INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 4, No. 1, p. 407-424, 2014

REVIEW PAPER OPEN ACCESS

Invasive flora of Pakistan: a critical analysis

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Key words: Invasive flora, Alien plants, Biological pollution, Biodiversity, Conservation.

http://dx.doi.org/10.12692/ijb/4.1.407-424 Article published on January 11, 2014

Abstract

Invasive species are mostly nonnative species introduced accidentally or intentionally by humans in natural or established habitat where they threat the environment, economy and/or health. Several thousands of the alien species have become established in different parts of the world over the past couple of centuries. This biological pollution is considered as second potential threat to natural biodiversity after habitat loss. Fortunately the magnitude of invasive species in Pakistan is not as great as in some other countries but unfortunately, there is deficit in context of invasion biology literature. Current effort intends to present a systematic review of sporadic studies undertaken in past to record invasive alien plant species on a small scale with prime goals of: establishing a preliminary inventory of reported invasive plants; analyze the family and life form contribution in total invasive flora; describe status, impacts, management approaches and world's perspective about worst terrestrial invasive plants in Pakistan.

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Introduction

Biological invasion is a form of biological pollution that is probably more disastrous than the chemical pollution (Khan *et al*., 2010) therefore considered as the second greatest global threat to biodiversity after habitat destruction (Reddy, 2008). Invasives are widely distributed in all kinds of ecosystems throughout the world including all categories of living organisms (Raghubanshi *et al*., 2005) nevertheless plants, mammals and insects comprise the most common types of invasives in terrestrial environments (Hoenicka and Fladung, 2006). The plants are considered one of the worst invaders in the world attributed to their huge biomass (Holm *et al*., 1991). Historically IAS (Invasive Alien Species) spread through exploration and colonization. Today two main invasion routes are: introduction by chance (unintentionally in shipping containers, lurking under the bark of log imports, infesting fruits carried by tourists, swimming in ballast water exchanged in a harbor, quietly reproducing in the intestines or bloodstream of an unsuspecting travelers, or hidden in soil of imported ornamental plants) and introduction by hand (intentional introduction of horticultural, medicinal, silvicultural or agricultural pants for economic purposes that escape from captivity). Some unwanted effects of these species may include increase in rate of soil erosion, reduced soil value, alteration in composition of natural flora and fauna, water bodies choking thus affecting quality of water and fish population, economic losses and risk to human health (Marwat *et al*., 2010), modification of hydrology, soil nutrient composition, forest fire cycle and other ecosystem processes (Dogra *et al*., 2010), reduction in agricultural yields, grazing areas, water availabilities and contribution to spread of vector born diseases (Etana, 2013).

Charles S. Elton's (1958) book "The ecology of invasions by animals and plants" is recognized as the starting point for focused scientific attention on biological invasions acclaimed variously as 'an accessible and enduring classic', the ' bible of invasion biology', 'a classic book', 'the cornerstone work in invasion ecology', an 'invasion classic', 'a magisterial book', 'one of the most forward-looking publications in ecology', a 'pioneering work' and a 'seminal work' (Richordson and Pysek, 2008). Worldwide significant numbers of ecological studies have so far conducted to conceptualize and quantify plant invasions. The impact of exotic invasive plants on native organisms is widely acknowledged but still poorly understood. Keeping in view the impact of invasive weeds on environment, article 8(h) of the Convention on Biological Diversity (CBD) signed by 161 countries at the Earth Summit in 1992; urges the parties to "prevent the introduction of, control, or eradicate those alien species which threaten ecosystem, habitat or species" and Pakistan being a member of CBD, has to play its role judiciously.

Invasive species: Key concepts

What the Term 'Invasive' Exactly Means?

There is considerable confusion to define "invasive". Terms exotic, introduced, alien naturalized and weed have broadly understood meanings and attempts to redefine the term in one word that are now considered partial to particular definition. Invasive alien species can be defined in one of several ways (a): Species establishing in wild beyond their natural distribution ranges following intentional or accidental transportation of whole plants or propagules by humans or human related activities (Arroyo *et al*., 2000) (b): Naturalized species capable of spreading considerably with harmful effects (Richardson *et al*., 2000) (c): An alien species which becomes established in natural or semi natural ecosystem or habitat and threatens native biological diversity" (IUCN, 2013) (d): Nonnative organisms that cause or have the potential to cause harm to the environment, economies, or human health" (GISP, 2013). There is an increasing general acceptance that IAS is sub set of naturalized organisms that has introduced as a result of human activity, deliberately or accidently and is recognized by its rate of spread and represent a threat to environment, economy and/or human health (Table 1).

What Makes 'Alien' An 'Invasive'?

Invasive plants are characterized to be long lived, voracious, aggressively pervasive, very resilient, showing rapid growth, ability to move long distances and prolific breeding as these plants appear to have specific traits or combination of traits that allow them to compete with native plant species (Raghubanshi *et al.*, 2005; Valery *et al.*, 2008; Sujay *et al.*, 2010).

Table 1. Categories of Invasive Plants.

Aliens	Plants whose presence in an area, beyond their known historical range is the result of human-mediated transport (intentional or accidental)
Casual aliens	Alien plants that flourish and reproduce occasionally outside cultivation but do not form self-replacing populations and eventually die out; they rely on repeated introductions for their persistence.
Naturalized	Aliens that form self-replacing populations for at least 10 years without direct intervention by people; they often recruit offspring freely usually close to adult plants and do not necessarily invade ecosystems
Invasive	Plants are a subset of naturalized plants that produce reproductive offspring, often in large numbers, at considerable distances from parent plants and thus have the potential to spread over a large area.
Transformers	A subset of invasive plants which change the character, condition, form or nature of ecosystems over a substantial area relative to the extent of that ecosystem.

(a) They do not need special environmental requirement for seed germination; (b) have rapid seedling growth and produce seeds for longer period of time; (c) are highly tolerant to climatic and edaphic variations and have ability to compete and drive off other species from habitat; (d) because as an invasive species occurs outside its original ecosystem it often faces less competition, fewer diseases, lower predator pressure and other forms of control; (e) allelopathic potential of the invading species against the co-inhabitants in the introduced range is another factor that invasive species conquer novel areas within recipient ecosystems in which they becomes a dominant population.

Are all Aliens Invasive?

The biological process of invasion by alien organisms requires breaking physical, environmental and biological barriers in a series of steps, consolidated as 5 Es. These Es are Entry/Escape, Establish, Expand, Explode and Entrench (Williams, 1997). These phases are often influenced by abiotic factors of environment. The extent to which an introduced plant naturalizes and spreads depends on propagules pressure, properties of exotic species as well as ecosystem properties including new physical, chemical and biological environment in which it finds itself. If these factors are unsuitable, the plant is unlikely to become established (Lonsdale, 1999). Williamson's (1996) 'tens rule (ten-ten rule) of thumb of biological invasions' proposed a quantitative estimate of the proportion of introduced species that become pest. This rule suggests that only 10% of introduced species will become established in a host environment, and that only 10% of the established will become invaders. The rule was derived from European plant data but the general principle that successful invasions are rare (Richardson and Pysek, 2006). Over 70% of world's food comes from just nine crops (wheat, maize, rice, potato, barley, cassava, soybean, sugarcane and oats) each of which is cultivated far beyond its place of origin without posing any kind of threat (Sharma *et al.*, 2005). In this scenario predicting which species will become invasive among immigrants has become a challenge for ecologists and conservationists and there are obstacles in building support for regulatory policies as (a): biologists cannot predict how introduced species will behave in natural ecosystems (b): if some aspects of the environment are unsuitable, the plant may persist until there is an environmental shift in its favor or perhaps until it evolves to meet the adverse condition. Plants undergoing such a lag phase after introduction later may become significant noxious weeds (c): One other factor may be evolutionary changes that modify the plant genotypes resulting in

more suitable ecotypes for these habitats (d): certain native species may also become invasive due to habitat destruction causing ultimate dominance, for example in Pakistan, *Heracleum polyadenum* Rech. f. & Riedl weed had been left alone by the animals and the people so it got a chance of seed dispersal and this is the reason that though indigenous to the area, this herb has an invasive impact on the biodiversity (Sagoff, 2005; Marwat *et al.*, 2010; Rashid and Abbas, 2011) (Table 2).

Table 2. Opposing points that disable the Ecologists and Conservationists to present regulatory policies regarding plant invasions.

(a) Invasive plants, animals, and fungi are second only to habitat loss and degradation in endangering native plant species .	(a) Majority of successful invasions do not alter large-scale ecosystem properties and processes in a meaningful way. Nonetheless, some clearly do.
(b) Exotic species 'pollute', 'meltdown', 'harm', 'disrupt', 'destroy' and 'degrade' natural ecosystems.	(b) Invasion, adaptive radiation, and hybridization have been important factors in increasing the number of species in the world.
	(c) Introduced organisms typically, generally, and significantly add to species richness in ecosystems that is correlated with desirable ecosystem properties.

Highlights of biodiversity in Pakistan

Having an altitudinal gradient of more than 3000 km from coast in the South to snow peaked mountains in the North and with its broad latitudinal spread and immense altitudinal range, Pakistan embodies number of world's ecological regions. According to various classification systems, Pakistan includes examples of three of the world's eight biographic realms: the Indo- Malayan, Palaearctic and Africotropical; and four of the world's ten biomes: desert, temperate grassland, tropical seasonal forest and mountains, which in turn support a wide array of ecosystems (Gul, 2013). About 6,000 species of flowering plants have been reported including both native and introduced species, representing 22 families and about 150 genera. In a preliminary analysis of the flora of Pakistan, it has been found that the number of species per genus is much lower than the global average, indicating a high rate of diversity at the gene level (Shinwari and Shinwari, 2010). Four monotypic genera of flowering plants (*Douepia*, *Suleimania*, *Spiroseris*, *Wendelboa*) and around 400 species (7.8%) are endemic to Pakistan. Families with more than 20 recorded endemics are Papilionaceae (57 species), Compositae (49), Umbelliferae (34), Poaceae (32) and Brassicaceae (20); 31 of the endemics belong to the genus Astragalus, the largest genus in Pakistan with about 134 species. New endemics are still being discovered (GOP, WWF-P and IUCN-P, 2000). Despite the fact that the country is very rich in biodiversity, there remain very severe threats by over-grazing; over-harvesting; water-logging and salinization; deforestation; land conversion; soil erosion; desertification; alien invasive species; introduction of high yield varieties, agriculture expansion and dam construction and chemical pollution (Baig and Al-Subaiee, 2009).

Invasive plant problem in Pakistan

Pakistan has a long history of introduction of foreign plant and animal species. Most of current alien invasives in Pakistan were deliberately introduced with main objective behind to fill the gap between demand and supply of timber, fuel wood and fodder (Hussain and Zarif, 2003). Fortunately the magnitude of IAS in Pakistan is not as great as in some other countries but unfortunately the effect of exotic species on the native biodiversity has not been well documented (GOP, WWF-P & IUCN-P, 2000; Shinwari and Shinwari, 2010). There is no cataloging of invasive species yet exists and there is no dataset available that could give comprehensive information and impact of invasive species on native species

composition and diversity. Data deficit in the invasion biology literature is the result of insufficient and inadequate research efforts. The meager studies undertaken so far list 700 alien species of vascular plants (Khatoon and Ali, 1999); of these, *Broussonetia papyrifera, Prosopis juliflora*, *Parthenium hysterophorus* and *Lantana camara* can be regarded as high impact land invasives (Hussain, 2003).

Table 3. Inventory of Invasive Plants in Pakistan

Sr#	Botanical name	Common name	Life form	Family	Native range
1	*Achillea millefolium* L.	Yarrow	Herb	Asteraceae	USA
2	*Agave americana* L.	Agave	Herb	Agavaceae	Tropical America
3	*Ailanthus altissima* (Mill.) Swingle	Tree of heaven	Tree	Simarubaceae	China
4	*Alternanthera pungens* Kunth	Khaki booti	Herb	Amaranthaceae	Tropical America
5	*Amaranthus hybridus* L. subsp. hybridus	Chalwera	Herb	Amaranthaceae	Tropical and Subtropical America
6	*Amaranthus spinosus* L.	Spiny Amaranth	Herb	Amaranthaceae	Tropical America
7	*Amaranthus viridis* L.	Chulai	Herb	Amaranthaceae	South America
8	*Arundo donax* L.	Nar, Nara, Nal.	Grass	Poaceea	Africa
9	*Asphodelus tenuifolius* Cavan. L.	Piazi, Pimaluk	Herb	Liliaceae	Mediterranean
10	*Avena fatua* L.	Jangli Jai	Grass	Poaceae	Eurasia
11	*Bougainvillea glabra Chosy*	Paper flower	Tree	Nyctaginaceae	Brazil
12	*Bromus unioloides* Kunth	Prairie grass, rescue grass	Grass	Poaceea	Africa
13	*Broussonetia papyrifera* (L.) L'Herit. ex Vent	Paper mulberry, Gul toot	Tree	Moraceae	South East Asia
14	*Cannabis sativa* L.	Hemp, Mirijuana, Bhang	Herb	Cannabaceae	Central Asia
15	*Carthamus oxyacantha* M. Bieb.	Pohli	Herb	Asteraceae	Native
16	*Cassia obtusifolia* L.	Chakunda	Shrub	Caesalpinaceae	Australia
17	*Cassia occidentalis*L.	Kasondi	Herb	Caesalpinaceae	South America
18	*Citharexylum spinosum* L.	Ratanuath	Tree	Verbinaceea	West Indies
19	*Conyza bonariensis* (L.) Cronq.	Horseweed	Herb	Astraceea	Central and North America
20	*Cynodon dactylon* (L.) Pers.	Dub, Khabbal	Grass	Poaceea	Australia
21	*Dactylis glomerata* L.	Orchard grass	Grass	Poaceea	Europe
22	*Datura stramonium* L.	Thorn apple, Dhatura	Herb	Solanaceea	Central USA
23	*Duranta repens* L.	Golden dewdrop, pigeon berry, skyflower	Shrub	Verbinaceea	Americas
24	*Echium plantagineum* L.	Purple Vipers Bugloss, Blue Weed	Herb	Boraginaceea	Europe
25	*Eichhornia crassipes* (Mart.) Solms.	water hyacinth, gul-e-bakauli	Herb	Pontederiaceae	Africa
26	*Emex spinosus* (L.) Campd.	Prickly dock; Kafir kanda	Herb	Polygonaceea	Mediterranean Region
27	*Eucalyptus camaldulensis* Dehnh.	sufeda, lachi	Tree	Myrtaceae	Australia
28	*Eucalyptus citriodora* Hook.	Lemon eucalyptus	Tree	Myrtaceae	Australia
29	*Eucalyptus sideroxylon*A. Cunn. ex Woolls	Red Ironbark	Tree	Myrtaceae	Australia

30	*Eucalyptus tereticornis* Smith	Forest red gum	Tree	Myrtaceae	Australia
31	*Galium aparine* L.	Catchweed, bedstraw	Herb	Rubiaceae	Europe
32	*Heracleum polyadenum* Rech. f. & Riedl.	---	Herb	Apiaceae	Native
33	*Imperata cylindrica* (L.) Raeuschel.	Sword grass, Blady grass, Siru, Ulu	Grass	Poaceae	Europe
34	*Ipomoea carnea* Jacq.	railway creeper	Shrub	Convolvulaceae	Tropical America
35	*Ipomoea eriocarpa* R. Br.	Ilra, Bhanwar	Herb	Convolvulaceae	Tropical Africa
36	*Lantana camara* L.	Panch phuli	Shrub	Verbenaceae	Americas
37	*Leucaena leucocephala* (tant.) De wit.	ipil ipil, Kubabhal	Tree	Mimosaceae	Mexico, central America
38	*Leucanthemum vulgare* Lam.	Ox-eye daisy	Herb	Asteraceae	Europe
39	*Ligustrum lucidum Ait.*	Glossy privet	Tree	Oleaceea	China
40	*Lolium temulentum* L.	rye grass, Dhanak	Grass	Poaceae	Mediterranean
41	*Lotus corniculatus* L.	---	Herb	Papilionaceae	Europe
42	*Malva parviflora* L.	Sonchal	Herb	Malvaceea	Europe
43	*Medicago lupulina* L.	Black medic	Herb	Papilionaceae	Eurasia
44	*Medicago sativa* L.	Alfalfa, Lusan	Herb	Papilionaceae	North Africca
45	*Morus alba* L.	White mulberry, Sfaid tut	Ttree	Moraceae	Nothern China
46	*Nerium oleander*L.	Kunair, Ganira	Shrub	Apocyanaceae	Australia
47	*Parthenium hysterophorus* L.	White top, Congress grass, Carrot grass	Herb	Asteraceae	North Central America
48	*Phalaris minor* Retz.	Dumbi sitti	Grass	Poaceae	Europe
49	*Phragmites australis* (Cay.) Trin. ex Steud.	Ditch Reed, Nal, Dila	Grass	Poaceae	Australia
50	*Phragmitis karka* (Retz.) Trin. ex Steud	Drumbi, Nar, Nalu	Grass	Poaceae	Africa
51	*Pistacia chinensis* Bunge	Chinese pistacia, green almond	Tree	Anacardiaceae	China
52	*Pistia stratiotes* L.	Water lettuce; Jal kumbi	Herb	Araceae	South America
53	*Plantago lanceolata* L.	Danichk, Brohi Barz	Herb	Plantaganaceae	Europe
54	*Prosopis juliflora* (Sw.) DC.	Kabuli kikar, valayati jand	Tree	Mimosaceae	North and South America
55	*Ricinus communis* L.	Arind	Shrub	Euphorbiaceae	Africa
56	*Robinia pseudo-acacia* L.	Black locust	Tree	Papilionaceae	North America
57	*Rumex conglomeratus* Murray	Clustered dock	Herb	Polygonaceae	Europe
58	*Rumex crispus* L.	Curly dock	Herb	Polygonaceae	Europe
59	*Salvinia molesta* Mitch.	water fern	Fern	Salviniaceae	South America
60	*Sapium sebiferum* (L.) Roxb	Pahari Shisham	Tree	Euphorbiaceae	Japan, China
61	*Sida cordata* Blumea	Sida	Herb	Malvaceea	India
62	*Silybum marianum*(L.) Gaertn.	Kandiari	Herb	Astraceea	China
63	*Sorghum halepense* (L.) Pers.	Baru, Baran	Grass	Poaceae	Americas
64	*Tagetes minuta* L.	Gul-e-Sadbarg; Mexican marigold	Herb	Asteraceae	Southern South America
65	*Thuja orientalis* L.	Mor Pankh	Tree	Cupressaceae	China
66	*Trianthema portulacastrum* L.	It-sit, Wisakh	Herb	Aizoaceae	Tropical America

67	*Trifolium dubium* Sibth.	Suckling clover	Herb	Papilionaceae	Western Eurasia
68	*Trifolium pratense* L.	Red clover	Herb	Papilionaceae	Meditteranean
69	*Verbascum thapsus* L.	Jangli Tamak, Sfaid bhang	Herb	Scrophulariaceae	Eurasia
70	*Verbena tenuisecta* Briq.	Moss verbena	Herb	Verbinaceea	South America
71	*Veronica persica* Poir.	Common field speedwell	Herb	Scrophulariaceae	Europe
72	*Vulpia myuros* (L.) C.C.Gmel.	Rat-tail fescue	Grass	Poaceae	Europe
73	*Xanthium strumarium* L.	Common cocklebur	Herb	Asteraceae	North America

High impact invasive land plants in Pakistan

Parthenium hysterophorus L.

Common names

Gandi booti, ragweed, carrot grass, congress grass, white top, baby flower; Family: Astraceae; Native range: Mexico and Central America).

Parthenium hysterophorus L. is ranked one of ten worst weeds in the world that has become a curse particularly in Australia, China, Ethopia, India, Kenya and Pakistan (Javaid *et al*., 2010). Rapid growth rate, high reproductive potential, adaptive nature (photo-insensitivity and drought resistance), allelopathy and absence of natural enemies may be considered as main factors for invasiveness (Khalid, 2000).

History of Introduction

Parthenium was accidently introduced to India around 1955 as a contamination in the wheat consignment from America. It is suspected to have come in Pakistan around 1980,s through livestock, food commodities or vehicles transport contaminated with the weed seeds from India (Vehra and Khan, 2011; Khan *et al*., 2012).

Table 4. Worst land invasive plants in Pakistan and world's perspective.

Plant Species	Purpose of Introduction	Major Impacts	World's Perspective
Broussonetia papyrifera (L.) L'Herit. ex Vent Southeast Asia (China, Japan) (1960,s)	To make capital area (Islamabad) green in short duration	Serious human and cattle allergen, Competitor of natural biodiversity	Dispersant in production of ZnO nanopowder (Liewhiran *et al*., 2006); Pharmacology {Treatment of Non-insulin-dependent diabetes mellitus (type II) (Chen *et al*., 2002), antioxidant (Zhou *et al*., 2010) Antimicrobial (Khan *et al*., 2011), antioxidant and anti-inflammatory (Zhao *et al*., 2011)}
Parthenium hysterophorus L. Central and North America (1980,s)	Accidental	Hazardous to human health and cattle, crop loss, threat to natural biodiversity, Alternative host to TSV	Green manure in rice ecosystems (Biradar *et al*., 2006), Adsorbent to remove CR(VI) from aq. Soln. (Singh *et al*., 2008), Silver nanoparticles formation for biomedical uses (Parashar *et al*., 2009; Logaranjan *et al*., 2012), compost in organic farming (Khaket *et al*., 2012), growth factors for improved growth of desired plants (Lalitha *et al*., 2012), Bioethanol production (Ghosh *et al*., 2013, Swati *et al*., 2013), pharmacology {anti-inflammatory, antioxidant, anticancer, antimicrobial, pesticidal, wound healer, hypoglycemic, thrombolytic, treatment of Migraine and Rheumatoid Arthritis (Roy and Shaik, 2013)}, Biochar production (Kumar *et al*., 2013)
Prosopis juliflora (Sw.) DC.	Sand dunes stabilization	Replacement of natural biodiversity at huge scales, cattle poisoning	Bio-char Production (Kazmi *et al*., 2010); low cost activated carbon {*Prosopis juliflora* bark carbon

North and South America (1878)			(PJBC)} (Kumar and Tamilarasan, 2013); Larvicidal against malaria vector *Anopheles stephensi* (Varun *et al*., 2013); Potential Feed for Livestock (Mahgoub *et al*., 2013); Phytopathology and plant protection (Ikram and Dawar, 2013); Products for animal and human consumption, multiple uses of wood, gum, carbon sequestration, medicinal value, soil reclamation (Tewari *et al.,* 2013)
Lantana camara L. Unknown (----)	Americas	Change in vegetation picture of certain areas, repel the associated fauna by its strong odor, cattle poisoning	Ecological pest management (Kong, 2010), Silver nanoparticles formation for biomedical uses (Sivakumar *et al*., 2012), Pharmacology {antioxidant, antimicrobial, antifungal, antiulcerogenic, antimalarial, wound healer, antihelmintic, antipyretic, antihyperglycemic (Saxena *et al*., 2012; Joy *et al*., 2012)}; phytoremidiation (Waoo *et al*., 2013), pesticide (Kalita and Bhola, 2013)

Current Distribution in Pakistan

In Pakistan, parthenium has become a major wasteland weed replacing the native flora in rain fed areas of the Punjab province and is also spreading in North Western Frontier Province (NWFP) and Kashmir (Riaz and Javaid, 2011). Okara (Javaid and Riaz, 2007), Lahore (Javaid *et al.*, 2009), Wah cantt (Riaz and Javaid, 2009), Hafizabad (Riaz and Javaid, 2010), Attock (Riaz and Javaid, 2011), Kasur (Anwar *et al.*, 2012), Nankana Sahib (Riaz and Javaid, 2012), Sialkot and Shekhupura (Javaid and Riaz, 2012), Rawalpindi (Fatimah and Ahmad, 2012), Islamabad (Shabbir and Bajwa, 2006; Hassan *et al.*, 2012), Peshawar valley (KPK) (Khan *et al.*, 2011), Dera Ismail Khan, Lakki Marwat, Bannu, Kohat, Peshawar, Mardan, Charsada (Hassan *et al.* 2012), Chitral, Hango, Swat (Khan, 2012) are adversely affected areas.

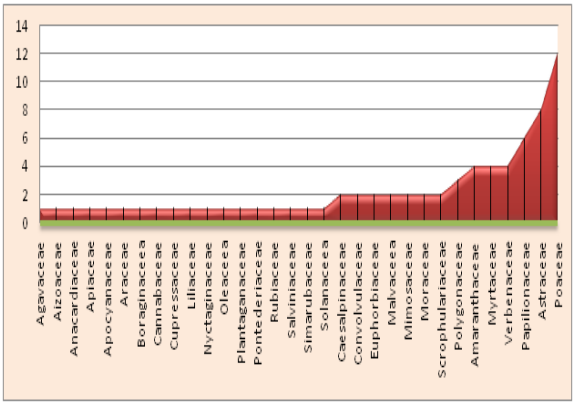

Fig. 1. Contribution of Different Families in Invasive Flora of Pakistan.

Major Impacts

Parthenium weed is serious menace to human health, livestock, crop production and biodiversity.

Human health and cattle

All the plant parts contain toxins called sesquiterpene lactones. Major component of toxin being 'Parthenin' is lethal to humans and livestock. Prolonged skin contact with this weed can result in allergic contact dermatitis. Inhalation of pollens causes allergenic rhinitis which can develop into asthma and bronchitis (Shabbir and Bajwa, 2006). Cattle generally don't eat this weed, if grazed mistakenly; develop severe dermatitis and toxic symptoms (Javaid and Riaz, 2012). In Australia thousands of dollars worth meat gets tainted by parthenium weed (Shabbir, 2006).

Threat to biodiversity

Medicinal herbs in wastelands of Islamabad are under a serious threat due to aggressive colonization of parthenium weed (Shabbir and Bajwa, 2006).

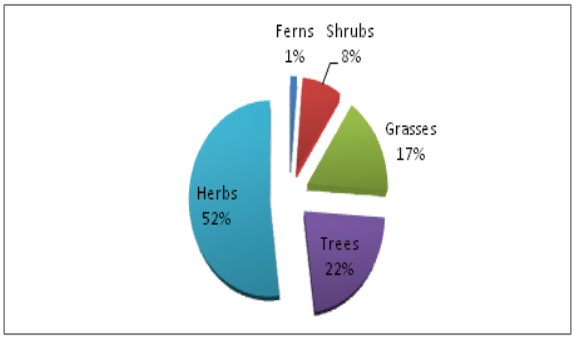

Fig. 2. Contribution of Different Life Forms in Invasive Flora of Pakistan.

Crop loss

Yield losses of up to 40% are reported in several crops in India (Adkins and Navie, 2006). In Pakistan this weed has been reported from major cereal crops like wheat, maize and sorghum (Shabbir and Javaid, 2010). Among the weeds in wheat crop, *parthenium* is although not a major weed currently but it is suspected to become and may cause great production losses to the crop in the near future (Khan *et al.*, 2012).

Alternative host to TSV

Tobacco Streak Virus (Ilarvirus TSV) of sunflower and mung bean from Pakistan being present on Parthenium (Ahmed *et al.*, 2003).

Fig. 3. Worst terestrail invasive flora of Pakistan: A - *Parthenium hysterophorus* L., B - *Broussonetia papyrifera* (L.) L'Herit. ex Vent., C - *Prosopis juliflora* (Swartz) DC., D - *Lantatna camara* L.

Management Approaches

Chemical control

Buctril Super and Chwastox (Javaid *et al*., 2006), Atrazil 38% SC, Ametryn+Atrazine 80WP, Bromoxynil+MCPA 40EC, Butachlor 60EC, Glyphosate 41SL (Javaid, 2007) Glyphosate, metribuzin, Primextra Gold 720 SC (Khan *et al*., 2013) are proposed herbicides against parthenium weed.

Potential organic herbicides for Parthenium control

Aqueous extracts of allelopathic grasses *Desmostachya bipinnata* (Javaid *et al*., 2005), *Dicanthium annulatum* Stapf., *Cenchrus pennisetiformis* Hochest, *Sorghum halepense* Pers. (Javaid and Anjum, 2006), aqueous leaf extracts of allelopathic trees viz., *Azadirachta indica* (L.) A. Juss., *Ficus bengalensis* L., *Melia azadarach* L., *Mangifera indica* L. and *Syzygium cumini* (L.) Skeels (Shafique *et al*., 2005) have potential to control germination and seedling growth of Parthenium weed. Suppressive ability of aqueous extract of plant parts (root, shoot and flower) of *Tagetus eructus* (Shafique and Shafique, 2011), *Alstonia scholaris* leaf and bark extracts (Javaid *et al*., 2010b), aqueous extract form roots and shoots of *Datura metel* (Javaid *et al*., 2010c, Shafique *et al*., 2011), Shoots of *Withania somnifera* (Javaid *et al*., 2011a; Shafique *et al*., 2011), leaves of *Azadirchta indica* (L.) A. Juss., *Ficus bengalensis* L., *Melia azadarach* L., *Mangifera indica* L. and *Syzygium cuminni* (Shafique *et al*., 2005), metabolites of *Trichoderma* spp. can be exploited for the management of parthenium weed (Javaid *et al*., 2013). Parthenium weed management is reported by amending the soil with wheat residue (Javaid *et al*., 2011b).

Control through native flora

Allelopathic grasses *Imperata cylindrica* (L). Beauv., *Desmostachya bipinnata* Stapf (Javaid *et al*., 2005; Anjum *et al*., 2005) and native plant *Cassia occidentalis* (Shabbir and Bajwa, 2004) is advisable competitive weed of wastelands replacing *parthenium* weed gradually.

Biological control

Larvae of beetle *Zygogramma bicolorata* Pallister feed on leaves of and cause defoliation in *parthenium* weed (Dhileepan and Senaratne, 2009).

Broussonetia Papyrifera (L.) L'Herit. ex Vent. (Syn. Morus papyrifera L.)

Common names

Jangli toot, paper mulberry, tapa cloth tree; Family: Moraceae; Native range: Southeast Asia).

B. papyrifera is dioecious, deciduous tree and is a significant weed overseas especially in Pakistan, Argentina, Ghana and Uganda. The rapid growth rate, effective dispersal by birds and strategy of vegetative regeneration probably contribute to its success (Malik and Hussain, 2007).

History of Introduction

B. papyrifera was introduced to the Islamabad in 1960s. Its seeds were sprayed from helicopter over Islamabad to make the capital green in a short duration (Malik and Hussain, 2007).

Current Distribution in Pakistan

Paper mulberry is the most problematic invasive in northern Pakistan and metropolitan area in Pakistan (Marwat *et al*., 2010; Ashraf *et al*., 2012). In subtropical forest in the Himalayan foothills of Pakistan *B. papyrifera* is the largest possible invasion of woody species ever known (Malik and Hussain, 2007).

Major Impacts

Paper mulberry is a menace to biodiversity as well as human health.

Human health hazard

B. papyrifera pollens cause inhalant allergy in humans (Abbas *et al*., 2012). In a report by Pakistan Medical Research Council (1995), about 45.5% of allergic patients in Islamabad and Rawalpindi showed positive sensitivity to its pollens (Marwat *et al*., 2010).

Threat to Natural Biodiversity

Invaded areas are reported to have considerably lower richness and diversity of herbaceous as well as woody species. It has changed the xerophytic vegetation to mesophytic vegetation in and around Islamabad (Malik and Husain, 2007). This invasive species is a growing threat to the natural vegetation of National park and other valleys in the East of Islamabad up to south Azad Jammu and Kashmir (Marwat *et al*., 2010).

Other

Its fruits are relished by crows and other birds who thus act as the vector for its seed dispersal. The increased population of crows has become a nuisance for the residents of affected areas. Choking of sewerage lines in the urban set-up are attributed to the paper mulberry.

Management Approaches

The newly sprouting shoots from tree stumps and groundcovers are being cut and burnt but this operation is not effective as it continues to comeback due to its invasive nature. Mechanical cutting of the trees associated with application of non selective herbicide like glyphosate in case of small plants and through injectors in case of big trees control it effectively (Marwat *et al*., 2010).

Prosopis Juliflora (Swartz) DC. (Syn. Mimosa juliflora Swartz)

Common names

Devi, valayati jand, kabuli kiker, mesquite tree: Family: Mimosaceae; Native range: Central and South America).

P. juliflora is nitrogen fixing, perennial, ever-green plant, found both as bush and medium size tree with a sizeable crown and an open canopy growing to an average height of 5-10 m. At some places in Lower Sindh it may gain a height of 14-16 meters (Kazmi *et al*., 2010). This plant is invasive in various arid and semi-arid climate zones including parts of Southern America, Australia, India, the Pacific, Pakistan and several countries in Africa, the Arabic Peninsula, and the Middle East**.** Exceptional tolerance of drought, high salinity and water logging as well as prolific seed production contribute in invasiveness of this plant.

History of Introduction

P. juliflora was introduced to Sindh in 1857 (at time of un-divided India) for purpose of sand dunes stabilization followed by Government of Pakistan in 1950s and 1960s (Pasiecznik *et al*., 2001).

Current Distribution in Pakistan

During the last 45 years, it has invaded all kinds of communities in the flat plains of Karachi and has now become dominant by completely eliminating the natural vegetation (Noor *et al*., 1995). Lower Sindh and sizeable areas of the Makran coast of Balochistan are now home to the mesquite. In lower Sindh, mesquite tree has occupied various ecosystems; agricultural fields, urban settlements, river beds, rocks mountain-slopes, road-sides, saltish soils and the coastal belt (Kazmi *et al*., 2010).

Major Impacts

Livestock

The pods cause facial contortions, impacted rumen and constipation among livestock (Noor *et al*., 1995).

Threat to biodiversity

P. juliflora in effecected areas of Pakistan is eliminating the habitat of indigenous species at a catastrophic level.

Management Approaches

Mechanical control

Mechanical grubbing with tractor operated machines and burning is practiced in lighter infestations.

Chemical control

Heavy dosages of certain chemicals (e.g., Fernoxone) appear to have an inhibiting effect on *P. juliflora* (Khan, 1961) however the cost of treatment is unduly high compared with that of hand grubbing. Chemical control methods using herbicides are not successful owing to the thick bark and small leaves with a

protective waxy layer which all result into poor uptake of the chemical (Pasiecznik *et al*., 2001).

Control through utilization

The failure of extensive eradication efforts in many countries using the conventional control methods makes 'utilizing *Prosopis*' an effective strategy to control its spread. It can be potentially useful as source of fuel wood, timber and furniture wood, living fences and shelterbelts to halt the encroachment of sand dunes. Other products can be gums, fibers and medicines. In Pakistan, Muzaffar and Ahmad (1991) reported *P. Juliflora* as one of major source of bee forage. The incredible economic and physiological characteristics of *P. juliflora* make it a prime contributor to the development of many arid regions.

The challenge faced by Pakistan is how to respond to known invasives and to check new introductions that could potentially be invasives. Although not all alien species will become invasive or threaten the environment, this is an area in which a clear policy approach is necessary because of its potentially wide ranging impacts when they do become invasive and because of the difficulties, including financial costs, in reversing their impacts. Furthermore, there is need of international cooperation and interdisciplinary coordinated work through exchange of information in identifying invaded organisms and in assessing their ecological problems, environmental concerns in different ecosystems, economic damage and methods of control. Keeping in view the importance of the issue strenuous efforts are required to generate a good insight into the problem and suggest remedial measures; as the conservation of biodiversity is fundamental to achieving sustainable development.

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