries of *Lantana camara*

Lantana camara flowers in varied colours

Ecology

Lantana camara's diverse and widespread distribution is a reflection of its wide ecological tolerances. The species occurs in varied habitats ranging from open unshaded regions which include wastelands, rainforest edges, beachfronts and forests disturbed by activities such as fire or logging [5]. The species also thrives well in disturbed areas which includes roadside, railway tracks and canals [6].

Life Cycle

The life cycle of *Lantana camara* commences with dispersal of seeds by various dispersal agents such as fruit eating birds and few mammals. An individual plant produces upto 12,000 fruits each year. The process of germination starts once the seed has travelled through the gut of a bird or mammal.Pollination by insects such as butterflies, moths, bees and thrips are common. Besides these, vegetative mode of

propagation includes spread through layering or reshooting. *Lantana camara*'s repetitive growth at base of stems confirms its tenacity. Various studies attribute seed viability ranges from 2-5 years. However, exact time of seed viability is still unknown and is mostly dependent on plant varieties, soil types and moisture levels. Anthropogenic disturbances (Burning, slashing, clearing, construction activities) facilitate its germination and propagation. The growth of the plant occurs all year round but the peak is reached after summer rains. The species takes only few weeks to germinate. The dryness and open canopy promotes early germination. The mature thickets once established continue to persist for long. The plants start producing seeds after completing one season. In the areas of its establishment, it competes with native flora and subsequently smothers pasture through its allelopathic nature. The species dies only under extreme conditions[4].

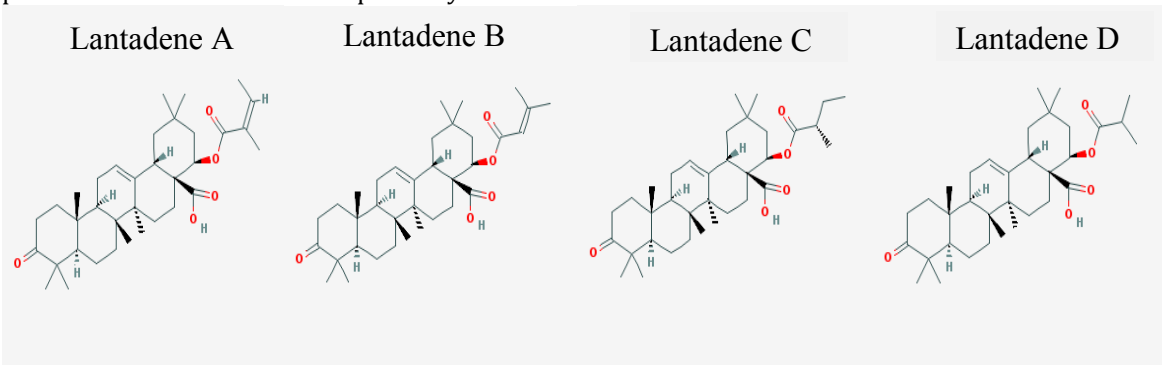
Table -1: Introduction record of *Lantana camara* in different regions

Region	*Introduction Records*
Australia	First reported in 1841 [7]
Bangladesh	Introduced in early 19th century [8]
Cook Island	First reported in 1969 [9]
Fiji	First reported around 1971[10]
Hawaii	Recorded as early as1898 [10]
India	Introduced in early 19th century [5]
Island of Rodrigues	Introduced in 1930 [11]
Mauritius	Early records suggest 1837 [11]
Newzealand	Introduced as a garden plant in 1890 [12]
South Africa	First recorded in 1858 in the Old cape Town gardens [13]

Source: [14]

Harmful effects of *Lantana camara* on Animals

1. In regions where the availability of quality forage to the grazing animal is inadequate,animals are compelled to consume weeds like *Lantana camara*.The lantadenes mainly present in the leaves of the plant have varying toxic effects among different species and strains of mammals/livestock. Lantadenesare pentacyclic triterpenes and often lead to hepatotoxicity, photosensitization and jaundice [15, 16,17].Lantadene A, Lantadene B, Lantadene C and Lantadene D are the major constituents of *L.camara*leaves (red flower variety)[18]. Reduced Lantadene A and Reduced Lantadene B are the minor constituents [19].Raw photosensitized areas are susceptible to blowfly, maggots and bacterial infections contributing to ill health of animals. Among ruminant cattle, buffalo and sheep are highly susceptible while goats are little resistant to lantadene toxicity [20, 17]. Guinea pigs show most typical signs of Lantana toxicity [21]. The toxic effects of Lantana have been seen in kangaroos and ostriches also [22, 23].Histopathological and biochemical alterations in different animal species on lantana toxicity is presented in Tables 2 and 3 respectively



Chemical structure of Lantadenes *Photo courtesy: PubChem*

Table – 2: Histopathological alterations in different animal species on lantana toxicity

Species	Histopathological alterations	References
Cattle	Degeneration of the periportal parenchymal cells, distended bile canaliculi, fatty degeneration, portal fibrosis, hyperplasia of bile ducts, edema of gall bladder in cattle.	[24, 25]
Goats	Hemorrhages of inter-sinusoidal spaces, coagulative necrosis, cirrhosis and proliferation of bile ductules, fatty degeneration of proximal convoluted tubules of kidneys, proliferation of bile ductules in the liver occurs.	[17]
Sheep	Centrilobular cells vacuolation with bile mainly in chronic cases	[17]
Guinea pigs and Rats	Periportal vacuolar degeneration, fatty degeneration, haemorrhages, bile duct proliferation with yellow-brown bile plugs, portal fibrosis in liver. Fatty degeneration of PCT, vacuolar degeneration of tubular epithelium of cortex, hyaline cast in kidneys. Oedema and haemorrhagic ulcer in gall bladder. Subepicardial petechial haemorrhages in heart along with pulmonary oedema and haemorrhages in lung.	[26, 27]
Rabbits	Portal fibrosis, bile canaliculi dilatation, degeneration and swelling of hepatic cells, biliary hyperplasia, biliary cirrhosis in the liver. Tubular nephrosis, inflammatory interstitial reaction, degeneration of tubules in the kidneys.	[17]

Source: [3]

Table -3: Biochemical alterations in different animal species on lantana toxicity

Species	Biochemical alterations	References
Cattle	Increase in direct and total bilirubin, increase in phylloerythrin levels, increase in serum AST, ALP, GLDH, serum total protein, serum albumin and serum globulin and decrease in albumin/globulin ratio.	[26, 28]
Goats	Rise of serum bilirubin, AST, creatinine, GGT and BUN levels	[29]
Sheep	No change in the serum ALP, AST and ALT levels	[30, 26]
Guinea pigs and Rats	Marked increase in conjugated form of bilirubin, AST, LDH, GLDH, BUM, ALT and SDH. No significant increase in total proteins, ACP and creatinine levels were observed in sub-acute toxicity of lantadenes while ALT, AST and ALP were significantly elevated.	[26, 17, 27]

2. Sub lethal doses of *Lantana camara* toxin causes reduction in production potential, manifested abortion, loss of milk production in dairy cows and chronic wasting in beef cattle.
3. A reduction in native forage species as a result of lantana invasions also contributes to a dramatic decline in livestock carrying capacities.Besides poisoning livestockand reducing livestock carrying capacities, dense thickets of lantana also hinder the movement of livestock [31, 32].

Treatment for lantana toxicity in Animals (Adapted from [3])

Specific treatment for lantana toxicity is still lacking, the preventive measures are more effective than curative measures to decline the harmful effect of this notorious weed [33], but there are some conventional treatment methods which can be applied [34, 17]. Keep the intoxicated animals away from light, provide fluid therapy and adequate feed.

1. Administration of activated charcoal 5g/kg body weight with electrolyte in stomach tube within 24h which reduces the absorption of lantadenes.
2. Administration of bentonite 5g/kg body weight. It is much cheaperthan charcoal but takes longer time to show desired effect.
3. Administration of Tefroli powder obtained from *Tephrosiapurpurea* plant.
4. Oral administration of liver tonic like Liv-52.
5. Vitamin B – complex administration
6. Enzymatic removal of bilirubin by bilirubin-oxidase which is effective in jaundice.
7. Herbal tea i.e. Yin Zhi Huang (YZH) from *Artemesiacapillaris* is effective in neonatal jaundice
8. Herbal plants like *Tinosporacordifolia*, *Gingko biloba*, *Berberis lycium* and *Hippophaesalicifolia* also show ameliorative effect on *Lantana camara* induced toxicity in guinea pigs.
9. Bacterial strains like *Pseudomonas picketii*, *Alcaligenes faecalis* and *Alcaligenesodorans* can be used which degrades the lantadenes.

Other Negative impacts of *Lantana camara*

1. Lantana imposes negative impact on plant diversity and abundance by suppressing native vegetation through allelopathy and competition for resources [35].Allelopathic effects resulting in either no growth or reduced growth close to *Lantana camara* have been demonstrated in crops such as *Triticum aestivum* (wheat), *Zea mays* (Maize) and *Glycine max* (soyabean). In disturbed native forests it becomes the understorey species thus dominating the flora, causing disruption in succession and loss in biodiversity.Volatile oils and water leachates of *Lantanacamara* significantly inhibits the seedling growth of cucumber, radish and tomato [36].
2. In tropical regions, *Lantana camara* harbors pests that affect human health by providing shelter during the day for tsetse flies (*Glossina sp.*)which are vectors of African sleeping sickness [37].
3. Fire regimes are altered immensely by the presence of *Lantana camara*in natural ecosystems [38]. The species burns readily in hot and dry conditions. Its occurrence on forest margins are seen as major threat to community, as a result of increased inroads of fire into the forest. This is particularly so when the species occurs on the edges of forest tracks and creeks in natural forests such as in national parks [4].

Management of *Lantana camara*

Despite *Lantanacamara*'s major ecological and economic impacts in many parts of the world, no standard methods have emerged for the effective management of the species. This may be because the species occurs across such a wide range of vegetation types and land-uses, where perceptions of the species as a weed, management goals and available resources differ considerably.

- Mechanical method of control for removal of *Lantanacamara* includes the use of bulldozers and tractors to remove plants [39]. This method minimizes disturbance to nearby vegetation and is effective in killing the plants, but is only feasible where the plants are small and where they occur in small, isolated clumps. These methods are impractical where large areas are invaded and not recommended in areas susceptible to erosion. The problem of regrowth occurs if the root stock is not completely removed while weeding. This is not the case in very dry areas where it is possible to first bulldoze and immediately plant pasture grass, and spray herbicide on any regrowth [40]. In India grubbing, slashing of branches and extensive digging of the root system are used to control the weed in forest ecosystems. However, this is disadvantageous as the soil is disturbed and weed seeds are exposed to light leading to stimulation of germination and establishment of seedlings as well as coppicing from slashed branches [41].
- **Cut Root stock method**: The state forest department of Himachal Pradesh has introduced a "Cut Root Stock (CRS)" method for the eradication of the weed. The following are the advantages of the Cut Root Stock method:

  a) The cut root stock method involves cutting the root exactly below the transition zone and thus eliminates the reproductive ability of the plant.

  b) It involves making a small cut below the soil level, with minimum disturbance of the soil. The scar left at the point of removal is 9-12 inches in diameter therefore there is very little disturbance of dormant lantana seeds lying in the soil.

  c) Because of the minimum disturbance of the soil other species of plants lying under the lantana bush including grass species are left unaffected, helping quicker regeneration.

  d) The Cut Root Stock method involves 50-60% less manual effort compared to cutting or slashing.
- Chemicals are an effective but expensive method of *Lantana camara* control and effectiveness depends on plant size, time of application, mode of application and the use of surfactant. Various herbicide treatments are used and said to be most effective when applied as a foliar spray or to the base of the stems and cut stumps [42]. Glyphosate is marginally effective as a foliar spray and regrowth is common. Fluroxypyr (Vista) plus aminopyralid when applied twice within six months is effective but costly. Even Fluroxypyr applied as a basal application is consistently effective. But, the use of chemicals tends to cause harm to the native biota of the ecosystem affecting food chain, soil health, causing water pollution and giving genesis to ancillary problems[4].
- Biological control of *Lantana camara* started in 1902, when 23 insect agents were imported from Mexico to Hawaii [39]. Biological organisms for controlling *Lantana camara* include *Ophiomyialantanae*(fruit mining fly), *Calcomyzalantanae* (agromyzid seedfly), *Teleonemiaelata* (leaf sucking bug), *Teleonemiascrupulosa* (leaf sucking bug) but mostly failed as they have several varieties or forms resulting in complicating the introduction and establishment of exotic insects. Several other host specific insects such as *Diastema tigris* (flower mining moth), *Salbiahaemorrhoidalis* (leaf folding caterpillar), *Uroplatagirardi*(leaf mining beetle) and *Epinotialantanae* (flower mining moth) have been introduced from time to time for biological suppression of *Lantana camara* but have not been effectivein controlling its infestation[4]. The main reason for the failures being the extreme variability of the weed, extensive climate range it invades and high level of parasitism on the natural enemies.

- Monitoring of Lantana population by mapping, remote sensing, GPS/GNSS techniques and satellite[4].
- Implementation of control measures like crop rotation, sowing pastures etc. are the key steps to be taken for successful control of this weed [4]. Preventing grazing for the first six months to one year will assist the growth of the pasture.
- Preventing the spread of Lantana is the most cost-effective management tool. This would further require the restriction of further importation of Lantana into your country, restriction of sale and use of Lantana in gardens and strategically controlling infestations wherever it currently occurs.

Impact of *Lantana camara* on Soil

S.No.	Invasion effect of *Lantana camara*	Reference
1.	*Lantanacamara* invaded areas had an increase in pH value, phosphorus, nitrogen, manganese, iron and total organic carbon.	[43]
2.	Soils invaded with *Lantana camara* recorded higher values of soil pH, higher concentration of magnesium, calcium and potassium compared to uninvaded sites suggesting that it can improve the nutrient levels of soils and therefore influence nutrient cycling resulting in making the ground better for its growth.	[44]
3.	Soils samples that were collected from underneath *Lantana camara* recorded significantly higher values of total carbon, total phosphorus and soil moisture and were repellent compared to the natural sites.	[45]
4.	Concentration of organic carbon and total nitrogen were significantly higher in habitats having larger lantana cover.	[46]
5.	Soils underneath the canopy of *Lantana camara* had higher pH, total N, total P, available N, available P, soil respiration, enzyme activities and microbial biomass N and P compared to that away from it.	[47]
6.	Sites heavily invaded with *Lantana camara* recorded the highest values of rhizosphere soil pH, carbon, total N and K, NH_4^+-N, NO_3^- - N and available K contents, enzymatic activity compared to newly invaded sites, non-invaded sites.	[48]
8.	Moisture, pH, Ca, OC and total N (but not exchangeable N in the form of NO_3^-) were significantly elevated while sodium, chloride, copper, iron, sulphur and manganese were present in lower levels in *Lantana camara* invaded soils.	[49]
7.	Dominance of *Lantana camara* resulted in increase in soil erosion thereby increasing threat to forest ecosystem stability and water resource management.	[50]

S.No.	Incorporation effect of Lantana camara	Reference
1.	Incorporation of lantana as green manure in rice-wheat cropping system increased the available soil nitrogen status.	[51]
2.	In rice-wheat cropping system, Lantana additions increased the organic carbon (OC) of the 0–15 cm soil layer by 11–24%, and of water-stable aggregates (WSA, 0.50–8.0 mm diameter) by 10–21%; OC of WSA <0.50 mm diameter remained unaffected. About 17–25% of the applied OC was retained in the soil. The OC increase resulted in a decrease in bulk density of the plough layer (0–15 cm) by 7%, a decrease in aggregates of 2–8 mm diameter and of clods by 4% and 6%, respectively. There was an increase in water-stable aggregates and aggregate porosity, and a decrease in clod-breaking strength from 420 to 216 kPa. Soil cracking at the surface changed from wide, deep cracks in hexagonal pattern to a close-spaced network of fine cracks. Lantana additions increased <5mm wide cracks at the expense of 10–20 mm wide cracks; 5–10 mm wide cracks remained unchanged. Total volume of cracks decreased by 36% and surface area of cracks by 55% compared with the control plots.	[52]
3.	Incorporation of chopped Lantana camara improved the N, P and K status of soil in rice-wheat cropping system when compared to control.	[53]
4.	In Lentil and Rajma incorporation of Lantana camara as green manure reduced the soil bulk density and increased the average mycorrhizal spores in soil.	[54]

5.	In wheat crop the application of Lantana camara vermicompost improved the soil fertility status compared to control	[55]
6.	Vermicomposting with Lantana camarahelped in improving the soil fertility and yield in Trigonella crop.	[56]
7.	Addition of lantana vermicompost reduced the particle and bulk density of soil, increased the percentage total porosity, water holding capacity and microbial biomass carbon.	[57]
8.	Decomposed Lantana camara leaf litter increased the level of soil urease, invertase, protease, catalase and cellulase, and the contents of soil organic matter, total N, P, K, available N, P and K. The BIOLOG results indicated that Shannon index, McIntosh index, Simpson index and Richness index of microbial communities in soil samples were also higher in the treatments with increasing levels of Lantana camara leaf litter.	[58]

S.No.	Mulching effect of *Lantana camara*	Reference
1.	In case of wheat sown after maize, mulching with *Lantana camara* along with conservation tillage resulted in higher soil moisture in different soil layers compared to conventional tillage.	[59]
2.	In wheat- rice cropping cycle mulching with Lantana proved to be superior with regard to soil moisture conservation and soil fertility compared to oak and pine leaf litter mulch.	[60]

Uses of *Lantana camara*

1. *Lantana camara* parts are being used effectively in making furniture which is equally sturdyandcheaper than cane. The furniture lasts long and does not get easily eaten away by termites. Soligas, the tribal artisans of South India are ingeniously utilizing the invasive weed as a substitute for rattan and *Wrightiatinctoria* and converting into value added products such as furniture, toys and articles of household utility [61].
2. The twigs and stems of *Lantana camara* serve as useful fuel for cooking and heating in many regions of India [21], although it is less important than other fuel sources such as windrows, woodlots or natural bush[62].
3. *Lantana camara* has several therapeutic uses mainly as herbal medicine [17, 63]. Leaf extracts exhibit antimicrobial, fungicidal, insecticidal, nematicidal, biocidal activity [17]. Lantana oil is used externally for leprosy and scabies [63]. Lantana exhibits anticancer [64], antibacterial [65], antidiabetic [66], anti-inflammatory, analgesic, antimotility [67], antiulcer and antioxidant actions [64]. The list of useful compounds obtained from different parts of *Lantana camara* is presented in Table 4.

Table - 4: Useful compounds obtained from different parts of *Lantana camara*

S.No.	Part	Compounds	Action
1.	Leaves, stem	Oleanonic acid	Anti-inflammatory
2.	Leaves, stem, roots	Oleanolic acid	Antimicrobial, antitumour, anti-inflammatory
3.	Aerial parts	Camarinic acid, Lantanoside	Nematicidal
4.	Leaves	Lactones containing euphanes	Anti-thrombin
5.	Leaves	Apigenin	Anti-proliferative
6.	Leaves	Camaraside	Anti-tumour
7.	Leaves and branches	Martynoside	Cardioactive

(Sources: 17,68,69)Adapted from [3]

4. Essential oils obtained from *Lantana camara* leaves have adulticidal activity against mosquitoes [70]. Lantana is formed into incense cakes that are used as mosquito repellents [82].
5. The flowers of Lantana serve as a nectar source for butterflies and moths [71,39].
6. Lantana being a drought tolerant plant can be regarded as a good option for xeriscaping.
7. *Lantana camara* having 75.03% holo-cellulose, 8.46% extractive, 18.21% lignin and 2.31% silica can be a good potential source of raw material for paper making [72]. Research conducted by 72, 73, 74 have demonstrated *Lantana camara* as potential source of raw material for paper making.
8. *Lantana camara* is nowadays being utilized for vermicomposting [57].
9. In metal polluted tropical and sub-tropical countries, this weed is used in phytoextraction of heavy metals especially lead [75,76,77] and phytoremediation of particulate pollution [78, 79, 80].

10. The ripened berries of *Lantana camara* are nowadays often used for preparing silver nanoparticles [81].
11. Lantana leaves and fruits are edible. The young leaves mixed with salt are eaten to stimulate digestion and ripe fruits are eaten in many remote and underdeveloped areas [82].
12. The leaf extracts of this weed are having inhibitory effect on aquatic weeds like *Microcystis aeruginosa* and *Eichhornia crassipes* [17] and are often used for controlling pests and almond moths in an environment friendly way [83].
13. A number of endangered bird species utilize Lantana thickets as shelter when their natural habitat is unavailable.
14. *Lantana camara* can be utilized as a good source of green manuring.
15.Serves to nurse parasitic seedlings and as a support for Yam vines [82].
16. The easy availability of the withered leaves of this common weed can make it a cheaper enzyme (Alkaline protease) source and potential additive in detergents [82].
17. Lantana flowers abundantly available have been used to extract an eco-friendly natural coloured dye for silk [82].

CONCLUSION

The present state of *Lantana camara* suggests that there is an urgent need to control this weed to save the native biodiversity. So it is very important to develop measures to control this weed in a desirable and cost effective way. Only the utilization of this plant is supposed to be an effective method for managing the weed. This utilization approach can help get rid of the negative impact of this weed on environment and can help to promote economic upliftment of rural economy.

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