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INVASIVE ALIEN PLANT SPECIES IN PUNJAB

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EDITORIAL

The World Conservation Union (IUCN) defines alien invasive species as organisms that become established in native ecosystems or habitats, proliferate, alter, and threaten native biodiversity. These aliens come in the form of plants, animals and microbes that have been introduced into an area from other parts of the world, and have been able to displace indigenous species. Invasive alien species are emerging as one of the major threats to sustainable development, on a par with global warming and the destruction of life-support systems. Increased mobility and human interaction have been key drivers in the spread of Indigenous Alien Species.

Invasion by alien species is a global phenomenon, with threatening negative impacts to the indigenous biological diversity as well as related negative impacts on human health and overall his well-being. Thus, threatening the ecosystems on the earth.

The Millennium Ecosystem Assessment (MA) found that trends in species introductions, as well as modelling predictions, strongly suggest that biological invasions will continue to increase in number and impact. An additional concern is that multiple human impacts on biodiversity and ecosystems will decrease the natural biotic resistance to invasions and, therefore, the number of biotic communities dominated by invasive species will increase.

India one of the 17 "megadiverse" countries and is composed of a diversity of ecological habitats like forests, grasslands, wetlands, coastal and marine ecosystems, and desert ecosystems have been reported with 40 percent of alien flora species and 25 percent out of them invasive by National Bureau of Plant Genetic Resource. In India, invasive plants infest extensive tracts of agricultural and forest land. Various aspects of control of alien weeds and pests are being dealt with by a number of authorities. Insight to above views and identifying the array of effects that invasive alien species have, the present issue of Newsletter deliberates upon the Invasive Alien Plant Species. Based on the available databases and some regional reports, most of the invasive plants, irrespective of their origin, belong to the family Asteraceae, while families such as Poaceae, Solanaceae and Fabaceae also predominate. Further, invasive plants belong to a variety of life forms as herbs, shrubs, trees, climbers/vines, grasses and aquatic plants. The most important invasive plants that have created havoc in a number of habitats include terrestrial herbaceous weeds (e.g. Ageratum conyzoides and Parthenium hyterophorus), shrubs (e.g. Lantana camara and Chromolaena odorata) trees (e.g. Proposis juliflora and Leucaena leucocephala), vines (e.g. Mikania micarantha) and aquatic plants (e.g. Eichhornia crassipes).

The present article documents the four major invasive alien plant species in Punjab namely, *Lantana camara, Parthenium hyterophorus, Ageratum conyzoides* and *Eichhonia crassipes*. It is hoped that this inventory and assessment of alien flora will help in designing informed management and monitoring strategies against problematic plant invasions in the state.

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ENVIS Centre, PSCST as a partner in Regional Centre of Expertise (RCE) Chandigarh on Education for Sustainable Development (ESD) endeavors to promote the prevention and control of invasive alien plant species in the region for conservation of the Biological resources Sustainable Development.

Introduction

During evolution the natural bio-geographical barriers of oceans, mountains, rivers and deserts provided the isolation essential for unique species and ecosystems to evolve. But, colonization of Africa and Asia by the European powers between the 15th and 19th centuries led to an exponential increase in the movement of organisms both plants and animals from one part of the world to another through trade, transport, travel and tourism. During this period many plant species have been either accidentally or deliberately translocated far from their native areas (Khuroo *et, al.* 2007).These plant species that move from one geographical region to the other, establish and proliferate there and threaten native ecosystem, habitats and species are known as invasive alien plants (Pysek *et al.* 2004). The invasive plants are also known as alien, exotic or introduced ones, which are new to a specific area, become dominant, replacing / substituting the native plant species. The definition of invasive alien species, however, in the context of the Convention on Biological Diversity (CBD), is given in **Box 1**. Colonial invasions have brought in a number of invasive alien species into the India subcontinent that has transformed native landscapes.

History of Invasion in India

For a major part the introductions and subsequent naturalization **(Box 2)** of plant species native to other countries into India were guided by the colonial government policies (Kannan *et al*. 2012). However, over the years, many of these introductions went on to become Invasive. For example, Sankaran *et al*. in 2009 listed *Chromolaena odorata*, *Lantana camara*, *Mikania micrantha* and *Mimosa diplotricha* as the major invasive alien plants in India.

In the recent past, *Prosopis juliflora* was introduced as an alternative fuelwood tree in southern India. The history of introduction of *Prosopis juliflora* into India in about 130 years old. *Lantana* was introduced into India at the East India Botanical Gardens, Calcutta in 1807 as an ornamental plant by the British. Since then, *Lantana* has spread to most parts of the country, in farmlands and forestlands, and has posed a formidable challenge to farmers and foresters alike.

Status of Invasive Plants in India

Despite the recent recognition of the impacts caused by invasive plants worldwide (Mooney and Hobbs, 2000), there are still many regions in the world where basic information on naturalized plant taxa and plant invasions is only anecdotal or completely lacking, e.g. Asia and neighboring regions (Meyer, 2000). Establishment of a database of naturalized species is the first step in the development of invasion biology, and which also serves as a stepping-stone for further detailed studies on the biology and impact of individual species (Wu *et al*, 2004).

The Indian region, because of its diverse climate and environmental conditions, is highly vulnerable to biotic invasion. Moreover, a burgeoning population, high rate of trade and transport, coupled with greater movement of people favour the accidental and intentional entry of plant species in this region. The

Box 1. Invasive alien species (IAS)

In the context of the Convention on Biological Diversity (CBD), invasive alien species means an 'alien species whose introduction and/or spread threaten biological diversity' (CBD 2002). CBD visualize 'biological invasion of alien species as the second worst threat after habitat destruction'. Biological invasions may be considered as a form of biological pollution and significant component on human-caused global environmental change and one of the major causes of species extinction. The opportunity of accidental introductions will may become more with rapidly increasing global commerce

Source: Drake *et al*, 1989.

Box 2. Naturalization

Naturalization has been recognized as the first phase of biological invasions. A *naturalized species* is defined as an introduced (non-native, exotic, alien) species, that can consistently reproduce and sustain populations over many generations without (or despite) direct intervention by humans.

After successful local establishment, some naturalized species disperse and produce viable offspring in areas distant from the sites of introduction. Such naturalized species are called invasive.

Source: Richardson *et al*, 2000 & Pysek et al, 2002.

Major Invasive Alien Plant Species in India (Sankaran et al., 2009)

Chromolaena odorata
(Siam Weed, Christmas Bush, Devil Weed, Camfhur Grass & Common Floss Flower)

Lantana camara
(Big Sage, Wild Sage, Red Sage, White Sage & Tickberry)

Mikania micrantha
Bitter Vine or Climbing Hemp Vine or American Rope & Mile-a-Minute Vine

Mimosa diplotricha
(Giant Sensitive Plant & Nila Grass)

recent fast rate of economic growth of the country is also expected to leave its mark on loss of plant diversity including endemic species, also reflect a high rate of habitat degradation where opportunist invasive species can easily established themselves. Consequently, a number of invasive species have made their abode in the region. The three main reasons for the greater invisibility of this region are as under :

- Excessive human populations that migrate frequently and carry seeds or propagules of invasive plants from one place to another.
- Availability of fragmented /disturbed habitats or species-poor regions due to habitat fragmentation and degradation that provide habitat for alien species; and
- Favorable environmental and climatic conditions owning to the diversity of invasive species an opportunity to establish.

Despite several known invasive plants in India, there is no complete listing of the status of invasive plants. Though there are several other reports available that provide information on the invasion flora of a particular region/area.

Khuroo *et al.* (2007) reported 571 alien species belonging to 352 genera and 104 families from the Kashmir Himalayan, their origins traceable from Europe, Asia and Africa. Negi and Hajra (2007) reported 308 woody and 128 herbaceous exotic species from the Doon Valley of north-western Himalayan of which many are harmful invasives that

have created several environmental, socio-economic and health problems. A detailed study was conducted by C. Sudhakar Reddy during 2003 –2007, to compile a comprehensive list of invasive alien plant species in India.

Further, in 2006 Kohli *et al.* also conducted a study wherein a list of 173 species (in all kinds of systems like forests, crop lands, waste lands, plantations, gardens and road sides) in 117 genera and under 44 families were documented as invasive alien plant species, representing 1% of the Indian flora **(Annexure 1)**. According to this study tropical America (with 128 species) region contribute the greatest to the number (74%) followed by tropical Africa (11%). The other regions, which contribute minority, are Afghanistan, Australia, Brazil, East Indies, Europe, Madagascar, Mascarene Islands, Mediterranean, Mexico, Peru, Temperate South America, Trop. West Asia, West Indies and Western Europe. Further, Habit wise analysis shows that herbs with 151 species (87.3%) predominate followed by shrubs (14), climbers (5) and trees (3). In this study, out of the 44 families documented, 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), Mimosacceae (6) and Tiliaceae (5). The top ten families contribute 110 species with proportion of 63.6%. The 17 families represent one species each, i.e. Apocynaceae, Araceae, Arecaceae, Balsaminaceae, Cactaceae, Liliaceae, Melastomataceae, Nyctaginaceae, Oxalida-ceae, Papaveraceae, Passifloraceae, Piperaceae, Polygonaceae, Rubiaceae, Salviniaceae, Typhaceae and Urticaceae. The 33 species are invaders of wetlands, i.e. *Aerva javanica*, *Aeschynomene americana*, *Alternanthera-paronychioides*,

Invasive Alien Plants Species of Wetlands (Kohli et al., 2006)

Saccharum spontaneum
()

Salvinia molesta
()

Typha angustata
()

Ipomoea Canea
()

Alternanthera philoxeroides, *Asclepias curassavica*, *Cassia alata*, *Corchorus trilocularis*, *Cyperus difformis*, *Cyperus iria*, *Echinochloa colona*, *Echinochloa crusgalli*,*Eclipta prostrata*, *Eichhornia crassipes*, *Fuirena ciliaris*, *Gnaphalium coarctatum*, *Gnaphalium pensylvanicum*, *Gnaphalium polycaulon*, *Grangea maderaspatana*, *Ipomoea carnea*, *Ludwigia adscendens*, *Ludwigia octovalvis*, *Ludwigia perennis*, *Mecardonia procumbens*, *Monochoria vaginalis*, *Pistia stratiotes*, *Portulaca quadrifida*, *Rorippa dubia*, *Saccharum spontaneum*, *Salvinia molesta*, *Sesbania bispinosa*, *Sonchus asper*, *Sonchus oleraceus* and *Typha angustata*.

Recently in 2012, K. Chandra Sekar, undertook a study to document a comprehensive list of Invasive alien plants of Indian Himalayan Region. A total of 190 invasive alien species under 112 genera, belonging to 47 families were recorded in this study. Among these, the dicotyledons represent by 40 families, 95 genera and 170 species; mono-cotyledons represent by 7 families, 17 genera and 20 species. The analysis of invasive species reveals that 18 species have been introduced intentionally, while the remaining species established unintentionally through trade. In terms of nativity, amongst 13 geographic regions, the majority of invasive plants reported from American continent (73%). While in life form analysis, the herbs (148 species) are dominant, followed by shrubs (19 species), Grass (11 species), Trees (4 species), sedges and climber (3 species each). Most of the invasive species are annual habit (63%). Apart from these, 90 species (47%) are being used by locals for medicinal purposes.

Chromolaena odorata
()

Based on the available databases and some regional reports, Kohli *et al* (2004) nearly 60 invasive plants have been identified from the Indian region, the majority from South and tropical America and Australia, Africa, Europe and even the Asian region. Most the invasive plants, irrespective of their origin, belong to the family Asteraceae, while families such as Poaceae, Solanaceae and Fabaceae also predominate. Furthermore, invasive plants belong to a variety of life forms as herbs, shrubs, trees, climbers/vines, grasses and aquatic plants.

The most important invasive plants that have created havoc in a number of habitats include terrestrial herbaceous weeds (e.g. *Ageratum conyzoides and Parthenium hyterophorus*), shrubs (e.g. *Lantana camara* and *Chromolaena odorata*) trees (e.g. *Proposis juliflora* and *Leucaena leucocephala*), vines (e.g. Mikania micarantha) and aquatic plants (e.g. *Eichhornia crassipes*).

Proposis juliflora
()

Leucaena leucocephala
()

Lantana camara is perhaps the best known example of a serious weed having been intentionally introduced for ornamental value. Another weed introduced in India as an ornamental plant is *Chromolaena odorata (*APFISN, 2005) and this is also included in the list of the top 100 worst invaders (GISD, 2010). It is also one of the most obnoxious weeds in the Western Ghats, north-eastern parts of the country and impacts on coconut, rubber, coffee and teak plantations (Singh, 1998). Trees such as *Leucaena leucocephala and Proposis juliflora* introduced under various forestry programmes are also now of invasive proportions.

Other important specie introduced accidentally to the region, *Parthenium hysterophorus* is one of the most harmful weeds and the best-known example (Kohli and Rani,1994).

Mechanisms of Plant Invasion

Not every introduction results in naturalization and only a few of those that become naturalized become invasive. As a statistical generalization, Williamson and Fitter (1996) proposed the *Tens Rule* (**Box 3**)

Although the percentage of plants crossing borders and becoming invasive seems low, the few that eventually do have radical effects on native species population, communities, and ecosystem processes. There is a wide array of reasons as to why invasive plants may have rapid growth and spread in their new environments. Disturbance may reduce competition, allowing for the establishment of invaders invasive plants. These plants may escape herbivores or parasites, which keep their population low in their native lands. The invasive plants may alter their new environment in order to promote their own community that can be filled by an introduced plant. There are several plausible explanations and several mechanisms for invasion have been proposed. The fact that several mechanism for invasion have been proposed in recent years and that basically no generalization can be made about the nature of invasive plants, indicates that research in this area is still fairly new and needs much attention. No one has yet explained invasion patterns across a large range of systems and this may simply due to the fact that each invasive species is unique and that invasions are unpredictable (Williamson 1999; Dietz and Edwards 2006).

One hypothesis to explain invasive species success is the novel weapons hypothesis, whereby an invading species possesses a trait novel to the invaded ecosystem. The invasive species can then take advantage of this trait in its new ecosystem during interactions with native species that are evolutionarily-naïve to the trait. In plants, allelopathy **(Box 4)** can represent a novel weapon and can have direct plant-to-plant effects, whereby allelochemicals directly impact other species.

Alternatively, allelopathy may have indirect effects on other plants, through changes in soil ecology or mutualisms. Allelopathic effects may vary depending on target species or conditions such as life stage and nutrients (Cipollini *et al*, 2012).

It has recently been proposed, however, that the conflicts in invasion theory result from the examination of different parts of the invasion process and it

Box 3. Tens Rule

Tens Rule suggests that 1 in 10 of the biota brought into a region will escape and appear in the wild, 1 in 10 of those will become naturalized as a self-sustaining population, and 1 in 10 of those population will become invasive.

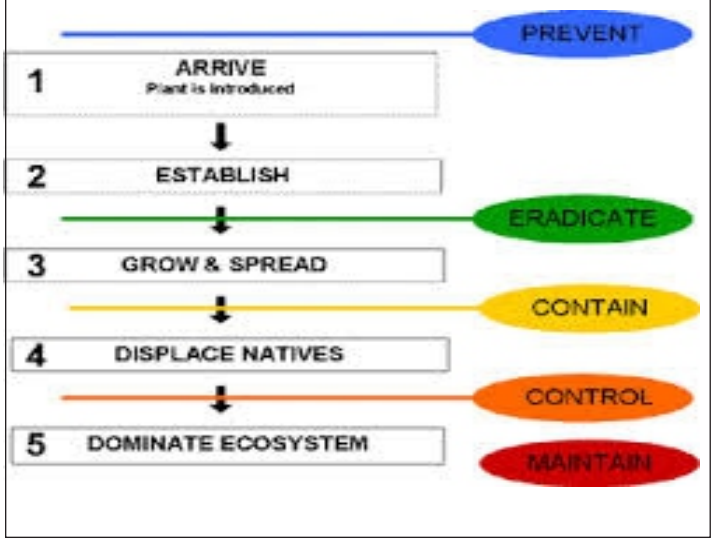
Source: Williamson and Fitter, 1996

Box 4. Meaning of Allelopathy

Plants synthesize a variety of chemicals as a result of secondary metabolism, and this forms the basis of allelopathy-a type of plant-plant interaction. Though the historical data indicate that knowledge of plant interactions mediated through chemicals is very old and dates back to 300 B.C., the term *allelopathy* originated only in the twenthieth century (Singh, Batish and Kohli, 2001).

The genesis of the term allelopathy dates back to 1937, when Hans Molisch combined two Greek words, *Allelo* and *Pathos*, literally meanings 'mutual sufferings'. According to Molisch, all plants including microbes, mutually interact through the release of chemicals in the environment. Later Rice (1984) defined allelopathy as any direct or indirect positive or negative effect of one plant (including microbe) on the other through the release of chemicals into the environment.

Chart 1. Mechanism of Plant Invasion and Control



should be recognized that the processes enabling a species to invade change over the course of the invasion (Dietz and Edwards 2006).

Control Measures

Presently the following species specific methods are being employed for prevention and control of weeds:

Mechanical: Mechanical control involves hoes, cultivators, harrows, rotary weeders, discs, ploughs, scythes, mowers and manual uprooting. The weeds are physically lifted from the soil, cut off or buried. In most of the forestry operations the invasive such as *Lantana, Eupatorium, Mikania,* etc. are uprooted manually and either burnt or buried. In some places, those are being used for making compost.

Chemical: This is one of the most common methods employed for control of invasives. Most chemicals are species specific though their use is not always desirable due to environmental degradation and pollution that they often cause and their effects on other useful species.

Tillage: Tillage helps in the burial of most small annual weeds. If all growing points are buried, most annual weeds will be killed. Tillage also disturbs the rooting system of most of the perennial weeds. The root system is cut to enough depth so that the plant dies from desiccation before it can re-establish its roots. In moist soils or if it rains soon after tillage, the roots may quickly re-establish themselves. In effect one may transplant the weed with little or no injury. Mowing is effective on tall growing plants. Tall annual weeds are mowed or scythed to reduce competition with crop plants and to prevent seed production.

Crop competition: Crop competition is one of the cheapest and most useful methods farmers can use. Often it means using the best crop production methods so favorable to the crop that weeds are crowded out. Actually competition makes full use of one of the oldest laws of nature-"Survival of the fittest". Weeds compete with crop plants for light, soil moisture, nutrients and carbon dioxide. One mustard plant (weed) requires twice as much nitrogen and phosphorus, four times as much potassium, and four times as much water as well developed oat plant. Early weed competition usually reduces crop yields far more than late season weedy growth. Therefore, early weed control is extremely important. Late weed growth may not seriously reduce yields, but it makes harvesting difficult, reduces crop quality, and reinfests the land with seeds and harbors insects and diseases. In planning a control programme, it is important to know the weed's life cycle. If it is possible to interrupt the cycle it becomes very effective control. In crop production, this may be a shift in planting date or a well-timed chemical spray; thus the crop gets the upper hand or competitive advantage. Smothering with plastics, tar, paper, straw, saw dust or any other similar material is largely a matter of competition for light. Most weed seedlings cannot penetrate the thick coverings and die because of lack of light.

Crop rotation: Certain weeds are more common in some crops than in others. Besides the annual weeds, for the parasitic weeds, such as striga in sorghum and orbanche in tobacco, the hosts are the crop species grown. Rotation of crops is an efficient way to reduce weed growth. A good rotation for weed control usually includes strong competitive crops grown in each part of the rotation. In growing mixed crops as in the tropics; the weed problem is eliminated to a greater extent in most of the irrigated crops.

Biological control: In biological weed control, a 'natural enemy' of the plant is used which is harmless to desired plants. Insects or diseases organisms are the usual natural enemies. Also parasitic plants, selective grazing by livestock, and highly competitive

replacement plants are other forms of biological control. The outstanding example of biological weed control is the one on Cactus (*Opuntia spp*.) with a moth borer *Cactoblastic cactorum* and or *Lantana camara* with several kinds of caterpillars and a fly, which damages the berries. Researchers have located and tested numerous biological agents against Parthenium weed. These include a gall forming moth, leaf minor, weevil, beetles and a rust fungus.

Invasion of IAS in Punjab

The some of the important invasive alien plants which one would notice in the state of Punjab are viz. *Lantana camara, Parthenium hystero-phorus, Ageratum conyzoides, Ricines communis, Eupatorium odoratum, Artemisia scoparia, Datura stramonium*, *Chenopodium ambrosioides, Cassia occidentalis* and *Bidens pilosa.* These are highly established invasive plant species in the shivalik hills of Punjab and Himachal Pradesh (Dogra *et al, 2009*). All Ramsar sites in the state are infested with the invasive weed *Eichhornia crassipes*. However, in Punjab alien plant like *Lantana camara, Parthenium hysterophorus, Ageratum conyzoides* and *Eichhornia crassipes* are the most problematic (Kohli *et al*. 2004). They have established themselves not only in the plains but also in hilly areas, particularly in the Himalayan ecosystems (Kohli et al. 2004). Vast areas in Shivalik are infested with these plants. Water hyacinth (*Eichhornia crassipes)* infestation in the wetlands and marshes of Punjab is threatening to such eco-system. This article covers these four invasive alien plant species.

Lantana camara

(Big Sage, Wild Sage, Red Sage, White Sage & Tickberry)

History : The forests of Punjab have been invaded by several exotic plants of which *Lantana camara*, stands out because of its rapid spread, intensity of

Ricinus communis

Chenopodium ambrosioides

Bidens pilosa

Cassia occidentalis

L. camara infestation

infestation, and tenacious resistance to cutting and burning. *Lantana* is a native of tropical America, and it was introduced into India in 1809 as an ornamental hedge in Calcutta's gardens. Since then, the species has spread rapidly into both farm and forest lands, and is one of the most widespread, terrestrial invasive species in India today.

Characteristics : *L. camara* is a low, erect or subscandent, vigorous shrub with 2-4 m ht. It is able to climb to 15m with support. Lantana flowers throughout the year having 20-40 flowers in a flower head. It produces enormous (number ranges from 10,000 to 12,000 per plant) fruits varying in size from 3 to 6 mm in diameter and contain 1–2 seeds that are dispersed to other areas through bird droppings or by goats and sheep or accidentally by even humans (Kohli et al 2004). These germinate quickly and form dense impenetrable thickets that can survive even after forest fires. Seed germination and suckering are stimulated by burning and slashing, both roots and shoots can coppice after cutting, browsing or herbicidal treatment.

Infestation and Impacts : *Lantana camara* have many negative impacts including potential to disrupt succession cycle, displacing native biota resulting in decreased biodiversity (Murali and Setty, 2001). Its infestations alter the structural and floral composition of native communities (Sharma and Raghubanshi, 2010). As the density of *Lantana camara* in forest increases, allelopathic interactions increase and hence there is decline in species richness (Day *et al.,* 2003). It is a major problem in agriculture lands in various regions of India including Punjab because once established the species forms dense and impenetrable thickets thereby outcompeting native pastures, blocking the movement of grazers in addition to causing poisoning. *Lantana camara* has numerous secondary impacts as it harbors serious pests such as malarial mosquitoes and tsetse flies, resulting in grave health issues. These alter fire regimes significantly by providing fuel load provided. The species has been implicated in destructive wildfire in various regions of India (Hiremath and Sundaram, 2005).

Control : Lantana (medium sized plant) can be controlled mechanically by stick racking, bulldozing, ploughing and grubbing. Hand cutting is also done but feasible for small areas. Chemical control is done when soil has good moisture and dusty active growing period by using chemicals namely fluoxypyr ortriclopyr and Grozon DS with post emergence application of glyphosate. In biological control measures it has been reported that *Teonesmia scrupulosa* (Heminptera) and sap-sucking bug are effective for controlling weed infestation. However, the biological control has not been effective due to extreme variability of plants. It is recommended to use biological, mechanical, cultural and chemical methods integrated way. The plant has medicinal properties, used as fire wood, mulch and as hedge. Stems after treatment can be used for producing paper, making basket and temporary shelters.

Parthenium hysterophorus

(Carrot weed, white top, congress grass, star weed)

History : The weed has spread throughout India after its noticeable occurrence in Pune (Maharashtra) in 1955. During the 1980s, *Parthenium* weed used to be considered a weed of fallow and wasteland but now it has become a weed of every crop and also into the forested land. It is an aggressive annual herbaceous plant native to the Tropical America. It is now widely distributed in a number of tropical and sub-tropical countries. The weed has achieved major weed status in India only within the last few decades. In Punjab, the weed is very common along with the road sides, around the agricultural fields and on waste lands.

Characteristics : *Parthenium hysterophous* is an annual herb, erect up to 2m in ht. Flower heads are

***Parthenium* plant with flowers**

creamy white and about 4 mm across arising from the leaf forks. It flowers profusely, producing abundant seeds (approx. 25,000 per plant) and forms an enormous seed bank in soil. Seeds, small and light, are easily disseminated by wind or water for quick colonization in uninvaded areas.

Infestation and Impacts : Its seeds germinate throughout the year (irrespective of photoperiod, temperature variations, or seasons) and, if moisture is favourable, form dense monocultural stands. It grows luxuriantly in the rainy season and in more humid areas and climates. Under water-stressed conditions, it remains a rosette and bolts with the onset of the rains or moisture. Further, it regenerates quickly from the root stumps or parts, even petioles or midribs left in the soil (Kohli and Rani 1994). *P. hysterophorus* is considered as a noxious weed because of its prolific seed production and fast spreading ability, allelopathic effect on other plants, strong competitiveness with crops and health hazard (allergic) to human as well as animals. Thus, degrades eco-system.

Control : Manual uprooting of Parthenium before flowering and seed setting is the most effective method. This is easily done when the soil is wet. It has been reported by Food and Agriculture Organization of the Unites States. Competitive that replacement of Parthenium can be achieved by planting species like *Cassia sericea, Croton bonplandianus* and *C. sparsiflorus, Amaranthus spinsosus, Sida acuta, Temphrosia purpurea, Stylosanthes scabra* and *Cassia auriculata*, which will complete with weed and reduce its population. In certain parts of India, crop rotation using marigold during rainy season, instead of the usual crop, is found effective in reducing Parthenium infestation is cultivated areas. Burning is not a useful control strategy for this plant. The large scale utilization of Parthenium may be one of the effective methods. Parthenium has been well documented for its insecticidal, nematicidal and herbicidal properties. It is also used for mulching and for producing biogas, paper and compost. A large number of chemicals have been tried. The use of glyphosate, atrazine, and metribuzin has been promising. The timing of chemical control is critical. Several insects and pathogens have been tried from time to time. The leaf-feeding beetle. Parthenium *Zygogramma bicolorata* is now widely used in India to control it .

***Ageratum conyzoides* plant**

Ageratum conyzoides

(Billy goat weed, Chicle weed, Goat weed, white weed)

History : This species is native to tropical America, now pantropical in distribution. As regards the mode and time of Ageratum entry into India, no information is available. However, it was known to exist in India well before 1882 as reported in 'The Flora of British India' (Hooker 1882). Furthermore, probably it was introduced as an ornamental plant and later it escaped and assumed a weedy habit, though no authentic report is available in this regard (Kohli *et al* 2006).

Characteristics : Annual herb up to 120 cm tall, flowers grouped on a terminal head. The flowers are tubular with white or blue petals. Within India, it is found throughout upto an altitude of 2000m., and in the Middle Andamans. It is found along plains as well

Eichhornia crassipes plant

as the ghats, it is commonly observed in waste places, roadsides, gardens, plantations and forest understoreys. Commonly it is called Billi goat weed. It is an aromatic invasive that quickly encroaches upon any given area. Ageratum possesses a number of ecological strategies such as fast growth rate, quick regenerative and reproductive potential, and greater tolerance/adaptability, helping it to form monocultural stands in the Shivalik Ranges of the north-western Himalayas.

Infestation and Impacts : The weed has spread extensively in the Shivalik of both Punjab and Himachal Pradesh occupying various habitats (forests, plantations, agriculture fields, wastelands, grassland) and now greatly affects the landscape (Kohli *et al.,* 2004).

Control : Ageratum becomes troublesome in plantations after grasses have been suppressed. It can be controlled mechanically when young by hand pulling or hoeing. Seedling and young stages can be controlled by 2, 4-D, MCPA and other growth regulators that are used on cereal crops. However, it has some medicinal properties and else insect repellent also.

Eichhornia crassipes

(Water hycinath.....)

History : It is a native of Brazil and Equador region. It has spread to more than 50 countries on five continents. The plant originated in the Amazon Basin and was introduced into many parts of the world as an ornamental plant due to its beautiful flowers. It has invaded many areas and could now be found on almost all continents.

Characteristics : *Eichhornia crassipes* grows in all types of freshwaters. It is particularly suited to tropical and subtropical climates and has become a problem plant. The stems and leaves contain air-filled tissue which give the plant its considerable buoyancy. They vary in size from a few inches to over three feet tall. They have showy lavender flowers. Their leaves are rounded and leathery, attached to spongy and sometimes inflated stalks. The plant has dark feathery roots. The plant tolerates extremes in water level fluctuations, seasonal variations in flow velocity, nutrient availability, pH, temperature and toxic substances (Gopal, 1987).

Infestation and Impacts : Water hyacinth (Eichhornia crassipes) is an aquatic plant which can live and

Weevils on Water Hyacinth

reproduce floating freely on the surface of fresh waters. Its rate of proliferation under certain circumstances is extremely fast and it can spread to cause infestations over large areas of water causing a variety of problems. It grows in mats up to 2 metres thick which can reduce light and oxygen, change water chemistry, affect flora and fauna and cause significant increase in water loss due to evapotranspiration. It also causes practical problems for fishing and at intakes for hydro power and irrigation schemes. Therefore, it is now being considered as a serious threat to biodiversity.

Singh et al. (1984) reported that the daily average productivity of water hyacinth was 0.26 ton of dry biomass per hectare in all seasons. It also grows from seed which can remain viable for 20 years or longer.

Control : There are several popular control mechanisms for controlling the spread of, or eradication of, water hyacinth. The 3 main mechanisms used are biological, chemical and physical control. Each has its benefits and drawbacks. Chemical control is the least favoured due the unknown long-term effects on the environment. Biological control involves release of weevils (Eichornia) which eat the plant stem and controls its growth. but it is effective only in stagnant waters.

Management of Invansive Alien Plant species in Punjab : Initiatives & Suggestions

Use of Lantana Biomass:

Lantana is a biomass Resource abundantly available in Punjab , especially in Shivalik area.This can be used in Biomass power generation units. Deptt. of Forests & PEDA , with technical help of TERI are in process of installation of a unit based on Lantana for power generation as well as preparation of charcoal through pyrolysis. Lantana can also be used in biogas production. In addition, Lantana is being used for manufacture of furniture items by ATREE, Bangalore.

Biological Control of water hyacinth:

Water hyacinth invasion has been reported from all the wetlands of the state. At Harike, a large portion of the wetland is covered by water hyacinth which grows in standing water. Nearly 43.1 sq. km under marsh and swamps can be put into this class (PRSC, 1999). Remote sensing studies for both Ropar and Kanjli Wetland show vast presence of this invasive plant. Irrigation & Power Research Institute, Amritsar is releasing weevils to control its population. About 5 Acre ponded area has been cleared through use of weevils at Harike, Punjab.

Cleared Harike Wetland

Ever since these weeds became a menace in India, efforts are being made to manage these weeds by different methods. But so far, no single method has been proved satisfactory, as each method suffers from one or more limitations such as high cost, impracticability, environmental safety, temporary relief etc.

The precise management measures adopted for any plant invasion will depend upon factors such as the terrain, the cost and availability of labour, the severity of the infestation and the presence of other invasive species.

The best form of invasive species management is prevention. If prevention is no longer possible, it is best to treat the weed infestations when they are small to prevent them from establishing (early detection and rapid response). Controlling the weed before it seeds will reduce future problems. Control is generally best applied to the least infested areas before dense infestations are tackled. Consistent follow-up work is required for sustainable management.

Annexure 1: Prominent Invasive Alien Plants

Sl. No.	Species	Family	Habit	Nativity
1	Acacia farnesiana (L.) Willd.	Mimosacceae	Tree	Trop. South America
2	Acacia mearnsii De Wild.	Mimosacceae	Tree	South east Australia
3	Acanthospermum hispidum DC.	Asteraceae	Herb	Brazil
4	Aerva javanica (Burm.f.) Juss.ex Schult.	Amaranthaceae	Herb	Trop. America
5	Aeschynomene americana L.	Papilionaceae	Herb	Trop. America
6	Ageratina adenophora (Spreng.) King & Robinson	Asteraceae	Herb	Trop. America
7	Ageratum conyzoides L.	Asteraceae	Herb	Trop. America
8	Ageratum houstonianum Mill.	Asteraceae	Herb	Trop. America
9	Alternanthera paronychioides A. St. Hil	Amaranthaceae	Herb	Trop. America
10	Alternanthera philoxeroides (Mart.) Griseb.	Amaranthaceae	Herb	Trop. America
11	Alternanthera pungens Kunth	Amaranthaceae	Herb	Trop. America
12	Alternanthera tenella Colla	Amaranthaceae	Herb	Trop. America
13	Antigonon leptopus Hook. & Arn.	Polygonaceae	Climber	Trop. America
14	Argemone mexicana L.	Papaveraceae	Herb	Trop. Central & South America
15	Asclepias curassavica L.	Asclepiadaceae	Herb	Trop. America
16	Asphodelus tenuifolius Cav.	Liliaceae	Herb	Trop. America
17	Bidens pilosa L.	Asteraceae	Herb	Trop. America
18	Blainvillea acmella (L.) Philipson	Asteraceae	Herb	Trop. America
19	Blumea erianthaDC.	Asteraceae	Herb	Trop. America
20	Blumea lacera (Burm. f.) DC.	Asteraceae	Herb	Trop. America
21	Blumea obliqua (L.) Druce	Asteraceae	Herb	Trop. America
22	Borassus flabellifer L.	Asteraceae	Tree	Trop. Africa
23	Calotropis gigantea (L.) R.Br.	Asclepiadaceae	Shrub	Trop. Africa
24	Calotropis procera (Ait.) R. Br.	Asclepiadaceae	Shrub	Trop. Africa
25	Cardamine hirsuta L.	Brassicaceae	Herb	Trop. America
26	Cardamine trichocarpa Hochst. ex A. Rich.	Brassicaceae	Herb	Trop. America
27	Cassia absus L.	Caesalpiniaceae	Herb	Trop. America
28	Cassia alata L.	Caesalpiniaceae	Shrub	West Indies
29	Cassia hirsuta L.	Caesalpiniaceae	Herb	Trop. America
30	Cassia obtusifolia L.	Caesalpiniaceae	Herb	Trop. America
31	Cassia occidentalis L.	Caesalpiniaceae	Herb	Trop. South America
32	Cassia pumila Lam.	Caesalpiniaceae	Herb	Trop. America
33	Cassia rotundifolia Pers.	Caesalpiniaceae	Herb	Trop. South America
34	Cassia tora L.	Caesalpiniaceae	Herb	Trop. South America
35	Cassia uniflora Mill.	Caesalpiniaceae	Herb	Trop. South America
36	Catharanthus pusillus (Murray) Don	Apocynaceae	Herb	Trop. America
37	Celosia argentea L.	Amaranthaceae	Herb	Trop. Africa
38	Chamaesyce hirta (L.) Millsp.	Euphorbiaceae	Herb	Trop. America
39	Chamaesyce indica (Lam.) Croizat	Euphorbiaceae	Herb	Trop. South America
40	Chloris barbata Sw.	Poaceae	Herb	Trop. America
41	Chromolaena odorata (L.) King & Robinson	Asteraceae	Herb	Trop. America
42	Chrozophora rottleri (Geis.) Spreng.	Euphorbiaceae	Herb	Trop. Africa

Sl. No.	Species	Family	Habit	Nativity
43	Cleome gynandra L.	Cleomaceae	Herb	Trop. America
44	Cleome monophylla L.	Cleomaceae	Herb	Trop. Africa
45	Cleome rutidosperma DC.	Cleomaceae	Herb	Trop. America
46	Cleome viscosa L.	Cleomaceae	Herb	Trop. America
47	Clidemia hirta (L.) D. Don	Melastomataceae	Herb	Trop. America
48	Conyza bipinnatifida Wall.	Asteraceae	Herb	Trop. America
49	Corchorus aestuans L.	Tiliaceae	Herb	Trop. America
50	Corchorus fascicularis Lam.	Tiliaceae	Herb	Trop. America
51	Corchorus tridens L.	Tiliaceae	Herb	Trop. Africa
52	Corchorus trilocularis L.	Tiliaceae	Herb	Trop. Africa
53	Crassocephalum crepidioides (Benth) Moore	Asteraceae	Herb	Trop. America
54	Crotalaria pallida Dryand	Papilionaceae	Herb	Trop. America
55	Crotalaria retusa L.	Papilionaceae	Herb	Trop. America
56	Croton bonplandianum Boil.	Euphorbiaceae	Herb	Temperate South America
57	Cryptostegia grandiflora R.Br.	Asclepiadaceae	Herb	Madagascar
58	Cuscuta chinensis Lam.	Cuscutaceae	Herb	Mediterranean
59	Cuscuta reflexa Roxb.	Cuscutaceae	Herb	Mediterranean
60	Cyperus difformis L.	Cyperaceae	Herb	Trop. America
61	Cyperus iria L.	Cyperaceae	Herb	Trop. America
62	Cytisus scoparius (L.) Link	Papilionaceae	Herb	Europe
63	Datura innoxia Mill.	Solanaceae	Shrub	Trop. America
64	Datura metel L.	Solanaceae	Shrub	Trop. America
65	Dicoma tomentosa Cass.	Asteraceae	Herb	Trop. Africa
66	Digera muricata (L.) Mart.	Amaranthaceae	Herb	SW Asia
67	Dinebra retroflexa (Vahl) Panz.	Poaceae	Herb	Trop. America
68	Echinochloa colona (L.) Link	Poaceae	Herb	Trop. South America
69	Echinochloa crusgalli (L.) Beauv.	Poaceae	Herb	Trop. South America
70	Echinops echinatus Roxb.	Asteraceae	Herb	Afghanistan
71	Eclipta prostrata (L.) Mant.	Asteraceae	Herb	Trop. America
72	Eichhornia crassipes (C. Martius) Solms-Loub.	Pontederiaceae	Herb	Trop. America
73	Emilia sonchifolia (L.) DC.	Asteraceae	Herb	Trop. America
74	Euphorbia cyathophora Murray	Euphorbiaceae	Herb	Trop. America
75	Euphorbia heterophylla L.	Convolvulaceae	Herb	Trop. America
76	Evolvulus nummularius (L.) L.	Convolvulaceae	Herb	Trop. America
77	Flaveria trinervia (Spreng.) C. Mohr.	Asteraceae	Herb	Trop. Central America
78	Fuirena ciliaris (L.) Roxb.	Cyperaceae	Herb	Trop. America
79	Galinosoga parviflora Cav.	Asteraceae	Herb	Trop. America
80	Glossocardia bosvallea (L.f.) DC.	Asteraceae	Herb	East Indies
81	Gnaphalium coarctatum Willd.	Asteraceae	Herb	Trop. America
82	Gnaphalium pensylvanicum Willd.	Asteraceae	Herb	Trop. America
83	Gnaphalium polycaulon Pers.	Asteraceae	Herb	Trop. America
84	Gomphrena serrata L.	Amaranthaceae	Herb	Trop. America
85	Grangea maderaspatana (L.) Poir.	Asteraceae	Herb	Trop. South America

Sl. No.	Species	Family	Habit	Nativity
86	Hyptis suaveolens (L.) Poit.	Lamiaceae	Herb	Trop. America
87	Impatiens balsamina L.	Balsaminaceae	Herb	Trop. America
88	Imperata cylindrica (L.) Raensch.	Poaceae	Herb	Trop. America
89	Indigofera astragalina DC.	Papilionaceae	Herb	Trop. America
90	Indigofera glandulosa Roxb. ex Willd.	Papilionaceae	Herb	Trop. America
91	Indigofera linifolia (L.f.) Retz.	Papilionaceae	Herb	Trop. South America
92	Indigofera linnaei Ali	Papilionaceae	Herb	Trop. Africa
93	Indigofera trita L.f.	Papilionaceae	Shrub	Trop. Africa
94	Ipomoea carnea Jacq.	Convolvulaceae	Shrub	Trop. America
95	Ipomoea eriocarpa R.Br.	Convolvulaceae	Herb	Trop. Africa
96	Ipomoea hederifolia L.	Convolvulaceae	Herb	Trop. America
97	Ipomoea obscura (L.) Ker.-Gawl.	Convolvulaceae	Herb	Trop. Africa
98	Ipomoea pes-tigridis L.	Convolvulaceae	Herb	Trop. East Africa
99	Ipomoea quamoclit L.	Convolvulaceae	Herb	Trop. America
100	Ipomoea staphylina Roem. & Schult.	Convolvulaceae	Herb	Trop. Africa
101	Lagascea mollis Cav.	Asteraceae	Herb	Trop. Central America
102	Lantana camara L.	Verbenaceae	Herb	Trop. America
103	Leonotis nepetiifolia (L.) R.Br.	Lamiaceae	Herb	Trop. Africa
104	Leucaena leucocephala (Lam.) de Wit	Mimosacceae	Herb	Trop. America
105	Ludwigia adscendens (L.) Hara	Onagraceae	Herb	Trop. America
106	Ludwigia octovalvis (Jacq.) Raven	Onagraceae	Herb	Trop. Africa
107	Ludwigia perennis L.	Onagraceae	Herb	Trop. Africa
108	Macroptilium atropupureum (DC.) Urban	Papilionaceae	Climber	Trop. America
109	Macroptilium lathyroides (L.) Urban	Papilionaceae	Climber	Trop. Central America
110	Malachra capitata (L.) L.	Malvaceae	Herb	Trop. America
111	Malvastrum coromandelianum (L.) Garcke	Malvaceae	Herb	Trop. America
112	Martynia annua (Houstoun in Martyn) L.	Pedaliaceae	Herb	Trop. America
113	Mecardonia procumbens (Mill.) Small	Scrophulariaceae	Herb	Trop. North America
114	Melilotus alba Desv.	Papilionaceae	Herb	Europe
115	Melochia corchorifolia L.	Sterculiaceae	Herb	Trop. America
116	Merremia aegyptia (L.) Urban.	Convolvulaceae	Herb	Trop. America
117	Mikania micrantha Kunth	Asteraceae	Climber	Trop. America
118	Mimosa pigra L.	Mimosacceae	Shrub	Trop. North America
119	Mimosa pudica L.	Mimosacceae	Herb	Brazil
120	Mirabilis jalapa L.	Nyctaginaceae	Herb	Peru
121	Monochoria vaginalis (Burm.f.) C. Presl.	Pontederiaceae	Herb	Trop. America
122	Nicotiana plumbaginifolia Viv.	Solanaceae	Herb	Trop. America
123	Ocimum americanum L.	Lamiaceae	Herb	Trop. America
124	Opuntia stricta (Haw.) Haw.	Cactaceae	Herb	Trop. America
125	Oxalis corniculata L.	Oxalidaceae	Herb	Europe
126	Parthenium hysterophorus L.	Asteraceae	Herb	Trop. North America
127	Passiflora foetida L.	Passifloraceae	Herb	Trop. South America
128	Pedalium murex L.	Pedaliaceae	Herb	Trop. America
129	Pennisetum purpureum Schum.	Poaceae	Herb	Trop. America

Sl. No.	Species	Family	Habit	Nativity
130	Peperomia pellucida (L.) Kunth	Piperaceae	Herb	Trop. South America
131	Peristrophe paniculata (Forssk.) Brummitt	Acanthaceae	Herb	Trop. America
132	Phyllanthus tenellus Roxb.	Euphorbiaceae	Herb	Mascarene Islands
133	Physalis angulata L.	Solanaceae	Herb	Trop. America
134	Physalis pruinosa L.	Solanaceae	Herb	Trop. America
135	Pilea microphylla (L.) Liebm.	Urticaceae	Herb	Trop. South America
136	Pistia stratiotes L.	Araceae	Herb	Trop. America
137	Portulaca oleracea L.	Portulacaceae	Herb	Trop. South America
138	Portulaca quadrifida L.	Portulacaceae	Herb	Trop. America
139	Prosopis juliflora (Sw.) DC.	Mimosacceae	Shrub	Mexico
140	Rhynchelytrum repens (Willd.) C.E. Hubb.	Poaceae	Herb	Trop. America
141	Rorippa dubia (Pers.) Hara	Brassicaceae	Herb	Trop. America
142	Ruellia tuberosa L.	Acanthaceae	Herb	Trop. America
143	Saccharum spontaneum L.	Poaceae	Herb	Trop. West Asia
144	Salvinia molesta D. S. Mitch.	Salviniaceae	Herb	Brazil
145	Scoparia dulcis L.	Scrophulariaceae	Herb	Trop. America
146	Sesbania bispinosa (Jacq.) Wight	Papilionaceae	Shrub	Trop. America
147	Sida acuta Burm.f.	Malvaceae	Herb	Trop. America
148	Solanum americanum Mill.	Solanaceae	Herb	Trop. America
149	Solanum seaforthianum Andrews	Solanaceae	Climber	Brazil
150	Solanum torvum Sw.	Solanaceae	Shrub	West Indies
151	Solanum viarum Dunal	Solanaceae	Herb	Trop. America
152	Sonchus asper Hill	Asteraceae	Herb	Mediterranean
153	Sonchus oleraceus L.	Asteraceae	Herb	Mediterranean
154	Spermacoce hispida L.	Rubiaceae	Herb	Trop. America
155	Spilanthes radicans Jacq.	Asteraceae	Herb	Trop. South America
156	Stachytarpheta jamaicensis (L.) Vahl	Verbenaceae	Herb	Trop. America
157	Stachytarpheta urticaefolia (Salisb.)Sims	Verbenaceae	Herb	Trop. America
158	Stylosanthes hamata (L.) Taub.	Papilionaceae	Herb	Trop. America
159	Synadenium grantii Hook. f.	Euphorbiaceae	Shrub	Trop. America
160	Synedrella nodiflora (L.) Gaertn.	Asteraceae	Herb	West Indies
161	Torenia fournieri Linden ex E. Fournier	Scrophulariaceae	Herb	Australia
162	Tribulus lanuginosus L.	Zygophyllaceae	Herb	Trop. America
163	Tribulus terrestris L.	Zygophyllaceae	Herb	Trop. America
164	Tridax procumbens L.	Asteraceae	Herb	Trop. Central America
165	Triumfetta rhomboidea Jacq.	Tiliaceae	Herb	Trop. America
166	Turnera subulata J.E. Smith	Turneraceae	Herb	Trop. America
167	Turnera ulmifolia L.	Turneraceae	Herb	Trop. America
168	Typha angustata Bory. & Choub.	Typhaceae	Herb	Trop. America
169	Ulex europaeus L.	Papilionaceae	Shrub	Western Europe
170	Urena lobata L.	Malvaceae	Shrub	Trop. Africa
171	Waltheria indica L.	Sterculiaceae	Herb	Trop. America
172	Xanthium strumarium L.	Asteraceae	Herb	Trop. America
173	Youngia japonica (L.) DC.	Asteraceae	Herb	Trop. South America

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NEWS

EVENTS

2013 2nd International Conference on Biodiversity and Climate Change (ICBCC 2013)

17th to 18th November 2013

Venue: Abu Dhabi, United Arab Emirates

Website: http://www.icbcc.org/

Contact person: Mr Issac Lee

Organized by: CBEES

13 4th International Conference on Agriculture and Animal Science (CAAS 2013)

23rd to 24th November 2013

Venue: Phuket, Thailand

Website: http://www.cbees.org/caas/

Contact person: Ms Sophia Du

Organized by: CBEES

Conference of Natural Resources and Development

25th to 28th November 2013

Venue: Viña del Mar, Valparaíso, Chile

Website: http://confnrd2013.info/

Contact person: Daniela Serrano

Organized by: Center for Natural Resources and Development + UNEP

International Conference on Bio-Diversity 2013

16th to 17th December 2013

Venue: Colombo, Sri Lanka

Website: http://futureevents.org/biodiversity

Contact person: Prabhath Patabendi

Organized by: International Center for Research & Development (ICRD).

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NEWSLETTER

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