



Ecological Impacts, Distribution and its Management Approaches of *Lantana camara* L, in Ethiopia: A Review Paper

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Received date: 14 September, 2022, Manuscript No. JPPP-22-74640;

Editor assigned date: 19 September, 2022, PreQC No. JPPP-22-74640 (PQ);

Reviewed date: 03 October, 2022, QC No. JPPP-22-74640;

Revised date: 16 January, 2023, Manuscript No. JPPP-22-74640 (R);

Published date: 23 January, 2023, DOI: 10.4172/2329-955X.1000281.

Abstract

Lantana camara L. (Family: Verbenaceae) as one of the most ten world's dangerous invasion alien species. The aims of this review paper were to review ecological impacts, distribution and management approaches of the invasive species of *Lantana camara* L. shrubs in Ethiopia. The distribution of *Lantana camara* L. in Ethiopia is unlimited and many ecosystems are affected by this species are cultivated and non-cultivated land, road side, grazing area, rural villages, river side, wetlands, forest and urban areas. They are introduced in to anew country either through by human or natural cases (winds, birds, animals, water). Biodiversity loss, socioeconomic problems, agricultural loss, human and animal wellbeing problems and invasion of in national parks are the known impacts that *Lantana camara* L. posed within the country of Ethiopia. Utilization of *Lantana camara* L. for several purposes, prevention of its further spreading into non-infected areas, use of fire, mechanical, chemical, biological control and awareness creation are the recommended to management policies that can bring solutions to the threats posed by the clear within the country. Then, the country of Ethiopia should evaluate frequently the distribution and socioeconomic impact of this species to take proper protection actions and to prevent further introduction and spread of the *Latana camara* L. species in new areas that are not yet infested.

Keywords: Ecological impacts; *Lantana camara* L; Invasion alien species; Ethiopia

Introduction

Invasion of invasive alien species is among the most important globally series problems experienced by expected ecosystems. Even though this biological invasion is a natural process, the recent quickly rate of invasions is clearly anthropogenic phenomenon and constitutes one of the most important effects that humans have created on the earth. Invasive alien species characterize one of the chief hazards to

biodiversity, human health and all economic sectors, especially in developing countries.

Lantana camara L. is one of the worst worldwide invasive species. It is upright and a hardy timeless perennial shrub up to 5 m height. It is a species of flowering plant within the family of Verbenaceae. It is inborn to tropical and subtropical America and the West Indies. It is common as an attractive plant in all parts of the vegetation of Ethiopia within an altitudinal range of 500-2500 meter above sea level.

Like several other countries in the tropics, many aggressive alien species have been presented to Ethiopia. Amongst the announced invasive alien species 35 have been so far well-known. From the so far known invasive alien species *Parthenium hysterophorus*, *Prosopis juliflora*, *Eichhornia crassipes*, *Euphorbia stricta*, *Mimosa diplotricha*, *Xantium strumarium* and *Lantana camara* L. are the primary ones which are a pronounced concern in Ethiopia that are affectation particular problems on biodiversity, agricultural lands, rangelands, national parks, waterways, lakes, rivers, power dams, roadsides and urban green spaces with great economic and ecological consequences.

The distribution of *Lantana camara* in Ethiopia is great and many ecosystems are affected by this species are cultivated and non-cultivated land, road side, grazing area, pastoral villages, river side, wetlands, forest and urban areas. It reasons the destruction of extreme amount biodiversity [1].

Lantana camara has usually been purposely presented into various localities in Ethiopia as an ornamental shrub and has been rapidly spread by birds and animals that eat its fruits but cannot digest the woody seeds [2]. In Ethiopia, it is one of the four major IAPs those posing harmful impacts on country's biodiversity. Therefore, this review aims to review ecological impact, distribution and management strategy of the invasive species *Lantana camara* in Ethiopia Local name of *Lantana camara* Yewof kolo (Amhara); Hamaressa, rate kate, shimbero (Oromia); Burkaati, qarfa-weyn (Somolia).

Literature Review

Declaration of the problem

Biological invasion is careful as the second most widespread danger to global biodiversity next to anthropogenic habitat loss and ecosystem destruction [3]. *Lantana camara* L. is among the worst invasive alien species that are categorized universal. In Ethiopia, it is also recognized by the environmental policy and the national biodiversity strategy and action plan as a major risk to the biodiversity of the country are stated.

Lantana camara L. can become the main understory shrub in farming areas, massing out other native species and reducing biodiversity. The allelo chemicals which controlled in different parts of the plant can inhibit with seed germination and initial growth and biomass production of many plant species. It may also affect native vegetation indirectly through changes in soil properties [4]. In addition to the loss of biodiversity, interference with seed germination and early growth, *Lantana camara* L. can reduce the effectiveness of development by choking irrigation canals, placing constraints on sustainable development, poverty mitigation and food security within the country of Ethiopia. Even though *Lantana camara* L. is a major

risk it is given less attention and most of the time it is ignored in Ethiopia.

The aim could be the fact that the disaster impacts arising from this weed may often be considered not high enough to interest the attention of managers (since very little is known about the threats and dispersal of *Lantana camara* L. in Ethiopia) and/or impact of this invasive alien species often misinterpreted. According to Binggeli and Desalegn, currently *Lantana* has spread almost all over the country, but still, it is not much observed as a chronic environmental problem, except in few parts of Ethiopia, such as Oromia and Somali regions.

The objective of review article

- To review the distribution and ecological impacts posed by *Lantana camara* in Ethiopia.
- To review the method of controlling the expansion of *Lantana camara* in Ethiopia.

Historical background of *Lantana camara* L.

Lantana camara L. was presented in 1809 at Calcutta botanical garden from Sri Lanka as ornamental hedge bearing multi-color flowers. Because of its productive seed production, it runaway to cultivated land and now has become a serious weed in pastures, wastelands, road sides and forests replacing local vegetation in most parts of India. This species was first recognized as a serious weed in forested areas near Madras in 1893. It had occupied 2000 hectares during 1917 and by 1941, it became serious difficult on 40000 ha.

Plant invasion is a strong risk to the species diversity around the world during the 21st century after habitat loss. Large number species of IAP are introduced to native country in the world and few of these become problematic they are introduced in to a country either through human or natural (e.g. winds, birds, animals, water). Thousands of plant species have been transported by humans to areas far from their natural habitats accidentally or intentionally (e.g. agro-forestry, horticulture, forestry and animal farming purposes). However, invasions by IAPS are one of the largest threats to the ecosystems of the earth and the services.

Lantana camara L. one of the world's worst invasive species is a perennial woody shrub, going to the family Verbenaceae. Literature writers indicated the natural occurrence of *Lantana* in Mexico, the Caribbean and tropical and subtropical central and South America. The species was only widely dispersed around the world during the 19th and early 20th century. During the 18th century *Lantana* became a preferred green house plant and many new varieties were propagated.

Reports on its geographical range indicate its presence in many Pacific Island nations on the Pacific realm it occurs in Australia, New Zealand, China, Thailand, Cambodia, Viet Nam, Malaysia, Indonesia and Philippines. In the Indian Ocean Islands it occurs on Mauritius, La Reunion and Rodrigues.

Lantana is called as a highly variable species it may be erect in the open and scrambling in scrubland, ranging in height from 2-5 centimeters. Difference in flower size, shape and color; leaf size, hairiness and color; stem thorniness; growth rates; shade tolerance; toxicity to livestock; chromosome number and DNA content have been widely reported [5].

Lantana flowers when the soil is moist and the air is warm and humid. Germination may occur at any time of the year when enough moisture is present. Initial seedlings grow this slow until the roots

become established after which close stems intertwine and begin to form thickets. It can reproduce from the base if the shoot dies, spreading the life of the individual plant.

Butterflies, bees and other insects are attracted by the nectar and pollinate *Lantana* flower. About half of the flowers produce seeds, typically 1-20 seeds on each flower head. Mature plants can produce up to 12,000 seeds every year. Seeds are thought to remain viable for several years under natural conditions.

Studies on its fast mechanism documented layering in which stems send roots in to the soil, allowing it to quickly form dense stands and spread short distances. Also birds and other animals consume and pass the seed in their droppings, potentially spreading it over quite long distances. Invasive pathway to new localities is also nursery trade. Local dispersal methods are digestion, excretion and garden escape/garden waste.

Lantana occurs in agricultural areas, disturbed areas, natural forests range/grass lands, shrub lands, urban areas and wetlands. Many studies documented disturbance, decreasing competition and increasing resource availability associated with fire and grazing as promoters of *Lantana* invasions whereas shedding is a limiting factor but some invasive populations are somewhat shade tolerant.

Lantana camara L. also known as big-sage; white-sage is fast-growing woody thicket-forming shrub, is native to tropical and subtropical South and Central America and currently widely distributed in many countries including Ethiopia.

Lantana camara is presented into Ethiopia as an ornamental shrub often used as prevaricate plant. *Lantana* is well known in Ethiopia especially as a showy garden plant, for example, the horticultural society recommends its planting in Addis Ababa home gardens. It has also been seen growing around home farmsteads as a live hedge along the Nazareth Welenchiti road [6].

Importance of *Lantana camara* L.

Lantana camara have important levels of nitrogen and phosphorus, when grown as a cover crop and combined in to the soil; it pays to fertility at not at all price but for the labor of planting and soil combination [7].

It is used traditionally to treat various ailments like tetanus, rheumatism, malaria, cough, fevers, cold, rheumatism, asthma to mention a few of animal and human diseases. Many phytochemical surveys have been done on this plant. The plant can be also used as hedges which protect wind erosion in dry lands. It also used for camel calves as feed because calves cannot reach to browse like *Acacia brevispica* during shortage of milk from their mother in dry season in Eastern Ethiopia.

Studies illustrate many importance of *Lantana*. For example, it is grown as hedge plant; its firewood are used as raw materials for paper and pulp, which is used for wrapping, writing and printing paper. Its bark is astringent and is used as a lotion in cutaneous eruptions, leprosy ulcers, etc.; seeds as lamb food, biogas production when its straw is mixed with dung. Alkaloid fractions obtained from *Lantana*, have been found to lower the blood pressure, accelerate deep respiration and stimulate intestinal movements in experimental animals. It is also used as ornamental, erosion control and anti-feedant and repellent of harmful insects, as fodder for cattle and goats [8].

Characteristic features

IAS is one of the most significant drivers of environmental alteration worldwide. Four main features are associated with invasive plants; show productive seeding and primary age of first reproduction, have indigestible vegetation, can simply start in degraded environments and have an ability to redevelop freely from direct seeds, stems or roots. These structures make them good competitors amongst other plant species and allow their survival and abundant establishment.

However, *Lantana* presented less vegetative growth, less reproductive success and more looked in the forest. So, *L. camara* is less successful in the forest gaps than at the limits of the forests and hedges. The quick spread of *Lantana* is related with human induced disturbance. Fruits are widely dispersed by many birds including hosted species. In areas where natural fires occur they stimulate thicker re-growth. It accepts a widespread range of climates.

It cultivates healthy on poor soils. It produces also allelopathic chemicals from its plant parts.

Taxonomic description of *Lantana camara*

Lantana camara L is small perennial plant which can grow to around 2 m tall and form dense brushes in a variety of environments. It has small cylindrical shaped flowers which each have four petals and are agreed in clusters in terminal areas stems. Flowers come in various different colors including red, yellow, white, pink and orange which differ depending on location in inflorescences, age and maturity. After pollination occurs the color of the flowers alteration (typically from yellow to oranges, pinkish or reddish), this is believed to be a sign to pollinators that the pre-change color contains a reward as well as being sexually feasible, thus increasing pollination efficiency (Table 1).

Plant parts	Description
Steam	Four angled, armed with recurved thorns
Leaves	Opposite, ovate to ovate-lanceolate, 2.5 cm to 10 cm long, 1.75 cm to 7.5 cm wide, acuminate, the margins are crenate to dentate, upper surface is scabrous and rugose and lower surface is finely pubescent
Petiole	2 cm long
Inflorescence	A dense, axillary, flat topped head-like spike, 1 cm-3 cm across
Calyx	Cup shaped, 1.2 mm-2.2 mm long, shallowly 2 lobes, subtended by a bracteole
Corolla	Salver form, tube covered, 6 ng-910 ng, limb spreading, 4 mm-8 mm across, yellow, orange, red or pink in the same head (generally yellow and pink on opening of corolla but changing to orange and red, sometimes blue or purple)
Petals	Four
Peduncle	2.5 em to 7.5 em long
Fruit	A drupe, globular, dark purple to black, 4 mm-6 mm across at maturity, borne In clusters
Seed	One, about 1.5 mm long

Table 1: Description of *Lantana camara* and its parts.

Ecology of *Lantan camara* L

It is a weed of cultivated land, fence lines, pastures, rangelands and waste places. It succeeds in dry and wet regions and often grows in valleys, mountain slopes and coastal areas. It is highly light-demanding species and thrives well on well drained soils with sufficient moisture and with climate moderately without extremes of heat and cold (areas with 1250 mm-3750 mm rainfall). It can tolerate both humid and dry heat but cannot survive very low temperatures. It is slightly shade-tolerant and consequently can become the dominant understory in open forestry or in tropical tree crops. However, excessive shade such as dense forests inhibits its growth. It has low tolerance for marshy soils, saline soils and is susceptible to frost.

Ecological distribution

Lantana camara L. is one of the vilest IAPS worldwide. It is upright and a hardy evergreen perennial shrub up to 5 m tall. It is a species of flowering plant within the Verbenaceae family. It is native

to tropical and subtropical America and the West Indies. It is common as an ornamental plant in all parts of the Flora of Ethiopia within an altitudinal range of 500 to 2500 meter above sea level.

The dispersal of *Lantana camara* in Ethiopia is great and many ecosystems are affected by this species are cultivated and non-cultivated land, road side, grazing area, rural villages, river side, wetlands, forest and urban areas. It causes the loss of maximum amount biodiversity.

Lantana camara has usually been purposely introduced into various localities in Ethiopia (particularly urban settings) as an ornamental shrub and has been rapidly spread by birds and animals that eat its fruits but cannot digest the woody seeds. In Ethiopia, it is one of the four major IAPSs those posing damaging impacts on countries of biodiversity. It is found commonly in East and South Africa where it occurs at altitudes below 2000 m and often invades previously disturbed areas such as recorded forests and areas cleared for agriculture.

Human made and natural disturbances act together to help the introduction and spread of invasive alien species. *Lantana camara* L.

spread over sixty (60) countries in the world *viz*, New Zealand, Mexico, Florida, Jamaica and Brazil. It is stated in several African countries including Ethiopia Kenya, Uganda, Tanzania and South Africa.

The different colors of *Lantana camara* L. flowers helped it to be cultivated for its ornamental purpose in Ethiopia. This process helps the plant to spread faster than other weed plants. Its use for fencing also contributed to its dispersal within the country.

Lantana camara L. biological attributes like high number of production of fruits each year (prolific seed production) and duration of fruit production (which is throughout the year when conditions are favorable such as adequate light and moisture) its ability to propagate vegetative by a process called layering where horizontal stems take root when they are in contact with moist soil better competitive ability compared to native flora, widespread geographic range (wide ecological tolerance) contributed to the success of its dispersal.

The ability of *Lantana camara* L. to rapidly colonize areas of land which have been disturbed (in countries like Ethiopia where activities such as logging and clearance for agriculture are common) may allow its dispersal too.

In addition to its biological attributes, the fast spread of its fruit by birds (which are predominant dispersers) and animals that eat its fruits may have contributed to its dispersal; after its careful introduction to various localities of Ethiopia. Transportation of seeds by running water with the country may also contribute to its spread.

Although *Lantana camara* can be originated in Ethiopia like Adama Jimma, Mekella Gamo, Gofa Bahir DarBorna and Gujji Deber Zeit, Dire Dawa, Harar, Somali are the hotspot areas of the weed in Ethiopia Benishangule Gumize [9-13].

The impacts of *Lantana camara* L

Socio-economic impacts: *Lantana camara* was introduced to Ethiopia as an ornamental plant owing to its beautiful aromatic flowers. However, because of productive seed production and easy dispersal, it escaped cultivation and became a pest in the social, ecological and economic concerns. Currently, it has spread almost all over the country, but still it is not much professed as a chronic environmental problematic, except in few parts of Ethiopia, such as Oromia and Somali regions.

Currently, there is little information obtainable on spatial distribution of *Lantana camara* invasion and its potential geographic extent. *Lantana* is relatively inedible, poisonous to stock, causing loss of appetite, frequent urination, dehydration and yellowing of inner mouth and eyes. Hairs are lost from the skin, the mouth and eyes swell and ulcerate and animals may die within one or four weeks. The fruits are also poisonous to children. In some areas, *Lantana* coverings provide a breeding ground to tsetse flies, which transmit the parasitic trypanosomes that cause an animal form of sleeping sickness.

According to several of the problems of *Lantana camara* attack, include invading bush lands, quickly takes over valuable grazing lands and its dense growth inhibited grasses and other useful forages under its canopy [14].

Agriculture loss

In agricultural areas *L. camara* can become the leading underwood shrub, crowding out other native species and reducing biodiversity. The formation of dense thickets of *L. camara* can significantly slow down the regeneration of forests by preventing the growth of new trees.

The different parts of *Lantana* contain allelic chemicals mainly aromatic alkaloids and phenolic compounds which can inhibit seed germination and early growth of many plant species [15]. *Lantana* can also inhibit growth of nearby plants by outcompeting for soil nutrients and changing microenvironment (e.g. light, temperature) by forming dense coverings. Despite its recognition as among the worst invasive alien species in the world, information on the ecological interference of *Lantana* on the growth and establishment of native plants, especially on agronomic crops, is scanty in Ethiopia.

The opposing impacts of *Lantana camara* L. on agriculture have been studied in some parts of the world. *Lantana camara* L. may have an indirect effect on crop production due to host for many insect pests that can affect human health. In addition to its result on root and shoot growth, biomass and host for vectors, the weed can affect mustering of cattle (by out competing native pastures that are better feed for the cattle) hence disturbed agriculture. *Lantana* may also affect agriculture by providing shelter for threatening wild animals like wild cats, hyena (these animals may consume cattle, goat and sheep), warthog (can damage crops) and others [16].

On biodiversity loss

Among the attackers that will have the largest impacts are those that directly change ecosystems. They have cascading effects for resident biota (plants, animals and micro-organisms). Exotics can disturb ecosystems by changing system level flows, availability or quality of nutrients, food and physical resources (e.g. living space, water, heat or light). Many writings suggest that introduced ecosystem contrives either: Increase habitat complexity or heterogeneity which tends to cause abundances and/or species richness to raise or decrease difficulty tends to have the opposite effect on ecosystem services.

Ecosystem services can be characterized into four main service areas in general;

- Provisioning service (e.g. food, freshwater, fiber, fuel, genetic resources).
- Regulating services (e.g. air quality regulation, climate regulation, water regulation).
- Traditional services are nonmaterial benefits, (e.g. aesthetic values, recreation/tourism, spiritual/ religious values), supporting services.
- Overarching, indirect and occur on large temporal scales (e.g. photosynthesis, primary production, nutrient cycling).

IAPS threats to these ecosystem services; IAPS pose a global threat to the conservation of biodiversity through: Their proliferation and spread, displacing or killing native flora and fauna and affecting ecosystem services. They are particularly damaging in geographical or ecological islands, which are rich in endemic species, Invasive plants smother, outcompete and displace indigenous species, changing the composition and function of entire ecosystems.

Lantana camara L. colonizes disturbed sites, impacting croplands and range lands. It generates allelic chemicals by roots in the soil through root exudates. These allelic chemicals inhibitors (like phenolic acids and alkaloids) inhibit the germination, growth and yield of neighboring plants through the mechanism called non-resource mediated interference and this may adversely affect plant species diversity by displacing mature vegetation or limiting juvenile recruitment. The other mechanism by which *Lantana* can affect biodiversity is through competition for resources (e.g. water, nutrients, sunlight). In addition to allelopathy, its fast growth and inedible nature (due to its unpalatability the weed experience relatively little pressure

from natural predators compared to those which have evolved in their native land favored the weed to affect biodiversity by competing out native species.

It readily invades pastureland outcompeting palatable species, resulting in a decrease in carrying capacities and restricted access and movement of animals, humans and vehicles. It is also unpalatable and in large doses (approximately 1% of total body weight) is poisonous, cause skin lesion in sheep particularly to cattle. *Lantana* is one of the known allelopathic weed plants in many parts of the world. For example, experiment conducted in Northern Ethiopia. Accordingly, *Lantana* leaf powder significantly inhibits seed germination, speed of germination, shoot and root length, stem thickness and biomass of wheat and maize.

Impacts on human and animals health

The natural and severity of the influence of invasive alien species on health in global concern. *L. camara* is one of the potential invasive alien species that can be pose threat human health. The effect of *Lantana* camera on human health can be direct or indirect. Feeding on the green fruit of *Lantana* has proved to be fatal and this can be considered as the direct consequence of *Lantana camara* L. on human health. However, this may not be always true because children and adults often consume suitable fruits of *Lantana camara* L. without any ill effects in India. Also, in Ethiopia traditional healers have been used (such as leaf and stem) *Lantana camara* L. to treat various diseases in humans. These debated research findings may come from the point that some varieties are poisonous and some are not but it is difficult to tell which variations are toxic so it is better to reflect some forms as possibly poisonous.

Indirectly *Lantana camara* L. can cause a health problem in humans by protecting malarial mosquitoes in bushes and tsetse flies. In Ethiopia the information on toxic plants like *Lantana* is uncommon. However, the findings of in Tigray region, Northern Ethiopia and in Gamo Gofa zone indicated that *Lantana camara* L. is a constraint to both human and animal health. Moreover, the report of indicated that consumption of *Lantana camara* L. leaves at Wollega Zone, Western Ethiopia result in livestock toxicities (bloody urine). Also in Cheffa (300 km north of Addis Ababa) research results demonstrated that *Lantana camara* L. has affected the quality of livestock production.

Invasion in national park degradation

Infestation in national parks can unfavorably affect plant (by causing a negative impact on native plant species and slowly reducing the endemic species) and wild animal biodiversity and this finally may result in degradation of these protected areas and promotion up management costs. According to *Lantana camara* L. invasion in South Africa has been related to the decrease in invertebrate diversity, tourism industry and industrial sites. The national parks in Zimbabwe Kenya Australia and South Africa have been invaded by the weed. Similarly, the spread of *Lantana camara* L. in Ethiopia national parks currently becomes a growing concern [17].

Management/controlling approaches

There are diverse management approaches of IAPS after attack: Strategies are mechanical, chemical, biological and Fire. The reasonably common switch method applied in Ethiopia is the displacing of the tree manually. Efforts to control *L. camara* using mechanical, chemical and biological means have met with incomplete

achievement. *Lantana* is problematic to control, as it will wood and form denser thickets if it is simply slashed and left. Management by use can also eradicate *Lantana camara* L. delay can be controlled by using its biomass before the plant set seeds. The best management option is an integrated approach is required for controlling.

Utilization of *Lantana camara*

Unique of the likely options to succeed *Lantana camara* L. invasion is through utilization. *Lantana camara* L. can be utilized for the production of biogas, compost especially vermicompost and as a green manure. Plants up to pre-bloom stage should only be used otherwise while handling such material, dispersal may take place.

Lantana camara L. can be used to control root-knot nematode (due to its nematicidal properties), protect seed potatoes from potato tuber moth damage during storage and protect Tomato (*Lycopersicon esculentum*) (due to its antibacterial activity) from bacterial wilt caused by *Ralstonia solanacearum*.

Lantana camara L. also has insecticidal properties on *Musca domestica* (house fly) and thus can be utilized as insecticidal. It can be used as a source for firewood and fuel briquette (clean energy source). It has medicinal properties too [18].

In addition, it can be used to treat Ticks bites in livestock [19]. Currently, in India *Lantana camara* L. is used as a craft material for weaving baskets and making furniture. It is also used as an input for paper production. Thus, utilization of *Lantana camara* L. for such resolve may help in its elimination and control in Ethiopia.

Fire

Regular burning will reduce the capacity of invasive alien species to survive; however, initial kill rates are variable. This method will depend on the suitability of available fuel loads, litter moisture content, fire intensity, temperature, relative humidity, soil moisture and season. Pasture re-establishment can then provide competition to inhibit *Lantana camara* L. seed germination.

Although, *Lantana camara* L. burns readily during hot, dry conditions, even when green, moderate and low intensity fires can promote the persistence and spread of its thickets, rather than reducing them. Furthermore, the elimination of competing native plant species (native plant species that are not fire tolerant) and increases in soil nutrients following burning (since burning can promote the release of nutrients from organic matter) can increase *Lantana camara* L. germination.

So care should be taken when utilizing this method for *Lantana camara* L. control and removal. The other limitation of this method is that it cannot be used in non-fire tolerant vegetated areas such as rainforest or wooded or plantation areas. But this method is favorable for savannas (since plants in savannas are fire tolerant).

Chemical control

Additional expensive but effective method for management of *Lantana camara* L. is the utilization of chemicals but its effectiveness depends on plant size, time of application and way of application. Numerous herbicide treatments can be used and are said to be effective when applied as a foliar spray or to the base of the stems and cut stumps. When applied as a foliar spray or to the base of the stems and cut stumps. According to some herbicides (belonging to the

phenoxy acid and benzoic acid) can be effective on *Lantana camara* L. control and removal. Similar the other management strategies utilization of chemicals needs care and follow-up.

Biological control

Biological control can be careful relatively as the greatest and most necessary control option for the control of *Lantana camara* L. because it will not be influenced by restrictions (because the other management options like mechanical and chemical are dependent on the land use, extent and density of the invasive populations, openness to invaded areas, economic value of land and the associated costs). In addition, utilization of chemicals may not only be expensive and difficult but may also result in long-term environmental pollution and possible serious problems which may come upon in the future.

Some bio-control agents (insects) have been released from time to time to manage *Lantana camara* L. biologically. The utilization of defoliating herbivores like *Teleonemia scrupulosa* Stal and *Uroplata girardi* Pic (since leaf defoliation can result in decreased seed production and dieback of leaves and some branches) can be used to remove and control *Lantana camara* L.

In utilizing biological controls (like insects) one must make sure that natural enemies of those insects (insects which will feed upon them after the weed control or removal) are present in the area in which the method is planned to apply to them for the control of *Lantana camara* L. If not, utilization of biological control has also its own limitation (disadvantage).

Mechanical/physical control

Mechanical measures may minimize disruption to neighboring vegetation and effective in killing the weed they also had their own limitation. The use of excavators and tractors and plowing by Oxen may set the difficulty in removing *Lantana camara* L. where large areas are occupied and may result in regrowth from stumps and/or increased seedling germination from the disturbed soil. Mechanical measures can also make areas susceptible to soil erosion and other opportunistic weeds (since the measures may result in soil disturbance) unless proper care and follow up is considered.

Although manual controls are expensive (e.g. bulldozers and tractors) and time consuming (e.g. plowing using oxen) and cannot be used in areas where *Lantana camara* L. is not found in isolated clumps, they can provide some relief.

The use of bulldozers and tractors in some cases plowing by oxen, grubbing, the slashing of branches and extensive digging of the root system are some of the mechanical measures that can be used to remove and control *Lantana camara* L. in Ethiopia.

Though mechanical measures, in general, may minimize disturbance to nearby vegetation and effective in killing the weed they also had their own limitation. The use of bulldozers and tractors and plowing by oxen may set the difficulty in removing *Lantana camara* L. where large areas are invaded and may result in regrowth from stumps and/or increased seedling germination from the disturbed soil. Similarly, if care is not well thought out grubbing, the slashing of branches and extensive digging of the root system may also result in the establishment of coppicing from slashed branches of *Lantana camara* L.

Awareness creation

Currently, issues linking to invasive woody plants like *Lantana camara* L. are mainly and sometimes only, the concern of scientists and conservationists. This may create difficulties or limitation in eradicating and controlling the invasive plants. *Lantana camara* L. can invade any area in villages, towns and cities in the locality of housing and other buildings in favor of its Morphological and ecological characteristics, unlike other weeds. So society awareness, consent and participation are a key to control and eradicate *Lantana camara* L.

Consequently, in order to be actual in the control of the weed in Ethiopia, mass awareness programmers should be organized by Universities, NGOs, Environmental protection authority and others for the local people to make them aware of the hazards of this harmful invasive weed. These can serve as an excellent source of knowledge about the dangers of *Lantana camara* L. and may help in its mechanical control (local people can involve voluntarily during its uprooting) in its early age in areas from which the local people come from. Additionally, if it is planned to save the national parks and biodiversity, reduce the potential impact on agriculture, awareness creation programs should be organized once a year throughout Ethiopia [20].

Prevention methods

Avoidance of invasive alien species is the most actual controlling strategy because it minimizes the risks (like environmental) associated with utilization of other methods (for example chemicals) and reduces management costs.

According to prevention of invasive alien species includes regulating intentional introductions and minimizing accidental introductions (through the identification of potential high-risk species and corridors) and the measures to prevent their establishment can be applied pre-border (before it leaves the source country), at the border (as it enters a country) or post-border (once it is already within a country). Even though pre-order and at the border prevention measures cannot be applied to prevent *Lantana camara* L. in Ethiopia (because the weed is already established within the country), post border measures such as strict quarantine laws not to transport the weed from infested to the non-infested area within the country can be effective in controlling and managing the spread of the weed in to another area.

People should reduce utilization of *Lantana camara* L. as an ornamental plant in the vicinity of their home or crop fields. This may also help prevention of *Lantana camara* L. further in Ethiopia. Furthermore, at a regional level, each regional government must have a biosecurity plan that covers invasive plants like *Lantana camara* L. in its area (this may also help to reduce its spread into areas in which the weed is not currently found).

Discussion

Ethiopia has various ecosystems which are home to large number of flora, fauna and microbial species. However, there are pressures to ecosystem services and biodiversity loss due to habitat conversion, invasive species, unmanageable utilization of biodiversity resources, replacement of local varieties and breeds and climate change and pollution. Invasive alien species such as plants are exotic which are introduced purposely or unintentionally outside their natural habitat naturally or through human activities. In new areas, invasive alien

species inhabit the native ecosystems; have either positive or negative consequences on the ecosystem services. Invasive alien species are found in all taxon or organisms and exist all over the world in all ecosystems.

Newly, 35 invasive weed species are identified in Ethiopia and they are posing negative impacts on native biodiversity, agricultural and range lands, national parks, water ways, lakes, rivers, power dams, road sides and urban green spaces with huge economical as well as social consequences. Some of these species include: Mesquites (*P. juliflora*), parthenium weed (*P. hysterophorus*), water hyacinth (*E. crassipes*), *Lantana* weed (*L. camara*), Acacia species and other weeds such as *Orobanche* and *Cuscuta* species that are identified as major plant invaders. These IAPS are more antagonistic in disturbed, arid and semiarid vegetation ecosystems like Acacia Commiphora woodlands, aquatic, wetlands, agro-ecosystems and rangelands in Ethiopia. IAPS have peculiar characteristics of invasiveness and distribution that overtake the native species such as number seeds they produce, reproductive outputs and some allelochemicals inhibit other native species loss. As the result, they have impacts on biodiversity, social services and health problems both on human and animals in all ecosystems in the new areas. In order to war such threats countries in the world and Ethiopia have their own strategies to control IAPS in the native ecosystems. But, there are management blocks to implement such strategies.

Conclusion

Mechanical, chemical, fire regime for some invasive species like water hyacinth and biological control method are some methods after invasion of the species. These aforementioned methods have their own cons and prions to control IAPS. Prevention, integrated management strategies and management of the species by utilization as measure used to control *L. camara* in Ethiopia, are among the best management of the control measures. Therefore,

- It needs for an integrated, coordinated and multi-stakeholder and multiple level actions that the community, government and development partners shall participate in the eradication of the invasive plant *L. camara*.
- Sustainable and multidisciplinary approach studies regarding history, properties of the invasiveness of the species and their impacts in relation to ecological impacts on ecosystems and socioeconomic consequences have to be conducted.
- Create awareness for stakeholders about the history, cause and impacts of *Lantana camara* is very important.
- Close monitoring and management of all natural and agro ecosystems from disturbances to reduce the arrival and colonization of IAPS.
- Secure quarantine measures needs to be introduced in boarder areas where tourism, trade, travels agents are flowing.
- Countries with IAPS countries share information and working relationships in order to control the transfer of IAPS from one to another.
- The society should be awarded not to use the land for grazing or browsing more than its carrying capacity, as disturbance in the form of herbivory is found to be the major factor facilitating invasion and encroachment of the species.
- Establishment of training on how to use the species to improve biophysical and socio-economic environment. For example; planting it on eroded areas for rehabilitation of the areas and in

erosion prone areas to prevent erosion and to use it for live fence around farmsteads and home gardens.

- Removing it before seed production for seed production is the major means of encroachment to UN invaded areas.
- Determination of the beginning level for decline in biodiversity and the identification of “management barriers” to invasion.

Acknowledgement

Firstly I thank to my God. We are grateful to all the authors of the scientific papers used in this article.

Conflict of Interest

The author declares there is no conflict of interest.

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