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RESEARCH ARTICLE

INVASIVE ALIEN SPECIES IN DISTRICT KATHUA (NORTH-WEST HIMALAYAS), JAMMU AND KASHMIR, INDIA

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ABSTRACT

A case of Jammu and Kashmir is one of threats to the biodiversity of region through the invasion of invasive alien species. Species which are either introduced or spread outside of their natural habitat may out-compete native species and sometimes become invasive and noxious weeds. Such species are designated as Invasive Alien Species (IAS). The study aimed to document the invasive alien species prevalent in the area along with their harmful effects. Most of the invasive alien weeds have naturally intruded into the area due to its geographical position in the vicinity of northern plains of India and have successfully colonized in most of the area. The invasive alien species studied over the period of time have been enlisted and described along with other relevant information. All the alien weeds seriously affect the native biodiversity. The severity of the problem demands appropriate eradication measures.

INTRODUCTION

Humans have been transporting plants from one part of the earth to another for thousands of years, sometimes deliberately for social or personal gains and sometimes unintentionally. In most cases, such introductions are unsuccessful, but if they establish in the natural or semi-natural ecosystems they may become invasive. The area of research is one of the Biodiversity hotspots in India including many endemic plant species. India accounts for 8 percent of the global biodiversity existing in only 2.4 percent area of the world. According to Nayar (1989) the number of flowering plant species endemic to India is 4900 out of a total of 15000, which in percentage is 33%. The whole Himalayan belt is a mega-hotspot having 8 critical areas including Jammu and Kashmir. The biodiversity of Jammu and Kashmir has been subjected to degradation due to a number of reasons. One of the threats to the biodiversity of the region is the invasion of invasive alien species. Species which are either introduced or spread outside of their natural habitat may out-compete native species and sometimes become invasive and noxious weeds causing huge economic loss or damage to the biodiversity of the region. Such species are designated as Invasive Alien Species (IAS). United Nations General Assembly at its 65th session declared the period 2011-2020 to be “ the United Nations Decade on Biodiversity” with a view to contribute to the implementation of the Strategic Plan for Biodiversity.

United Nations Convention on Biodiversity, adopted in 1992, binds all the 191 nations who were parties to the convention to prevent the introduction, promote control and eradicate those alien species which threaten ecosystems, habitat or species. Throughout the ‘United Nations Decade on Biodiversity’ governments are encouraged to document status survey of biodiversity for its overall conservation at regional, national and international level. However, in parts of Asia the issue of invasive alien species has low profile attention and priority due to a number of other priority concerns of socio-economic and political nature. Raising awareness and providing up-to-date scientific information is an essential requirement to achieve the global 2020 biodiversity targets. The aim of the study is to document the invasive alien species prevalent in the region, to determine their dispersal mechanisms, impact on biodiversity and control and eradication measures undertaken and to be needed to mitigate the losses. The present study in part will support the implementation of the Strategic Plan for Conservation of Biodiversity.

MATERIALS AND METHODS

The study followed a random sampling method so that no bias is introduced. The survey areas were divided into every Tehsil of the district for the ease and exhaustive sampling during the work. The author has conducted many random field trips in different villages of the research area. Each study unit was sub-divided into different land use types such as agricultural fields, forest areas, orchards, grasslands waste lands, disturbed areas and wet land. The various localities visited for the sampling include Ramkote, Dinga-amb, Billawar, Machhedi, Malhar, Bani, Basohli, Mahanpur, Hiranagar, Marheen and Nagri.

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The units selected for the study were revisited many times of the year to record every stage of the species concerned like flowering, fruiting, seed dispersal etc. The samples were collected, systematically pressed and stored for identification. The plant specimens were identified by applying taxonomic keys and reference to the local floras. The identification was also facilitated by way of consultations with experts in the field of taxonomy and final confirmation was done by visiting to the local herbaria. Online identification system and ISSG database were also used to identify and determine the alien origin of species. The common names of the plants were ascertained by way of investigations from the elderly men in the vicinity. The information gathered by way of questioning to the farmers and native men was cross verified and then recorded. The equipments, tools and other related material employed in the study include microscope, dissection microscope, camera lucida, magnifying lens, plant press, cutters, Photographic camera, field note-book and polythene bags. The plant specimens were also photographed in their wild state in the ecosystems of their occurrence. The plant specimens and photographs of species explored during the course of study were handed over and kept for record in nearest concerned institution. The survey and data collection on the invasive alien species of Kathua district was carried out from 2014 to 2016. Studies on various aspects of the problem like origin, impact, toxicity levels and invasiveness of species were done and have been discussed.

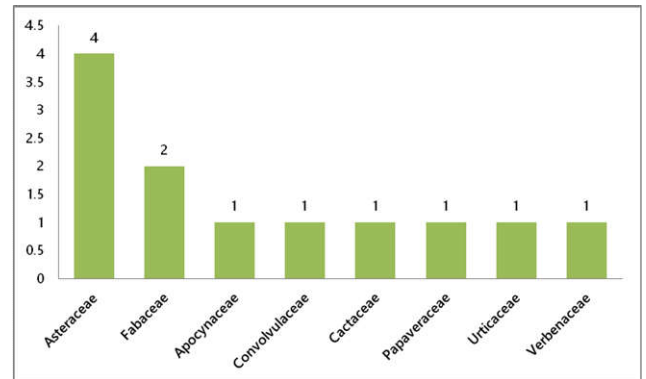


Fig 2. Dominant families of Invasive Alien Species (IAS) present in district Kathua

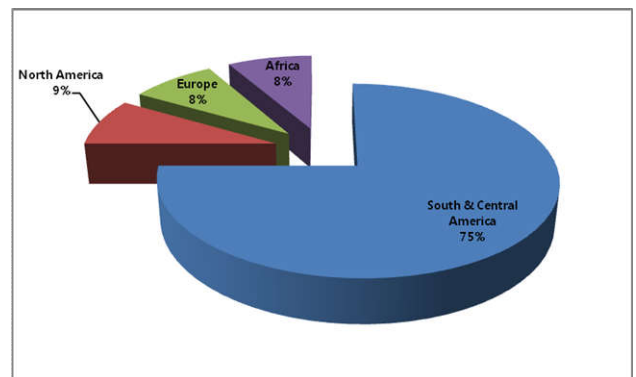


Fig. 3. Native Range of the invasive alien species (IAS) of district Kathua

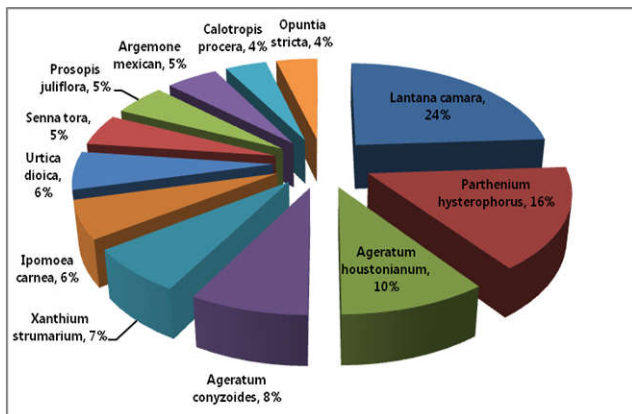


Fig-1 Dominant Invasive Alien Species (IAS) present in district Kathua

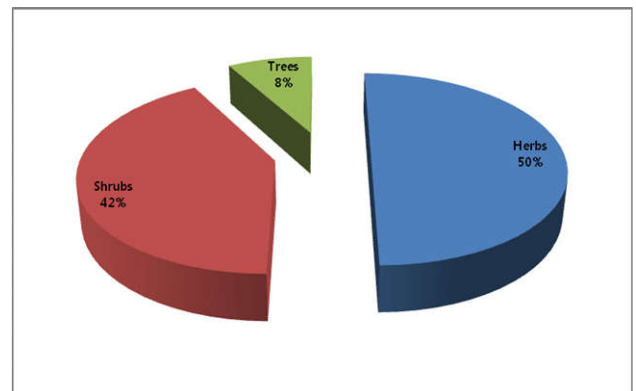


Fig. 4. Predominant life-forms of Invasive Alien Species (IAS) present in district Kathua

STUDY AREA

Kathua district is situated at the southern end of Jammu and Kashmir. It is also referred as the “Gateway of Jammu and Kashmir”. The geographical location of the district is between 32° 17' to 32° 55' north latitude and 75° 70' to 76° 16' east longitude at an altitude of 311 m above sea level. The total geographical area of the district is 2651 Sq. Kms. It shares its boundaries with Gurdaspur district of Punjab in the south-east, Chamba district of Himachal Pradesh in the north-east, district Doda and Udhampur in the north and north-east, district Samba in the west and Pakistan in the south-west. It has been divided into 19 development blocks, 11 tehsils and 512 villages. Physiographically district Kathua is divided into two regions- foothill plains and the mountainous Himalayan region. The southern and south-western area lies in the foothill plains with an elevation of 280-500 m above sea level. This track which is an extension of the Punjab plains is occupied by Kathua, Nagri, Mahreen and Hiranagar tehsils. The northern and north-eastern region of the district is hilly and mountainous.

Siwalik Hills are situated north of the foothill plains. The Middle-Himalayas rise to the north of the Siwalik Hills. Both the outer and Middle-Himalayan ranges are almost parallel to each other with a north-east trend. This region is dotted by many small valleys. Seven tehsils of the district- Billawar, Malhar, Mahanpur, Ramkote, Dinga-amb, Basohli and Bani lie in this Himalayan region. The lush green meadows, steep slopes, gushing streams, evergreen conifer forests and snow-clad mountains impart natural beauty to this area. Bani is a small glaciated valley situated at a height of 4162 m in the lap of lofty mountains. The meadows of Sarthal are famous for their enchanting beauty which is an attraction to the local and outside tourists. Banjal is a well known for its beautiful blooms of Rhododendron and many other wild flowering plants. It is also known as Garden of Natural Flowers.



Fig. 5. Invasive Alien Species (IAS) present in different ecosystems of the study area

Chhatargalla is the only pass connecting Bani with Bhaderwah in the Doda district. The Himalayan region of the district abounds rich biodiversity in its flora and fauna. The entire region is drained by many ephemeral and small perennial streams including the mighty Ravi which forms a natural boundary with Punjab and Himachal Pradesh in the east and north-eastern sides. Ravi springs arise at the junction of Dhauladhar and Lahul mountain ranges at an altitude of 4877 m in Himachal Pradesh. The length of this river from its source to junction with Chenab is 1014 Kms. The Ujh river traverses through Rajbagh towards the west of Kathua. Its source lies in the Basantgarh area of district Udhampur at an altitude of 3962 m. It flows through a hilly terrain for about 80 Kms before it traverses the foothill plains. There is much diversification in the climate due to the variation of altitude in the area. The foothill plains experience the tropical heat of summer with mercury rising up to 48°C. June is the hottest month of the year. The summer is comparatively mild in the highlands. The general climate of the region is significantly influenced by the advent of north-west monsoons from July to mid September which cause moderate to heavy rainfall in the

entire region. The winter is cool with temperature falling down as low as sub zero in the hills. The western disturbance which arises in the Mediterranean Sea significantly influences the weather conditions of the season. It causes a moderate rainfall in the foothill plains and the Siwalik Hills but there is a moderate to heavy snowfall in the higher reaches of Bani, Malhar and Billawar. January is the coldest month of the year. The average annual rainfall in the district is about 1672 mm.

RESULTS AND DISCUSSION

A total of 12 invasive alien species (IAS) belonging to 8 families of angiosperms present in district Kathua of Jammu and Kashmir State have been documented. They were found growing under different habitat such as forest land, grass land, fallow land, waste land and agricultural areas. The habit, morphology, dispersal mechanisms and the impacts of invasive alien species on the native biodiversity besides agriculture and the people were observed, analyzed and recorded. Out of 12 invasive alien species recorded in the study area 9 have their origin in the Tropical America, one

each in Europe, Africa and North America. All the 12 invasive alien species are discussed as under:

Ageratum conyzoides Linn.

Common Name: Billy goat Weed, White Weed.

Family: Asteraceae.

Native Range: South and Central America.

Description: An erect, softly hairy, annual herb with rank smell, stem 10-50 cm tall. Leaves ovate, crenate, cordate or cuneate, lamina 4-5 cm long. Heads pale-blue or pinkish purple or white, 6-10 mm in diam., in dense, terminal corymbs. Involucral bracts narrowly linear, ribbed, scarious margined, glabrous. Achenes black, hairy along the angles, pappus hairs concave below.

Dispersal: Propagation occurs through seeds which are easily blown by wind to long distances.

Impact: An aggressive invader of agricultural land, grassland, forestland, orchards, fallow land and by virtue of competition, habitat destruction and allelopathy it reduces the native plant diversity. The toxicity of weed results in liver lesions and tumors.

Prevention and Control: (i) Due to the shallow rooted habit the weed is relatively easy to uproot and control by using mechanical means rather than hand-picking. (ii) It is susceptible to a wide range of standard herbicides like butachlor, 2, 4-D, bentazone, oxidiazon, ametryne, terbutryne and acetochlor.

Parthenium hysterophorus Linn.

Common Name: Congress grass.

Family: Asteraceae.

Native Range: Tropical North America.

Description: An annual herb, stem 50-150 cm tall, rigid, branched, whitish hairy, longitudinally grooved. Leaves simple, pinnately and irregularly much dissected, alternate, forming rosette in younger plants, dissected tips acute, entire. Heads axillary and terminal, whitish with minute or hairy involucre bracts, 4-5 mm across, heterogametic, ray florets usually 5, fertile, disc florets 50 or more. Achenes ellipsoid-obovate and dark brittle.

Dispersal: The propagation of weed takes place through seeds formed in large numbers, about 10,000-15,000 per plant with high longevity and dispersed by different agencies like wind, water, birds and vehicles.

Impact: A noxious, allelopathic invasive weed of crops, forest land, grass land, fallow land, wasteland, roadsides disrupting natural ecosystems by replacing native species and also drastically reduces crop yields. It is toxic to cattle and humans causing dermatitis, respiratory disorders and occasional death.

Prevention and Control: (i) Hand picking of weed is not advisable due to allergic effects. (ii) Eucalyptus oil is used as a

natural herbicide. It is susceptible to the standard broad leaved herbicides like 2, 4-D, dicamba, glyphosate, atrazine, S-metolachlor.

Argemone mexicana L.

Common Name: Mexican Poppy.

Family: Papaveraceae.

Native Range: Tropical South America.

Description: A prickly, annual herb, 60-100 cm tall. Stem branched, glaucous, bluish-green, yellow sap, glabrous. Leaves alternate, semi-amplexical, simple, lobed, sinuate-pinnatifid, variegated, lamina 10-20 cm long, veins white, spinous. Flowers solitary-terminal, 2.5-5 cm in diam., sessile or subsessile, calyx 3, prickly, corolla yellow, petals 4-6, free, caducous, stamens 13 or more, free. Ovary 1-celled, stigma sessile. Capsule ellipsoid, 2-4 cm long, prickly, 4-6 valves. Seeds 300-400, globose, netted, brownish-black.

Dispersal: The propagation of weed occurs through seeds which are dispersed through water, animals and human activities.

Impact: It is widely distributed in arable land, cereal crops, grassland, wasteland, pastures, fallow land and roadsides. A dense crowding and allelopathy results reduced native species diversity. Seeds are highly toxic which through unintentional or intentional adulteration of vegetable oil cause epidemic dropsy.

Prevention and Control: (i) The uprooting of seedlings reduces infestation. (ii) A light tillage of the affected land at the seedling stage controls the aggressive colonization of weed. (iii) It is susceptible to a wide range of standard herbicides like picloram, butachlor, 2, 4-D, dicamba, diuron and terbutryne.

Lantana camara L.

Family: Verbenaceae.

Common Name: Lantana, Tick berry.

Native Range: Central and South America.

Description: An aromatic straggling, gregarious shrub, branches prickly, 4-angled, densely interlaced into large impenetrable thickets. Leaves rugose, scabrid with rough hairs, ovate or ovate-oblong, 3-10 by 3-6 cm, base cordate, cuneate or rounded. Flowers variable, yellow or orange-red. Fruit black and shining.

Dispersal: The propagation of weed occurs through seeds which are dispersed by birds to long distances. Vegetative propagation through axillary shoots also takes place.

Impact: It is an aggressive invasive colonizer of grassland, field margins, forest edges, often forming permanent thickets and excludes native plant species. It is also toxic to cattle.

Prevention and Control: It is susceptible to broad-leaved standard herbicides. Often cleared areas are rapidly colonized

through root sprouting or seed. A combination of mechanical and chemical treatment is more effective to control this weed.

Ageratum houstonianum Mill.

Common Name: Blue Weed, Mexican Paint Brush.

Family: Asteraceae.

Native Range: Central America.

Description: An annual, hairy herb, 15-60 cm long, erect or decumbent, stem reddish to green, pubescent. Leaves ovate to deltoid, lower opposite, upper alternate, hairy, lamina 3-6 by 2-4 cm, crenate-serrate. Heads homogametic, in terminal corymbs, 5-8 mm across, several disc florets only, ray florets absent, corolla 5, tubular, lavender blue, pink, lilac or white. Involucral bracts stipitate glandular on outer surface. Achenes hairy, pappus scales 5, white.

Dispersal: Propagation occurs through seeds dispersed by different agencies like wind, water, animals and vehicles.

Impact: An allelopathic invasive weed which usually grows in dense patches in grass land, agricultural land, forestland, fallow land with negative impacts on local biodiversity and also agriculture.

Prevention and Control: (i) Hand picking of weed is not advisable due to allergic effects. (ii) A 20% solution of common salt can be safely used in non-cropping areas. (iii) It is susceptible to the standard broad leaved herbicides like 2, 4-D, dicamba, metsulfuron-methyl. Diphenamid application to the soil also reduces the growth of the species.

Urtica dioica L.

Common Name: Stinging Nettle, European Nettle.

Native Range: Europe.

Description: A stinging herbaceous perennial, 80-175 cm. Stem robust, upright, grooved, pubescent, fibrous arising from basal rhizomes. Leaves simple, opposite, 5-10 cm, lower ovate, upper lanceolate, base cordate, acuminate, coarsely serrate, petiolate, stipules free, four at each node, 1-2 mm wide, lamina with conspicuous stinging hairs at least on the upper surface, non-stinging hairs relatively coarse and sparse. Inflorescences axillary, spike-like, four per node, many-flowered, flowers small, greenish, unisexual, male and female flowers are found on separate plants, flowers tiny, greenish, male with four perianth segments and four stamens, ovary unilocular, stigma tufted. Fruits single seeded achenes, flattened, encircled by persistent perianth.

Dispersal: Propagation takes place through underground rhizomes and seeds formed in large numbers. Seeds are dispersed through wind, water and animals.

Impact: An invasive weed generally seen in places like wasteland, fallow land, grassland, forest fringes, orchards, roadsides, often forming monospecific stands and by virtue of competition and aggressive invasion restricts or prevents the growth of many native species. The stinging trichomes cause

irritation, pain and burning sensation related health problems in humans and animals.

Prevention and Control: The control and eradication of stinging nettle is difficult due to stinging leaves and a large root mass. (i) It can be controlled to some extent by repeated tillage and cultivation of the infested area. Repeated cutting also prevents monospecific stand formation. (ii) Repeated herbicide treatment by using picloram, 2, 4-D, clopyralid, triclopyr and dicamba. (iv) Biocontrol by using natural pests and pathogens like *Eupateryx urticae*, *Liocoris tripustulatus*, *Dasinura urticae* and *Trioza urticae* need to be examined.

Opuntia Stricta (Haw.) Haw. var. stricta

Family: Cactaceae.

Common Name: Common prickly pear.

Native Range: South America.

Description: An erect or sprawling, succulent, perennial, shrub, 2-3 m, stem branched from base. Cladodes green to bluish-green, flattened, obovate, 10-25 cm by 7-10 cm, glabrous, areoles scattered bearing tiny glochids and spines. Spines yellowish, stout, curved, 2-4 cm long, arise from areoles. Leaves dark brown, about 5 mm long, slightly recurved, caducous. Flowers yellow arise from the margins of cladodes, 5-6 cm in diam., epigynous, perianth 12, free, yellow, outside red or pinkish, stamens many, free. Fruit a berry, obovoid, succulent, 4-8 cm long, covered with glochids, deeply depressed at apex, reddish when ripe, purplish or reddish pulp containing several seeds.

Dispersal: The pulpy fruits are eaten and dispersed by birds and mammals. Clonal propagation occurs through dislodged cladodes.

Impact: Often forms dense stands in open land, grassland, fallow land, wasteland in arid and semi-arid areas. The weed infestation increases pressure on pastures and grasslands. It has negative impacts on biodiversity besides agriculture, forestry, animal husbandry, humans, aesthetics and recreation.

Prevention and Control: (i) Difficult to control through physical and even mechanical methods. Isolated plants are cleared physically. (ii) Many herbicides are effective against this cactus but the treatment proves very costly. (ii) Biocontrol by involving insect pests like cactus moth *Cactoblastis cactorum* and the cochineal *Dactylopius opuntiae* seem more promising.

Prosopis juliflora (Sw.) DC.

Common Name: Southwest thorn, Mesquite.

Family: Fabaceae.

Native Range: South America and Mexico.

Description: A deciduous tree or shrub, 3-12 m tall, bark brownish, fissured in long vertical stripes, main branches crooked, young zigzag, more or less flat topped canopy, spines axillary, paired, rarely absent, straight, divergent, 1-4 cm long. Leaves bipinnate, pinnae 1-3 pairs, 4-18 cm long, leaflets elliptic-oblong, emarginate or obtuse, up to 29 pairs. Flowers

in axillary racemes, cylindric, 7-15 cm long, solitary or 2-4, florets pale to greenish yellow, sessile, densely clustered, mildly fragrant and visited by bees. Fruit- compressed legume, 10-25 cm long, curved straw yellow, endocarp segments up to 25. Seeds oval, brown.

Dispersal: Propagation occurs through seeds which are dispersed by different agencies like animals, humans and even water.

Impact: An aggressive colonizer adapted to a wide range of soils and seen growing in grasslands, fallow lands, forest lands, disturbed lands where it often forms dense thorny thickets and edges out native tree species.

Prevention and Control: (i) It is difficult to control the weed through mechanical and chemical methods due to reintroduction and re-establishment of seeds. The widespread use of herbicides may have adverse effects on environment. (ii) Cultural control by hand clearance and burning of young seedlings prevents dense growth. (iii) The integrated control by using mechanical clearance coupled with herbicide treatment seems effective to curb the menace.

Ipomoea carnea (Mart. Ex Choisy) Austin.

Family: Convolvulaceae.

Common Name: Morning glory.

Native Range: Tropical America.

Description: A robust, perennial shrub, up to 3 m tall, erect or sub-erect, gregarious, diffuse, milky latex present in all parts, stem slender, woody, hollow, glabrous, light-brown in older parts. Leaves simple, alternate, petiolate, ovate, cordate, entire, acute, pubescent, 12-26 by 5-15 cm. Flowers purplish-pink, terminal cymes, trumpet like, 7-8 by 6-7 cm., sepals 5, free, petals 5, gamopetalous, funneliform, stamens 5. Capsule ovoid, 1.5 by 1.2 cm. Seeds black, densely silky with long and brownish hairs.

Dispersal: Propagation occurs through stem fragments and seeds which are dispersed through wind and water.

Impact: An invasive naturalized weed seen in thick patches in swamps, pools, ponds, ditches as well as on land where its dense growth coupled with allelopathic effects results in loss of aquatic habitat and disruption of ecosystems besides loss to local biodiversity.

Prevention and Control: (i) Both manual and mechanical removal is not effective in the aquatic environment. (ii) Although the weed is susceptible to the commonly used herbicides but their use is restricted in aquatic habitats due to the harmful effects on other organisms.

Calotropis procera (Willd.) R.Br.

Family: Apocynaceae.

Common Name: Apple of Sodom.

Native Range: Tropical Africa.

Description: An erect or sub erect, perennial, hoary shrub, 1-1.5 m in height. Stem branched, branches cylindrical, woody at the base, densely white tomentose, all parts containing milky latex. Leaves opposite-decussate, thick, ovate, ovate-oblong to elliptic, 6-18 by 4-12 cm, with several erect, cordate or amplexicaul, shortly acuminate, entire, white tomentose when young, later glabrescent, glaucous. Inflorescence in axillary and terminal umbellate cymes, flowers white, blotched with purple or purplish-pink, 2-2.5 cm diam., pedicel 1-3 cm long, peduncles stout, calyx 5, free, corolla 5, fused, twisted, corona staminal, stamens 5, fused with stigma forming gynostegium. Follicles turgid, 8-10 by 4-6 cm, sub-globose to obliquely ovoid, recurved. Seeds many, 6 mm long, pappus silky white.

Dispersal: Propagation occurs through seeds which are formed in large numbers and dispersed chiefly by wind. Also propagates through root suckers.

Impact: An invasive weed generally seen in dense thickets in poor and over-grazed areas like grassland, fallow land, open land, waste land and roadsides causing reduction in native species diversity through competition and habitat disruption. It is also toxic to humans and animals.

Prevention and Control: It is difficult to control due to the deep root system and succulent habit. The weed control involves (i) Uprooting the weed through mechanical methods. (ii) Use of herbicide foliar spray to the seedlings. Chemical control is only successful if the top of the roots is also removed.

Senna tora (L.) Roxb.

Family: Fabaceae.

Common Name: Sickle Senna.

Native Range: Tropical America.

Description: An erect, 30-75 cm tall, gregarious annual, unpleasant odour, branched. Leaves pinnately compound, alternate, leaflets usually in 3 pairs, obovate-oblong, 2-6 by 1-3.5 cm, obtuse, margins ciliate. A rod like gland is situated between each of the lowest two pairs of leaflets. Flowers about 1.2 cm long, pedicellate, axillary, 1 or 2, sepals 5, free, corolla of 5 petals, free, yellow. Fruit a legume, slender, falcate, 12-20 cm long, imperfectly septate between the seeds, brown. Seeds many, cylindric, obliquely truncate, brownish, shining.

Dispersal: Propagation occurs through seeds dispersed by water, animals, contaminant of agricultural produce and human activities.

Impact: An invasive gregarious weed of fallow land, waste land, grassland, forest land and agricultural crops where it out-competes the native species of the ecosystems.

Prevention and Control: (i) The uprooting of seedlings reduces infestation. The light tillage of the affected land at the seedling stage controls the aggressive colonization of weed. (ii) It is susceptible to a wide range of standard herbicides like picloram, butachlor, 2, 4-D, dicamba, diuron and terbutryne. (iii) Biological control by way of the introduction of seed bruchid *Sennius instabilis* seems useful. The fungal pathogens-

Pseudocercospora nigricans and *Pseudoperonospora cassiae* with herbicidal effects need to be employed.

Xanthium strumarium Linn.

Family: Asteraceae.

Common Name: Common Cocklebur.

Native Range: South America.

Description: A stout, unpleasant smelling, coarse annual up to 1.3 m tall with purple spotted stem. Leaves undulate, scabrid, 5-14 cm long and usually as broad, obscurely lobed, toothed. Heads green, males 6 mm diam., towards the top of inflorescence, female involucre with 2 enclosed apetalous flowers. Fruiting involucre ovoid, hard, 1.5-2 cm long, clothed with hooked prickles. Achenes black, 1.5 mm long, ribbed on the faces, topped with remains of styles.

Dispersal: Propagation occurs through seeds which remain viable up to 5 years. The spiny burs get attached to animals, human clothing and also dispersed by water.

Impact: An invasive weed of agricultural lands, grass lands, fallow lands, disturbed lands, open lands, usually seen in thick stands and often displaces native species besides drastically reducing soil fertility and crop yields. The glandular hairs on leaves and stem cause dermatitis and also considered poisonous to mammals.

Prevention and Control: (i) Cultivation of land reduces the invasiveness, adoption of zero tillage can reduce population because burs seldom germinate on the soil surface (ii) It is susceptible to most of broad-leaved herbicides like glyphosate, 2, 4-D, dicamba, paraquate and triazines etc. (iii) Biocontrol by using natural insect pests and fungal pathogens like *Puccinia xanthii* and *Alternaria helianthi* is useful to check the growing populations.

Conclusion

The invasive alien species have naturally intruded into the area due to its geographical position in the vicinity of northern plains of India. Majority of them have their origin in the countries of Tropical America. A significant impact of the invasive alien species is the widespread loss of habitat. The invasive alien weeds are aggressive invaders with the result they marginalize, out-compete and eliminate the native species from the ecosystems of their occurrence since the time immemorial. As such, invasive alien species are proving to be a great threat to the local biodiversity. Some of the invasive alien species have caused catastrophic effects on the native flora. The invasive alien species studied over the period of time have been listed and described along with the necessary information regarding their morphology, spread, toxic effects and impacts on other populations in the ecosystems of their occurrence, leaving much more scope for further investigations.

Most of the invasive alien weeds have successfully colonized in almost all the areas of the district. In the context of present study, all the invasive alien species listed there seriously affect the native biodiversity and have contributed significantly to drag the native species towards vulnerability with serious threats of extinction. Apart from biodiversity degradation, the

invasive alien weeds also exert serious negative impacts on agriculture, forestry and human health. There has been a lack of co-ordinated efforts to control and eradicate the invasive alien species from the area. The severity of the problem demands immediate collaborative efforts in a way to deal with the growing threat to biodiversity through a combination of preventive and control measures. One such way is to follow the conventional methods of cropping like crop competition and crop rotation which are the cheapest and most useful methods to curb the weed menace. Crop competition often means using the best crop production methods so favourable to the crop that weeds are crowded out. Early weed competition usually reduces crop yields more than late season weed growth. The alien weed control and eradication programmes need to focus on the issues like (i) Use of certified "Weed Free" seeds. (ii) Building management capacity (iii) Early detection and eradication (iv) Promote sharing of information (v) Promote biological control (vi) Use of safe herbicides, and (vi) Education and awareness.

Conflict of Interest

The author declares that there is no conflict of interest regarding the publication of this article. All the contents of this research article including observations, discussion, results, conclusion and figures are based on the original research work of the author.

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